Final Draft Project Summary Report

Pre-Feasibility Study for a Road into Northern Labrador

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	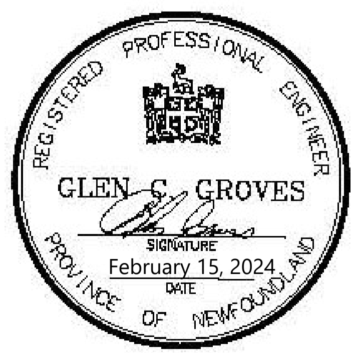
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TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

APPENDICES

EXECUTIVE SUMMARY

Community Consultations

This report presents a summary of feedback received from the Indigenous and community consultation process for the pre-feasibility study for the road into Northern Labrador, which Norlogics led with the assistance of Allnorth for our client, the Government of Newfoundland and Labrador (Department of Transportation and Infrastructure).

In addition to direct engagement with Indigenous governments and organizations open house style public consultation sessions took place between March 22-June 20, 2023, in Northern Labrador and Upper Lake Melville communities. Advertising for these public consultation sessions took place via email, social media, and through the project website, www.northcoastroad.ca. More than 190 North Coast residents and 70 Upper Lake Melville residents attended a consultation session, while 12 residents submitted written submissions through the project website.

Residents mostly supported the idea of a road into Northern Labrador. Reasons included the freedom of choice of transportation means, access to advanced healthcare, the current transportation network not being sufficient, climate change impacts, creation of a 'Southern Hub', increased infrastructure development, and economic development opportunities. Residents who opposed the idea of a road were most concerned about the impacts to fish, land, and wildlife, along with the increased access to drugs and alcohol. Both those for and against a road mostly agreed that more consultation needs to occur before a road is built and that interim enhancement to the current transportation network is required.

Route Selection and Appraisal

The enclosed report is a desktop route selection analysis based on technical design criteria with considerations for costs, environment, and socio-economic factors.

Technical criteria for the route horizontal and vertical alignments are based on Transportation Association of Canada (TAC) "*Geometric Design Guide for Canadian Roads*" for an 80 km/hr design speed.

Potential routes were investigated with a goal of minimizing lengths of routes where feasible. Shorter routes tend to be associated with lower costs for construction, maintenance, and operations. Shorter routes also require less land for construction and thereby a smaller environmental footprint and potentially less impact on other land uses.

The communities to be connected are located along the North Coast of Labrador and in most cases, they are separated by bays that prevent a single route. In those instances, separate access routes are necessary to make the connection. Other factors that guided the route selection process included Indigenous and community consultation feedback, the location of major water bodies, rivers, wetlands, mountains, valleys, and other topography that can have a significant impact on the design and cost of road construction and maintenance.

A desktop study using Google Earth and topographic maps was completed on many potential routes. The routes were investigated to determine potential adherence to established technical criteria. Where this proved to be difficult, alternate routes were also identified and investigated. Where more than one viable option was identified, a high-level ranking table was used to compare options based on available information. As well, the advantages and disadvantages of each option was recorded as a part of this exercise.

Rough order of magnitude (ROM) costs (±50%) for construction and maintenance of the selected routes were completed. The estimates are based on assumptions and allowances for the type of construction anticipated. Some of the work units, such as granular quantities, can be accurately estimated whereas other items, such as excavation/fill quantities, are estimated using an allowance per kilometer based on engineering judgement, considering the type of topography and typical road cross-section standards. The "current year" pricing for the individual work units is based on historical bid prices for similar work and adjusted for inflation and location.

A road into Northern Labrador would require approximately 809 km of new road construction. The ROM cost of construction is estimated at approximately $2.1 billion. Paving of the road is estimated to cost an additional $600 million. The estimated annual maintenance cost is in the order of $13 million. These costs are based on current year pricing and will need to be adjusted for inflation, depending on project timelines.

Permafrost and Hydraulic Risk

The enclosed report provides an opinion on technical aspects of the work related to hydrotechnical and geotechnical feasibility design in a permafrost environment.

A desktop study identified several reference documents relevant to the pre-feasibility assessment for regional characterization of geomorphology, permafrost and meteorology. There was limited site-specific data on permafrost in peatlands and is unlikely to be relevant to any specific structure. In general, the desktop phase of the pre-feasibility assessment identified a deficiency in public domain technical data for design of drainage systems and potential foundation complications related to discontinuous permafrost.

The presence of isolated and sporadic discontinuous permafrost is likely for the preferred and alternate alignments. Where present, permafrost is likely randomly distributed but may be concentrated in shaded areas, areas with additional vegetation canopy and areas with peat as the surface vegetation. An initial risk-informed opinion on climate change sensitivity determined the area has a "Medium" level of climate sensitivity with "Minor to Major" consequences of infrastructure failure and an overall risk rating B and C.

The assessment opinion is the climate risk is acceptable for the preferred and alternate alignments provided there is further detailed geotechnical characterization and thermal assessments required as part of the feasibility design. During the feasibility level design development, the extent and nature of permafrost should be evaluated using a two-stage geotechnical investigation. The first stage can use remote technology to catalogue, group and discretize periglacial and other landforms that may cause structural risk to the road and drainage infrastructure. The second stage geotechnical investigation will include test pits in late summer to understand the extent of the "Active Zone" and core drilling in winter to define ice content. Additional site characterization may be required during detailed design.

There are sparse meteorological and hydrometric stations for drainage design. As part of feasibility design, additional flow monitoring and meteorological stations placed at strategic locations can be used to calibrate areas to more effectively transpose long-term monitoring available in the area. Using the current data to develop regional models based on physiographic features can be an effective way to manage infrastructure sizing as design is developed. There are several long-term monitoring locations in the region to develop predictive models for hydrology and hydraulics.

Because climate change effects are current and ongoing, the impacts are not adequately reflected in the historical record. All published climate related projections for Labrador predict rapid temperature increases and an increase in total precipitation that includes more rainfall and less snow. The impacts of climate change result in risk and uncertainty for design and construction of drainage infrastructure in Northern Labrador in two principal ways:

- An increasing mean annual air temperature will result in less annual snowpack and may change the timing and intensity of the Spring freshet, currently expected to occur late May to early June. This trend may not be uniform over the proposed alignment where northern areas may get more snow and a larger Spring freshet.

- The change in precipitation may result in more intense rainfall events of short duration during the summer months that may govern design of drainage infrastructure.

Drainage design can be completed using standard civil engineering tools with varying complexity as the infrastructure investment increases. Tools can vary from simple empirical tools where the consequences of failure are low to more robust technical methods for more consequential infrastructure. Computer modelling technology can be applied at relatively moderate cost for all watershed sizes. Computer models are more effective when calibrated with actual observations. To be consistent with current design standards and industry practice with respect to drainage infrastructure, the road into Northern Labrador drainage infrastructure should be sized for the expected runoff with a 100-year annual exceedance probability, with allowance for climate change. The duration of the storm event will vary as a function of the time of concentration for the watershed.

Environmental
The environmental overview was prepared to provide a general understanding of the features identified within the general proposed road alignment, as well as recommendations for pre-construction studies and construction considerations.

- Geology - Surficial geology along the proposed road is primarily granitic rock, with areas of course and fine till sediment (increased near larger watercourse crossings). Areas of sediment deposits and acid generating rock should be avoided as feasible. Large cuts in unstable areas may require geotechnical assessment;
- Vegetation - Limited baseline vegetation survey information was found for Labrador. A preliminary review of the listed vegetation species included within Newfoundland and Labrador 57/02: Endangered Species List Regulations indicated no known presence within the proposed road corridor;
- Wildlife – Limited baseline wildlife survey information was found for Labrador. There are two documented rare/endangered species habitat ranges within the proposed road corridor (Northern Brown Myotis and Red Wine Caribou herd);
- Watercourses - The proposed road will traverse several watersheds of productive salmon rivers, with potential for multiple crossings of the rivers or their tributaries. Crossings of salmon-bearing rivers and their tributaries will require review by Fisheries and Oceans Canada (DFO);
- Parks and Protected Areas – Potentially, one (1) Provincial Protected Area will be impacted. This area is located on the north side of Little Lake near North West River and is identified in the Provincial Land Use Atlas as “Parks: Grand Lake Transfer, 1985”.

Gap Analysis
An analysis has been completed to identify information gaps and to make recommendations with respect to future effort and investigations needed to support informed decision making at the feasibility stage of the project. This includes Indigenous and community consultations as well as route selection and appraisal work.

The Request for Proposal (RFP) provided a list of items that were excluded from the pre-feasibility study scope of work. These items are subject to future analysis and are included to give the reader context on the scope of work and limitations of the pre-feasibility study.

1 INTRODUCTION

On October 28, 2022, the Government of Newfoundland and Labrador (GNL) – Department of Transportation and Infrastructure (DTI) issued a Request for Proposals to Consultants to conduct a pre-feasibility study on a potential extension of the Trans-Labrador Highway into Northern Labrador. A total of four Amendments were issued to respond to Proponent inquiries in accordance with the terms outlined in the Request for Proposals. On December 9, 2022, Consultant submissions were received by DTI. The RFP then moved into the stated Evaluation Process as outlined in the Request for Proposal. On January 24, 2023, the DTI awarded Allnorth Consultants Ltd. (Allnorth) the contract to undertake the scope of work, and the project was officially kicked off on February 2, 2023.

Allnorth provided Prime Consultant services as well as highway design and environmental expertise. Norlogics Inc. (Norlogics), a Nunatsiavut Inuit-registered business, led the community consultation program, and Meco Engineers (Meco) was sub-contracted to provide expertise related to drainage and hydrology, as well as geotechnical design in a permafrost environment.

The Indigenous community consultation program was used in conjunction with existing background information and open-source spatial data to support the route selection and appraisal work. Factors such as projected climate change data, Indigenous knowledge, socio-economic considerations, and others were also considered in the route selection and appraisal work.

2 BACKGROUND INFORMATION AND SCOPE OF WORK

A road into Northern Labrador would potentially start in the North West River area and extend as far north as Nain, including access roads to Postville, Makkovik, Hopedale, Rigolet ·and Natuashish. Constructing a road to cover this distance in remote and rough terrain will be a costly undertaking and require considerable time to plan, design, and construct. Currently, there is insufficient information to inform a decision regarding such a project and consequently the Government of Newfoundland and Labrador committed to conducting this pre-feasibility study. This study considers the potential routes, post construction road maintenance and operation, and identifies other key technical and non-technical factors that require study and analysis to inform decision-making. This study also identifies significant socio-economic, cultural, and environmental considerations associated with the potential construction of new road infrastructure in this area, adjacent to several Indigenous peoples and communities. These considerations include but are not necessarily limited to the social determinants of health (e.g., access to health services, social inclusion and connectivity); potential changes to the natural environment; Indigenous values, land use and knowledge; and residents' views on the advantages and disadvantages of increased access to the area.

Community Consultation

As part of this study, Indigenous and community consultations were required and led by Matthew Pike of Norlogics Inc., and Kirk Peddle from Allnorth. From March 22 to June 20, 2023, community consultations were held in Nain, Natuashish, Hopedale, Postville, Makkovik, Rigolet, North West River, and Happy Valley – Goose Bay. In each community, a two-hour morning, afternoon and evening, open house consultation session was held.

In the North Coast communities, more than 190 North Coast residents attended an in- community consultation and 12 submitted comments through www.northcoastroad.ca. In Upper Lake Melville, more than 70 residents attended a session in North West River and/or Happy Valley – Goose Bay.

Public community consultations were conducted prior to the completion of other aspects of this study (i.e., route selection analysis) and consultation session were based on perceptions of a road in general. While these were public sessions, names have been redacted and some identifying information has been changed.

Route Selection and Appraisal

Connecting the six Northern Labrador communities (Rigolet, Makkovik, Postville, Hopedale, Natuashish and Nain) to the road network will require road and bridge construction in a northern climate where there is steep terrain, extensive wetlands, major rivers, and permafrost that all present challenges in highway design and must be considered in the route selection process. There are also socio-economic and environmental considerations that influence the route selection process. The recommended routing segments try to strike a balance of the various project objectives.

The route selection process was completed in iterations with the overall goal of determining the shortest possible routes that would connect all Northern Labrador communities while considering the following project objectives:

- Avoid crossing major water bodies;
- Maintain buffers around water bodies where possible to minimize environmental impacts on water quality and fish habitat;
- Minimize crossing distance of rivers;
- Avoid or minimize crossing of wetlands, swamps, and bogs;
- Meet minimum road design standards based on 80 km/hr design speed for horizontal curves (10 km/hr higher than the proposed posted speed limit) and a maximum grade of 10%;
- Avoid deep cuts where snow accumulation would negatively impact future road maintenance and operation;
- Minimize steep side slopes;
- Minimize impacts on other land use.

There were other important factors to consider during the route selection and appraisal process. Many of those were common to the various route options considered and include potential impacts on Indigenous lands, impacts on wildlife, the extent on permafrost, etc.

When considering route options, the shortest possible routes generally have many advantages, when the topography is comparable. For example:

- Lower construction cost;
- Lower maintenance costs;
- Less environmental impact;
- Shorter travel distances and thereby lower travel costs for users;
- Lower shipping costs when a common carrier makes deliveries to each community in one trip.

Permafrost and Hydraulic Risk

Meco was engaged by Allnorth as a sub-consultant to inform the report on technical aspects of the work related to drainage and hydrology and geotechnical design in a permafrost environment.

The scope of work includes two technical services related to collecting background information:

- Literature review of available information on geomorphology and permafrost risks for the proposed alignment;

- Catalogue available public domain data sources for developing a hydrological model for drainage along the proposed route.

Environmental

A pre-feasibility environmental overview is intended to provide a coarse overview of the publicly available information for the general corridor alignment, as well as identify areas for further investigation. An Environmental Assessment process is likely to be triggered by this project, which would require additional study and investigation of environmental features and impacts of the project to satisfy regulatory agencies. The EA process (federal and provincial) can vary on a project-by-project basis, and further assessment of key environmental features during the Feasibility Study will assist with development of the preliminary scope prior to registration. Field studies would be undertaken during the Concept Design, to determine site-specific features, required planning, and management strategies. Management Plans are typically developed during the EA process, with construction-level planning completed during detailed design.

Pre-Feasibility Cost

The cost of constructing and maintaining roads in Northern Labrador is impacted by the challenges of delivering materials and equipment to remote areas, providing accommodations for workers, a relatively challenging terrain and relatively short construction season. Similarly, maintenance costs are also impacted by similar challenges as well as long winter seasons that impact snow removal and ice control.

To effectively construct a road, work must be completed in phases that optimize access to each area in a manageable sequence. For instance, building the road from several available access points to permit multiple crews and/or contractors to work simultaneously and constructing access to river crossings in the early phases so that bridges can be constructed for access to points beyond.

For a pre-feasibility study, there is limited information available that can be used for cost estimating. Topographic maps, aerial imagery, software applications (i.e. ArcGIS, Google Earth Pro) are useful in determining such things as type of terrain, steepness of slopes, water bodies and stream/river crossing widths. At this stage, many assumptions must be made on items that are unknown such as the quality of materials to be excavated along the route and can it be used for embankment construction.

3 COMMUNITY CONSULTATIONS

3.1 Background And Methodology

On October 28, 2022, following engagement with Indigenous government and organizations on a draft scope of work, DTI issued a Request for Proposals (RFP) to Consultants to conduct a pre-feasibility study on a potential extension of the Trans-Labrador Highway into Northern Labrador.

On November 8, 2022, the Government of Newfoundland and Labrador (GNL) announced $400,000 from the Transport Canada National Trade Corridors Fund for a pre-feasibility study for the construction of a road into Northern Labrador and announced a Request for Proposals (RFP)[1]. In terms of required consultation with Indigenous governments, organizations and communities, the RFP stated the proponent was to:

"Consider Indigenous knowledge and culture in all aspects of the study. This will require consultation at the community level with the five Inuit Community Governments of Nain, Hopedale, Postville, Makkovik, and Rigolet, and the Mushuau Innu First Nation, in addition to consultation with Nunatsiavut Government (NG), Innu Nation, Sheshatshiu Innu First Nation, and NunatuKavut Community Council (NCC)."

In a November 10, 2022, press release, the NG expressed an expectation that "comprehensive" and "public community level consultation" take place before any firm decisions to proceed with construction are made. The communities of North West River and Happy Valley – Goose Bay were later added as communities to be consulted. In-person consultations were to include identification of, without limiting the scope of those consultations:

- Indigenous land use, harvesting and cultural and ecological values;
- Potential changes in the nature and character of daily life and community (e.g., out-migration and increased "outsider" pressures);
- Settled or asserted Aboriginal rights in the proposed areas;
- Key high level socio-economic and environmental considerations for constructing a road in the region, including food security; cost of living; access to health and other services; social determinants of health; environmental sensitivities such as George River caribou herd habitat and calving grounds; climate change impacts; and,
- Tourism, resource, and other economic developments, including potential impacts on historical and/or culturally important sites.

On January 26, 2023, the Government of Newfoundland and Labrador awarded Allnorth the contract to conduct a pre-feasibility study for a road into Northern Labrador. As part of this study, Indigenous and community consultations were to be led by Matthew Pike of Norlogics Inc., a Nunatsiavut Inuit-registered business, and Kirk Peddle from Allnorth.

In early February, the bi-annual Northern Lights Conference and Tradeshow took place in Ottawa and many NG and Innu Nation/community representatives were in attendance. Immediate feedback from Indigenous and community leaders was that the public needed to be included directly in the consultation process. In mid February 2023, Inuit Community Governments formally requested that public, open-house style consultations take place. Over the coming weeks DTI gave approval to include public community consultations in five North Coast Inuit communities, two Innu communities as well as Happy Valley-Goose Bay and North West River.

3.2 Who and How We Engaged

3.2.1 Who We Engaged

Below is an overview of comments and participation from Indigenous governments, organizations and communities. all the identified Indigenous governments, organizations and communities were invited to participate and provided with the opportunity to participate in the Pre-Feasibility Indigenous Community Consultation Program. Non-involvement of some Indigenous organizations and communities should not be negatively reflected upon as they all have significant competing priorities. For example, Sheshatshiu Innu First Nation was dealing with an Inquiry into the treatment of Innu children in care (along with Innu Nation) and was faced the resignation of their multi-term Band Council Chief during the same time we were trying to set up community consultations for a road into Northern Labrador.

Scheduling/weather delays did pose a challenge in completing some community consultations, but the consultations did include the five (5) Inuit community governments (Nain, Hopedale, Postville, Makkovik and Rigolet), as well as the Innu Community of Natuashish, Happy Valley-Goose Bay and North West River.

3.2.1.1 Nunatsiavut Government (NG)

The NG were heavily involved in the consultation process, and it was clear that NG officials (both elected and non-elected) are keen to see this pre-feasibility study completed on time.

Several members of the NG Assembly, including members of the Executive Council, attended one or several public consultations. NG officials who participated in the public consultation sessions supported the pre-feasibility study moving onto a feasibility study, especially since a feasibility study would lead to more in-depth analysis and consultation on key issues.

The NG also provided a written submission (Appendix B), which provided background on the current airline and ferry service, pros and cons of a road, and four recommendations:

1. Due to inconsistency of air travel because of weather, the high cost of air travel/shipping, lack of space, as well the ferry service only running from June to early December, which is subject to weather, ice conditions and space available, the Government of Newfoundland and Labrador should immediately move from a pre-feasibility study for a road into a feasibility study to determine if a road is feasible to some or all Nunatsiavut communities;
2. As this process will take years to complete, any delay in decision making from pre-feasibility to feasibility, to environmental assessment and eventual construction, may cause delays to the process. If the decision is made to move from pre-feasibility to feasibility for a road, the Minister needs to authorize that as soon as possible, and budget for it in the next fiscal year;
3. If approved, the feasibility study needs to incorporate pavement of the road from the beginning;
4. Ensure feedback from community consultations are available to community members, Inuit Community Governments, and the NG.

3.2.1.2 Innu Nation

Despite numerous attempts, we did not formally meet with the Innu Nation leadership, nor did we receive any written commentary from them. Then, and now former, Deputy Grand Chief, attended the public consultation session held in Natuashish and provided insights into the impacts of a road for her community and the entire North Coast. A key message from the former Deputy Grand Chief was that more in-depth consultation and information sharing is required before Innu Nation can consider providing consent for the construction of a road.

3.2.1.3 NunatuKavut Community Council (NCC)

The NCC have asserted claim to lands that would include a potential road into Northern Labrador. The NCC were invited to provide commentary for this process and indicated they would do so. However, no written submission was received.

3.2.1.4 Mushuau Innu First Nation (MIFN)

We did not formally meet with Chief and Council of the MIFN but worked closely with them to organize a time and location for community consultation sessions. Several current MIFN staff members and former elected leaders attended our community session in Natuashish and provided key insights for consideration.

3.2.1.5 Sheshatshiu Innu First Nation

We did not formally meet with Chief and Council of the SIFN but worked closely with staff to attempt to organize a time and location for community consultation sessions. North Coast communities were given priority for consultations during this process and with the weather and schedule delays, community consultation sessions in the Lake Melville region were pushed until June. It was during this time that the now former Chief resigned from his role, leading to competing priorities within the SIFN and community. As such, we could not find a suitable time and location to hold community sessions in Sheshatshiu.

3.2.1.6 Inuit Community Governments

In all Inuit communities, the AngajukKâks attended one or more community consultation sessions, along with several elected community councillors and staff members. They provided key insights for considerations and were supportive in securing meeting spaces for the community consultations.

3.2.2 How We Engaged

In consultation with Inuit Community Governments, the Innu Nation, and Mushuau Innu First Nation, the first draft schedule was completed in early March with North Coast communities as a priority. However, due to logistical challenges (namely weather, but also community scheduling issues), it took many extra weeks to complete the community consultation process. From March 22 to June 20, 2023, community consultations were held in Nain, Natuashish, Hopedale, Postville, Makkovik, Rigolet, North West River, and Happy Valley-Goose Bay. Consultation sessions were advertised via the project website (www.northcoastroad.ca), email (i.e., to Angajukkâks and area MHA) and social media, particularly on Facebook through highly used Facebook Groups provided at the recommendations of communities. In some instances, community sessions were advertised on local radio stations. Immediate updates were posted to the project website and in Facebook groups, along with direct emails, if there were sessions delays and/or postponements due to weather or other logistical challenges. Appendix A provides an overview of communications between the consultants and key stakeholders and rightsholders.

The project website was launched in early February 2023 and the public notice issued indicated comments would be received up until June 16, 2023. From February to June, there were over 1200 visitors to the project website and the website address was only advertised in consulted communities.

In the North Coast communities, more than 190 North Coast residents attended an in-community consultation session and 12 submitted comments through www.northcoastroad.ca. In Upper Lake Melville, more than 70 residents attended a session in North West River and/or Happy Valley – Goose Bay (Table 3.1).

Community Consultation Sessions				
Community	**Date**	**Times**	**Number of attendees**	**Indigenous Organization Attendance (elected)**
Hopedale	March 23, 2023	9:00 – 11:00	27	Angajukkâk (Hopedale)
Hopedale		14:00 – 16:00		
Hopedale		19:00 – 21:00		
Nain	March 28, 2023	10:00 – 12:00	30	Angajukkâk (Nain) NG Minister of Education and Economic Development, NG Minister of Language, Culture and Tourism
Nain		14:00 – 16:00		
Nain		19:00 – 21:00		
Rigolet	April 18, 2023	10:00 – 12:00	75	Angajukkâk (Rigolet)
Rigolet		14:00 – 16:00		
Rigolet		19:00 – 21:00		
Postville	April 20, 2023	10:00 – 12:00	15	Angajukkâk (Postville), NG First Minister
Postville		14:00 – 16:00		
Postville		19:00 – 21:00		
Makkovik	May 9, 2023	10:00 – 12:00	31	Angajukkâk (Makkovik)
Makkovik		14:00 – 16:00		
Makkovik		19:00 – 21:00		
Northwest River	June 6, 2023	10:00 – 12:00	31	Mayor (North West River)
Northwest River		14:00 – 16:00		
Northwest River		19:00 – 21:00		
Happy Valley - Goose Bay	June 7, 2023	10:00 – 12:00	40	Angajukkâk (Nain), NG Minister of Health and Social Development, NG Ordinary Member (Lake Melville)
Happy Valley - Goose Bay		14:00 – 16:00		
Happy Valley - Goose Bay		19:00 – 21:00		
Natuashish	June 19, 2023	15:00 – 17:00	11	Innu Nation Deputy Grand Chief
Natuashish		19:00 – 21:00		
Natuashish	June 20, 2023	9:00-11:00		

Table 3.1-Summary of Community Consultation Sessions

Consultations were conducted prior to the completion of other aspects of this study (i.e., route selection analysis) and consultation session were based on perceptions of a road in general[3]. At each consultation session, a PowerPoint presentation was shown to all in attendance and potential topics of discussion were left on the screen throughout the sessions to provoke discussion (see Appendix C). Translation services (English-Innu-aimun, English-Inuttitut) were offered to each community, but none were required.

To assist with route selection and to help avoid culturally significant or sensitive environmental areas, participatory mapping sessions (see Figure 3.1) were conducted at each session. This process involved providing a large blank map of Labrador and another large blank map of the area (e.g.,~200km radius) surrounding the community. Indigenous and traditional knowledge holders were able to take markers and pinpoint areas of interest for the consultants to consider in their route design.

Figure 3.1-Example of a Participatory Mapping Session in Rigolet.

At the end of every consultation session, participants were reminded that the website was available should they wish to provide further commentary and each participant was provided with a business card from both consultants. In consultation with GNL and communities, we set a deadline of Friday, June 16, 2023, to accept written submissions through the website. This deadline was to ensure the public had adequate opportunities (from February to June) to submit their thoughts for consideration and to allow the analysis and report writing to begin to ensure a timely completion.

3.3 What We Heard

High level summaries of consultation with Indigenous and community organizations are provided below. Key themes are broken down into three categories (Table 3.2): support for a road (section 3.3.1), opposition to a road (section 3.3.7), and other considerations (section 3.3.8).

Support for a road	Opposition to a road	Other considerations
Freedom of choice	Impacts to fish and wildlife	More in-depth consultations must occur
Access to advanced healthcare	Increased access to drugs and alcohol	Long wait for a road/interim support needed
Current transportation/cargo network not sufficient		Construction considerations
Climate change impacts felt in the communities		
'Southern Hub' concept		
Infrastructure development		
Economic development		
High Cost of Living		
Food Security		

Table 3.2-Summary of Key Themes into One of Three Categories: Support for a Road, Opposition to a Road, and Other Considerations

3.3.1 Overall Support for The Road

In summary, most of the residents in this consultation process supported the idea of a road into Northern Labrador. The sense of freedom, the choice of travel means, a positive impact to food security, increased infrastructure development, increased economic development (i.e., mineral exploration and mining) and overall improvement to quality of life were cited as key reasons for supporting a road into Northern Labrador.

It must be noted there was much more clear support for a road in the southern Nunatsiavut communities of Rigolet, Postville, and Makkovik than the rest of the region. In Upper Lake Melville, most residents also supported the idea of a road into Northern Labrador.

3.3.1.1 Freedom of Choice

A key message from many residents was that they wanted the freedom to choose how to travel in and out of their communities and not have to plan everything around ferry and airline schedules. As one resident of Rigolet explained,

"I think to have a choice that, just a choice to do it, because I think, just personally for myself, I'm kind of tired of being under the grip of a monopolized airline and you only go when the airline says you can go. But if you had a road, you get access to healthcare, go when you want, goods will be cheaper and, in my opinion, I guess they would be and those kinds of things. But it gives people the opportunity to go at a more affordable way of doing it, I think."

For one resident of Makkovik, it was simply the freedom to head out for a long weekend with family that makes him support the road:

"It'd be nice to be able to – like four-day weekend, jump in my truck, go off to Goose Bay, go seeing family out there. They could come here for a four-day weekend, and we'd go fishing and camping. I mean I've got a brother out there. He hasn't been to the cabin in, my gosh, years."

For many, the freedom of choice was also captured in relation to other themes such as accessing advanced healthcare, alleviating the high cost of living, and strengthening food and housing security. A resident of Rigolet provided an example of how the choice of road would strengthen their access to healthcare and food security,

"Being able to get into your vehicle too and have that option if you wanted to drive to Goose Bay and buy a couple of weeks' worth of meats. Or go, because you have an appointment, but at the same time then you can fill up on fresh produce and fruits and stuff. And drive home after your appointment is done with your vehicle, right? Like those options, people, we don't have it right now and I think if we had it, it would make world of a difference for a lot of people in a good way."

3.3.1.2 Access to Advanced Healthcare

Access to advanced healthcare on the North Coast of Labrador has been an issue for decades. With no doctors or specialists located in the communities, residents must fly south to Happy Valley – Goose Bay, St. Anthony, Corner Brook, St. John's or somewhere outside of their home community for advanced healthcare. It is important to note that access to advanced healthcare is the issue identified here, as nursing care provided in community received high praise. As one resident of Postville explained,

"I mean, the health care in this community is ten times better than what it is in Corner Brook. You got access – I know people grumble about these little clinics, but the fact of the matter is that you call a nurse and she'll come meet you at the clinic no matter what it is. But for major health conditions, you're rolling the dice on air and on sea." – Resident of Postville

Depending on favourable weather to fly out of communities for a medical appointment can be stressful for many, as you are dependent on a clear day with acceptable winds, something residents of Northern Labrador will tell you is sometimes a difficult combination to get. While a road would be a long ride for someone in an ambulance, it would be beneficial for those who need to get to the hospital in Happy Valley – Goose Bay to seek urgent care or attend a long- awaited appointment. For example, one participant in Hopedale shared that her husband was forced to wait several days to get to Happy Valley – Goose Bay after a workplace injury, *"he had a head injury at work. It happened Monday afternoon, and we couldn't get out until the following Saturday, because of the weather."*

Residents not only depend on the weather for them to leave for medical appointments, but also need favourable weather for doctors/specialists to visit their community. As one resident noted, "*A specialist comes in from outside of Goose Bay. If the people on the North Coast have got a serious medical problem, the weather is down, they can't come in. The specialist goes and they got to wait another six months to probably a year to get another appointment. There's no where else in this province that that happens. And that can be fixed with a road."*

Several North Coast residents shared their frustrations of using all their annual leave from their workplace to attend medical appointments. As one resident of Makkovik explained,

"I can't stand using all my leave every year to go to a ten-minute hospital appointment and I've got to take three days leave. Heaven forbids the weather gets bad and I lose another seven days. When my work counterpart in Goose Bay is going to the same damn appointment and they took an hour off work."

Other residents of Makkovik and Postville echoed the same concerns and supported the idea of a road to improve access to advanced healthcare, *"I think the quality of life will change big time if we get a road just. Like we're so restricted now with the medical. Like I mean you got to go – you got to spend a week away if you got an appointment in St. John's. Like I think [the road] is inevitable, it's going to happen at some point. I can see it's come to a point where it's really needed."*

"If you're here and we haven't had a plane for seven days, heaven forbid it be an emergency and something happens. Or it could be the case of people who are waiting for seven to ten days on prescription refills. And if people are suffering from conditions, which a lot of people do and have to take medication regularly, that adds stress to them which adds to their physical health as well. So, I think that's one big thing to consider."

"There's so many people that misses hospital appointments because of the weather." – Resident of Postville

Residents were also keen to point out that it's not just the access to advanced healthcare, but for the simple healthcare matters that still depend on air or ferry access, and the weather. As two residents of Rigolet explained,

"*Access to, you know, getting your braces tightened or whatever. And like you said, like there's a specialist that comes in for that maybe once a year, six months, every six months. You don't get it without appointment. It's going to be another twelve months, six months before you actually get a chance to be seen."*

"I'm thinking back to appointments and stuff too, it's like some people has regular medication come down and schedule regular, and when the planes are not flying, their kids are going without those types of medications. And it's crucial. Someone here not long ago had it on Facebook because her boy's medication didn't get down. Still not down, planes are not flying. If they had access to drive out and probably get it, or you know, a delivery company can deliver meds, right?"

Finally, as most mothers living in Northern Labrador know all too well, the requirement to leave their home community several weeks before their due date can be challenging. As one resident of Rigolet explained, a road may be helpful in those circumstances:

"Just like when women have to go have babies, when women have to leave their home for what is it now? One month. At least a month they have to leave, and they probably got other children at home, they got other appointments at home. Because when I had [my son], I had to go up six weeks prior before he was born. So, when we talk about health, [the road] could make a big difference of how long they have to be away from home to homeland."

3.3.1.3 High Cost of Living and Food Security

The cost of living in Northern Labrador is notoriously high, and residents noted the last several years of inflation and supply chain issues caused by the COVID-19 pandemic have driven costs to new heights.

Food Costs and Food Security

Residents provided many examples of the costs of food and difficulty in obtaining healthy foods. As a former resident of Rigolet stated,

"Last year, I'll just give you an example in Rigolet, I don't drink water in Rigolet. So, I'm taking water with me. Went down to the store there, $32 for a case of Big8 water. Came home a week later, went up to Bargain Store in Goose Bay, same case of water, six bucks. That's only one small example."

A resident in Makkovik shared,

"Anything that impacts the cost of living in a positive way has got to be invited. Like I shouldn't have to pay my whole salary, which is a decent salary, on groceries and gas. Like I really shouldn't. But that's basically where it goes. And I'm

thinking any way that we can do that without – yeah, there will be – there's negatives and positives to everything, but the way we can see to mitigate the cons, we can do that for the most part."

Many participants acknowledged a road may not lower the costs of food delivered to the community, especially since it is unclear if subsidies such as Nutrition North would still be applicable. However, the advantage of year-round transport truck access or being able to drive to Happy Valley – Goose Bay (or another larger community) and filling their vehicles full of groceries was seen as a tremendous opportunity for those able to afford a highway-worthy vehicle and fuel. A resident of Nain explained,

"And now, yeah, and now it's springtime and you could see by the shelves that you're getting limited, some things are not available. Even that's happening during the winter months, just basic stuff to is running out during the winter months, when you want to have a jiggs dinner and you don't have no split peas or corn starch to make your gravy or."

A resident in Makkovik shared their support for a road in order to increase food security,

"We're no longer going to be at the whim of the owners [of North Mart/Northern stores] *who are like just making money hand over fist on the coast. We don't see it in Makkovik, we don't see it at all. Nain and Rigolet in those Northern Stores, it is freaking crazy. The cost of paying for stuff in those communities. In Rigolet they're paying – there's times that I've bought food, like frozen food here and I've shipped it on the plane to my* [family members*] and it's cost them less than if they went to the Northern Store in Rigolet. If it was even ever going to be there and bought it there. And they can get away with it because they have the monopoly. And everywhere else is exactly same way. They have the monopoly."*

Also, participants said a road would end the "produce days" in communities such as Postville, which some has described as stressful:

"From a food perspective alone and I can tell you – and I'm still not used to it, I'm here [for many] years, the anxiety that grips me come Thursday. And I'm sitting here on my phone waiting for [the store] to post a picture of six boxes of produce that's been frozen and kicked around the tarmac and left for five days because it missed the plane." They continued, "It's like the Kentucky Derby, right? And then boom, as fast as you can get to the store. Well, if there's a nice day, and the weather is good, and you can get out – if you're not there in 45 minutes, you're eating carrots and sweet potatoes because there ain't nothing left. So, these guys, I can only imagine how many phone calls – she works at the front counter – how many phone calls, she gets a day, produce in yet? Produce in yet? Milk in yet? Milk in yet? Totally unreliable."

Air Travel

The high cost of air travel to and from the North Coast of Labrador was a prominent theme in all communities and was a key reason why many residents supported a road to their community. Several residents shared their concerns and experiences with the high cost of air travel/cargo:

"Just like I said, it's good to go on a vacation. I mean going out to St. John's from here with some of my family members, it would be good to see my family in Newfoundland but I'm not spending $5,000 on their plane tickets and then more on the hotel stay or buy your own food or buy clothes, they are shopping or whatever. It takes a big chunk out of five days, it's a $1,000 a day." – Resident of Nain

"I mean to fly out of here for me, for me to fly just to Goose Bay alone it will cost, there and back is a thousand bucks, right, so. And I mean, being able to transport goods and stuff like that for, personally it would be a big cost saving…When you open up a road, you got access to the world basically and right now I keep a vehicle in Goose Bay just for that purpose. I got family living out on the island and I fly to Goose Bay and then I drive." – Resident of Nain

"You take – to fly down here [to Natuashish from Goose Bay] *one-way. You're looking at $400. OK, you got a family. How in the hell are you going to get one-way – you got two, three kids, and plus man and woman, two, three kids come down here on Air Borealis for $400 a ticket. Come here for a week, turn around, go back. How can you afford it?"* – Resident of Natuashish

"The cost of living here is extremely high. A flight for me from here to Goose Bay, 45 minutes is 800 bucks. I sent my daughter to [Europe], from [Western Canada] for $1100. It's 45-minute flight on a Twin Otter. Straight out the door, this cost me 800 bucks. So, for my wife and I, 1600 bucks, just to go out." – Resident of Postville

"Well just 45 minutes, direct flight is 45 minutes. Just like $1300. That's crazy money." – Resident of Postville

"Well, if you can't go for medical reasons, you better take your wallet out. The government classifies the shipping season as an essential service for transportation. And it's subsidised like crazy. They send a skidoo out for 35 bucks. You can't get a ticket across the Gulf for that amount. But they don't do anything about the airfare. No subsidy on the airfare. And what else – what other link do you have in the wintertime?" – Resident of Postville

"We could offer all kinds of jobs here. But when you stack all that up, I mean as a non- beneficiary, if you get to go out twice a year, cost you $8000 to see your family. Who's going to move here? And there's some great jobs here, it's posted all over." – Resident of Postville

"Just to give you an example of something like affecting my life with regards to not being able to afford transportation that's available. Like going to a hockey game, like we wanted to go to an NHL hockey game, and it was going to cost me and my son $2,000 to get from here to Goose Bay. $2000 on a 30-minute plane ride. Whereas to go from Goose Bay to Montreal, it was just under $3000, which is almost the same. So that's what we're dealing with on the coast. We have one airline and it's taken it or not. And if we had the road then at least we have some freedom and we'd be able to like, get supplies on the way you know, because like the Northern store here, a lot of stuff that I need is not there, it's not available. They have come in sometimes on a freight plane and it cost like double the cost. And when I place an order through NorthMart or whatever, the shipping rate is really high. Just from here to Goose Bay, so it costs a lot." – Resident of Rigolet

"I'm just thinking about what we will do for our kids, like our kids going away through school and playing sports…not so much in St. John's even just Goose Bay. Sports teams, you have to travel. Not have to worry too much about the cost of travel like on a plane, like for our athletes, I can only manage to raise enough money to go one trip. Whereas if we had a road, then they can go on many trips for that same price. That's not only to Goose Bay, but to all around the province." – Resident of Makkovik

3.3.2 Current Transportation/Cargo Network not Sufficient

Similar to the cost of air travel, much of the conversations were dominated by discussion over the insufficiency of the current transportation and cargo network. With only one airline and one ferry servicing the North Coast, Air Borealis and the Kamautik W were the topic of many discussions.

3.3.2.1 Ferry Service

Many long conversations were had about the ferry system, both past and present. While most agree the ferry service is affordable, it is by no means a quick or comfortable way to travel. As two residents of Hopedale explained,

"It takes what, 30 – over what, 36 hours or something to travel out from here. So, you don't use it that often to travel or take it in, but for a family that's trying to get out on vacation it's a lot cheaper to go on the boat than to fly."

"For us, we're looking at a two-day trip. It cost almost $300 to get our truck to Goose Bay."

Many residents discussed the removal of the cargo shipping service out of Lewisporte, Newfoundland and how that has impacted people in Northern Labrador. As several residents of Makkovik explained,

"You could get snowmobiles a whole lot cheaper if you bought them in Newfoundland and had them shipped in, or vehicles. And then just an ordinary thing like going online and seeing a vehicle for sale on the island. If it was anywhere – like I think the last vehicle I bought it from Carbonear and even the seller had to drive to Lewisporte. They put it on the boat, next thing, you know, it's here. You can't do that now because you have to get the vehicle you bought from Carbonear to Goose Bay and pay the shipping cost to get it here. So, it's not only that but it was like your choices of stuff. Now your choices are so limited in Goose Bay."

"Me, [the current roll on-roll off ferry] *is a great thing to have but the price of the freight and everything now where we got to get it from the island and into Goose Bay and then to hear it's more than double, more than double."*

"All my life shipping by boat has always been cheaper than any other way. And it was until they freaked up the service we had here."

Similar to Makkovik, many residents in Nain expressed their dissatisfaction with the removal of the marine cargo service between Northern Labrador and Newfoundland,

"I don't know what they thought taking out the boats. We need more than one. Now more than ever."

"You had the co-op in Lewisporte. Then you had Murray's Meats started in Conception Bay. You had companies out of St. John's, you had a variety. If you ship your boat up from either Central [Newfoundland] or King's Point, it was only a couple of hundred bucks from the dock there to the dock here. Now it's - last summer it was $3,500. And that's even before it got on the boat in Goose Bay, $3,500."

"We had better ferry service 50 years ago than we do now. Way better. Now you got frozen goods coming out of the ferry, you got to go down there at two or three o'clock in the morning to pick it up, there's no storage facilities or nothing here."

Many of the conversations about the ferry service pivoted to what would happen to the ferry service if a road was built to all communities in Northern Labrador. When in Rigolet, residents in one consultation session were asked if they expected the ferry service to continue operating if a road was constructed and the general response was "yes."

However, in Postville, one resident had no expectation of a ferry service if a road is constructed,

"We had the ferry service; people want the road. So, I get kind of confused some time to hear, I want to say politicians on radio. They want to bring back ferries. We had that. People want the road. Now we can't have cake and eat it too. You don't expect – you asked the question; would you still expect the ferry if you've got a road. That's having a cake and eating it too. We'll have one source of transportation, that's what people want."

3.3.2.2 Airline Service

In addition to the high costs of air travels, residents did not hold back on their feelings about the region's one airline, Air Borealis. The airline provides a vital service for communities but high costs, weather delays, and Transport Canada regulations leads to a lot of frustration for residents. As several residents of Nain explained, *"Well, we can only fly Twin Otters in here. And when you leave Goose Bay, all they can take is 11 people. Trying to get reservations sometimes and short notice? You might as well forget it. Nain is limited too because you can only get day flights, you can't get night flights. And then the volume of freight that's going up here during the wintertime too now depending on just a Twin Otter. It's not the answer."*

"I think, I can't speak for the airline, but there's been instances when I think the weather is fine, but they say they don't fly, but maybe they're timed out or there are not enough airlines after being stuck for a few days for winter. And then when it is good, of course you get passengers out, but I don't know if they're moving other people to certain places 30 kilometers that way or."

"I don't think they got enough planes to service the coast themselves, but I'm hearing the last few days that their freight is six weeks behind, backup in Goose Bay, just the freight alone."

Despite the reported frustrations with air travel, there were concerns about what would happen to airline service if a road were constructed. As one current resident of Happy Valley – Goose Bay (former resident of the North Coast) stated,

"The only thing that worries me or concerns me is if we eliminate the air travel or the ferry service to the North Coast. The time it would take say for, to go to Nain from Goose Bay driving, I guess doesn't work. I'd rather fly. I wouldn't want to take my vehicle every time I got to go to Nain for a meeting."

3.3.3 Climate Change Impacts Felt in Communities

"You can't trust the ice anymore."

Climate change impacts are driving many previously opposed to a road to become supporters, as the impacts are leading to longer ice freeze up periods in the fall and earlier ice break up periods in the spring. As one participant from Rigolet noted,

"I used to be 100% against [the road], *now I'm 100% for it, I think. Because it's getting harder when you're stuck in town October, and you can't get around until, this year it was almost the end of January. So, November, December, a couple and a half month stuck in then. You can't get anywhere."*

Residents in Hopedale indicated they require quality sea ice to cut and transport firewood. With some wood cutting areas located upwards to 80kms from the community, the untrustworthiness of the sea ice is of concern. As one resident explained,

"I think the thing you got to think about is climate change. If you don't have a road, where you going to get your wood, where you going to get your heat, where you going to get your wood? That's one big benefit of having a road is you can drive in and cut your wood."

In Nain, some residents described what they called "wild weather changes" in their community during the winter,

"The other week [in February] *they closed school on a Friday because it was too cold. Come Monday they closed school because it was raining and the roads were too wet, to slushy for the kids."*

In Makkovik, one long-time resident described the ice conditions from when they were younger to present day, *"I remember growing up we'd be going on skidoo until the end of June sometimes. We'd haul our – take our nets and haul up in the bay where we'd go fishing and seal hunting in spring and the ice is different. You're not getting – we would get this really hard, solid ice in the start of the spring. Like even if, you know, there's close water, you could still pick your way around easily. Now it's different, you have to be very careful. The difference for the young people is they've got these high horse-powered skidoos, they don't care if it's water or not, they'll just cross it. But for the older folks who are used to, it's a considerable difference in the conditions on the ice."*

Similar sentiments were shared by a long-term resident of Nain,

"Its' getting later and later to get the ice freeze up. To get from one place to another, from your cabin to your hunting grounds, you need to go through community to community. Climate change has changed everything and even the modes of the transportation. It used to be that you look forward to it and we'd be able to go where we wanted to go at a certain time of year. But now you can't depend on that, it's not like about 30 years ago, you could do that. Now it's changed so fast…The last ten years, it changed, a big change."

Further south in North West River, residents continued to speak about the impacts of climate change on ice conditions. As one resident explained,

"You talk about climate change. For an old fellow like me, it doesn't make a whole lot of difference. For the young person for example, I would say in 15, 20 years' time, you won't be going on the ice. The youth don't go on ice, because there won't be any ice. So, then the roads will play a major role, another major role for transportation and that."

Extensive climate change research has been undertaken in Rigolet in recent years.[4] Similar reflections were described by several residents in the community consultations for this study,

"It's going to be harder. Climate change is making us more isolated. Double Mer it's not like it used to be. My husband, and I'll say it very proudly, his father taught him well about the land. Last year, he went cross Double Mer. And they always have people go across and check the ice. He went over a couple times. And this was when it was really cold, turn really mild, turn cold again. He went over and he went in, and he lost his komatik. And thank God he never lost his life."

"Well, I find our winter is getting shorter and shorter. And I mean, it's even less time that we can get out on the ice or on the land. And I think by having a road, we would have more opportunity to partake in traditional activities. Or even to move around because presently, when the ice goes, we're stuck on a little island or in a circle."

"I like to go out [on the land] *to disconnect from the internet and disconnect from all the technology. And that's why I enjoy going out because I don't have anything like that at my cabin. And its kind of just rejuvenates me, it kind of kick starts me again. But because of the forecast and the way the weather is changing with climate right now, it's almost like you can't depend on that anymore. But if you have that road, you could probably jump in your vehicle with your skidoo in the back of your truck or your ATV and drive down the highway so many miles and then pull off on the side of the road and then go out somewhere. Whether it's berry picking or partridge hunting or whatever."*

"You can't come and go [on the land] *like you could years ago. You can't say OK I'm going to go, because you got to wait 'til the last four or five hours of the forecast to see what, because it could change, and it does change quick. Even in the summertime, the winds. It's crazy now. We were stuck in town for days. And when you're stuck, your mental health is deteriorating because you can't get out and do what you want to do."*

A resident of Makkovik noticed more wind in recent years, which causes issues with transportation services, *"One of the major things we've seen with climate in the last two or three years is the increasing wind. It's – the wind is stronger. We're having windy periods, which are lasting much longer. Times of the year that normally you wouldn't have wind like that, and that's impacting the marine industry. So, we're hitting a double whammy, where the planes aren't making it in, the boats can't go and it's just – when you think of the potential that the road brings."*

Climate change is having significant impacts on the way of life in Northern Labrador, and some residents feel it is only going to get worse. As one resident in Natuashish explained,

"There were scientists here and we talked with them. They said in 50 years' time there will be no snow here. So, you've got to start thinking about how we think about food and sustain our way of life. And that it may mean building a road into Labrador to access our caribou and hunting grounds."

3.3.4 'Southern Hub' Concept

At the very first community session we hosted (in Hopedale), the idea of a 'Southern Hub' was discussed by residents. In Hopedale, some residents acknowledged the challenging terrain north of Postville/Makkovik and felt road construction would take a significant amount of time to their community. Acknowledging this, some participants felt an expedited road construction to Postville (Makkovik and Rigolet as well) would benefit communities north of Postville in the near term as they could travel by snowmobile or boat to Postville and drive their stored vehicles onwards to Happy Valley – Goose Bay and beyond,

"Do you understand a road to Postville alone – just a road to Postville – how much it would benefit the North Coast? I mean it would upgrade our standard of living, at least 100%. The only community on the North Coast I'd say that wouldn't avail of that, would be Rigolet. But all the rest of the communities. I mean if you had a road to Postville, to North West River – instead of having my truck here all winter – I would have it in Postville. So that way, if I wanted to go, I could take a plane from here to Postville, or a snow machine, or whatever and I could drive to Goose Bay, pick up my month's supply of groceries, and come back here. And that alone, is tremendous. I mean tremendous. I mean, you look at our prices and everything else, for me and my wife to go to Goose Bay to do a shopping, to pick up a winter or a fall supply, the plane fare alone is $1500."

The idea of a 'Southern Hub' is not a new concept for the North Coast, as it was discussed during a session at the 2018 Combined Councils of Labrador with Dr. Robert Way.[5] While the Southern Hub concept was not a prominent discussion in Makkovik, it was very much so in Postville and Rigolet. In both communities, residents offered their opinions of why their community would be the ideal community for a Southern Hub. In Postville, it was clear they wanted their community as the hub for communities North of them,

"Personally, I think that it's time for us to really put some serious thought in. I know, this is the first step into building a road. I don't agree with building a road North of this community. I don't think that – beneficiaries North of us are prepared for that. I don't think the environment North of us can sustain it."

"I think the road should come to Postville and should definitely be the hub for Northern Labrador, and possibly the Arctic into the future. I think there's been a lot of historical work done in that regard. And I don't think that – I think without it – I've seen this community, I've lived here for 40 years, this community is not going to survive for the next 100 if we don't. And I'm worried about outmigration and all I see up there. We've already been hit with outmigration. If we get hit with any more economic impacts to this community, we're not going to exist. When I grew up, there was 60 kids in school, now there's 20."

A resident of Rigolet argued that their community should the Southern Hub for Nunatsiavut due to its year-round open port and Postville's far in-land port, where ice breaking would be necessary:

"Because if you're going in here and she's already open and you're going to Postville, you know you're breaking. You're in the bay a long ways. A deep-water port but you're breaking in a long way. You've got a Voisey's Bay situation then."

3.3.5 Infrastructure Development

3.3.5.1 Municipal Infrastructure Development

The impacts of a road on infrastructure development were cited as mostly positive. As described in Nain,

"The next five-year plan is to repair the old sewer system; they started that within the last year. And we have at least four years of repairs to do before we can look at new [land] *zoning. After the four years are up, we're going to be able to offer plots of land for the housing. Up until then the housing crisis is going to be, remain the same, and when that housing is finally addressed, we struggled in that short period of time from bring the materials in. Of course, we're not going to have a road by then, but this shows the effects of the road being advantageous to the community of Nain, when it gets here, to bring in materials in."*

The inability of the current ferry service to transport dangerous goods (i.e., explosives for land development) have led to lengthy delays for land development. Upon arrival in Makkovik, a noticeable noise could be heard throughout the community. One resident explained that it was months of rock busting to develop a home, *"if we had a road, we certainly wouldn't be going on month seven of having a f***ing rock busted because they cannot send that ferry as a dangerous goods."*

In Rigolet, not having road access meant that specialized plumbing equipment was not available until the ferry service began. One resident explained what that has meant for their community this past winter,

"Well, look at the town's example when the water froze up here. If you had access to be able to get a plumber to come in with his plumbing steam machine – whatever truck they uses to get that out, in a matter of hours. You probably wouldn't have had to have the water running by the fire hydrant all winter long on top of the ground and dealing with that all winter long. You could've easily called a plumbing company out of Goose Bay, come in to fix it right then there if we had a highway."

3.3.5.2 Housing

Northern Labrador has been dealing with a housing crisis for decades. The time and costs to construct homes in the region are lengthy and expensive. As explained in Makkovik, a road would help alleviate these issues,

"We heard the federal and provincial governments has a pretty big incentive to bridge the gap in infrastructure in Indigenous communities by 2030. A road would allow us to get materials cheaper, build year-round, allow us to get materials year-round, a significant cost decrease because right now it's actually cheaper for us to barge materials in from the island than putting them on the [ferry], *it's actually a cheaper cost. So, from the infrastructure and development perspective and bridging the infrastructure gap, having a road is a critical piece to solving that. I know the road is going to take a long time and so is bridging the gap in infrastructure. It's not going to be done by 2030, but it would significantly help, yes."*

"One of the other things that needs to be recorded with respect to losing our ferry service from [Newfoundland] *is the cost of housing construction. Residential housing, and commercial housing. Right now, in order to get the material and everything that they need, a contractor has to charter a vessel to bring everything in. That means that you can only build one house less each year in a community because of that cost. So, either subsidize it or put our freight service back on so we can get the material that's needed to construct homes."*

In Nain, previously described infrastructure issues are impacting any new construction of housing,

"No matter what and no matter how much the federal government announces for new housing, you can't touch it here in Nain until you get the sewer infrastructure. To complete it, that's going to take four years."

Another resident of Nain described the challenges of constructing a home in their community,

"We have a housing crisis. And right now, we're dependent on the last boat to get your materials in and if you want to renovate and say you may have forgotten something, you have to wait until next season in order to order those materials in. That's just the materials, but I mean, for instance, someone might order a dryer and they sends a washer instead now you got to wait the whole year and, but that's just materials. And if there was a road, you'd have the opportunity, we don't have a Home Hardware as such or anything like that to go to the store and pick up your renovation stuff or whatever."

In Natuashish, a resident explained the extensive waitlist for new housing and their infrastructure challenges in building new homes,

"There was – according to [MIFN leadership]*, and they said there was over a hundred on the waiting list. In the last five, six years, they've erected about 45 new homes. The problem is that we don't have enough* [electrical] *power* [capacity] *to build more houses."*

In Happy Valley – Goose Bay, some residents felt that a road would lead to more pressure on the already stressed housing market as more residents would relocate into the central Labrador community. As one resident explained,

"Well, certainly could be immigration from other communities into the town. So, that would have impacts in the way of housing, especially now where housing is such a big deficit in the region. And so you have that potential for more people to immigrate into the town of Happy Valley – Goose Bay, because of the services that are available here in the town that are probably not available now in some of the remote communities."

3.3.6 Economic Development

While the construction of the road itself would be a significant economic undertaking, residents of Northern Labrador spoke of the opportunities associated with it. For example, a resident of Rigolet explained,

"I think there's a big difference from 15 years ago. Even back then we had a lot of support, but a lot of people were scared of change. And of course, any kind of change with the road is going to change a lot of different things in every different aspect. But at the same time, I think we have to think about our next generation. I think there's so many spinoffs with the road, with the economic, social, recreational, that it is time. Rigolet is a real ideal place for economic development. It's open for it. We have so many opportunities in the past – and I don't want to go into the past. The past is the past. We weren't ready for it. And I'm not saying we are now. I'm just saying my input because I think we've got a lot to offer here for potential economic growth. Port open around the year. We had opportunities in the past and we weren't ready for it but just so much from natural resources to forestry to you know – there's no limit to it. The cons I understand is going to change that group dynamic of the isolation of the Inuit community. I understand that. But if we always stop and scared of change, we'll never change."

3.3.6.1 Tourism

Tourism currently makes up for a small portion of economic activity inside Nunatsiavut communities. As a resident of Hopedale involved in the industry described, "*tourism only counts for a small percentage of the people that come and* *stay. Yes, a small, small percentage."* They also stated that they did not know of anyone in Nunatsiavut who has full-time employment in the tourism industry (not including Nunatsiavut Government employees).

Some residents discussed the current ferry service and how it is not set up for tourism. As one resident of Makkovik stated,

"I mean the ferry service right now, it's great but it's not meant for tourism. I'd say the majority of summer now is like a load-and-go situation. You don't have time to spend in the community. Like it's more cargo, that's the main goal and not tourism."

In Nain, several residents believe there is opportunity for more tourism,

"I don't think the community is set up. And there's no place to set up for it. But I'm sure it would be booming if you had someone that was into all year round, boat charters, tourism charters north in the summer; this time of year, snowmobile trips up north."

"And a road up here would be certainly a gateway for tourists to travel north, and I mean even now we get a lot of people canoeing, kayaking and all this sort of stuff, right."

Consultation sessions in Happy Valley – Goose Bay provided a glimpse into the tourism potential for the North Coast of Labrador, if there was road access. As one resident involved in the tourism industry explained,

"More and more tourists - they're coming to look and coming to view and see the things. And that's a great economic thing. Whether that's accommodations, whether that's hotels, whether it's gas, whether it's whatever. So, I think there's huge opportunity in tourism. When [the Town of Happy Valley – Goose Bay] *were putting together the national park, we met with representatives of Parks Canada. And they informed us they were tracking the hits on the website of Parks Canada. And the largest hit they were having was Mealy Mountains National Park. People couldn't wait to get to it. Because there was air access, there was boat access or water access, and it was road access. And road access was the key, they could go into Cartwright, you could come here, they can go to different places. So, tourism and I even talked about, will be a huge thing for these communities."*

3.3.6.2 Mineral Exploration and Mining

Labrador is known to have significant mineral resources, and many believe the construction of a road will lead to more mineral exploration and mining, which some residents are supportive of. For example, one resident of Makkovik said,

"I think [a road] *is going to open it up to more like mines and stuff. Well, I think that's a good thing because there's very little employment and like I'm all for employment."*

For mineral exploration purposes, one resident of Nain said it is a great opportunity as many residents already possess skills required for exploration,

"I think [a road] *would be great for the mineral exploration industry, because many people here are very skilled in exploration related activities."*

Even with the high costs of exploration in Labrador, the push for critical minerals is increasing exploration in the region. A resident of Nain explained, *"Right now* [mineral exploration] *is geared more towards critical minerals, that is true, but there is still gold exploration and rare earth and there is more potential, for sure, but it is geared towards critical minerals too."*

In Happy Valley – Goose Bay, anecdotal evidence was provided that this year is one of the most significant years of exploration in recent memory,

"This morning I had a talking with a gentleman from Air Borealis and he told me that this year is one of the largest years for exploration work on the North Coast of Labrador. He said it's unbelievable the number of companies that they're flying in and up and down. They said it's probably the largest exploration that he's seen up there in the last 30 years."

In North West River, one resident discussed exploration activity on the south coast of Labrador since a road was constructed,

"You know, you're not reinventing the wheel. Look at the south coast, they've been prospecting down there like crazy since the road was there because it's a lot cheaper to get in there. Before that it was all chopper, and it was really expensive."

Many residents also pointed out that Nunatsiavut has regulations on mining and mineral exploration that must be followed. *"We have very stringent mineral exploration standards,"* said one resident of Postville.

In response to concerns about the destruction of the land, one resident of Rigolet explained,

"Like development and mines and taking our resources, people just can't come in and do that. You have to put in a proposal, you have to put in applications to the government. It has to be passed before anyone can stick the stake in the ground and say the own claim to that. It can't be just done like that. A mining company cannot just come in no matter how much money they got. They can't come in and say I'm going to mine out your lands or wherever. They can't do that. It has to be approved."

3.3.7 Opposition to a Road

While there was mostly support for the road into Northern Labrador, there were residents who opposed the idea of a road and brought forward important considerations, including but not limited to: impacts to fish and wildlife and increased access to drugs and alcohol, both areas of which residents attributed to outside pressure on the region if a road is constructed.

3.3.7.1 Impacts to Fish and Wildlife

For both those supporting or opposing the road, impacts of a road to fish and wildlife were of concern. In Nain, residents made it clear that no matter where you put the road, there will be impacts to hunting and fishing grounds,

"Essentially everywhere you go, whether it's just outside of town and it's anywhere around in our area, these are hunting areas. So, anytime we think about putting explosives or doing some construction or whatever, you're destroying hunting grounds that's been used for a long time."

"So, the caribou population is already struggling as it is, and it's been fluctuating over the last number of years. So, protecting the caribou should be at the forefront and their migrating grounds, their grounds needs to be at the forefront of any thoughts you put into creating roads because essentially anywhere inlands is hunting grounds. A lot of – almost anywhere inland is migration routes for the caribou."

"I'd say eventually a road will be built. You should put it off for as long as you can just to try to protect the land and the animals. And just try preserve what we can of our culture because it's already dwindling. So, I think if we do have the power, we should try to protect that for our children so they can know what it's like to lead the Inuit way of life."

"I just don't want to see a decline in more wildlife, as it's already done with the caribou up here. Because I don't know, I don't want to see people going on the road to go partridge hunting, like the people down in Goose Bay does, they go between Goose Bay and Labrador City to go partridge hunting. And I'm worried about those rivers where the fishes, where everybody goes fishing, I really don't want to see."

"Because of the ban they got on the caribou, if we can't be hunting the caribou, I think every bit of land that the caribou travel should be protected. When they first had that caribou ban come in, I came down to the consultation and I told them that. Before I came to the consultation, I looked online and Voisey's Bay was a breeding ground for the caribou, now they don't come. Now that we're on a great big ban and the caribou is declining, I just think there shouldn't be any kind of production of anything in this area."

In response to a question about whether their community supports a road, an Innu hunter in Natuashish responded with, *"Only non-hunters. Those people that don't hunt, they would want a road"*. A further conversation revealed that hunters do not want to see any more destruction of land. As the Natuashish community consultation sessions took place later than others, the route selection work was more advanced. We shared with the group a working draft of the preliminary route selection and the hunters indicated that the proposed route goes directly through key hunting and fishing grounds for the Innu.

In Hopedale, which is near world-class salmon fishing rivers, residents expressed great concern over the impacts to salmon rivers and expressed doubt of the ability to enforce hunting and fishing regulations in such a large area,

"*I mean Labrador is one of the last frontiers that's left and once you pushed your road through, all your fly-fishing rivers and everything, you'll be the same as the rest of them, you'll be shoulder to shoulder with your fly fishing. Right now, you can go and pick your own spot, sit there all day, and not see a soul. Once your road comes through it opens up everything the tourism, everything, the whole thing. There's no control."*

Similar doubt on the ability of quality enforcement of hunting and fishing regulations was expressed in Makkovik,

"Anybody can hunt anything at any time as much as they want really. Like when was the last time anybody was actually stopped?"

While most of the concerns of impacts to fish and wildlife came from Nain, Hopedale, and Natuashish, some residents in more southern Inuit communities also expressed concerns about the impacts. One resident of Rigolet explained how they feel the road will impact their time on the land,

"The negatives outweigh the pros. In my eyes anyway. And that's what we're here for, right? For everyone to voice their opinion and I hope the road is not going to be in my lifetime. I want my kids to experience exactly how I grew up. On land, going to the cabin, fishing, hunting, whatever. Not having to worry about, oh there's a road here. I can't go here, can't hunt here because you can't shoot within a thousand metres of road or something. That road is going to run right through my freaking backyard."

Concerns between communities about impacts to fish and wildlife vary, as different communities and individuals view the impacts through different lens. Some residents felt there will not be an influx of people coming to Northern Labrador to hunt and fish illegally. As one resident of Makkovik explained, *"There's still lots of wildlife. Lots of it. But things about it is – what I'm trying to say is that you're not going to have a whole bunch of people coming from God knows where and just shooting up the place and taking every fish that's there. That won't happen. They're travelling, they're going point A to point B. They're just travelling."*

For those supporting and opposing the road, everyone agreed that conservation efforts must be a priority if a road is constructed. As a resident of Nain explained,

"Enforcement is not the only answer too. Our people, we have to agree to stop killing caribou. It's not only [other communities] that are killing caribou, our people are too. So, unfortunately [conservation] is part of an answer, not the only answer. We should have stricter wildlife laws before [a road is constructed], that we have to abide by. People still harvest it you know. That's the way of life."

3.3.7.2 Increased Access to Drugs and Alcohol

Several residents in all communities raised concerns about the increased access to drugs and alcohol that would likely come with a road. In many instances, residents acknowledged that if someone truly wants drugs or alcohol, they could access it now with relative ease. As one resident of Postville explained,

"Well put it this way, Nain, Hopedale, don't matter where you live along the coast. If you wants it and willing to pay for it, you're going to get it. No matter what. It's not going to make any difference."

However, most acknowledged that a road could increase the number of drugs and alcohol in communities. It was top of mind for one resident of Hopedale who opposed the idea of a road,

"The first thing for me, all I could see is drugs and alcohol. That's all I can see. Too much in-flow. It's already here but I think having that road will be just too much more."

Some residents of Rigolet shared this concern,

"I still have that feeling too about how our life is going to change and the first thing I think about is crime and the drugs. Well, drugs are here anywhere and they're going to be here and they're always going to be here. But the ease and accessibility of drugs is my concern."

"I'm afraid with this road going through it's going to not only take all the land, but it's going to bring a lot of drugs and violence into our community. Like we do have that here, but of course it's going to be worse. It'll be a larger scale."

"I just picture Goose Bay and that's going to be Rigolet, because of all the addictions and stuff. I, that's all I could see."

"Now, I'm against [the road] *because it's going to destroy really what this community is all about. We live here isolated. We live off the land. And I think it's going to bring in too much disruption. A lot of drugs, a lot of violence, a lot of land that's going to go that everybody uses here for themselves."*

Another resident of the North Coast explained their concern with increased access to drugs and alcohol,

"My children are – well my oldest is [in their thirties] *now. I have* [several] *children, and my youngest is* [in their twenties]. *And several of them are well into alcohol and drugs. I hate it. I hate it."*

As in Inuit communities, some residents of Natuashish shared concerns of the increased access to drugs and alcohol, *"When it comes to commuting back and forth, a lot of families will have the concerns when it comes to dealing with youth for example. A lot of times we'll – especially with what's going on in the other Indigenous groups across Canada, the highways and the other stuff like that. And we have so many missing children. We're facing a lot of murdering of Indigenous women and where you know a lot of people leave their communities and it would be easy for kids to run away from their homes because of drugs and addictions and the other addictions."*

"There are going to be drugs. There are going to be alcohol brought in and this may be an easy way for the drug dealer or booze – for them to make money. But there's also some education protocols that are out there for each community. Right now, we have CSOs (Community Safety Officers) that are trying to prevent booze coming and drugs coming. And yet they are still coming in. Either it's by air or by boats. And it's going to take community efforts to tackle that issue and I recognize that. And we've done that in our community to the best of our ability. And obviously that's something that needs to be worked on also."

3.3.8 Other Considerations

3.3.8.1 More In-Depth Consultations Must Occur

Many residents expressed they were pleased to see community consultations take place this early for a road into Northern Labrador. Many still have negative perceptions of the consultation process, or lack thereof, when the ferry was changed for Northern Labrador in 2018. As one resident of Makkovik described,

"It's been so frustrating for people. Because of the way that the problems are just avoidable. Making decisions, you know? And then say 'well we need consulting' because when they put the [current ferry] in place and took away all the freight services from the island, they said that they consulted. They came here, a representative from the department, put the information on the table and basically said this is [the ferry] you're going to deal with for now on. And they've got a clear message that we want our freight service from now continuing until there's a road, like everywhere else. That all fell on deaf ears."

Similar sentiments were heard in the community consultation sessions in Nain,

"We're happy that the Government has decided to open stuff to the public for consultation because that's something they never did when they took away the ferry service from the island. It was done for the good of the North Coast without asking 'is it what we wanted."

Given that this was a pre-feasibility study and participants understood more consultation would need to take place before a road is/is not approved, most felt the current process was adequate. However, for future studies, participants expressed that much more in-depth consultations with the communities must take place, especially to hear the views of elders, youth, women and those living below the poverty line.

"Most of the people that's coming and speaking out is people with money. That can afford vehicles, right? You're not hearing from the poor people." – Resident of Makkovik

"I think seniors, people on income support, those people are people that needs to [be heard] they're not showing up to your meetings, they're not saying we needs a road, or we don't need a road. They're not saying, either way, they're not putting their voices in here, but their voices are just as important as anybody else's." – Resident of Makkovik

"I think you have to consider the cultural impacts too. Moving forward I think it's important to include in there that each community needs their own elder/cultural advising committee for each area. Especially if you are going to be looking at

creating a map of where that road is. That's going to require an immense amount of traditional knowledge." – Resident of Nain

"I'd like to suggest maybe for you guys to ask the school to get the kids to come down, because I'd like to see the youth who is going to be adults, if there is going to be a road. I want to hear and see what they have to say, because I'm not going to live to be 100. I'm probably at the middle of my lifetime. And it's not going to affect me as much as it the youth down the road. If it's going to take 20 years, 10 years, I'll be retired by then and I already said I don't want to see a road up here. But if it does come anyway, I'm not going to use that road for a long period of my lifetime, but the kids in the school is going to use that road for their whole adult lifetime." – Resident of Nain

"There's going to be a lot of side effects on this. For example, land use. It's going to affect the animals and the community back and forth. I know a lot of Indigenous groups are thinking about the hunting areas where it's going to be much cheaper to go back and forth to the nearest resources. The other part is this is very new to us again, because it's starting – the conversations are starting to come around and I believe there still needs to be work done. We're not saying we agree on this. We're not saying we don't agree. I mean the consultation is there. You're bringing it in, but we need more information. [The road] is going to have a lot of side effects. For example, the Innu and Inuit are still very much having a rich culture when it comes to hunting and practicing their own traditions." – Resident of Natuashish

"But you know some – maybe in the next round of consultations, the more – like you were saying this is the high end but then the more intensive rounds of consultations. Maybe some of [Provincial Government officials] need to come in too and listen to our concerns or answer our questions. Because like you said, you don't have the answer to it. You're not sure or whatever, you're just taking our general feedback and going back to the province. But most definitely I think next round they need to consider sending people in." – Resident of Rigolet

"And making decisions without consulting us. Or again, like it's going to take more than [one day community consultation sessions]. Sometimes it's going to take more than just a few times a year. Consultation has to be constant and culture and environment and traditional knowledge, they need to be prioritized and compensated accordingly. So, you know it's good that you guys came here, nice to see for a change instead having decisions made for us. But again, it's going to take more than just one time, it's going to have to be continuous. Continuous consultation, continuous communication and have that open line, not just between the leaders or the Government but also the people." – Resident of Nain

"As long as it's not a conversation between Government officials, as long as the public gets involved and the community gets involved. It will probably take a longer, longer time with the public involved instead of just Government. But it will work a lot better." - Resident of Nain

Youth engagement will be critical to future studies, as many pointed out that they will be adults once this road is constructed and must live with the consequences. In Rigolet, a mixed kindergarten/grade 1 class attended one of the community consultation sessions and provided drawings of why they supported/did not support a road into their community (see Appendix D). Decisionmakers can benefit from this type of engagement in future studies.

3.3.8.2 Long Wait for a Road/Interim Support Needed

For many residents, the discussion of a road to their community has been ongoing for decades. As one resident of Rigolet explained,

"This community has been saying it for more than 20 years, more than 30 years; we want road access to – because of the limitations of the ferry and the high cost of travel on airlines we're captured out here."

One resident in Natuashish described conversations about a road to Davis Inlet back in the 1980s,

"There was a concept of road and people were talking about having a road and that was a while ago. And some of the elders have passed on now and they were anxious to see that road. They passed along long ago now."

In North West River, one resident provided a bit of history of the road work preparation for the proposed uranium mine near Postville,

"The first [conversation about the road] *was done in the seventies. They actually done the first survey. Freeman Baikie and Leslie Michelin were the two fellows that walked the whole trail. They walked it, they surveyed the whole thing right to Michelin* [Lake uranium deposit] *in those days."*

One resident in Happy Valley – Goose Bay believes that despite a long wait for a road, its construction can be expedited,

"[Labrador Inuit Association] *were fighting for a land claims deal for almost 30 years. And we couldn't get nowhere. Until Voisey's Bay came along…And* [former Premier] *Brian Tobin said, well hey we want to fast track negotiations. For one reason only, right? To get Voisey's Bay. There's no reason why they can't fast track this thing either, come to a full decision soon about a road to the North Coast."*

For many residents in Northern Labrador, even if they fully support the construction of a road, they know it is still many years away. In Nain, one resident doesn't expect to see it completed in their lifetime,

"I'd love to see one, I know that, but then again, given my age, I don't ever expect to see one in my lifetime."

For some residents in Makkovik, for example, interim measures need to be put in place to alleviate the current transportation network shortcomings,

"In reality the road, whether we gets it or not, it's a good 20 years away. So, we've got to live through the best of our needs and that means that which is why you're hearing about the airfare and the boat. It's not like we're going to see a change next year."

"It's a big project, but it will be a long project. So, what do we do in the meantime, you know? What kind of service do we get?"

"As I said earlier, the biggest recommendation to the province right now is to, until there is a road and I guess a project that people can accept, we want our freight service back to the island until there's a road. Or the province subsidizes the trucking cost to Goose Bay and then we pay different from there."

3.3.8.3 Construction Considerations

Conversations in communities often shifted from support/opposition of the road to ideas on how to ensure the road is constructed in a timely and sound manner. Acknowledging a short construction season and the length of a road required to connect all communities, residents wanted to ensure provincial officials made best efforts to construct the road properly, the first time,

"I guess the cost of building the road is… Just make sure it's done proper, like not a half-assed job. Use the right materials, rather than rush through do it right the first time. The same with like all the bridging and ditching, snow removal, make sure everything is taken into consideration. There is going to be lots of snow removal and snow build-up, you don't want

the road washing out every year in one spot and yes, do it right. Spend the money. It's going to be a lot of money; it's going to be a lot of money no matter what." – Resident of Makkovik

One resident of Hopedale, along with many others, wanted to ensure pavement is a consideration from the start of construction,

"You got to pave the roads. People are going to want them paved eventually, right? Does the south coast have dirt road? No. So I mean if you got a road there, you got to be paving it."

Considering pavement in future studies is aligned with one of the Nunatsiavut Government's recommendations outlined above and in Appendix B.

A former resident of Northern Labrador and current resident of Happy Valley – Goose Bay described the importance of including local knowledge into the road construction design,

"As you incorporate the local knowledge, not only Indigenous but local traditional knowledge, specifically from Hopedale north certain areas will need rock cuts. On the South coast, remember there was a rock cut that kept drifting in because they did not listen to the local people?"

For one resident of Rigolet, who has experience with capital works projects, wanted to ensure the right contractor(s) were selected for the road construction,

*"I know that working with the municipality, Capital Works Projects for example, they're put out by RFP, by the government and then we're just stuck with whoever we get and then half the time they don't know what the f*** they're doing. So, have they put into consideration like how different the landscape is from Rigolet to the North Coast and are they going to be specialized for the changes, you know what I mean? Because our trees and our land and our ground is way different than it is up Nain because that's bare tundra up there."*

4 ROUTE SELECTION AND APPRAISAL

4.1 Background

Connecting the six Northern Labrador communities (Rigolet, Makkovik, Postville, Hopedale, Natuashish and Nain) to the road network will require road and bridge construction in a northern climate where there is steep terrain, extensive wetlands, major rivers, and permafrost that all present challenges in highway design and must be considered in the route selection process. There are also socio-economic and environmental considerations that influence the route selection process. The preferred options try to strike a balance of the various project objectives.

Construction of roads in Northern Labrador has been the subject of articles and studies in the past[7]. The Independent published an article on October 29, 2015, by Dr. Robert Way, Environmental Scientist titled: "Is a road to Labrador's North Coast feasible?". The article includes a map showing possible routes to connect Northern Labrador communities and discusses some of the design challenges, costs as well as socio-economic considerations. An August 2009 report by AMEC for Fronteer Development Group Inc., outlines a possible route from North West River to Postville to service a proposed Michelin Uranium Project[8].

4.2 Route Selection Criteria

The route selection process was completed in iterations with the overall goal of determining the shortest possible routes that would connect all Northern Labrador communities while considering the following project objectives:

- Avoid crossing major water bodies. These areas are typically exposed to the negative impacts of storm surges and often require costly mitigative design feature (e.g., armour stone protection). They are also commonly associated with more severe driving conditions including strong winds and blowing snow. There are also environmental concerns that must be considered (e.g., siltation and impact on fish habitat);
- Maintain buffers around water bodies where possible to minimize environmental impacts on water quality and fish habitat;
- Minimize crossing distance of rivers. Minimizing the crossing distance will reduce the costs associated with building and maintaining bridge structures;
- Avoid or minimize crossing of wetlands, swamps, and bogs. Road construction in these areas is costly since the native ground isn't suitable for road building and must be mitigated (e.g., sub-excavation and removal, addition of geogrids, etc.) These open areas are also prone to strong wings and drifting snow which typically has a negative impact on driving conditions and increases snow removal and ice control costs;
- Meet minimum road design standards based on 80 km/hr design speed for horizontal curves (10 km/hr higher than the proposed posted speed limit) and a maximum grade of 10%. The design speed and maximum grade are consistent with DTI's requirements and comply with the recommendations outlined in the "*Geometric Design Guide for Canadian Roads*"[9] by Transportation Association of Canada;
- Avoid deep cuts where snow accumulation would negatively impact future road maintenance and operation;
- Minimize steep side slopes. These areas tend to require high side cuts and embankments that may pose stability issues and require mitigative measures (e.g., slope protection, benches, berms, guide rail);
- Minimize impacts on other land use. Route selection should consider possible conflicts with other land uses, and, where possible, alternate routes should be investigated to avoid sensitive areas.

When considering route options, the shortest possible routes generally have many advantages, when the topography is comparable. For example:

- Lower construction cost;
- Lower maintenance costs;

- Less environmental impact;
- Shorter travel distances and thereby lower travel costs for users;
- Lower shipping costs when a common carrier makes deliveries to each community in one trip.

4.3 Route Selection Process

With these criteria in mind, the main route was selected in such a way to minimize lengths of the access routes to Rigolet, Makkovik, Postville, Hopedale and Natuashish. In contrast, a more direct route to Nain with longer access routes to other communities would increase the overall costs for road construction and maintenance, as well as the travel costs for most users. Also, a more direct route to Nain would involve construction through more mountainous terrain which would add to those costs.

Google Earth Pro was used as the primary tool for the initial route selection process. Its imagery and elevation information provide an efficient method to effectively compare various route alternatives. Upon completion of the initial route selection in Google Earth Pro, these routes were then uploaded into a Geographic Information System (GIS) for further analysis and refinement. Open-source spatial data was uploaded into GIS so that the routes could be analyzed further with respect to the Provincial Land Use Atlas (LUA). Also in GIS, various base maps could be applied and studied including topographic maps with contour information, water bodies, streams, and rivers.

At the outset of the route selection process, straight line routes were developed to minimize distances while avoiding major water crossings (see Figure 4.1).
Based on this initial assessment, the approximate distances to connect the communities were measured to be:

- North West River to Nain 481 km
- Rigolet Access Route 99 km
- Makkovik Access Route 73 km
- Postville Access Route 21 km
- Hopedale Access Route 60 km
- Natuashish Access Route 35 km
- Total Distance 769 km

These were further refined to minimize river crossings, wetland crossings and mountainous terrain. At that point, each route profile was checked to determine where maximum grades exceeded 10%. Where possible, routes were realigned again to avoid grade violations. Sometimes this involved the introduction of tight horizontal curves or major departures from the shortest route. Where feasible, alternate routes were explored including those identified in our background review. These included the approximate routes suggested previously by Robert Way[7] and the proposed route to the Michelin Uranium Project. Sections of those routes were used if they offered advantages.

The next stage involved a check of the horizontal alignment using approximate measurements of the curves in Google Earth. Adjustments to the alignments were made again where possible to ensure the horizontal curve radii were equal to or greater than 250m. At that stage, it became evident that there were areas where it would be difficult to meet both the vertical and horizontal alignment design criteria. Also, some of the preferred river crossings could not be utilized, and wider crossings would be required to meet the road design criteria.

This iterative process for selecting viable routes considered many alignments (see Figure 4.2).

Figure 4.1-Initial Route Selection

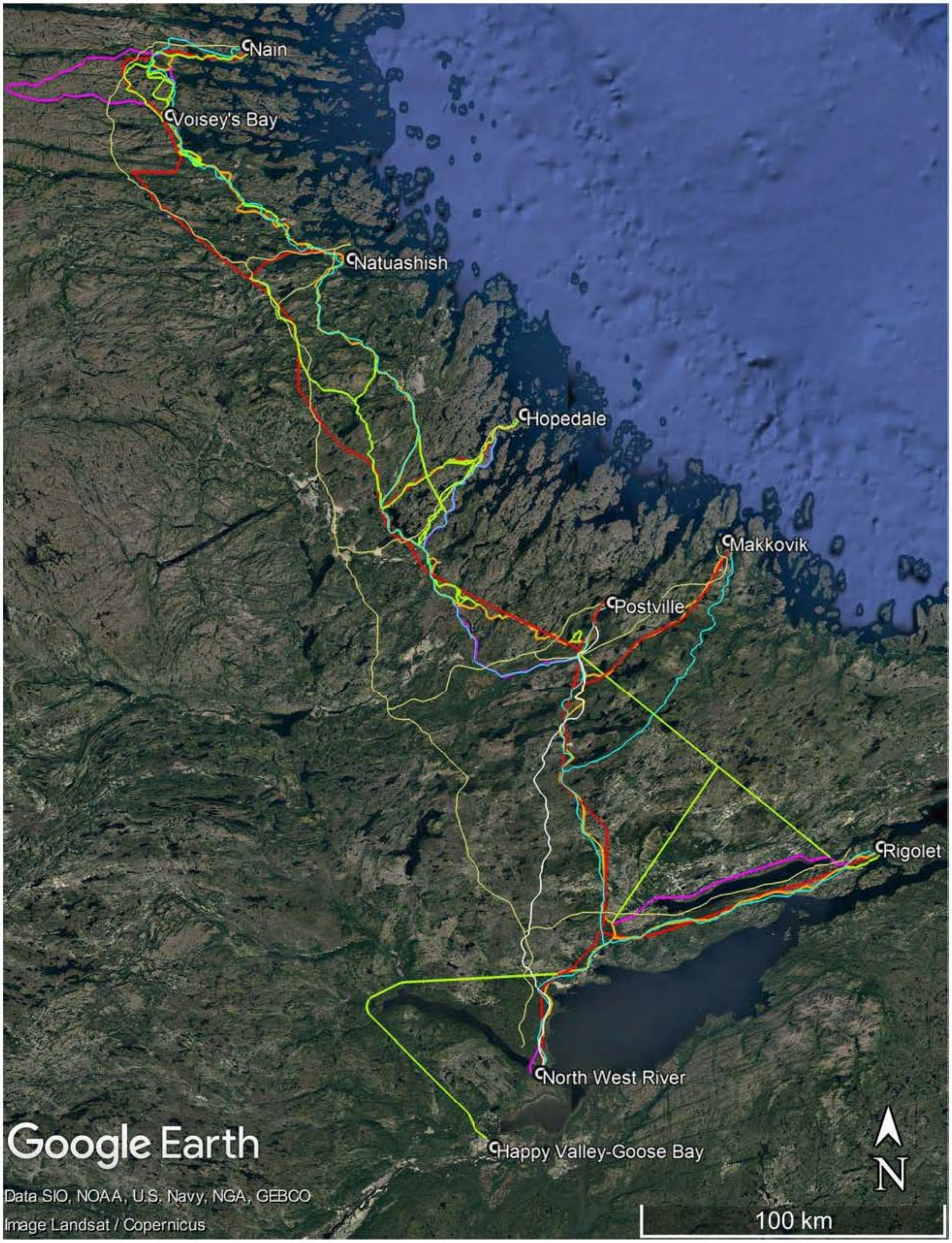

Figure 4.2-Routes Considered

Maximum grade violations may be addressed in some cases by a combination of cut and fill. Therefore, in addition to noting the maximum grades, the average grades were also recorded as a method of determining whether the grade challenges could possibly be addressed during design. There are several areas where more exploratory work will need to be undertaken to design a route that will meet all criteria. These are noted in the sections that follow.

For the purposes of this study, all recommended routes are designated by the route segment letter identifier followed by the number one (e.g. Route A1, Route B1, etc.). These are the routes on which costs and travel distances are based on throughout the report. For some road segments, optional routes were also investigated to determine their relative viability and/or to overcome technical challenges with difficult terrain. Optional routes are designated by the route segment letter identifier followed by a number greater than one (e.g. Route A2, Route D2, etc.). Both the recommended routes and the optional routes identified in the report are recommended for further analysis in a future feasibility study.

To compare route options, a high-level ranking table was developed based on the main project objectives and information that is currently available. The table simply does a relative comparison of two options whereby the most desirable result is given the maximum score for a particular unit of measure and the other option is scored based on the degree of variance from the best result.

For this study, the ranking table is broken down into the following categories:

- Cost – Capital Cost and Maintenance cost;
- Technical – Compliance with Horizontal and Vertical Alignment Design Criteria;
- Environmental – Impact on Rivers and Streams;
- Socio-economic – Travel Time to Service Center and Connectivity with other Communities.

In consultation with DTI, each of these categories were given weighting factors based on their relative importance overall. This is represented by a distribution of 100 as follows:

- Cost 50%;
- Technical 30%;
- Environmental 10%;
- Socio-economic 10%.

As a means of comparing route options, these weighting factors were further broken down by units which could be measured from available information. For this analysis, rivers and streams are identified from topographic maps with streams being depicted by a single line on the map and rivers depicted as two lines where the width could be measured. Again, in consultation with DTI, each of these units of measure were assigned a distribution of the weighting factors allocated for each of the categories:

- Cost
    - i. Overall Construction Length (km) 25%
    - ii. Bridges > 150m – Total Crossing length (m) 15%
    - iii. Bridges ≤ 150m – Total Crossing length (m) 10%
- Technical
    - i. Number of Average Grade Violations 15%
    - ii. Number of Grade Violations 5%
    - iii. Number of Horizontal Curve Violations 10%
- Environmental

        i. Number of River Crossings 6%
        ii. Number of Stream Crossings 4%

- Socio-economic
        i. Distance to Happy-Valley Goose Bay (km) 7%
        ii. Distance to Nearest Community (km) 3%

The units in each category are scored on a scale of 1 to 5. For criteria that compare distances, the option with the shortest distance is given a score of 5 and a comparable option is scored based on a range whereby an increase in distance of 50% is assigned a score of 1. For all other criteria, units per kilometer are calculated for all routes analysed under this study to determine the best and least favourable results overall. The minimum number of units per km is assigned a score of 5 and the maximum number of units per kilometer is assigned a score of 1.

The scores are assigned in the ranking tables based on the ranges established below and prorated as necessary:

- Overall Construction Length (km)
    - Score of 5: Shortest Option
    - Score of 1: 50% Longer than Shortest Option
- Bridges > 150m Length – Total Crossing Length (m) per km
    - Score of 5: Best Result Overall = 0
    - Score of 1: Least Favourable Result Overall = 9.277
- Bridges ≤ 150m Length – Total Crossing Length (m) per km
    - Score of 5: Best Result Overall = 0
    - Score of 1: Least Favourable Result Overall = 5.496
- Number of Grade Violations per km
    - Score of 5: Best Result Overall = 0
    - Score of 1: Least Favourable Result Overall = 0.397
- Number of Average Grade Violations per km
    - Score of 5: Best Result Overall = 0
    - Score of 1: Least Favourable Result Overall = 0.093
- Number of Horizontal Curve Violations per km
    - Score of 5: Best Result Overall = 0
    - Score of 1: Least Favourable Result Overall = 0.104
- Number River Crossings per km
    - Score = 5: Best Result Overall = 0
    - Score = 1: Least Favourable Result Overall = 0.076
- Number of Stream Crossings per km
    - Score = 5: Best Result Overall = 0
    - Score = 1: Least Favourable Result Overall = 0.772
- Distance to Happy-Valley Goose Bay (km)
    - Score = 5: Shortest Option
    - Score = 1: 50% Longer than Shortest Option
- Distance to Nearest Community (km)
    - Score = 5: Shortest Option
    - Score = 1: 50% Longer than Shortest Option

Points for each unit are calculated by multiplying the weighting factor by the score with the maximum points for a route being 500 (weighting factor of 100 x score of 5).

This ranking table has its limitations but serves as a tool to simply compare one option to another based available information and when the routes have similar characteristics that could be measured.

In addition to the units measured in the ranking table, there are other factors that are also important to consider during route selection. Many of these are common to both options (e.g., extent of permafrost, impact on wildlife, impact on indigenous lands, etc.) and therefore not included in the ranking table. There are other factors that may only apply to one route and therefore difficult to incorporate and quantify in a ranking table. Those considerations are identified in advantages/disadvantages tables that accompany the ranking tables.

4.4 Route Options, Comparisons and Rankings

For the purposes of this study, routes were broken down into segments that could be analysed and described with respect to both route selection and possible construction phasing (see Table 4.1).

Segment	Description
A	North West River to Rigolet Junction
B	Rigolet Junction to Makkovik Junction
C	Makkovik Junction to Postville Junction
D	Postville Junction to Hopedale Junction
E	Hopedale Junction to Natuashish
F	Natuashish to Voisey's Bay
G	Voisey's Bay to Nain
H	Rigolet Access Route
I	Makkovik Access Route
J	Postville Access Route
K	Hopedale Access Route

Table 4.1-Proposed Route Segments

4.4.1 Segment A – North West River to Rigolet Junction

4.4.1.1 Route A1

North West River was chosen as the most logical point to begin the road into Northern Labrador since it is already connected to Happy Valley-Goose Bay by 38 km of provincially maintained highway. Any direct connection to Happy Valley-Goose Bay would require construction of a road around the northwest side of Grand Lake for an additional 88 km which would significantly increase construction costs, maintenance costs, travel time and environmental impacts.

Route A1 starts in the community of North West River and follows a predominantly coastal route to Rigolet Junction for a distance of 61 km. To access the start of the route, traffic will cross the existing provincial bridge on the south side of North West River and then utilize approximately 1.8 km of municipal roads through the town to reach the north side of the community and the start of the new route. The municipal roads in North West River are mainly local residential roads with intersections that may require upgrading to service any additional traffic from the northern communities.

The route is predominantly within forested land with gentle slopes. Permafrost along the route is characterized as “isolated patches of permafrost with low ground ice content (<10%)”. Two potential bridge crossings will be required at Sabashachu River and Mulligan River. Refer to Figure 4.3.

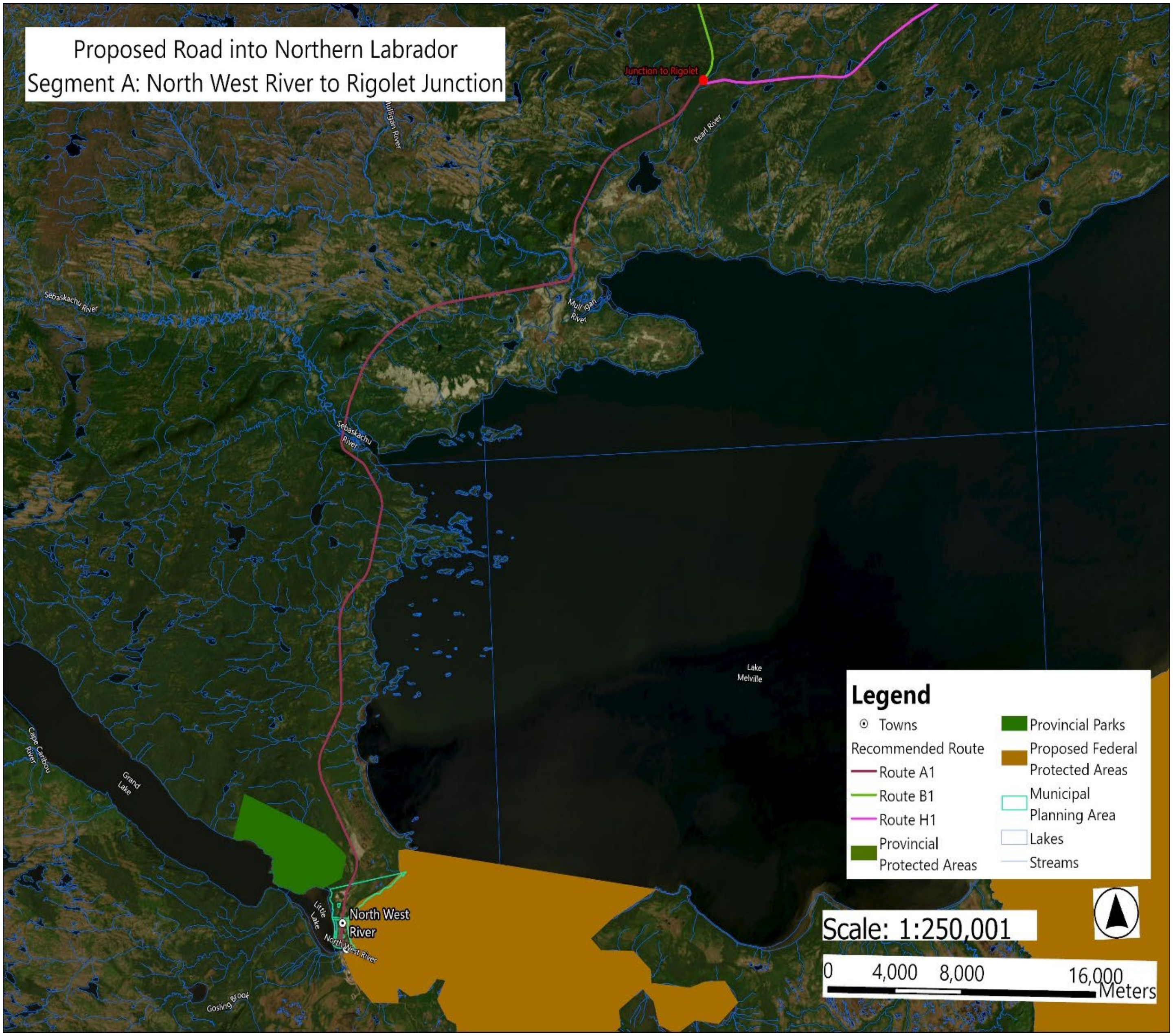

Figure 4.3-Route A1 – North West River to Rigolet Junction

4.4.1.2 Route A2 – North West River Bypass Option

Route A2 follows Route A1 with the exception of a 10 km section in the area of North West River where the proposed road bypasses the community completely. This would avoid the use of residential municipal roads for highway traffic. However, it would require the construction of a new bridge (~160m in length) across the channel between Little Lake and Grand Lake. On the north side of Little Lake, a portion of this bypass route crosses land that is identified in the Provincial Land Use Atlas (LUA) as "Parks: Grand Lake Land Transfer 1985" with no development permitted or approved in the defined area. Refer to Figure 4.4.

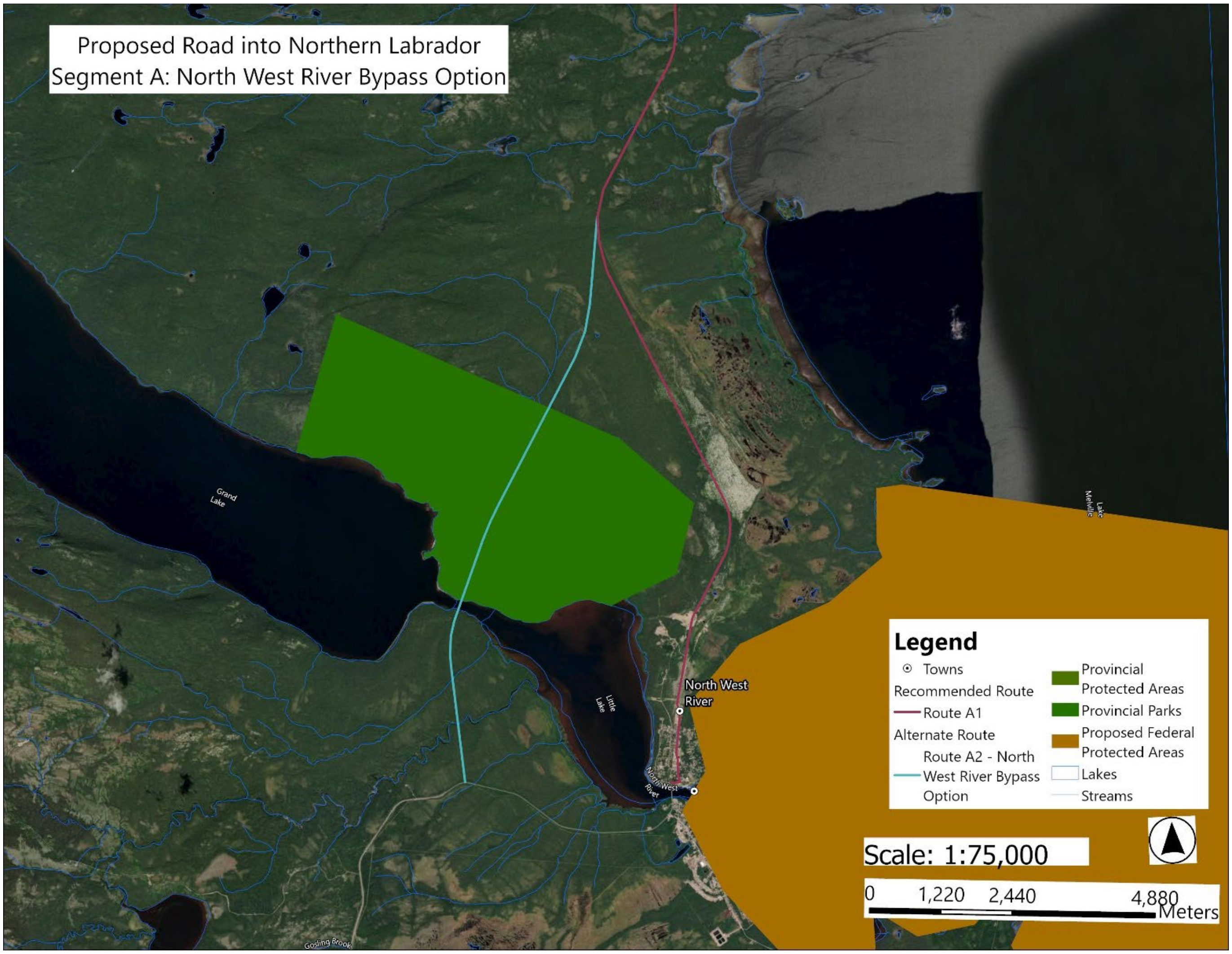

Figure 4.4-Route A2 – North West River Bypass Option

Route A1	Route A2
Advantages: • The existing bridge at North West River can be utilized which results in reduced capital cost. • Access to the start of the route is currently available, which is advantageous for the construction schedule. • Shorter distance from northern communities to North West River. Disadvantages: • Section of Route through North West River is along municipal roads and will require consultations with the municipality regarding upgrading and future maintenance. • Longer distance from northern communities to Goose Bay. • Poor horizontal alignment through North West River requiring speed reductions.	Advantages: • Shorter distance from northern communities to Goose Bay. • Does not require use of municipal roads. • Horizontal alignment meets design criteria. • Outside municipal planning area. Disadvantages: • Requires construction of a major bridge near the start of the route. This increases the cost of construction and negatively impacts construction scheduling north of the bridge crossing. • Longer distance from northern communities to North West River. • Land on the north side of Little Lake is designated as "Parks: Grand Lake Land Transfer 1985" with no development permitted or approved.

Table 4.2-Route A1 vs Route A2 – Advantages / Disadvantages

		Route A1 - North West River to Rigolet Junction			Route A2 - North West River Bypass Option		
Ranking Criteria Categories / Units Measured	WF	Unit	Score	Score x WF	Unit	Score	Score x WF
Cost - Capital Cost and Maintenance Cost							
Overall Construction Length (km)	25	61.2	5.0	125	60.9	5.0	125
Bridges > 150m - Total Crossing Length (m)	15	0	5.0	75	160	3.9	59
Bridges ≤ 150m - Total Crossing Length (m)	10	140	3.3	33	140	3.3	33
Sub-total				233			217
Technical - Compliance with Horizontal and Vertical Alignment Design Criteria							
Number of Grade Violations	5	1	4.8	24	3	4.5	23
Number of Average Grade Violations	15	0	5.0	75	0	5.0	75
Number of Horizontal Curve Violations	10	4	2.5	25	1	4.4	44
Sub-total				124			142
Environmental - Impact on Rivers and Streams							
Number of River Crossings	6	2	3.3	20	3	2.4	14
Number of Stream Crossings	4	43	1.4	6	47	1.0	4
Sub-total				26			18
Socio-economic - Travel Time to Service Center and Connectivity with Other Communities							
Distance to Happy-Valley Goose Bay (km)	7	102.2	4.6	32	97.6	5.0	35
Distance to Nearest Community (km)	3	61.0	5.0	15	66.6	4.3	13
Sub-total				47			48
Total Points out of a Maximum of 500				430			425
Ranking				1			2

WF = Weighting Factor: Number out of 100 based on relative importance overall.

Ranking Criteria Categories / Units Measured	*Ranking Criteria Score Range*	
	Score = 5	*Score = 1*
Overall Construction Length (km)	*Shortest Option*	*50% Longer than Shortest Option*
Bridges > 150m - Total Crossing Length (m) per km	*0*	*9.277*
Bridges ≤ 150m - Total Crossing Length (m) per km	*0*	*5.496*
Number of Grade Violations per km	*0*	*0.397*
Number of Average Grade Violations per km	*0*	*0.093*
Number of Horizontal Curve Violations per km	*0*	*0.104*
Number of River Crossings per km	*0*	*0.076*
Number of Stream Crossings per km	*0*	*0.772*
Distance to Happy-Valley Goose Bay (km)	*Shortest Option*	*50% Longer than Shortest Option*
Distance to Nearest Community (km)	*Shortest Option*	*50% Longer than Shortest Option*

Table 4.3-Route A1 vs Route A2 – Ranking Table

4.4.2 Segment B – Rigolet Access Junction to Makkovik Junction

4.4.2.1 Route B1

Route B1 is approximately 104 km in length starting at Rigolet Junction and extends in a northerly direction to Makkovik Junction. Permafrost along the route is characterized as "isolated patches with low ground ice content (<10%)". The topography has gentle slopes suitable for road building. Four river crossings were identified as requiring potential bridge construction along the route.

The proposed route generally follows a straight line between Rigolet Junction and Makkovik Junction and doesn't require any major diversions to meet the design criteria. Therefore, it was considered the overall shortest and most viable route. Refer to Figure 4.5.

Other route options were considered early in the route selection process but are not deemed to be viable alternatives to the selected route. For example, the proposed access road to the Michelin Uranium Project site is further inland and would require a longer access road to Rigolet. Likewise, a more direct route between Rigolet and Makkovik would require a major bridge crossing on the east side of Double Mer and longer road segments.

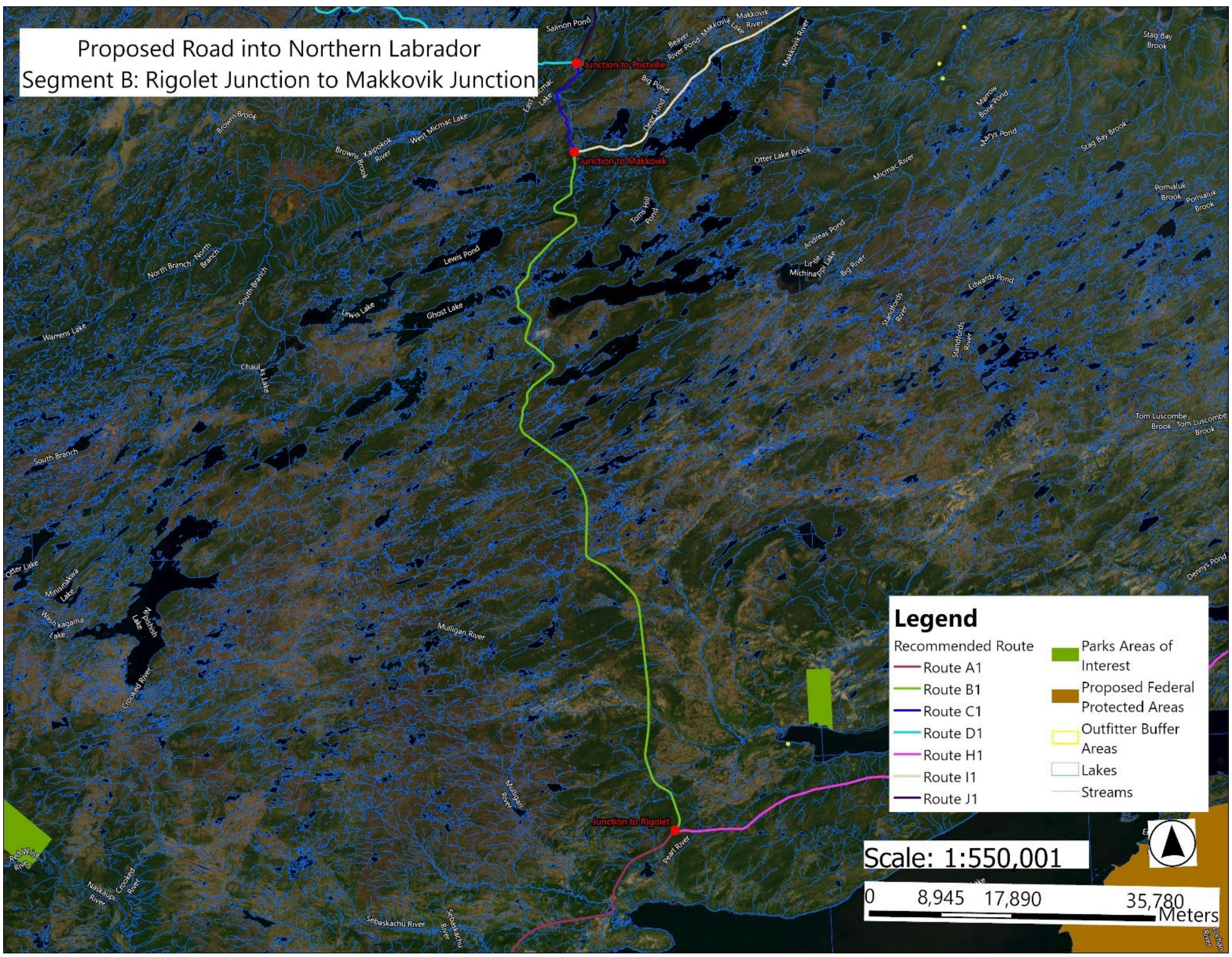

Figure 4.5-Route B1 – Rigolet Junction to Makkovik Junction

4.4.3 Segment C – Makkovik Junction to Postville Junction

4.4.3.1 Route C1

Route C1 is approximately 13 km in length starting at Makkovik Junction and extends in a north/northeast direction to Postville Junction. The southern end of the route starts in a permafrost zone characterized as isolated patches with low ground ice content (<10%) and crosses into a zone with sporadic discontinuous permafrost with low ground ice content to nil ice content (<10% to 0%) on the northern end. The topography has gentle slopes suitable for road building. One major bridge crossing is required at the Kaipokok River. Refer to Figure 4.6.

This is a relatively short section with generally straight lines between Makkovik Junction, the preferred Kaipokok River crossing, and Postville Junction. No major deviations were required to meet the design criteria.

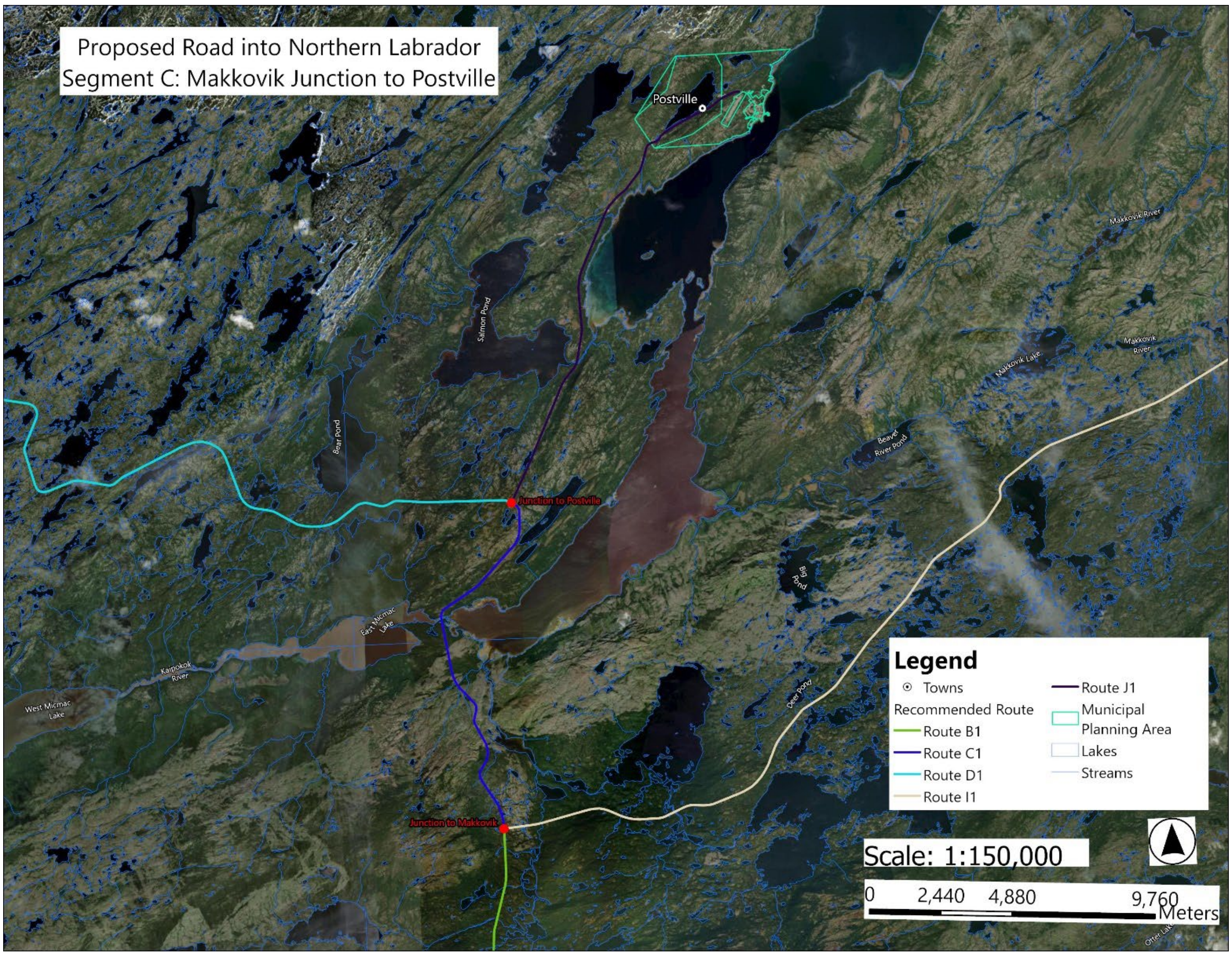

Figure 4.6-Route C1 – Makkovik Junction to Postville Junction

4.4.4 Segment D – Postville Junction to Hopedale Junction

4.4.4.1 Route D1

Route D1 is approximately 103 km n length route starting at Postville Junction and extends in a northwest direction to Hopedale Junction. This route is in two permafrost zones ranging from "Sporadic discontinuous with low ground ice content to nil ice content (<10% to 0%)" to "Sporadic discontinuous permafrost with low ground ice content (<10%)". Seven (7) river crossings were identified along this route where bridges will be required including the Kanairiktok River.

North of Postville, there are areas with steep slopes making it more challenging to achieve the design grade criteria (≤ 10%). Three noteworthy areas were identified:

- Approximately 4 km north of Postville Junction (south of Bear Pond);
- Approximately 5 km southeast of the Kanairiktok River;
- At the west side of Udjuktok Bay.

While there are several steep slopes within these areas, the average grades meet the design criteria. A more detailed analysis of these areas will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills. Refer to Figure 4.7.

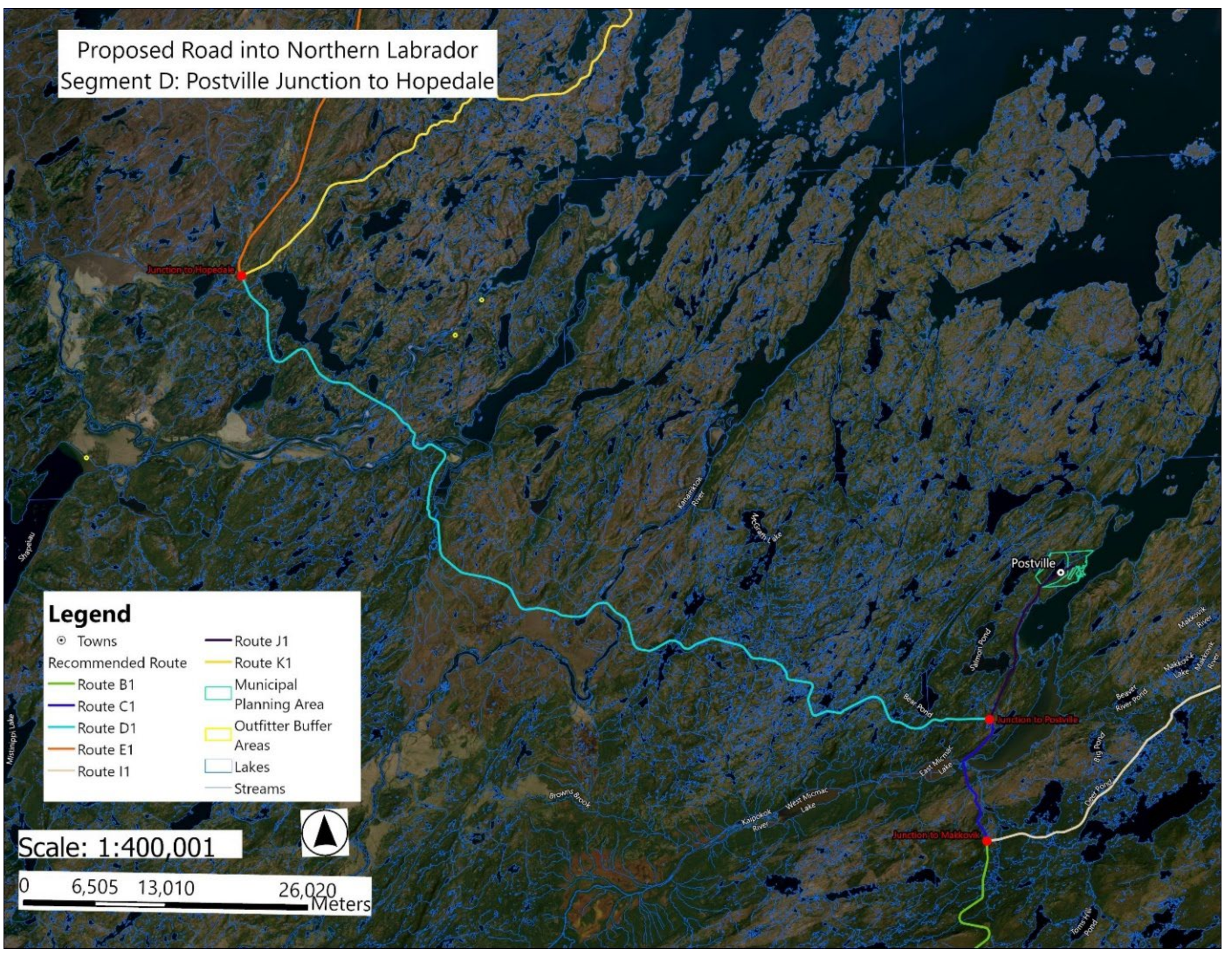

Figure 4.7-Route D1 – Postville Junction to Hopedale Junction

4.4.4.2 Route D2 – Southern Route around Micmac Lake Option

Route D2 follows Route D1 except for a 58 km section that wraps around the southern side of Micmac Lake. This diversion avoids the first two grade challenges identified along Route D1. The topography along this section of Route D2 has more gentle slopes that are favorable for road building. However, this route will require approximately 4 km of additional road construction and an additional 180m of bridge construction including a second bridge across the Kaipokok River. Refer to Figure 4.8.

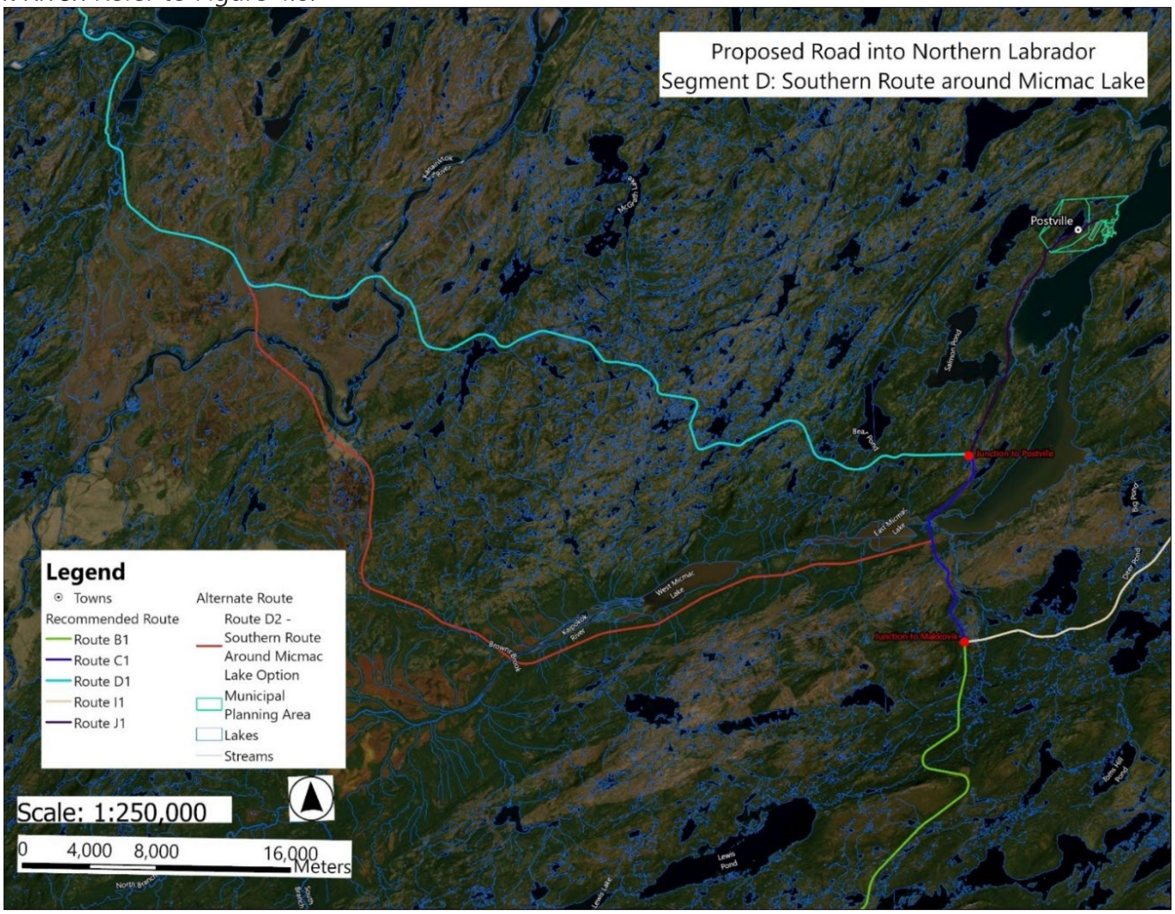

Figure 4.8-Route D2 – Southern Route around Micmac Lake Option

Route D1	Route D2
Advantages: • Shorter overall construction length (-4 km). • Shorter travel distance between Hopedale and Postville (-10.5 km). • One (1) less river crossing • Less overall bridge construction (-180m). Disadvantages: • Longer distance to Happy Valley-Goose Bay for communities north of Postville (+2.3km). • More stream crossings (+9) • More steep slopes with grade violations.	Advantages: • Shorter distance to Happy Valley-Goose Bay for communities north of Postville (-2.3km). • Less stream crossings (-9). • Better slopes with less grade violations. • Avoids a section through "High Subarctic Tundra". • Approximately 29km section is in a less severe permafrost zone. Disadvantages: • Longer overall construction length (+4km). • Greater travel distance between Hopedale and Postville (+10.5km). • One (1) additional river crossing. • Additional overall bridge construction (+180m).

Table 4.4-Route D1 vs Route D2 – Advantages / Disadvantages

		Route D1 - Postville Junction to Hopedale Junction			Route D2 - Southern Route around Micmak Lake Option		
Ranking Criteria Categories / Units Measured	WF	Unit	Score	Score x WF	Unit	Score	Score x WF
Cost - Capital Cost and Maintenance Cost							
Overall Construction Length (km)	25	102.5	5.0	125	106.6	4.7	118
Bridges > 150m - Total Crossing Length (m)	15	0	5.0	75	152	4.4	66
Bridges ≤ 150m - Total Crossing Length (m)	10	472	1.6	16	500	1.6	16
Sub-total				216			200
Technical - Compliance with Horizontal and Vertical Alignment Design Criteria							
Number of Grade Violations	5	14	3.6	18	10	4.0	20
Number of Average Grade Violations	15	1	4.6	69	0	5.0	75
Number of Horizontal Curve Violations	10	0	5.0	50	0	5.0	50
Sub-total				137			145
Environmental - Impact on Rivers and Streams							
Number of River Crossings	6	7	1.4	8	8	1.1	7
Number of Stream Crossings	4	70	1.5	6	61	2.0	8
Sub-total				14			15
Socio-economic - Travel Time to Service Center and Connectivity with Other Communities							
Distance to Happy-Valley Goose Bay (km)	7	280.3	4.9	34	278.0	5.0	35
Distance to Nearest Community (km)	3	119.6	5.0	15	130.1	4.3	13
Sub-total				49			48
Total Points out of a Maximum of 500				416			408
Ranking				1			2

WF = Weighting Factor: Number out of 100 based on relative importance overall.

Ranking Criteria Categories / Units Measured	*Ranking Criteria Score Range*	
	Score = 5	*Score = 1*
Overall Construction Length (km)	*Shortest Option*	*50% Longer than Shortest Option*
Bridges > 150m - Total Crossing Length (m) per km	*0*	*9.277*
Bridges ≤ 150m - Total Crossing Length (m) per km	*0*	*5.496*
Number of Grade Violations per km	*0*	*0.397*
Number of Average Grade Violations per km	*0*	*0.093*
Number of Horizontal Curve Violations per km	*0*	*0.104*
Number of River Crossings per km	*0*	*0.076*
Number of Stream Crossings per km	*0*	*0.772*
Distance to Happy-Valley Goose Bay (km)	*Shortest Option*	*50% Longer than Shortest Option*
Distance to Nearest Community (km)	*Shortest Option*	*50% Longer than Shortest Option*

Table 4.5-Route D1 vs Route D2 – Ranking Table

4.4.5 Segment E – Hopedale Junction to Natuashish

4.4.5.1 Route E1

Initially it was envisioned that more direct route towards Nain would be a preferred route with a separate access road to the community of Natuashish. However, early in the development of this route, it became apparent the more direct inland route towards Nain is not viable due to the mountainous terrain with steep slopes and deep valleys that cross the path. During the process, it was determined that it is possible to connect directly to the community of Natuashish without having to build a separate access road. The topography along the chosen route is better than an inland route and the overall road construction length is less.

Route E1 is approximately 114 km in length starting at Hopedale Junction and extends in a northerly direction to Natuashish. The route is within a permafrost zone characterized as "Sporadic discontinuous permafrost with low ground ice content (<10%)". Seven (7) river crossings were identified along this route where bridges will be required including Hunt River, Flowers River, and Sango Brook.

Two areas are noted approximately 15 km and 18 km south of Natuashish where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). However, the average grades through those areas meet the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills.

The route is relatively close to outfitters camps at Hunt River and another in an area approximately 15 km south of Flowers River.

A portion of the route is within the Natuashish Reserve lands and the Sango Brook domestic water supply, but this would apply to any possible route into Natuashish. Refer to Figure 4.9.

Early in the route selection process, another route option was considered further inland for approximately 56 km starting near Hopedale Junction. It is a slightly more direct route, but the topography was more challenging with significantly more water body crossings and steeper slopes. Therefore, it was not deemed to be a viable alternative for the recommended route.

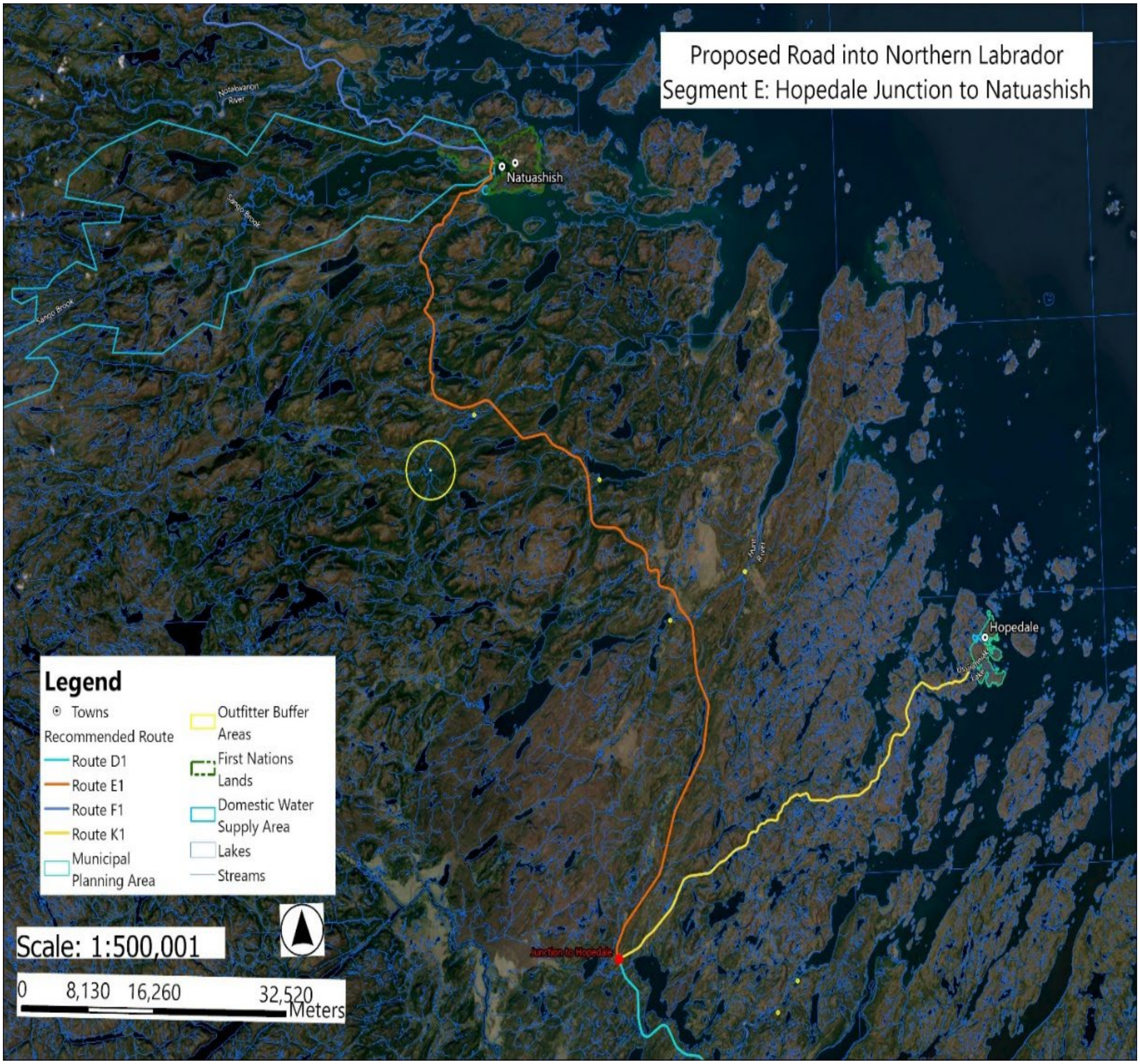

Figure 4.9-Route E1 – Hopedale Junction to Natuashish

4.4.6 Segment F – Natuashish to Voisey's Bay

4.4.6.1 Route F1

Route F1 is approximately 99 km in length starting at Natuashish and extends in a northwest direction to the Voisey's Bay Mine site. While connection the Voisey's Bay Mine site was not a stated objective of this study, the site is located along the preferred route due to the topography in the area.

The route is in two permafrost zones characterized as "Sporadic discontinuous permafrost with low ground ice content (<10%)" and "Sporadic discontinuous permafrost with medium to low ground ice content (20% to <10%)". Six (6) river crossings were identified along this route where bridges will be required including Notakwanon River, Side Brook, Kogaluk River, Konrad Brook, and Kogluktokoluk Brook.

Twelve (12) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). One of those areas is an 11 km section starting approximately 8 km north of the Notakwanon River crossing. Another noteworthy area is approximately 6 km in length located approximately 6 km north of Kogaluk River. The average grades through those areas meet the design criteria but a more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills. A portion of the route is within the Natuashish Reserve lands and the Sango Brook domestic water supply, but this would apply to any possible route into Natuashish. Refer to Figure 4.10.

Figure 4.10-Route F1 – Natuashish to Voisey's Bay

4.4.7 Segment G – Voisey's Bay to Nain

4.4.7.1 Route G1

Route G1 is 66 km in length starting at Voisey's Bay and extending to Nain generally following the coast of Anaktalik Bay. Permafrost along this route is characterized as "Sporadic discontinuous permafrost with medium to low ground ice content (20% to <10%)". Two (2) river crossings were identified along this route where bridges will be required including Reid Brook and Anaktalik Brook. Refer to Figure 4.11.

Eighteen (18) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). Most of the more severe grades are within a thirteen (13) km section west of the Voisey's Bay Mine marine port. At least six (6) sections within this area have average slopes that exceed the maximum grade criteria (≤ 10%) and present significant challenges for road design. Alternate routes have been considered to avoid some or all the steep slopes, but they also have design challenges as described in the following sections.

Other severe slopes were identified in a seven (7) km section entering Nain but the average grades through that area meet the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills. Sections of this route are within other land use areas including the Nain municipal planning area as well as Voisey's Bay Mineral Development Area and a Vale Crown Lease.

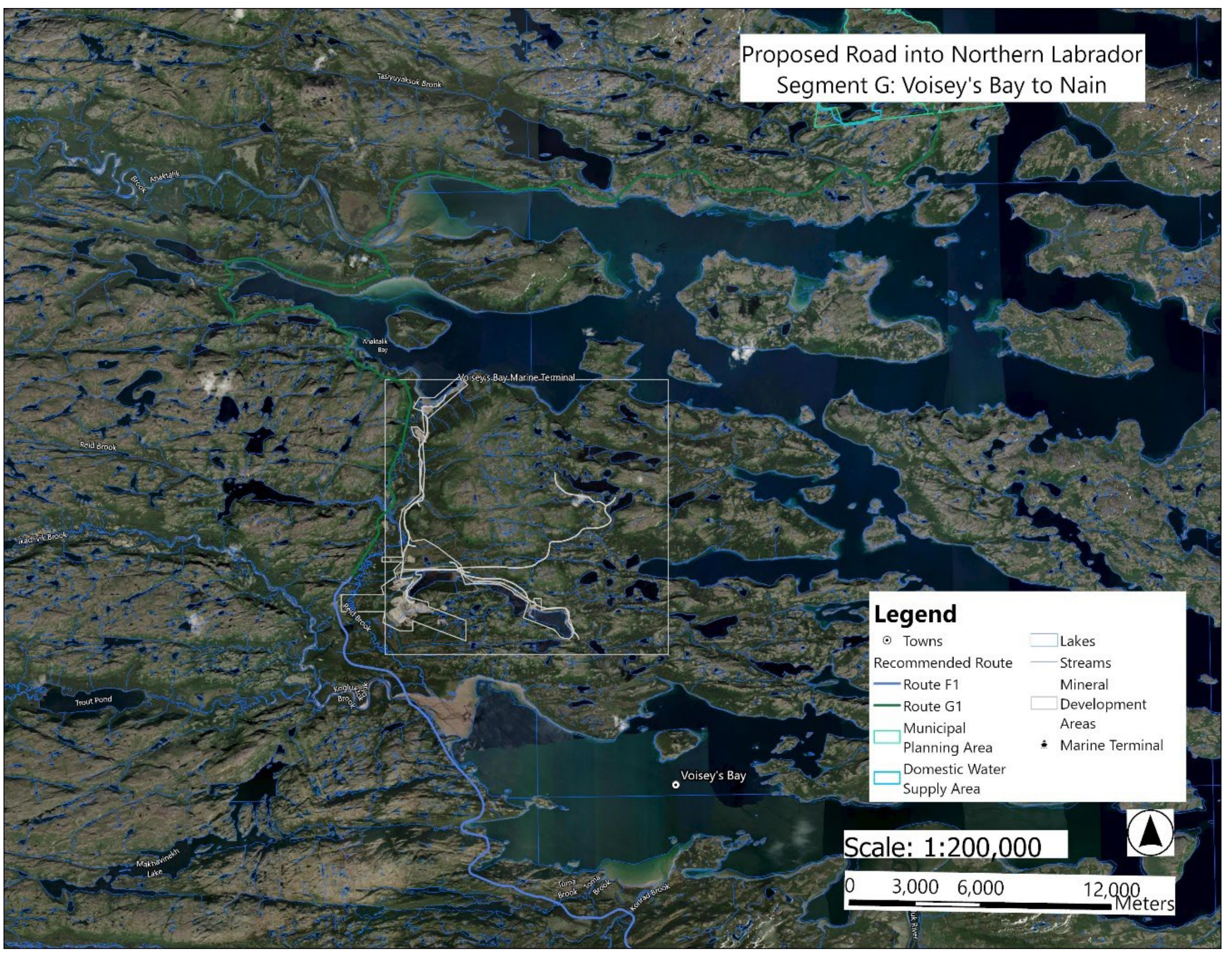

Figure 4.11-Route G1 – Voisey's Bay to Nain

4.4.7.2 Route G2 – Anaktalik Bay Shoreline Option

Route G2 follows Route G1 except for a 5.4 km section that follows the shoreline west of the Voisey's Bay Mine marine port and thereby bypasses several the steep grades. However, it will require eight (8) horizontal curves that do not meet the design criteria (≥250 m). Also, some of the alignment will require construction in coastal waters. The depth of the water and extent of storm surge protection required are beyond the scope of this report and will require a more in-depth analysis to determine if it is feasible. Refer to Figure 4.12.

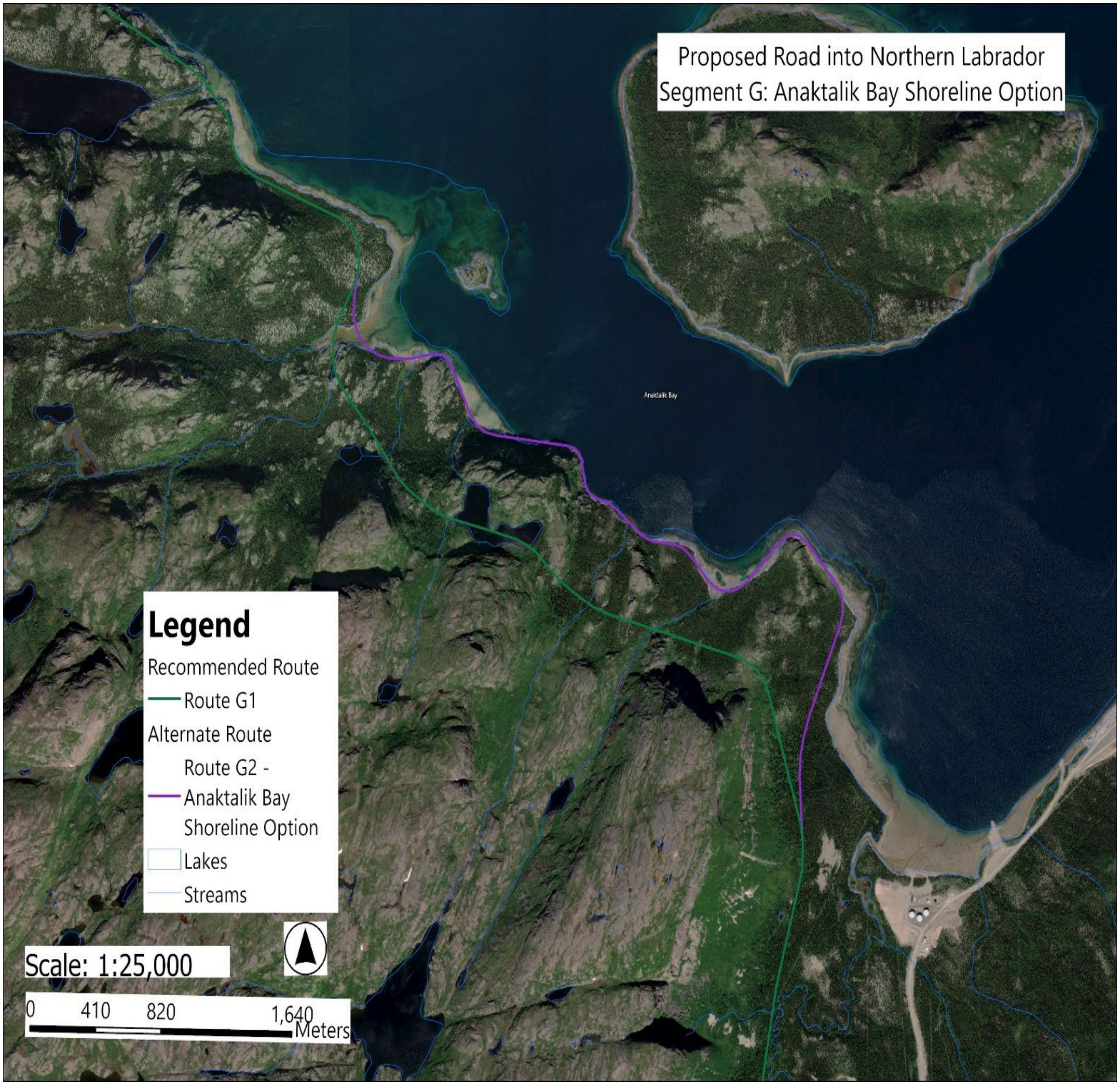

Figure 4.12-Route G2 – Anaktalik Bay Shoreline Option

4.4.7.3 Route G3 – Anaktalik Bay Causeway Option

Route G3 follows Route G1 except for a 6.6 km section that extends across Anaktalik Bay near the Voisey's Bay Mine marine port. It connects to an island with two (2) causeways at lengths of approximately 850 m and 1800 m. This route effectively bypasses the most challenging slopes. However, this option has other significant design challenges with respect to construction of the causeways in possibly deep water where storm surge protection and a significant bridge structure will be required over navigable waters. These factors are beyond the scope of this report and require detailed analysis to determine if it is an option worth considering. Refer to Figure 4.13.

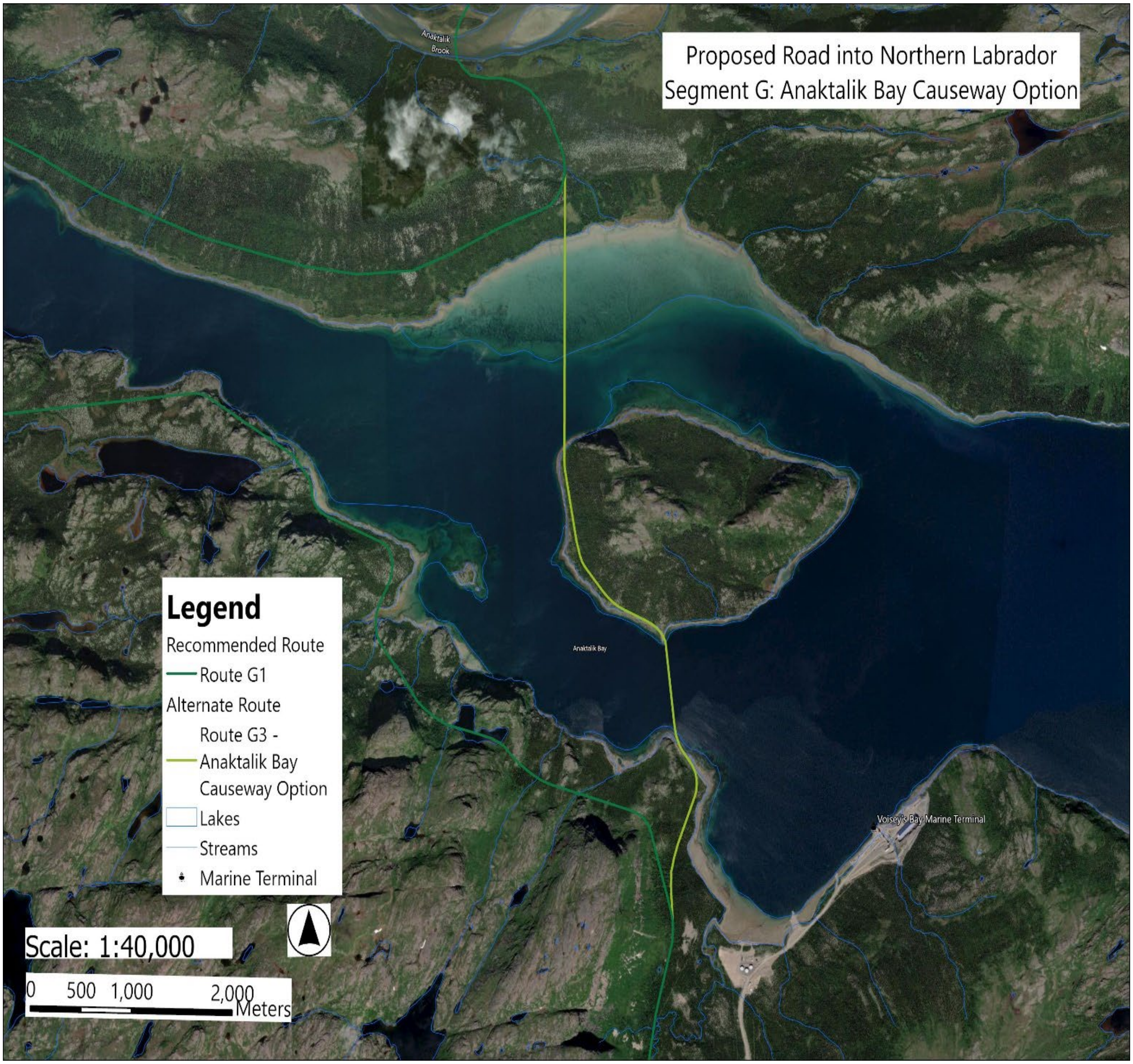

Figure 4.13-Route G3 – Anaktalik Bay Causeway Option

4.4.7.4 Route G4 – Ikadlivik and Anaktalik Valleys Option

Route G4 follows Route G1 except for a 118 km section that extends west from Voisey's Bay along the Ikadlivik Brook valley and then east/northeast along the Anaktalik Brook valley. This route effectively bypasses the most challenging slopes. It is outside the Voisey's Bay Mine Mineral Development Area and Vale Crown Lease Area but does cross five (5) mineral staked claims.

This option also has some less challenging slopes but with significantly more river and stream crossings. A route through these valleys may also be prone to significant snow accumulation and winter maintenance issues. The western section of this route is in a permafrost zone classified as "Extensive discontinuous permafrost with medium to low ground ice content (20% to <10%)". Figure 4.14.

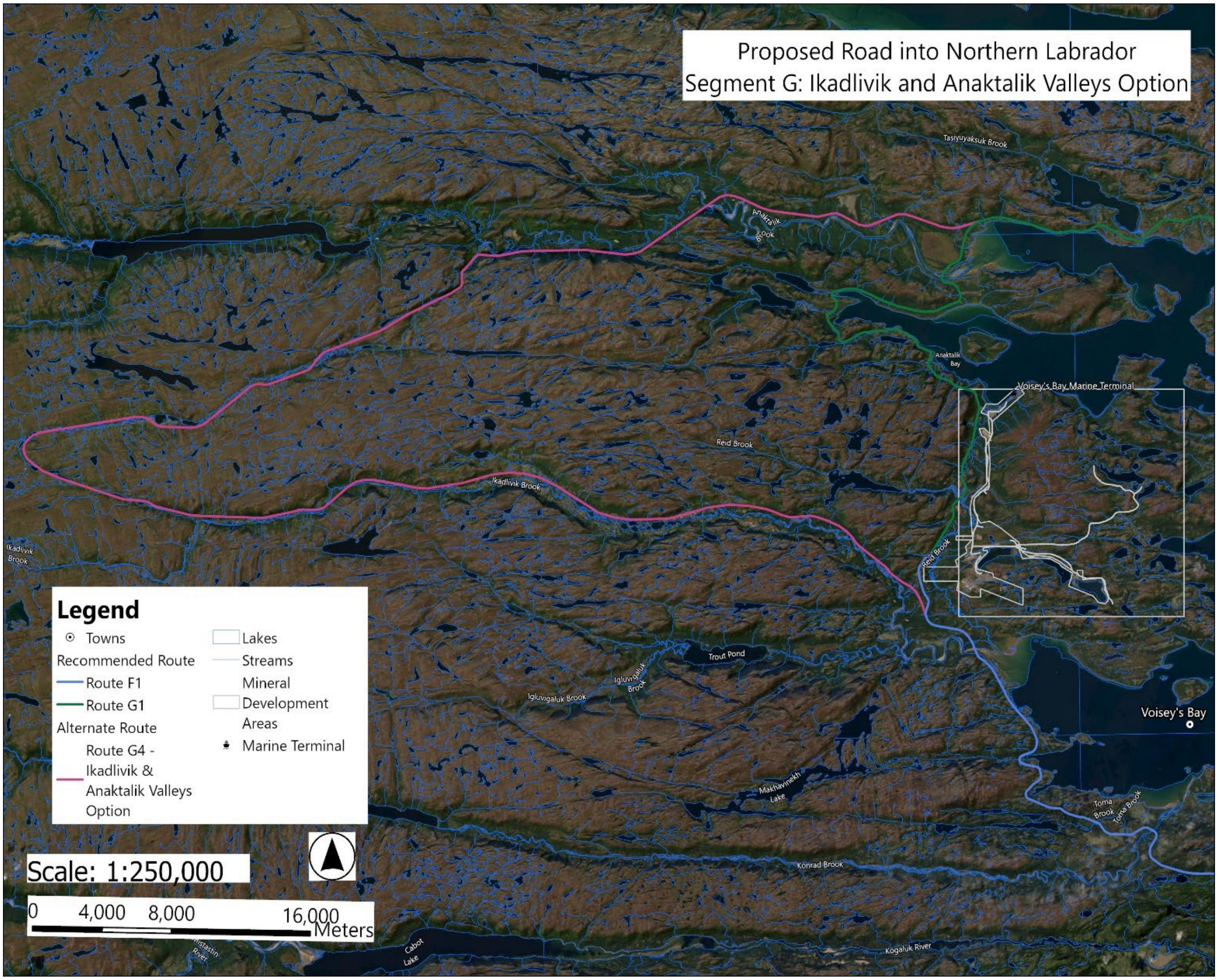

Figure 4.14-Route G4 – Ikadlivik and Anaktalik Valleys Option

Route G1	Route G2	Route G3	Route G4
Advantages: • Construction is inland with no requirement for storm surge protection. • Horizontal alignment meets design criteria. Disadvantages: • Significant vertical alignment design challenges. • Crosses Voisey's Bay mineral development area and Vale crown lands lease area.	Advantages: • Less vertical alignment design challenges than Route G1. Disadvantages: • Slightly longer than Route G1. • Horizontal alignment does not meet design requirements and would necessitate a posted speed reduction. • Requires construction in coastal waters and will require storm surge protection. • Crosses Voisey's Bay mineral development area and Vale crown lands lease area. • Crosses shoreline in front of a possible camp site.	Advantages: • Significantly shorter length overall than all other options. • Least number of vertical alignment design challenges. • Horizontal alignment meets design criteria. Disadvantages: • Two long causeways across coastal waters with need for storm surge protection. • Will be subject to navigable waters design requirements. • Greatest exposure to open areas which may limit visibility in storm conditions. • Crosses Voisey's Bay mineral development area and Vale crown lands lease area.	Advantages: • Less road vertical alignment design challenges than Routes G1 and G2. • Construction is inland with no requirement for storm surge protection. • Outside Voisey's Bay mineral development area and Vale crown lands lease area. Disadvantages: • Significantly longer overall construction length. • Significantly longer travel distance between Nain and other communities. • More river and stream crossings. • Higher likelihood of snow accumulation. • Increased exposure to permafrost. • Crosses other mineral staked claims.

Table 4.6-Route G1, G2, G3 and G4 – Advantages / Disadvantages

Route G3 is the shortest option overall and would be the most desirable if future analysis of the bathymetry and navigable waters requirements proved that it is viable. However, due to the high level of uncertainty at this stage, it was not used as the recommended option for cost and distance calculations.

Route G4 is much longer than the other options and not recommended for consideration in a future feasibility study unless there are no other viable alternatives.

		Route G1 - Voisey's Bay to Nain			Route G2 - Anaktalik Bay Shoreline Option			Route G3 - Anaktalik Bay Causeway Option			Route G4 - Ikadlivik & Anaktalik Valleys Option		
Ranking Criteria Categories / Units Measured	WF	Unit	Score	Score x WF	Unit	Score	Score x WF	Unit	Score	Score x WF	Unit	Score	Score x WF
Cost - Capital Cost & Maintenance Cost													
Overall Construction Length (km)	25	66.3	2.6	65	67.2	2.5	63	51.2	5.0	125	143.5	**-9.4**	-235
Bridges > 150m - Total Crossing Length (m)	15	475	1.9	29	475	2.0	30	475	1.0	15	0	5.0	75
Bridges ≤ 150m - Total Crossing Length (m)	10	0	5.0	50	0	5.0	50	60	4.1	41	408	2.9	29
Sub-total				144			143			181			-131
Technical - Compliance with Horizontal & Vertical Alignment Design Criteria													
Number of Grade Violations	5	18	2.3	12	13	3.1	16	10	3.0	15	12	4.2	21
Number of Average Grade Violations	15	6	1.1	17	2	3.7	56	0	5.0	75	3	4.1	62
Number of Horizontal Curve Violations	10	0	5.0	50	7	1.0	10	0	5.0	50	1	4.7	47
Sub-total				79			82			140			130
Environmental - Impact on Rivers & Streams													
Number of River Crossings	6	2	3.4	20	2	3.4	20	0	5.0	30	6	2.8	17
Number of Stream Crossings	4	33	2.4	10	33	2.5	10	20	3.0	12	96	1.5	6
Sub-total				30			30			42			23
Social & Economic - Travel Time to Service Center and Connectivity with Other Communities													
Distance to Happy-Valley Goose Bay (km)	7	600.0	4.9	34	600.9	4.8	34	589.4	5.0	35	672.2	3.9	27
Distance to Nearest Community (km)	3	165.1	4.2	13	166.0	4.1	12	150.0	5.0	15	242.3	**0.1**	0
Sub-total				47			46			50			27
Total Points out of a Maximum of 500				300			301			413			49
Ranking				3			2			1			4

WF = Weighting Factor: Number out of 100 based on relative importance overall.

Ranking Criteria Categories / Units Measured	*Ranking Criteria Score Range*	
	Score = 5	*Score = 1*
Overall Construction Length (km)	*Shortest Option*	*50% Longer than Shortest Option*
Bridges > 150m - Total Crossing Length (m) per km	*0*	*9.277*
Bridges ≤ 150m - Total Crossing Length (m) per km	*0*	*5.496*
Number of Grade Violations per km	*0*	*0.397*
Number of Average Grade Violations per km	*0*	*0.093*
Number of Horizontal Curve Violations per km	*0*	*0.104*
Number of River Crossings per km	*0*	*0.076*
Number of Stream Crossings per km	*0*	*0.772*
Distance to Happy-Valley Goose Bay (km)	*Shortest Option*	*50% Longer than Shortest Option*
Distance to Nearest Community (km)	*Shortest Option*	*50% Longer than Shortest Option*

Notes:

G1 has substandard average grades; G2 requires a speed reduction due to substandard horizontal alignment; G2 and G3 require construction in unknown water depths. Due to its much longer route, G4 falls outside the ranking criteria range of plus 0 to 50% for "Overall Construction Length" and "Distance to Nearest Community". The increased distances are approximately +180% and +62% respectively, for these criteria.

Table 4.7-Route G1 vs Route G2 – Ranking Table

4.4.8 Segment H – Rigolet Access Route

4.4.8.1 Route H1

Route H1 is 98 km in length and extends in an east/northeasterly direction to Rigolet from the proposed northern route. It is in a permafrost zone characterized as "Isolated patches with low ground ice content (<10%)".

Seven (7) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). However, the average slopes in those areas are within the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills.

A section of this route is within the Rigolet municipal planning area. Refer to Figure 4.15.

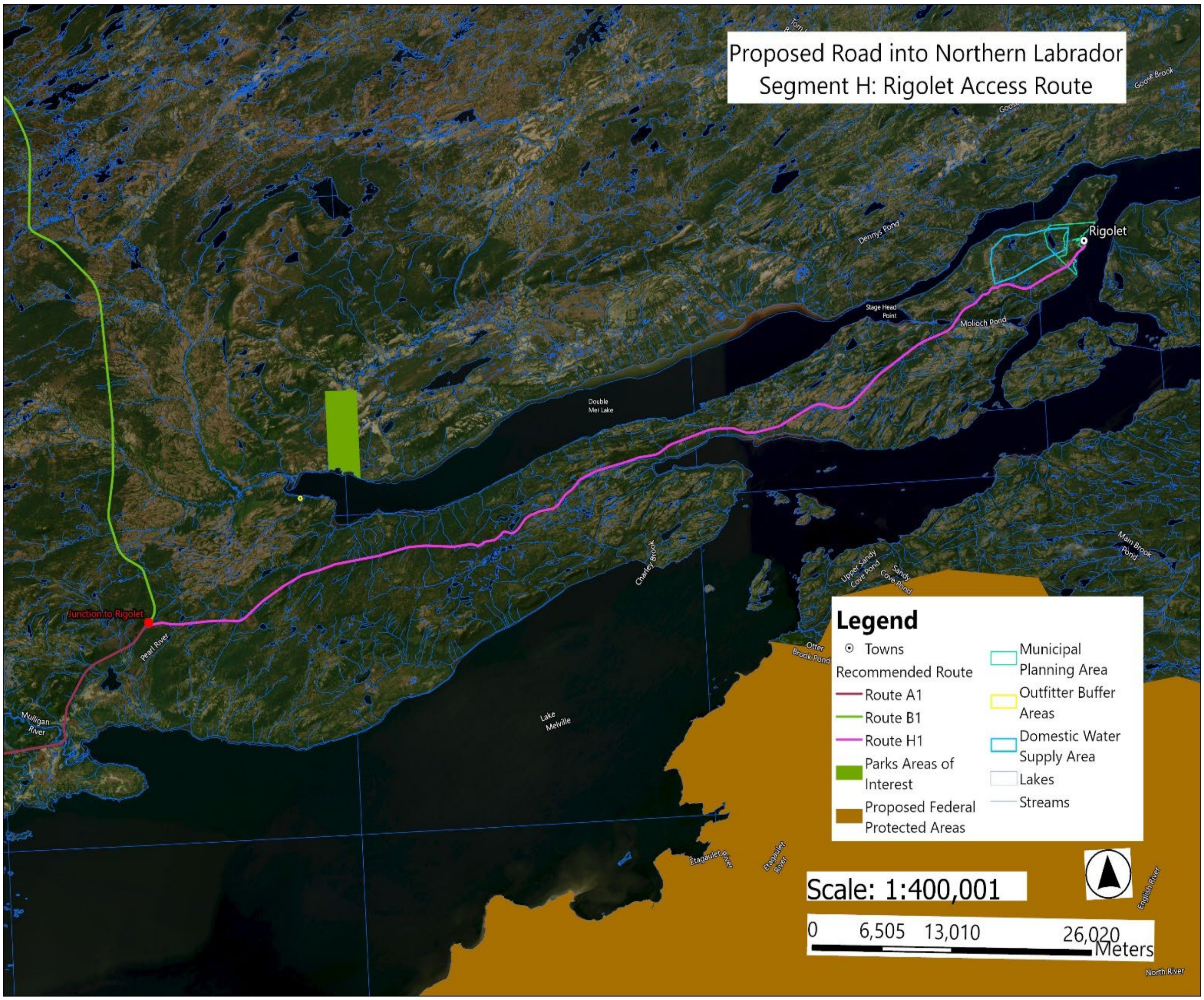

Figure 4.15-Route H1 – Rigolet Access Route

4.4.8.2 Route H2 – North Side of Double Mer Option

Route H2 extends for approximately 85 km around the north side of Double Mer, where the slopes are gentle and better for road construction, and then follows Route H1 towards Rigolet. However, to make the connection to Rigolet, a major bridge (~550 m span) is required near Stage Head Point. Immediately south of the channel crossing, a short radius (<250 m radius) horizontal curve is required to avoid a steep slope. This route also crosses a "parks area of interest" on the west end of Double Mer. Refer to Figure 4.16.

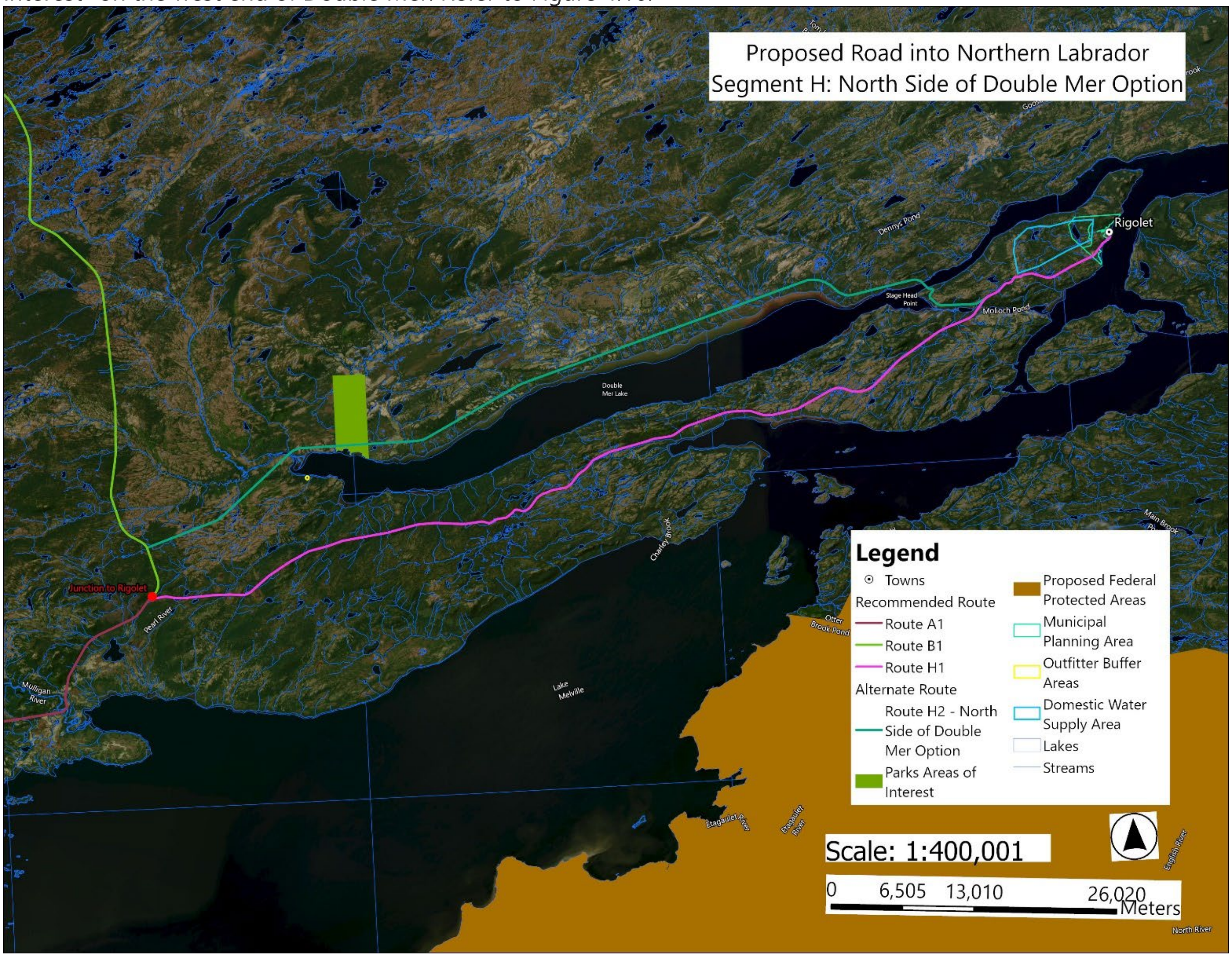

Figure 4.16-Route H2 – North Side of Double Mer Option

Route H1	Route H2
Advantages: • Shorter distance from Rigolet to the nearest community and Happy Valley-Goose Bay (-5.2km). • No river crossings required. • Horizontal alignment meets design criteria. Disadvantages: • More road profile design challenges.	Advantages: • Less road profile design challenges. Disadvantages: • Longer distance from Rigolet to the nearest community and Happy Valley-Goose Bay (+5.2km). • Three river crossings are required, including a long span structure at one location. • Horizontal alignment does not meet design criteria at one location.

Table 4.8-Route H1 vs Route H2 – Advantages / Disadvantages

Ranking Criteria Categories / Units Measured	WF	Route H1 - Rigolet Access Route			Route H2 - North Side of Double Mer Option		
		Unit	Score	Score x WF	Unit	Score	Score x WF
Cost - Capital Cost and Maintenance Cost							
Overall Construction Length (km)	25	97.9	5.0	125	98.3	5.0	125
Bridges > 150m - Total Crossing Length (m)	15	0.0	5.0	75	550	2.6	39
Bridges ≤ 150m - Total Crossing Length (m)	10	0	5.0	50	0	5.0	50
Sub-total				250			214
Technical - Compliance with Horizontal and Vertical Alignment Design Criteria							
Number of Grade Violations	5	7	4.3	22	5	4.5	23
Number of Average Grade Violations	15	0	5.0	75	0	5.0	75
Number of Horizontal Curve Violations	10	0	5.0	50	1	4.6	46
Sub-total				147			144
Environmental - Impact on Rivers and Streams							
Number of River Crossings	6	0	5.0	30	3	3.4	20
Number of Stream Crossings	4	55	2.1	8	58	1.9	8
Sub-total				38			35
Socio-economic - Travel Time to Service Center and Connectivity with Other Communities							
Distance to Happy-Valley Goose Bay (km)	7	200.1	5.0	35	205.3	4.8	34
Distance to Nearest Community (km)	3	159.1	5.0	15	164.3	4.7	14
Sub-total				50			48
Total Points out of a Maximum of 500				485			434
Ranking				1			2

WF = Weighting Factor: Number out of 100 based on relative importance overall.

Ranking Criteria Categories / Units Measured	*Ranking Criteria Score Range*	
	Score = 5	*Score = 1*
Overall Construction Length (km)	*Shortest Option*	*50% Longer than Shortest Option*
Bridges > 150m - Total Crossing Length (m) per km	*0*	*9.277*
Bridges ≤ 150m - Total Crossing Length (m) per km	*0*	*5.496*
Number of Grade Violations per km	*0*	*0.397*
Number of Average Grade Violations per km	*0*	*0.093*
Number of Horizontal Curve Violations per km	*0*	*0.104*
Number of River Crossings per km	*0*	*0.076*
Number of Stream Crossings per km	*0*	*0.772*
Distance to Happy-Valley Goose Bay (km)	*Shortest Option*	*50% Longer than Shortest Option*
Distance to Nearest Community (km)	*Shortest Option*	*50% Longer than Shortest Option*

Table 4.9-Route H1 vs Route H2 – Ranking Table

4.4.9 Segment I – Makkovik Access Route

4.4.9.1 Route I1

Route I1 is approximately 72 km in length and extends in a northeasterly direction to Makkovik from the proposed northern route. It crosses two permafrost zones characterized as "Isolated patches with low ground ice content (<10%)" and "Sporadic discontinuous permafrost with low ground ice content to nil ice content (<10% to 0%)".

Five (5) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤ 10%). However, the average slopes in those areas are within the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills. A section of this route is within the Makkovik municipal planning area and Ranger Bight Pond domestic water supply drainage area. It also crosses the Aurora Energy proposed road reservation and Aurora Energy mineral staked claims. Refer to Figure 4.17.

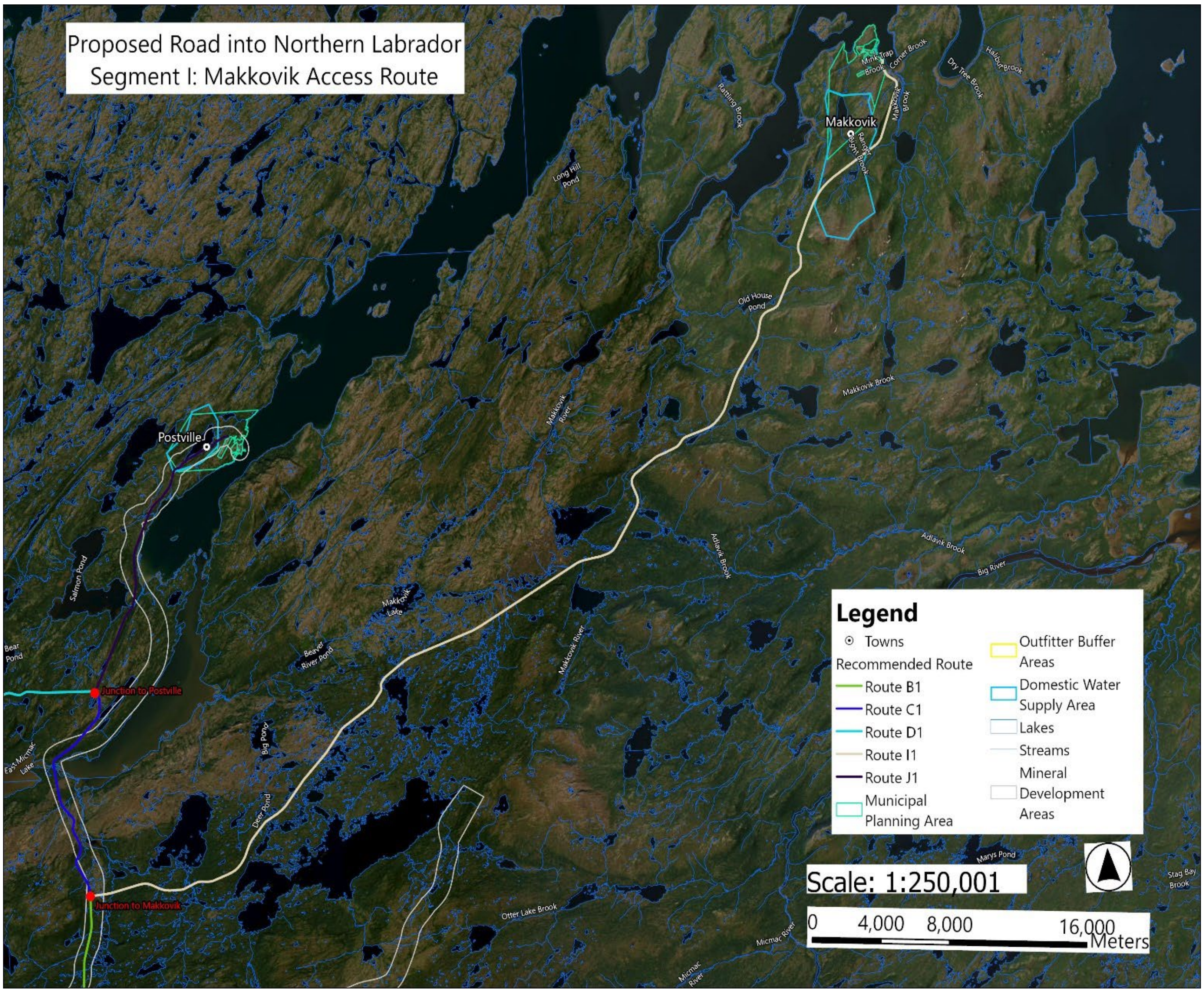

Figure 4.17-Segment I1 – Makkovik Access Route

4.4.9.2 Route I2 – Makkovik Southern Route Option

Route I2 is 106 km in length beginning approximately 17 km south of Ghost Lake and extending in a northeasterly direction to Makkovik. There are slightly fewer slopes on this route that present design challenges. However, this option will require more road construction overall (+36 km) and one (1) additional river crossing. This option does not cross Makkovik's water supply drainage area, the Aurora Energy proposed road reservation or the Aurora Energy mineral staked claims. However, it does cross two other mineral staked claims. Refer to Figure 4.18.

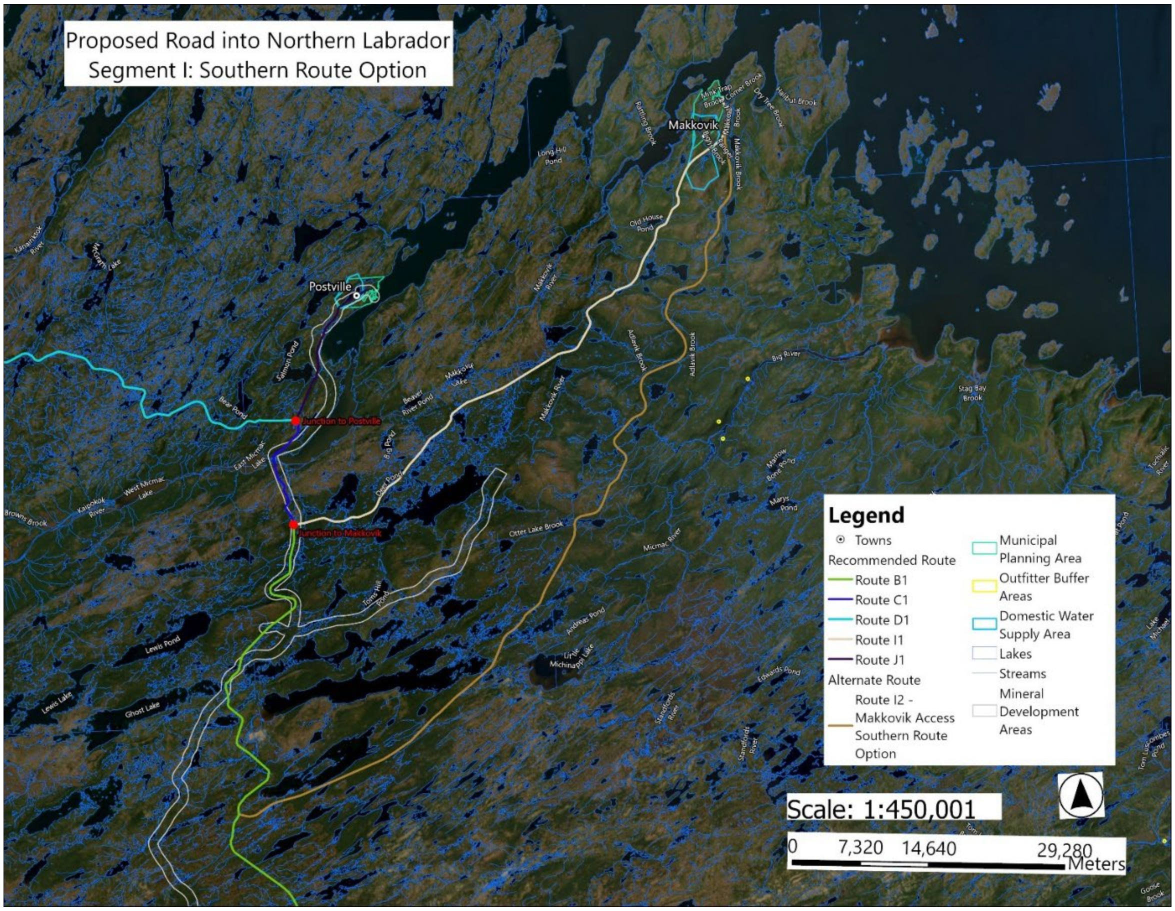

Figure 4.18-Route I2 – Makkovik Southern Route Option

Route I1	Route I2
Advantages: • Shorter distance construction distance overall (-35.7 km). • Shorter distance from Makkovik to the nearest community (Postville) (-76.9 km). • Less river crossings (only one required). Disadvantages: • Longer distance from Makkovik to Happy Valley-Gosse Bay (+5.5 km). • More road profile design challenges. • Crosses more mineral staked claim areas. • Crosses Makkovik's domestic water supply catchment area.	Advantages: • Shorter distance from Makkovik to Happy Valley-Gosse Bay (-5.5 km). • Less road profile design challenges. • Crosses less mineral staked claim areas. • Does not cross Makkovik's domestic water supply catchment area. Disadvantages: • Longer distance construction distance overall (+35.7 km). • Longer distance from Makkovik to the nearest community (Postville) (+76.9 km). • More river crossings (two required).

Table 4.10-Route I1 vs Route I2 – Advantages / Disadvantages

Ranking Criteria Categories / Units Measured	WF	Route I1 - Makkovik Access Route Unit	Route I1 Score	Route I1 Score x WF	Route I2 - Makkovik Access Southern Route Option Unit	Route I2 Score	Route I2 Score x WF
Cost - Capital Cost and Maintenance Cost							
Overall Construction Length (km)	25	72.4	5.0	125	106.2	1.3	33
Bridges > 150m - Total Crossing Length (m)	15	0.0	5.0	75	0	5.0	75
Bridges ≤ 150m - Total Crossing Length (m)	10	28	4.7	47	104	4.3	43
Sub-total				247			151
Technical - Compliance with Horizontal and Vertical Alignment Design Criteria							
Number of Grade Violations	5	5	4.3	22	2	4.8	24
Number of Average Grade Violations	15	0	5.0	75	0	5.0	75
Number of Horizontal Curve Violations	10	2	3.9	39	2	4.3	43
Sub-total				136			142
Environmental - Impact on Rivers and Streams							
Number of River Crossings	6	1	4.3	26	2	4.0	24
Number of Stream Crossings	4	32	2.7	11	37	3.2	13
Sub-total				37			37
Socio-economic - Travel Time to Service Center and Connectivity with Other Communities							
Distance to Happy-Valley Goose Bay (km)	7	278.1	4.8	34	272.6	5.0	35
Distance to Nearest Community (km)	3	102.6	5.0	15	179.5	**-1.0**	-3
Sub-total				49			32
Total Points out of a Maximum of 500				469			362
Ranking				1			2

WF = Weighting Factor: Number out of 100 based on relative importance overall.

Ranking Criteria Categories / Units Measured	*Ranking Criteria Score Range: Score = 5*	*Score = 1*
Overall Construction Length (km)	*Shortest Option*	*50% Longer than Shortest Option*
Bridges > 150m - Total Crossing Length (m) per km	*0*	*9.277*
Bridges ≤ 150m - Total Crossing Length (m) per km	*0*	*5.496*
Number of Grade Violations per km	*0*	*0.397*
Number of Average Grade Violations per km	*0*	*0.093*
Number of Horizontal Curve Violations per km	*0*	*0.104*
Number of River Crossings per km	*0*	*0.076*
Number of Stream Crossings per km	*0*	*0.772*
Distance to Happy-Valley Goose Bay (km)	*Shortest Option*	*50% Longer than Shortest Option*
Distance to Nearest Community (km)	*Shortest Option*	*50% Longer than Shortest Option*

Note:

I2 falls outside the ranking criteria range of plus 0 to 50% for "Distance to Nearest Community" due to the much longer distance. The increased distance is approximaley +75%.

Table 4.11-Route I1 vs Route I2 – Ranking Table

4.4.10 Segment J – Postville Access Route

4.4.10.1 Route J1

Route J1 is approximately 17 km in length and extends in a northeasterly direction to Postville from the proposed northern route. It is in a permafrost zone characterized as "Sporadic discontinuous permafrost with low ground ice content to nil ice content (<10% to 0%)". One (1) river crossing, and one (1) stream crossing were identified along this route. There were no road design challenges noted. A section of this route is within the Postville municipal planning area and Big Pond domestic water supply drainage area. It also crosses the Aurora Energy proposed road reservation. Refer to Figure 4.19.

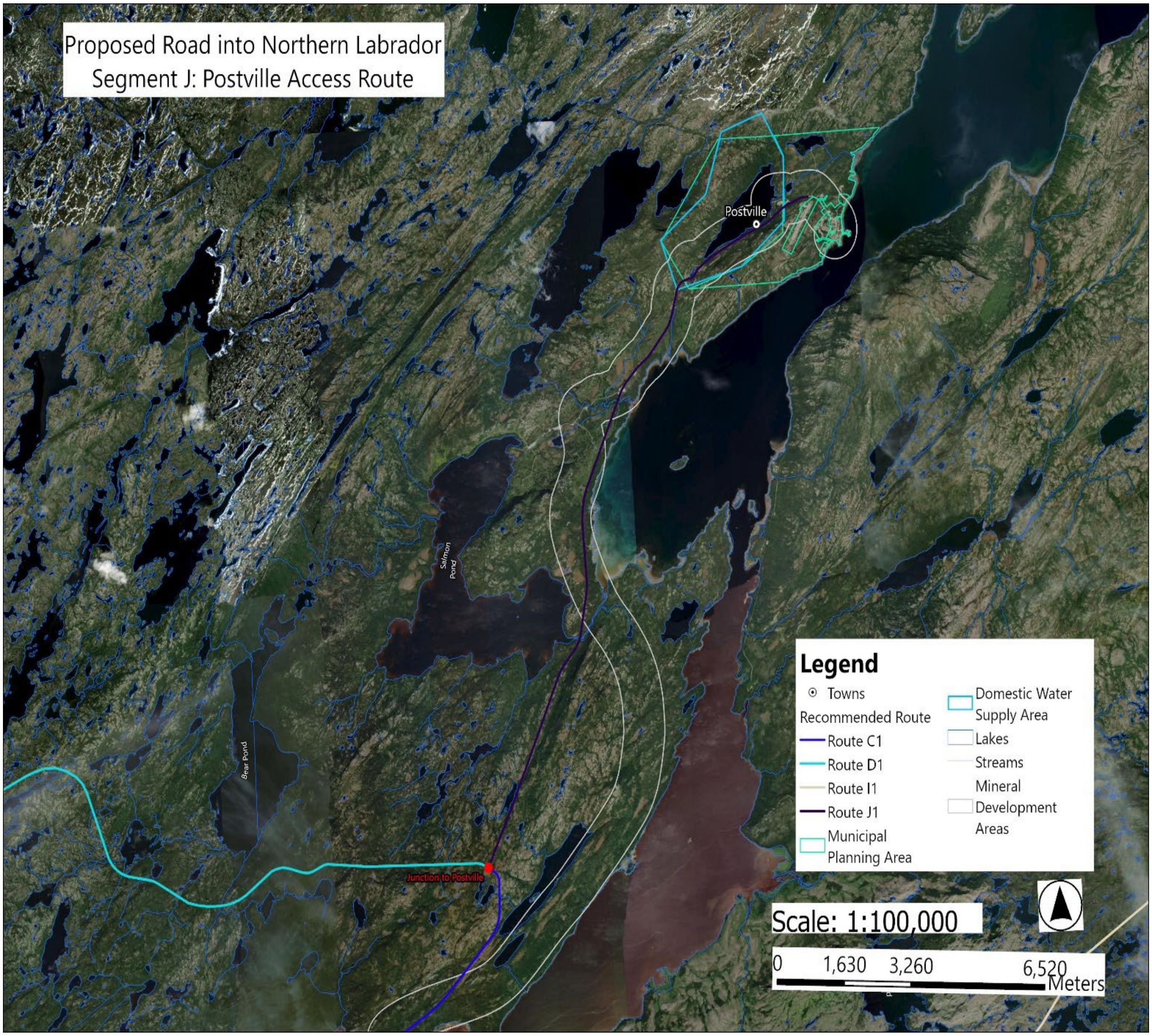

Figure 4.19-Route J1 – Postville Access Route

4.4.11 Segment K – Hopedale Access Route

4.4.11.1 Route K1

Route K1 is approximately 63 km in length and extends in a northeasterly direction to Hopedale from the proposed northern route. It crosses two permafrost zones characterized as "Sporadic discontinuous permafrost with low ground ice content (<10%)".

Eighteen (18) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤ 10%). However, the average slopes in seventeen (17) of those areas are within the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills. A section of this route is within the Hopedale municipal planning area. Refer to Figure 4.20.

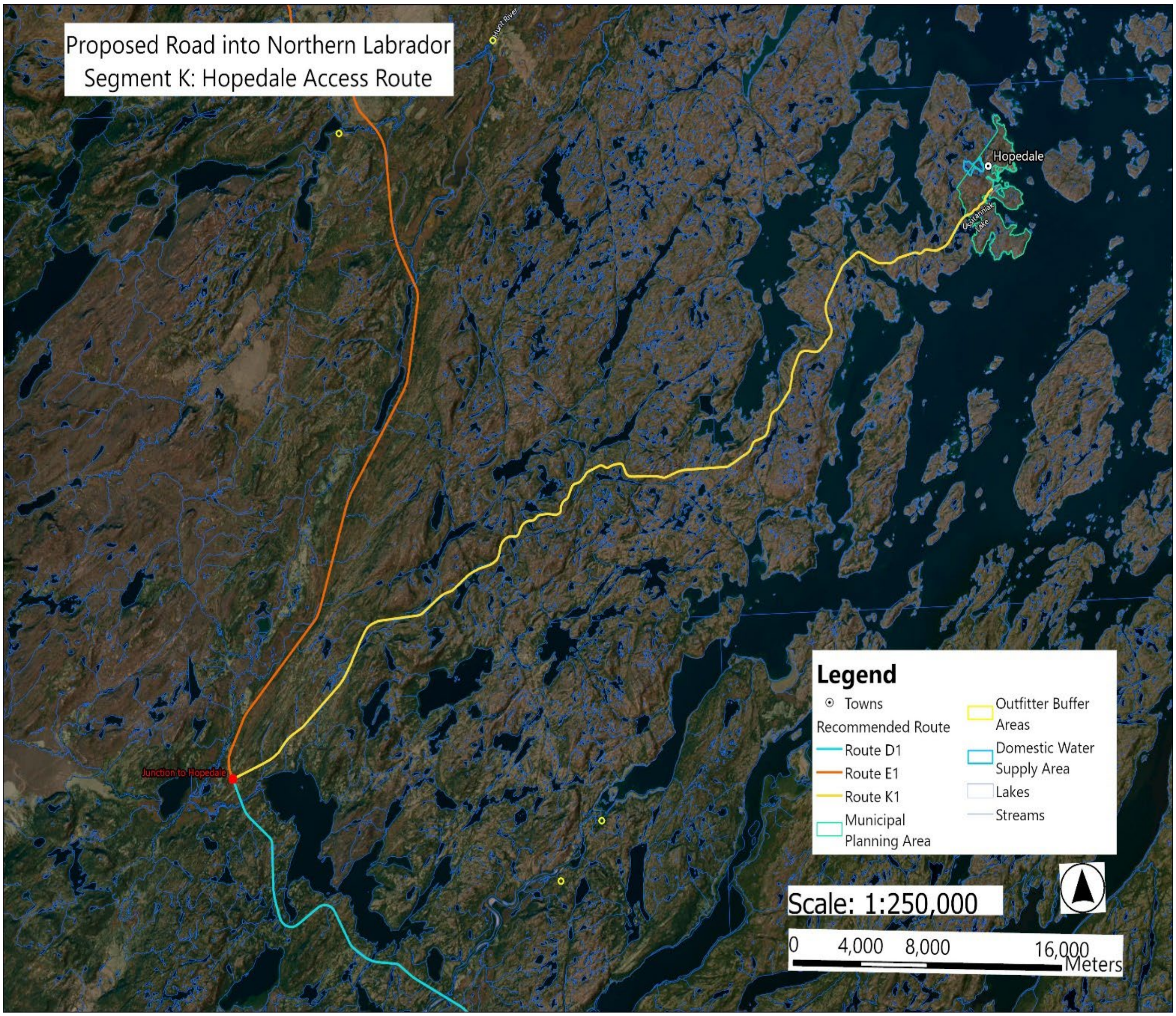

Figure 4.20-Route K1 – Hopedale Access Route

4.4.11.2 Route K2 – Hopedale Southern Route Option

Route K2 extends for 53km from at a point approximately 4km north of Udjuktok Bay and then continues in a northeasterly direction until it connects with Route K1 to Hopedale. This option has a shorter distance from Hopedale to Happy Valley-Goose Bay by approximately 20km but slightly longer overall road construction length. There are more slopes along this route that present design challenges and there is a river crossing. The route is also adjacent to two outfitter locations. Refer to Figure 4.21.

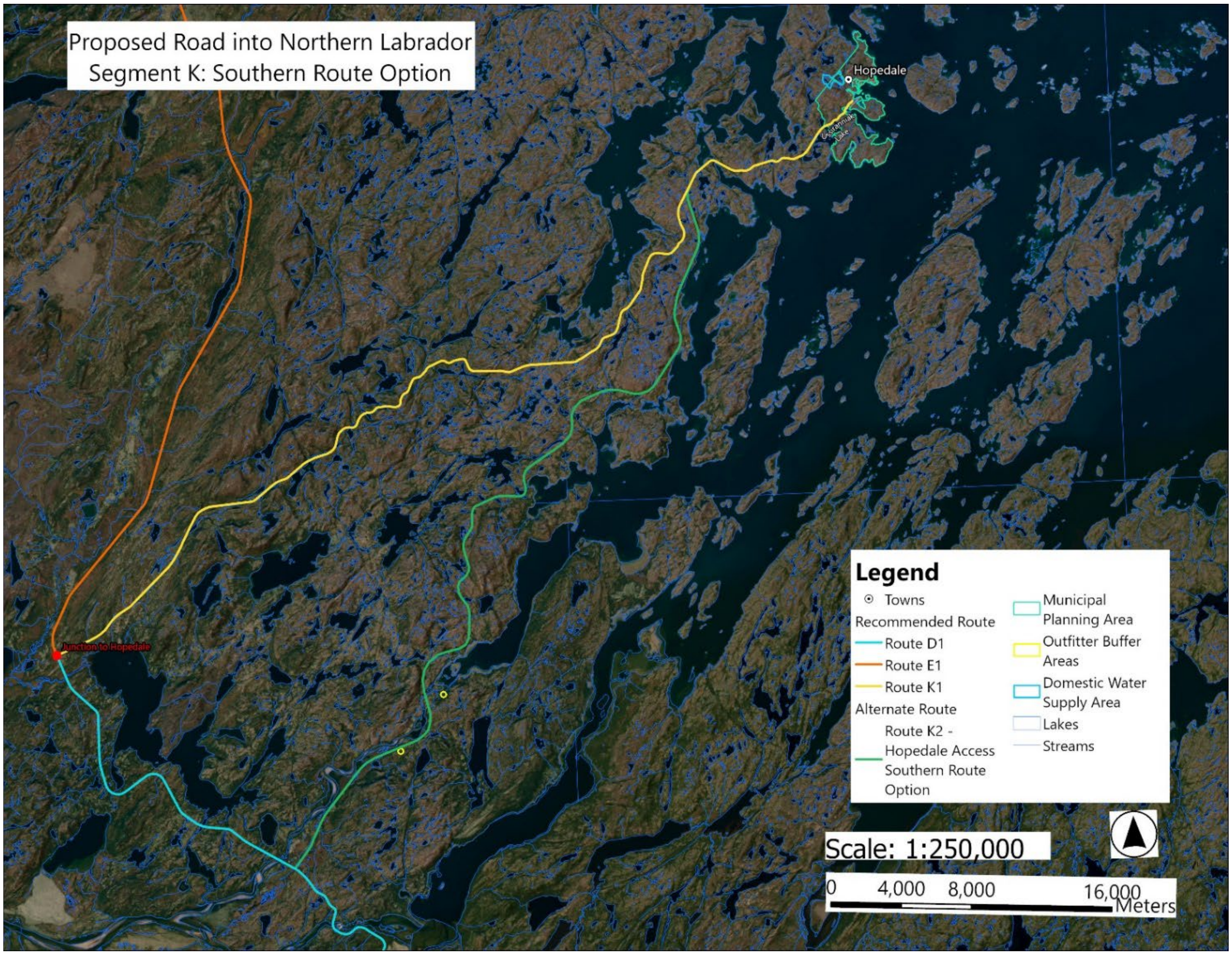

Figure 4.21-Route K2 – Hopedale Southern Route Option

Route K1	Route K2
Advantages: • Shorter construction distance overall (-1.8 km). • Shorter distance from Hopedale to the nearest community (Natuashish) (-23.4 km). • Less road profile design challenges. • No river crossings required. Disadvantages: • Longer distance from Hopedale to Happy Valley-Gosse Bay (+19.8 km).	Advantages: • Shorter distance from Hopedale to Happy Valley-Gosse Bay (-19.8 km). Disadvantages: • Longer construction distance overall (+1.8 km). • Longer distance from Hopedale to the nearest community (Natuashish) (+23.4 km). • More road profile design challenges. • River crossing required. • Adjacent to two outfitting buffer locations.

Table 4.12-Route K1 vs Route K2 – Advantages / Disadvantages

Ranking Criteria Categories / Units Measured	WF	Route K1 - Hopedale Access Route			Route K2 - Hopedale Access Southern Route Option		
		Unit	Score	Score x WF	Unit	Score	Score x WF
Cost - Capital Cost and Maintenance Cost							
Overall Construction Length (km)	25	62.8	5.0	125	64.6	4.8	120
Bridges > 150m - Total Crossing Length (m)	15	0.0	5.0	75	0	5.0	75
Bridges ≤ 150m - Total Crossing Length (m)	10	0	5.0	50	54	4.4	44
Sub-total				250			239
Technical - Compliance with Horizontal and Vertical Alignment Design Criteria							
Number of Grade Violations	5	18	2.0	10	25	1.0	5
Number of Average Grade Violations	15	1	4.3	65	6	1.0	15
Number of Horizontal Curve Violations	10	0	5.0	50	0	5.0	50
Sub-total				125			70
Environmental - Impact on Rivers and Streams							
Number of River Crossings	6	0	5.0	30	1	4.2	25
Number of Stream Crossings	4	23	3.1	12	30	2.6	10
Sub-total				42			35
Socio-economic - Travel Time to Service Center and Connectivity with Other Communities							
Distance to Happy-Valley Goose Bay (km)	7	384.1	4.6	32	364.3	5.0	35
Distance to Nearest Community (km)	3	176.4	5.0	15	199.8	3.9	12
Sub-total				47			47
Total Points out of a Maximum of 500				464			391
Ranking				1			2

WF = Weighting Factor: Number out of 100 based on relative importance overall.

Ranking Criteria Categories / Units Measured	*Ranking Criteria Score Range*	
	Score = 5	*Score = 1*
Overall Construction Length (km)	*Shortest Option*	*50% Longer than Shortest Option*
Bridges > 150m - Total Crossing Length (m) per km	*0*	*9.277*
Bridges ≤ 150m - Total Crossing Length (m) per km	*0*	*5.496*
Number of Grade Violations per km	*0*	*0.397*
Number of Average Grade Violations per km	*0*	*0.093*
Number of Horizontal Curve Violations per km	*0*	*0.104*
Number of River Crossings per km	*0*	*0.076*
Number of Stream Crossings per km	*0*	*0.772*
Distance to Happy-Valley Goose Bay (km)	*Shortest Option*	*50% Longer than Shortest Option*
Distance to Nearest Community (km)	*Shortest Option*	*50% Longer than Shortest Option*

Table 4.13-Route K1 vs Route K2 – Ranking Table

4.5 Route Selection Summary

Based on the analysis in the preceding sections, the recommended routes for a road into Northern Labrador are depicted in Figure 4.22. The total length of the recommended routes is approximately 809 km, approximately 5% greater than the initial straight-line routes that were developed early in the process without consideration for any technical criteria (e.g., maximum grades, minimum horizontal curve radii, preferred river crossings, etc.).

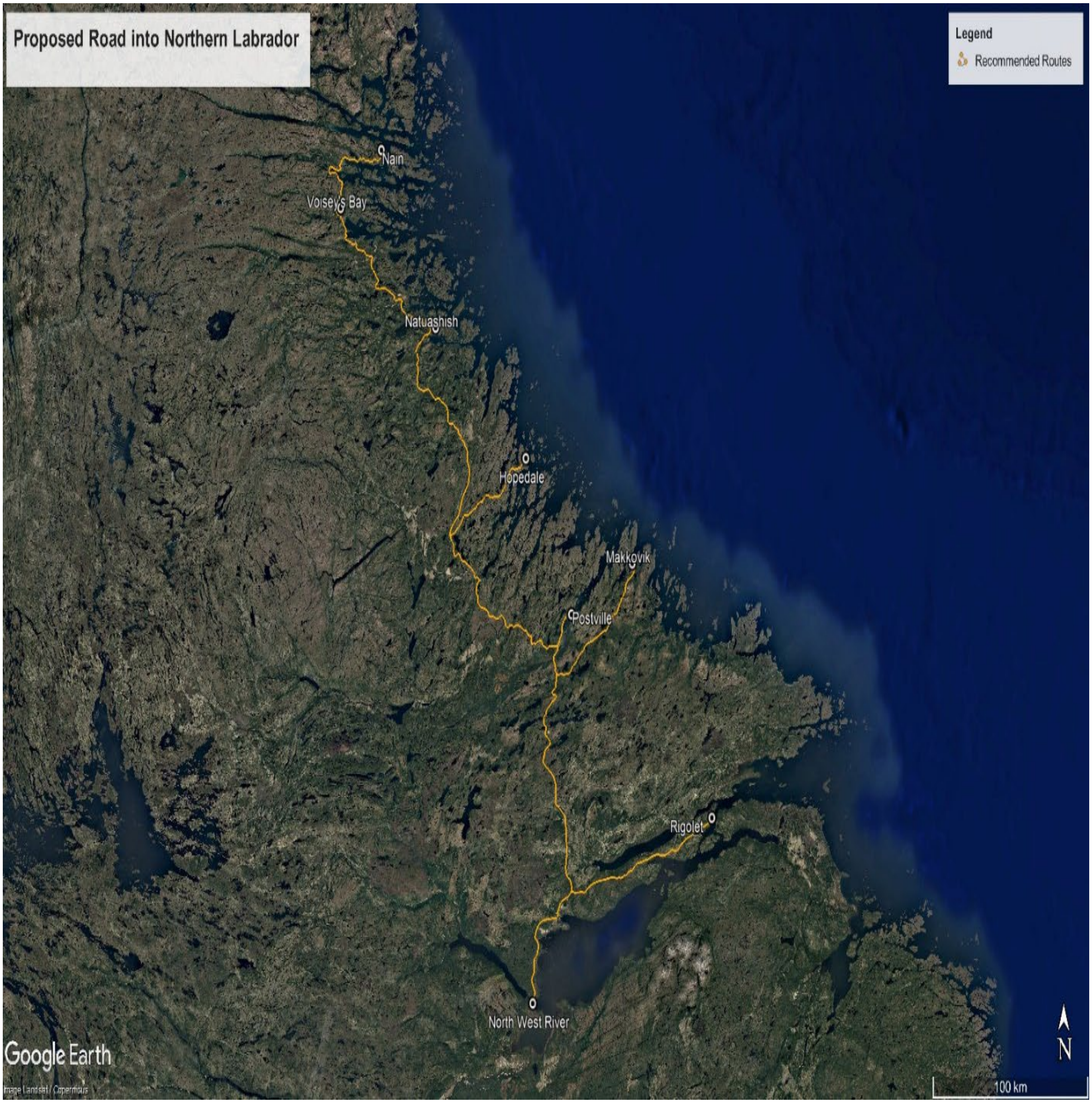

Figure 4.22-Recommended Routes

The recommended route segment lengths are listed in Table 4.14.

Segment	Description	Length (km)
A	North West River to Rigolet Junction	61.2
B	Rigolet Junction to Makkovik Junction	103.5
C	Makkovik Junction to Postville Junction	13.1
D	Postville Junction to Hopedale Junction	102.5
E	Hopedale Junction to Natuashish	113.6
F	Natuashish to Voisey's Bay	98.8
G	Voisey's Bay to Nain	66.3
H	Rigolet Access Route	97.9
I	Makkovik Access Route	72.4
J	Postville Access Route	17.1
K	Hopedale Access Route	62.8
	Total:	809.2

Table 4.14-Recommended Routes Segment Lengths

Route travel distances between communities (and Voisey's Bay Mine) based the recommended routes are listed in Table 4.15.

	North West River	Rigolet	Makkovik	Postville	Hopedale	Natuashish	Voisey's Bay	Nain
North West River		159.1	237.1	194.9	343.1	393.9	492.7	559.0
Rigolet	159.1		273.8	231.6	379.8	430.6	529.4	595.7
Makkovik	237.1	273.8		102.6	250.8	301.6	400.4	466.7
Postville	194.9	231.6	102.6		182.4	233.2	332.0	398.3
Hopedale	343.1	379.8	250.8	182.4		176.4	275.2	341.5
Natuashish	393.9	430.6	301.6	233.2	176.4		98.8	165.1
Voisey's Bay	492.7	529.4	400.4	332.0	275.2	98.8		66.3
Nain	559.0	595.7	466.7	398.3	341.5	165.1	66.3	

Table 4.15-Recommended Route Travel Distances

4.5.1 Design Challenges

Throughout the analysis, challenges were identified along various routes with respect to topography and land use. The most noteworthy challenges are summarized below:

- A direct road connection to Happy-Valley Goose Bay will require construction of a road on the northwest side of Grand Lake.
- A route through North West River will require utilization of existing municipal roads and will require consultations with the Town regarding: a) increased traffic, b) road upgrades that may be necessary, and, c) level of service for future road maintenance.
- A bypass around North West River will require construction of a major bridge across the channel between Grand Lake and Little Lake. Also, land on the north side of the bridge is identified in the Provincial Land Use Atlas (LUA) as "Parks: Grand Lake Land Transfer 1985" with no development permitted or approved in the defined area.

- On the segment from Postville Junction to Hopedale Junction, several areas with steep slopes will make it more challenging to achieve the design grade criteria (≤10%). Grade issues were identified at: a) approximately 4 km north of Postville Junction, b) approximately 5 km southeast of the Kanairiktok River, and c) at the west side of Udjuktok Bay.
- An alternate route around the south side of Micmac Lake will require approximately 4 km of additional road construction and approximately 180m of additional bridge construction.
- On the segment from Hopedale Junction to Natuashish at approximately 15 km and 18 km south of Natuashish, steep slopes will make it more challenging to achieve the design grade criteria (≤10%). However, the average grades through those areas meet the design criteria.
- On the segment from Natuashish towards Voisey's Bay, twelve (12) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). One of those areas is an 11 km section starting approximately 8 km north of the Notakwanon River crossing. Another noteworthy area is approximately 6 km in length located approximately 6 km north of Kogaluk River. The average grades through those areas meet the design criteria but a more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills.
- The segment from Voisey's Bay Mine to Nain has the most significant design challenges. Eighteen (18) areas were noted where steep slopes will make it more challenging to achieve the design grade criteria (≤ 10%). Most of the more severe grades are within a 13 km section west of the Voisey's Bay Mine marine port and is by far the most challenging section of the overall route. **Six (6) sections within this area have average slopes that exceed the maximum grade criteria (≤10%).** Average grades range from 12% to 17% and could require significant cut/fills to overcome. Alternate routes have been considered to avoid some or all the steep slopes, but they also have design challenges. Other steep slopes were identified in a 7 km section entering Nain but the average grades through that area meet the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills.
- An alternate route that follows the shoreline west of the Voisey's Bay Mine marine port bypasses several steep grades. However, it will require eight (8) horizontal curves that do not meet the design criteria (≥250 m). Some of these may be as low 100m radius which would require a speed reduction to 50km/hr or less in that area. Also, some of the alignment will require construction in coastal waters and may require storm surge protection. The depth of the water and the extent of storm surge protection required would need to be investigated further to determine if this is a viable alternative.
- An alternate route that extends across Anaktalik Bay near the Voisey's Bay Mine marine port will require construction of two (2) causeways at lengths of approximately 850 m and 1800 m. This route effectively bypasses the most challenging slopes but has other significant design challenges with respect to construction of the causeways in possibly deep water where storm surge protection will be required. The depth of the water and the extent of storm surge protection required would need to be investigated further to determine if this is a viable alternative. This option will also be subject to review under the Navigable Waters Act which could influence the size of a bridge structure within one, or both, causeways.
- An alternate route that extends west from Voisey's Bay along the Ikadlivik Brook valley and then east/northeast along the Anaktalik Brook valley effectively bypasses the most challenging slopes. This option has fewer steep grades but with significantly more river and stream crossings. A route through these valleys may also be prone to significant snow accumulation and winter maintenance issues. The western section of this route is in a permafrost zone classified as "Extensive discontinuous permafrost with medium to low ground ice content (20% to <10%)" which may require greater mitigative measures.

- The recommended route into Rigolet has seven (7) areas identified where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). However, the average slopes in those areas are within the design criteria.
- An alternate route to Rigolet located on the north side of Double Mer, would require a major bridge (~550 m span) near Stage Head Point. Also, immediately south of the channel crossing, a short radius (<250 m radius) horizontal curve is required to avoid a steep slope.
- The recommended route into Makkovik has five (5) areas identified where steep slopes will make it more challenging to achieve the design grade criteria (≤ 10%). However, the average slopes in those areas are within the design criteria.
- An alternate route into Makkovik (southern route option) has two (2) areas identified where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). However, the average slopes in those areas are within the design criteria.
- The recommended route into Hopedale has eighteen (18) areas identified where steep slopes will make it more challenging to achieve the design grade criteria (≤10%). However, the average slopes in seventeen (17) of those areas are within the design criteria. A more detailed analysis will be required to determine if the grade challenges can be addressed effectively by designing an acceptable road profile with a combination of cuts and fills.
- An alternate route into Hopedale (southern route) has twenty-five (25) areas identified where steep slopes will make it more challenging to achieve the design grade criteria (≤10%), including six (6) where the average slope exceeds the design grade criteria (≤10%).
- Maintaining recommended buffers around water bodies along all routes will require careful consideration. Where possible, attempts were made to maintain 30m buffers from water bodies. However, this was not always possible and therefore mitigative measures and permits to encroach on these buffers may be required.
- Due to road alignment technical challenges, some rivers may have to be crossed where the banks are wider. For example, the proposed crossing locations at Reid Brook and Anaktalik Brook, between Voisey's Bay and Nain, are downstream of a narrow section of the river. In those instances, a causeway across part of the river may be an option to reduce the overall bridge length.

In addition to these items, other design challenges include:

- Presence of permafrost;
- Snow accumulation in road cuts;
- Exposed areas where drifting snow may reduce visibility;
- Proximity to hunting and fishing locations;
- Proximity to existing lodges and cabins;
- Proximity to archaeological sites;
- Proximity to mineral rights;
- Proximity to public water supply catchment areas;
- Proximity to private land.

4.6 Permafrost and Hydraulic Risk

4.6.1 Introduction

Meco was engaged by Allnorth as a sub-consultant to inform the report on technical aspects of the work related to drainage and hydrology and geotechnical design in a permafrost environment.

Meco, as part of a team lead by Allnorth undertook a scope of work that included two technical services related to collecting background information:

- Literature review of available information on geomorphology and permafrost risks for the proposed alignment;
- Catalogue available public domain data sources for developing a hydrological model for drainage along the proposed route.

4.6.2 Desktop Study

A literature review identified public domain references and guideline documents for the likely alignment. Reference sections of the references are summarized below. There was no site-specific information available, but the data provides a reasonable assessment of regional classification of physiography and meteorology.

4.6.2.1 Permafrost

CSA 4011-10 Technical Guide: Infrastructure in Permafrost: A Guideline for Climate Change Adaptation[10]

This guidance document, published by CSA, is intended to assist decision makers in planning, purchasing, developing or operating community infrastructure in permafrost regions. Of key concern is the effect of climate change on inducing changes in permafrost. It provides the reader with i) a better understanding of permafrost and climate change related issues, and a means for locating key information.

Geological Survey of Canada – Canada Permafrost, The National Atlas of Canada[11]

The Geological Survey of Canada published a map file that presents spatial distribution of permafrost, along with a volumetric percentage of excess ground ice in the top 5 meters.

Geological Survey of Canada - Ground Ice Map of Canada[12]

This Geological Survey of Canada published an update of national-scale mapping of ground ice conditions in Canada. It presents spatial distribution of permafrost originally published in 1995, along with a volumetric percentage of excess ground ice in the top 5 meters based on recent research (O'Neill, Wolfe, & Duchesne, 2019). The map further differentiates ground ice(permafrost) as “segregated”, “wedge”, or “relict” ice.

Significant Underestimation of Peatland Permafrost along the Labrador Sea Coastline in Northern Canada[13]

This paper published in “The Cryosphere, 17, 63-78” describes a multi-stage, consensus-based point-inventory of peatland permafrost complexes in coastal Labrador. The authors argue that the presence of peatland permafrost extends further south and is more prolific than previously published.

4.6.2.2 Geological

Geological Survey of Canada – Surficial Geology of Canada[14]

This map file, published by the Geological Survey of Canada, is a 1:5,000,000 scale digital map of surficial materials and associated landforms across Canada. It is an update to the most recent surficial geology map, Map 1880A (1995), with additional information such as inclusion of soil types below modern sea level.

Geological Survey of Canada – Bedrock Geological Map of Canada[15]

This map file, published by the Geological Survey of Canada, is a 1:5,000,000 scale digital map of bedrock across Canada.

Geoscience Atlas – Newfoundland and Labrador[16]

This interactive map was originally released in 2013 and has since been updated. The Geoscience Atlas is a web-accessible interface to a Geographic Information System that provides NL geoscience datasets including geology maps, mineral occurrences, map staked claims information, geochemistry data, and geophysical images and links to reports. There is also an online ArcGIS interface which presents the same information. Both are maintained by the Terrain Sciences and Geoscience Data Management Section of the Geological Survey of Newfoundland and Labrador (GSNL). It has a bedrock geology layer which is at 1:1,000,000, and bedrock geology tiles which are a 1:50,000 resolution and cover the extent of the proposed highway alignment. 1:50,000 surficial geology is only partially mapped along the alignment. The best resolution surficial geology where 1:50,000 is unavailable is 1:5,000,000 provided by CGS.

4.6.3 Hydrologic

Water Survey of Canada (WSC) HYDAT Database

The Water Survey of Canada (WSC) manages a series of hydrometric stations in Labrador that monitor stream and river flows. The WSC publish a HYDAT dataset that includes daily and monthly mean flow and water level, peak flows, and sediment concentrations. The HYDAT database can be explored and filtered graphically using the Environment Canada Data Explorer (ECDE), which is publicly available for download from the National Water Data Archive: https://collaboration.cmc.ec.gc.ca/cmc/hydrometrics/www/. The data in the ECDE can be viewed within the application or exported as .csv.

Environment and Climate Change Canada (ECCC) Climatologic Data

Historical climate data is maintained by the Canadian Centre for Climate Services. They provide a climate data extraction tool where the station is selected via a map interface located at https://climate-change.canada.ca/climate-data/#/hourly-climate-data.

There are seven (7) climate stations in Labrador dating back to 1953. All stations are currently active. The database is updated to present-day.

Historical data is also available for extraction from the Historical Climate Data Website located at https://climate.weather.gc.ca/historical_data/search_historic_data_e.html.

Regional Flood Frequency Analysis (RFFA) Report Update for Newfoundland and Labrador[17]

A Regional Flood Frequency Analysis (RFFA) is a method by which sets of equations for estimating return period flood flows in ungauged watersheds are developed to be used at ungauged sites in the area. This report provides a deterministic means to determine extreme floods for Labrador for a given drainage area. This report is publicly available on the Newfoundland and Labrador Government website. https://www.gov.nl.ca/ecc/waterres/reports/rffa/

Water Resources Management Division – Chapter 4: Environmental Guidelines for Bridges[18]

This guideline provides the recommendation that Freeways (Trans-Canada Highway) and Urban Arterials be designed to pass a flood with an annual exceedance probability of 1 in 100 years. It also provides recommendations on the appropriateness of installing bridges and culverts. Chapter 5: Environmental Guidelines for Culverts provides more guidance on culvert installation. https://www.gov.nl.ca/ecc/files/waterres-regulations-appforms-chapter4.pdf

Automatic Data Retrieval System (ADRS)[19]

The NL Government provides an interactive map of active real-time data hydrometric stations in Newfoundland and Labrador. The map shows thirty-five (35) live real-time stations in Labrador where the hydrometric data is updated every two hours. Links are provided to view hydrographs via NL Government site, and via environment Canada website. Links to live cameras are available for some stations.

The map can be accessed here: https://www.mae.gov.nl.ca/wrmd/ADRS/v6/Graphs_List.asp.

Newfoundland and Labrador Climate Data and Climate Change Projections

Environment and Climate Change Newfoundland provides Intensity Frequency Duration (IFD) Curves for Newfoundland and Labrador up to 100-year return period. The available data is for the present-day climate, as well as for the future predicted climate, which is expected to produce larger amounts of rainfall during the same return periods.

This information can be found at https://www.gov.nl.ca/ecc/occ/climate-data/

4.6.4 Permafrost Environment

A desktop study of prevalence of permafrost at the preferred and alternate alignment was completed using public domain geological information on bedrock and surficial geology for the area provided by the Geological Survey of Canada and the Government of Newfoundland and Labrador, as well as other relevant publications.

4.6.4.1 Permafrost Distribution

The preferred and alternate alignments of a road into Northern Labrador traverses a region of discontinuous permafrost, which can be understood as permafrost existing together with layers of frozen ground[20].

The Geological Survey of Canada published the Permafrost Map of Canada[11], which identified the Labrador region as an area of potential permafrost. Recently, the ground ice abundance mapping was updated[12] with further details. Permafrost is defined as soil or rock where the ground temperature remains below 0°C for a minimum of two (2) consecutive winters and the intervening summer.

Potential for permafrost around the preferred and alternate alignments is presented in Drawing 003 in Appendix F and in Figure 4.23. The mapping available identified the extent of permafrost near the preferred and alternate alignments as varying from "Isolated Patches" in the southern alignment to "Sporadic Discontinuous" in northern areas. Permafrost is reported as a % area coverage, as well as by % volume ground ice abundance (% excess ice volume in soil matrix). Isolated patches are defined as 0-10% of the land area underlain by permafrost compared with 10-50% for Sporadic Discontinuous Permafrost. At the northern reaches of the alignment, the percent land mass is approaching the 50% limit as it borders the "Extensive Discontinuous" Permafrost zone. The presence of ground ice in permafrost varies from non-existent (0%) to predominantly less than 10%, with a small area to the northern region containing 10% to 20% ground ice content in permafrost areas. Intuitively, the likelihood of encountering permafrost increases in northern areas.

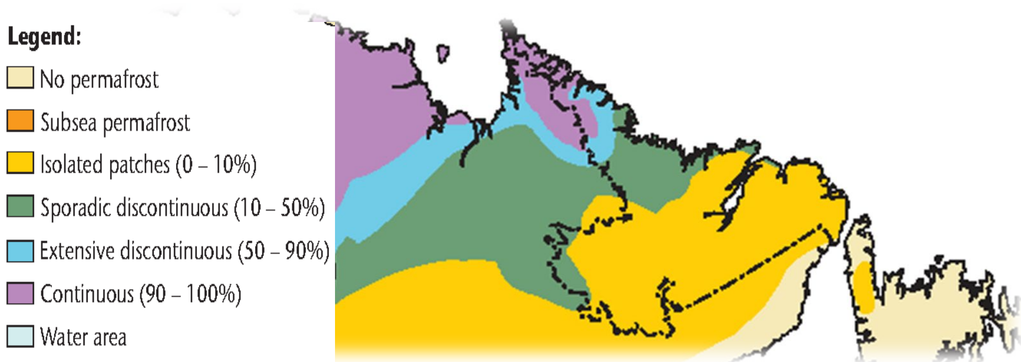

Figure 4.23-Permafrost Distribution in Canada (CSA 4011)

Recent research survey along the coast of Labrador used remote aerial techniques to identify wetland complexes which potentially contain permafrost[13]. The study indicated over 50% of wetlands of interest (WOIs), or 1,119 out of 2,092 sites, as likely containing peatland permafrost landforms, with an additional 187 wetland complexes classified as possibly containing peatland permafrost landforms. The study concluded current estimates of the distribution of permafrost in Labrador us significantly underestimated. Peatland permafrost complexes were primarily found in lowlands within 22 kilometers of coastal waters with the largest clusters of complexes occurring approximately 110 km south of the previously mapped limit of sporadic discontinuous permafrost.

The distribution of permafrost and ground ice within the soil matrix will vary based on vegetation cover, drainage, topography and microclimate variations. Ground ice is further influenced by soil texture with tills and other fine-grained soils generally containing more ground ice than coarse grained gravels and sands. In discontinuous permafrost regions, areas favorable for permafrost are usually covered by peat, a thick vegetative mattress or shaded by terrain that insulates the frozen ground from air temperatures above freezing. The distribution of soil type at the alignment is presented visually in Drawing 004 in Appendix F. Table 4.16 lists a description of the different soil layers intersected by the proposed alignment.

Soil Type	Description
GFc – Glaciofluvial sediments: ice-contact	Sand and gravel and locally diamicton; variable thickness; complex of ice-contact stratified drift, and outwash; locally includes till and bedrock.
GFp – Glaciofluvial Sediments: outwash plain	Sand and gravel; variable thickness; deposited as outwash sheets, valley trains, and terraced sediments.
GMn – Glaciomarine sediments: littoral and nearshore	Sand and gravel; variable thickness; deposited as sheet sands, deltas, and extensive flights of beaches in marine and glaciomarine environments.
Gmo – Glaciomarine sediments: offshore	Dominantly silt and clay, locally containing stones; variable thickness; deposited in quiet water marine and glaciomarine environments.
GMv – Glaciomarine sediments: veneer	Sand, gravel, and pockets of finer sediment; thin to discontinuous sediment veneer and residual lag developed during marine submergence; includes areas of washed till and bedrock.
R – Bedrock: Undifferentiated	Bedrock; area of abundant (greater than 75%) rock outcrop; alpine and non-alpine settings; may include colluvial deposits, till, and other minor surficial sediments.
Tb – Glacial Sediments: blanket	Diamicton; thick and continuous; may include fluted landforms, drumlins and morainal deposits.
Tm – Glacial Sediments: moraine complex	Diamicton; variable thickness; end and interlobate moraines; may include glaciofluvial sediments.
Tv – Glacial Sediments: veneer	Diamicton; thin and discontinuous; may include extensive areas of rock outcrop.

Table 4.16-Surficial Geology Types Along the Alignment

4.6.5 Climate Risk Assessment

Infrastructure may be sensitive to the impacts of climate change on permafrost. At specific sites where permafrost is identified in the soil or rock, screening assessments can be performed in accordance with procedures contained in Canadian Standards Association CSA 4011, "Infrastructure in Permafrost: A Guideline for Climate Change[10]". CSA 4011 provides a decision-making framework for infrastructure planning and a method for incorporating climate change into the decision, illustrated in Figure 4.24. The screening process is a 2-stage process that provides a rational basis for determining the scope of the site investigation(s) and subsequent design services required for effective adaptation of infrastructure to climatic uncertainty and warming.

4.6.5.1 Stage 1 Risk Assessment

Stage 1 uses a risk-informed framework to evaluate an infrastructure project in a permafrost environment. The goal of Stage 1 is to assess for both climate warming-induced sensitivity of the permafrost environment ("material sensitivity") and the eventual consequence of any permafrost-induced impact or failure. The nexus separating Stage 1 and Stage 2 assessment is the level of climate and permafrost risk and whether the level of risk is:

- Acceptable to proceed to design;
- Acceptable with further detailed thermal and other assessments to proceed to design, or;
- Reject the preliminary engineering and repeat the Stage 1 assessment for a different concept.

There are five (5) steps in a Stage 1 assessment beginning with "Site Characterization". The proposed northern highway alignment traverses inland of the coast through vast swaths of peatland juxtaposed with near surface bedrock and thin veneers of mineral glacial till soil. Drainage is likely poor where local relief is small, with the rivers through geologically controlled linear landscape features controlling runoff from the area. Secondary roads to communities will align with the geologically controlled linear landscape from the highway to the coast.

The second step is to establish "Functional Criteria". The proposed northern highway is a gravel top two-lane highway likely constructed of borrow from local quarries forming an embankment with drainage by culverts, multiplate arches, single and multi-span bridges. The road embankment is a linear structure and can tolerate moderate settlement but may be susceptible to differential settlement. Likewise, drainage features can likely tolerate moderate total settlement but may be susceptible to differential settlement.

The third step expands on the site characterization to assess Permafrost Sensitivity, i.e., sensitivity of the permafrost to the infrastructure considering the structure at the "end" of the design life. Permafrost can be predicted based on mean annual ground temperature (MAGT). The desktop study did not identify any public or private monitoring station in the region that reports MAGT while mean annual air temperature (MAAT) is monitored and reported by Environment Canada. Empirical studies suggest a generalized relationship between MAAT and MAGT is that MAGT is 4.5° C less than MAAT.

Permafrost sensitivity is evaluated as either Low, Medium or High as a function of the origin and composition of the ground material, soil or rock, and the estimated MAGT. Sensitivity may vary with depth through the zone of influence of the infrastructure. For the study area permafrost sensitivity considers two primary thermal regions, the "Active Zone" and the "Depth of Zero Amplitude". The Active zone is the area above permafrost that thaws and re-freezes annually while the depth of zero amplitude is the distance below the Active Zone where ground temperature is unaffected by surface radiation, which literature suggests is approximately 15 metres below ground surface. Increases in the MAAT directly related to climate change will increase the MAGT and result in loss of permafrost in the Active Zone, and eventually raise the ground temperature of the zone of zero amplitude above freezing temperature. The opinion of permafrost sensitivity in the region is medium sensitivity to climate change.

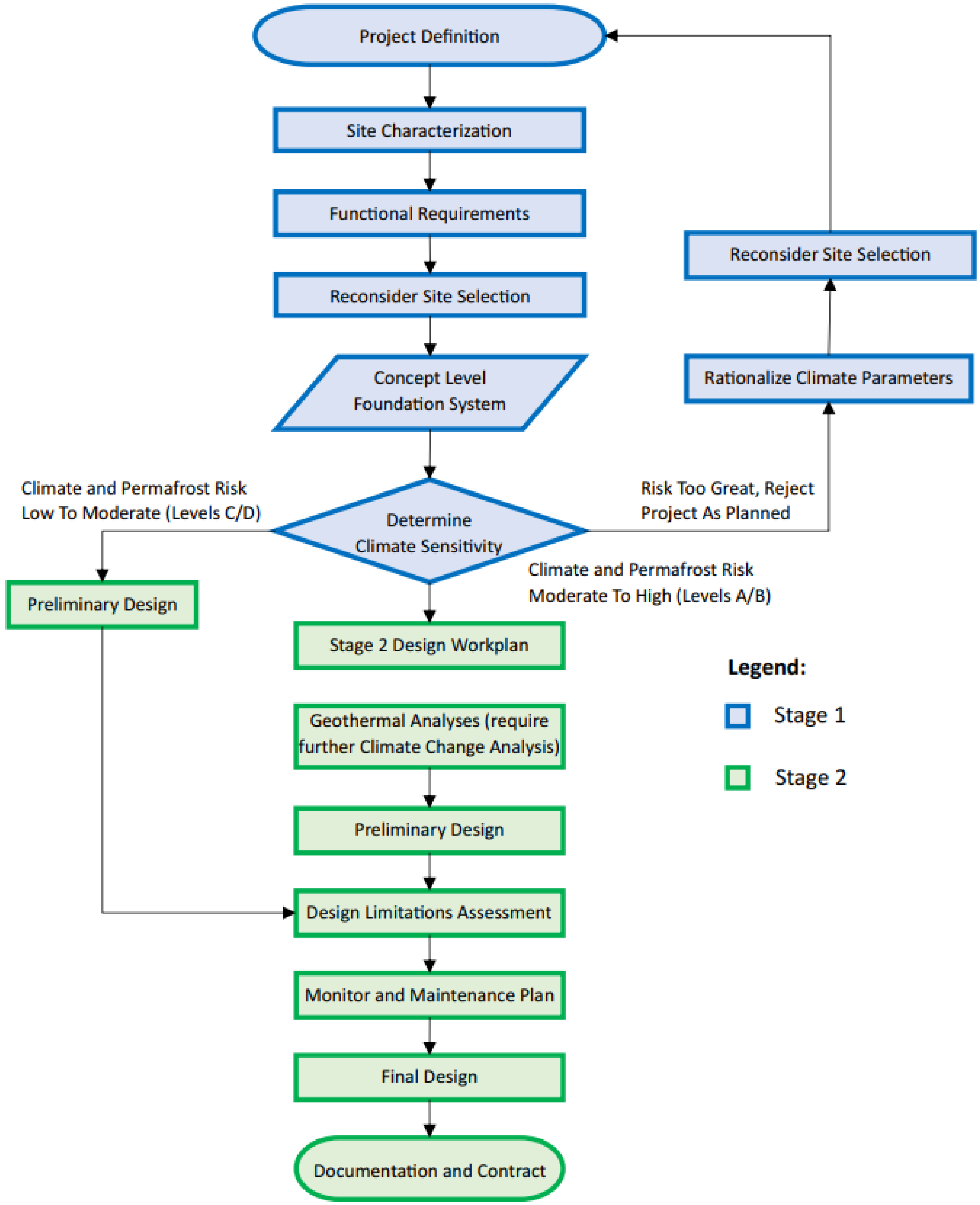

Figure 4.24-Climate Change Sensitivity Decision Framework (CSA 4011)

The fourth step is to evaluate preliminary engineering concepts for failure modes. Failure modes may be evaluated as qualitative, semi-quantitative or quantitative through the design life, but at the pre-feasibility level the Stage 1 assessment relies on a qualitative assessment of likely failure modes. For climate change screening, permafrost (or "material") sensitivity is evaluated by considering five (5) main factors:

1. Likelihood of thaw settlement from "Active Layer" deepening;
2. Generation of landslides and slope instability;
3. Deep foundation failure through lateral sliding;
4. Strength reduction and creep resistance due to warming of the frozen ground, and;
5. Potential for accentuated frost heaving.

The consequences of the event if the failure mode is realized is evaluated as either Negligible, Minor, Major or Catastrophic. The appropriate category is qualitative and subjective and objective criteria are required for evaluation. Potential consequences may include life safety, environment, economic, etc. Criteria are region specific and will be established by the Government of Newfoundland and Labrador, in consultation with the local communities. For the pre-feasibility assessment, the opinion on consequences is that they are likely to be Minor for much of the alignment, but potentially becoming Major at larger drainage infrastructure areas, or at areas of concentrated landforms containing permafrost.

The final step in the Stage 1 assessment is the "Climate Change Analysis". The result is a risk rating matrix of sensitivity against consequences expressed in a 3x4 matrix as shown in Table 4.17. The risk rating is used to determine the level of analysis recommended in Stage 2. Results of the qualitative evaluation are rated as A-Detailed quantitative analysis, B-Semi-quantitative analysis, C-Qualitative analysis, or D-No detailed analysis.

Sensitivity	**Consequences**			
	Negligible	**Minor**	**Major**	**Catastrophic**
High	C	B	A	A
Medium	D	**C**	**B**	A
Low	D	C	C	B

Table 4.17-Risk Rating Matrix

The Stage 1 climate risk assessment for the pre-feasibility level opinion on risk rating is the area of the preferred and alternate alignment has a "Medium" level of climate sensitivity with consequences of an infrastructure varying from "Minor to Major" for the preferred and alternates alignments, for a risk rating B and C. The assessment opinion is the climate risk is acceptable with further detailed geotechnical characterization and thermal assessments required as part of the feasibility design.

4.6.5.2 Stage 2 Risk Assessment

Stage 2 climate risk is the design implementation stage where climate change poses a significant risk. In Stage 2, the concept design should be upgraded to a preliminary design level with a defined alignment. The risk of permafrost for the alignment and drainage infrastructure should be evaluated with a grid-based level 1 geotechnical assessment of landforms to inform the design risk. And will generally include a thorough, quantitative, future-looking analysis of the ground thermal regime beneath the structures. Stage 2 at the feasibility level will include defining foundation systems appropriate for structures that are identified as in need of a Stage 2 design process and potential conceptual solutions that may be used for the development.

4.6.5.3 Geotechnical Characterization in a Permafrost Environment

Permafrost is not a material property, but the moisture in a soil matrix freezes and forms ground ice that does impact the mechanical behavior of the soil. Standard methods of geotechnical investigation apply to determining the engineering properties of soil and bedrock with potential for permafrost. The frequency and location of investigation sites does not need to vary from standard practice, although descriptions of soil are required to note the presence of ice. Properties for design can be evaluated based on the classification of frozen ground as defined in ASTM D4083. A soil classification system for permafrost soils is presented in Table 6.1.

Geotechnical hazards at the proposed highway include settlement, thaw-induced settlement where permafrost is present, strength loss and shear failure, as well as creep. Specific discussion of engineering properties and their changes at layers of frozen ground are discussed in detail by others[20].

4.6.6 Hydraulic Crossings and Drainage

A desktop study of distribution and quality of hydrometric and meteorological sources of data near the preferred and alternate alignments was completed using public domain information provided by the Environment and Climate Change Canada and the Government of Newfoundland and Labrador, as well as other relevant publications.

The road into Northern Labrador will impede natural drainage without adequate hydraulic structures to route and discharge the accumulated volume of water upland from the structure. The terrain at the preferred and alternate alignments is undeveloped with natural drainage controlled by landforms and governed by gravity. All topographic low areas require a means to discharge accumulated drainage without causing backup and flooding that may risk the highway or other infrastructure. Hydraulic structures include culverts for lower flows, multiple culverts and arches for medium flows and bridges for larger flows. Other factors in selection of the appropriate drainage system include potential for ice, hydraulic gradient and potential for debris. Special considerations for fish passage should be site specific and determined based on the biodiversity of the site.

At the preferred and alternate alignments, there are several river crossings, with varying size catchment areas ranging from as little as 2.5 km^2 to more than 10,000 km^2. Table 4.18 and Table 4.19 lists river crossings at the preferred alignment and alternate alignment, respectively. River crossings are labeled in Drawing 001 in Appendix F. River span, measured from bank to bank, are approximated from Google images and vary from eight (8) metres to more than 500 metres, with an average width of approximately 60 metres. There are six (6) river crossings with widths greater than 100 metres.

Regardless of whether drainage will be through a bridge or a buried structure, standard engineering practice for hydrological and hydraulic design are applicable to the region. The integrity and egress of rivers and streams are to be maintained such that there are no negative impacts on fish and fauna, erosion, etc. The volume of water and the peak rate of runoff on any section of highway/road is a function of the catchment area, soil and rock type, depth and classification, as well as lakes and wetlands.

Culverts are an efficient way to manage drainage for smaller watershed areas and areas controlled by streams and brooks. Culverts are manufactured in a variety of diameters and can discharge large volumes of water, especially if multiple culverts are installed. A potential drawback for culverts is the impact on fish passage. Other options for discharge that include fish passage are open-bottom arch structures and bridges. Bridges may be single span, or multi-span with piers in the river. Piers in-river are complex to construct and may require more than one construction season to install. Previous construction practice in Labrador replaced multi-span bridge crossings with embankment approach causeways coupled with a single span steel bridge in lieu of multi-span bridges.

River Crossing	River Width (m)	Drainage Area (km^2)
A-Bridge 1 (Sebaskachu River)	70	556
A-Bridge 2 (Mulligan River)	70	1,071
B-Bridge 1	35	210
B-Bridge 2	90	293
B-Bridge 3	25	137
B-Bridge 4	25	32
C-Bridge 1 (Kaipokok River)	72	2,472
D-Bridge 1	12	
D-Bridge 2 (Kanairiktok River)	80	9,347
D-Bridge 3	60	468
D-Bridge 4 (Udjuktok River – South Fork)	110	10,468
D-Bridge 5 (Udjuktok River – North Fork)	90	
D-Bridge 6	80	621
D-Bridge 7	40	385
E-Bridge 1	50	141
E-Bridge 2 (Hunt River)	60	1,087
E-Bridge 3	27	69
E-Bridge 4 (Flowers River)	100	1,392
E-Bridge 5	50	403
E-Bridge 6 (Sango Brook South Passage)	40	775
E-Bridge 7 (Sango Brook North Passage)	40	
F-Bridge 1 (Notakwanon River)	300	4,501
F-Bridge 2	40	166
F-Bridge 3 (Side Brook)	30	218
F-Bridge 4 (Kogaluk River)	60	5,026
F-Bridge 5 (Konrad Brook)	116	543
F-Bridge 6 (Kogluktokoujk Brook [1])	360	1,009
F-Bridge 7	40	41
F-Bridge 8 (Northern Bight)	30	101
G-Bridge 1 (Reid Brook [2])	225	84
G-Bridge 2 (Anaktalik Brook)	250	1,805
G-Bridge 7 (Tasiyuyaksuk Brook)	60	117
G-Bridge 8	15	8
I-Bridge 1	28	31
J-Bridge 1	30	40

Table 4.18-Water Crossings – Primary Alignment

[1] Possibly use causeway portion with 100m bridge opening.

[2] Possibly use causeway portion and use shorter span bridge.

Alternative Route Option Name	River Crossing	River Width (m)
A2-Northwest River Bypass Option	A2-Bridge 1	160
D2-Southern Route Around Micmac Lake Option	D2-B-ALT1 (Kaipokok River)	152
	D2-Bridge 1	20
	D2-Bridge 2 (Kanairiktok River)	100
G3-Anaktalik Bay Option	G3-Causeway 1	850
	G3-Causeway 2	1800
G4-Ikadlivik & Anaktalik Valleys Option	G4-Bridge 1	62
	G4-Bridge 2	75
	G4-Bridge 3	40
	G4-Bridge 4	65
	G4-Bridge 5	40
	G4-Bridge 6	126
H2-North Side of Double Mer Option	H2-Bridge 1 (Double Mer)	550
I2-Makkovik Access Southern Route Option	I2-Bridge 1	64
	I2-Bridge 2	40
K2-Hopedale Access Southern Route Option	K2-Bridge 1	54

Table 4.19-Water Crossings – Alternate Routes

4.6.6.1 Hydrologic Data

Estimates of volume and peak flows for use in drainage design rely on historical rainfall observations published by Environment Canada. There are no site-specific meteorological or hydrometric monitoring sites at any of the major river crossings and data have to be transposed for evaluation or compiled into regional averages.

Engineering design of drainage infrastructure for highways and roads generally include (1) rainfall-runoff analysis and (2) transposing measured flow from a gauged watershed to an ungauged watershed. Both methods rely on data from previously observed events to predict future events.

Precipitation Data

Environment Canada, Atmospheric Environment Services (AES), maintain eight (8) active meteorologic stations in Labrador and two more near the Quebec border, listed in Table 4.20. Stations which are nearby to the preferred and alternate alignments are shown in Drawing 002 in Appendix F. The stations span from Nain in the north to Mary's Harbour in the south and Wabush in the west and provide sparse coverage for the region.

There are four (4) coastal climate stations parallel to the highway alignment and connector roads that are specifically relevant to drainage design of the road into Northern Labrador. These stations are associated with local airports and have relatively long periods of record for rainfall, snow fall, total precipitation, wind speed/direction and temperature. However, because these stations are adjacent to the coast, they may not accurately reflect upland meteorological conditions.

When Environment Canada make changes to the monitoring, they assign a new Station ID number that has resulted in multiple climate IDs for essentially the same station location. Each climate station ID data will be published in a separate dataset and should be combined for statistical analysis to maximize the data series. Observation data published by ECCC (www.canada.ca/en/environment-climate-change.html) include rainfall precipitation, snowfall, total precipitation, wind speed and direction, temperature and other environmental loading data.

Station Name	Total Years	Climate ID	Location			Durations Recorded	
			Lat	Long	Elev	First	Last
Mary's Harbour A	40	850B5R1 8502590 8502591 8502592	52.25	-55.60	9	1994-02-01 2013-12-09 1983-10-17 2013-12-09	2014-01-14 2015-03-04 2013-12-12 2023-10-08
Churchill Falls A	55	8501130 8501131 8501132	53.55	-64.10	439	1994-02-01 2011-12-12 1968-11-11	2021-12-21 2023-10-08 1993-03-31
Cartwright	70	8501100 8501101 8501106	53.71	-57.04	14	1953-01-01 2015-03-09 2015-07-28	2015-03-12 2018-09-12 2023-10-15
Goose Bay A	70	8501900	53.32	-60.42	48	1953-01-01	2023-10-08
Makkovik A	38	8502580 8502NHR 8502588	55.08	-59.19	71	2015-03-12 1985-12-06 2015-03-12	2023-10-08 2015-03-12 2023-10-08
Hopedale (Aut)	70	8502400	55.45	-60.22	11	1953-01-01	2023-10-08
Nain	39	8502799 8502810 8502800 8502801	56.55	-61.68	7	1994-02-01 2015-03-12 1984-09-01 2015-03-09	2023-10-08 2023-10-08 2015-03-12 2023-10-08
Wabush Lake A	62	8504175 8504176 8504177	52.93	-66.87	551	1961-01-01 2013-02-12 2014-09-16	2013-02-14 2023-10-08 2023-10-08
Lourdes De Blanc Sablon A	53	7040813 7040815 7040816	51.45	-57.18	37	1970-01-01 2014-12-02 2016-01-13	2014-12-04 2023-10-08 2023-10-08
Lac Eon	29	704C64L	51.87	-63.28	589	1994-02-01	2023-10-08

Table 4.20-ECCC Stations in Labrador and Near the Quebec Border

Hydrometric Data

Hydrometric data is collected at several stations throughout Labrador by the Water Survey of Canada (WSC) on behalf of the National Hydrometric Program (NHP). The WSC publishes results in many forms, including hourly, daily and monthly flow values. The program lists 86 hydrometric stations for the area but does not list a drainage area for 32 of the stations. Of the 54 remaining stations, 29 listed in Table 4.21 were selected as having 10 or more years of reliable data. The literature review[23] notes that "a 100-year flood cannot be reasonably computed if the hydrometric data only cover 10 years". Stations with more than twenty (20) years of data are shown graphically in Figure 002 in Appendix F.

Station Name	ID	Catchment (km²)	Last Year	Total Record	LAT	LONG
Wabush Lake At Dolomite Road	03OA014	8.1	2020	13	52.97	-66.86
Tributary To Reid Brook	03NE012	15.1	2019	16	56.31	-62.09
Camp Pond Brook Below Camp Pond	03NE002	24.3	2021	26	56.34	-62.11
Luce Brook Below Tinto Pond	03OA012	43.4	2020	18	52.99	-66.88
Big Pond Brook Below Big Pond	03OE010	71.4	2018	24	53.51	-60.29
Reid Brook At Outlet of Reid Pond	03NE001	75.7	2021	26	56.37	-62.16
Flora Creek Below Trans Labrador Highway	03OA015	139	2022	10	52.96	-66.84
Reid Brook Below Tributary	03NE011	158	2020	17	56.31	-62.09
Pinus River	03OE011	780	2020	22	53.15	-61.56
Wabush Lake At Lake Outlet	03OA005	1600	2022	22	53.15	-66.79
East Metchin River	03OD007	1750	2014	16	53.43	-63.23
Riviere Joir Near Provincial Boundary	02XA004	2060	1996	16	52.16	-60.06
Alexis River Near Port Hope Simpson	03QC002	2310	2022	44	52.65	-56.87
Minipi River Below Minipi Lake	03OE003	2330	2014	35	52.61	-61.19
Mcphadyen River Near the Mouth	03OA003	3610	1982	10	54.10	-66.56
Atikonak River Above Atikonak Lake	03OC005	3680	2000	28	52.29	-64.33
Naskaupi River Below Naskaupi Lake	03PB002	4480	2012	34	54.13	-61.43
Little Mecatina River Above Lac Fourmont	02XA003	4540	2021	43	52.23	-61.32
Kepimits River Below Kepimits Lake	03OC004	7070	2000	28	52.65	-64.85
Ugjoktok River Below Harp Lake	03NF001	7570	2021	42	55.23	-61.30
Ashuanipi River Below Wightman Lake	03OA004	8310	1983	11	53.23	-66.21
Kanairiktok River Below Snegamook Lake	03NG001	8930	1996	17	54.62	-60.98
Naskaupi River At Fremont Lake	03PB001	8990	1970	15	54.12	-63.22
Eagle River Above Falls	03QC001	10900	2021	55	53.53	-57.49
Atikonak River Above Panchia Lake	03OC003	15100	2021	49	52.97	-64.66
Ashuanipi River At Menihek Rapids	03OA001	19000	2010	58	54.46	-66.63
Unknown (Atikonak) River at Lake 51	03OD003	19900	1971	16	53.45	-64.76
Atikonak River At Gabbro Lake	03OC006	21400	2010	37	53.77	-65.40
Unknown (Atikonak) River at Twin Falls	03OD002	22800	1976	14	53.50	-64.54

Table 4.21-WSC Stations for Hydrological Analysis

In addition to long-duration historical data, there are several “real-time” hydrometric stations that publish hourly flows. The Newfoundland and Labrador Government, Department of Environment and Climate Change, operate and manage the “Automatic Data Retrieval System” (ADRS) website which shows the locations of all “real time” stations across Newfoundland and Labrador and provides links to their data series.

The ARDS data may be used for calibrating hydraulic models by comparing actual flow at a specific site with predicted flow, and then adjusting the model parameters to improve reliability. Instrumentation to measure flow or water levels at the target site are required prior to the calibration event. A screenshot of the interface, Figure 4.25 provides a sample of live real-time stations in Labrador.

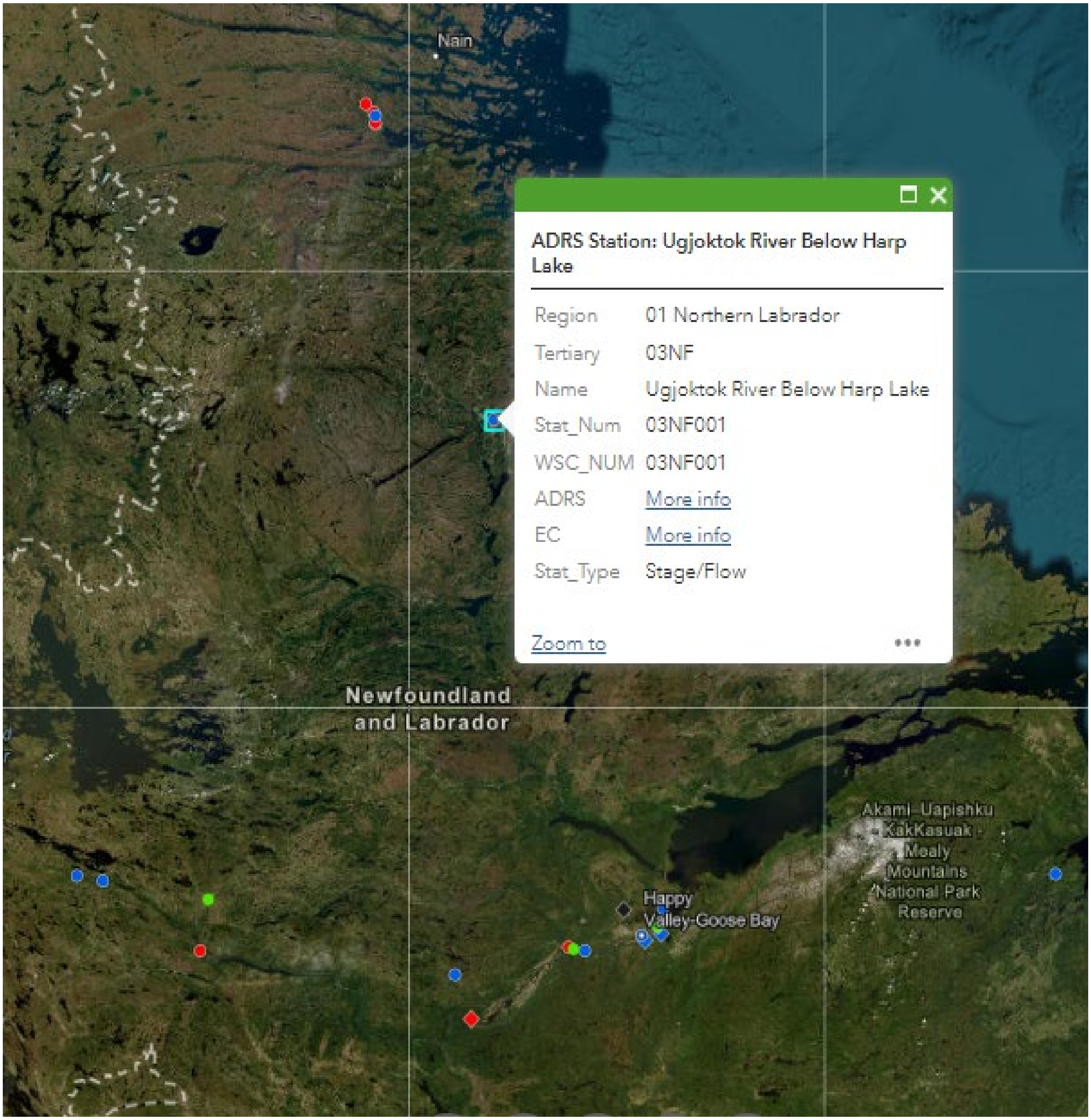

Figure 4.25-NL ECC ADRS Near-Real Time Stations Interface

4.6.6.2 Climate Risk Assessment

Drainage infrastructure may be sensitive to the impacts of climate change on hydrology. The adoption of meteorological and climate data in engineering design traditionally relies on observations of past events to predict future events. Because climate change effects are current and ongoing, they are not adequately reflected in the historical record. Potential outcomes of climate change are generated through global circulation models (GCMs) but understanding climate change's impacts on the hydrologic cycle is an evolving process. All published projections for Labrador predict rapid temperature increases and an increase in total precipitation that includes more rainfall and less snow.

The Government of Newfoundland Labrador provides a reliable source of information on guidance in selecting rainfall intensity-duration-frequency (IDF) graphs that incorporate climate change into future values for the year 2041-2070 and 2071-2100. The website provides projected rainfall data for Nain, Churchills Falls, Goose Bay and Mary's Harbour in Labrador in a range of outcomes with 10th, 50th and 90th percentile amounts. The IDF curves can be used in rainfall-runoff models but are not applicable to transposing gauged flow values to ungauged watersheds. There is no guidance on the WSC website on including climate change in extreme value analysis (EVA) of the recorded data, although anecdotal guidance on adjustments indicates escalating the predicted values for 20 to 35 percent.

The climate features assessed on websites such as www.climateatlas.ca or www.climatedata.ca provide projections for changes in precipitation levels, temperature and other attributes such as the number of cool days on a seasonal basis. The ECCC model projections are published for Representative Concentration Pathways (RCPs). The RCP represents different emission reduction pathways with RCP2.6 being the lowest emission course and RCP8.5 the highest. More recent projections use Coupled Model Intercomparison Project (CMIP), with the 6th version, CIMP6. Projected future values for temperature and total precipitation are listed in Table 4.22 These values reflect those of the ~10 km x 6 km grid cell that Goose Bay lies within and do not necessarily reflect the exact point that you select, particularly in areas with varying microclimates.

Parameter	Goose Bay, NL	Nain, NL
Temperature (ºC)		
Historical (1971 – 2000)	+4.8	-3.4
Projected (2021 – 2050)	+6.9	-0.5
Projected (2051 – 2080)	+8.8	+2.2
Annual Precipitation (mm)		
Historical (1971 – 2000)	1152	792
Projected (2021 – 2050)	1255	935
Projected (2051 – 2080)	1278	974

Table 4.22-Climate Change Projections (www.climatedata.ca)

The impacts of climate change result in risk and uncertainty for design and construction of drainage infrastructure along the alignment for a highway into Northern Labrador.

- An increasing mean annual air temperature (MAAT) will result in less annual snowpack and may change the typical timing and nature of the Spring freshet, currently expected to occur late May to early June. This trend may not be uniform over the proposed alignment where northern areas may actually get more snow and a larger Spring freshet.

- The change in precipitation may result in more intense rainfall events of short duration during the summer months that may govern design of drainage infrastructure.

4.6.6.3 Runoff Analysis Methods

Bridges and buried structures are sized for a design event, generally described as a flood with a certain annual exceedance probability. Buried structures include culverts but may also include arched multi-plate structures. In Newfoundland and Labrador, the Provincial Government Water Resources Management Division has published "Environmental Guidelines for Bridges"[18] which recommends water crossings on freeways are designed to pass a flood with an annual exceedance probability of one in 100 years (AEP100). Typically, the floodplain width also coincides with the AEP100 flood[21]. As well as design discharge, the natural channel width and flood plain width are used to determine the appropriate opening width and whether a bridge or buried structure is appropriate for drainage.

Rainfall intensities and totals for a period can be transposed into actual runoff that will include evaluation of precipitation, depression and interception storage, evaporation, transpiration, and infiltration. Because of the multiple variables involved in a rainfall-runoff analysis, the predicted flow generated in models will vary from empirical to computer generated as the level of complexity increases. Because of the multiple variables involved in a rainfall-runoff analysis, the predicted flow generated will vary from empirical methods and computer-generated models as the level of complexity increases. Run off analysis using WSC gauged data aggregates many physiographic and meteorological variable by measuring flow directly and then relies on variance in watershed comparisons and similarities to transpose a flow. The appropriate method will vary depending on watershed and available data.

Computer Models

Computational modeling is useful for performing detailed hydrological and hydraulic analysis. Computer based rainfall-runoff models generate an expected watershed response based on rainfall, snowpack, temperature sequence and watershed parameters such as coverage, reservoirs, and catchment lag time. The model evaluates a digital terrain model (DTM) and meteorological input values to generate a runoff hydrograph, as well as water levels, velocity and depth parameters. Models should be used cautiously as the onus is on the modeler to ensure the input parameters and results of a model are reasonable and accurate. Model results should always be checked against other empirical methods and simplified analysis methods such as envelope curves or empirical relations.

SWMM

Storm Water Management Model (SWMM) software is developed by the U.S. Environmental Protection Agency, Water Supply and Water Resources Division. SWMM is a dynamic rainfall-runoff simulation model used for single event, long-term simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each sub-catchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation.

SWMM is widely used for planning, analysis and design related to stormwater runoff, and other drainage systems in urban areas, with many applications in non-urban areas as well. SWMM accounts for various hydrologic processes that produce runoff from urban areas. These include:

- time-varying rainfall,
- evaporation of standing surface water,
- snow accumulation and melting,
- rainfall interception from depression storage,
- infiltration of rainfall into unsaturated soil layers,

- percolation of infiltrated water into groundwater layers,
- interflow between groundwater and the drainage system, and
- nonlinear reservoir routing of overland flow.

HEC-HMS

HEC-HMS was created by the U.S Army Corp of Engineers (USACE) and is a flood hydrograph package which can model runoff from precipitation on a complex, multi-catch basin, multi-channel river system. The program is limited to analyzing single events as there is no provision for recovery of rainfall abstraction rates during dry periods.

Snowmelt can be computed using either the degree-day method or the energy budget method. Rainfall losses (infiltration and depression storage) are computed by a function relating loss rates to rainfall intensity and accumulated loss. The program will compute a unit hydrograph or will apply a user-supplied unit hydrograph. Channel routing can be carried out using one of six optional hydrologic procedures.

HEC-RAS

HEC-RAS was created by the U.S Army Corp of Engineers (USACE) and is used for modelling both steady and unsteady, one-dimensional, gradually varied flow in both natural and man-made river channels. The model is capable of modelling sub-critical, supercritical, and mixed flow regime water surface profiles. HEC-RAS can model a single river reach, a dendritic river system, or a full network (looped system) of stream channels. Other special features include optimization of flow splits, automatic roughness calibration, and multiple-opening bridge and culvert analysis.

The HEC-RAS system will ultimately contain three one-dimensional hydraulic analysis components for: (1) steady flow water surface profile computations; (2) unsteady flow simulation; and (3) movable boundary sediment transport computations. In addition to the three hydraulic analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed: including bridge scour computations, uniform flow computations, stable channel design, and sediment transport capacity.

HY-8 Culvert Design Package

The computer program HY-8 was developed by the Federal Highway Administration (FHWA), which is a division of the United States Department of Transportation (USDOT). HY-8 is primarily used for analysis and design of culverts in roads and other transportation infrastructure projects. HY-8 can also be used for sensitivity analysis in hydraulic modeling of culverts to evaluate different factors. Features of HY-8:

- Culvert Analysis: HY-8 is primarily used for the hydraulic analysis of culverts. It helps engineers, and hydrologists assess how water flows through culverts under different conditions;
- Geometry and Sizing: The software allows users to input the geometric characteristics of the culvert, such as size, shape, and slope. It aids in determining the appropriate size of culverts, for efficient water flow;
- Hydraulic Calculations: HY-8 performs hydraulic calculations to evaluate the capacity of the culvert under various scenarios, including different flow rates and water levels;
- Inlet and Outlet Control: The software considers factors affecting the culvert's performance, such as inlet and outlet control conditions, to provide a comprehensive analysis, and;
- Graphical Interface: HY-8 typically offers a user-friendly graphical interface that facilitates data input, visualization of results, and interpretation of analysis outputs.

Analytical Methods for Smaller Basins

Advances in computation power have superseded traditional approaches to drainage design that relied on empirical and analytical approaches based on terrain knowledge, past performance and observed responses. As with computational based models, these empirical approaches are based on short periods of observation and should be used cautiously as the onus is on the engineer to establish the common parameters for comparisons. Available methods include both rainfall-runoff approaches and flow data accumulation approaches.

Rational Method

The rational method is an empirical method commonly used for analysis of small drainage areas, typically less than 5 km^2. The method estimates a peak flow as a function of catchment area and rainfall intensity, with the terrain analysis captured in a runoff coefficient, estimated as follows.

$$Q_p = 0.278CIA$$

Where, Q_p = Peak Flow (m^3/s)

C = Runoff Coefficient

I = Rainfall Intensity (mm/hr)

A = Catchment Area (km^2)

Catchment area of the watershed can be found from topographic maps or aerial photography. Rainfall intensity can be found using Intensity-Duration-Frequency (IDF) curves published by Environment Canada. A limitation of the method is IDF curves assume intensity is constant for a period equal to the time of concentration of flow, and therefore applies to small watersheds. Time of concentration is commonly estimated using an empirical formula, such as the Kirpich formula, presented below.

$$t_c = \frac{0.00325L^{0.77}}{S^{0.385}}$$

Where, t_c = Time of Concentration (hours)

L = Length of the Principal Watercourse (km)

S = Dimensionless Main Channel Slope (m/m)

If the time of concentration is more than a couple of hours, the rational method may overestimate peak flow. The runoff coefficient can be determined using published data. These coefficients are commonly found in municipal design manuals and other published literature.

SCS Runoff Curve Number Method

The runoff curve number method was developed by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) and can be used for any size catchment area but is commonly applied to catchments that are 250 km^2 or smaller. The SCS method estimates the volume of runoff and requires an additional step to estimate flow. The method is effective when the watershed is sub-divided into a network with different attributes. Runoff depth over the entire catchment is calculated as a function of total rainfall depth and the runoff curve number, CN, for each sub-basin. The runoff curve number is a function of four (4) parameters.

1. Soil Group Classification
   - Group A consists of soils of low runoff potential, having high infiltration rates even when wetted thoroughly. They are primarily deep sands and gravels with a high rate of water transmission.
   - Group B consists of soils with moderate infiltration rates. They are primarily moderately deep, moderately drained, with moderately fine to coarse textures. They have a moderate rate of water transmission.
   - Group C are soils with slow infiltration rates when wetted thoroughly. They primarily have a layer that impedes water movement or movement of fine textures.
   - Group D consists of soils with high runoff potential with slow infiltration rates. They are primarily clayey soils or soils with a clay layer near the surface. They have a slow rate of water transmission.

2. Hydrologic Condition
   - Whether the catchment land is in poor, fair or good condition.
3. Land Use and Treatment
   - Land use pertains to the catchment cover, whether it is fully developed with residential lots and streets or of an agricultural nature, with crops.
4. Antecedent Moisture Condition
   - The condition of the soil can be broken into one of three types – AMC I (low moisture or dry conditions), AMC II (average moisture) or AMC III (high moisture or wet conditions). Most of the published data for curve numbers assume the AMC II condition. If AMC I or AMC III is present, the CN can be converted using the formulas presented below.

$$CN_I = \frac{CN_{II}}{2.3-0.013CN_{II}}$$

$$CN_{III} = \frac{CN_{II}}{0.43+0.0057CN_{II}}$$

The runoff curve number (CN) can be found from a number published literature. All charts are based on an average antecedent moisture condition (CN_{II}) and an initial abstraction (I_a) of 0.2S, in which 0.2 is the standard coefficient recommended by SCS. The initial abstraction (I_a) is the interception, infiltration, and surface storage, which are parameters that occur before the runoff begins. The depth of runoff can be calculated from the intensity duration frequency curves equation presented in Appendix I.

$$Q = \frac{(P-I_a)^2}{P-I_a+S}$$

Where, Q = Depth of Runoff (cm)
P = Rainfall (cm)
I_a = Initial Abstraction = 0.2S
S = Potential Maximum Retention = 26400/CN – 10

The runoff curve number method is used in practice to determine a runoff depth based on rainfall amounts and curve numbers, with no account for rainfall intensity and duration. The results of the curve number method are extremely sensitive to the estimation of the curve number. Caution should be taken when estimating the curve number.

Index Flood Method

The index flood method (IFM) can be used to determine the magnitude and frequency of peak flows for catchments of any size, whether gauged or ungauged. The method relies on the HYDAT database published by the WSC which publishes an annual extreme value data set for mean daily and peak flow, as well as minimum daily flow. In its simplest form, IFM can estimate a peak flow with a regression analysis using only drainage area as the independent variable. While other physiographic factors may influence flood flow, drainage area is the primary attribute, normally explaining between 85% to 90% of the variance in predicted flows.[22] The IFM method estimates the peak flow and required an additional step to estimate volume of runoff.

The Governments of Newfoundland and Labrador published regression equations that relate watershed size, i.e., drainage area (DA) to estimates of the appropriate AEP_{100} peak inflow for any watershed (Amec, 2014). The published regression equation for Labrador is as follows:

$$Q_{100} = 0.909 \times DA^{0.84}$$

Hydraulic frequency analysis was used to develop a regional frequency growth curve in-house. Frequency analysis for extreme events is based on maximum hourly peak values recorded for each year of record with extreme values for annual exceedance probabilities (AEP) of 10, 50 and 100 years generated using a Generalized Extreme Value (GEV) distribution. The relationship in Table 4.23 suggests a linear relationship for smaller watersheds. The results provide comparable values with the regression equation above for watersheds less than 100 km^2 but estimate higher values for larger watersheds and are less likely to underestimate a flood.

All regression equations should be used cautiously because of variability in average estimates, and the higher variance for events with higher AEP events. For drainage areas which are less than 50 km^2, alternative methods should be used for verifying the design flow. These methods require rainfall data, hydrometric stage, and flow data, and/or land coverage data such as surficial geology and vegetation.

Event	DA < 750 km^2	DA > 750 km^2
AEP_{10}	$Q_{10} = 0.222 \times DA^1$	$Q_{10} = 1.0 \times DA^{0.78}$
AEP_{50}	$Q_{50} = 0.336 \times DA^1$	$Q_{50} = 1.6 \times DA^{0.78}$
AEP_{100}	$Q_{100} = 0.413 \times DA^1$	$Q_{100} = 2.0 \times DA^{0.78}$

Table 4.23-Regional Extreme Event Average Peak Flow Estimation Values

Unit Hydrograph Techniques

A hydrograph provides an estimate of flow at a certain location over time and is represented by a flow rate on the vertical axis and time on the horizontal axis. The volume of flow is represented by the area under the curve. The shape of the curve is triangular skewed to the left. When using rainfall-runoff analysis methods, the shape of the hydrograph is governed by volume and the peak flow estimated. When using WSC peak value analysis, the peak of the hydrograph is governed by flow and the shape of the hydrograph estimated for a specific period of time.

Synthetic methods of hydrograph development relate the time base of the hydrograph to the catchment lag. In turn, catchment lag is related to the catchment response characteristics, including shape, length and slope of the watershed. Several methods are commonly used in the synthetic approach, but we will focus on the SCS synthetic unit hydrograph. This method is based on three properties:

1. Catchment lag;
2. Ratio of time base to time-to-peak;
3. Ratio of actual time base to time-to-peak.

The peak flow formula used in the SCS synthetic unit hydrograph approach is presented below.

$$Q_p = \frac{2.08A}{t_p}$$

Where, Q_p = Peak unit flow, attributing to 1 cm depth of runoff (m^3/s)
A = Catchment Area (km^2)
t_p = Time-to-Peak (hours)

These relationships allow calculation of the peak flow for the catchment. In many cases, it may be advantageous to use this peak flow and develop a storm hydrograph. The SCS unit hydrograph method has developed hydrograph ordinates to aid in the construction of the unit hydrograph. The ordinates are presented in the table below.

To construct the hydrograph, use the estimated flow and divide the ordinates in Table 4.24 by the calculated values. The resulting unit hydrograph will have a base time of 5 hours but can be simply adjusted to a more suitable hydrograph of a 12-hour, 24-hour, etc. duration.

t/t_p	Q/Q_p	t/t_p	Q/Q_p
0.0	0.00	2.6	0.107
0.2	0.10	2.8	0.077
0.4	0.31	3.0	0.055
0.6	0.66	3.2	0.040
0.8	0.93	3.4	0.029
1.0	1.00	3.6	0.021
1.2	0.93	3.8	0.015
1.4	0.78	4.0	0.011
1.6	0.56	4.2	0.010
1.8	0.39	4.4	0.007
2.0	0.28	4.6	0.003
2.2	0.207	4.8	0.0015
2.4	0.147	5.0	0.0000

Table 4.24-SCS Unit Hydrograph Ordinates

4.7 Environmental Review

4.7.1 Introduction

The final road design will incorporate consideration of environmental features, including regulatory restrictions and sensitive/avoidance areas. This environmental overview has been prepared to provide a general understanding of the features identified within the general proposed road alignment, as well as recommendations for pre-construction studies and construction considerations.

An environmental assessment process would be triggered via:

- Newfoundland and Labrador Environmental Protection Act, Environmental Assessment Regulation
    - 35(1): Roads construction or realignment
- Federal Impact Assessment Act, Physical Activities Regulations (SOR/2019-285)
    - Section 51 - The construction, operation, decommissioning and abandonment of a new all-season public highway that requires a total of 75 km or more of new right of way.

A detailed review of the Environmental Assessment process and required screening information to assist in development of the scope would be detailed during the Feasibility assessment.

4.7.2 Environmental Overview

The proposed road has a limited section within the Boreal Shield (southern extent, access to Rigolet), with the majority in the Taiga Shield (see Figure 4.26). The boreal and taiga zones circle the globe at high latitudes, dominated by conifers, the growth of which is frequently challenged by thin soils, rock barrens, sand plains, and wet peatlands.

The climate of Labrador is more Arctic than Atlantic because of its location on the eastern side of the continent and experiences strong seasonal contrasts. Winters are very cold, lasting almost eight months with normal daytime temperatures for January between -10ºC and - 15ºC. The summer season is brief and cool along the coast with July average temperatures between 8ºC to 10ºC (with rare hot spells bringing temperatures as high as 35ºC).

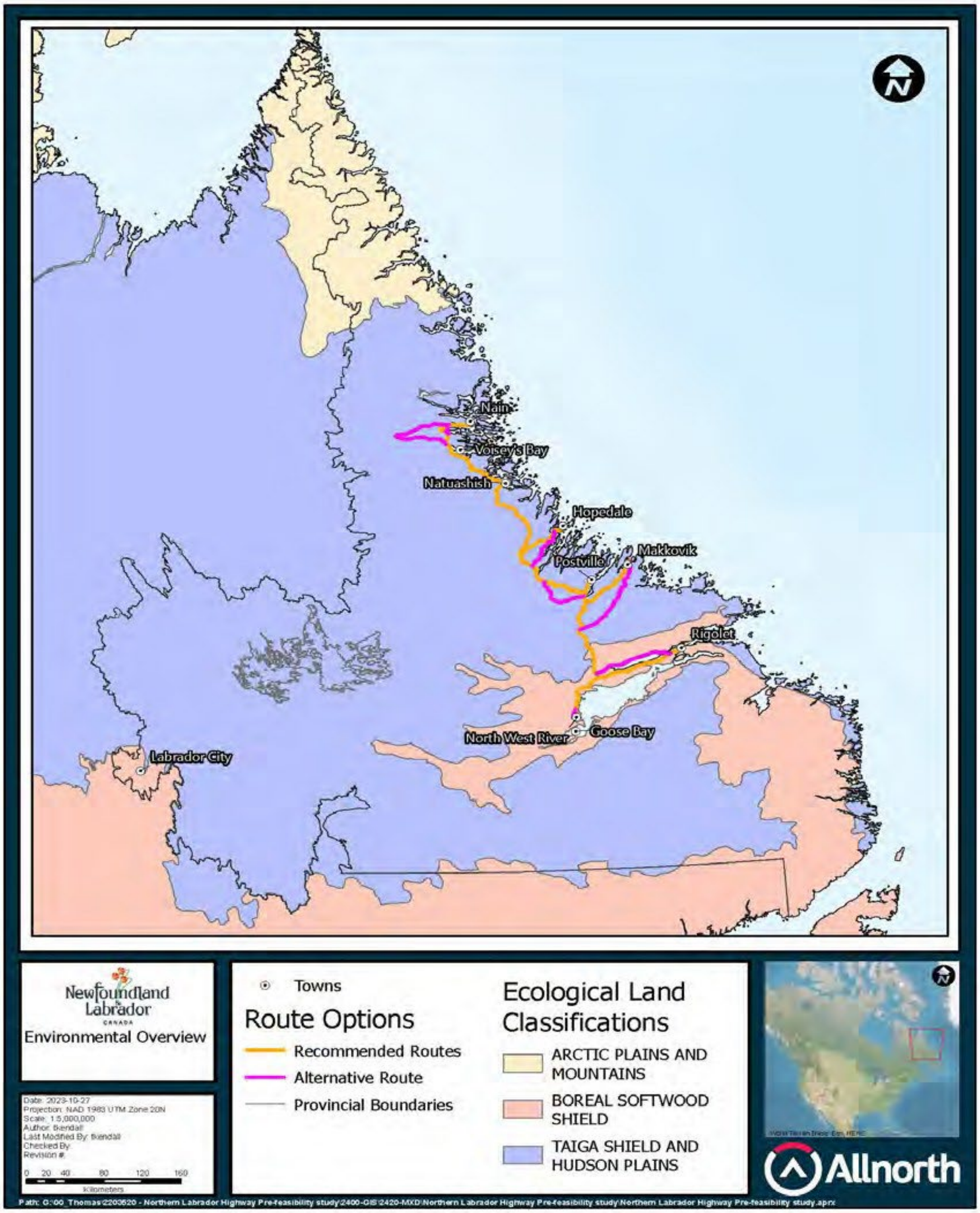

Figure 4.26-Ecological Land Classification of Labrador

4.7.3 Land Cover

The proposed road spans the mid coast of the Labrador Peninsula, approximately from Lake Melville and Northward to Nain. The road location crosses or is adjacent to forests, scrub land, rivers, wetlands, lakes, ocean inlets, and exposed soil and rock. The variety of local vegetation species expressed on the land are adapted from the local environmental features and conditions.

The majority of the proposed road traverses three primary land cover types (see Figure 4.27):

- Sub-Polar Taiga Needleleaf Forest;
- Temperate or Sub-Polar Needleleaf Forest, and;
- Wetland.

Generally, a lower tree cover is favorable for linear developments, as less tree clearing is required during construction and field-of-view impact to wildlife (which could increase wildlife predation, modify wildlife transportation routes, etc.) is relatively low.

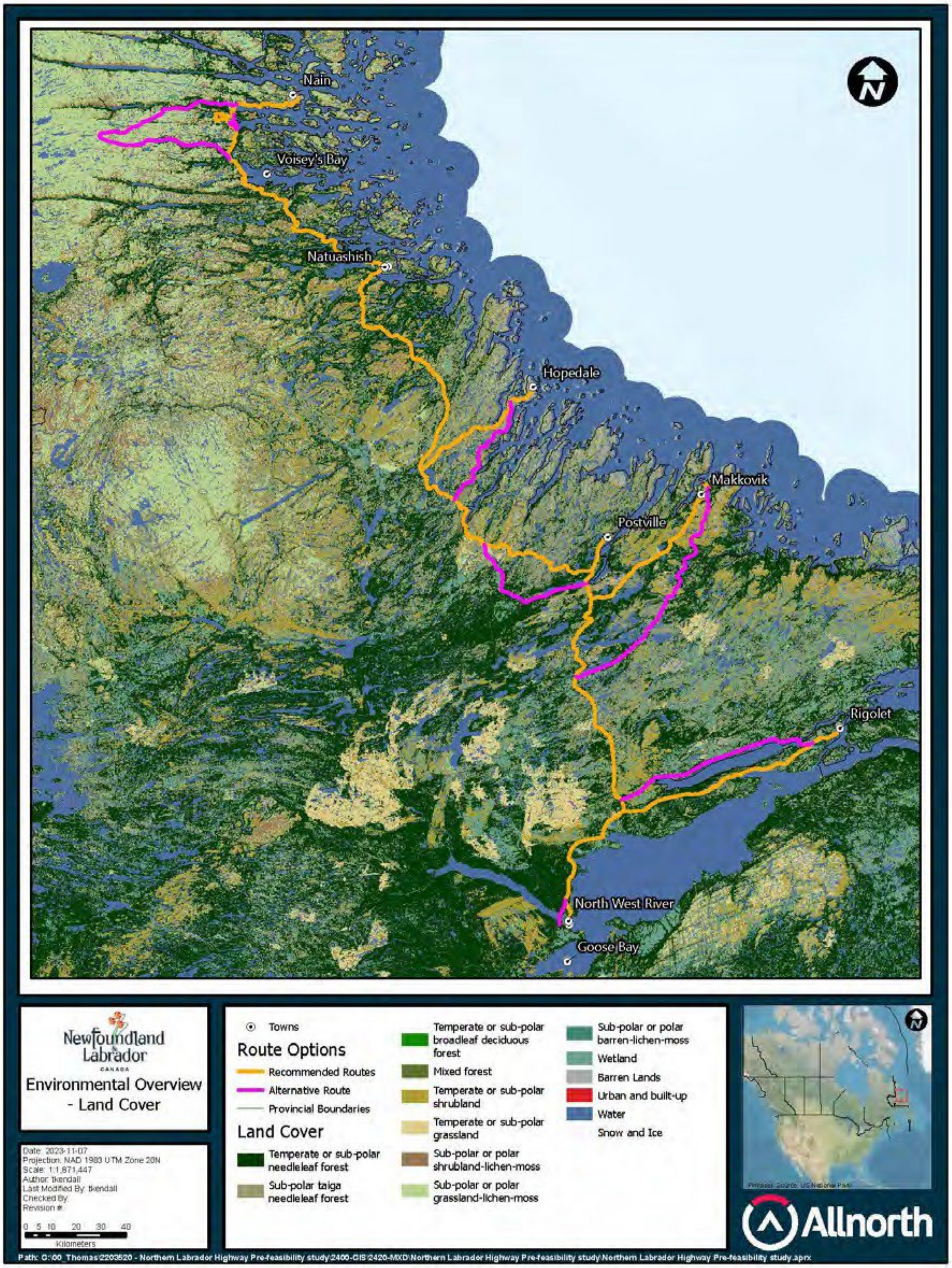

Figure 4.27-Land Cover of Labrador

4.7.4 Geology

Surficial geology along the proposed road is primarily granitic rock, with areas of coarse and fine till sediment (increased near larger watercourse crossings). Erosion and sedimentation issues will be elevated in areas where sediment deposits occur (see Section 4.7.9.4, Erosion and Sediment Control). Refer to Figure 4.28.

Metal leaching or acid rock generating (ML/ARD) rock may be encountered during road construction (excavation and blasting) activities. An assessment of the corridor by a qualified professional is recommended to identify areas of exposed/high potential for ML/ARD Rock and guide an appropriate identification and response strategy within a ML/ARD Management Plan. The Plan would guide proper segregation, waste disposal and cover of exposed areas to minimize risk of downstream influences. Disposal of ML/ARD rock is typically to a sub surface, capped or sub aqueous location, and it may not be used as riprap or construction fill material.

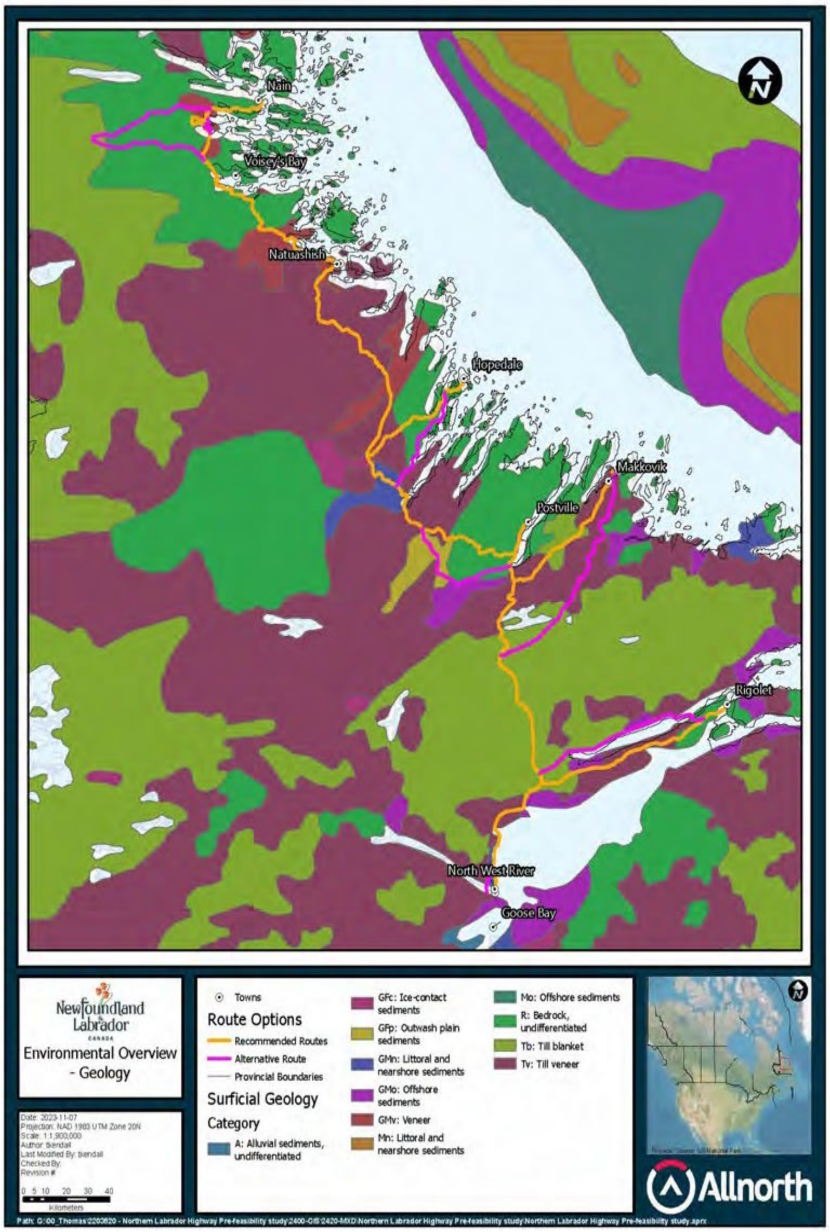

Figure 4.28-Geology of Labrador

4.7.5 Vegetation

Newfoundland and Labrador's Endangered Species Act provides special protection for plant and animal species considered to be endangered, threatened, or vulnerable in the province. The act designates species as endangered, threatened, or vulnerable based on recommendations from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and/or the Species Status Advisory Committee (SSAC), listed in Appendix J.

- Endangered: A species facing imminent extirpation or extinction;
- Threatened: A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction;
- Vulnerable: A species that has characteristics which make it particularly sensitive to human activities or natural events (equivalent to COSEWIC's designation of Special Concern).

Limited baseline vegetation survey information appears to be available for Labrador. A preliminary review of the listed vegetation species included within Newfoundland and Labrador 57/02: Endangered Species List Regulations[24], indicate that only one (1) has known occurrence in Labrador (but with no known presence within the proposed road corridor):

- Mountain Bladder Fern (*Cystopteris Montana*) – Schedule A (ENDANGERED);
  - Species is often found on limestone or dolomite, growing in often mature, spruce - fir woods, often in sheltered, damp gullies, often under alders and near water; but also, occasionally, in muskeg or alpine areas[25].

There is potential for additional listed rare or endangered species to have occurrences in Labrador and within the proposed road corridor, which may have not been documented to- date due to lack of available access/survey information in this area. A full list of species included within the NL ESLR is included as Appendix J. Refer to Figures 4.29 and 4.30.

Figure 4.29-Mountain Bladder Fern (Cystopteris Montana) Image

Figure 4.30-Known historic and recent locations of Cystopteris Montana in Labrador, and nearby Québec

4.7.6 Wildlife

The Government of Newfoundland and Labrador's Endangered Species Act provides special protection for animal species considered to be endangered, threatened, or vulnerable in the province. A preliminary review of the listed wildlife species included within Newfoundland and Labrador 57/02: Endangered Species List Regulations (Appendix A), indicate several with known occurrences in Labrador, however only two (2) with high potential for occurrence within the proposed road Corridor:

- Northern Brown Myotis (Myotis lucifugus)– Schedule A (ENDANGERED) (see Section 4.7.6.1)
- Red Wine Caribou herd – Schedule B (THREATENED) (see Section 4.7.6.2)

There is potential for additional listed rare or endangered species to have occurrences in Labrador and within the proposed road corridor, which may have not been documented to- date due to lack of available access/survey information in this area. A full list of species included within the NL ESLR is included as Appendix J. Refer to Figure 4.31.

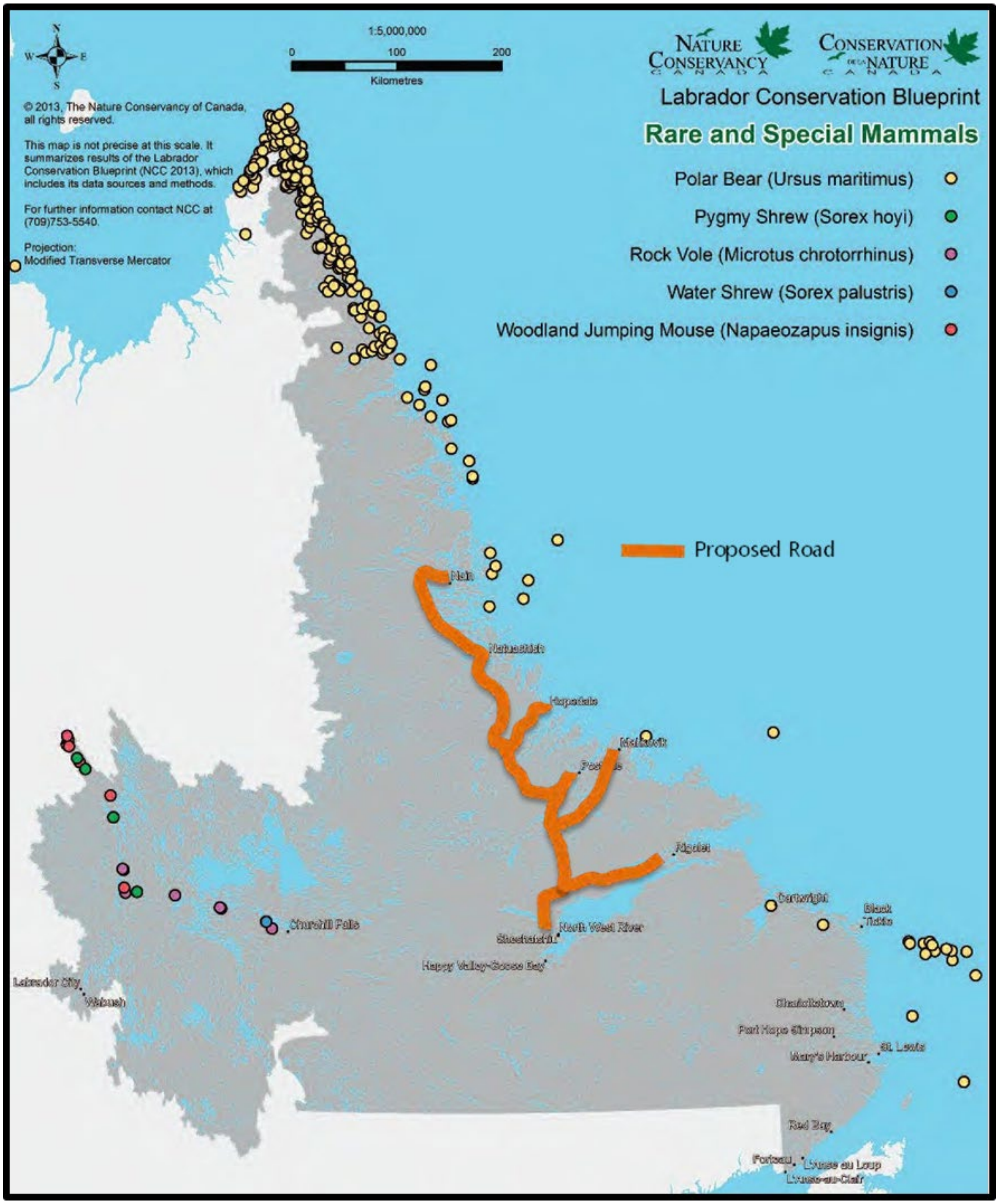

Figure 4.31-Rare and Special Ground Mammals of Labrador

4.7.6.1 Northern Brown Myotis

The Northern Brown Bat is found virtually anywhere there are trees, buildings, or caves, however, have been significantly impacted by a fungal disease over the past 15 years[26] leading to a 94% population decline. In the summer they will roost in buildings or trees. In winter, the bats need to find frost-free places in which to hibernate, such as caves, mineshafts, cellars, tunnels, or unoccupied buildings. Little Brown Myotis exhibit high fidelity to hibernacula (ie. will return to their over-wintering habitat every year). Refer to Figure 4.32.

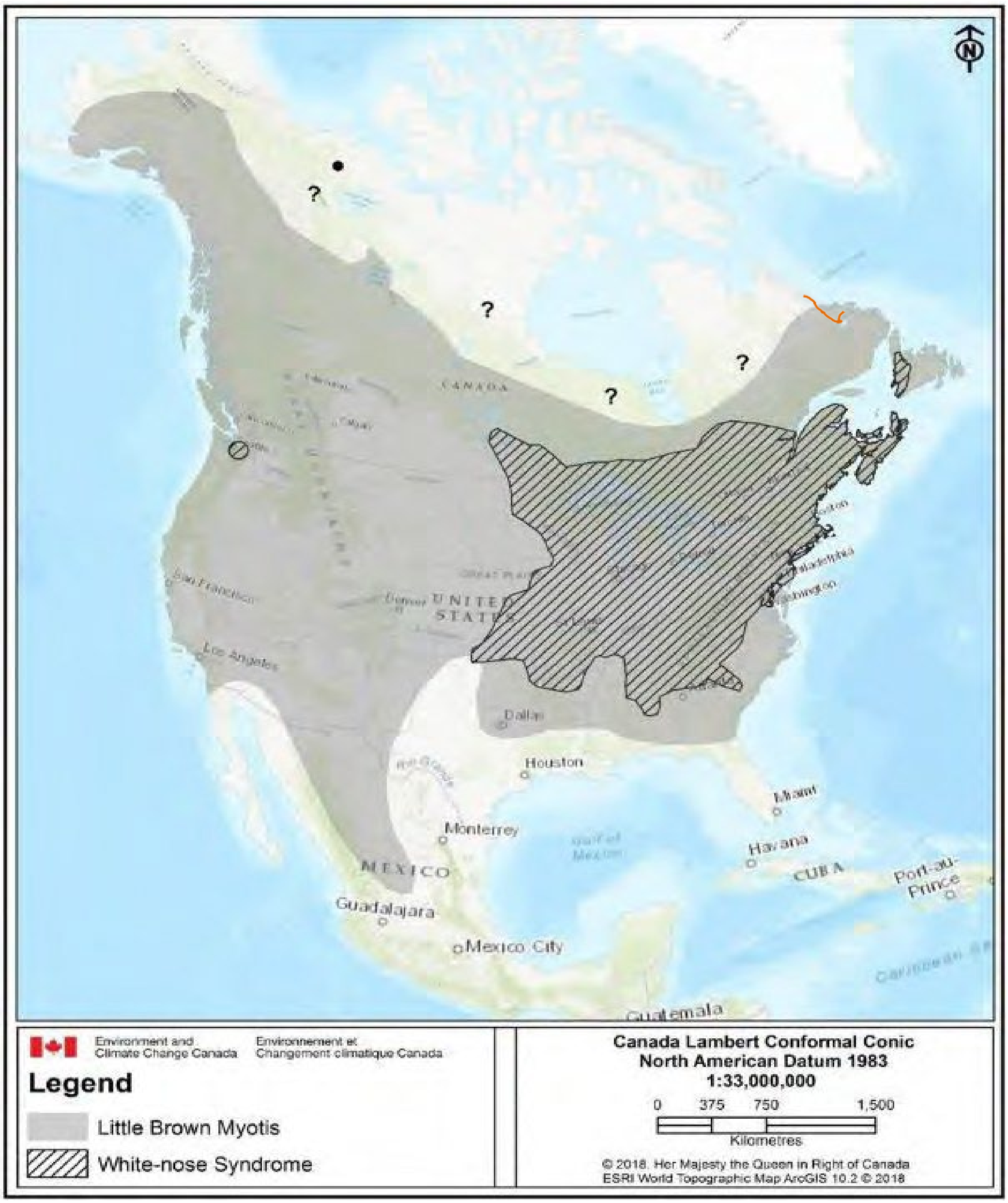

Figure 4.32-Range of Little Brown Myotis in Canada

4.7.6.2 Caribou

Caribou populations face variable threats such as habitat loss and predation, and as a result populations have decreased, and ranges have contracted. The George River Herd is the largest herd in Canada, numbering at approximately 500,000 caribou. There is active dialogue about Newfoundland Labrador Caribou herd management, and further study of the potential impacts of the proposed road to the local caribou ranges is required.

The proposed road does not conflict with known calving areas of the regional caribou population, however, will traverse within the George Herd range at the northern extent of the alignment, and the Red Wine Mountain Herd range at the southern extent (see Figure 4.33). The Red Wine herd is listed under the Endangered Species Act as 'Threatened'.

Environmental management planning should include measures to avoid conflicts with ungulates during construction, with appropriate signage in areas where known crossings/highly frequented areas are present. See Section 4.7.9 for Construction Considerations.

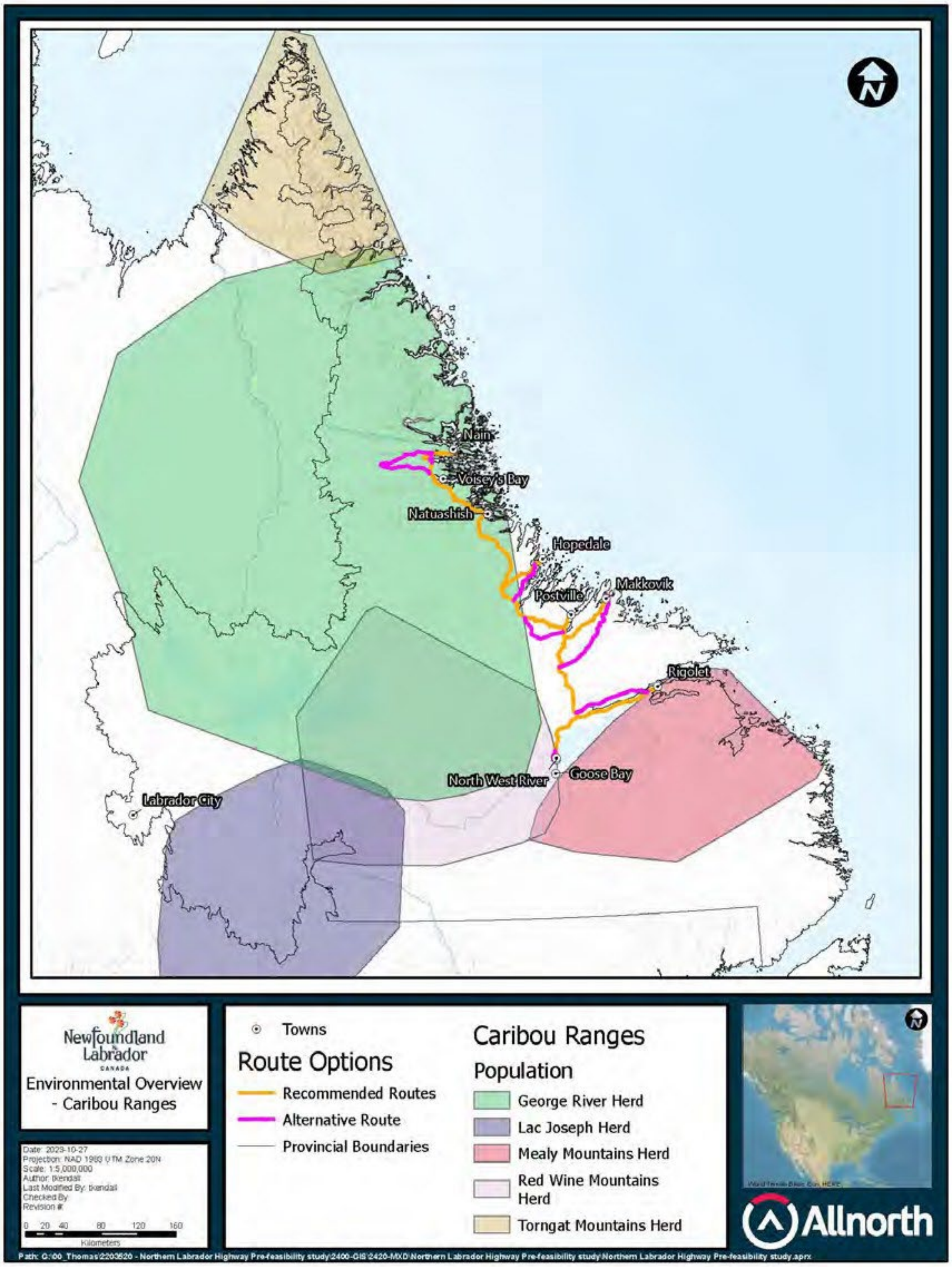

Figure 4.33-Caribou Ranges in Labrador

4.7.6.3 Birds

Birds are abundant in Labrador, including several species of interest (see Figures 4.34 and 4.35) that have been listed as rare, endangered or vulnerable. Though wetlands are not as common on the landscape, wetlands are used by the greatest number of priority bird species. Coastal habitat (above high tide) and coniferous forests are also important habitats. Herbaceous, lichens/mosses and urban habitats are used by the fewest number of priority bird species[27]. Migratory birds are protected under the Federal Migratory Bird Regulation (MBR), which prohibits damage, destruction, disturbance or removal of migratory bird nests when they contain a live bird or viable egg.

High-ranked threats to birds in this region include habitat loss or degradation from changes in habitat structure (e.g., drying, thawing of tundra) or food webs, shifts in species' ranges, and altered timing of seasonal cues (e.g., egg laying, migration) due to climate change.

Development of the proposed roadway is unlikely to significantly alter habitat of birds, however construction considerations will be required to mitigate acute impacts:

- Avoidance of alignment that would necessitate destruction of nests of species listed in Schedule 1[28] of the MBR (ex. Puffin, Heron, etc);
- Preservation of riparian areas (wetlands) (see Section 4.7.7.1), and;
- Avoidance of disturbance or destruction of active nesting sites (construction scheduling, pre-construction surveys).

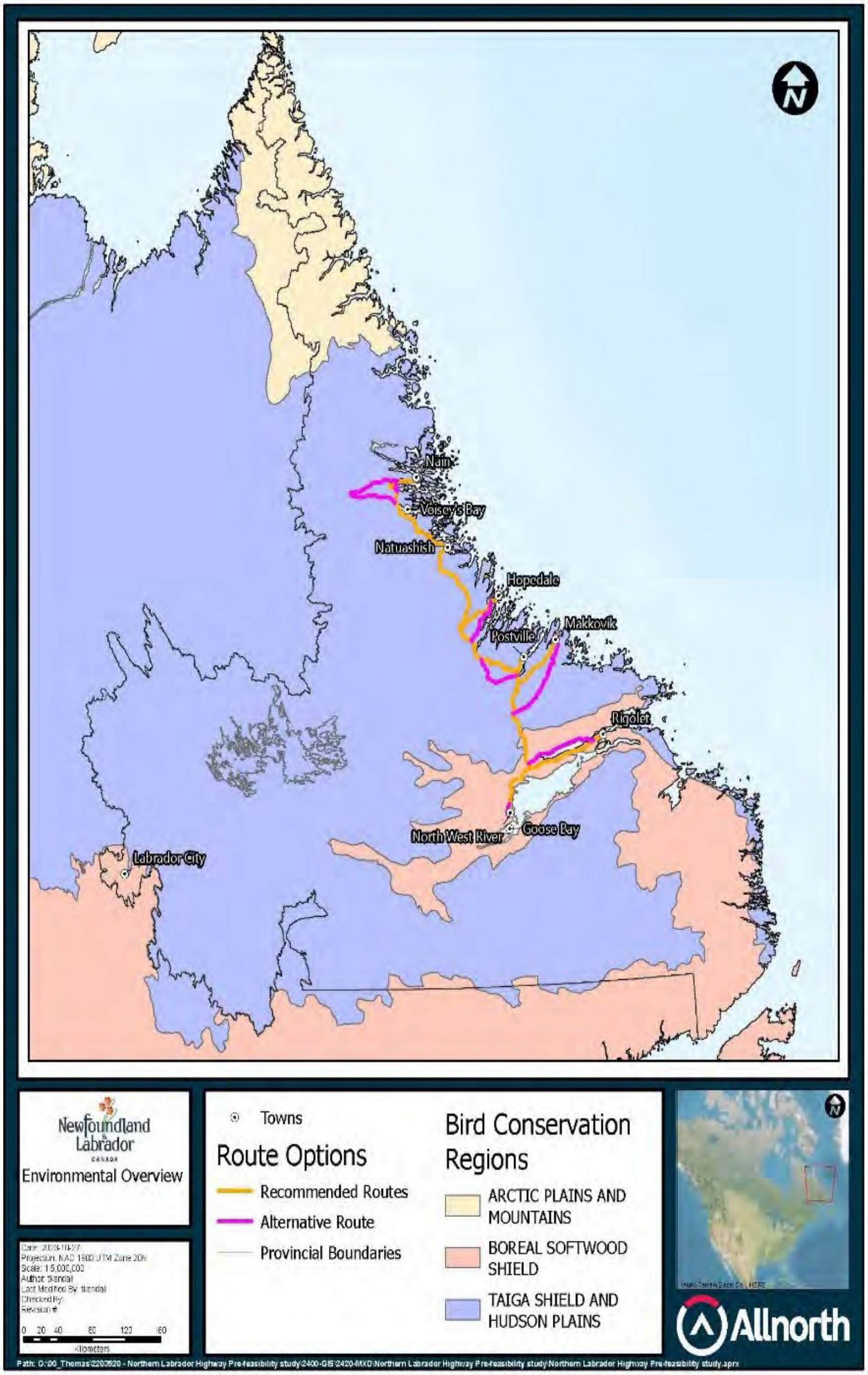

Figure 4.34-Bird Conservation Regions in Labrador

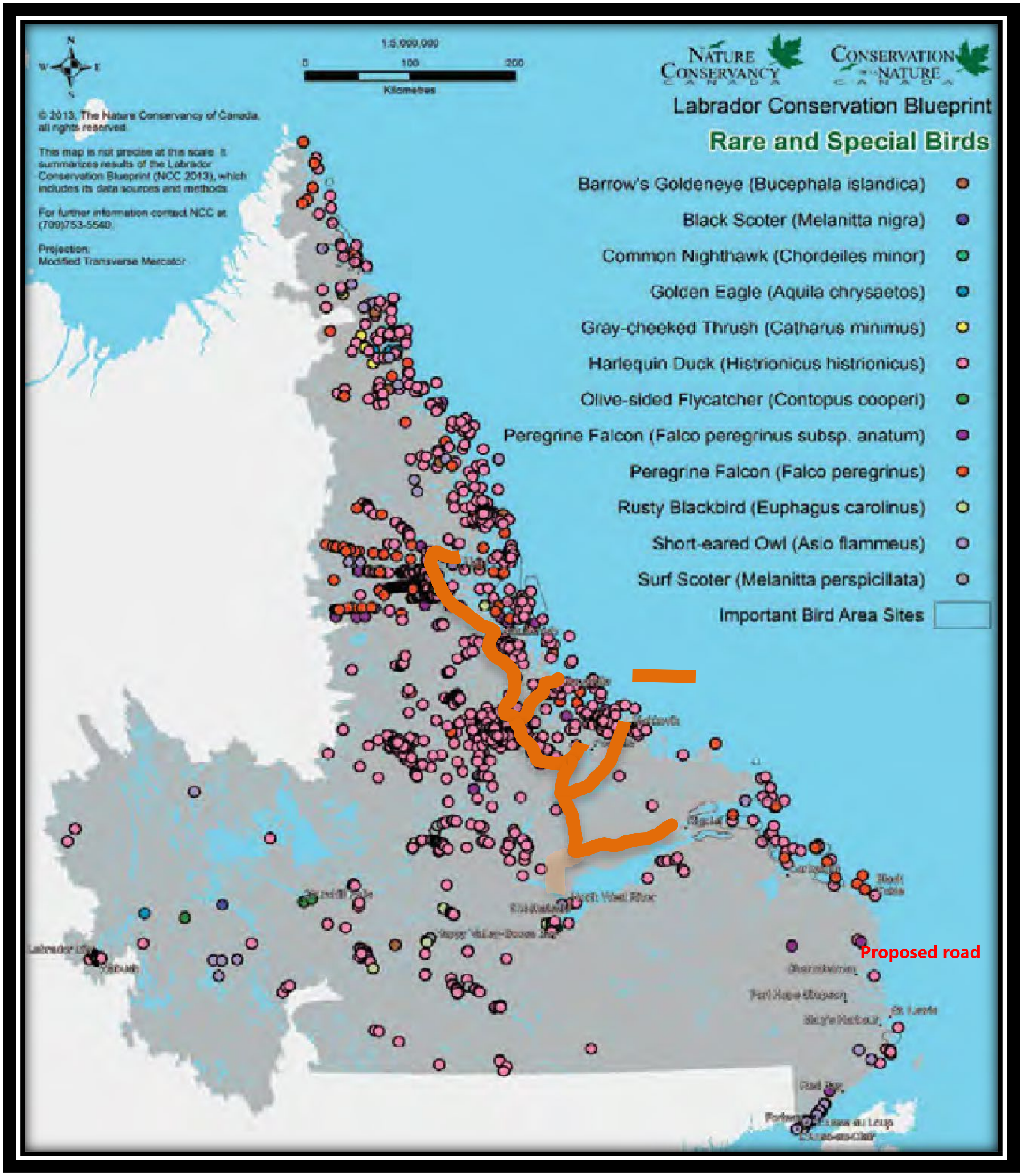

Figure 4.35-Rare and Special Birds in Labrador

4.7.6.4 Invertebrates

There are no known occurrences of rare or endangered invertebrates within the proposed road corridor, and critical habitat areas appear to be primarily coastal. Refer to Figure 4.36.

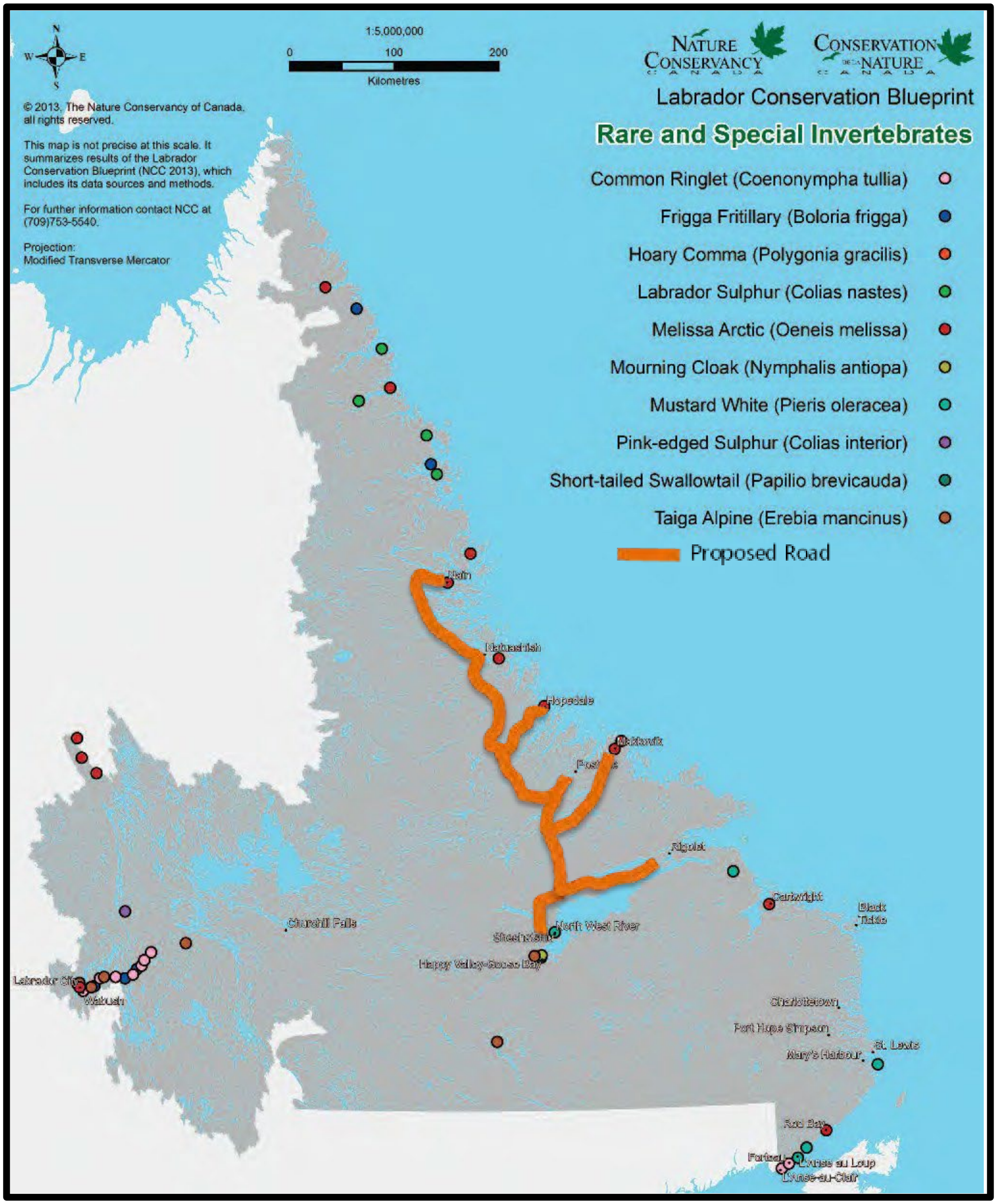

Figure 4.36-Rare and Special Invertebrates in Labrador

4.7.7 Watercourses

Freshwater habitats along the Labrador coast remain largely pristine. The proposed road will traverse several watersheds of productive salmon and Arctic char rivers, with potential for multiple crossings of the rivers or their tributaries (see Figure 4.37). Commercial fish-bearing watercourses (salmon, char, etc.) and their tributaries are regulated under the Federal Fisheries Act (DFO).

Under the Fisheries Act, no one may carry out works, undertakings and activities that result in the harmful alteration, disruption or destruction (HADD) of fish habitat, or the death of fish, unless it has been authorized by DFO. DFO's approval under the Species at Risk Act is also required if an activity affects an aquatic species at risk, any part of its critical habitat or the residences of its individuals.

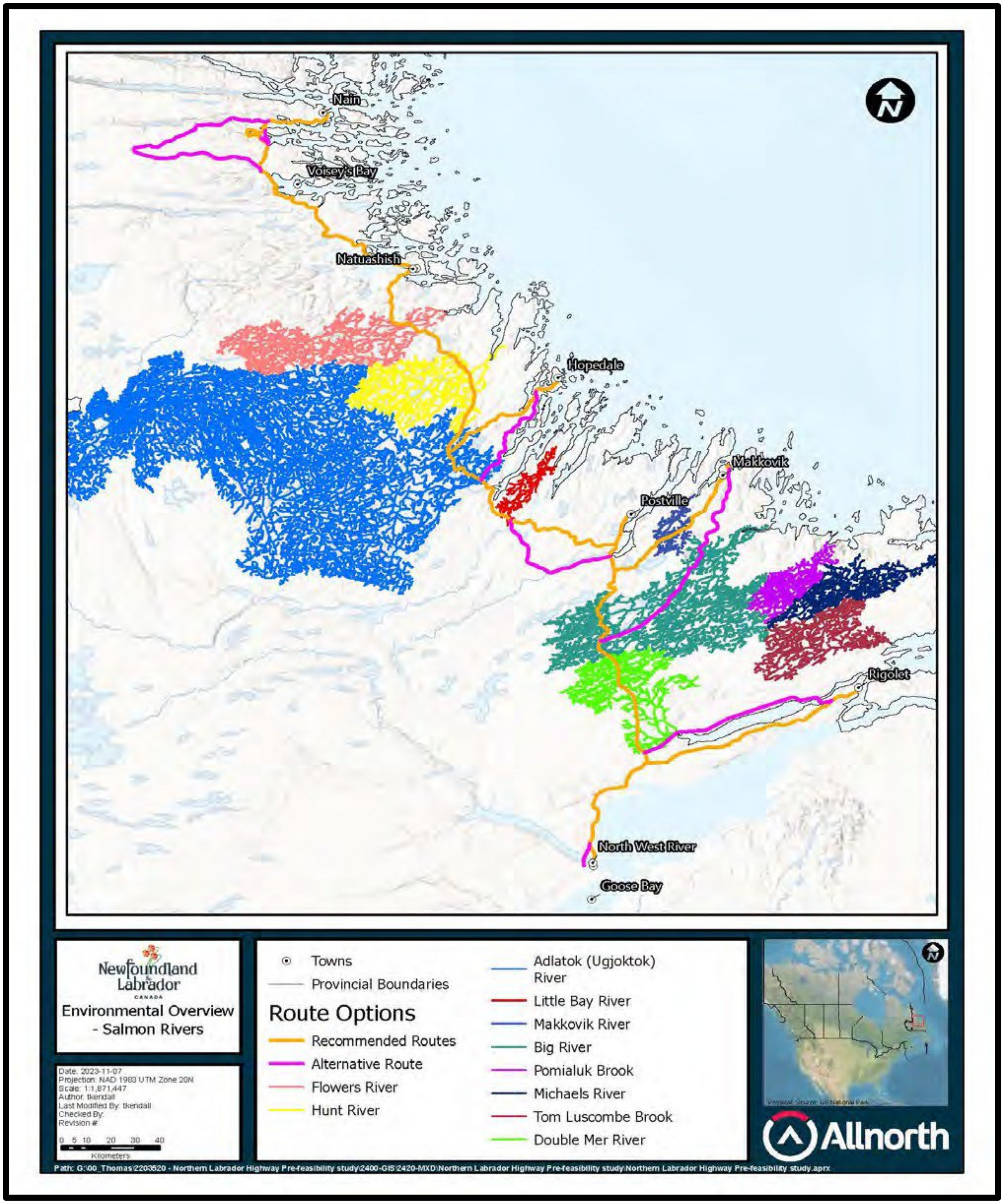

Figure 4.37-Salmon River Watersheds in Labrador

4.7.7.1 Riparian Protection

Riparian vegetation protection is a general best practice for road development, and includes limiting corridor extents within riparian buffer zones, limiting vegetation removal where encroachment is necessary, and enhancing environmental management measures during construction to mitigate impacts to water quality.

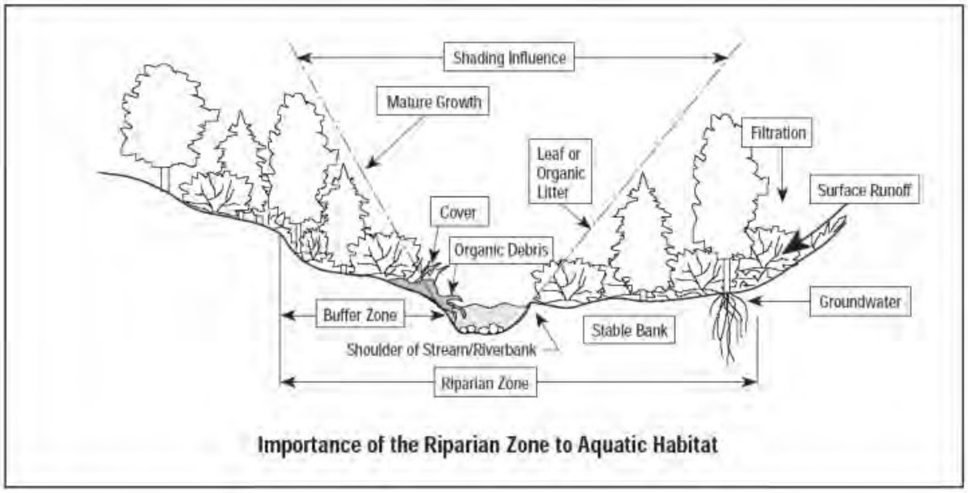

Figure-4.38 Riparian Area Protection

The vegetation in riparian zones is crucial for maintaining and nurturing fish habitat by providing the following:

- Shade - The vegetation along the banks of the watercourse scatters the sunlight and shades the water, protecting it from the heating effects of the direct sun;
- Food - Riparian vegetation contributes insects and detritus such as leaf litter into the watercourse which act as food sources for the fish;
- Shelter - Riparian vegetation, in the form of tall grasses, shrubs and trees, protects fish from predators;
- Erosion Control - The root system of vegetation contributes to bank stability and intercepts runoff which limits erosion and sedimentation, protecting fish habitat from the harmful effects of sedimentation;
- Filter - Vegetation and root systems act to filter out pollutants such as pesticides, bacteria, fertilizers, heavy metals, sediment, and hydrocarbons.

According to the guidebook: Beneficial Management Practices for Riparian Zones in Atlantic Canada[31], the Government of Newfoundland and Labrador has the following criteria for riparian zones *(original source reference not found):*

- Crown land reserve of 15 meters along all water represented on a 1:50,000 NTS topographic map;
- Buffer zone is measured from the high-water mark and is required to be forested;
- 15-meter buffer zone requirement on all watercourses larger than 1 meter wide not represented on a 1:50,000 NTS topographic map, and;
- When the slope of the land exceeds 30% the width of the buffer zone is required to be 15 meters plus 1.5 times the slope (%).

Minimization of works within riparian areas along the proposed road will occur to the greatest extent possible, however crossings will be required to traverse streams and wetland areas. Mapping of stream and wetland crossings and riparian encroachments will occur during the detailed design stage of works. Appropriate crossing structures (bridge, culvert) will be determined based on the hydrology of the watercourse.

A pre-construction survey by a qualified professional to inventory, assess and classify stream crossings within the proposed road corridor will be required for the WRA Section 48 application, with additional Request for Project Review to DFO for fish-bearing waters (including tributaries to salmon rivers).

4.7.7.2 Wetlands

Wetlands are highly productive and biologically diverse habitats that provide ecological and economic services such as habitat for plants and animals, improved water quality, water storage, flood and erosion control, and carbon sequestration. Labrador peatlands are notable for their patterned fens and fen-bog complexes, which provide important breeding habitat for waterfowl and Canada Goose. The proposed road alignment will generally seek to avoid wetland areas as, in addition to the environmental sensitivity of these features, construction conditions are challenging due to the poor soils and drainage.

The following are common elements of wetlands:

- Permanently or seasonally waterlogged;
- Water less than 2 metres in depth;
- Characterized by vegetation that is adapted for life in saturated/flooded soil conditions;
- May be treed, shrubby or open;
- May be stagnant systems or moving/dynamic systems that transport water over long distances;
- Often interconnected with other wetlands, lakes or streams and vulnerable to developments that can block their natural flow;
- Most boreal wetlands are vegetated;
- Water may be present above, at, or below surface production and peat harvest;

Five classes of wetlands occur in Labrador:

- Bogs - are peatlands that receive water only through precipitation. Bogs are nutrient poor and isolated from groundwater and surface run-off. Bogs are stagnant, non- flowing systems and have low plant diversity due to low nutrient availability. The surface of a bog is typically dry, but the thick peat below is saturated with water like a wet sponge. All bogs have a thick ground cover of Sphagnum mosses. Some bogs contain stunted black spruce and low-lying shrubs;
- Fens - are peatlands that receive water from a combination of precipitation, surface runoff and groundwater. They are more nutrient rich than bogs because of surface and groundwater inputs and have greater plant diversity. Fens can be nutrient rich or nutrient poor depending on water sources and nutrient availability. Nutrient-poor fens more closely resemble bogs, while nutrient-rich fens have more diverse and robust vegetation. Fens have a complex hydrology with high water tables, and can transport large volumes of water and nutrients across the landscape often connecting wetland systems over large distances;
- Swamps - are mineral wetlands that may have deeper peat soils in some settings. Swamps receive water from run-off, precipitation and groundwater. Water movement ranges from stagnant to dynamic. They are commonly recognized as shoreline areas of streams, lakes and floodplains. Swamps have fluctuating water tables and are seasonally flooded. They have fertile soils that periodically dry out supporting a diversity of trees, shrubs and other plants. Swamps are distinguished from other wetlands and from upland forests by hummocky ground that may contain pools of water and by a tall dense canopy of water tolerant shrubs or trees;
- Marshes - are often a transition between open water and shorelines. Marshes receive water from precipitation and associated run-off, groundwater and stream inflow and fluctuate seasonally. They have

mineral based soils with shallow organic deposits. Marshes dry out periodically exposing them to oxygen resulting in a nutrient rich area;
- Shallow Open Water - these wetlands have a water depth of less than two metres yet are too deep for emergent plants such as cattails and rushes to become established. Open Water wetlands receive water from precipitation, run-off, groundwater and streams. They look like shallow lakes with pond-lily or submerged aquatic vegetation in more nutrient rich settings. They are generally permanently flooded but may fluctuate seasonally resulting in exposed mudflats.

The Government of Newfoundland and Labrador has established a Policy for Development in Wetlands, which establishes the criteria for issuing a permit under Section 48 of the Water Resources Act for all development activities in and affecting wetlands. The objective of the policy is to permit developments in wetlands which do not adversely affect the water quantity, water quality, hydrologic characteristics or functions, and terrestrial and aquatic habitats of the wetlands.

Per the Policy, the following activities are permissible with written permission:

- 5.2.4 Infilling, dredging, or any other disturbance of wetlands for the construction of permanent or temporary roads, bridges, culverts, trails, power and telecommunication transmission lines, pipelines, etc., through wetlands which would necessitate only minor disturbances to the vegetation and organic cover, the flow drainage pattern of the area and ground slope.

A pre-construction survey by a qualified professional to inventory, assess and classify wetland crossings within the proposed road corridor will be required for the Section 48 application. As feasible, the road alignment should endeavor to avoid wetlands and their riparian areas to the greatest extent feasible.

4.7.8 Parks and Protected Areas

There are no provincial or federal Parks or Protected Areas within the proposed road corridor, aside from a small area north side of Little Lake near North West River that would be traversed in potential Route A2 (see Section 4.4.1.2). This one (1) Provincial Protected Area is identified in the Provincial Land Use Atlas as “Parks: Grand Lake Transfer, 1985”. Refer also to Figure 4.39.

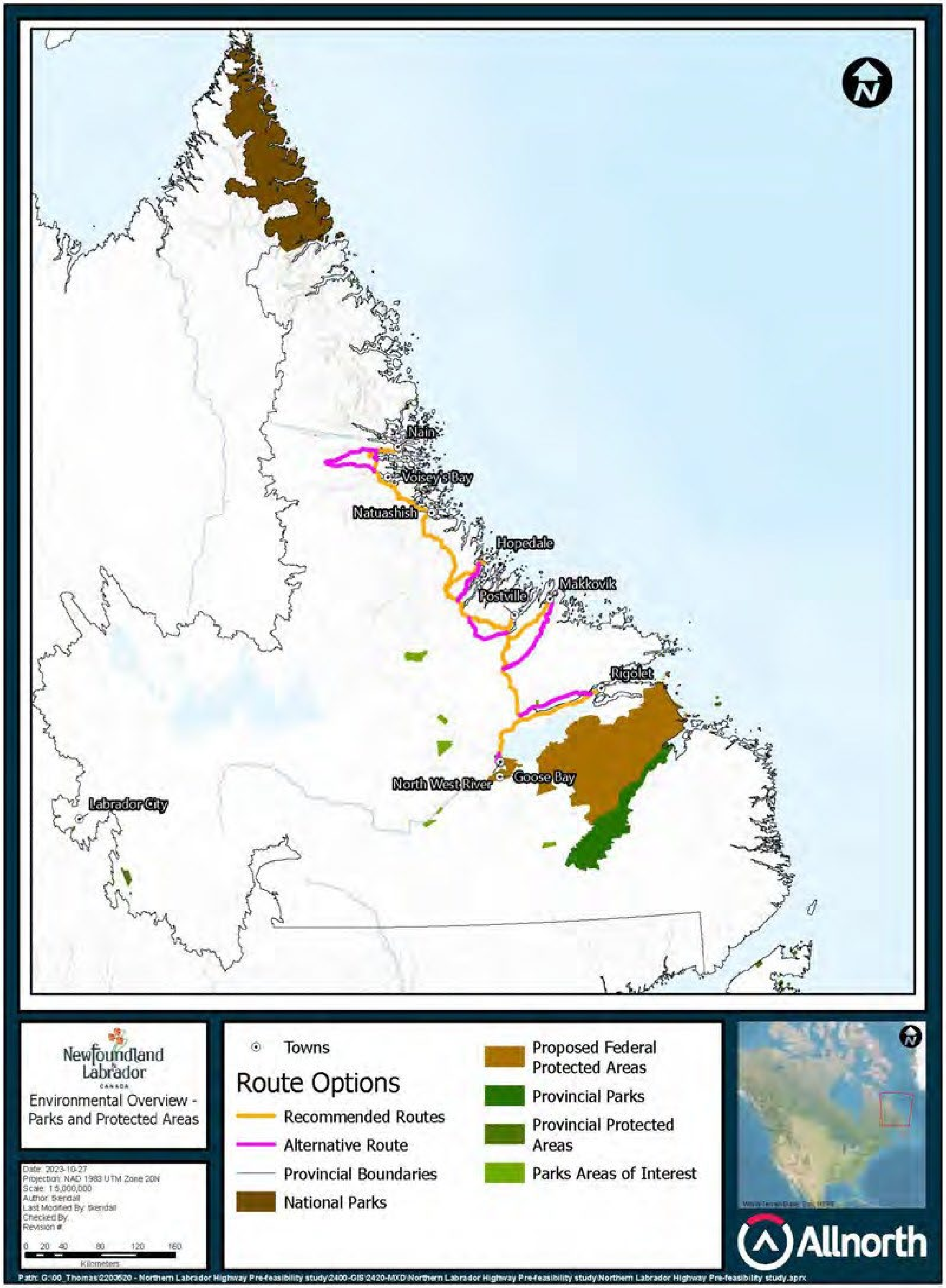

Figure 4.39-Parks and Protected Areas

4.7.9 CONSTRUCTION CONSIDERATIONS

All highway design, construction and maintenance within the Province must follow industry standards for environmental protection, including (but not limited to):

- Government of Newfoundland and Labrador Highways Specifications Book: Division 8 – General Environmental Requirements
- Government of Newfoundland and Labrador Water Management Division - Chapter 10: Environmental Guidelines for General Construction Practices
- Fisheries and Oceans Canada - Codes of Practice
- Fisheries and Oceans Canada - Best Management Practices for the Protection of Freshwater Fish Habitat in Newfoundland and Labrador

4.7.9.1 Construction Scheduling

Appropriate timing of construction of the development will help ensure that terrestrial, riparian and aquatic habitat values and fish and wildlife populations are protected from the adverse impacts.

- Plan construction activities for those times of the year when the potential risk of adverse impacts on wildlife and fish populations is negligible;
- Disruptive, intrusive operations such as blasting should be avoided during those times of the year when wildlife is under significant environmental and physiological stress (such as lambing/kidding/calving season and periods of winter range use);
- Avoid concentrations of wildlife, areas of high value wildlife habitat and/or rare plant communities, when determining locations and routes. A biologist or ecologist specialized in the discipline of concerns must be retained to identified and assess such areas of concern;
- In the event that concentrations of wildlife species are present in the proposed construction area, consider re-scheduling construction and maintenance activities until such time when the numbers of animals present are reduced or absent from the worksite.

4.7.9.2 Vegetation Removal and Reclamation

Maintain habitat values and reduce the potential for deleterious impacts on watercourses through vegetation retention during construction and maintenance of the roadway.

- Restrict vegetation removal to that necessary to meet access needs and maintain slope stability;
- Minimize the clearing right of ways and temporary workspaces;
- Retain as much existing riparian and upslope vegetation as possible, when working near watercourses, to reduce the erosion potential;
- Avoid the unnecessary removal or trimming of woody vegetation. If woody species must be removed, ensure that the herbaceous plant layer remains intact;
- Use alternative methods of vegetation removal to minimize the adverse impacts on ground cover plant species (i.e. high blade, hand cutting);
- During construction, salvage and conserve all topsoil for reclamation purposes;
- For project areas that have been exposed to mineral soil, must be re-countered and re-seeded/planted, utilizing all available techniques to stabilize the site and facilitate its return to a vegetated state;
- Re-vegetate slopes with native and agronomic species where possible, to stabilize the site and prevent the invasion of weed species;
- Ensure that certified seed mixes are utilized for reclamation purposes, to reduce the risk of weed invasion and exotic introductions;

- Avoid the use of legumes (nitrogen fixing plants) species in the seed mix. Legumes are the preferred food source for many ungulates (and other wildlife species), so using a seed mix void of these plants, may reduce the risk of animals being drawn to right of ways in search of this food type;
- Avoid excessive clearing that might impact riparian vegetation at stream crossings, and consider habitat enhancements where rights-of-way cross streams and wetlands;
- Retain and use large woody debris to enhance habitats along corridors but avoid creation of long linear stacks of woody debris (windrows) that might prevent animal movements;
- Top hazard trees at 3–5 m or higher, rather than completely removing them. These rotting snags provide a food source for many species such as woodpeckers and potential nesting sites for owls and other wildlife.

4.7.9.3 Invasive Plants

- Be alert for new invasive plants growing along rights of way and remove them promptly before they become established and spread;
- Avoid excessive soil disturbance when removing invasive species, as this will encourage new invasions;
- Re-vegetate all cleared areas promptly with high quality native seed and low-growing plants to reduce weed establishment. This also minimizes encroachment by trees and shrubs which might block sightlines;
- Minimize use of herbicides by implementing integrated pest management (IPM) approaches. In many cases, once-annual mowing of roadsides can help to prevent invasive species from becoming established and setting seed;
- Pressure-wash machinery between work sites to reduce the risk of spreading seeds of invasive species from one place to another.

4.7.9.4 Erosion and Sediment Control

The potential for deleterious impacts to terrestrial and aquatic ecosystems will be minimized through site stability/suitability assessment and erosion control planning during construction.

Protection of salmon-bearing watersheds will be of critical importance during construction of the proposed road, as disturbances may trigger the Federal Fisheries Act (DFO) S.34, which prohibits activities that cause release of deleterious substances (including sediment) to fish- bearing waters:

- Canada Fisheries Act, "deleterious substance" means:
  - any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water; or
  - any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.

Protection of the natural environment during construction will be enhanced with proper implementation of Erosion and Sediment Control (ESC) best practices:

- Prepare detailed plans for sediment and erosion control prior to any work;
- Protect water quality by directing surface runoff into swales or constructed wetlands;

- If pre-planning activities reveal that acid generating rock formations will be exposed during construction, ensure that an acid rock drainage-monitoring program is in place for the project, to ensure the protection of aquatic resources in the area;
- Identify regions of concern such as slide prone areas, concave slope and areas with erodible soils;
- Evaluate the time of year (seasonality) when project construction activities are to be initiated. Construction activities proposed on highly erodible soils should be constructed during the dry summer months;
- Ensure that appropriate erosion and sediment control structures are in place prior to the commencement of construction activities;
- Routinely inspect and maintain as necessary, installed erosion and sediment control structures, especially during times of seasonal melt or increased precipitation;
- Keep the erosion and sediment control measures in place until disturbed ground has been stabilized;
- Review weather advisories and schedule work to avoid wet, windy and rainy periods that may result in high flow volumes and/ or increase erosion and sedimentation;
- Minimize earthmoving activities when soils appear excessively wet;
- Install settling basin and/or filtration system for water flowing onto the site and water being pumped or diverted from the site, including:
  - holding back runoff water until suspended sediment has resettled in the settling basin and runoff water is clear; and
  - dewatering gradually to prevent sediment resuspension and bank destabilization.
- Disposing of and stabilizing all excavated material at least 30 m from the high-water mark or top of bank of nearby waterbodies and ensuring sediment re-entry to the watercourse is prevented;
- Regularly monitor nearby watercourse for signs of sedimentation during all phases of the work, undertaking or activity and taking corrective action if required;
- Use biodegradable erosion and sediment control materials whenever possible and removing all exposed non-biodegradable erosion and sediment control materials once site is stabilized;
- Ensure that site supervisors and contractors performing construction/maintenance activities are familiar/experienced with working in areas of erodible/fine soils, unstable terrain or in proximity to fish-bearing watercourse to reduce the potential deleterious impacts.

4.7.9.5 Spill Prevention and Response

No substance, sediment, debris or material that could adversely impact the stream is permitted to enter the stream or stream channel without the specific consent of Ministry and DFO.

- Ensure equipment utilized during in-stream works:
  - Is clean and in good operating condition (i.e. no hydraulic leaks);
  - Is fuelled at least 100 m away from any watercourse;
  - Has an appropriate number of spill kits.
- Develop a response plan to be implemented immediately in the event of a spill of a deleterious substance;
- Keep sufficient emergency spill kit(s) on site;
- Stop work and contain deleterious substances to prevent dispersal;
- Report any spills of sewage, oil, fuel or other deleterious material whether near or directly into a water body;
- Ensure clean-up measures are suitably applied so as not to result in further alteration of the bed and/or banks of the watercourse;
- Clean up and appropriately dispose of the deleterious substances;
- Maintain all machinery on site in a clean condition and free of fluid leaks to prevent any deleterious substances from entering the water;

- Washing, refueling and servicing machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water;
- Ensure that building material used in a watercourse is handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

4.7.9.6 Instream Works

- Natural stream flows must be maintained during all in-stream activities, such that there isn't any modification to flow or water level, nor obstructing or interfering with the movement and migration of fish;
- Any in-stream worksite must be isolated from stream flow. Construction site isolation minimizes the erosional and sedimentary impacts that in-stream disturbances can create. Suggested examples of diversions include dam/pump, dam/flume, or other similar structures. In other site-specific situations however, silt barriers or fences may be appropriate;
- A fish salvage may be required prior to de-watering an area in order to create an isolated worksite on fish bearing streams or streams suspected of being fish bearing. This salvage must be done before any in-stream work activities occur. Fish captured from within an isolated worksite must be returned to a suitable in-stream location. Permits for fish salvage would be required;
  - Fish salvage must be conducted by a qualified individual/company.
- Any rock used as rip rap must be:
  - Durable, clean and free of organic debris;
  - Non-acid-generating;
  - Angular in shape, large enough in size and keyed into the banks to prevent movement under various hydrological conditions;
  - Placed in a manner that does not constrict the stream channel.
- Any cast in place concrete must be isolated from fish bearing waters until completely set (approximately 48 hrs);
- Blasting criteria as per DFO Regulations needs to be maintained at any stream crossing.

4.7.9.7 Bird Nest Survey

Prior to vegetation removal/disturbance, a pre-construction nesting survey should be performed to identify any active nests present within the construction footprint, including raptor nests. Nesting surveys are typically valid from 3-7 days, depending on the site conditions, and can be performed by onsite Environmental Monitors incrementally as clearing activities progress. During construction of the proposed road, nesting surveys would generally be required from Late May to Late July. Any active nests would have a no-disturbance buffer applied until the nestlings fledge. Refer to Figure 4.40 for Bird Nesting Zones and timing windows in Labrador.

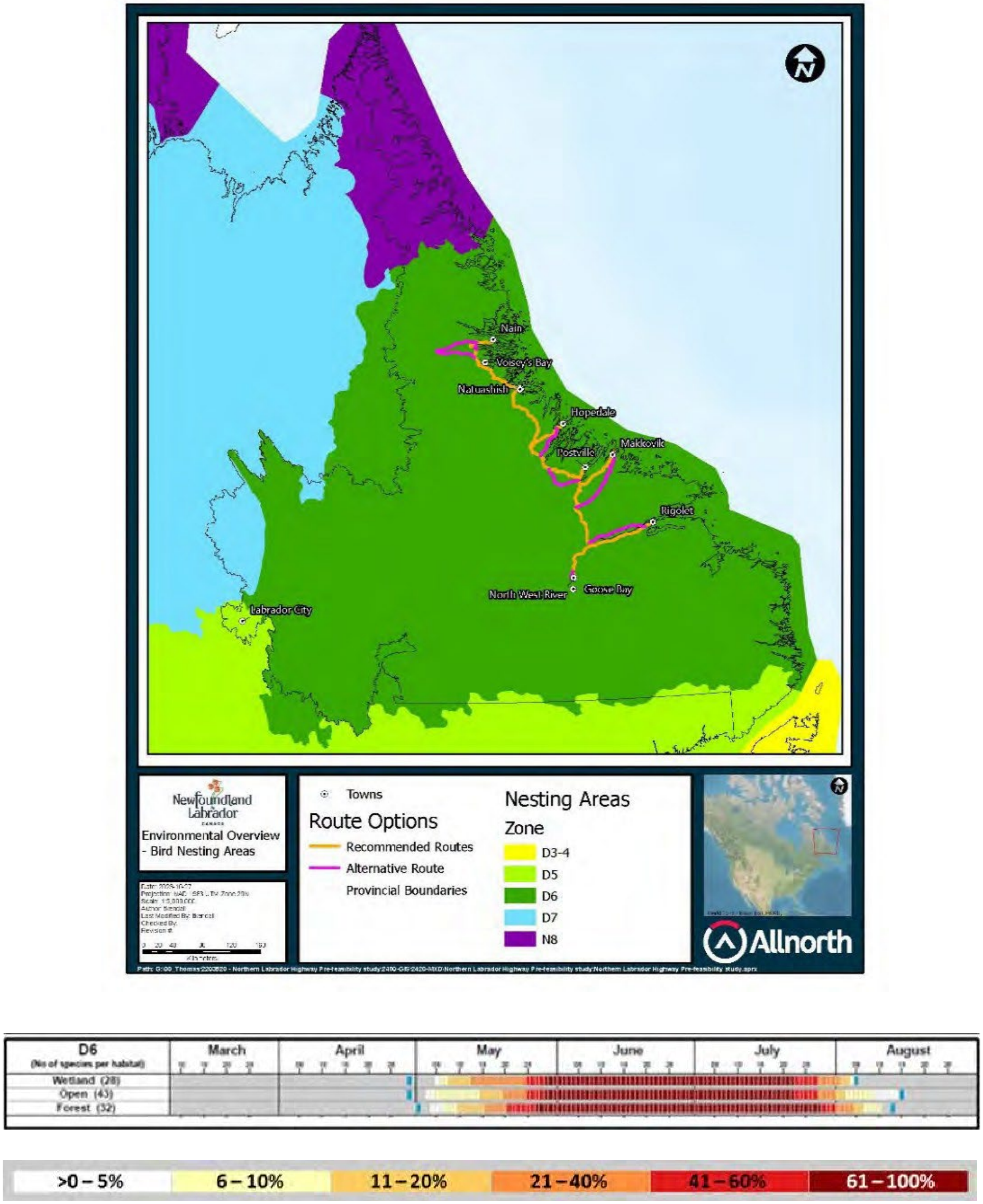

Figure 4.40-Bird Nesting Zones and Timing Windows in Labrador (D6)[32]

4.7.9.8 Snow Management

- During snow clearing activities, if feasible, a layer of snow pack should remain on gravel areas/road ways to prevent debris and material from contaminating equipment and being transported;
- Wildlife escape routes through snow banks on each side of ploughed roads should be maintained;
  - At least every 500 m along a ploughed roadway, a 'wildlife escape route' will be made and maintained;
  - Escape routes will be at least one blade width wide and extend to the edge of the surrounding vegetation to enable individual animals to exit the roadway.
- Snow should be deposited in a location that considers safety and access, and will not melt into any sensitive environmental features (streams, wetlands, etc);
- Snow should not be stockpiled in a location that may cause erosion or bank instability;
- Snow ploughing into ditch lines should be avoided to the greatest extent practicable, to facilitate drainage during freshet conditions.

4.7.9.9 Maintenance Camps

Development of the proposed road will necessitate temporary or permanent work and maintenance camps along the alignment. Camps will typically require housing, fuel storage, machinery storage, and domestic amenities (water, sewer, waste disposal).

- Local health authorities will dictate requirements for water and sewage disposal, and appropriate permits for operation will be required;
- Fuel storage should not be located within 30 m of any watercourse, and secured with double-walled tanks and adequate spill response equipment;
- Waste storage should be animal-proof, and any incinerators should be designed for full combustion;
- Fencing or other wildlife deterrents should be considered, to mitigate potential for human-wildlife interaction.

4.7.10 Summary

Environmental Feature	Pre-Design Information Requirements	Pre-Construction Activities	Construction Activities
Geology	Alignment reviewed against available surface soil information. Areas of sediment deposits should be avoided as feasible. Large cuts in unstable areas may require geotechnical assessment. Assessment for potential locations of ML/ARD rock.	Preparation of Erosion and Sediment Control Plan, with Site-Specific prescriptions as appropriate. Areas of sediment deposits should be flagged in design, with pre-construction planning for appropriate ESC. ML/ARD Management Plan .	Periodic Environmental Monitoring. Areas with seepage/erosion evident may require geotechnical stabilization.
Vegetation	Review of alignment by a qualified professional to identify any rare/endangered species. Realignment to avoid critical habitat if feasible, or appropriate permits for destruction of habitat.	Preparation of Vegetation Management Plan. Any identified sensitive areas should be clearly flagged prior to construction. Consideration for spring/summer preparations for fall/winter works (where vegetation not visible)	Implementation of Vegetation Management Plan, minimization of areas of disturbance and prompt revegetation seeding to minimize duration of exposure.
Wildlife	Review of alignment by a qualified professional to identify any rare/endangered species, wildlife features and critical nesting sites. Realignment to avoid critical habitat if feasible, or appropriate permits for destruction of habitat.	Preparation of Wildlife Management Plan. Pre-construction surveys for dens/nests/wildlife activity within the alignment.	Implementation of Wildlife Management Plan. Scheduling of activities to avoid vegetation disturbance within Bird Nesting Window. Nesting surveys during clearing activities within window, buffers as needed.
Watercourses	Crossings of fish-bearing rivers and their tributaries will require review by DFO. No harmful alteration, disruption or destruction of fish habitat may occur without approval. Clear-span structures generally avoid regulatory requirements. Approvals from DFO (Project Review) and Ministry (Water Resources Act). Review of alignment by qualified professional to identify streams, wetlands and other water features that may require design consideration, including protection/avoidance of crossings and riparian areas.	Preparation of Erosion and Sediment Control Plan. Site-specific planning for crossing construction. Any identified sensitive areas should be clearly flagged prior to construction. Consideration for spring/summer preparations for fall/winter works (where water features not visible)	Implementation of Erosion and Sediment Control Plan, Spill Prevention and Response Plan. Environmental monitoring, including water quality monitoring, during construction in vicinity of active watercourses/features.
Parks and Protected Areas	N/A	N/A	N/A

5 PRE-FEASIBILITY COST

5.1 Background

The cost of constructing and maintaining roads in Northern Labrador is impacted by the challenges of delivering materials and equipment to remote areas, providing accommodations for workers, a challenging terrain and relatively short construction season. Maintenance costs are also impacted by similar challenges as well such as long winter seasons that impact snow removal and ice control.

For a pre-feasibility study, there is limited information available that can be used for cost estimating. Topographic maps, aerial imagery, software applications (i.e., ArcGIS, Google Earth Pro) are useful in determining such things as type of terrain, steepness of slopes, water bodies and stream/river crossing widths. At this stage, many assumptions must be made regarding items that are unknown such as the quality of materials to be excavated along the route and suitability for embankment construction.

For this analysis, the project cost is estimated by calculating anticipated quantities based on available information and applying historical unit prices. This method takes into consideration specific information along the routes such as the topography and number of river/stream crossings. Allowances are made for any unknowns.

5.2 Historical Unit Prices

Historical unit bid prices for Labrador (2019-2022) are adjusted for inflation to predict current pricing. Also, adjustments are made to reflect differences in location. For example, historical bid prices for work in Northern Labrador are significantly higher than those on the island area of the province and they are also higher than those in southern Labrador. This is attributed to many factors such as the challenges of mobilization and demobilization to a remote area, travel cost (e.g., airfare), limited services and accommodations and limited competition.

Most of the individual unit prices for this study were based on bid prices for other road projects in Labrador including:

- **Project 85-19THR** - Upgrade and Pave 11KM of Route 510, KM 66 to KM 77 between County Cat Pond and Red Bay, Labrador;
- **Project 86-19THP** - Paving of Route 510 Trans Labrador Highway, Goose Bay towards Cartwright Junction from KM 160 to KM 287.3 at Cartwright Junction;
- **Project 64-20THP** - Upgrade and Pave 11KM of Route 510, KM 66 to KM 77 between County Cat Pond and Red Bay, Labrador;
- **Project 130-22 Part 'A'** – Rehabilitate and Pave Sections of Route 520, Northwest River Road between Dump Road Access and Goose River Bridge, KM 13.9 - KM 19 & Part 'B' - Rehabilitate and Pave Sections of Route 520, Northwest River Road from Goose River Bridge toward Gosling Lake, KM 19 - KM 22.

Bridge construction costs will vary significantly depending on the site conditions, type of structure, length of structure, etc. For this study, bridge construction costs were estimated by reviewing the costs of other bridge construction projects throughout the province and calculating a cost per meter based on each bridge length. Bridge project costs were provided by DTI related to provincial bridge construction projects throughout the province during the period from 2015 to 2023. Also, information on bridge construction costs for the period from 2010 to 2013 were obtained from a report retrieved from www.nlcpr.com/NewfoundlandAndLabrador_Highways.php.

5.3 Costing Assumptions and Methodology

To prepare current estimates of costs, the following allowances and assumptions have been used:

- A contingency of 15% of the overall construction costs to make allowances for miscellaneous items that are difficult to quantify at this stage and not captured under the other estimated items;
- Due to the remoteness of the site, mobilization and demobilization will be the maximum permitted under DTI's specifications[29] (15% of the overall construction costs);
- The road between North West River and Voisey's Bay to be built to 'RLU-80" cross-section. The road between Voisey's Bay and Nain and access roads to Rigolet, Makkovik, Postville and Hopedale to be built to "RLU-70 Modified" cross-section[29]. Refer to Appendix E for DTI Highway Design Division Information on typical cross section construction details;
- Clearing quantity is based on an estimated percentage of the overall route where vegetation is evident from aerial photography;
- Grubbing quantity is based on an estimated percentage of the overall route based on a review of aerial photography;
- Grading quantities are an estimate of the amount of fill, cuts, borrow, excavation of ditches, excavation of muskeg or bog including overhaul. The quantity is estimated with the assumption that, as a minimum, one meter (1 m) of fill will be required on average throughout. This will allow for minor cuts and fills in relatively good topography with gentle slopes. In areas where the terrain is steeper, the depths of the cuts and fill will increase. Therefore, on segments with the most grade violations, it is assumed 2.5m of fill will be required on average. Other segments are assumed to fall within this range based on the number of grade violations. The estimated unit price for this item is assumed to be an average of "Solid Rock" and "Other Material" unit prices;
- For the road construction phase, a 250mm layer of Maintenance Grade No. 3 will be used to provide a suitable driving surface;
- Paving will be completed in a later phase. The road surface will be scarified and reshaped and then resurfaced with 150mm of Granular 'B', 100mm of Granular 'A' and 50mm of Surface Course Asphalt as per the standard cross-sections;
- Large diameter culverts (i.e., >1000 mm diameter and ≤ 3000 mm diameter range) are required at all locations where watercourses are visible on 1:50,000 topographic maps and are depicted as a single line;
- Bridge structures are required at all locations where watercourses are visible on 1:50,000 topographic maps and are depicted as double lines. The watercourse widths in those instances are measured in Google Earth Pro and/or Arc GIS (bank to bank);
- Small diameter culverts (i.e., 600 mm diameter to 1000 mm diameter range) will be required for local drainage from roadside ditches and small depressions. These do not include any water courses that are visible on 1:50,000 topographic mapping. It is assumed that there will be at least one waterway crossing every 400 m along a route. The small diameter crossings are calculated by dividing the segment length by 400 m and subtracting the number of watercourse crossings visible on topographic mapping;
- Single-post signs (Type "A" and Type "B') will be required for regulatory signs such as speed limits and warning signs such as approaches to curves or steep grades. The actual number of signs will depend on the final design characteristics of the road. For this study, one (1) Type "A" or Type "B" sign is assumed per kilometer of road;
- Double-post signs (Type "C" and Type "D") will be required at the beginning/ends of route segments for information purposes such as directions and distances. For this study, four (4) Type "C" or Type "D" signs are assumed per end of each route segment;
- Guide rail will be required throughout the routes in areas where heights of embankments are excessive, where the road is adjacent to water bodies and in other areas as deemed necessary during the detailed road design process. Generally, high embankments will be a function of the number of steep grades in a road segment which often result in more extensive cuts and fills to meet the vertical alignment criteria. For this study, an allowance is made for guiderail based on the following:
  - 200 m per kilometer for route segments with the least number of steep grades;
  - 500 m per kilometer for route segments with the greatest number of steep grades;

  - Other route segments are assumed to fall in between this range based on the number of steep grades.
- Maintenance depots will be required along the routes. An allowance of one (1) depot per 100 kilometers of road based on information provided by DTI. Each depot will require:
  - Salt storage shed;
  - Single-bay heavy equipment garage;
  - Small office with stockroom, washroom, and kitchen/eating area;
  - Water and sewer services (i.e., drilled well and on-site sewage system);
  - Electrical services (i.e., diesel generator).

5.4 Rough Order of Magnitude (ROM) Unit Price Estimates

For this study, two (2) ROM cost estimates (±50%) were prepared:

- The first estimate is for construction of 809 km of gravel-surface roads that can be opened to traffic upon completion (see Table 5.1). The cost of road construction is estimated at approximately $2,089,790,000;
- The second estimate is for 809 km of paving (see Table 5.2). The cost of paving is estimated at approximately $602,393,000.

These estimates are based on 2023 costs without any adjustment for future inflation. Increases due to inflation over the construction period of the project can be expected and this will depend on project construction timelines. These estimates will be refined in future studies and during the design phase if the project moves forward.

NO.	TENDER ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
DIV. 1	**GENERAL**				
156	Contingency Amount (15%)	Lump-Sum	176,160,000	1.00	176,160,000
157	Mobilization & Demobilization	Lump-Sum	229,600,000	1.00	229,600,000
DIV. 2	**GRADING**				
202	Clearing	ha	1,800	6,000.00	10,800,000
203	Grubbing	ha	1,200	7,000.00	8,400,000
204, 206, 207, 208, 212	Grading of Fill / Grading of Cuts / Borrow / Excavation of Ditches / Excavation of Muskeg or Bog including Overhaul	m^3	17,130,000	22.00	376,860,000
DIV. 3	**PAVEMENT, SELECTED GRANULAR BASE COURSE AND RELATED MATERIALS**				
315	**Selected Granular Base Course**				
315(a)	Maintenance Grade No. 3 (250 mm Thick)	tonnes	4,113,000	32.00	131,616,000
DIV. 4	**DRAINAGE RELATED ITEMS**				
421	**Supply and Installation of Pipe Culverts Aluminized Type 2**				
421(a)	600 mm to 1000 mm Diameter c/w Dewatering, Excavation, Bedding, Rip Rap	m	28,700	1,000.00	28,700,000
421(b)	1200 mm to 3000 mm Diameter c/w Dewatering, Excavation, Bedding, Rip Rap	m	10,400	4,000.00	41,600,000
DIV. 5	**MISCELLANEOUS ITEMS**				
580	**Sign & Signpost Installations**				
580(a)	Supply & Install Type 'A' & Type 'B'	each	750	360.00	270,000
580(b)	Supply & Install Type 'C' & Type 'D'	each	90	1,900.00	171,000
DIV. 6	**PROTECTION**				
640	Standard Type Guide Rail c/w Buried Ends	m	246,900	160.00	39,504,000
DIV. 9	**STRUCTURES**				
904	**Concrete Structures**				
904(a)	Bridge Construction, ≤150m Crossing c/w Dewatering, Excavation, Backfill, Rip Rap, Approach Guide Rail etc.	m	1,500	175,000.00	262,500,000
904(b)	Bridge Construction, >150m Crossing c/w Dewatering, Excavation, Backfill, Rip Rap, Approach Guide Rail etc.	m	1,100	200,000.00	220,000,000
Other	**MAINTENANCE DEPOTS**				
n/a	Maintenance Depot Construction c/w Site Work, Water Supply, On-site Sewage Disposal System, Power Supply, Office/Stock Room/Kitchen Building, Single-bay Heavy Equipment Garage & Salt Shed	Lump-Sum	9	6,000,000.00	54,000,000
				Construction Total:	1,580,181,000
				Engineering (15%):	237,027,150
				HST (15%):	272,581,223
				Total:	2,089,789,373

Table 5.1-ROM (±50%) Estimate – Construction of 809 km Road into Northern Labrador

NO.	TENDER ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
DIV. 1	**GENERAL**				
125	Wages of Flagperson	Hours	227,000	30.00	6,810,000
156	Contingency Amount (15%)	Lump-Sum	51,779,000	1.00	51,779,000
157	Mobilization & Demobilization	Lump-Sum	58,524,000	1.00	58,524,000
DIV. 3	**PAVEMENT, SELECTED GRANULAR BASE COURSE AND RELATED MATERIALS**				
301	Scarifying and Reshaping	m^2	6,270,000	2.00	12,540,000
315	**Selected Granular Base Course**				
315(a)	Granular "A" (100 mm Thick)	tonnes	1,480,000	32.00	47,360,000
315(b)	Granular "B" (150 mm Thick + Shouldering)	tonnes	3,397,000	30.00	101,910,000
330	**Hot-Mix Asphalt**				
330(a)	Asphaltic Surface Course (50 mm Thick)	tonnes	709,000	110.00	77,990,000
330(b)	Liquid Asphalt	tonnes	46,100	2,100.00	96,810,000
330(c)	Blending Sand	tonnes	70,900	25.00	1,772,500
				Construction Total:	455,495,500
				Engineering (15%):	68,324,325
				HST (15%):	78,572,974
				Total:	602,392,799

Table 5.2-ROM (±50%) Estimate – Paving of 809 km Road into Northern Labrador

5.5 Maintenance/Operational Considerations and Costs

In addition to the cost of constructing and paving a road into Northern Labrador, there will be ongoing maintenance costs associated with general road maintenance, structure maintenance as well as snow removal and ice control. Typical maintenance activities include:

- Scarifying and reshaping;
- Brush clearing;
- Ditching;
- Sign repairs;
- Guide rail repairs;
- Bridge/culvert inspections & repairs;
- Snow removal;
- Ice control.

DTI reported maintenance cost of a paved road in Labrador is currently approximately $13,500 per kilometer which includes summer and winter maintenance and the purchase of road salt.

Road maintenance costs in Northern Labrador are expected to be higher due to the remoteness of the location which will increase delivery costs of maintenance equipment, materials and supplies including fuel. Extended winter conditions further north will increase snow clearing and ice control costs. Furthermore, if the road into Northern Labrador is not paved, additional maintenance costs can be expected for periodic grading and replacement of surface granulars.

At DTI's current cost per kilometer for a paved road in Labrador plus an additional 20% as an allowance for the more remote location and extended winter seasons, maintenance of 809km of road in Northern Labrador is estimated at approximately $13M annually.

5.6 Project Phasing

5.6.1 Phasing Considerations

To effectively construct a road into Northern Labrador, work must be completed in phases that optimize access to each area in a manageable sequence. For example, building the road from several available access points permits multiple contractors to work simultaneously. Constructing access to river crossings in the early stage will expedite bridge construction for access to points beyond.

Some of the key considerations for phasing of this project include:

- Province's overall goal with respect to a possible start date and timeframe for completion;
- Community access priorities;
- The number of access points to work areas;
- Location of major river crossings that limit access beyond that point until bridge construction is completed;
- The number of qualified contractors available;
- The size of contracts that a contractor can reasonably manage;
- Funding partnerships.

In the following analysis, it is assumed that a contractor can construct fifteen (15) km of road per year and each river crossing will add one additional year to the schedule. This will vary throughout the project depending on the nature of the topography and width of river crossings. In some instances, a temporary bridge can be installed to facilitate construction beyond the bridge to avoid delays in the schedule.

5.6.2 Possible Phasing Scenario

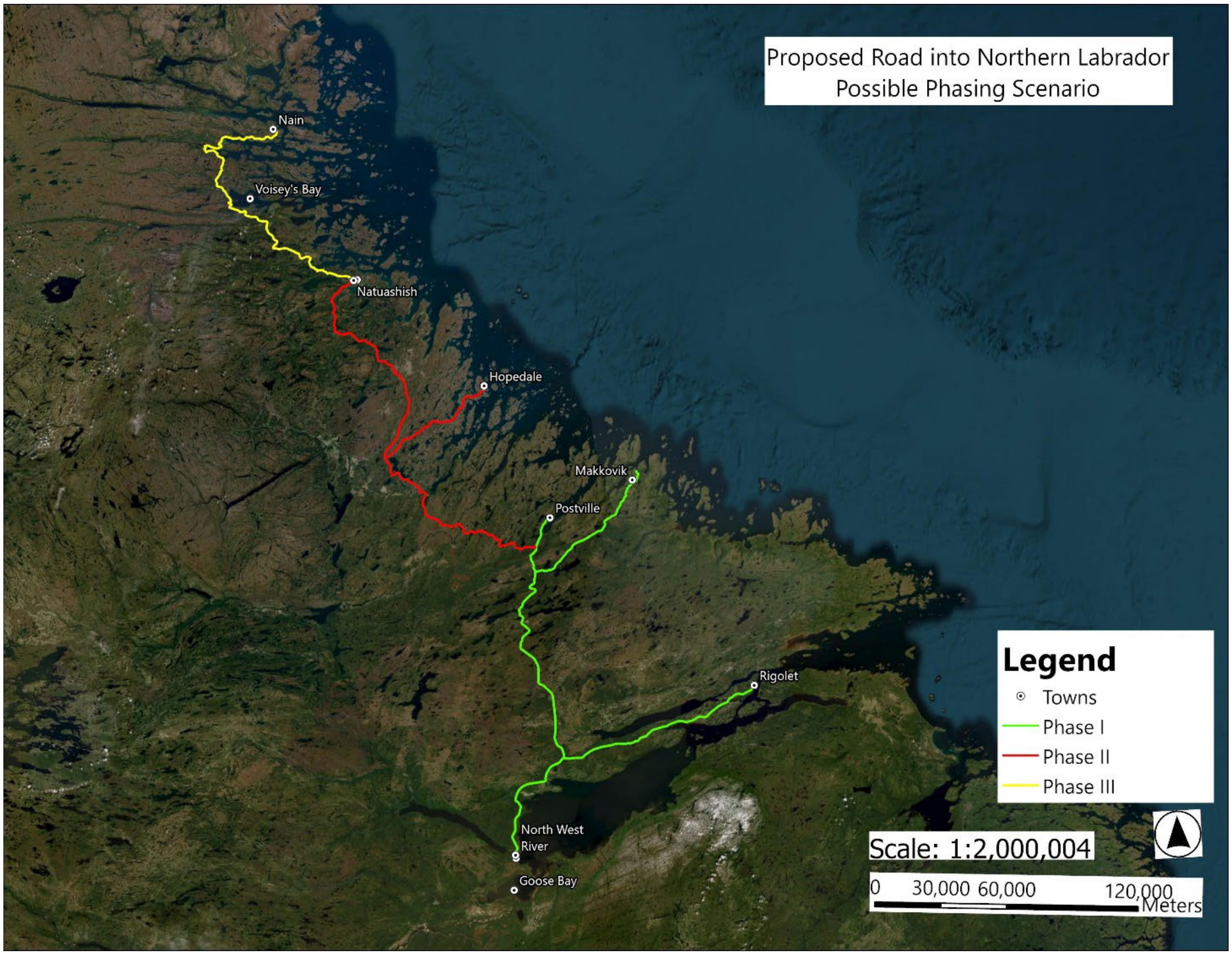

Figure 5.1-Possible Phasing Scenario

<u>Phase I</u>

Construction of road from North West River to Postville including Access Roads to Rigolet and Makkovik.

Total length of Phase I: 365 km
Total population connected at the end of Phase I based on 2021 census: 880 (25%)

Schedule:

- Year 1: Commence construction from North West River towards Rigolet Junction.
- Year 1: Commence construction from Rigolet towards Rigolet Junction.
- Year 1: Commence construction from Makkovik towards Makkovik Junction.
- Year 1: Commence construction from Postville towards Postville Junction.
- Year 2: Postville Access Road completed.
- Year 3: Commence construction from Postville Junction towards Makkovik Junction.
- Year 4: Postville Junction to Makkovik Junction completed.
- Year 5: Commence construction from Makkovik Junction towards Rigolet Junction.
- Year 6: Makkovik Access Road completed.
- Year 6: North West River to Rigolet Junction completed.

- Year 7: Commence construction from Rigolet Junction towards Makkovik Junction.
- Year 7: Rigolet Access Route completed.
- Year 11: Rigolet Junction to Makkovik Junction completed.

Phase II

Construction of road from Postville Junction to Natuashish including Access Road to Hopedale

Total length of Phase II: 279 km

Total population connected at the end of Phase II based on 2021 census: 2332 (66%)

Schedule:
- Year 1: Commence construction from Postville Junction towards Hopedale Junction
- Year 1: Commence construction from Natuashish towards Hopedale Junction
- Year 1: Commence construction from Hopedale towards Hopedale Junction.
- Year 4: Hopedale Access Road completed.
- Year 5: Commence construction from Hopedale Junction towards Postville Junction.
- Year 5: Commence construction from Hopedale Junction towards Natuashish.
- Year 10: Postville Junction to Hopedale Junction completed.
- Year 10: Hopedale Junction to Natuashish completed.

Phase III

Construction of road from Natuashish to Nain

Total length of Phase III: 165 km

Total population connected at the end of Phase III based on 2021 census: 3536 (100%)

Schedule:
- Year 1: Commence construction from Natuashish towards Voisey's Bay.
- Year 1: Commence construction from Voisey's Bay towards Nain.
- Year 1: Commence construction from Nain towards Voisey's Bay.
- Year 4: Voisey's Bay to Nain completed.
- Year 6: Natuashish to Voisey's Bay completed.

Under this scenario, Phases II and III can occur simultaneously with Phase I if the intention is to complete the entire route at the earliest possible time. However, this would require ten (10) road construction projects and a minimum of three (3) bridge construction projects occurring simultaneously over the life of the project.

6 GAP ANALYSIS

6.1 Indigenous and Community Consultations

6.1.1 Proceed with Feasibility Study

Based solely on the outcome of the consultation process, it is recommended, in partnership with Northern Labrador communities and Indigenous groups, that the Government of Newfoundland and Labrador (GNL) immediately proceed with a feasibility study for the road into Northern Labrador. This aligns with the sense of urgency in the written submission from the NG, and from many residents who attended the community consultation sessions. In the opinion of Allnorth (and Norlogics), there was nothing discovered in the community consultations that warrants any hesitation from moving to a feasibility study.

6.1.2 Considerations For Feasibility Study

6.1.2.1 Consider a Two-Phased Approach to a Road into Northern Labrador

From the community consultations held thus far, the communities of Postville, Makkovik, and Rigolet heavily favour a road. For the feasibility study, it is recommended that a two-phased road construction approach be studied with the following phases:

Phase 1: Road from North West River to the communities of Postville, Makkovik, and Rigolet, with a ferry service from a southern Inuit community to all points North of Postville.

Phase 2: Continuation of the road to the communities of Hopedale, Natuashish, and Nain, or allocate ferry service from a southern Inuit community to all points North of Postville on a permanent basis.

This also aligns with the NG written submission as they identify a benefit of a road would be that it *"may shorten the turn around times for the ferry service if a port is located in one of the southern Nunatsiavut communities."* Further, it aligns with the sentiment of many residents in Nain, Hopedale, and Natuashish who indicated a road would have significant impacts on traditional hunting grounds and on the social fabric of communities. A phased approach would allow more time to study the impacts north of Postville.

6.1.2.2 Conduct In-Depth Consultations during Feasibility Study

As part of the feasibility study, it is recommended that more in-depth community consultations take place, including visits to local schools to hear the views of youth, home visits to elders who cannot attend public consultations to ensure Indigenous knowledge is captured, women-only public consultations, and online mechanisms to capture feedback, especially on social media.

With recommended routing segments, engagement on the specifics of a road can now be discussed with community members and Indigenous/Traditional/Local Knowledge can help inform study designs and results interpretations. For future studies, it is recommended that GNL provide adequate funding for in-community support and representation from the North Coast communities on the consulting teams. Practically speaking, this could be providing extra evaluation points in an RFP for North Coast representation in bid submissions.

Furthermore, the GNL's Aboriginal Consultation Policy states:

"The Government of Newfoundland and Labrador (NL) is committed to consulting Aboriginal organizations when NL contemplates making land and resource development decisions that have the potential to adversely impact asserted Aboriginal rights or asserted treaty rights."[6]

Given that this was a pre-feasibility study and certainly not constituting a decision to proceed with development, the level of consultation was appropriate. However, for future studies including feasibility, it is recommended that consultations be conducted in accordance with the GNL Aboriginal Consultation Policy (i.e., Quebec Indigenous groups as well given their asserted land claim area and the potential impact a road into Northern Labrador could have on, amongst other things, caribou migration between Labrador and Quebec).

6.1.2.3 Conservation Enforcement Considerations a Key Priority

Impacts on fish and wildlife were a key concern in every community, both from those who opposed or supported the idea of a road into their community. As indicated by NG in their written submission, there are jurisdictional issues and a historic lack of enforcement by provincial and federal wildlife officers. Everyone agrees that a road would bring some level of increased pressure on fish and wildlife, therefore it is recommended that future studies prioritize the creation of a robust conservation and enforcement plan should a road be approved for construction.

6.1.2.4 Study Impacts on Ferry and Airline Services

There were differing levels of expectations on what the impact would be to airline and ferry services. Some residents expect the ferry and airline services to remain if a road is constructed, while others anticipate the airline service would be reduced and ferry service would be removed altogether, as that appears to be the provincial government policy.

While the airline is a privately-run business, it is recommended they be consulted to determine the impact to their business should a road be constructed. Also, the provincial government should be clear on the anticipated impact to the ferry service should a road be constructed and what the impacts would be for phase 1 and 2 of construction.

6.1.2.5 Study Alternatives to a Road

The focus of this pre-feasibility study was on a road into Northern Labrador. However, several participants brought forward alternatives to a road that could potentially improve the current transportation network for Northern Labrador, including:

- A rail or monorail service, which was heavily supported by one participant who attended five different community consultation sessions in North West River and Happy Valley – Goose Bay;
- Significant upgrades to runways, port facilities, and ferries that could increase service capacity and reduce weather delays; and
- Return of ferry cargo service between Newfoundland and Northern Labrador.

One or a combination of several of these options should be considered in parallel during the feasibility study process. As with any project, it would be prudent to study viable alternatives to provide residents and decisionmakers with all pertinent information. However, the strong support for a road over other alternatives must be noted.

6.1.3 Consult With Communities About Near-Term Solutions to Transportation Network

Labrador residents are keenly aware of the time required to construct a highway, as a paved Trans-Labrador Highway has been decades in the making. While mostly are supportive of a road, residents in Northern Labrador know a road to their communities is many years away, even with an expedited approval and construction process.

Many residents expressed their frustration at the costs and/or quality of the current ferry and air service and insisted that near term solutions to the current transportation network are needed. It is recommended, separate from the road project studies, that the provincial government consult with Northern Labrador communities, Innu Nation, and Nunatsiavut Government on solutions to alleviate the current issues with the transportation network, including, but not limited to subsidized airfare (for both passenger travel and cargo) and marine cargo transportation service to/from Newfoundland.

6.2 Route Selection and Appraisal

Recommended route segments in this study are limited by the information that is currently available. Google Earth, GIS and topographic maps are a starting point to get an understanding of the topography and land use along the proposed routes. These tools provided the basis on which the routes were selected, however, they do not provide the level of detail required for a complete feasibility study.

Section 4.5.1 describes design challenges identified along some of the routes. These include vertical and horizontal alignment violations, major river crossings, conflicts with other land use and construction in coastal waters. These will need further detailed analysis to determine if a feasible solution is possible within the design criteria established for the road. Some notable areas include:

- Route G2 Anaktalik Bay Shoreline Option-This route requires construction along the Shoreline in unknown water depths. It is not recommended without further analysis in the feasibility stage;
- Route G3 Anaktalik Bay Causeway Option-This route required approximately 2.7km of causeway construction in unknown water depths. It is not recommended without further analysis in the feasibility stage;
- Route A1 North West River to Rigolet Junction-This route has impacts on municipal transportation infrastructure in North West River. Traffic type and volume should be assessed, and impacts evaluated during the feasibility stage.

Future studies should include:

- Further consultations with all Indigenous and community stakeholders for input and feedback on the recommended routes.
- Topographic surveys of recommended route segments and optional routes using LiDAR technology;
- Assess current cadastral mapping and perform legal surveys as required to update the mapping;
- Bathymetry in Anaktalik Bay using LiDAR technology;
- Geotechnical investigations of potential structure locations and existing materials that may be encountered along the route (e.g., depth of bogs, suitability of potential road cuts for road building materials, potential pit/quarry sites, etc.);
- Permafrost investigations;
- Hydrology investigations;
- Slope stability and avalanche risk studies for any locations along the route that are identified as an area of concern;
- Navigable waters investigations at proposed bridge sites.

Future pre-design and design development work should be done in accordance with:

- Geometric Design Guide for Canadian Roads[9];
- Canadian Highway Bridge Design Code;
- NL DTI Highway Specification Book; and
- CSA Standard 4011[10].

6.2.1 Geomatics/Surveying Support and Constraints Mapping

Detailed surficial geology, geomorphology, and geotechnical constraints (geohazards) mapping should be completed for the recommended route segments (and optional routes) utilizing available high-resolution colour imagery acquired by flying in a manned aircraft. For this project, a helicopter would provide the better platform to complete the LiDAR surveys. To be cost effective, LiDAR data and photographs should be collected simultaneously due to the extent of the proposed road. The imagery dataset will be comprised of a series of digital colour images captured in stereo directly from the sensor on board the aircraft and by using the stereo imagery and associated Inertial Measurement Unit (IMU) data, this imagery can be imported into ArcGIS for interpretation.

Regarding spatial distribution of pulses and planned area coverage, the recommended route segments (and optional routes) should be externally buffered by 100 metres to create the "buffered project area". LiDAR pulse at 20pts/m^2 and imagery of 10cm Ground Sample Distance (GSD) is recommended.

Environmental conditions for LIDAR data collection should include:

- Cloud and fog free conditions between the aircraft and the ground;
- Ground to be free of snow accumulation;
- Areas that are affected by tides should be surveyed at tow tide; and,
- Scanning should occur within the operational inputs of the system including temperature and altitude ranges.

A digital stereo viewing software add-on within ArcGIS will allow the interpreter to digitize polygon information directly into the GIS related surficial geology and geohazard assessment. Vegetation data may be available from other EA activities that can be used to characterize the vegetation units for the study area and the attributes will be blended with the geology and geotechnical constraints mapping to form a very valuable tool for routing and infrastructure location assessment studies. In addition, digital terrain models should be developed based on resulting point clouds. The terrain models can be used to determine slope, aspect, and other terrain characteristics, which will assist in defining the geotechnical constraints and geohazards within the study area.

Using all spatial information gathered from each of the independent desktop assessments, a surficial geology/geotechnical constraint mapping exercise should be completed. The constraints analysis will aid in project planning and support the approval and permitting process.

A GIS team should work closely with discipline specialists, and the broader project team to determine appropriate weighting and ranking of routing elements. Weightings can be applied at the occurrence level within components and between the components themselves. The weighted component coverages will be mathematically overlaid using ArcGIS resulting in a single constraints map clearly showing areas of little to no concern and highlighting regions that may present `friction'. An Analytical Hierarchy Process (AHP) can be used to assist in defining appropriate weights across components, accounting for input from multiple stakeholders. This process assists in gaining consensus amongst the various project stakeholders. This model is very flexible and can be used to run differing scenarios. The constraints mapping can be made available in GIS format for use in subsequent phases of the project to allow for sound decision making.

6.2.2 Geotechnical Investigations

It is recommended that a field reconnaissance and investigation program be developed to assess existing conditions along the proposed routes. A field program should include a series of boreholes and test pits to assess the depth of bedrock and ground water elevation and to collect representative samples of materials. Any bog areas along the route should be probed to determine bog depths.

Boreholes are recommended at the foundation location of all proposed bridges and multi-plate structures. Test pits are recommended at potential road cuts and borrow sites. Samples collected should be analyzed in a certified laboratory using standard test methods. Tests include sieve analysis, moisture content, proctor, and Atterberg limits. In addition, rock samples should be tested for suitability for aggregate production using standard test methods including Los Angeles Abrasion, Petrographic Number and Micro-Deval. Proposed test sites along the route should be surveyed in the field prior to any drilling/sampling activity. If there is any deviation from the preferred sites, the actual test site locations should be surveyed again to accurately identify the new location.

6.3 Permafrost

There is no public domain literature that characterizes soil and bedrock engineering properties at the preferred and alternate alignments for a road into Northern Labrador. To establish a framework of potential geotechnical risk associated with the proposed highway, a two-phase geotechnical risk assessment is recommended.

6.3.1 Phase 1 Geotechnical Risk Assessment

Geotechnical screening for the preferred and alternate alignments is suggested to evaluate geotechnical risk at specific locations. Using remote technologies, a grid-based approach is suggested to delineate individual landforms associated with peatland and mineral soil areas, as well as river valleys and other linear physiographic areas where shading is expected. The purpose of the grid-based approach is to establish an inventory of areas of likely ground ice content, thermokarst potential, pre-existing spreading, and overall permafrost coverage.

<table>
<tr><th colspan="2">Classification Step</th><th colspan="5">Description</th></tr>
<tr><td>1</td><td>Describe Independent of Frozen State</td><td colspan="5">Classify Soil by The Unified Soil Classification System</td></tr>
<tr><td rowspan="9">2</td><td rowspan="9">Modify Soil Description by Description of Frozen Soil</td><th colspan="2">Major Group</th><th colspan="3">Subgroup</th></tr>
<tr><th>Description</th><th>Designation</th><th colspan="2">Description</th><th>Designation</th></tr>
<tr><td rowspan="3">Segregated ice not visible by eye</td><td rowspan="3">N</td><td colspan="2">Poorly bonded or friable</td><td>Nf</td></tr>
<tr><td rowspan="2">Well Bonded</td><td>No excess ice</td><td>Nbn</td></tr>
<tr><td>Excess ice</td><td>Nbe</td></tr>
<tr><td rowspan="4">Segregated Ice Visible by eye (ice less than 25mm thick)</td><td rowspan="4">V</td><td colspan="2">Individual ice crystals or inclusions</td><td>Vx</td></tr>
<tr><td colspan="2">Ice coatings on particles</td><td>Vc</td></tr>
<tr><td colspan="2">Random or irregularly oriented ice formations</td><td>Vr</td></tr>
<tr><td colspan="2">Stratified or distinctly oriented ice formations</td><td>Vu</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Modify Soil Description by Description of Substantial Ice Strata</td><td rowspan="2">Ice greater than 25 mm thick</td><td rowspan="2">ICE</td><td colspan="2">Ice with soil inclusions</td><td>ICE+Soil Type</td></tr>
<tr><td colspan="2">Ice without soil inclusions</td><td>ICE</td></tr>
</table>

Table 6.1-Soil Classification System in Permafrost (ASTM D4083)

Use of remote aerial photogrammetry methods to map periglacial landforms at the preferred and alternate alignments can be used to target a Phase 2 investigation using In Situ Methods, as well as identify potential sources of borrow, quarry locations and site for temporary construction facilities. Options available include InSAR that allows monitoring of changes in the environment over time, remote piloted aerial coverage for one-time analysis and delineation of areas of higher risk.

6.3.2 Phase 2 Geotechnical Risk Assessment

Remote and photogrammetric methods may be supplemented with field verification of conditions during feasibility where potential and actual periglacial landforms cannot be avoided. When evaluating areas of potential permafrost, the timing of the insitu geotechnical investigation will be critical to evaluating the results. In areas of potential permafrost, depth of the "Active Layer" should be evaluated during late summer, August and/or September, before freeze temperatures but at the maximum depth of ground thaw. Test sites should be evaluated using pits excavated to the frozen ground to evaluate the drainage, saturation level and degree of ice in the subsurface. The preferred time for other forms of investigation may be when the ground is frozen using coring to evaluate the percentage and nature of ice in the soil/fractured rock matrix.

The inclusion of physiographic variables, like soil conditions, frost susceptibility of sediments, and more detailed surficial deposit maps, is likely necessary for an improved representation of peatland permafrost in northern coastal regions. For areas other than linear road and highway infrastructure, site specific geotechnical investigation is required.

6.4 Hydrology and Hydraulics

To be consistent with current design standards and industry practice with respect to drainage infrastructure, the road into Northern Labrador drainage infrastructure should be sized for the expected runoff with a 100-year annual exceedance probability, with allowance for climate change.

The current distribution of meteorological and hydrometric monitoring sites is sparse and will likely result in potential error for estimates of extreme values for inflow-duration at the location of all drainage sites. A regional approach coupled with parameter sensitivity analysis will provide for uniform design approach while allowing for site specific variability.

- Computational capacity of desktop computers and modelling software sophistication provide an efficient platform for regional assessments of drainage, flood plains and assessments of hydraulic response for different infrastructure using rating curves. The primary driver in drainage design is watershed drainage area and specific terrain topography at the drainage site. Accuracy of computer models will be improved with updated topography based on LiDAR acquisition or orthorectification.
- Climate change impacts in the area of the road into Northern Labrador include increases in the MAAT (Mean Annual Average Temperature) that will change the total precipitation pattern from snowmelt and rainfall for the area. Potential changes may result in more or less snowpack, and more or less rainfall. Current guidance is an increase in total precipitation from climate change.
- The runoff will be different in the northern areas of the road into Northern Labrador where terrain consists of near surface bedrock and sparse soil cover, compared with southern areas of the alignment where there is a more extensive vegetative cover.
- The models for rainfall, snowpack and hydrometric flow models should be calibrated with select sites to verify regional models and for downscaling to specific sites. One or two years of data can reduce model inaccuracies.

6.5 Discussion and Recommended Activities (Permafrost, Hydrology, and Hydraulics)

The proposed road into Northern Labrador traverses the north of Lake Melville and extends north to Nain for a total length of 809 kilometres. The preferred and alternate alignments for the highway, as well as drainage infrastructure, is likely to encounter sporadic permafrost that will be affected by the impacts of climate change over the life of the structure.

A desktop study identified several reference documents that are incorporated into the pre-feasibility assessment for regional characterization of geomorphology, permafrost and meteorology. There was limited site-specific data on permafrost in peatlands and it is unlikely to be relevant to any specific structure.

The presence of isolated and sporadic discontinuous permafrost is likely for the preferred and alternate alignments, with the likelihood increasing where peatlands form the surficial cover. Peatlands are more prevalent in southern areas of the alignment where permafrost is indicated as occurring in "isolated patches" compared with northern areas where the ground cover is thin till veneer and bedrock. For the feasibility level, the presence of permafrost may be considered as equally likely for the full alignment. Where present, permafrost is also likely randomly distributed but may be concentrated in shaded areas, areas with additional vegetation canopy and areas with peat as surface vegetation.

Climate change is associated with increasing MAAT that will influence the mean annual ground temperature (MAGT) and permafrost losses as temperature rises from the impacts of climate change. Changes in permafrost environment will influence structural performance of roads and drainage infrastructure. A two-stage approach included in CSA4011 "Infrastructure in Permafrost: A Guideline for Climate Change" provides a risk-informed process for continually evaluation of climate change risk in suspected permafrost areas.

A Stage 1 climate risk assessment completed for the pre-feasibility level opinion on risk rating determined the area has a "Medium" level of climate sensitivity with consequences of an infrastructure varying from "Minor to Major" for the preferred and alternates alignments, with a resulting risk rating B and C. The pre-feasibility opinion is the climate risk is acceptable with further detailed geotechnical characterization and thermal assessments required as part of the feasibility design. The sensitivity screening process in CSA4011 should be continually applied throughout design development.

Frozen soil and permafrost soil will behave differently than non-frozen soil, but the methods of geotechnical characterization are similar and there is no requirement for specialized investigation techniques. During the feasibility level of design development, the extent and nature of permafrost should be evaluated using a minimum two-stage geotechnical investigation. The initial stage can use remote technology to catalogue, group and discretize periglacial and other landforms that may cause structural risk along the length of road and drainage infrastructure. The remote assessment may be developed using photogrammetry techniques from airborne images, or satellite images from commercial sources, and used to finalize the lowest risk alignment as well as to define targets for secondary insitu geotechnical investigations. Stage 2 geotechnical investigation will include test pits in late summer to understand the extent of the "Active Zone" and core drilling in winter to define ice content.

The current distribution of meteorological and hydrometric monitoring sites near the preferred and alternate alignment is sparse and will likely result in a wide range of expected values for inflow flood events for extreme values for inflow-duration at the location of all drainage sites. The risk of poor design can be mitigated by grouping data to develop regional models based on physiographic features that can be calibrated with site specific monitoring for flow rate and meteorological inputs. For example, the physiology varies from thick sediment in the south to till veneer over bedrock in the north. Different regional hydrological models for the two different physiographic areas will result in more reliable model development.

The impacts of climate change can be incorporated into expected performance of drainage infrastructure by designing for end of service life conditions. Drainage design can be completed using standard civil engineering tools with varying complexity as the infrastructure investment increases. Tools can vary from simple empirical tools where the consequences of failure are low to more robust technical methods for more consequential infrastructure. Computer modelling technology can be applied at relatively moderate cost for all watershed sizes. Computer models are more effective when calibrated with actual observations.

6.5.1 Recommended Activities during Feasibility

Recommendation 1 – Install flow monitoring devices at major river crossing site can be used to calibrate short periods of data at the site with longer records of meteorological data.

Recommendation 2 - There are currently no WSC hydrometric stations that are coupled with meteorological stations to couple climate data with runoff. Installing meteorological stations at existing WSC sites will provide a calibration of rainfall and snowmelt with run-off.

Recommendation 3 – For river crossings that are sensitive to hydraulic conditions, install a site-specific monitoring station to facilitate calibration of site-specific flows to regional patterns.

Recommendation 4 – A two-phase geotechnical program is suggested during feasibility level design. The first phase can be performed using remote technologies to finalize route selection and identify ground investigation targets. The second phase can include insitu testing using test pits and core drilling.

Recommendation 5 - When the presence of permafrost is verified in the foundation of infrastructure as part of geotechnical design, the sensitivity screening process in CSA4011 should be applied to evaluate the appropriate extent of investigation and design complexity.

Recommendation 6 - The effects of climate-change is overall warming and involves non-negligible impacts on drainage networks, with one of the main concerns being the increasing intensity of storm events. Climate change impacts on drainage should consider published Intensity Duration Frequency (IDF) values that incorporate climate change when evaluating drainage.

6.6 Environmental

A pre-feasibility environmental overview is intended to provide a coarse overview of the publicly available information for the general corridor alignment, as well as identify areas for further investigation. An Environmental Assessment process is likely to be triggered by this project, which would require additional study and investigation of environmental features and impacts of the project to satisfy regulatory agencies. The EA process (federal and provincial) can vary on a project-by-project basis, and further assessment of key environmental features during the Feasibility Study will assist with development of the preliminary scope prior to registration. Field studies would be undertaken during the Concept Design, to determine site-specific features, required planning, and management strategies. Management Plans are typically developed during the EA process, with construction-level planning completed during detailed design.

Summary of findings:

- Geology - Surficial geology along the proposed road is primarily granitic rock, with areas of course and fine till sediment (increased near larger watercourse crossings). Areas of sediment deposits and acid generating rock should be avoided as feasible. Large cuts in unstable areas may require geotechnical assessment;
- Vegetation - Limited baseline vegetation survey information was found for Labrador. A preliminary review of the listed vegetation species included within Newfoundland and Labrador 57/02: Endangered Species List Regulations indicated no known presence within the proposed road corridor;
- Wildlife – Limited baseline wildlife survey information was found for Labrador. There are two documented rare/endangered species habitat ranges within the proposed road corridor (Northern Brown Myotis and Red Wine Caribou herd);
- Watercourses - The proposed road will traverse several watersheds of productive fish-bearing rivers, with potential for multiple crossings of the rivers or their tributaries. Crossings of fish-bearing rivers and their tributaries will require review by Fisheries and Oceans Canada (DFO);
- Parks and Protected Areas – The proposed alignment generally avoids all parks and protected areas. There is potentially one (1) Provincial Protected Area located on the north side of Little Lake near North West River.

Environmental components that will require additional assessment:

- Geology – erosion potential assessment, ML/ARD assessment, field verification, management planning
- Vegetation – rare/endangered species habitat assessment, field verification, management planning, permitting as applicable.
- Wildlife – rare/endangered species habitat assessment (potential field verification), bird assessment (migratory and raptor), caribou habitat delineation, management planning, permitting as applicable.
- Watercourses – fish habitat assessment at crossings, wetland and riparian assessments, field verification, management planning, permitting as applicable.
- Parks – assessment and permitting as applicable.
- Construction –consistent with best management practices and provincial guidelines.

Other considerations in the Gap Analysis include:

- A ML/ARD assessment is recommended to be conducted during the Feasibility phase, to determine the general likelihood, locations and volumes of ML/ARD material that may be encountered (if any). Detailed field investigation of the subsurface geology in these areas may be needed to refine predictions, as subsurface conditions are difficult to accurately determine prior to construction. Management of ML/ARD waste material and exposed areas (if any) would form a component of the Environmental Assessment;
- A Vegetation assessment is recommended to be conducted during the Feasibility phase, to determine the general likelihood, locations and diversity of potentially rare or endangered vegetation occurrences. A survey of the corridor by a qualified professional in areas of high potential for listed species would guide an appropriate identification and response strategy within a Vegetation Management Plan. Management of vegetation would form a component of the Environmental Assessment. A permit may be required for under Endangered Species Act S28(4) for destruction of habitat of a Species at Risk;
- A Wildlife assessment is recommended to be conducted during the Feasibility phase, to determine the general likelihood of areas of high potential for listed species and wildlife features of potential concern. A survey of the entire corridor by a qualified professional would further refine areas of high potential for listed species and other notable wildlife features and guide an appropriate identification and response strategy within a Wildlife Management Plan. Management of wildlife would form a component of the Environmental Assessment. Specific focus should be made on identifying potential bat hibernacula (ie, caves, etc.), which

may be habitat for Little Brown Myotis. A permit may be required for under Endangered Species Act S28(4) for destruction of habitat of a Species at Risk;

- A Wildlife assessment is recommended to be conducted during the Feasibility phase (see Section 4.7.8), which should include an assessment of bird habitats including known raptor nests within proximity of the proposed corridor. A survey of the corridor by a qualified professional would identify areas of high potential for migratory birds and raptors and guide an appropriate identification and response strategy within a Wildlife Management Plan. Depending on the timing of works, a pre-construction survey may be necessary to identify any active nests within the construction corridor (see Section 4.7.9.7). A permit may be required for under the Migratory Bird Regulation for removal of an active nest;
- A Wildlife assessment is recommended to be conducted during the Feasibility phase (see Section 4.7.8), which should include an assessment of invertebrate habitat. A permit may be required for under Endangered Species Act S28(4) for destruction of habitat of a Species at Risk;
- Assessment of all stream crossings within salmon and Arctic char river watersheds is recommended to be conducted during the Feasibility phase. Proposed crossings should be assessed by a qualified professional to establish fisheries habitat assessments (required by DFO for Project Review) and confirm crossing requirements and environmental protection measures for construction. These crossings may require additional regulatory review and approvals (Fisheries Act S.34, Water Resources Act S.48) unless they can be constructed to the specifications of the Code of Practice for Clear-Span Bridges[29.] Management of stream crossings would form a component of the Environmental Assessment. See Section 4.7.9 for related Construction Considerations.

6.7 Cost Estimating

This pre-feasibility study provides a high-level order of magnitude estimate of costs associated with the project based on a desktop study of the topography, various assumptions regarding the extent of construction and pricing based on historical costs of similar projects. If the project advances to a full feasibility study, these costs should be refined based on a more detailed analysis of the recommended routes and pricing.

With respect the design and construction costs, a feasibility study should include:

- Information gathered from further Indigenous and community consultations, geotechnical investigations, permafrost risk assessments, hydrology/hydraulics studies, environmental studies and the developed constraints mapping should be used to refine the recommended route alignments;
- Using LiDAR technology, a detailed study of the areas where design challenges were identified should be undertaken to ensure viable solutions can be achieved;
- Information acquired from bathymetry measurements should be used to assess the viability of some of the optional routes;
- Locations of proposed bridge structures should be studied in greater detail to optimize the crossing locations and to assess the types and spans of structures required;
- Assumptions used in the development of the cost estimates should be studied in greater detail based on the information gathered throughout the feasibility study to determine if they are reasonable and adjusted as necessary;
- Unit pricing should be reviewed and updated to reflect changes in the construction industry with respect to availability of suitable contractors, the anticipated size and scheduling of contracts and changes in the costs of materials, supplies and labour;
- Potential phasing and scheduling should be studied to assess projected costs over the construction life of the project.

With respect to maintenance and operational costs, a feasibility study should include:

- An assessment of the anticipated road surface to be maintained, whether it will be paved surface or remain as a gravel surface. This will influence the type of maintenance activities required. For example, a paved road will require asphalt repairs and shoulder grading/repairs whereas a gravel road will require periodic grading and replacement of surface granulars. The summer maintenance costs can vary significantly for these options;
- The winter maintenance level of service required should be assessed. For instance, should the road be maintained at the current level of service as other roads in Labrador with respect to snow and ice control, including and the frequency, type, and application rates of ice control materials, or will there be some variation due to the climatic conditions? This decision should take into consideration whether an air service will remain upon completion of the road;
- An assessment of the maintenance program delivery method. Options include all work be performed with GOVNL equipment and personnel or contract the service through a 3rd party;
- The number and location of maintenance depots along the routes should be studied to optimize the delivery of road maintenance services.

6.8 Project Phasing

This pre-feasibility study provides a possible phasing scenario based on assumptions regarding access to the work sites and the length of new road that can be reasonably constructed per year. A future feasibility study should evaluate these assumptions and adjust them as necessary. For instance, to overcome delays in the schedule due to bridge construction, it may be possible to install a temporary bridge for equipment access. There may also be areas where access can be established from a temporary marine landing site. These options should be explored in a feasibility study.

Other items related to phasing that should be considered in a feasibility include:

- Evaluation of the information gathered from further Indigenous and community consultations to determine the greatest priorities for a road connection;
- Timelines for overall project completion. This could be impacted by the number of available contractors;
- Possible cash-flow restrictions from funding partners.

6.9 Future Analysis and Exclusions

The intent of the pre-feasibility study is to develop a high-level understanding of the impact of a road into Northern Labrador. The pre-feasibility Indigenous and community consultations are important on many levels, but if the project proceeds to the full feasibility stage, the following should be subject to more detailed analysis:

- Indigenous land use, harvesting and cultural and ecological values;
- Potential changes in the nature and character of daily life and community (e.g., out-migration and increased "outsider" pressures);
- Settled or asserted Aboriginal rights in the proposed areas; and,
- Socio-economic and environmental considerations, including:
  - Food security;
  - Cost of living;
  - Access to health and other services;
  - Social determinants of health;
  - Environmental sensitivities such as George River caribou herd habitat and calving grounds;
  - Climate change impacts; and,

    - Tourism, resource, and other economic developments, including potential impacts on historical and/or culturally important sites.
- Project Risk Assessment and risk registry.

Other items not included in the scope of services for this pre-feasibility study that will be analyzed should the project advance to a full feasibility study:

- Future potential infrastructure development requirements, such as electricity transmission lines and high-speed telecommunications;
- Consideration of the potential for enhanced exploration for critical minerals and potential future development;
- Project specific geotechnical investigation (in-situ conditions, stability issues, aggregate sourcing);
- Complete environmental assessment including:
    - A rare plant survey along the route;
    - Potential effects on existing outfitters;
    - Caribou migration and calving habitats;
    - Potential wolf dens identified, if existing;
    - Raptor nests identified;
    - Detailed consideration of climate change impacts; and,
    - Noise, air and water quality implications.

The RFP listed a number of specific exclusions and items for future analysis. Others that came to light during the pre-feasibility have been captured throughout Section 6.0.

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APPENDIX A

SUMMARY OF EMAIL COMMUNICATION WITH INDIGENOUS AND COMMUNITY ORGANIZATIONS

Date	Recipient(s)	Subject matter
January 27	1-10, 13-15	• Notice of contract award • Provided contact info if they wished to contact me directly regarding any aspect of PFS for North Coast Road
January 27	1-5, 9	• Responded to email about Nunacor's involvement in the PFS for North Coast Road
February 6	8	• Looking for confirmation Jan 27 email received • Received confirmation same day that IN would provide direction on their participation in near future
February 8	1-5, 8, 9	• Responded to email about NCC's involvement in the consultation process • Directed them to GNL's Aboriginal Consultation Policy
February 13	1-5, 10, 11, 12	• Proposed consultation schedule • Purpose of consultations • Included copy of RFP • Informed them of the project website (www.northcoastroad.ca)
February 15	6, 7	• Proposed consultation schedule • Purpose of consultations • Included copy of RFP • Informed them of the project website
February 15	8	• Proposed consultation schedule with specific meeting day possibilities • Purpose of consultations • Included copy of RFP • Informed them of project website
February 15	8	• As per their request, provided alternative dates to meet
February 15	1-15 + media	• Poster for sharing for public to provide commentary via project website
February 16	1-5, 9, 13-15	• Email received from Makkovik ICG stating they wish to see public consultations held, not just consultations with ICGs and Indigenous leaders
February 16	9	• Email received from NG formally requesting that open house style public consultation take place within Inuit communities
February 17	2	• Email received from Postville ICG stating they wish to see public consultations held, not just consultations with ICGs and Indigenous leaders
February 27	9	• Email requesting a call to discuss community consultations
February 27	1-5, 9, 13	• Emails to request a call to discuss changes in scope to community consultation process, which took place on March 1
March 2	1-5, 9, 13	• Email summarizing the March 1 phone call on planning the public consultation sessions in each ICG
March 2	6-8	• Provided information regarding change of scope to public consultations and requested info on who to work with to arrange logistics for public consultations
March 7	1-5, 8, 9, 13	• Draft public consultation schedule sent for commentary
March 9	1-5	• Requested to book community buildings to host public consultations and asked if interpreters were required
March 9	8	• Requested to meet with NG officials in Nain
March 9	6	• Requested support in securing a public building and sought recommendation on an interpreter
March 11	1-5, 8, 13	• Thanked MHA Torngat Mountains for offering to post the community consultation schedule on her social media platforms
March 13	1-5, 8, 13	• Poster of community consultation schedule sent for posting on social media/sharing by email • Confirmed that Project website was changed to make more user friendly at request of some ICGs and MHA Torngat Mountains
March 17	8	• At their request, sent confirmation of SIFN/MIFN consultation sessions • Provided website info to ensure they received latest updates in timely manner
March 17	1-5, 9, 13	• Provided social media poster with schedule for community consultations • Provided my detailed contact information in case they needed to contact me
March 19	1-5, 9, 13	• Responded to email from PICG about weather system forecasted to hit the North Coast
March 20	1-5, 9, 13	• Flights cancelled out of YYT, postponement of Rigolet and Postville • Planning underway to attend Hopedale
March 20	1-5, 9, 13	• Confirmed we got logistics sorted for Hopedale session on March 23
March 21	6	• Sought recommendations for interpreter and venue
March 21	4, 6	• Sought recommendations for interpreters
March 22	4	• Informed HICG that we could not find an interpreter for the session in Hopedale • Provided commitment that accommodation would be made to ensure concerns recorded if interpreter required
March 23	6	• Email to staff to secure venue

		• Sought recommendation for interpreter
March 23	9	• Requested meeting to meet with NG executive council members while in Nain
March 26	9	• Confirmed meeting with members of NG executive council while in Nain
March 27	1, 2, 9, 13	• Proposed new schedule for Rigolet and Postville consultation sessions
March 27	6	• Continued effort to secure an interpreter and venue for the consultation sessions
March 28	1, 2, 9, 13	• Confirmed request from ICGs to hold public consultations before the Easter Break
March 28	1, 2, 9, 13	• Attempted to secure new dates however there was a conflict for venue space due to previous booking
March 29	6	• Confirmed cancellation of public consultations in Natuashish due to availability of interpreter and funeral of prominent Innu leader
March 29	1-5, 9, 13	• Provided update on all the re-scheduling of public consultations • Encouraged them to continue to track changes via Project website as well
March 29	3	• Informed them of our logistical challenges and need to slightly adjust the Makkovik schedule
March 30	3	• Informed them that we were in the YYR airport on weather hold • A later email sent to confirm flight cancellation due to weather • A third email sent to confirm that project website and social media were updated to reflect the postponement
April 3	1-5, 9, 13	• Confirmed request from ICGs to hold off on public consultations until after the Easter Break (week starting April 17)
April 4	1-5, 9, 13	• Sent proposed schedule for Rigolet, Postville, and Makkovik for the week starting April 17
April 5	3	• Several emails working out the logistics of the Makkovik consultation session
April 12	1-5, 9, 13	• Confirmed of Rigolet, Postville, and Makkovik consultations sessions for the week of April 17 • Reiterated Project website is updated, along with social media
April 18	8	• Confirmed process for a member of NG executive council for how public to provide commentary on a road into Northern Labrador • Directed them to the website • Provided my email for direct submissions from public and/or NG reps
April 18	8	• Responded to a member of the NG Assembly and honoured their request to be copied on matters related to their community
April 19	3	• Several emails to MICG about weather delays • Flight ultimately cancelled for the day due to weather in Rigolet
April 26	3	• Proposed new schedule for Makkovik consultation sessions sent for review
April 26	6	• Proposed new schedule for Natuashish for week of May 9
April 26	6	• After receiving confirmation that week of May 9 would not work, attempted to schedule week prior but also unavailable • Committed to rescheduling to a later date
May 2	6, 13	• Attempted to secure dates for Natuashish community consultation session for early June
May 4	6, 13	• Responded to MHA Torngat Mountains inquiry about the extent of our consultations with the NG
May 4	3	• Confirmed logistics for May 8th consultation session in Makkovik
May 4	9	• Attempted to confirm consultation expectations of the NG
May 4	8	• Reached out once again to attempt to schedule a consultation session with IN leadership
May 4	10	• Reached out once again to attempt to schedule a consultation session with NCC leadership
May 5	9	• Several emails in seeking to understand NG consultation expectations and offered a range of dates to meet with NG executive council members, if they wished
May 7	3, 9	• Reminder sent to confirm date and location of Makkovik community consultations
May 11	6	• Attempted to confirm dates for Natuashish consultation sessions
May 11	1-5, 9, 13	• Notification that written submissions would be accepted until June 16/23. • Reiterated written comments can be submitted through the Project website
May 15	6	• Attempted to confirm dates for Natuashish consultations sessions • Response received shortly after that the Chief would be out of town and that the Inquiry into the treatment of Innu children would be in town for the first few weeks of June. • Confirmed dates for late June for Natuashish consultations sessions
May 16	11	• Reached out to confirm availability of community centre to host consultation sessions
May 16	7	• Attempted to confirm dates and venue for Sheshatshiu consultation sessions
May 23	7	• Once again, attempted to confirm dates and venue to host consultation sessions
June 2	1-14	• Notification of deadline to provide written submissions via the Project website/email was June 16/23 • Provided schedule for Lake Melville community consultations • Notified that due to Innu inquiry, Sheshatshiu would not be able to happen week of June 5
June 8	6	• Confirmed venue for Natuashish consultations
June 8	8	• Several emails back and forth attempting to schedule a meeting with IN leadership

		• Final email never responded to
June 9	7	• After a phone call, sent along a schedule of possible meeting times and days for their consideration
June 14	7	• After June 9 email, received no response and attempted to get one again
June 20	6	• Emails back and forth with MIFN leadership to attend community consultation session
July 10	10	• Received indication that NCC were going to provide a written submission • Attempted to get an update on timeline of response • No response ever received

Legend:

1. Rigolet Inuit Community Government
2. Postville Inuit Community Government
3. Makkovik Inuit Community Government
4. Hopedale Inuit Community Government
5. Nain Inuit Community Government
6. Mushuau Innu First Nation (Natuashish)
7. Sheshatshiu Innu First Nation
8. Innu Nation
9. Nunatsiavut Government
10. NunatuKavut Community Council (NCC)
11. Town of North West River
12. Town of Happy Valley – Goose Bay
13. MHA Torngat Mountains
14. MHA Lake Melville
15. Minister, Executive Council- Indigenous Affairs and Reconciliation

APPENDIX B

WRITTEN SUBMISSION BY THE NUNATSIAVUT GOVERNMENT

Nunatsiavut Government Submission
Prefeasibility Study North Labrador Coast

Transportation continues to be barrier for development in Nunatsiavut. The lack of affordable year-round transportation options inhibits the development plans of the Nunatsiavut Government and Inuit Community Governments. Construction season is limited to five or six months due to the ferry schedule.

Lack of affordable transportation options also severely limits the ability of residents to visit other communities or the rest of Canada. A road connection can potentially reduce the costs of transportation of goods; access to medical assistance in a more timely manner than waiting for a schedevac, allow access to more variety of goods as residents could drive to other locations (therefore, increase competition with businesses), less dependent on weather conditions (can drive in the fog or misty rain whereas on a plane may be impacted by freezing above the clouds/by hills etc.)

A road would cross LISA/LIL and would be subject to the EA process for NG; and consultation/archaeology provisions in LILCA.

Current Travel Options

There are two types of commercial/private travel available in Nunatsiavut, they are the Ferry service and Air Service.

Ferry Service

The north coast ferry service runs from mid-June to early December, servicing Rigolet, Makkovik, Postville, Hopedale, Natuashish and Nain on a weekly basis. This schedule is interrupted monthly to allow for shipping to Black Tickle.

- Vessel departure/arrival is subject to weather, ice, mechanical issues, which impacts the weekly schedule. This has a direct impact on travel plans for residents of the north coast as it could lead to cancellation of scheduled travel.
- Schedule is for the most part consistent, but will be variable when approaching the fall into December.
- Vessel is comfortable and offers the ability for residents to travel with their vehicles.
- Space is limited especially for vehicles; difficult to find availability during peak summer times.
- Wharves in many of the communities require upgrades, and are not ideal for the type of vessel currently used.

Air Service

Air Borealis provides the air service from Rigolet to Nain 7 days a week.

- The twin otter service has provided the north coast of Labrador with a reliable transportation service for decades. This is huge for medical and business travel.
- Aircraft is subject to weather. As climate change progresses it means more cancelled flights.
- Cost of air travel is extremely high.
- Space is quite limited on aircraft.
- Cost of shipping goods is high.

- Transport Canada regulations in the last couple of years has reduced the number of seats that are available on each aircraft and have also reduced the flight crew duty day hours which has an impact on travel especially when there are weather delays.

Pros and cons of a road to northern Labrador

Pros

- Residents of the north coast would have a choice of when to travel that is not dependent upon, for the most part, adverse weather, such as high winds, freezing precipitation, ice, etc.
- No limitation on space available as with the Ferry or Airline.
- This would give residents the option to travel 24/7, 365 days of the year.
- May shorten the turn around times for the ferry service if a port is located in one of the southern Nunatsiavut communities.
- Will provide residents with a more affordable option to get supplies in the months from December to June.
- Potential to reduce shipping costs in the winter and spring months.
- This will give another option to Residents who wish to travel between communities.
- Potential to provide an alternative means of emergent medical transportation/assistance when weather conditions does not allow air transportation.
- Could provide the option to bring in Hydro by powerline or Fiberoptic cables.
- Support for community members to assist other communities during emergency situations ie. citizens lost/fires threatening communities etc.
- Affordable, accessible option for the National Parks and other Tourism related activities.
- Opportunity for a trans shipment port in a Inuit Community
- Opportunity to develop other industries such as the fishery.
- May help make local businesses, such as hotels, restaurants and gas stations more successful.
- May reduce cost of mineral exploration and may lead to an increase of exploration in Nunatsiavut.

Cons

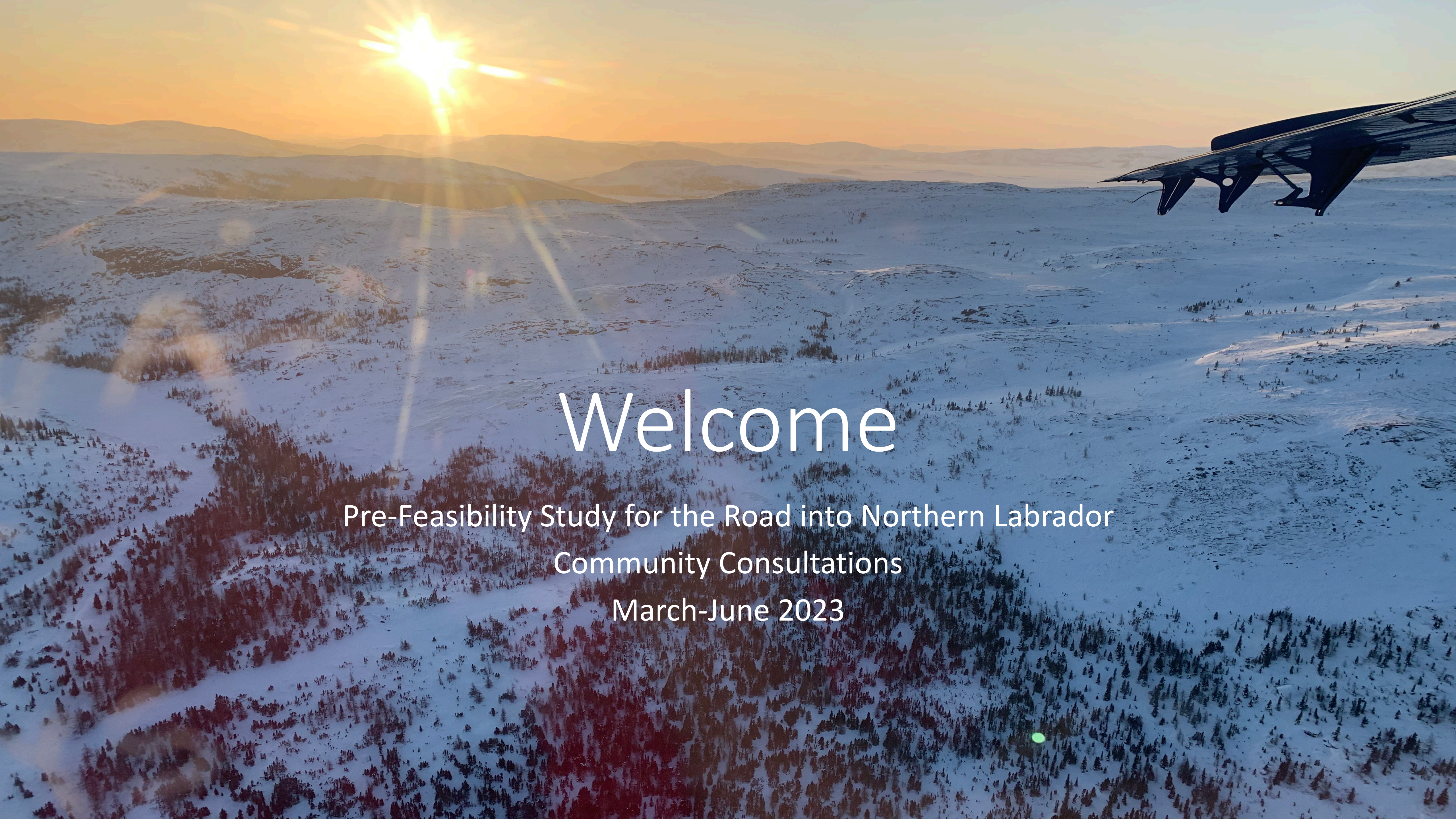
- There is no evidence that a road will reduce shipping costs as compared to shipping by marine in summer and fall months.
- Not all residents agree with a road connection, would like to remain isolated.
- A road may lead to more visitors, which may mean more strain on natural resources. Wildlife and fisheries resources would be hard hit, NG currently does not have the legislation or judicial systems in place to enforce by CO's and complete lack of DFO and or NL wildlife enforcement would exacerbate the issue.
- A road may provide easier access to illegal substances.
- Initially roads may not be paved, lots of wear tear on vehicles travelling on gravel road.

Recommendations

1. Due to inconsistency of air travel because of weather, the high cost of air travel/shipping, lack of space, as well the ferry service only running from June to early December, which is subject to weather, ice conditions and space available, the Government of Newfoundland and Labrador should immediately move from a pre-feasibility study for a road and into a feasibility study to determine if a road is feasible to some or all Nunatsiavut communities.
2. As this process will take years to complete, any delay in decision making from prefeasibility to feasibility, to environmental assessment and eventual construction, may cause delays to the process. If the decision is made to move from prefeasibility to feasibility for a road, the Minister needs to authorize that as soon as possible, and budget for it in the next fiscal year.
3. If approved, the feasibility study needs to incorporate pavement of the road from the beginning.
4. Ensure feedback from community consultations are available to community members, ICGS and the NG.

APPENDIX C

COMMUNITY PRESENTATION


Welcome
Pre-Feasibility Study for the Road into Northern Labrador
Community Consultations
March-June 2023

Agenda

- Introductions
  - Matthew Pike
  - Kirk Peddle
- Background of study
- Purpose of consultations
  - Hearing your perspectives

Considerations

- This is the beginning of consultations for a potential road
- Very early stages (consultations taking place before designs created)
- All consultations will be audio-recorded
- Opportunity to provide more feedback online at www.northcoastroad.ca

Background

- The advantages and disadvantages of potential routes
- The cost of constructing necessary infrastructure
- Post-construction road maintenance
- Weather conditions and climate change impacts
- Socio-economic and environmental impacts

Background

- Indigenous land use, harvesting and cultural and ecological values
- Potential changes in the nature and character of daily life and community (e.g., outmigration and increased "outsider" pressures)
- Key high level socio-economic and environmental considerations for constructing a road in the region, including:
  - Food security
  - cost of living
  - access to health and other services
  - social determinants of health
  - environmental sensitivities such as George River caribou herd habitat and calving grounds
  - climate change impacts
- Tourism, resource, and other economic developments, including potential impacts on historical and/or culturally important sites.


What are your thoughts?

APPENDIX D

CHILDREN'S DRAWINGS FROM KINDERGARTEN/GRADE 1 CLASS IN RIGOLET

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

ICAN go See my

dad.

Name: [redacted]

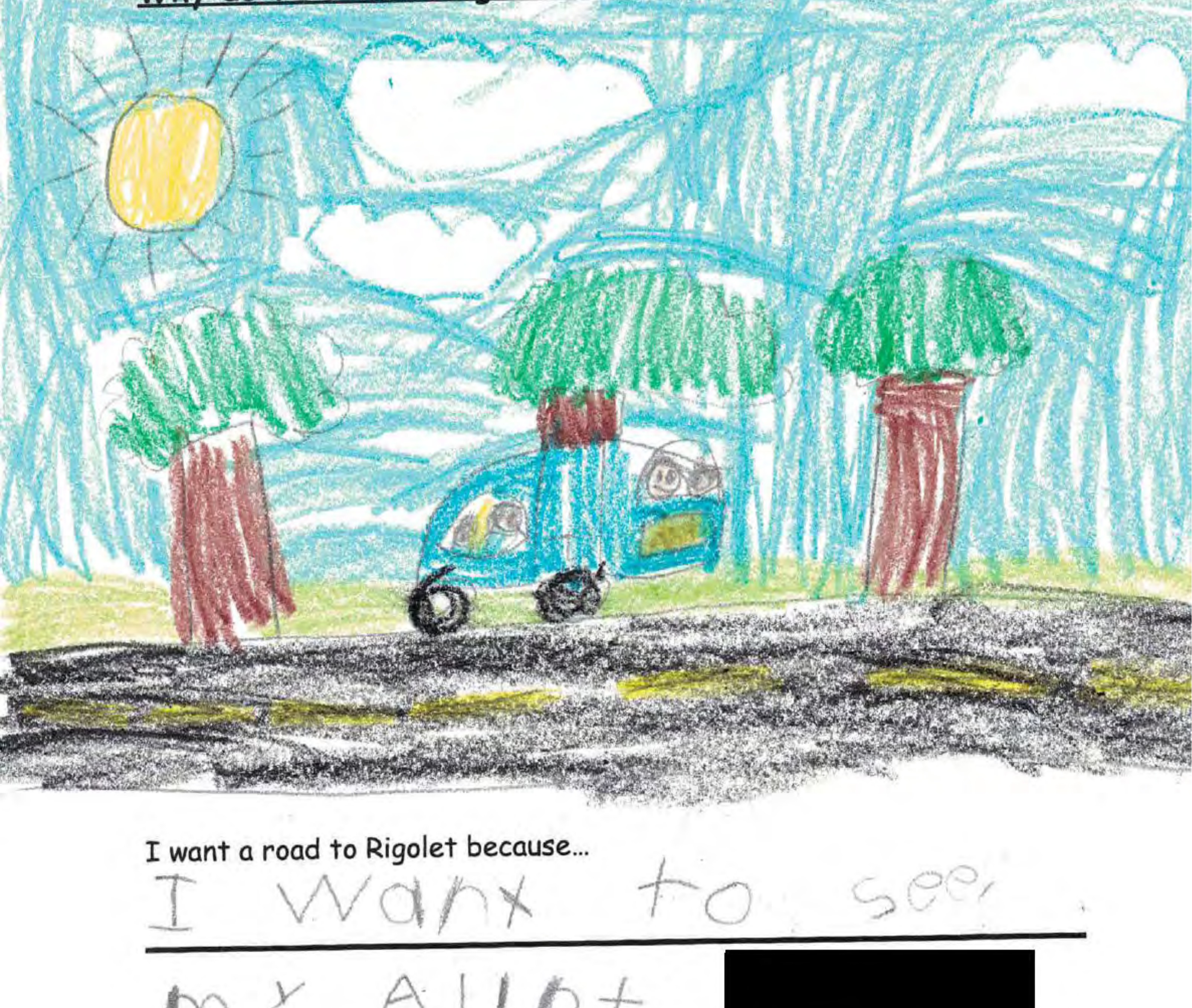
Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

I want to see my Aunt in Goose bay

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because...

I wanx to see

my Aunt [redacted]

Name: [redacted]

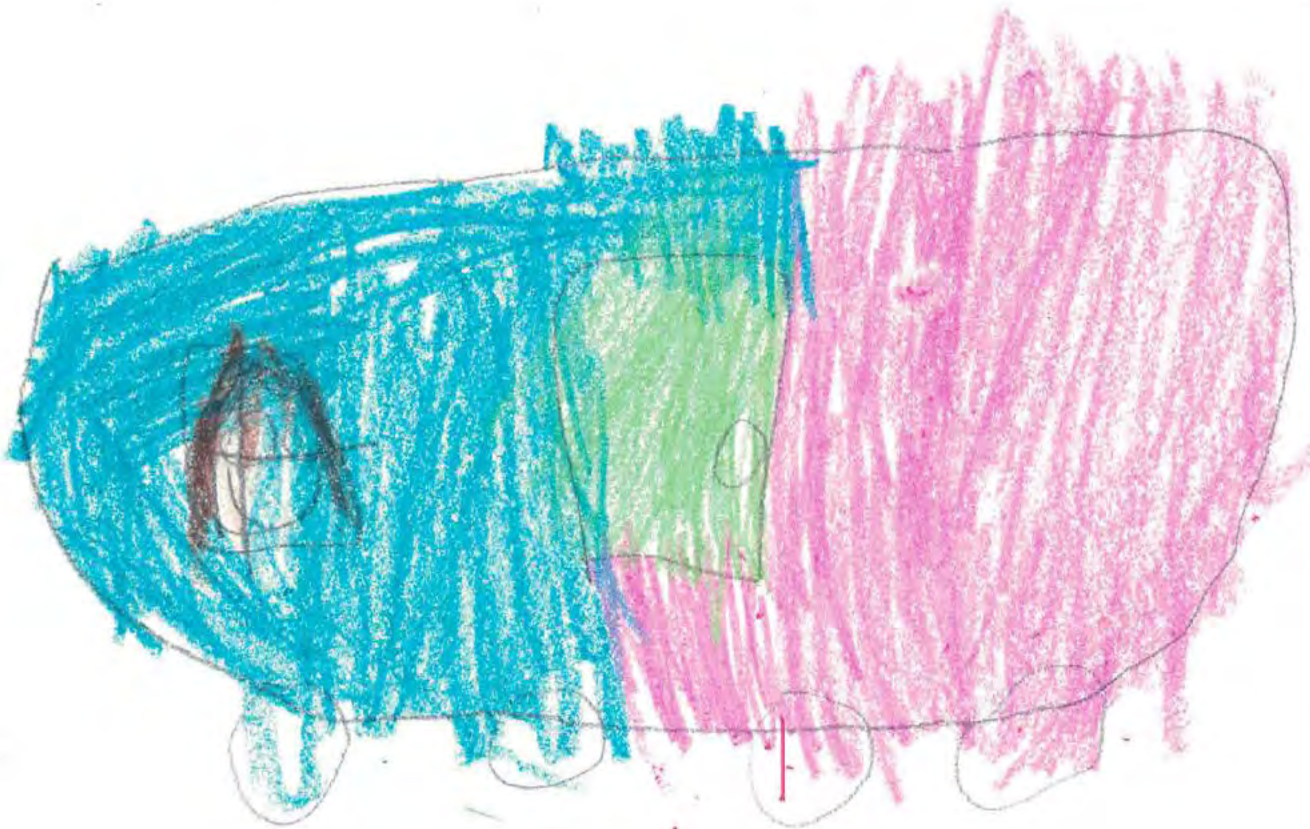
Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

I want to Go to Goose Bay to see grandma and Aunt [redacted].

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because...

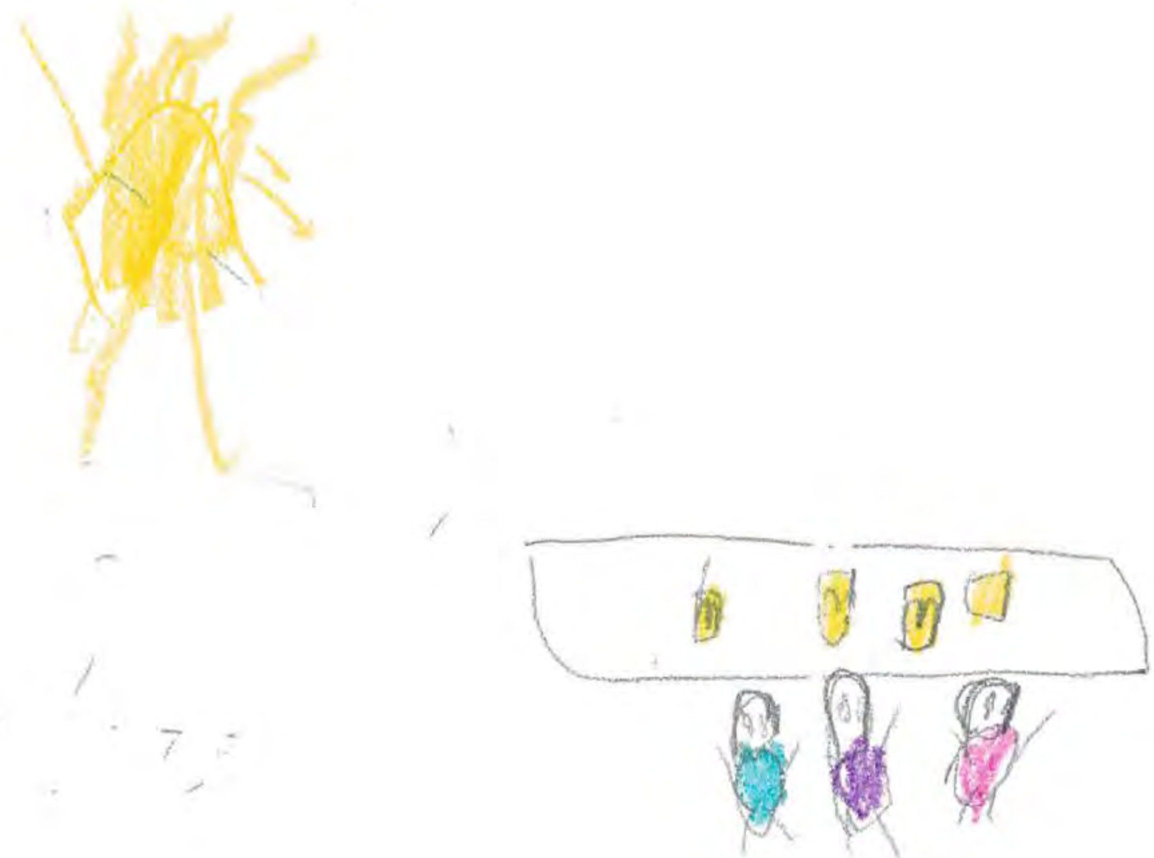
I wAnt to drive to

a int a L go see my

family

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because... I want to go to St. John's for McDonald's.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

3

I want a road to Rigolet because...

Iwant to see my bestfriend inGoose Bay.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

I want my Dad work.

at home.

Name [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

I want to see my [redacted]
in Newfoundland

2022

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

I want to go to

Cartwright [redacted]

[redacted]

Name: [redacted] Date: April, 18, 2023

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

If we get a road it will be less expensive. I want a road so you can see friends or family.

Name: [redacted] Date: APriL:18

Why do YOU think Rigolet should be connected by a road?

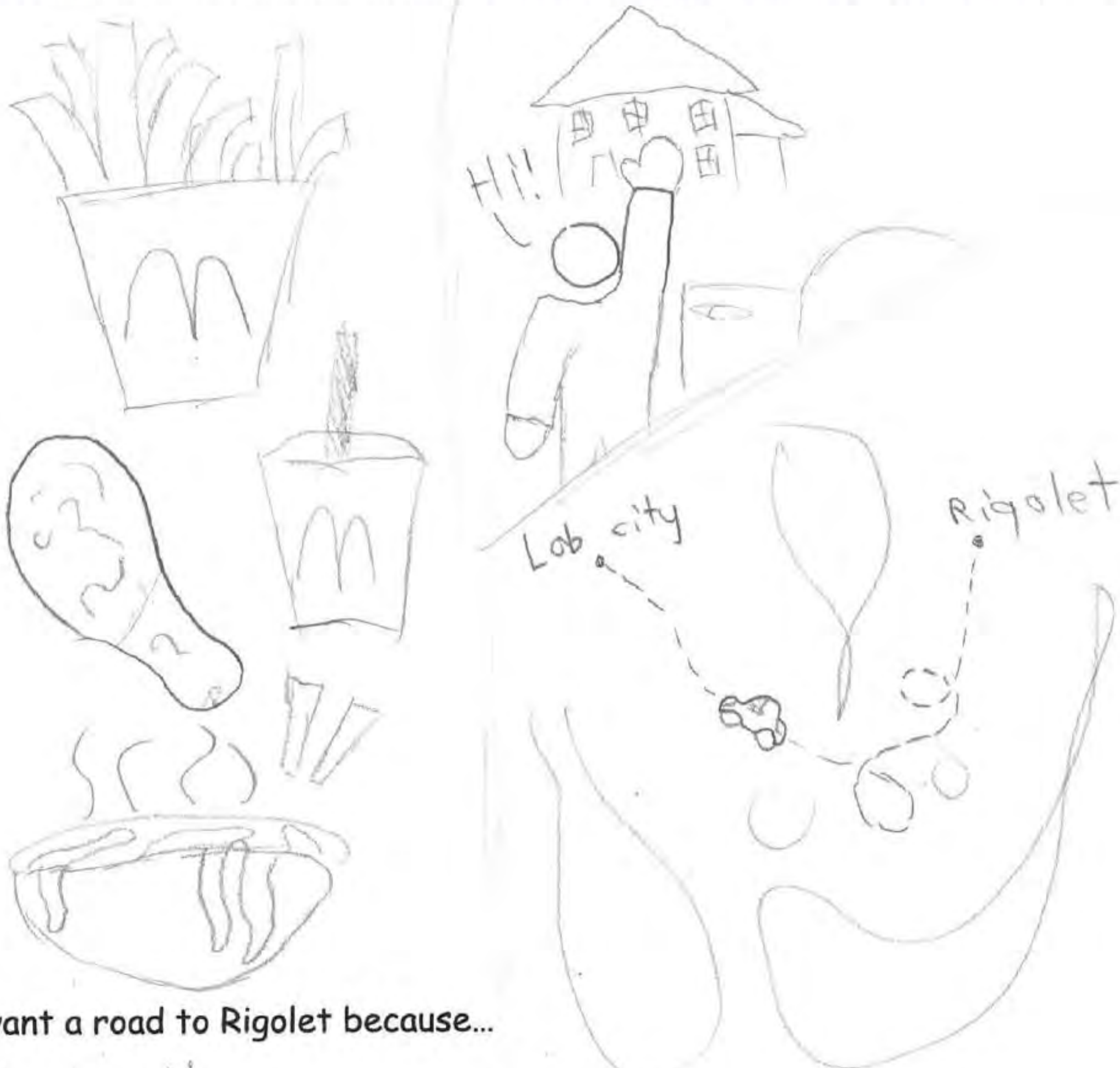
11:37

I want a road to Rigolet because...

So I cann GO to ottAWA Because I wint to see JmanCurLY Becau555555555555ese He is MY Favorite Youtuber

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

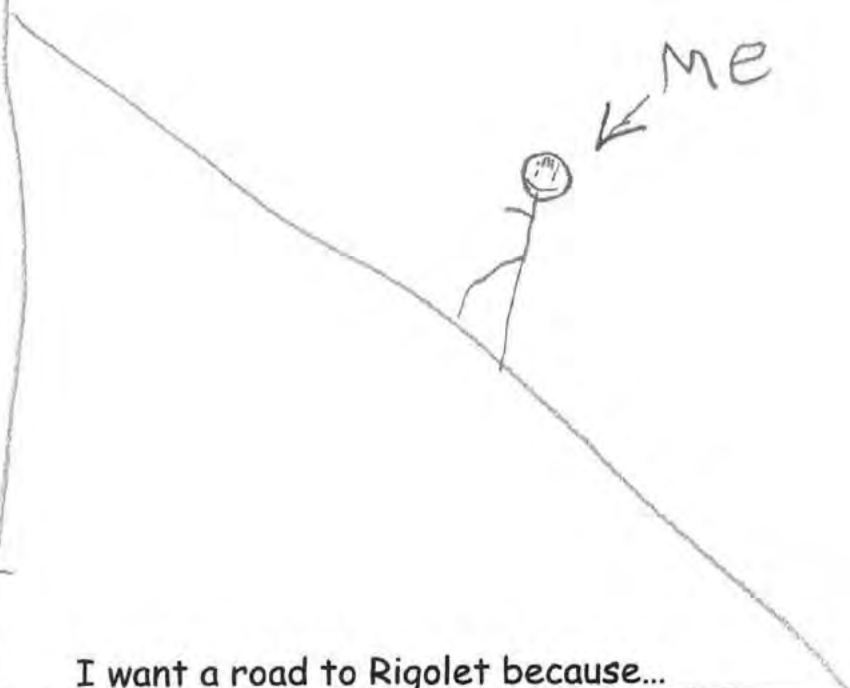


I want a road to Rigolet because...

It would be way easier to travel and see family member's in other places. And more Food. !!

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because...

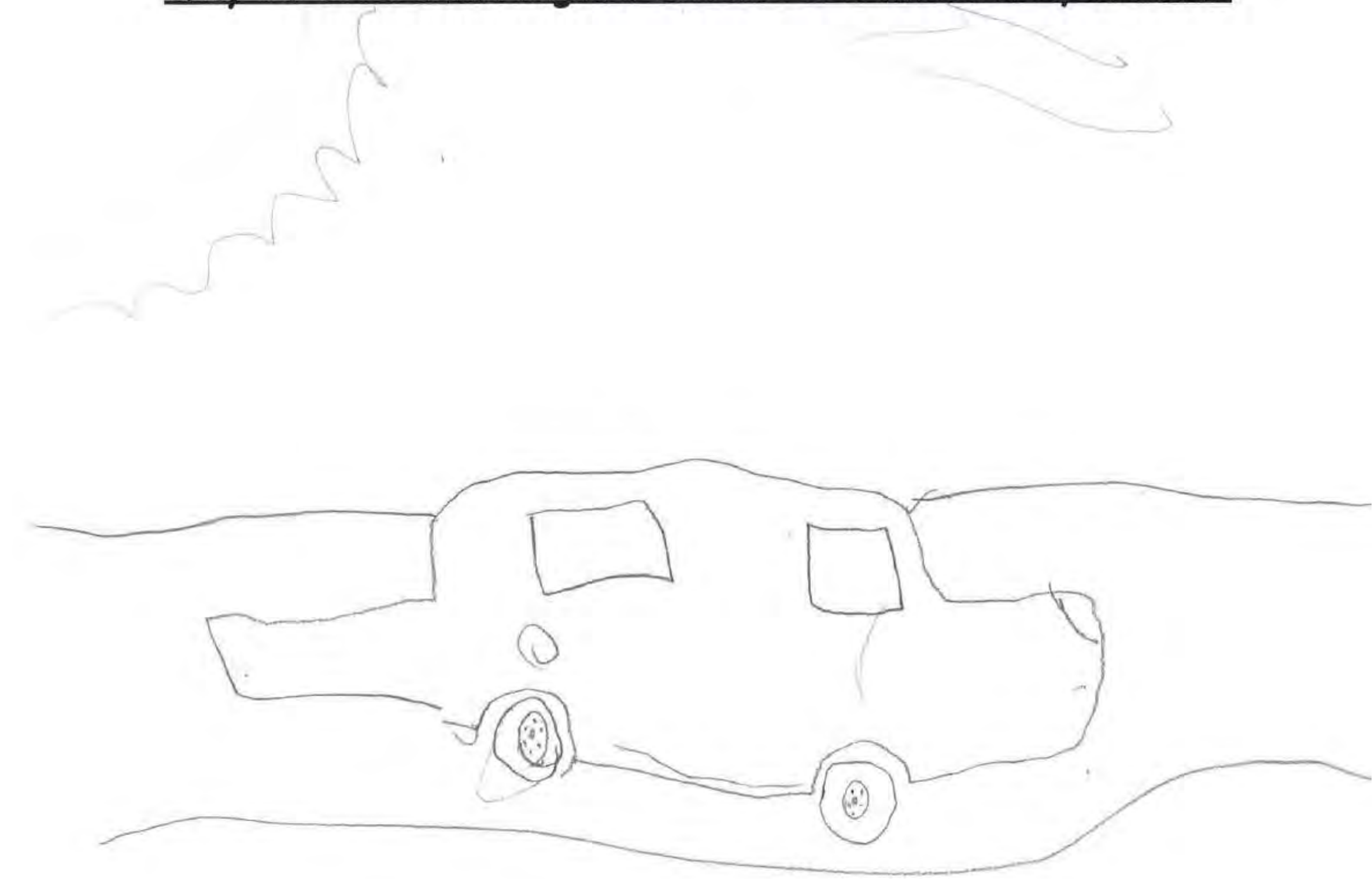
To NAiN So I Could

see My family and

sea friends

Name: [redacted] Date: April. 18

Why do YOU think Rigolet should be connected by a road?

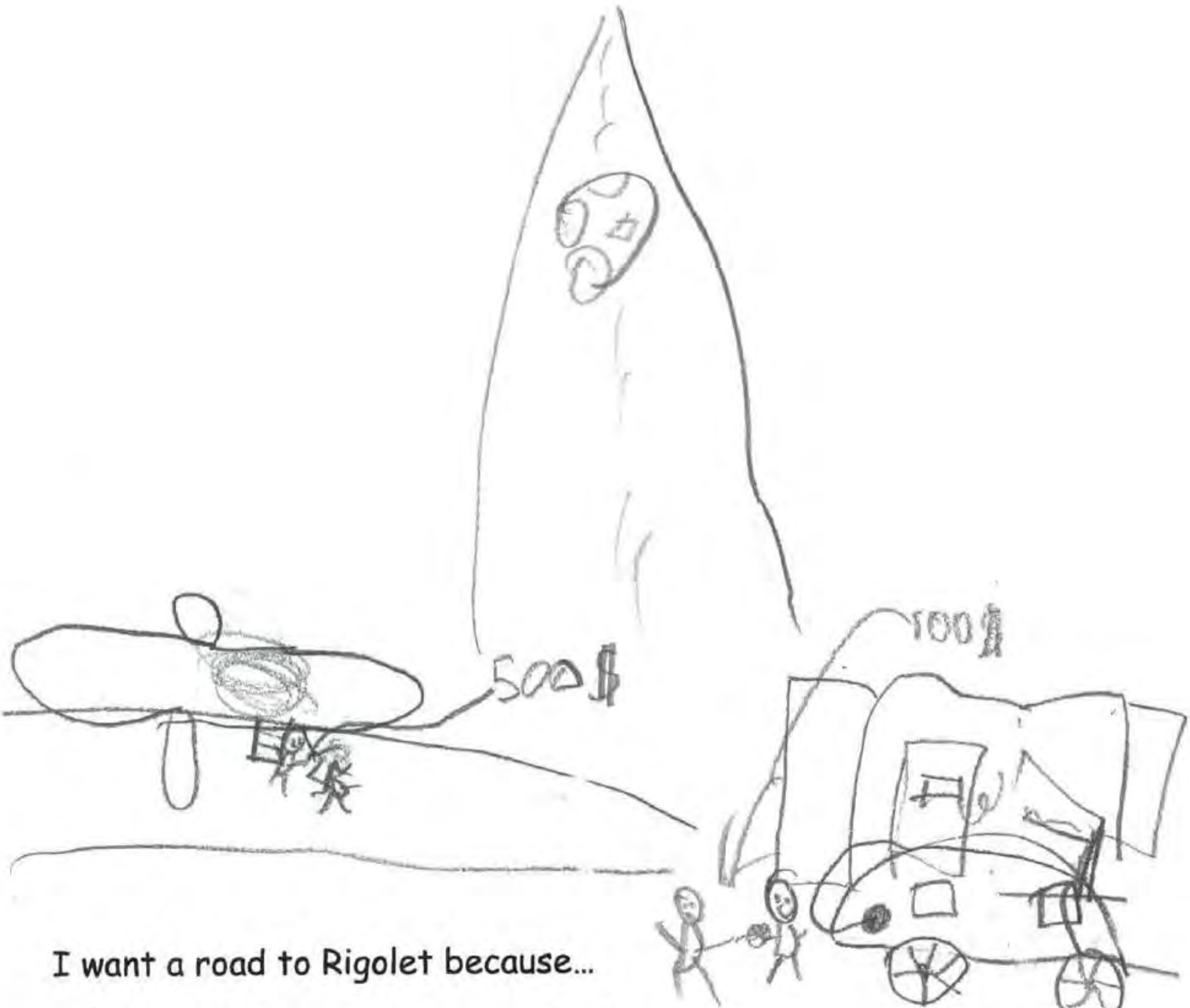


I want a road to Rigolet because...

To go on a road trip. To get more food. To see famiy members.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



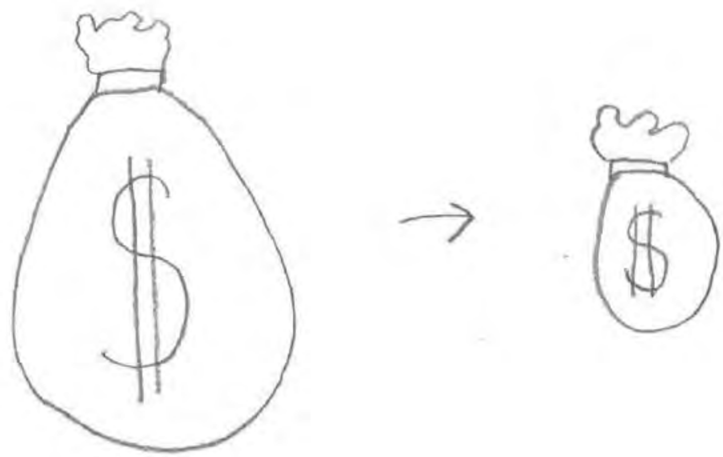
I want a road to Rigolet because...

It is cheaper thaun

ferry and plane.

Name:_[redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because...

it would be cheaper to go anywhere

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because... you could go to goose bay and go get mary brown and tim hortns

Name [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

It would be really convenient to be able to start in Rigolet

and drive to Toronto and Montreal EXT. There isint

really any reason not to make a rode system.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

We Will be able to drive anywhere from our

community. It will be more fun.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

because it is easierer to see Family.

It will Be easy to Goose Bay.

It will Be a his roadtrip.

Name:______________________________ Age:______ Date:___________________

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

____

____

____

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because... Net to BLUbit

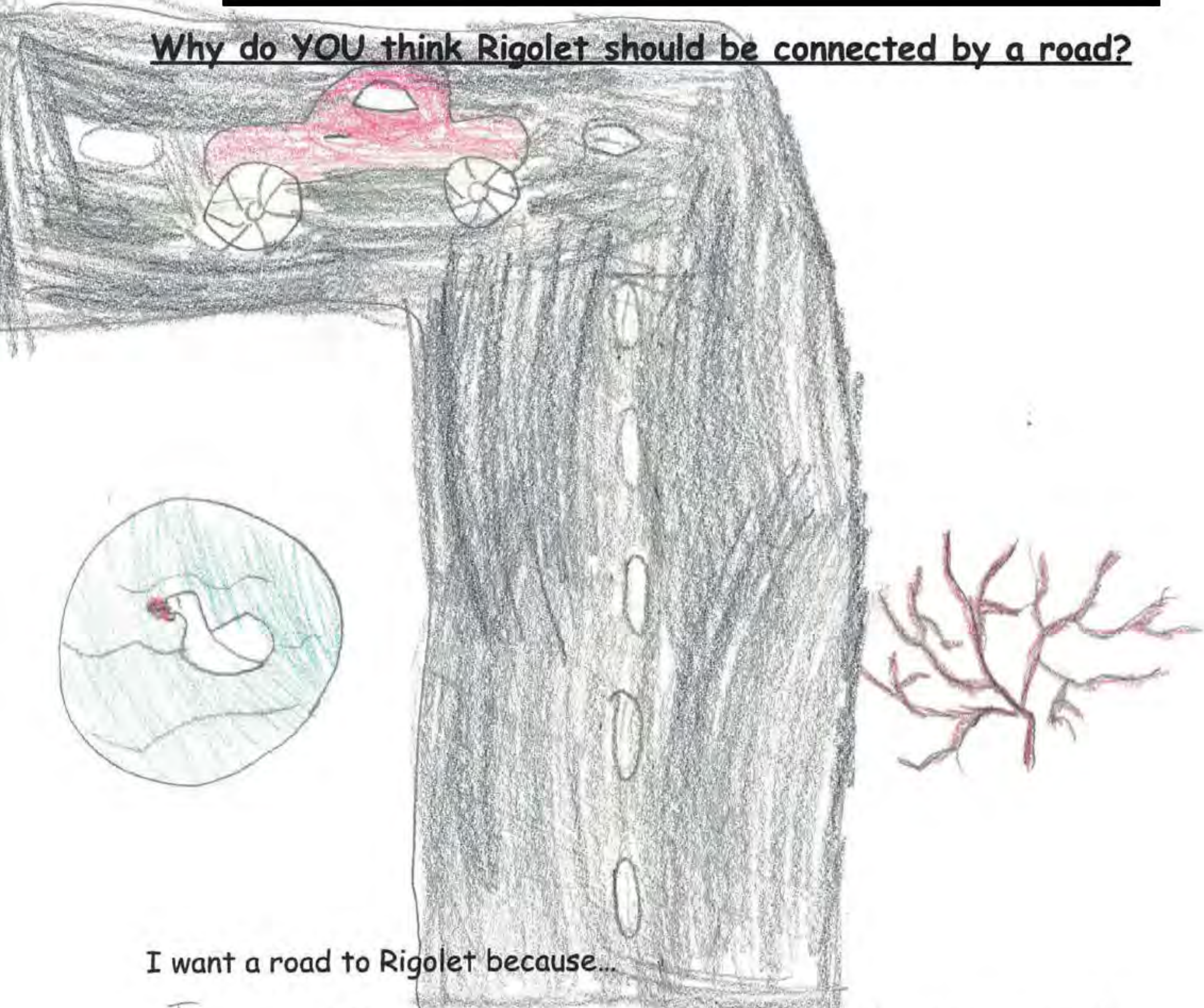
I Dot wot to sees ons

it iS Skrey

I Dot wat the ca[illegible]

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because...

I can see my family and friends and it would be easier.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because... I WAnt to go see nAn

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

my dad can pycke me up

And we can drive there.

Name: [redacted]

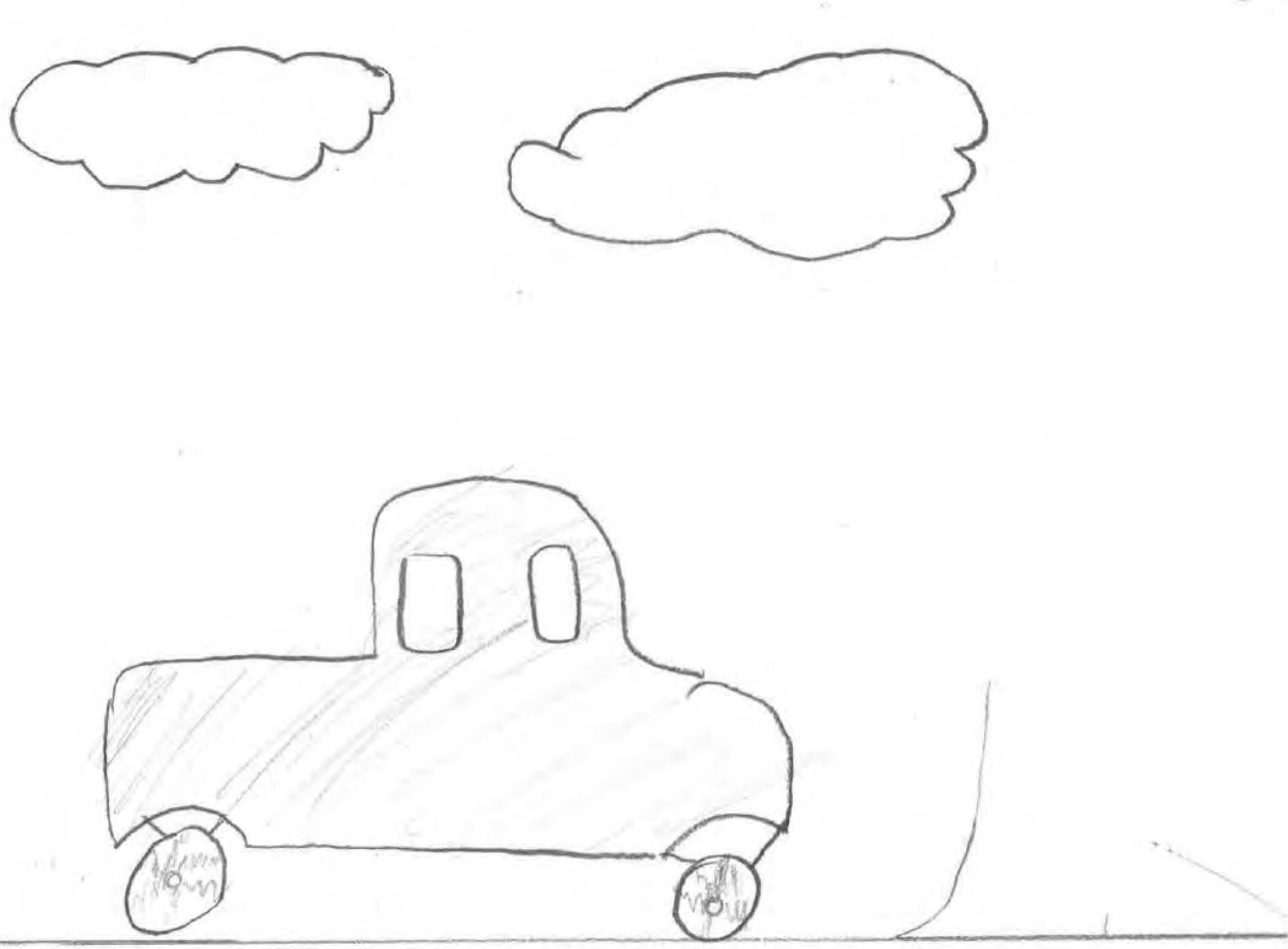
Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

in the summer I go Chance Cove in my moms car to goose Bay.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?



I want a road to Rigolet because...

I Can see my online Friends. and Family

By Driving There.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

We can go to the store to buy

a truck.

Name: [redacted]

Why do YOU think Rigolet should be connected by a road?

I want a road to Rigolet because...

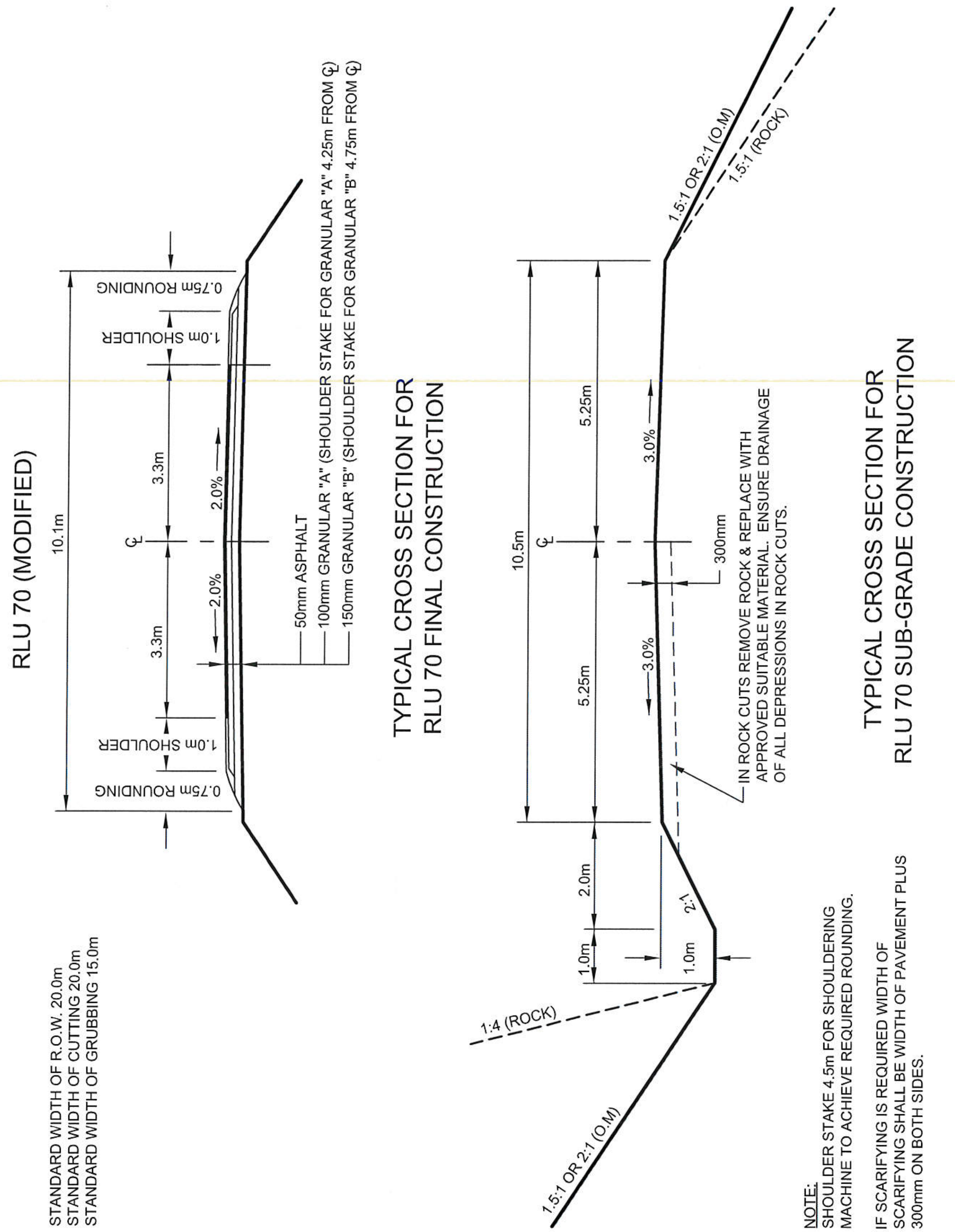
I Can go See my famIly in my car.

APPENDIX E

DTI HIGHWAY DESIGN DIVISION INFORMATION

- **TYPICAL CROSS SECTION (MODIFIED) RLU 70**
- **TYPICAL CROSS SECTION RLU 80**

RLU 70 (MODIFIED)



STANDARD WIDTH OF R.O.W. 20.0m
STANDARD WIDTH OF CUTTING 20.0m
STANDARD WIDTH OF GRUBBING 15.0m

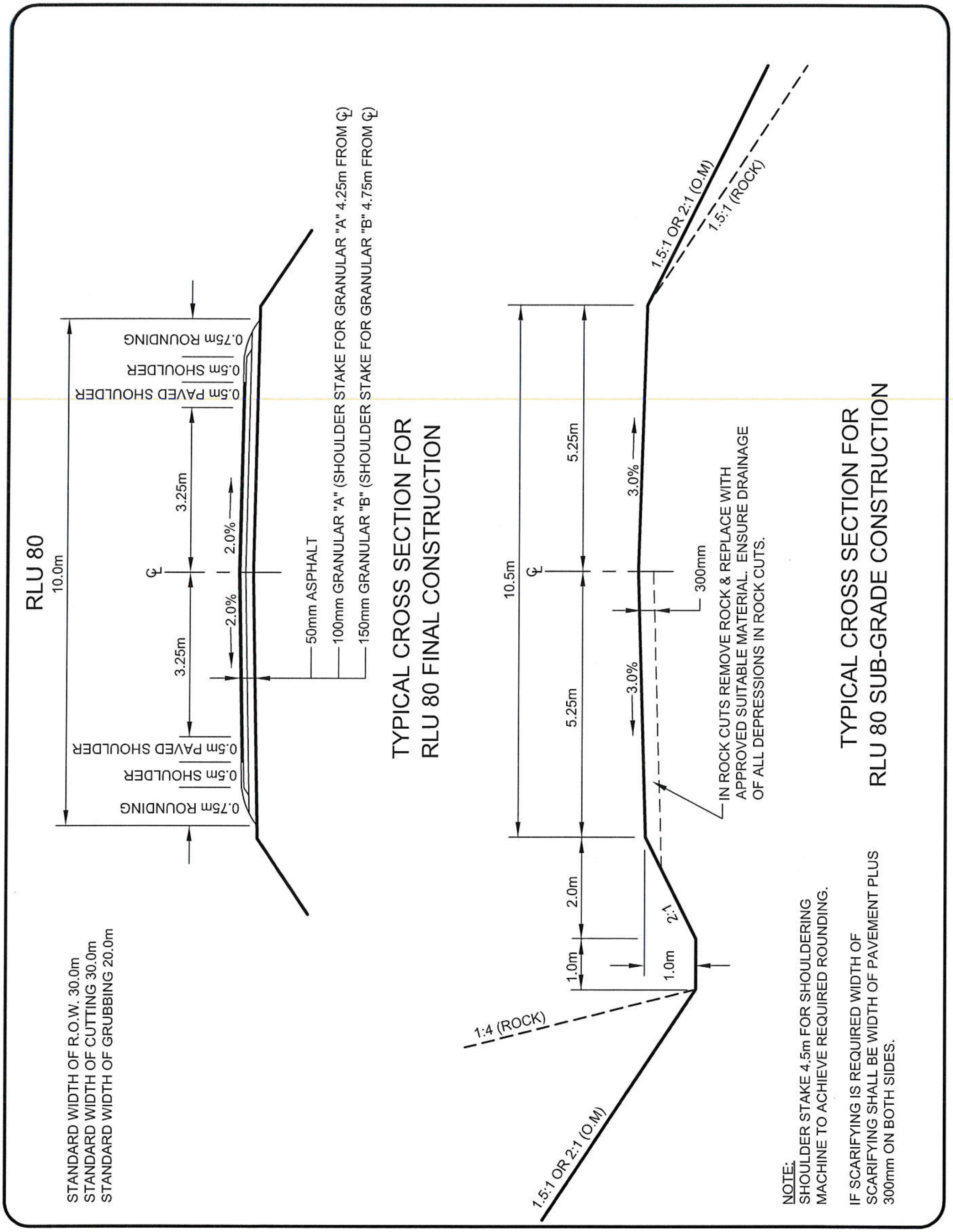
NOTE:
SHOULDER STAKE 4.5m FOR SHOULDERING MACHINE TO ACHIEVE REQUIRED ROUNDING.

IF SCARIFYING IS REQUIRED WIDTH OF SCARIFYING SHALL BE WIDTH OF PAVEMENT PLUS 300mm ON BOTH SIDES.

Newfoundland Labrador
TRANSPORTATION AND WORKS
HIGHWAY DESIGN DIVISION

TYPICAL CROSS SECTION (MODIFIED) RLU 70

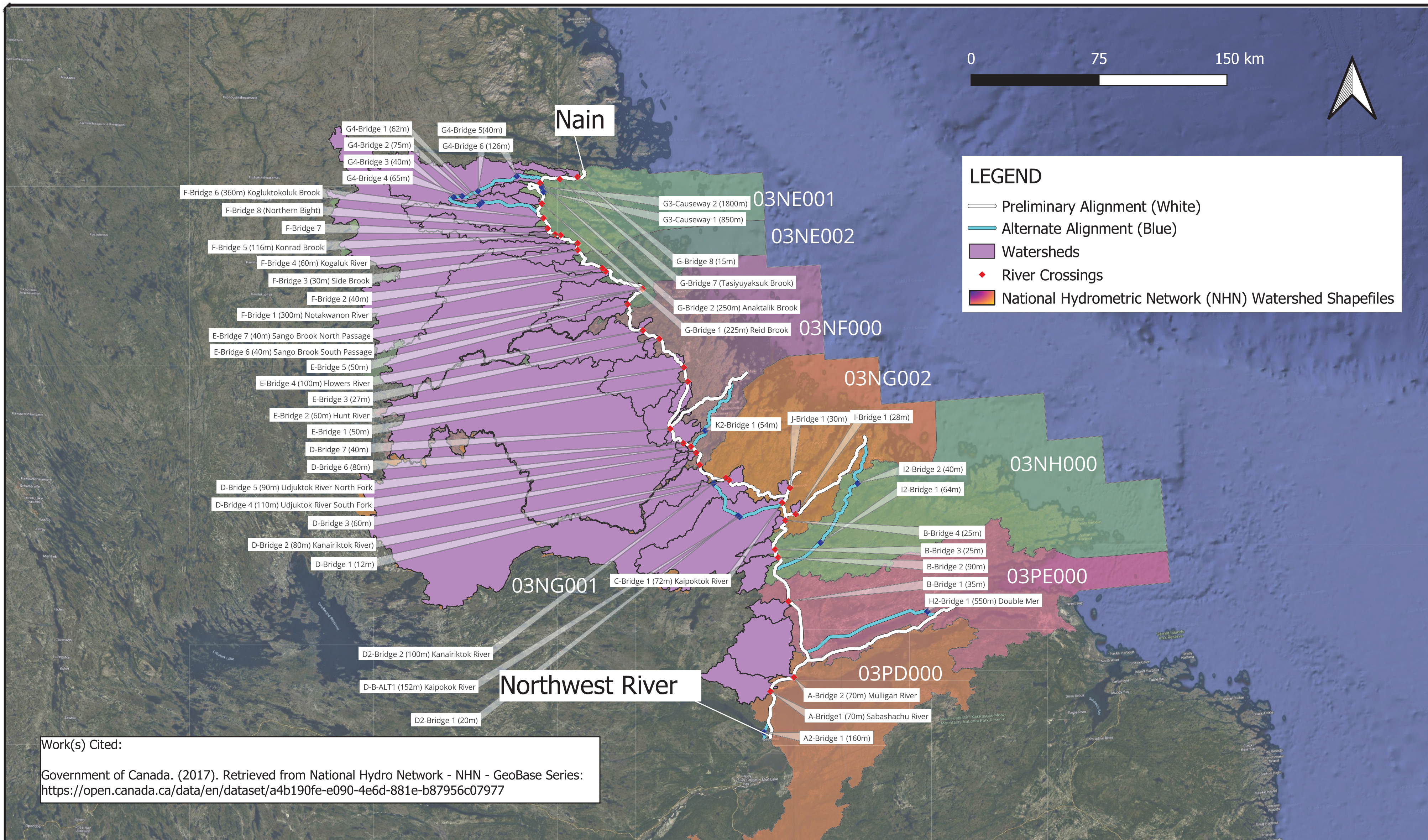
DRAWN BY: BMF	DATE: 02-01-10	SCALE 1:100



Newfoundland Labrador TRANSPORTATION AND WORKS HIGHWAY DESIGN DIVISION	TYPICAL CROSS SECTION RLU 80		
	DRAWN BY: BMF	DATE: 11-01-10	SCALE 1:100

APPENDIX F

SPATIAL MAPPING ALONG ALIGNMENT



Work(s) Cited:

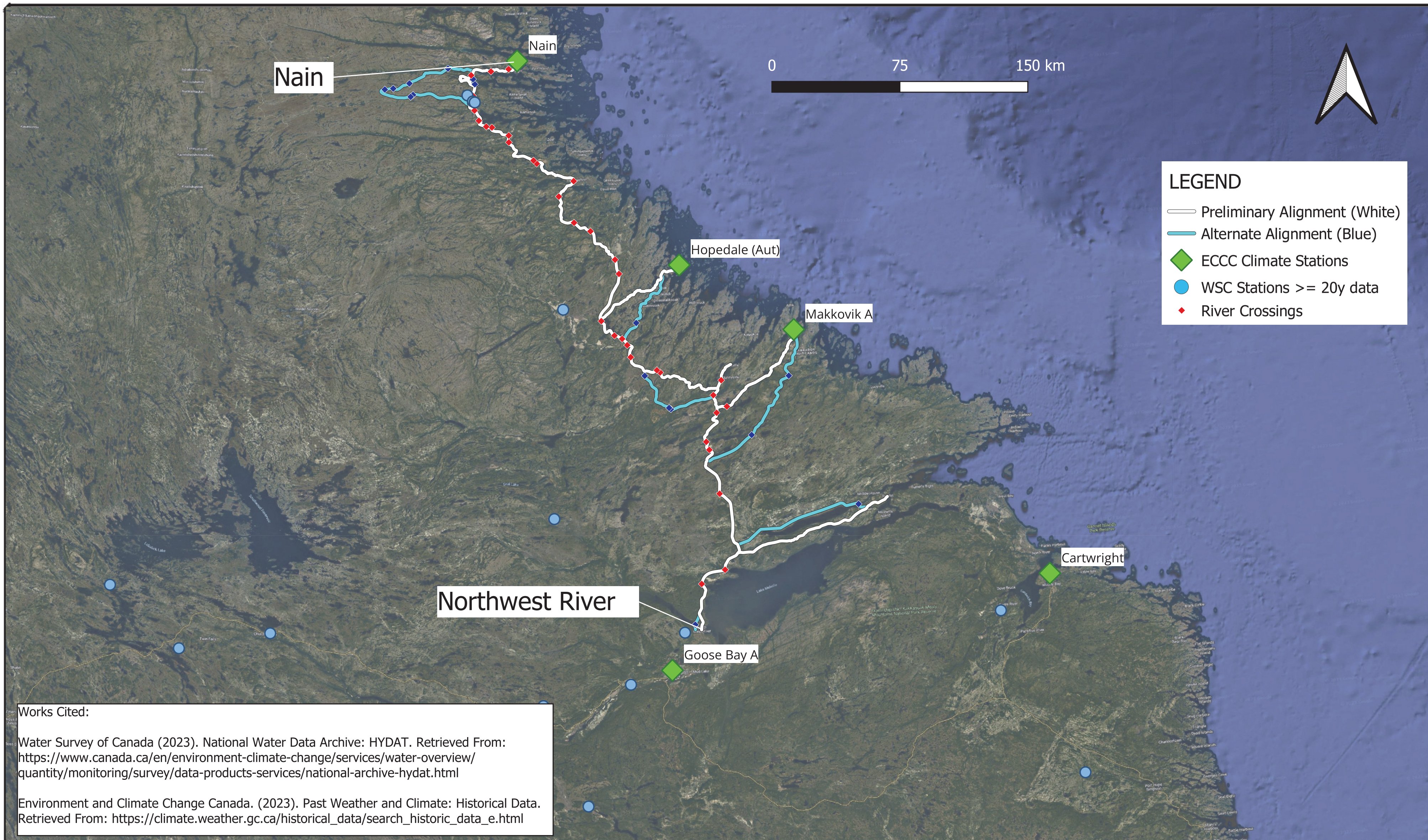
Government of Canada. (2017). Retrieved from National Hydro Network - NHN - GeoBase Series: https://open.canada.ca/data/en/dataset/a4b190fe-e090-4e6d-881e-b87956c07977

REVISON	DATE:	DESCRIPTION
D	05NOV2023	For Information
A	16JUN2023	For Information

Meco
Innovation I Reliability I Performance

ADDRESS: 109 Ilsley Avenue, Unit #14, Dartmouth, NS 3B 1S8
PHONE: (902) 444-3131
FAX: (902) 404-7777
WEB: www.MECOengineers.com

DESIGNED BY: Oscar Moyles
DRAFTED BY: Oscar Moyles
DATE: 05NOV2023
SCALE: As Shown
PROJECT: Pre-Feasibility Study - Road Into Northern Labrador
TITLE: Watershed Mapping - Crossings
PROJECT NO. 10708
DRAWING NO. 001
REV. D



Works Cited:

Water Survey of Canada (2023). National Water Data Archive: HYDAT. Retrieved From: https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/monitoring/survey/data-products-services/national-archive-hydat.html

Environment and Climate Change Canada. (2023). Past Weather and Climate: Historical Data. Retrieved From: https://climate.weather.gc.ca/historical_data/search_historic_data_e.html

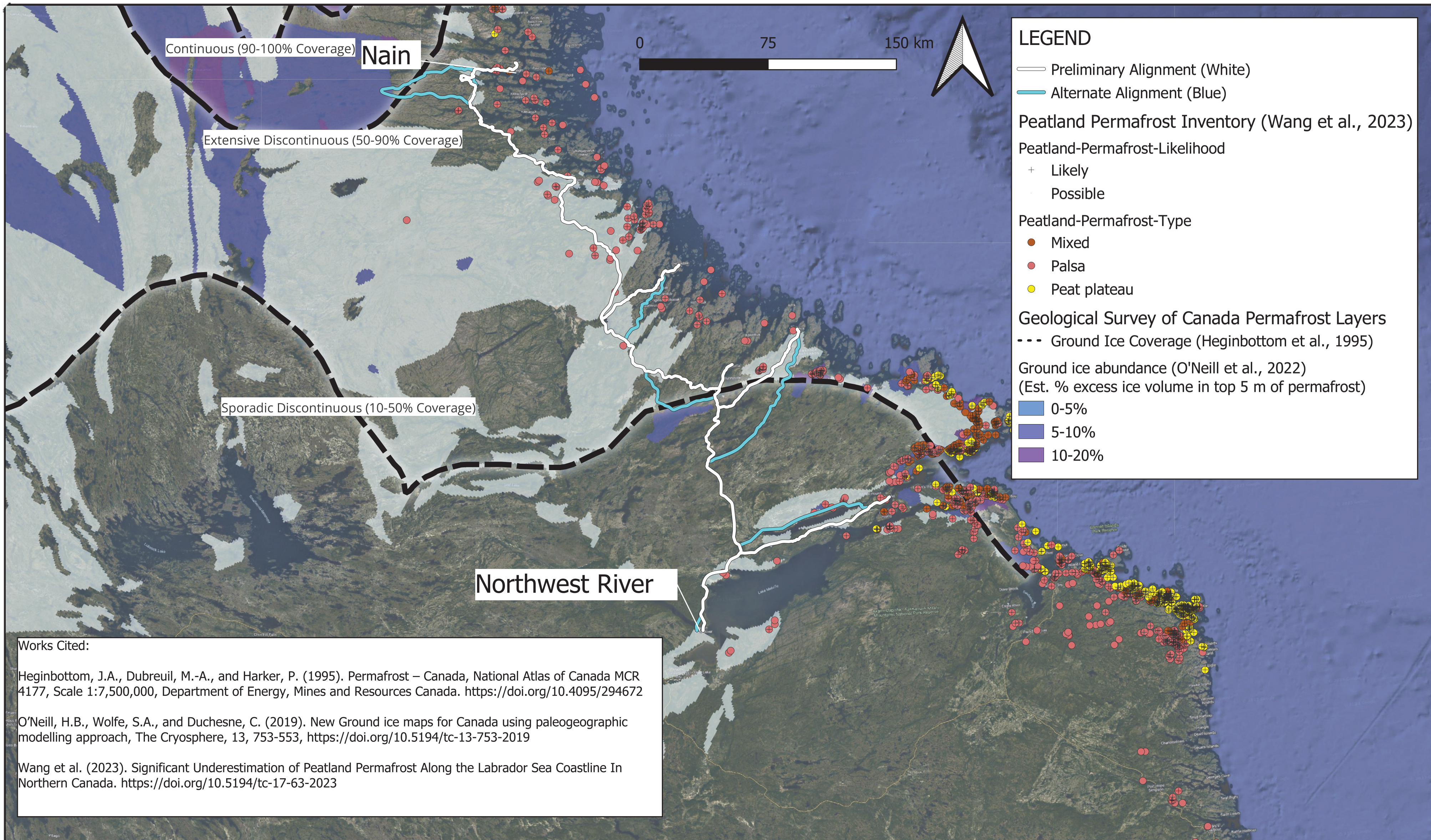
REVISON	DATE:	DESCRIPTION
B	05NOV2023	For Information
A	16JUN2023	For Information

Meco
Innovation I Reliability I Performance

ADDRESS: 109 Ilsley Avenue, Unit #14, Dartmouth, NS 3B 1S8
PHONE: (902) 444-3131
FAX: (902) 404-7777
WEB: www.MECOengineers.com

DESIGNED BY: Oscar Moyles
DRAFTED BY: Oscar Moyles
DATE: 05NOV2023
SCALE: As Shown

PROJECT: Pre-Feasibility Study - Road Into Northern Labrador
TITLE: WSC and EC Station Locations
PROJECT NO. 10708
DRAWING NO. 002
REV. B



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Heginbottom, J.A., Dubreuil, M.-A., and Harker, P. (1995). Permafrost – Canada, National Atlas of Canada MCR 4177, Scale 1:7,500,000, Department of Energy, Mines and Resources Canada. https://doi.org/10.4095/294672

O'Neill, H.B., Wolfe, S.A., and Duchesne, C. (2019). New Ground ice maps for Canada using paleogeographic modelling approach, The Cryosphere, 13, 753-553, https://doi.org/10.5194/tc-13-753-2019

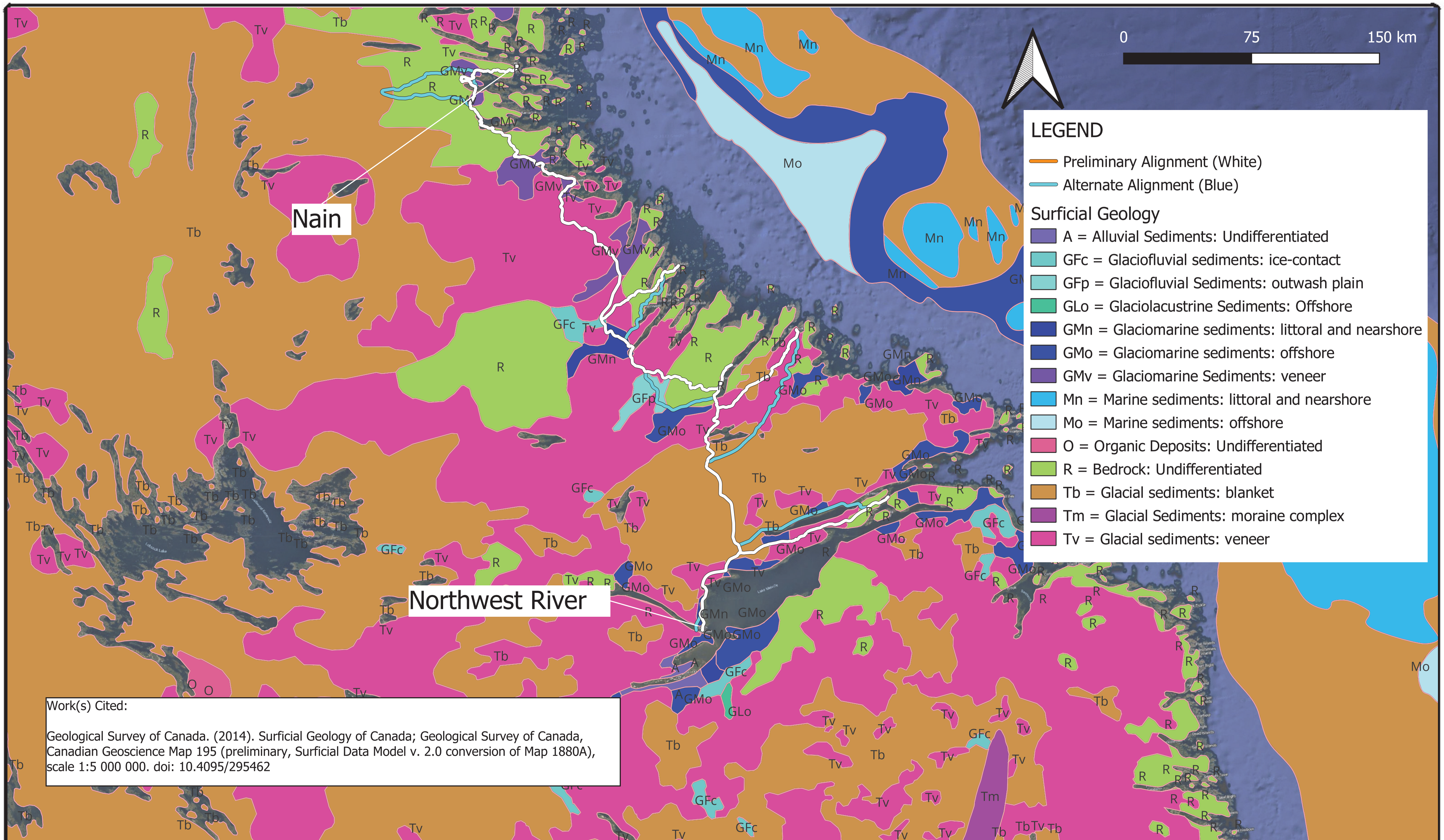
Wang et al. (2023). Significant Underestimation of Peatland Permafrost Along the Labrador Sea Coastline In Northern Canada. https://doi.org/10.5194/tc-17-63-2023

REVISON	DATE:	DESCRIPTION
C	05NOV2023	For Information
A	16JUN2023	For Information

MECO
Innovation I Reliability I Performance

ADDRESS: 109 Ilsley Avenue, Unit #14 Dartmouth, NS 3B 1S8
PHONE: (902) 444-3131
FAX: (902) 404-7777
WEB: www.MECOengineers.com

DESIGNED BY: Oscar Moyles	PROJECT: Pre-Feasibility Study - Road Into Northern Labrador
DRAFTED BY: Oscar Moyles	
DATE: 05NOV2023	TITLE: Ground Ice Abundance
SCALE: As Shown	PROJECT NO. 10708 / DRAWING NO. 003 / REV. C



REVISON	DATE:	DESCRIPTION
B	05NOV2023	For Information
A	16JUN2023	For Information

Meco Innovation I Reliability I Performance

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DESIGNED BY:	Oscar Moyles
DRAFTED BY:	Oscar Moyles
DATE:	05NOV2023
SCALE:	As Shown
PROJECT:	Pre-Feasibility Study - Road Into Northern Labrador
TITLE:	Surficial Geology 1:5000000
PROJECT NO.	10708
DRAWING NO.	004
REV.	B

APPENDIX G

RUNOFF COEFFICIENT TYPICAL VALUES

Table B - 1 Typical Runoff Curve Numbers

Character of Land Surface	Return Period (years)					
	2	5	10	25	50	100
Developed						
Asphaltic	0.73	0.77	0.81	0.86	0.9	0.95
Concrete/Roof	0.75	0.8	0.83	0.88	0.92	0.97
Grass Areas (lawns, parks, etc.)						
Poor Condition (grass cover less than 50% of the area)						
Flat, 0-2%	0.32	0.34	0.37	0.4	0.44	0.47
Average, 2-7%	0.37	0.4	0.43	0.46	0.49	0.53
Steep, over 7%	0.4	0.43	0.45	0.49	0.52	0.55
Fair Condition (grass cover on 50% to 75% of the area)						
Flat, 0-2%	0.25	0.28	0.3	0.34	0.37	0.41
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49
Steep, over 7%	0.37	0.4	0.42	0.46	0.49	0.53
Good Condition (grass cover larger than 75% of the area)						
Flat, 0-2%	0.21	0.23	0.25	0.29	0.32	0.36
Average, 2-7%	0.29	0.32	0.35	0.39	0.42	0.46
Steep, over 7%	0.34	0.37	0.4	0.44	0.47	0.51
Undeveloped						
Cultivated Land						
Flat, 0-2%	0.31	0.34	0.36	0.4	0.43	0.47
Average, 2-7%	0.35	0.38	0.41	0.44	0.48	0.51
Steep, over 7%	0.39	0.42	0.44	0.48	0.51	0.54
Pasture/Range						
Flat, 0-2%	0.25	0.28	0.3	0.34	0.37	0.41
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49
Steep, over 7%	0.37	0.4	0.42	0.46	0.49	0.53
Forest/Woodlands						
Flat, 0-2%	0.22	0.25	0.28	0.31	0.35	0.39
Average, 2-7%	0.31	0.34	0.36	0.4	0.43	0.47
Steep, over 7%	0.35	0.39	0.41	0.45	0.48	0.52

Source: Applied Hydrology. Chow, Maidment and Mays. McGraw-Hill. 1998

Table B - 2 Runoff Curve Numbers for Developed Areas

Cover Description **Cover Type & Hydrologic Condition**	**Average Percent Impervious Area**	**Curve Numbers for Hydrologic Soil Group** **A**	 **B**	 **C**	 **D**
<u>Fully developed urban areas (vegetation established)</u>					
Open space (lawns, parks, golf courses, cemeteries, etc.)					
Poor condition (grass cover less than 50%)		68	79	86	89
Fair condition (grass cover 50 to 75%)		49	69	79	84
Good condition (grass cover greater than 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets & roads					
Paved; curbs and storm sewers		98	98	98	98
Paved; open ditches		83	89	92	93
Gravel		76	85	89	91
Dirt		72	82	87	89
Urban districts					
Commercial & business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts					
1/8 ac. or less (town houses)	65	77	85	90	92
1/4 ac.	38	61	75	83	87
1/3 ac.	30	57	72	81	86
1/2 ac.	25	54	70	80	85
1 ac.	20	51	68	79	84
2 ac.	12	46	65	77	82
<u>Developing urban areas</u>					
Newly graded areas (no vegetation)		77	86	91	94

Source: <u>Engineering Hydrology Principles & Practices</u>. Ponce. Prentice Hall. 1989

Table B - 3 Runoff Curve Numbers for Undeveloped Areas

Cover Description		Curve Numbers for Hydrologic Soil Group			
Cover Type	**Hydrologic Condition**	**A**	**B**	**C**	**D**
Pasture, grassland, or range - continuous forage for grazing	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow - continuous grass, protected from grazing & generally mowed for hay		30	58	71	78
Brush - brush-weed-grass mixture with brush being the major element	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods - grass combination (orchard or tree farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77

Source: Engineering Hydrology Principles & Practices. Ponce. Prentice Hall. 1989

APPENDIX H

INTENSITY DURATION CURVES

15. Churchill Falls A

This station was updated in CRA (2015). The updated IDF curve from CRA (2015) is reproduced below, with the addition of the 20-year return period.

This IDF curve was updated using 6-hr data from two nearby stations: Churchill Falls and Churchill Falls A. The IDF curve generally increased during the update (Table 15.1).

Table 15.1 Differences Between IDF Curves for Churchill Falls A

Percent Difference in Precipitation Amount (%) (Difference in Precipitation Amount (mm))						
Duration	Return Period (years)					
	2	5	10	25	50	100
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	2.1 (0.4)	4.2 (1.1)	**5.2 (1.5)**	**6.1 (2.1)**	**6.6 (2.5)**	**7.0 (2.9)**
12-hr	4.3 (1.2)	2.1 (0.7)	1.1 (0.4)	0.1 (0.0)	-0.5 (-0.3)	-1.0 (-0.5)
24-hr	3.1 (1.1)	2.6 (1.1)	2.4 (1.2)	2.2 (1.2)	2.1 (1.2)	2.0 (1.3)

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

```
                Office of Climate Change and Energy Efficiency

           Short Duration Rainfall Intensity-Duration-Frequency Data
          Données sur l'intensité, la durée et la fréquence des chutes
                          de pluie de courte durée

                  Gumbel - Method of moments/Méthode des moments

                                 2015/10/30

================================================================================

 CHURCHILL FALLS A                                     NL        8501132
 Updated with 6-hr data measured at Churchill Falls (8501130): 1994 - 2011
 Updated with 6-hr data measured at Churchill Falls A (8501131): 2012 - 2013
 Latitude: 53 33'N    Longitude: 64 6'W     Elevation/Altitude: 439        m
 Years/Années : 1969 - 2013          # Years/Années :    23

================================================================================

********************************************************************************

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

********************************************************************************
```

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1969	6.6	7.9	8.4	8.4	9.7	16.0	33.8	44.4	49.3
EC-IDF	1970	3.0	6.1	7.1	9.1	10.2	12.2	21.6	27.9	29.5
EC-IDF	1971	3.0	4.6	5.8	7.1	8.9	10.2	13.5	20.6	28.2
EC-IDF	1972	4.8	5.6	5.8	6.6	10.7	17.5	26.4	31.0	32.8
EC-IDF	1973	4.6	8.4	10.7	12.2	13.7	14.0	21.8	30.7	35.1
EC-IDF	1974	3.8	5.6	5.8	6.1	7.1	9.7	12.7	18.8	29.5
EC-IDF	1975	4.3	5.1	5.3	6.1	9.1	16.5	35.8	53.3	59.9
EC-IDF	1976	5.1	7.4	8.1	9.4	11.2	11.7	19.6	30.7	38.1
EC-IDF	1978	3.7	5.3	5.8	5.8	8.2	12.4	21.9	38.4	48.7
EC-IDF	1979	5.9	6.1	7.3	10.2	11.8	16.5	29.0	33.7	36.8
EC-IDF	1980	2.9	5.2	7.9	13.3	16.0	18.7	20.0	25.6	29.7
EC-IDF	1981	5.8	7.7	10.1	14.3	14.4	16.1	16.9	25.4	39.4
EC-IDF	1982	3.4	3.6	5.1	8.6	14.3	18.4	20.4	24.2	38.6
EC-IDF	1983	3.7	3.7	3.7	6.7	8.6	10.3	18.3	20.7	22.7
EC-IDF	1984	4.9	6.2	8.1	10.3	11.0	13.7	23.7	32.4	43.6
EC-IDF	1985	4.4	4.8	5.1	7.5	8.1	11.5	14.2	22.3	30.9
EC-IDF	1986	8.3	11.7	13.5	14.7	15.0	15.2	23.9	28.2	48.5
EC-IDF	1987	9.6	15.7	18.4	20.2	20.2	21.2	26.0	27.6	33.1
EC-IDF	1988	3.7	3.9	4.8	6.8	7.5	9.7	15.3	24.2	34.6
EC-IDF	1989	6.3	8.0	12.0	16.0	17.2	17.4	18.4	24.7	29.3
EC-IDF	1990	8.6	10.1	10.6	13.3	13.3	13.3	16.5	26.1	36.3
EC-IDF	1991	2.1	3.6	5.1	7.4	9.8	16.4	29.8	34.8	34.8
EC-IDF	1992	2.0	2.5	3.3	3.8	5.1	8.9	16.6	20.1	25.5
UPDATE	1994	NM	NM	NM	NM	NM	NM	-99.9	29.0	36.0
UPDATE	1995	NM	NM	NM	NM	NM	NM	41.0	45.0	66.0
UPDATE	1996	NM	NM	NM	NM	NM	NM	35.0	35.0	38.0
UPDATE	1997	NM	NM	NM	NM	NM	NM	24.0	34.0	41.0
UPDATE	1998	NM	NM	NM	NM	NM	NM	22.0	26.0	29.0
UPDATE	1999	NM	NM	NM	NM	NM	NM	28.0	31.0	35.0
UPDATE	2000	NM	NM	NM	NM	NM	NM	13.0	19.0	29.0
UPDATE	2001	NM	NM	NM	NM	NM	NM	20.0	35.0	36.6
UPDATE	2002	NM	NM	NM	NM	NM	NM	15.0	28.0	30.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	25.0	29.0	36.0
UPDATE	2005	NM	NM	NM	NM	NM	NM	29.0	38.0	40.0
UPDATE	2006	NM	NM	NM	NM	NM	NM	25.0	41.0	48.0
UPDATE	2007	NM	NM	NM	NM	NM	NM	17.0	30.0	37.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	13.0	22.0	33.0
UPDATE	2009	NM	NM	NM	NM	NM	NM	13.0	21.0	31.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	28.0	38.0	50.0
UPDATE	2012	NM	NM	NM	NM	NM	NM	19.0	32.0	38.8
UPDATE	2013	NM	NM	NM	NM	NM	NM	-99.9	33.0	43.5
	# Yrs. Années	23	23	23	23	23	23	39	41	41
	Mean Moyenne	4.8	6.5	7.7	9.7	11.4	14.2	22.1	30.0	37.4
	Std. Dev. Écart-type	2.0	3.0	3.5	4.0	3.7	3.4	7.0	7.6	8.9
	Skew. Dissymétrie	0.91	1.55	1.43	0.95	0.63	0.12	0.72	0.84	1.24
	Kurtosis	3.65	6.31	5.68	3.83	3.41	2.45	3.29	4.10	5.14

*-99.9 Indicates Missing Data/Données manquantes

* NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité
pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1995	24 h	66.0	65.2

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.5	6.3	7.4	8.6	8.9	10.0	11.1	23
EC-IDF 10 min	6.0	8.6	10.4	12.0	12.6	14.2	15.8	23

EC-IDF 15 min	7.1	10.3	12.3	14.3	15.0	16.9	18.8	23
EC-IDF 30 min	9.1	12.6	15.0	17.2	17.9	20.1	22.3	23
EC-IDF 1 h	10.8	14.0	16.1	18.2	18.8	20.8	22.8	23
EC-IDF 2 h	13.7	16.7	18.7	20.6	21.2	23.0	24.9	23
UPDATE 6 h	21.0	27.2	31.3	35.2	36.5	40.3	44.2	39
UPDATE 12 h	28.8	35.5	40.0	44.3	45.6	49.8	54.0	41
UPDATE 24 h	35.9	43.8	49.0	54.0	55.5	60.4	65.2	41

* 6-hr data were used for the update: shorter durations were not updated

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	53.7	75.1	89.3	102.9	107.2	120.5	133.7	23
	+/- 9.1	+/- 15.3	+/- 20.7	+/- 26.1	+/- 27.9	+/- 33.4	+/- 38.9	23
EC-IDF 10 min	35.9	51.7	62.2	72.2	75.4	85.2	95.0	23
	+/- 6.7	+/- 11.3	+/- 15.3	+/- 19.3	+/- 20.6	+/- 24.6	+/- 28.7	23
EC-IDF 15 min	28.6	41.1	49.4	57.3	59.8	67.6	75.3	23
	+/- 5.3	+/- 8.9	+/- 12.1	+/- 15.3	+/- 16.3	+/- 19.5	+/- 22.7	23
EC-IDF 30 min	18.2	25.2	29.9	34.4	35.8	40.2	44.6	23
	+/- 3.0	+/- 5.1	+/- 6.8	+/- 8.6	+/- 9.2	+/- 11.0	+/- 12.8	23
EC-IDF 1 h	10.8	14.0	16.1	18.2	18.8	20.8	22.8	23
	+/- 1.4	+/- 2.3	+/- 3.1	+/- 3.9	+/- 4.2	+/- 5.0	+/- 5.9	23
EC-IDF 2 h	6.8	8.3	9.3	10.3	10.6	11.5	12.4	23
	+/- 0.6	+/- 1.1	+/- 1.4	+/- 1.8	+/- 2.0	+/- 2.3	+/- 2.7	23
UPDATE 6 h	3.5	4.5	5.2	5.9	6.1	6.7	7.4	39
	+/- 0.3	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.0	+/- 1.2	+/- 1.4	39
UPDATE 12 h	2.4	3.0	3.3	3.7	3.8	4.2	4.5	41
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.5	+/- 0.5	+/- 0.7	+/- 0.8	41
UPDATE 24 h	1.5	1.8	2.0	2.2	2.3	2.5	2.7	41
	+/- 0.1	+/- 0.2	+/- 0.2	+/- 0.3	+/- 0.3	+/- 0.4	+/- 0.4	41

* 6-hr data were used for the update: shorter durations were not updated

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	17.9	25.0	29.6	34.1	35.5	39.9	44.3
Std. Dev. /Écart-type (RR)	18.1	25.8	30.9	35.8	37.4	42.2	47.0
Std. Error/Erreur-type	0.8	2.2	3.2	4.1	4.4	5.3	6.2
Coefficient (A)	11.3	15.0	17.4	19.8	20.5	22.8	25.0
Exponent/Exposant (B)	-0.639	-0.669	-0.683	-0.692	-0.695	-0.702	-0.708
Mean % Error/% erreur moyenne	3.4	5.5	6.6	7.4	7.7	8.3	8.8

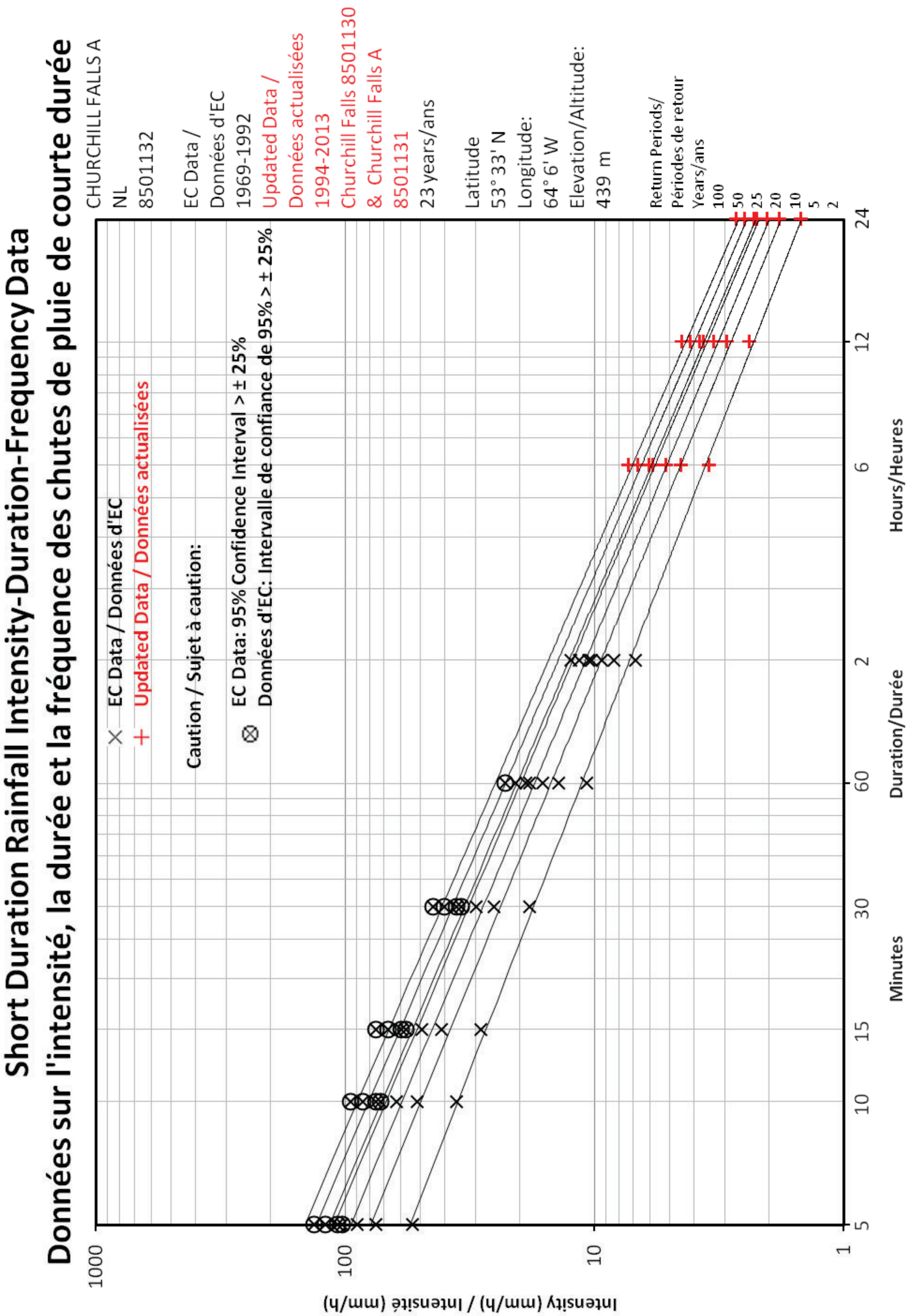

Figure 15.1 Churchill Falls A IDF Curve – Updated

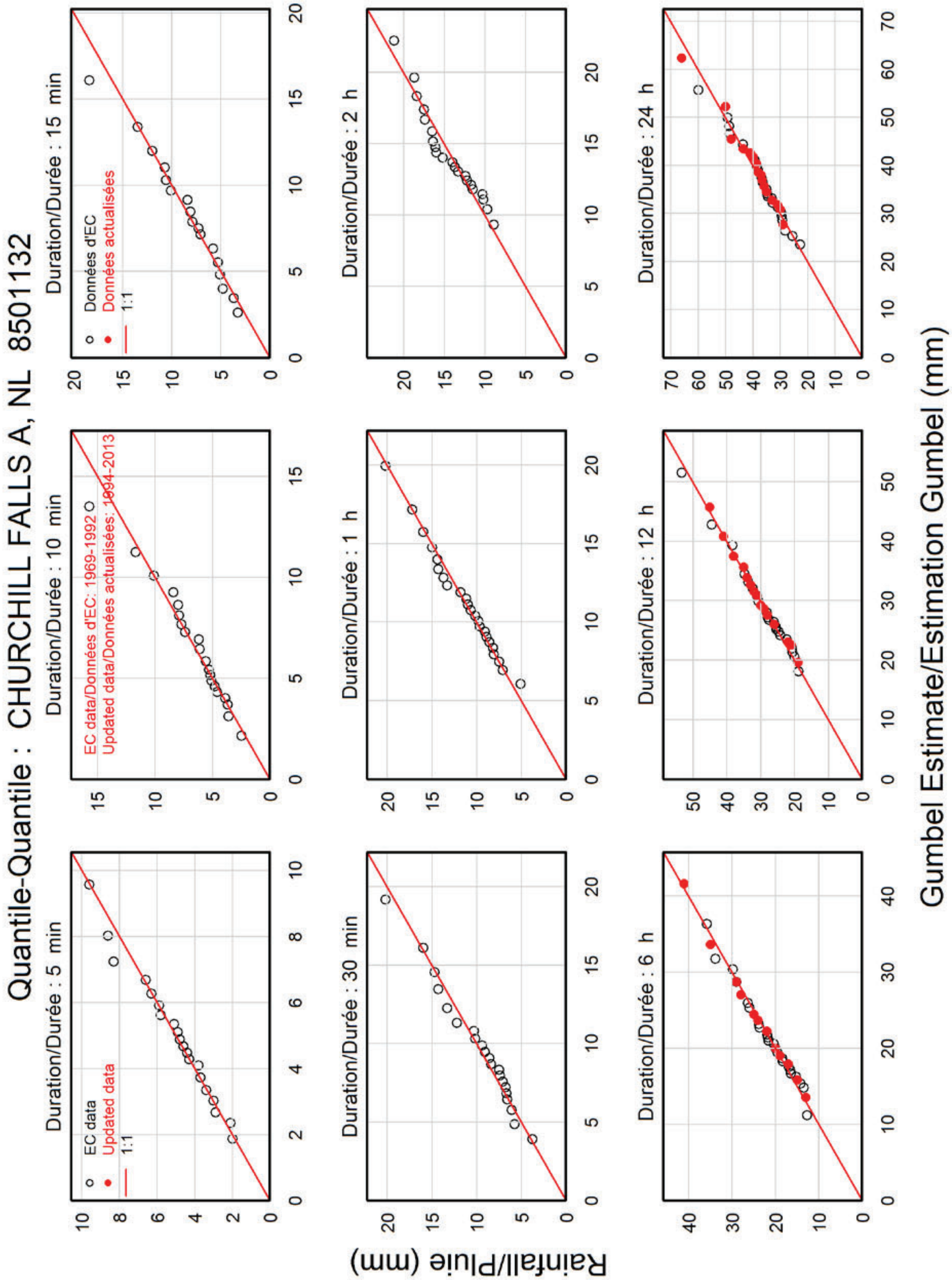

Figure 15.2 Churchill Falls A Quantile-Quantile Plot – Updated

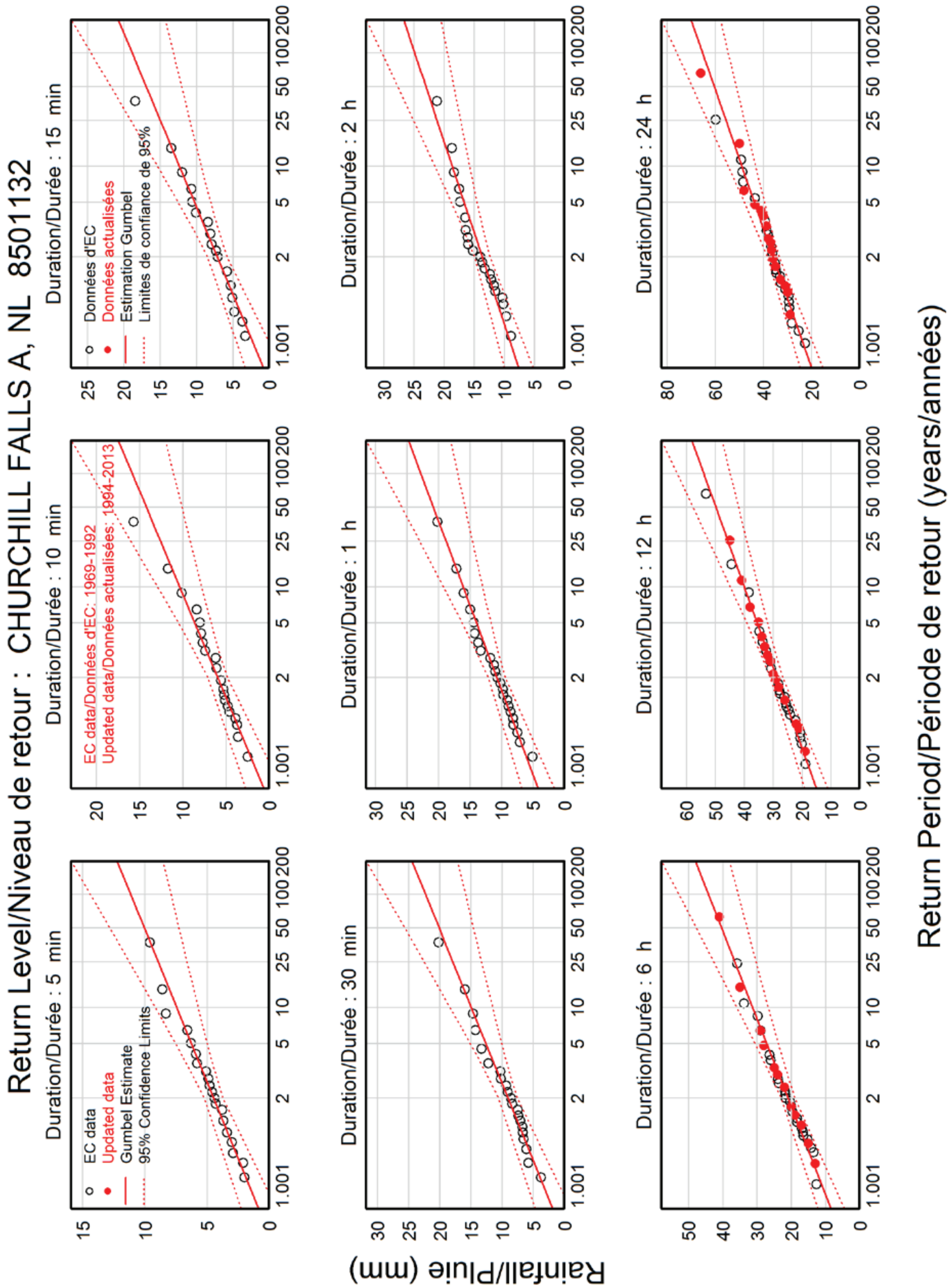

Figure 15.3 Churchill Falls A Return Level Plot – Updated

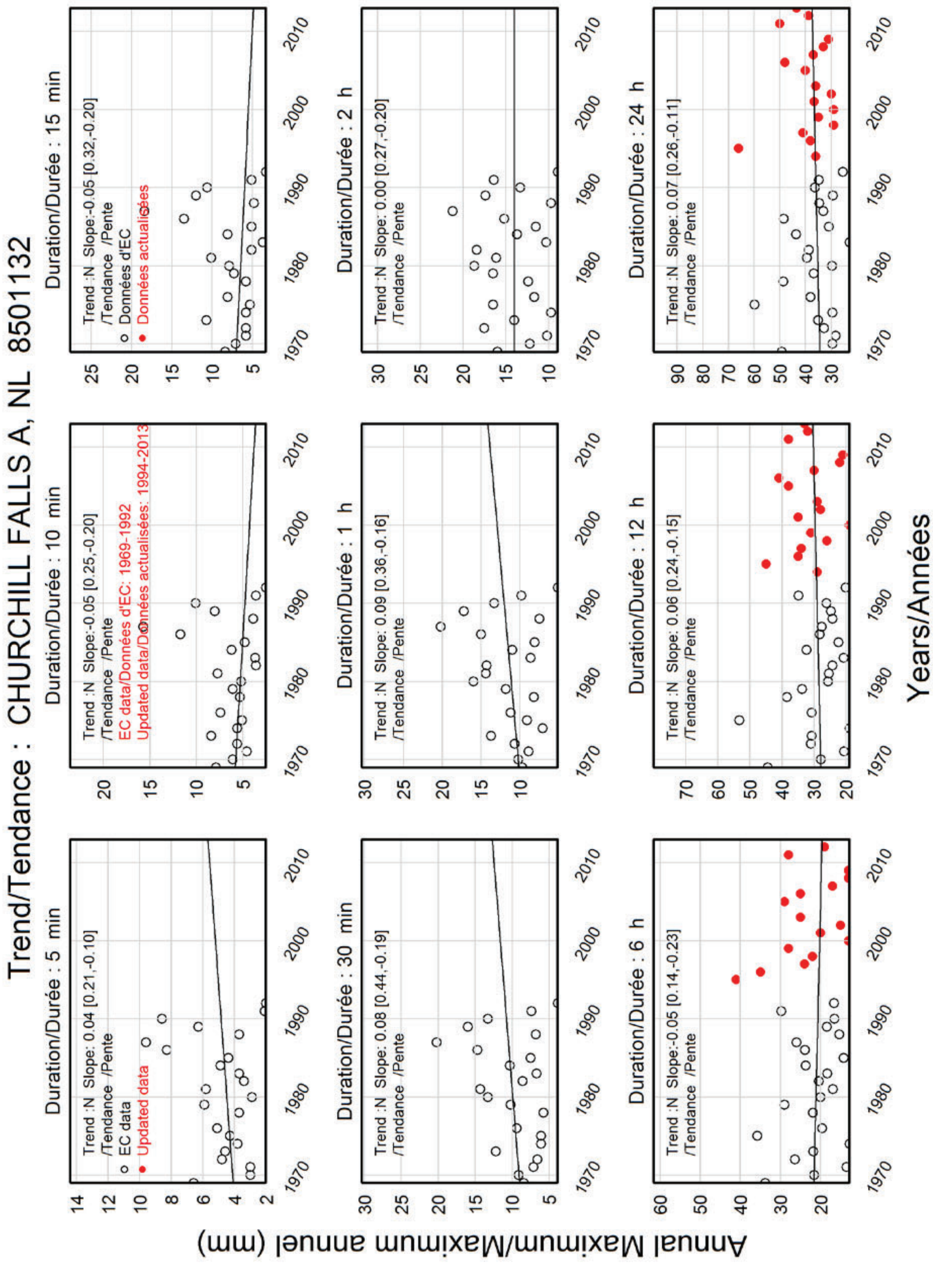

Figure 15.4 Churchill Falls A Trend Plot – Updated

16. Goose A

This station was not updated in CRA (2015) because it is an active IDF station and was updated by EC. The EC IDF V2.3 (2015) curve is reproduced below, with the addition of the 20-year return period.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/10/30

==

GOOSE A NL 8501900

Latitude: 53 19'N Longitude: 60 25'W Elevation/Altitude: 48 m

Years/Années : 1961 - 2013 # Years/Années : 50

==

****

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1961	2.3	4.1	4.1	7.1	8.4	12.7	22.9	37.6	57.4
EC-IDF	1962	4.1	5.1	6.3	6.9	6.9	9.9	20.6	33.0	37.8
EC-IDF	1963	11.2	20.1	24.6	33.3	35.6	39.1	61.2	67.8	75.2
EC-IDF	1966	5.8	11.2	11.4	11.4	11.4	14.2	26.7	44.2	59.9
EC-IDF	1967	5.6	8.9	9.1	13.5	15.7	17.3	18.3	24.4	36.8
EC-IDF	1968	2.5	3.6	4.3	5.3	8.1	13.5	24.4	31.7	44.7
EC-IDF	1969	2.8	5.3	7.6	8.6	15.5	16.3	28.4	37.3	38.1
EC-IDF	1970	4.1	6.6	8.9	11.7	15.7	24.4	30.2	36.8	46.2
EC-IDF	1971	5.3	7.1	7.9	8.1	8.1	9.4	20.6	29.7	31.7
EC-IDF	1972	5.1	7.4	9.1	10.4	14.0	14.2	20.1	31.0	39.6
EC-IDF	1973	6.3	9.9	12.4	15.0	19.3	31.7	38.9	40.9	41.1
EC-IDF	1974	3.0	4.6	5.1	6.9	10.7	11.2	22.1	33.3	43.9
EC-IDF	1975	4.1	5.1	6.1	7.9	9.1	11.7	13.7	18.0	18.8
EC-IDF	1976	3.3	3.6	5.6	8.6	10.7	14.2	30.2	44.2	50.3
EC-IDF	1977	3.8	4.1	4.1	4.8	6.6	8.1	19.3	27.2	31.2
EC-IDF	1978	3.0	3.6	4.6	5.6	8.4	12.1	21.3	26.0	33.8
EC-IDF	1979	3.9	4.7	4.7	4.7	8.0	10.6	24.0	30.2	36.3
EC-IDF	1980	1.9	3.3	5.2	6.8	8.1	10.6	26.3	33.6	44.3
EC-IDF	1981	2.2	4.0	4.8	6.5	10.6	19.4	44.6	60.0	68.0
EC-IDF	1982	1.4	1.7	2.5	4.7	8.8	13.9	20.9	22.5	22.8
EC-IDF	1983	3.7	7.3	7.3	8.8	10.5	13.0	26.0	32.4	43.6
EC-IDF	1984	3.2	4.3	4.9	5.9	8.1	11.1	21.4	24.2	29.5
EC-IDF	1985	4.5	5.2	5.4	7.0	8.3	15.3	28.8	40.3	47.3
EC-IDF	1986	5.6	9.0	9.8	10.5	11.2	12.5	24.7	32.9	40.9
EC-IDF	1987	5.5	6.6	6.8	7.9	11.8	18.2	21.0	31.7	36.4
EC-IDF	1988	2.6	3.6	4.0	5.5	7.2	14.3	24.8	28.9	30.8
EC-IDF	1989	6.2	6.6	6.6	6.6	7.4	12.6	22.7	35.3	56.6
EC-IDF	1990	4.5	7.1	8.3	9.6	9.8	10.8	18.4	23.4	27.2
EC-IDF	1991	4.4	8.0	10.4	16.8	17.4	17.4	26.3	37.8	43.2
EC-IDF	1992	2.5	3.2	4.0	6.7	8.8	11.1	18.2	25.2	33.1
EC-IDF	1993	2.8	4.3	5.0	6.3	10.8	11.9	15.1	24.9	34.1
EC-IDF	1994	3.1	4.2	4.7	6.2	12.2	15.1	26.8	34.4	39.8
EC-IDF	1995	4.6	5.2	6.3	7.9	13.0	16.9	20.0	22.2	29.8
EC-IDF	1996	3.9	5.4	7.4	11.6	15.9	21.5	25.3	34.8	51.1
EC-IDF	1997	3.7	5.3	6.2	7.3	10.0	13.3	26.7	39.7	55.1
EC-IDF	1998	5.4	10.5	11.9	15.7	15.9	15.9	17.8	25.3	34.3
EC-IDF	1999	8.2	11.9	15.8	15.8	18.5	22.3	28.0	43.8	72.2

EC-IDF	2000	3.5	4.1	5.7	6.3	8.2	12.2	24.0	29.5	32.2
EC-IDF	2001	7.1	7.3	8.7	13.0	13.6	13.6	26.9	35.0	50.6
EC-IDF	2002	5.1	6.3	7.1	7.3	8.5	16.1	28.2	41.3	52.5
EC-IDF	2003	2.8	4.4	5.4	8.8	9.6	11.2	19.1	22.7	32.9
EC-IDF	2004	4.4	7.3	9.9	13.3	14.3	15.9	38.8	40.4	47.7
EC-IDF	2005	1.9	2.4	3.2	5.4	9.6	15.6	28.6	31.6	40.6
EC-IDF	2006	6.9	10.8	15.0	20.3	20.3	20.3	20.5	26.6	37.1
EC-IDF	2007	2.6	4.8	5.4	9.2	11.4	13.4	24.5	30.5	41.9
EC-IDF	2008	3.8	6.3	8.2	10.9	16.2	23.1	29.2	45.7	61.6
EC-IDF	2009	5.1	7.5	11.3	15.8	17.4	17.6	-99.9	40.4	58.4
EC-IDF	2010	8.3	12.3	13.0	13.8	14.4	15.6	21.4	33.5	41.2
EC-IDF	2011	5.1	6.1	6.7	7.6	9.0	15.0	22.6	22.6	31.0
EC-IDF	2012	2.1	3.1	4.2	4.8	6.0	8.1	18.8	29.2	39.2
EC-IDF	2013	3.1	3.7	3.7	4.2	7.2	10.9	24.1	35.8	39.6
	# Yrs. Années	51	51	51	51	51	51	50	51	51
	Mean Moyenne	4.3	6.2	7.5	9.5	11.8	15.2	25.1	33.6	42.5
	Std. Dev. Écart-type	1.9	3.2	3.9	5.0	5.0	5.6	7.8	9.2	12.0
	Skew. Dissymétrie	1.30	1.96	2.08	2.44	2.36	2.21	2.51	1.39	0.77
	Kurtosis	5.74	9.01	9.47	11.87	11.96	9.82	12.27	6.63	3.65

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité
pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1963	5 min	11.2	10.2
1963	10 min	20.1	16.2
1963	15 min	24.6	19.7
1963	30 min	33.3	25.3
1963	1 h	35.6	27.5
1963	2 h	39.1	32.7
1963	6 h	61.2	49.4
1963	12 h	67.8	62.3

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.0	5.6	6.7	7.8	8.1	9.1	10.2	51
EC-IDF 10 min	5.7	8.5	10.4	12.2	12.8	14.5	16.2	51
EC-IDF 15 min	6.8	10.3	12.6	14.7	15.4	17.6	19.7	51
EC-IDF 30 min	8.7	13.1	16.1	18.9	19.8	22.6	25.3	51
EC-IDF 1 h	11.0	15.4	18.3	21.2	22.0	24.8	27.5	51
EC-IDF 2 h	14.3	19.2	22.5	25.6	26.6	29.6	32.7	51
EC-IDF 6 h	23.8	30.7	35.2	39.5	40.9	45.2	49.4	50
EC-IDF 12 h	32.1	40.1	45.5	50.6	52.3	57.3	62.3	51
EC-IDF 24 h	40.6	51.2	58.2	65.0	67.1	73.7	80.3	51

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	47.6	67.5	80.6	93.3	97.3	109.6	121.9	51
	+/- 5.7	+/- 9.6	+/- 12.9	+/- 16.3	+/- 17.4	+/- 20.8	+/- 24.2	51
EC-IDF 10 min	34.3	51.2	62.4	73.2	76.6	87.1	97.5	51
	+/- 4.8	+/- 8.1	+/- 11.0	+/- 13.9	+/- 14.8	+/- 17.7	+/- 20.6	51

EC-IDF 15 min	27.3	41.1	50.2	59.0	61.8	70.3	78.8	51
	+/- 3.9	+/- 6.6	+/- 8.9	+/- 11.3	+/- 12.1	+/- 14.4	+/- 16.8	51
EC-IDF 30 min	17.3	26.3	32.2	37.8	39.6	45.2	50.7	51
	+/- 2.5	+/- 4.3	+/- 5.8	+/- 7.3	+/- 7.8	+/- 9.3	+/- 10.9	51
EC-IDF 1 h	11.0	15.4	18.3	21.2	22.0	24.8	27.5	51
	+/- 1.3	+/- 2.1	+/- 2.9	+/- 3.6	+/- 3.9	+/- 4.6	+/- 5.4	51
EC-IDF 2 h	7.2	9.6	11.2	12.8	13.3	14.8	16.3	51
	+/- 0.7	+/- 1.2	+/- 1.6	+/- 2.0	+/- 2.1	+/- 2.6	+/- 3.0	51
EC-IDF 6 h	4.0	5.1	5.9	6.6	6.8	7.5	8.2	50
	+/- 0.3	+/- 0.6	+/- 0.7	+/- 0.9	+/- 1.0	+/- 1.2	+/- 1.4	50
EC-IDF 12 h	2.7	3.3	3.8	4.2	4.4	4.8	5.2	51
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.6	+/- 0.7	+/- 0.8	51
EC-IDF 24 h	1.7	2.1	2.4	2.7	2.8	3.1	3.3	51
	+/- 0.1	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.4	+/- 0.5	+/- 0.5	51

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	17.0	24.6	29.7	34.5	36.1	40.8	45.5
Std. Dev. /Écart-type (RR)	16.1	23.6	28.6	33.4	34.9	39.6	44.2
Std. Error/Erreur-type	1.1	3.5	5.1	6.7	7.2	8.8	10.4
Coefficient (A)	11.4	15.8	18.7	21.5	22.4	25.2	27.9
Exponent/Exposant (B)	-0.595	-0.629	-0.643	-0.653	-0.656	-0.663	-0.669
Mean % Error/% erreur moyenne	3.2	4.7	5.3	5.9	6.1	6.5	6.9

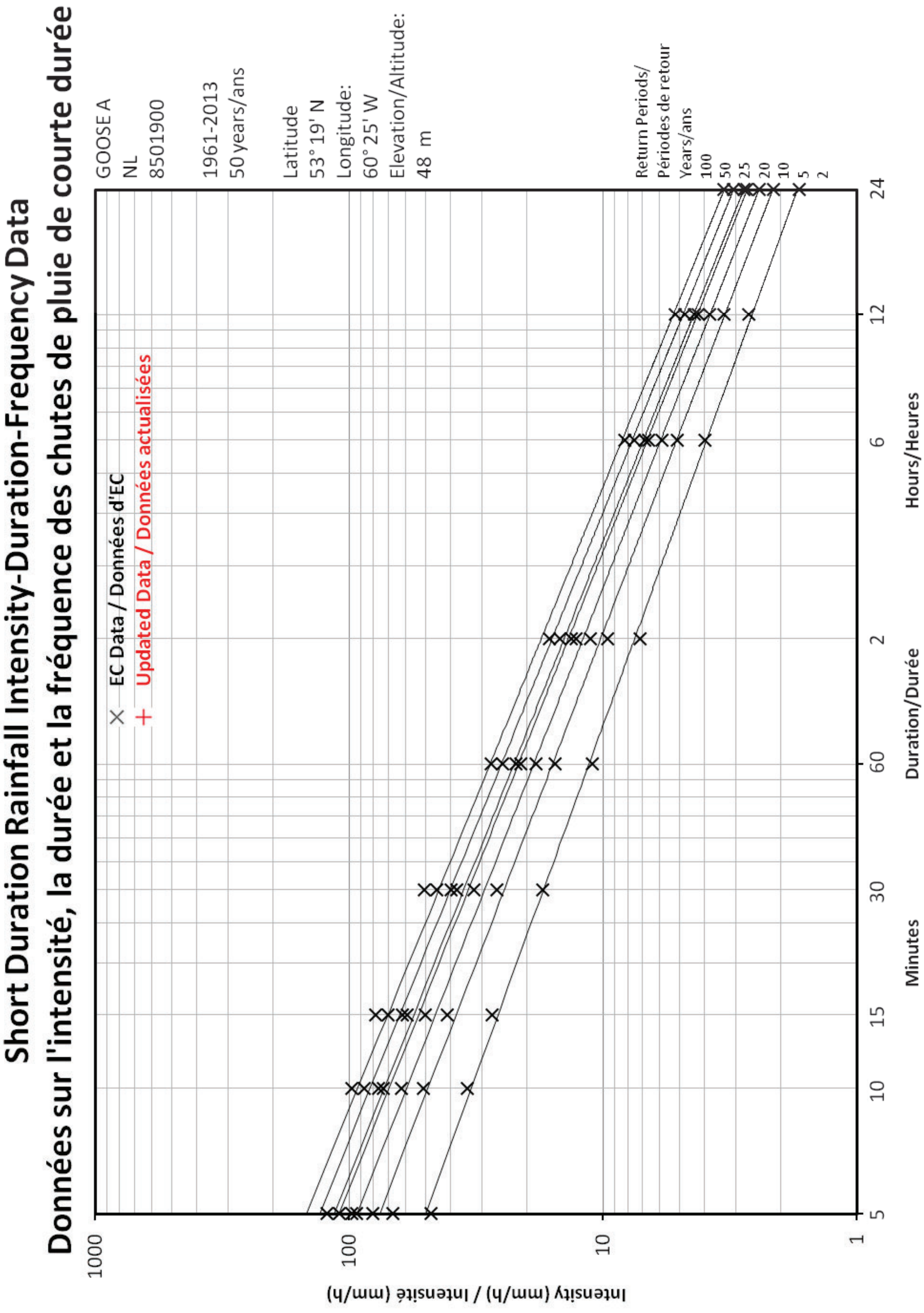

Figure 16.1 Goose A IDF Curve – EC IDF V2.3

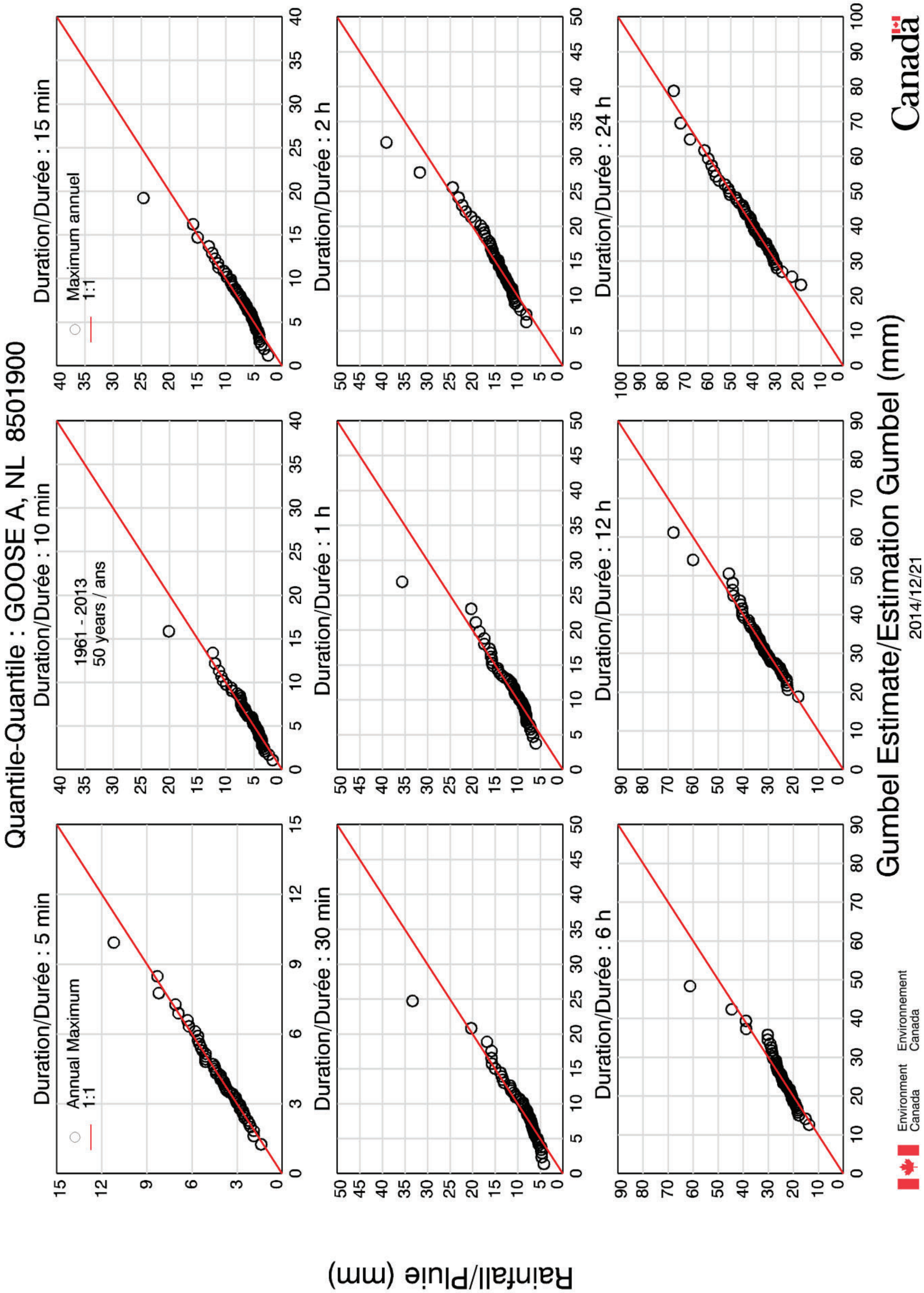

Figure 16.2 Goose A Quantile-Quantile Plot – EC IDF V2.3

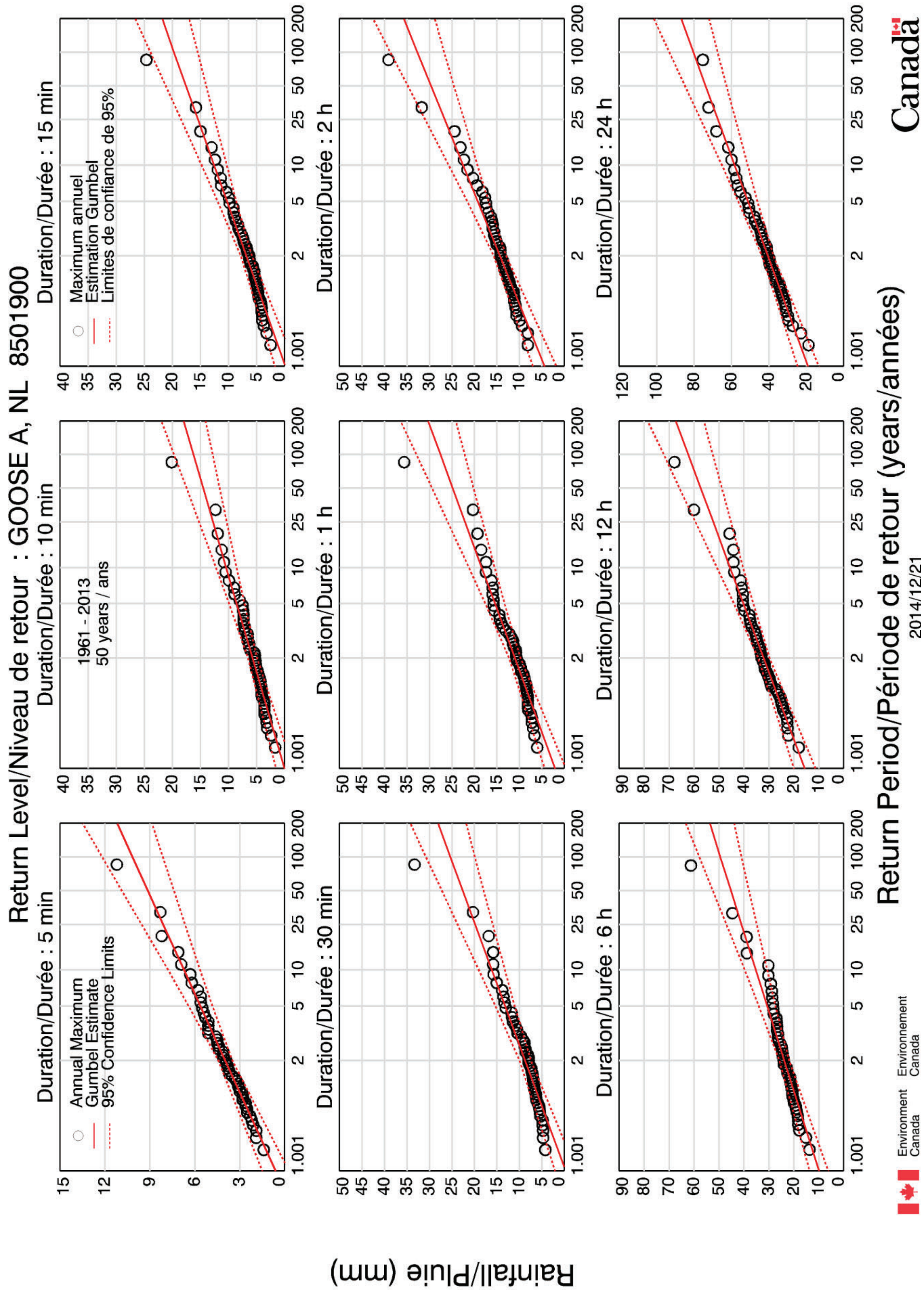

Figure 16.3 Goose A Return Level Plot – EC IDF V2.3

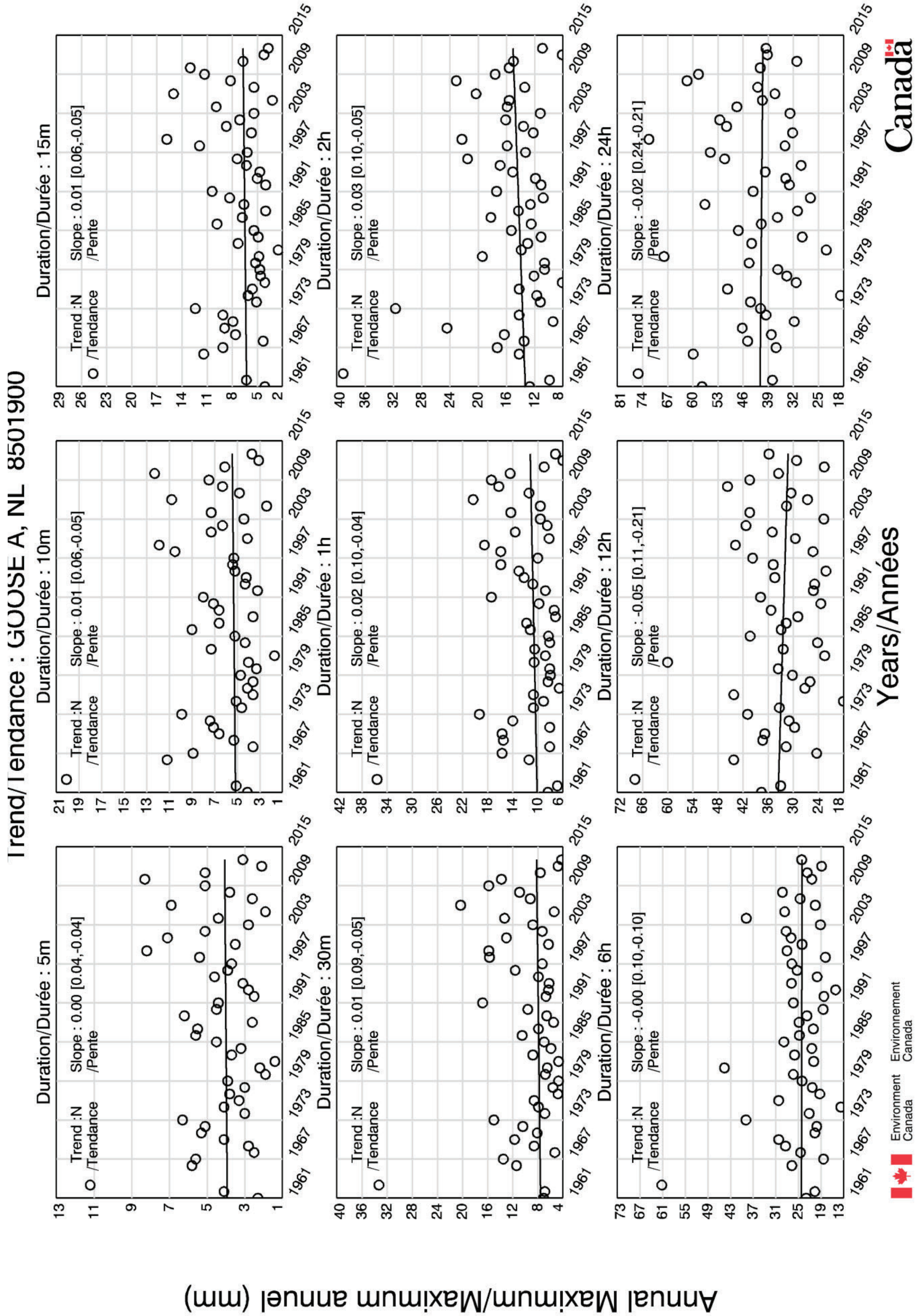

Figure 16.4 Goose A Trend Plot – EC IDF V2.3

17. Mary's Harbour A

This station was updated in CRA (2015). The updated IDF curve from CRA (2015) is reproduced below, with the addition of the 20-year return period.

This IDF curve was updated using 1-hr and 6-hr data from two nearby stations: Mary's Harbour and Mary's Harbour A. The IDF curve increased for most durations, but decreased for the 24-hr duration during the update (Table 17.1).

Table 17.1 Differences Between IDF Curves for Mary's Harbour A

Percent Difference in Precipitation Amount (%) (Difference in Precipitation Amount (mm))						
Duration	Return Period (years)					
	2	5	10	25	50	100
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	1.2 (0.1)	0.8 (0.1)	0.5 (0.1)	0.3 (0.0)	0.1 (0.0)	0.0 (0.0)
2-hr	2.3 (0.3)	2.2 (0.4)	2.2 (0.4)	2.2 (0.4)	2.2 (0.5)	2.2 (0.5)
6-hr	-2.6 (-0.7)	0.6 (0.2)	2.1 (0.7)	3.7 (1.4)	4.7 (1.9)	**5.5 (2.4)**
12-hr	4.1 (1.3)	**7.5 (3.0)**	**9.0 (4.2)**	**10.5 (5.6)**	**11.4 (6.6)**	**12.1 (7.7)**
24-hr	3.0 (1.2)	-0.3 (-0.2)	-1.7 (-1.0)	-2.9 (-2.2)	-3.6 (-3.0)	-4.2 (-3.8)

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

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            Office of Climate Change and Energy Efficiency

        Short Duration Rainfall Intensity-Duration-Frequency Data
       Données sur l'intensité, la durée et la fréquence des chutes
                         de pluie de courte durée

              Gumbel - Method of moments/Méthode des moments

                               2015/10/30

================================================================================

 MARY'S HARBOUR A                                       NL        8502591
 Updated with 6-hr data measured at Mary's Harbour (850B5R1): 1996-2013
 Updated with 1-hr data measured at Mary's Harbour A (8502592): 2014
 Latitude: 52 18'N    Longitude: 55 50'W    Elevation/Altitude: 10         m
 Years/Années : 1983 - 2014          # Years/Années :    12

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Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

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	Year / Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1983	3.4	4.0	4.4	6.4	10.0	11.9	21.7	25.6	25.7
EC-IDF	1984	3.9	4.3	5.3	6.0	7.2	11.6	20.7	29.0	38.8
EC-IDF	1985	1.8	2.7	3.5	6.2	10.8	13.0	32.7	42.2	43.3
EC-IDF	1986	4.6	4.6	4.6	5.7	6.2	8.4	16.5	17.2	21.2
EC-IDF	1987	2.5	3.9	4.9	6.8	9.4	12.5	22.7	28.4	35.0
EC-IDF	1988	3.9	5.3	5.5	8.4	10.0	12.3	23.3	34.5	51.6
EC-IDF	1989	4.0	6.2	7.0	7.5	11.6	13.2	21.9	30.6	31.6
EC-IDF	1990	2.1	3.5	5.1	9.9	11.0	18.4	33.4	36.2	49.1
EC-IDF	1991	3.8	3.8	3.8	6.8	8.6	15.4	22.7	29.0	29.0
EC-IDF	1993	2.0	4.0	5.0	7.0	10.8	20.4	33.2	55.0	78.0
EC-IDF	1994	2.5	4.6	6.7	8.4	10.5	14.6	28.6	38.1	45.9
EC-IDF	1995	1.1	1.5	2.1	3.7	6.7	13.2	29.9	38.5	57.7
UPDATE	1996	NM	NM	NM	NM	NM	NM	23.0	30.0	43.0
UPDATE	1997	NM	NM	NM	NM	NM	NM	25.0	32.0	35.8
UPDATE	1998	NM	NM	NM	NM	NM	NM	39.0	50.0	66.0
UPDATE	1999	NM	NM	NM	NM	NM	NM	18.0	28.0	28.0
UPDATE	2000	NM	NM	NM	NM	NM	NM	15.0	21.0	22.6
UPDATE	2001	NM	NM	NM	NM	NM	NM	23.0	40.0	44.0
UPDATE	2002	NM	NM	NM	NM	NM	NM	19.0	26.0	35.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	27.0	39.0	43.0
UPDATE	2004	NM	NM	NM	NM	NM	NM	20.0	29.0	31.0
UPDATE	2005	NM	NM	NM	NM	NM	NM	27.0	38.0	54.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	35.0	66.0	74.5
UPDATE	2009	NM	NM	NM	NM	NM	NM	20.0	35.0	44.0
UPDATE	2010	NM	NM	NM	NM	NM	NM	25.0	35.0	43.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	16.0	21.0	36.0
UPDATE	2012	NM	NM	NM	NM	NM	NM	34.0	58.0	58.5
UPDATE	2013	NM	NM	NM	NM	NM	NM	19.0	24.0	36.0
UPDATE	2014	NM	NM	NM	NM	10.8	17.8	35.8	48.2	50.9
	# Yrs. / Années	12	12	12	12	13	13	29	29	29
	Mean / Moyenne	3.0	4.0	4.8	6.9	9.5	14.1	25.1	35.3	43.2
	Std. Dev. / Écart-type	1.1	1.2	1.3	1.6	1.8	3.2	6.6	11.4	14.3
	Skew. / Dissymétrie	-0.17	-0.40	-0.30	-0.05	-0.89	0.51	0.48	0.95	0.76
	Kurtosis	2.56	5.03	4.37	4.77	3.11	3.81	2.47	4.03	3.61

*-99.9 Indicates Missing Data/Données manquantes
*   NM Indicates No Measurements/Aucunes mesures

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

	Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF	5 min	2.8	3.8	4.4	5.0	5.2	5.8	6.4	12
EC-IDF	10 min	3.8	4.9	5.6	6.3	6.5	7.1	7.8	12
EC-IDF	15 min	4.6	5.8	6.6	7.3	7.5	8.3	9.0	12
EC-IDF	30 min	6.6	8.0	8.9	9.8	10.1	11.0	11.8	12
UPDATE	1 h	9.2	10.8	11.8	12.8	13.1	14.1	15.1	13
UPDATE	2 h	13.5	16.4	18.3	20.1	20.7	22.5	24.2	13
UPDATE	6 h	24.0	29.9	33.7	37.4	38.6	42.2	45.8	29
UPDATE	12 h	33.4	43.6	50.3	56.7	58.7	65.0	71.2	29
UPDATE	24 h	40.8	53.4	61.8	69.8	72.3	80.1	87.9	29

* 6-hr and 1-hr data were used for the update: shorter durations were not updated

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée		2 yr/ans		5 yr/ans		10 yr/ans		20 yr/ans		25 yr/ans		50 yr/ans		100 yr/ans	#Years Années
EC-IDF 5 min		33.4		45.1		52.8		60.2		62.6		69.8		77.0	12
	+/-	6.9	+/-	11.6	+/-	15.6	+/-	19.7	+/-	21.0	+/-	25.2	+/-	29.3	12
EC-IDF 10 min		23.0		29.3		33.5		37.5		38.8		42.7		46.6	12
	+/-	3.7	+/-	6.2	+/-	8.4	+/-	10.7	+/-	11.4	+/-	13.6	+/-	15.8	12
EC-IDF 15 min		18.4		23.1		26.2		29.2		30.2		33.1		36.0	12
	+/-	2.8	+/-	4.7	+/-	6.3	+/-	7.9	+/-	8.5	+/-	10.2	+/-	11.8	12
EC-IDF 30 min		13.3		16.1		17.9		19.7		20.2		21.9		23.7	12
	+/-	1.6	+/-	2.7	+/-	3.7	+/-	4.7	+/-	5.0	+/-	6.0	+/-	7.0	12
UPDATE 1 h		9.2		10.8		11.8		12.8		13.1		14.1		15.1	13
	+/-	0.9	+/-	1.5	+/-	2.0	+/-	2.6	+/-	2.7	+/-	3.3	+/-	3.8	13
UPDATE 2 h		6.8		8.2		9.1		10.0		10.3		11.2		12.1	13
	+/-	0.8	+/-	1.4	+/-	1.8	+/-	2.3	+/-	2.5	+/-	3.0	+/-	3.5	13
UPDATE 6 h		4.0		5.0		5.6		6.2		6.4		7.0		7.6	29
	+/-	0.4	+/-	0.6	+/-	0.8	+/-	1.1	+/-	1.1	+/-	1.3	+/-	1.6	29
UPDATE 12 h		2.8		3.6		4.2		4.7		4.9		5.4		5.9	29
	+/-	0.3	+/-	0.5	+/-	0.7	+/-	0.9	+/-	1.0	+/-	1.2	+/-	1.4	29
UPDATE 24 h		1.7		2.2		2.6		2.9		3.0		3.3		3.7	29
	+/-	0.2	+/-	0.3	+/-	0.5	+/-	0.6	+/-	0.6	+/-	0.7	+/-	0.8	29

* 6-hr and 1-hr data were used for the update: shorter durations were not updated

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	12.5	15.9	18.2	20.4	21.1	23.2	25.3
Std. Dev. /Écart-type (RR)	10.7	14.3	16.7	19.0	19.7	21.9	24.2
Std. Error/Erreur-type	0.3	1.4	2.3	3.1	3.4	4.2	5.0
Coefficient (A)	9.4	11.8	13.4	14.9	15.4	16.8	18.3
Exponent/Exposant (B)	-0.508	-0.508	-0.508	-0.508	-0.508	-0.508	-0.508
Mean % Error/% erreur moyenne	3.3	4.8	6.0	6.8	7.1	7.7	8.4

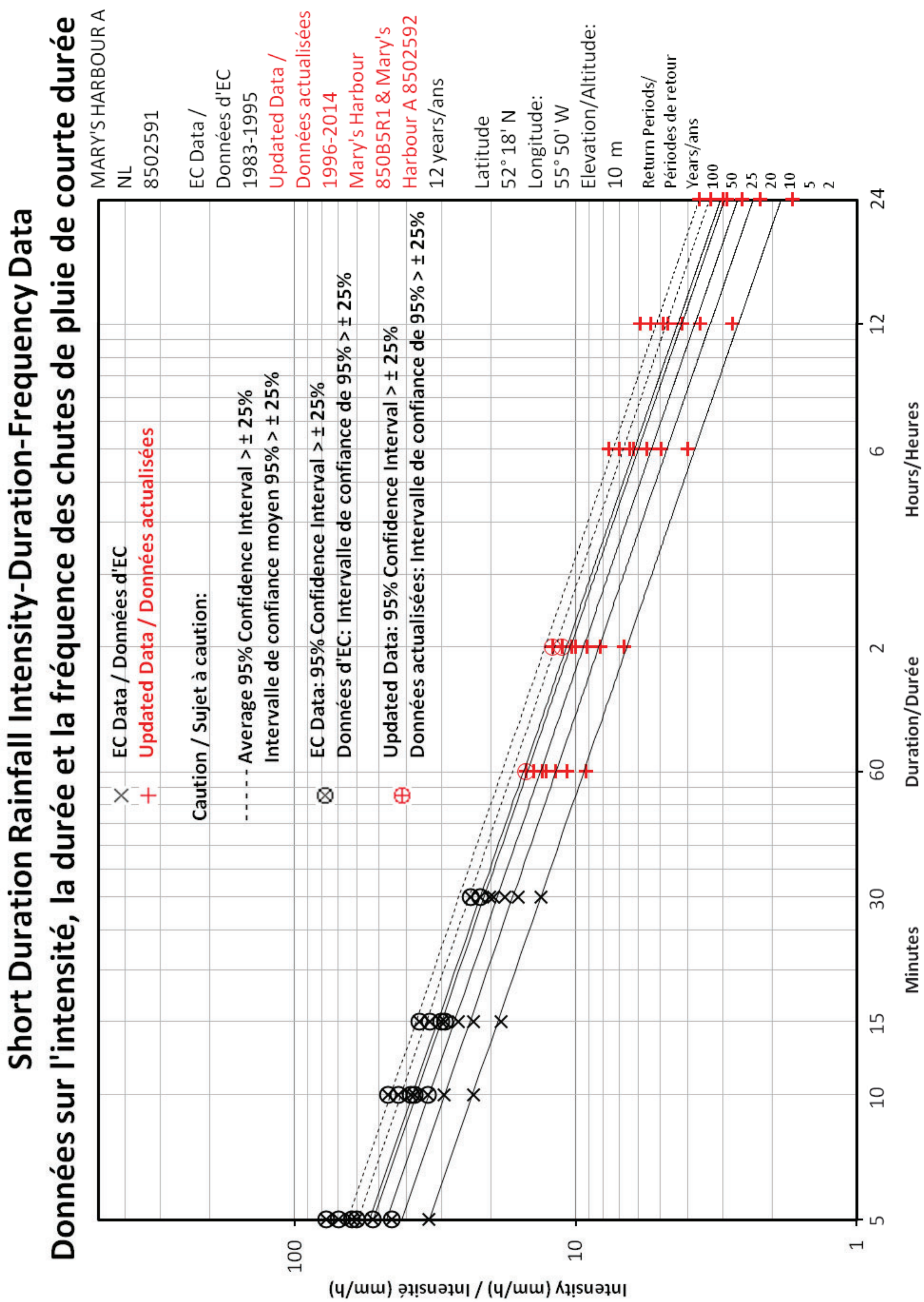

Figure 17.1 Mary's Harbour A IDF Curve – Updated

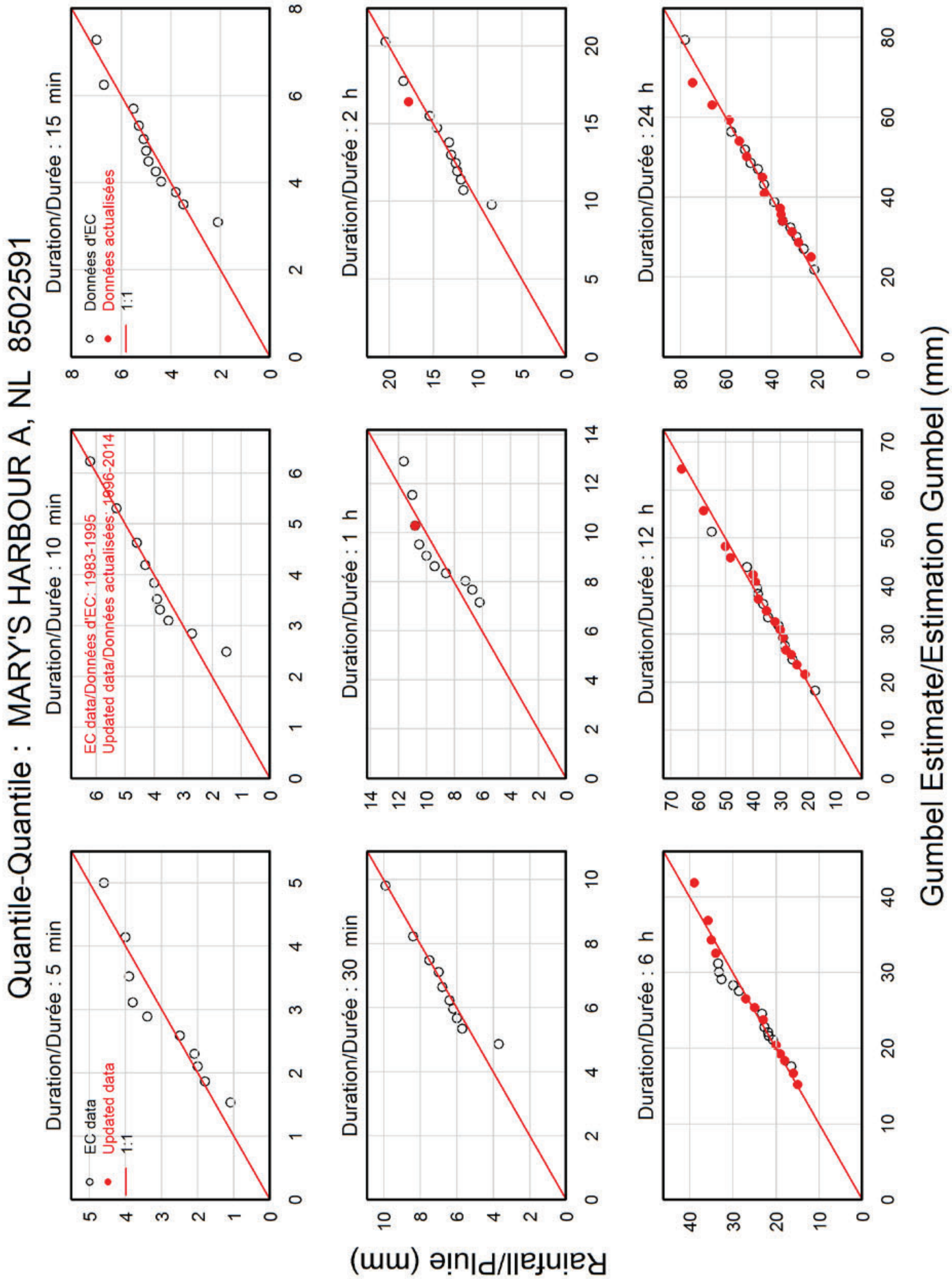

Figure 17.2 Mary's Harbour A Quantile-Quantile Plot – Updated

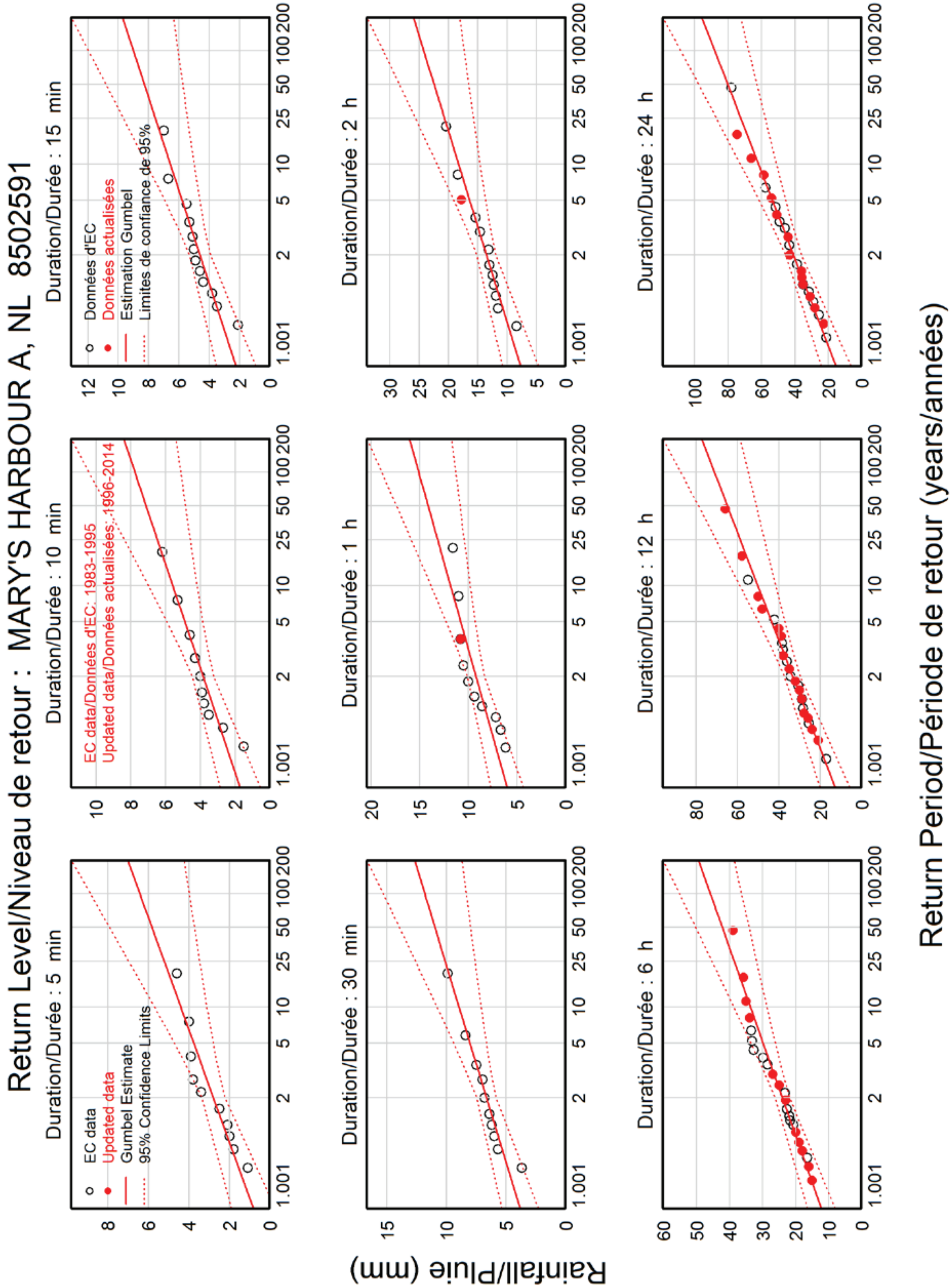

Figure 17.3 Mary's Harbour A Return Level Plot – Updated

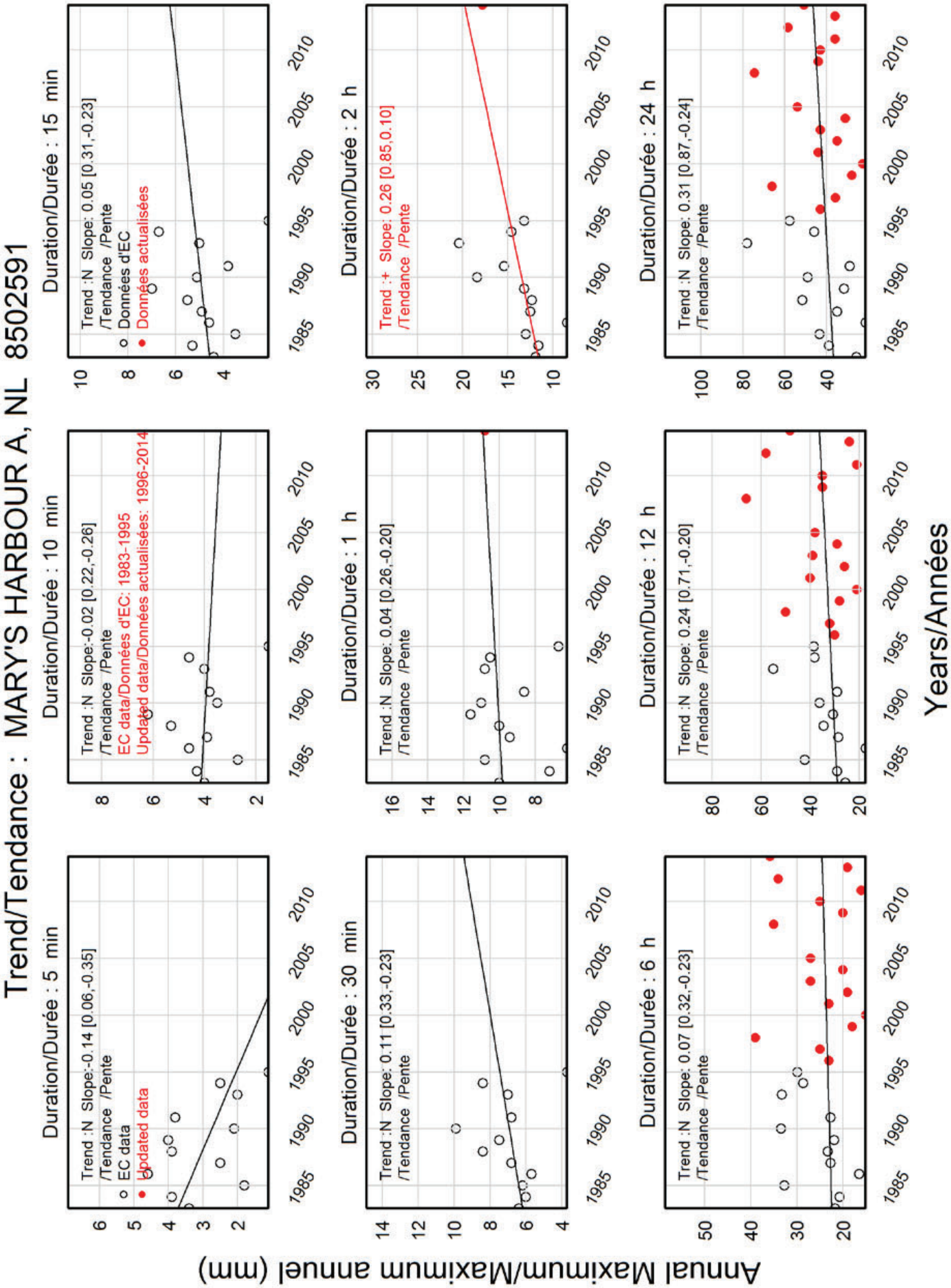

Figure 17.4 Mary's Harbour A Trend Plot – Updated

11. St. Anthony

This station was updated in CRA (2015) by creating a partial IDF curve for St. Anthony (8403399). There were insufficient data to create a full IDF curve at St. Anthony (8403399). For short durations (5, 10-, 15-, and 30-min) users must consult the original St. Anthony curve. For long durations, the St. Anthony (8403399) curve may be used. Both IDF curves are reproduced below

In general, the IDF curve increased during the update (Table 11.1), but some combinations of duration and return period decreased. Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve. The curves are reproduced below, with the addition of the 20-year return period.

Table 11.1 Differences Between IDF Curves for St. Anthony (8403399) and St. Anthony (8403401)

Percent Difference in Precipitation Amount (%) (Difference in Precipitation Amount (mm))						
Duration	Return Period (years)					
	2	5	10	25	50	100
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	**49.4 (6.2)**	**67.0 (10.4)**	**75.4 (13.2)**	**83.6 (16.8)**	**88.5 (19.4)**	**92.5 (22.0)**
2-hr	**22.0 (4.0)**	**29.2 (6.3)**	**32.8 (7.9)**	**36.4 (9.9)**	**38.5 (11.4)**	**40.4 (12.8)**
6-hr	**7.2 (2.2)**	**12.1 (4.4)**	**14.6 (5.9)**	**17.1 (7.8)**	**18.7 (9.2)**	**20.0 (10.6)**
12-hr	**7.0 (2.8)**	3.4 (1.6)	1.5 (0.8)	-0.3 (-0.2)	-1.4 (-0.9)	-2.4 (-1.7)
24-hr	-3.1 (-1.6)	**-7.3 (-4.6)**	**-9.3 (-6.6)**	**-11.2 (-9.2)**	**-12.4 (-11.1)**	**-13.4 (-12.9)**
Notes: Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period. Bold numbers indicate changes greater than 5 percent.						

Section 11.1 presents the IDF curves for 11.1 St. Anthony (8403401) – EC-IDF V2.3. Section 11.2 presents the partial IDF curves for St. Anthony (8403399) – Updated.

11.1 St. Anthony (8403401)

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/10/30

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ST ANTHONY NL 8403401

Latitude: 51 22'N Longitude: 55 36'W Elevation/Altitude: 11 m

Years/Années : 1971 - 1995 # Years/Années : 23

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Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1971	8.4	13.7	16.3	18.3	18.8	22.4	35.3	47.8	52.6
EC-IDF	1972	2.3	4.1	6.1	7.1	9.9	18.5	34.8	47.2	54.6
EC-IDF	1973	3.6	5.3	6.6	8.6	11.7	12.4	28.2	41.1	59.2
EC-IDF	1974	2.5	3.3	4.3	6.9	10.2	17.3	39.6	49.3	49.8
EC-IDF	1975	3.8	4.8	6.1	10.9	16.3	23.1	33.5	40.1	43.4
EC-IDF	1976	2.8	5.6	7.4	10.4	12.2	19.6	27.4	29.7	35.1
EC-IDF	1978	2.0	3.9	5.7	8.8	14.3	18.4	25.4	33.3	51.6
EC-IDF	1979	2.7	4.1	5.4	8.4	13.5	21.0	30.1	47.0	71.3
EC-IDF	1980	4.7	6.6	8.8	14.1	19.1	24.3	34.9	37.2	37.9
EC-IDF	1981	8.1	13.1	15.1	16.5	16.7	20.1	45.9	59.1	74.6
EC-IDF	1982	4.3	4.9	7.4	9.5	13.0	18.5	27.4	34.2	37.1
EC-IDF	1983	6.8	10.8	13.2	14.2	16.8	30.2	43.6	58.6	67.8
EC-IDF	1984	4.4	5.9	8.9	10.0	15.9	17.5	26.5	33.2	39.8
EC-IDF	1985	2.4	3.8	5.8	8.4	11.2	14.8	31.0	51.1	80.7
EC-IDF	1986	2.1	3.1	4.5	8.9	11.5	14.9	21.2	25.2	32.4
EC-IDF	1987	2.4	3.8	4.7	6.0	8.8	12.9	26.1	31.3	43.2
EC-IDF	1988	1.7	2.9	4.2	7.3	10.4	18.4	35.0	49.4	50.2
EC-IDF	1989	2.3	3.9	4.6	7.9	10.7	15.7	28.7	34.2	48.6
EC-IDF	1990	7.8	11.2	12.3	14.6	18.2	23.2	44.8	46.0	55.6
EC-IDF	1991	2.9	4.3	5.3	8.2	9.6	15.0	23.2	40.5	44.1
EC-IDF	1993	2.7	3.3	4.0	7.1	10.2	16.2	30.4	40.5	53.9
EC-IDF	1994	3.2	5.4	5.6	6.5	7.8	13.6	26.6	39.4	68.4
EC-IDF	1995	2.2	3.4	5.0	8.2	15.0	20.2	32.1	45.2	74.2
	# Yrs. Années	23	23	23	23	23	23	23	23	23
	Mean Moyenne	3.7	5.7	7.3	9.9	13.1	18.6	31.8	41.8	53.3
	Std. Dev. Écart-type	2.1	3.2	3.6	3.4	3.4	4.2	6.7	8.9	13.9
	Skew. Dissymétrie	1.37	1.62	1.49	1.24	0.36	0.84	0.72	0.19	0.44
	Kurtosis	3.94	4.69	4.46	3.91	2.25	4.41	3.22	2.91	2.56

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	3.4	5.2	6.4	7.6	8.0	9.1	10.2	23
EC-IDF 10 min	5.2	8.0	9.9	11.7	12.3	14.1	15.8	23
EC-IDF 15 min	6.7	9.8	11.9	14.0	14.6	16.6	18.5	23
EC-IDF 30 min	9.3	12.3	14.3	16.2	16.8	18.6	20.4	23
EC-IDF 1 h	12.6	15.6	17.5	19.4	20.0	21.9	23.7	23
EC-IDF 2 h	17.9	21.6	24.1	26.5	27.2	29.5	31.8	23
EC-IDF 6 h	30.7	36.6	40.6	44.4	45.5	49.2	52.9	23
EC-IDF 12 h	40.3	48.1	53.3	58.3	59.9	64.8	69.6	23
EC-IDF 24 h	51.0	63.3	71.4	79.2	81.6	89.2	96.8	23

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	40.9	62.8	77.3	91.2	95.6	109.2	122.7	23
	+/- 9.3	+/- 15.7	+/- 21.1	+/- 26.7	+/- 28.5	+/- 34.1	+/- 39.7	23
EC-IDF 10 min	31.0	48.2	59.5	70.4	73.9	84.5	95.0	23
	+/- 7.3	+/- 12.3	+/- 16.5	+/- 20.9	+/- 22.3	+/- 26.7	+/- 31.1	23
EC-IDF 15 min	26.7	39.4	47.8	55.8	58.4	66.2	74.0	23
	+/- 5.4	+/- 9.0	+/- 12.2	+/- 15.4	+/- 16.5	+/- 19.7	+/- 23.0	23
EC-IDF 30 min	18.6	24.6	28.5	32.3	33.5	37.2	40.9	23
	+/- 2.5	+/- 4.3	+/- 5.8	+/- 7.3	+/- 7.8	+/- 9.3	+/- 10.8	23
EC-IDF 1 h	12.6	15.6	17.5	19.4	20.0	21.9	23.7	23
	+/- 1.3	+/- 2.1	+/- 2.9	+/- 3.7	+/- 3.9	+/- 4.7	+/- 5.4	23
EC-IDF 2 h	9.0	10.8	12.1	13.2	13.6	14.8	15.9	23
	+/- 0.8	+/- 1.3	+/- 1.8	+/- 2.3	+/- 2.4	+/- 2.9	+/- 3.4	23
EC-IDF 6 h	5.1	6.1	6.8	7.4	7.6	8.2	8.8	23
	+/- 0.4	+/- 0.7	+/- 1.0	+/- 1.2	+/- 1.3	+/- 1.5	+/- 1.8	23
EC-IDF 12 h	3.4	4.0	4.4	4.9	5.0	5.4	5.8	23
	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.8	+/- 0.9	+/- 1.0	+/- 1.2	23
EC-IDF 24 h	2.1	2.6	3.0	3.3	3.4	3.7	4.0	23
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.6	+/- 0.7	+/- 0.8	+/- 0.9	23

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	16.6	23.8	28.5	33.1	34.5	39.0	43.4
Std. Dev. /Écart-type (RR)	13.7	21.6	26.9	32.0	33.6	38.6	43.6
Std. Error/Erreur-type	1.8	2.5	3.3	4.1	4.4	5.3	6.2
Coefficient (A)	12.3	16.5	19.1	21.6	22.4	24.9	27.3
Exponent/Exposant (B)	-0.523	-0.571	-0.591	-0.606	-0.610	-0.620	-0.629
Mean % Error/% erreur moyenne	4.8	3.9	4.9	5.9	6.2	6.9	7.6

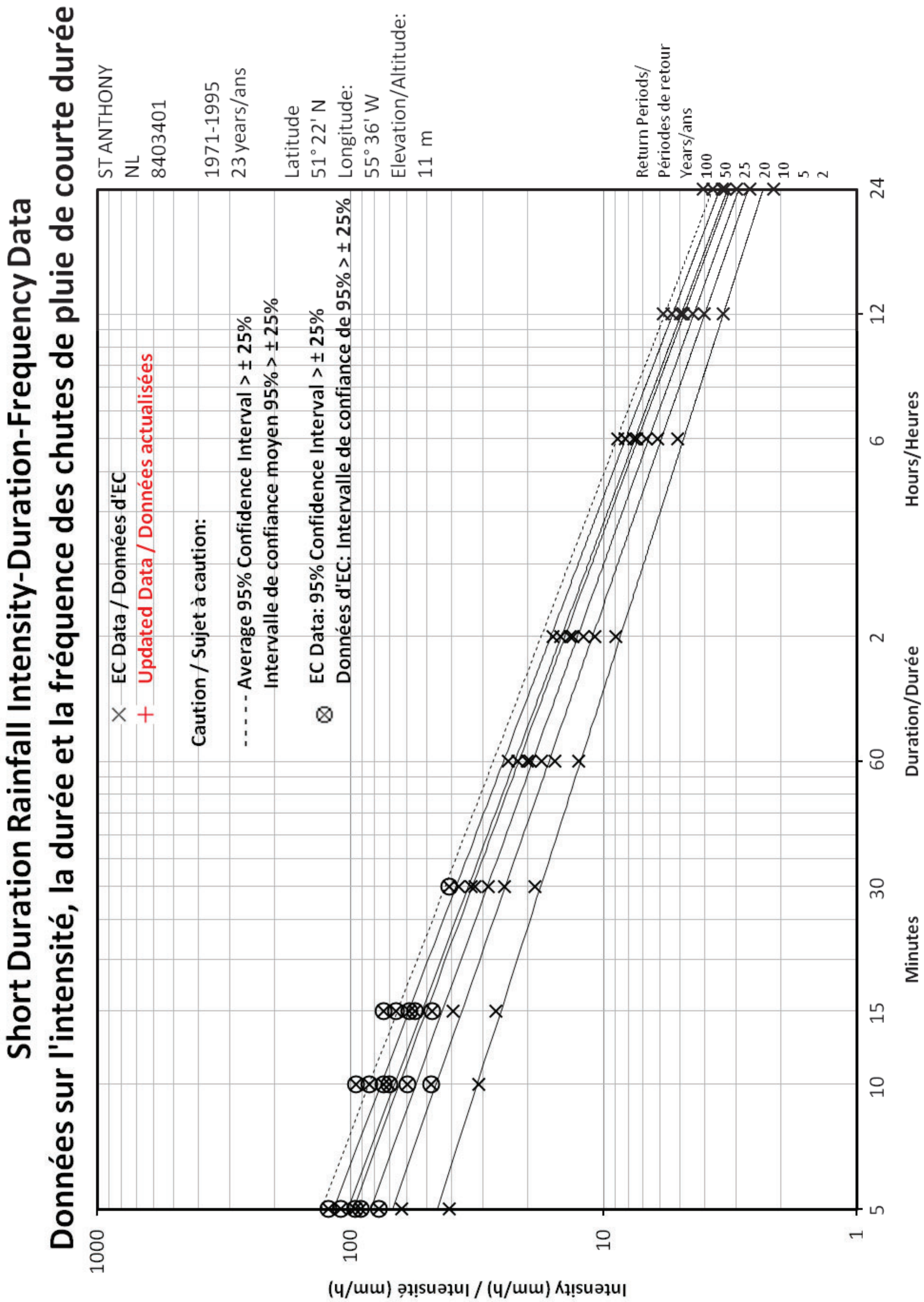

Figure 11.1 St. Anthony (8403401) IDF Curve – EC IDF V2.3

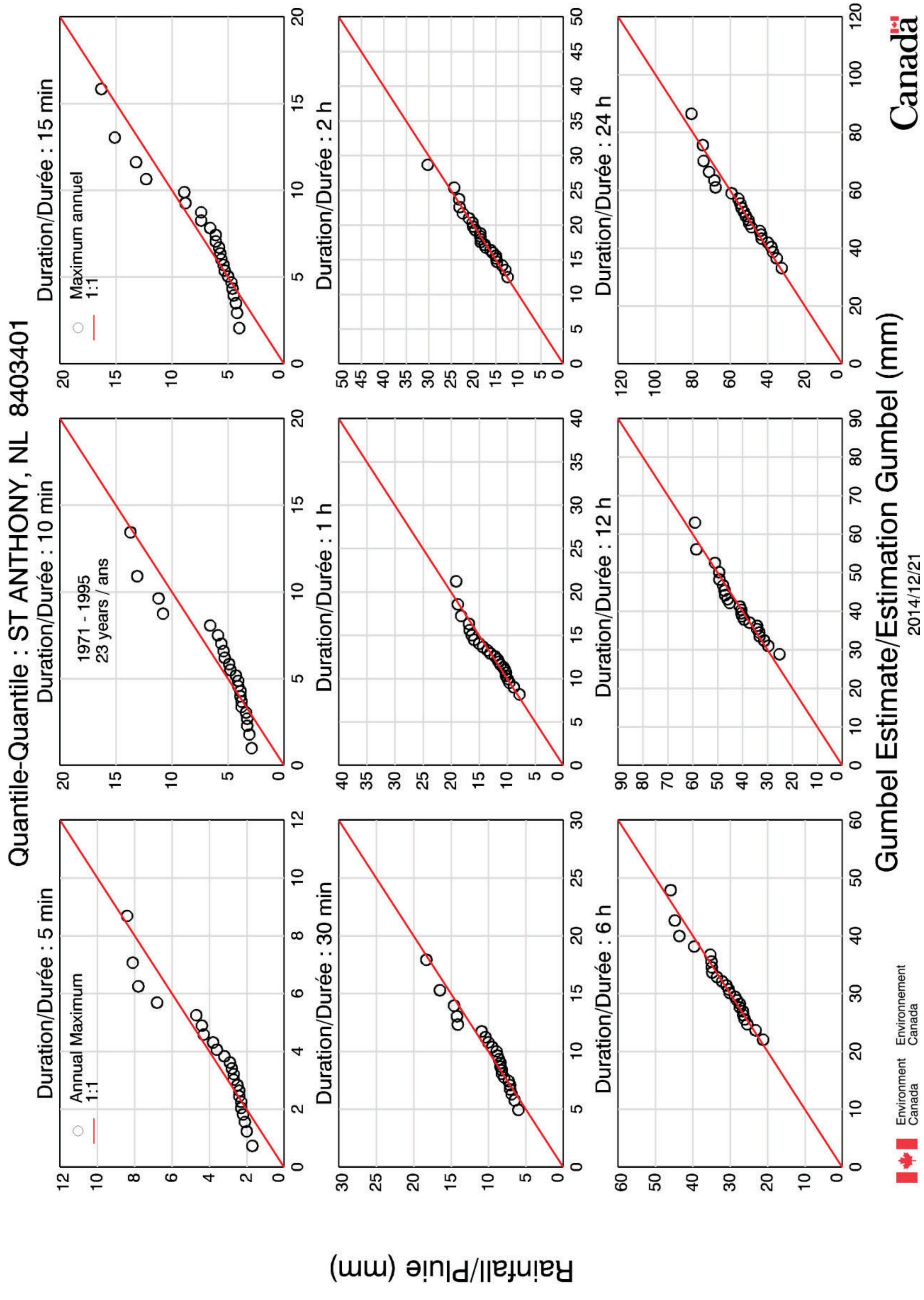

Figure 11.2 St. Anthony (8403401) Quantile-Quantile Plot – EC IDF V2.3

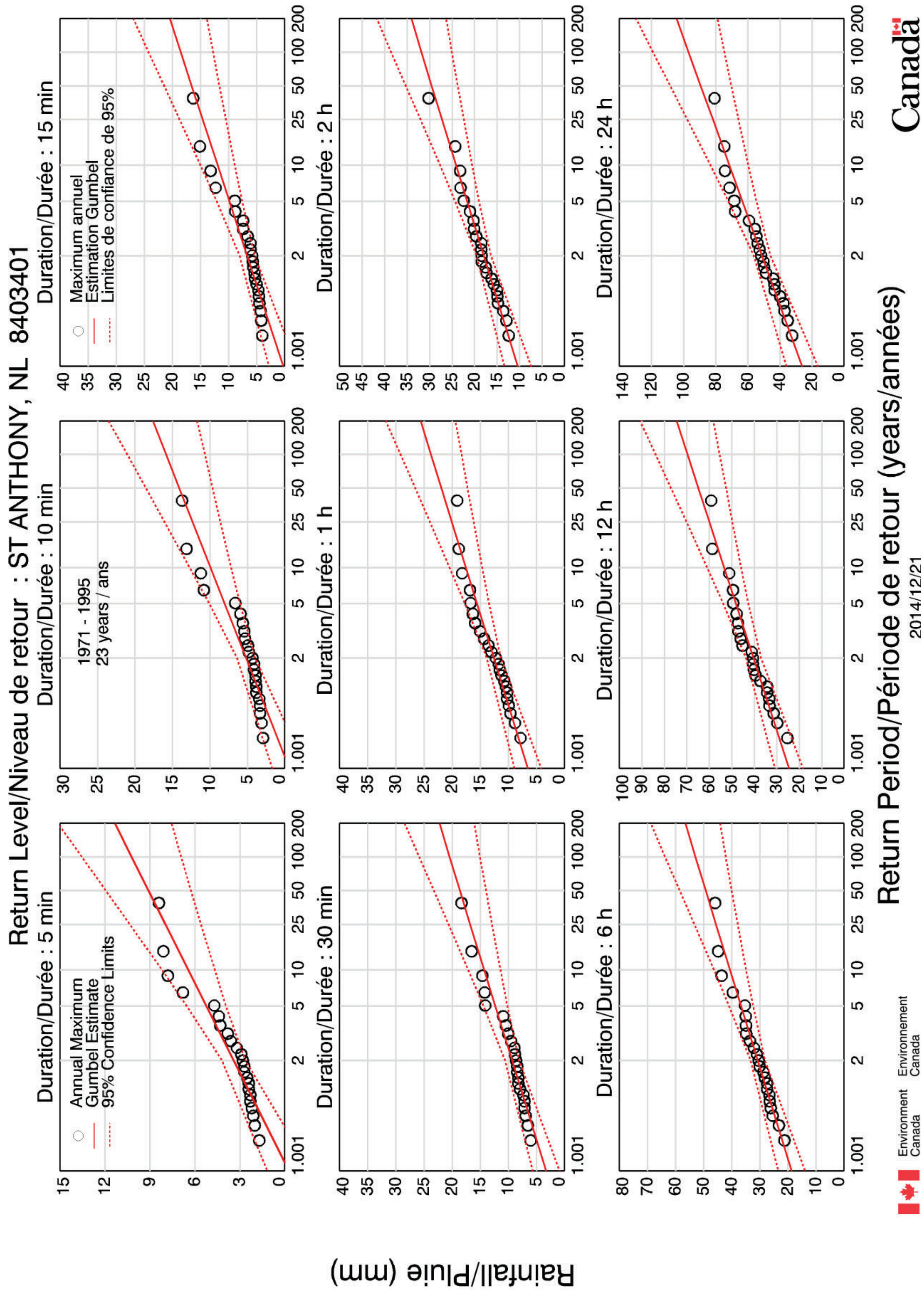

Figure 11.3 St. Anthony (8403401) Return Level Plot – EC IDF V2.3

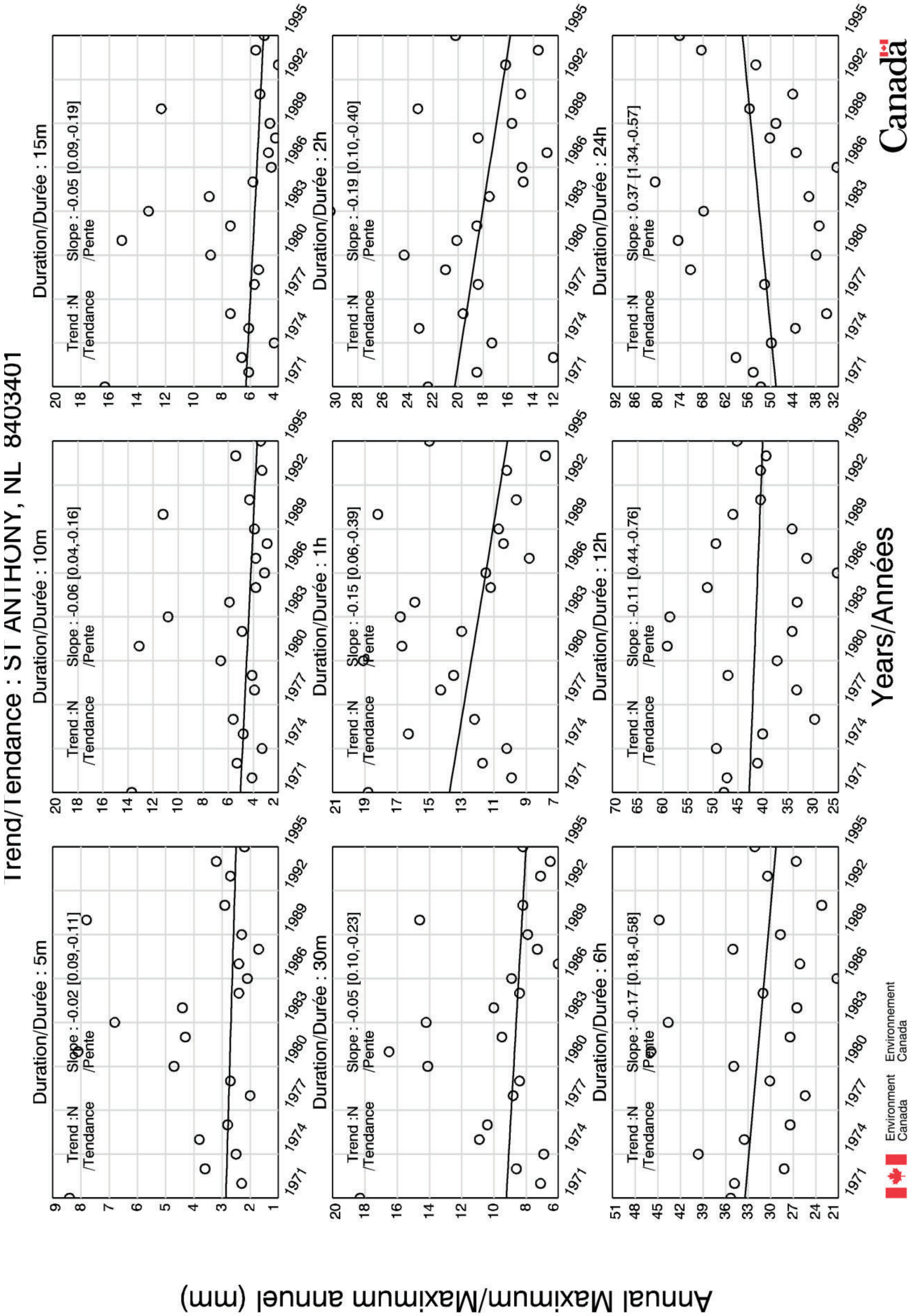

Figure 11.4 St. Anthony (8403401) Trend Plot – EC IDF V2.3

11.2 St. Anthony (8403399)

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/10/30

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ST ANTHONY NL 8403399
Generated with 6-hr and 1-hr data measured at St. Anthony (8403399): 2000-2014

Latitude: 51 23'N Longitude: 56 6'W Elevation/Altitude: 29.3 m
Years/Années : 2000 - 2014 # Years/Années : 10

===

****

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
UPDATE	2000	NM	NM	NM	NM	NM	NM	39.0	43.0	45.0
UPDATE	2002	NM	NM	NM	NM	NM	NM	43.0	59.0	74.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	35.0	51.0	62.0
UPDATE	2004	NM	NM	NM	NM	24.0	25.8	58.7	58.7	58.7
UPDATE	2005	NM	NM	NM	NM	16.4	20.5	29.7	43.6	47.1
UPDATE	2006	NM	NM	NM	NM	16.6	19.8	26.8	34.0	41.6
UPDATE	2007	NM	NM	NM	NM	19.3	19.3	28.4	41.1	41.9
UPDATE	2008	NM	NM	NM	NM	39.9	39.9	39.9	39.9	43.4
UPDATE	2009	NM	NM	NM	NM	17.7	20.9	24.0	44.0	46.9
UPDATE	2010	NM	NM	NM	NM	23.2	24.3	30.9	38.6	41.3
UPDATE	2011	NM	NM	NM	NM	21.1	25.9	31.7	41.6	64.7
UPDATE	2013	NM	NM	NM	NM	11.5	14.2	26.2	38.9	51.4
UPDATE	2014	NM	NM	NM	NM	11.4	19.5	34.4	43.4	46.8
	# Yrs. Années	0	0	0	0	10	10	13	13	13
	Mean Moyenne	-99.9	-99.9	-99.9	-99.9	20.1	23.0	34.4	44.4	51.1
	Std. Dev. Écart-type	-99.9	-99.9	-99.9	-99.9	8.2	6.9	9.3	7.5	10.4
	Skew. Dissymétrie	-99.99	-99.99	-99.99	-99.99	1.64	1.71	1.57	1.11	1.10
	Kurtosis	-99.99	-99.99	-99.99	-99.99	7.38	7.73	6.56	4.20	3.84

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée		2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF	5 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
EC-IDF	10 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
EC-IDF	15 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
EC-IDF	30 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
UPDATE	1 h	18.8	26.0	30.8	35.3	36.8	41.3	45.7	10
UPDATE	2 h	21.9	28.0	32.0	35.9	37.1	40.9	44.6	10
UPDATE	6 h	32.9	41.1	46.5	51.7	53.3	58.4	63.5	13

UPDATE 12 h	43.1	49.8	54.2	58.4	59.7	63.8	67.9	13
UPDATE 24 h	49.4	58.6	64.7	70.6	72.5	78.2	83.9	13

* There were insufficient data to generate the IDF curve for 5-, 10-, 15-, 30-min

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
EC-IDF 10 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
EC-IDF 15 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
EC-IDF 30 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
UPDATE 1 h	18.8	26.0	30.8	35.3	36.8	41.3	45.7	10
	+/- 4.6	+/- 7.8	+/- 10.6	+/- 13.3	+/- 14.2	+/- 17.0	+/- 19.9	10
UPDATE 2 h	10.9	14.0	16.0	17.9	18.6	20.4	22.3	10
	+/- 2.0	+/- 3.3	+/- 4.5	+/- 5.6	+/- 6.0	+/- 7.2	+/- 8.4	10
UPDATE 6 h	5.5	6.8	7.8	8.6	8.9	9.7	10.6	13
	+/- 0.8	+/- 1.3	+/- 1.7	+/- 2.2	+/- 2.4	+/- 2.8	+/- 3.3	13
UPDATE 12 h	3.6	4.1	4.5	4.9	5.0	5.3	5.7	13
	+/- 0.3	+/- 0.5	+/- 0.7	+/- 0.9	+/- 1.0	+/- 1.1	+/- 1.3	13
UPDATE 24 h	2.1	2.4	2.7	2.9	3.0	3.3	3.5	13
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.6	+/- 0.7	+/- 0.8	+/- 0.9	13

* There were insufficient data to generate the IDF curve for 5-, 10-, 15-, 30-min

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	8.2	10.7	12.3	13.9	14.4	16.0	17.6
Std. Dev. /Écart-type (RR)	6.8	9.6	11.5	13.3	13.9	15.6	17.3
Std. Error/Erreur-type	0.4	0.9	1.2	1.5	1.6	1.9	2.2
Coefficient (A)	18.3	24.8	29.2	33.3	34.6	38.7	42.7
Exponent/Exposant (B)	-0.677	-0.728	-0.751	-0.768	-0.773	-0.787	-0.798
Mean % Error/% erreur moyenne	3.3	3.1	3.2	4.0	4.3	4.9	5.4

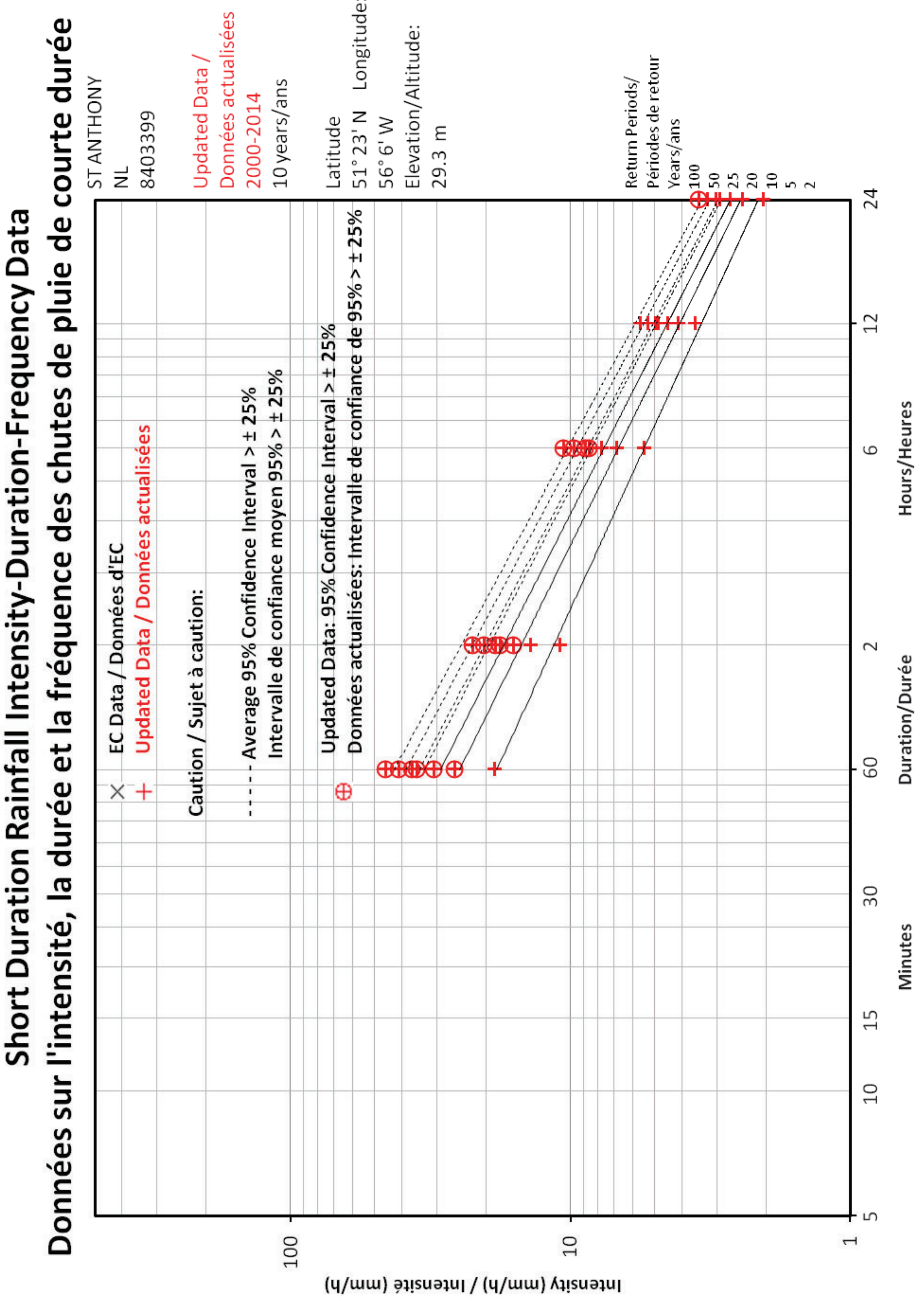

Figure 11.5 St. Anthony (8403399) IDF Curve – Updated

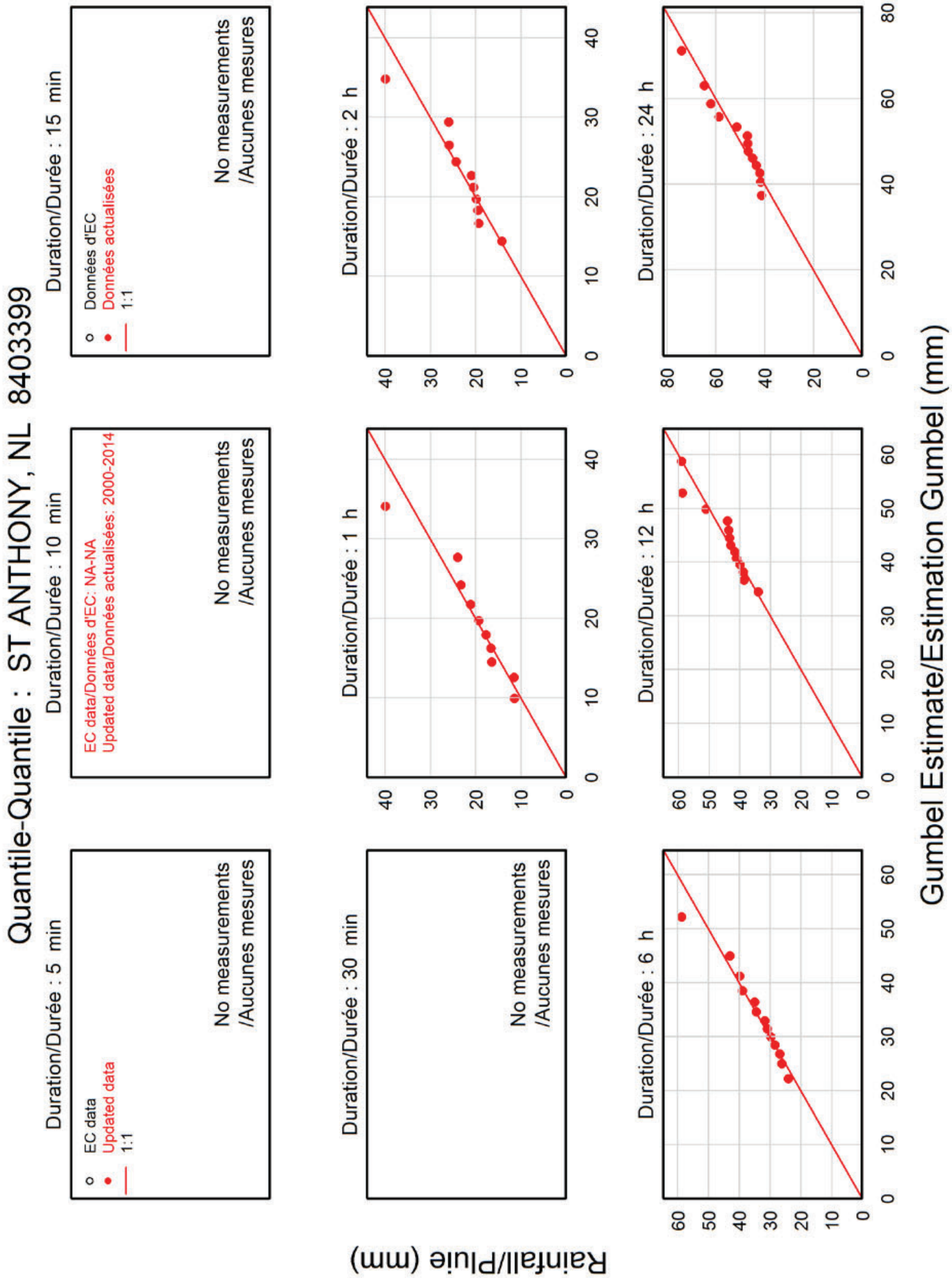

Figure 11.6 St. Anthony (8403399) Quantile-Quantile Plot – Updated

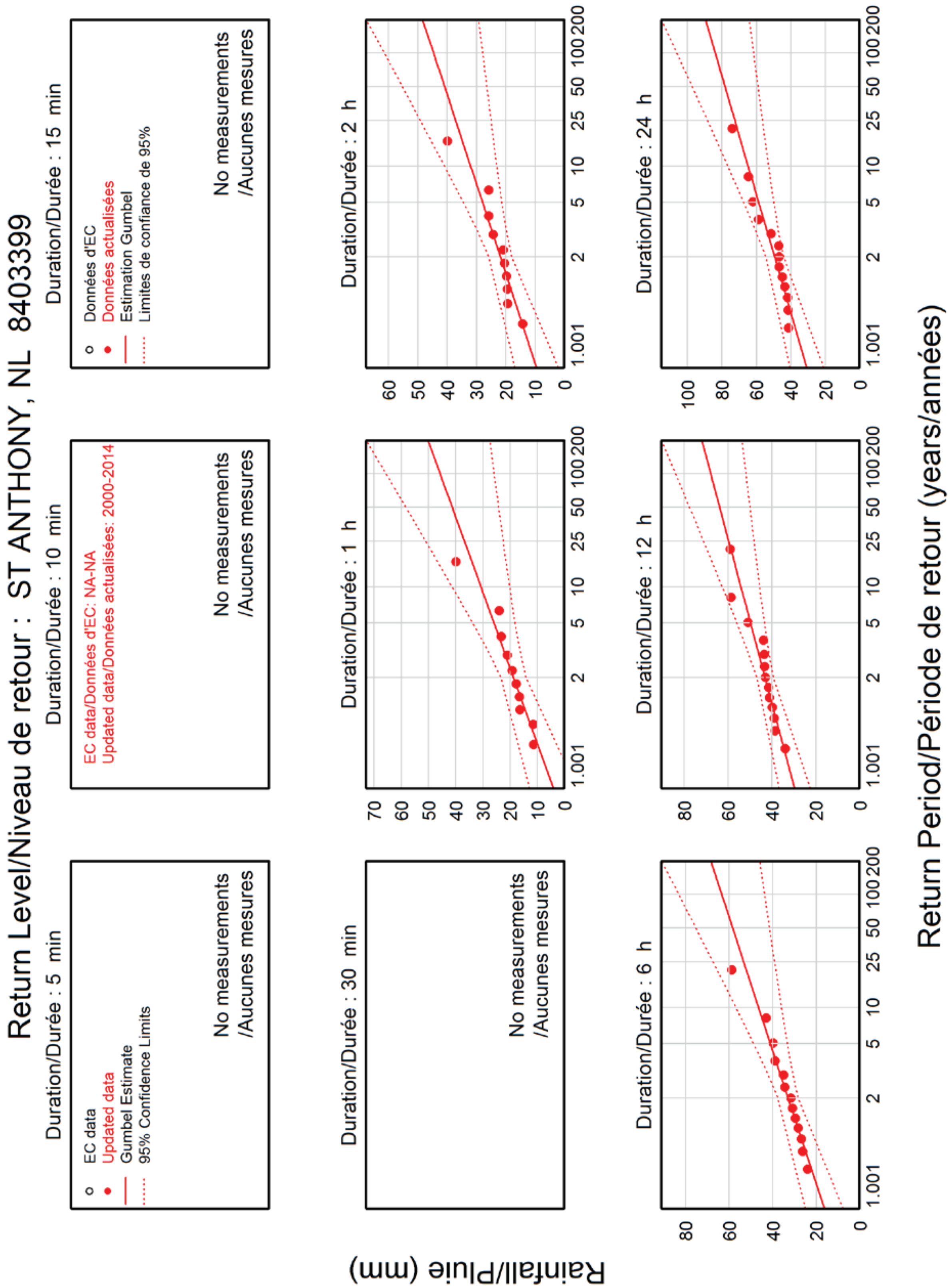

Figure 11.7 St. Anthony (8403399) Return Level Plot – Updated

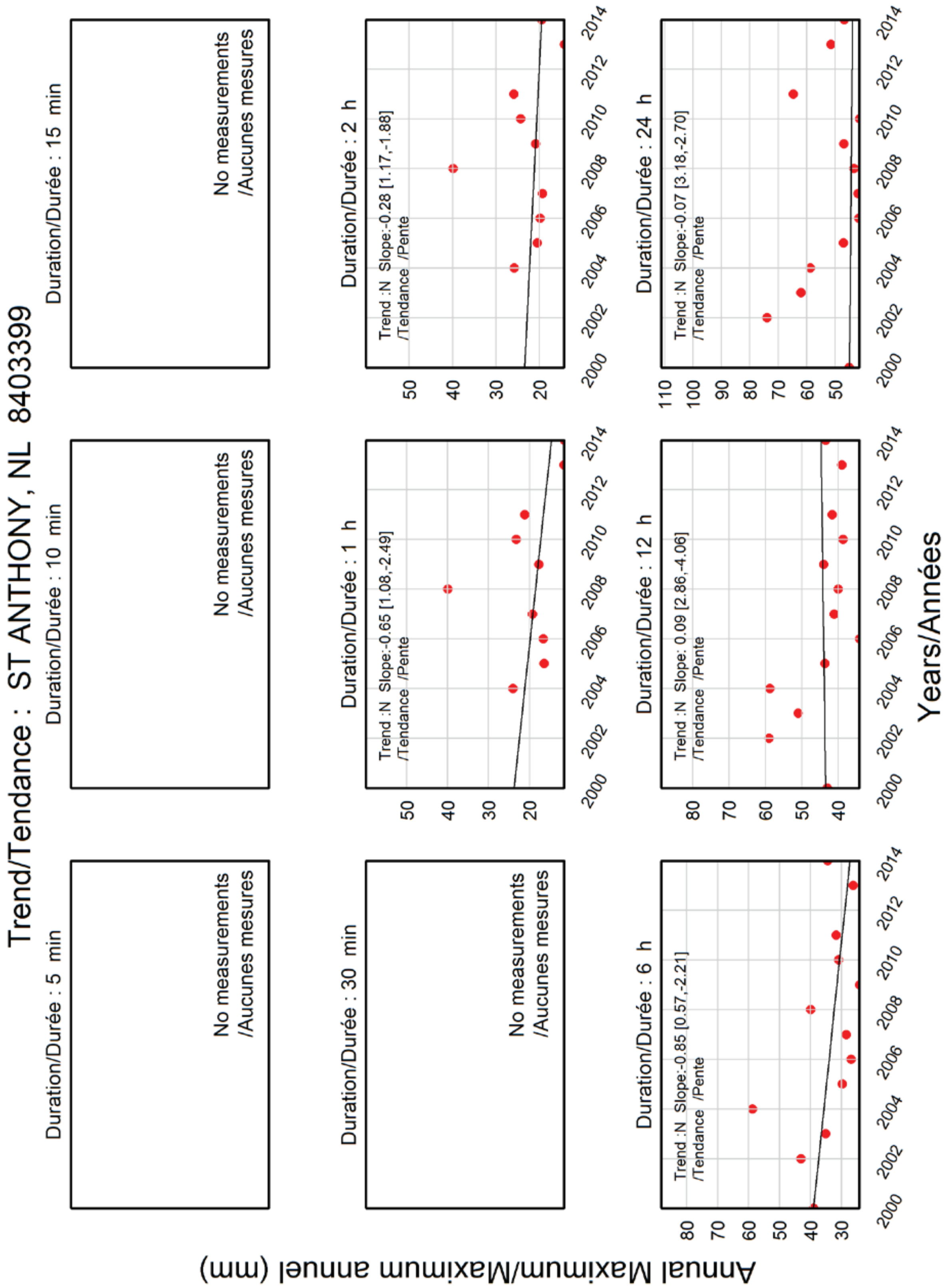

Figure 11.8 St. Anthony (8403399) Trend Plot – Updated

19. Wabush Lake A

This station was updated in CRA (2015). The updated IDF curve from CRA (2015) is reproduced below, with the addition of the 20-year return period.

This IDF curve was updated using 6-hr data from Wabush Lake A. The IDF curve increased during the update (Table 19.1).

Table 19.1 Differences Between IDF Curves for Wabush Lake A

Percent Difference in Precipitation Amount (%) (Difference in Precipitation Amount (mm))						
Duration	Return Period (years)					
	2	5	10	25	50	100
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	2.1 (0.4)	1.2 (0.3)	0.7 (0.2)	0.3 (0.1)	0.1 (0.0)	-0.1 (-0.1)
12-hr	2.3 (0.6)	3.2 (1.1)	3.7 (1.4)	4.1 (1.8)	4.4 (2.1)	4.6 (2.4)
24-hr	2.6 (0.9)	2.5 (1.1)	2.5 (1.2)	2.5 (1.4)	2.5 (1.5)	2.5 (1.7)
Notes: Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period. Bold numbers indicate changes greater than 5 percent.						

```
               Office of Climate Change and Energy Efficiency

            Short Duration Rainfall Intensity-Duration-Frequency Data
           Données sur l'intensité, la durée et la fréquence des chutes
                             de pluie de courte durée

                 Gumbel - Method of moments/Méthode des moments

                                   2015/10/30

================================================================================

 WABUSH LAKE A                                         NL        8504175
 Updated with 6-hour data measured at Wabush Lake A (8504175): 2004-2012

 Latitude: 52 56'N    Longitude: 66 52'W    Elevation/Altitude: 551        m
 Years/Années : 1974 - 2012           # Years/Années :    25

================================================================================

********************************************************************************

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

********************************************************************************
```

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF 1974	6.6	10.4	13.5	21.1	26.2	28.4	32.0	32.0	35.3
EC-IDF 1975	4.6	5.8	6.1	6.9	8.1	11.9	20.8	24.6	34.3
EC-IDF 1976	2.8	3.8	5.1	9.7	12.2	16.5	21.8	25.9	35.6
EC-IDF 1977	2.5	3.6	4.3	6.1	10.2	16.5	18.8	37.1	38.1
EC-IDF 1978	8.1	11.1	11.8	15.9	21.2	24.6	26.6	31.6	41.9
EC-IDF 1979	2.7	4.2	5.8	8.8	10.8	17.2	25.5	34.3	39.4
EC-IDF 1980	4.2	7.6	10.6	16.4	21.2	27.8	32.6	42.2	43.2
EC-IDF 1981	3.9	4.9	6.0	11.6	17.5	21.2	27.3	38.6	62.0
EC-IDF 1982	4.8	4.8	5.2	10.2	11.2	12.8	19.9	34.8	46.6
EC-IDF 1983	-99.9	-99.9	-99.9	-99.9	13.3	17.7	20.0	22.9	26.2
EC-IDF 1984	7.7	14.5	18.3	20.0	24.9	25.2	29.4	35.6	43.3
EC-IDF 1985	3.2	5.3	7.2	10.6	11.7	12.4	17.2	24.8	24.8
EC-IDF 1986	4.0	4.9	5.3	6.2	6.4	11.9	18.4	23.7	33.0
EC-IDF 1987	2.2	3.7	4.5	5.6	9.0	10.4	16.5	24.0	33.0
EC-IDF 1988	4.7	5.7	6.0	6.7	8.9	12.5	17.7	23.2	29.2
EC-IDF 1989	3.9	6.8	7.3	10.0	14.5	17.4	21.0	27.7	34.2
EC-IDF 1990	-99.9	-99.9	-99.9	-99.9	7.7	11.8	25.4	38.3	59.1
EC-IDF 1991	2.8	4.0	5.5	9.1	10.5	20.2	36.6	45.6	46.2
EC-IDF 1993	10.4	12.8	15.3	20.3	25.3	25.9	26.7	26.9	33.9
EC-IDF 1994	2.9	4.1	4.8	6.0	6.6	7.1	9.2	14.5	19.7
EC-IDF 1995	3.0	5.2	6.2	6.8	8.7	12.7	12.9	17.6	27.6
EC-IDF 1996	7.6	7.6	7.6	8.6	8.6	9.6	17.3	23.2	27.4
EC-IDF 1997	3.2	4.3	5.3	7.7	9.2	10.3	19.8	34.7	41.1
EC-IDF 1998	1.2	2.1	2.7	4.1	6.5	8.2	13.7	21.2	25.5
EC-IDF 2000	8.1	10.7	11.1	11.1	11.1	11.1	17.0	25.0	31.4
EC-IDF 2001	4.0	4.8	5.8	6.7	6.7	7.7	15.4	19.8	26.6
EC-IDF 2003	4.5	6.7	9.8	16.7	17.6	17.9	28.6	30.2	31.2
UPDATE 2004	NM	NM	NM	NM	NM	NM	29.0	37.0	38.0
UPDATE 2005	NM	NM	NM	NM	NM	NM	15.0	24.0	32.0
UPDATE 2006	NM	NM	NM	NM	NM	NM	20.0	28.0	30.6
UPDATE 2007	NM	NM	NM	NM	NM	NM	19.0	29.0	34.0
UPDATE 2008	NM	NM	NM	NM	NM	NM	19.0	21.0	36.0
UPDATE 2009	NM	NM	NM	NM	NM	NM	22.0	26.0	43.0
UPDATE 2010	NM	NM	NM	NM	NM	NM	33.0	53.0	66.0
UPDATE 2011	NM	NM	NM	NM	NM	NM	31.0	40.0	44.0
UPDATE 2012	NM	NM	NM	NM	NM	NM	23.0	28.0	33.0
# Yrs. Années	25	25	25	25	27	27	36	36	36
Mean Moyenne	4.5	6.4	7.6	10.5	12.8	15.8	22.2	29.6	36.8
Std. Dev. Écart-type	2.3	3.2	3.8	5.0	6.1	6.3	6.5	8.3	10.2
Skew. Dissymétrie	1.04	1.23	1.40	0.98	1.07	0.64	0.36	0.72	1.19
Kurtosis	3.72	4.01	4.69	3.11	3.23	2.62	2.70	3.67	4.86

*-99.9 Indicates Missing Data/Données manquantes
*   NM Indicates No Measurements/Aucunes mesures

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.2	6.2	7.5	8.8	9.2	10.4	11.7	25
EC-IDF 10 min	5.9	8.7	10.5	12.3	12.8	14.6	16.3	25
EC-IDF 15 min	7.0	10.4	12.6	14.7	15.4	17.5	19.6	25
EC-IDF 30 min	9.7	14.1	17.0	19.8	20.7	23.5	26.2	25
EC-IDF 1 h	11.8	17.2	20.8	24.2	25.3	28.7	32.0	27
EC-IDF 2 h	14.8	20.4	24.1	27.6	28.7	32.2	35.6	27
UPDATE 6 h	21.1	26.8	30.6	34.2	35.4	38.9	42.4	36
UPDATE 12 h	28.2	35.6	40.4	45.1	46.6	51.1	55.6	36
UPDATE 24 h	35.2	44.1	50.1	55.8	57.6	63.2	68.7	36

* 6-hr data were used for the update: shorter durations were not updated

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée		2 yr/ans		5 yr/ans		10 yr/ans		20 yr/ans		25 yr/ans		50 yr/ans		100 yr/ans	#Years Années
EC-IDF 5 min		50.1		74.1		90.1		105.4		110.2		125.2		140.0	25
	+/-	9.8	+/-	16.5	+/-	22.3	+/-	28.2	+/-	30.1	+/-	36.0	+/-	41.9	25
EC-IDF 10 min		35.1		51.9		63.0		73.7		77.0		87.4		97.8	25
	+/-	6.8	+/-	11.5	+/-	15.5	+/-	19.6	+/-	20.9	+/-	25.1	+/-	29.2	25
EC-IDF 15 min		28.1		41.5		50.4		59.0		61.7		70.0		78.3	25
	+/-	5.5	+/-	9.2	+/-	12.5	+/-	15.7	+/-	16.8	+/-	20.1	+/-	23.4	25
EC-IDF 30 min		19.4		28.2		34.1		39.7		41.4		46.9		52.4	25
	+/-	3.6	+/-	6.1	+/-	8.2	+/-	10.3	+/-	11.0	+/-	13.2	+/-	15.4	25
EC-IDF 1 h		11.8		17.2		20.8		24.2		25.3		28.7		32.0	27
	+/-	2.1	+/-	3.6	+/-	4.8	+/-	6.1	+/-	6.5	+/-	7.8	+/-	9.1	27
EC-IDF 2 h		7.4		10.2		12.0		13.8		14.4		16.1		17.8	27
	+/-	1.1	+/-	1.8	+/-	2.5	+/-	3.1	+/-	3.4	+/-	4.0	+/-	4.7	27
UPDATE 6 h		3.5		4.5		5.1		5.7		5.9		6.5		7.1	36
	+/-	0.3	+/-	0.5	+/-	0.7	+/-	0.9	+/-	1.0	+/-	1.2	+/-	1.4	36
UPDATE 12 h		2.4		3.0		3.4		3.8		3.9		4.3		4.6	36
	+/-	0.2	+/-	0.3	+/-	0.5	+/-	0.6	+/-	0.6	+/-	0.8	+/-	0.9	36
UPDATE 24 h		1.5		1.8		2.1		2.3		2.4		2.6		2.9	36
	+/-	0.1	+/-	0.2	+/-	0.3	+/-	0.4	+/-	0.4	+/-	0.5	+/-	0.5	36

* 6-hr data were used for the update: shorter durations were not updated

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	17.7	25.8	31.2	36.4	38.0	43.1	48.1
Std. Dev. /Écart-type (RR)	17.0	25.3	30.9	36.2	37.9	43.1	48.3
Std. Error/Erreur-type	2.0	4.0	5.3	6.7	7.1	8.4	9.8
Coefficient (A)	11.4	15.9	18.8	21.7	22.6	25.3	28.1
Exponent/Exposant (B)	-0.635	-0.670	-0.685	-0.695	-0.698	-0.706	-0.712
Mean % Error/% erreur moyenne	3.7	5.4	6.2	6.8	6.9	7.3	7.6

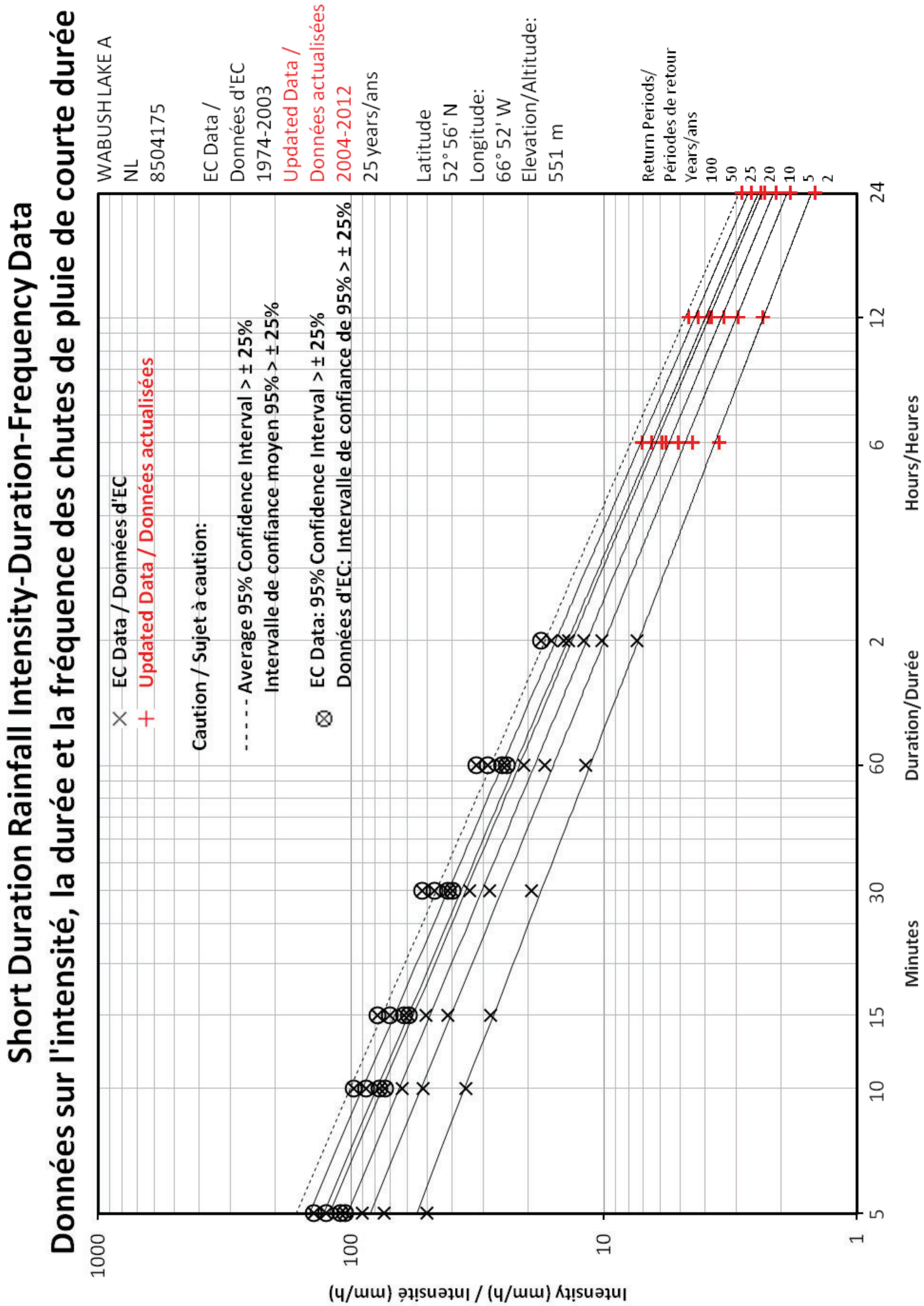

Figure 19.1 Wabush Lake A IDF Curve – Updated

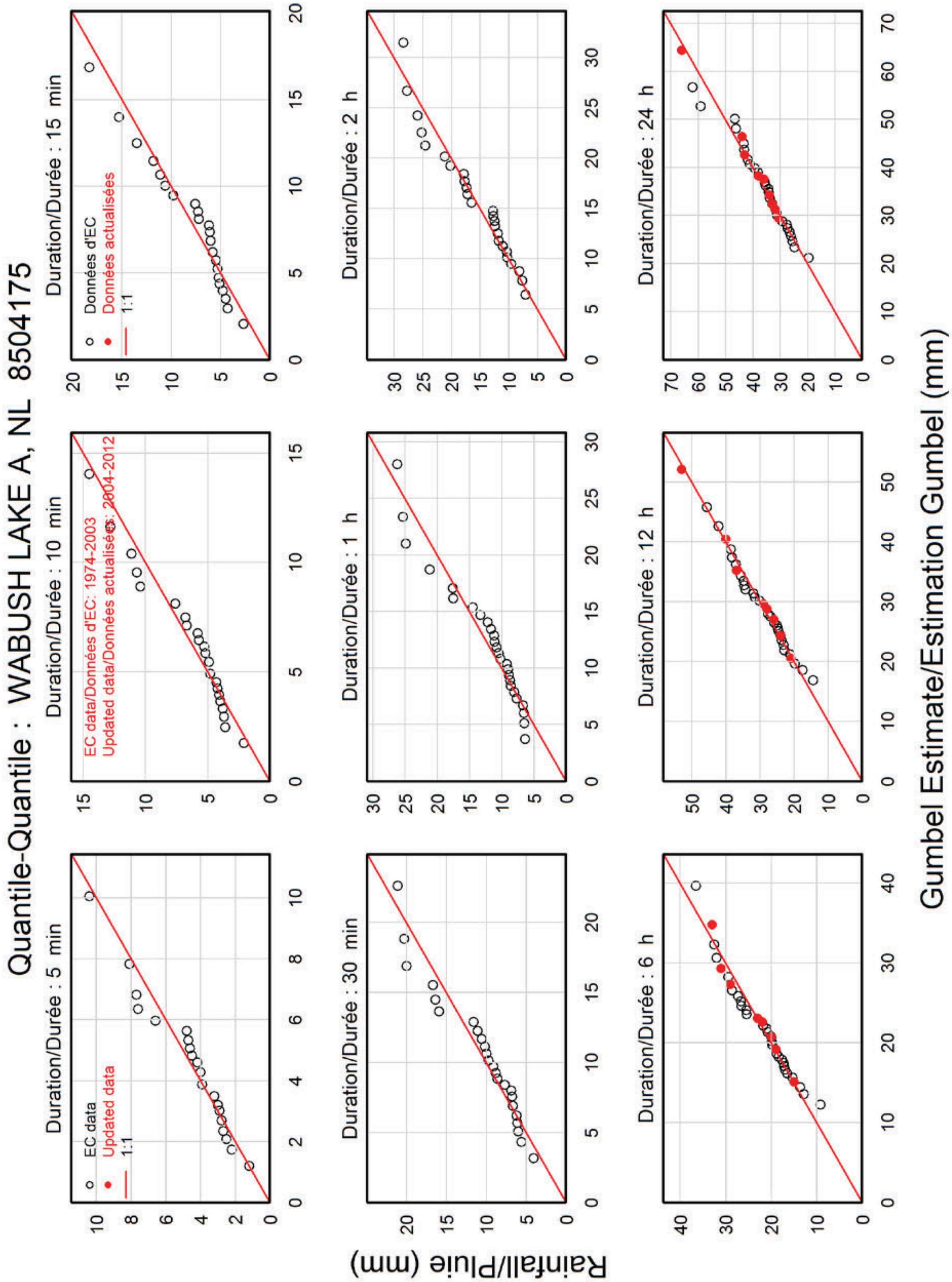

Figure 19.2 Wabush Lake A Quantile-Quantile Plot – Updated

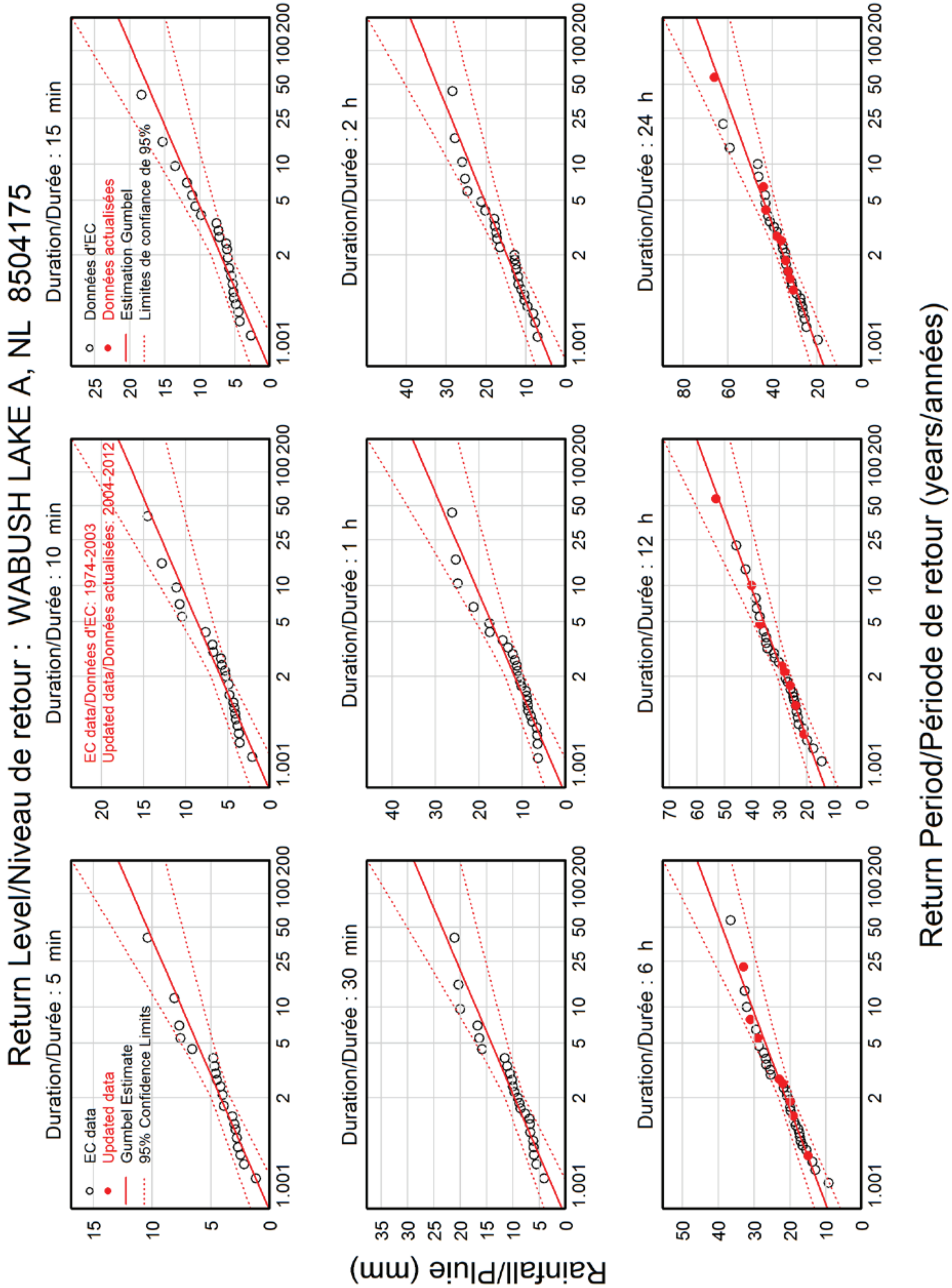

Figure 19.3 Wabush Lake A Return Level Plot – Updated

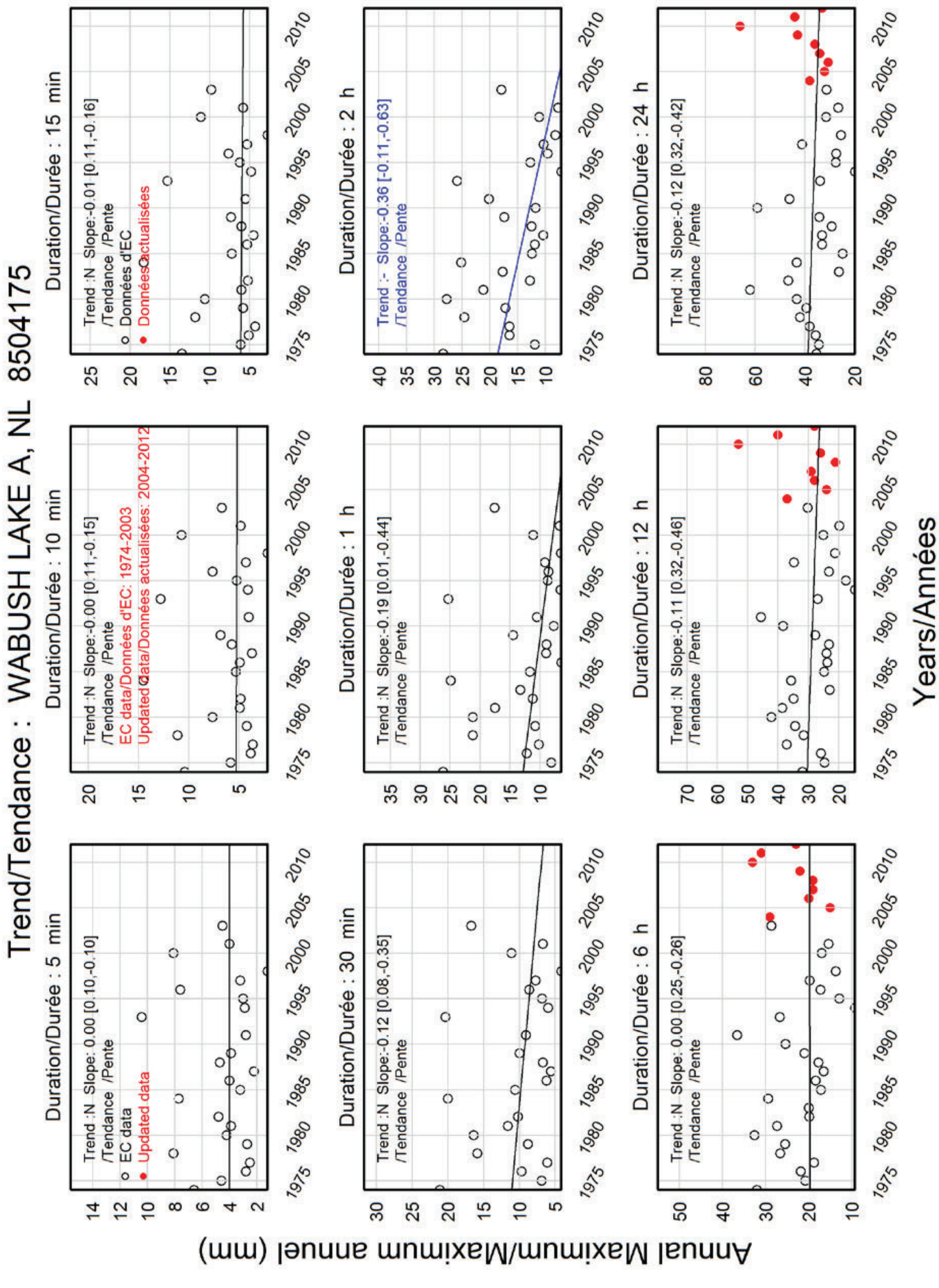

Figure 19.4 Wabush Lake A Trend Plot – Updated

18. Nain

This station was not updated in CRA (2015) because it is an active IDF station and was updated by EC. The EC IDF V2.3 (2015) curve is reproduced below, with the addition of the 20-year return period.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/10/30

==

NAIN NL 8502799

Latitude: 56 33'N Longitude: 61 41'W Elevation/Altitude: 7 m

Years/Années : 1993 - 2013 # Years/Années : 17

==

****

Table 1 : Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1993	3.8	6.0	6.2	7.4	8.8	11.6	18.8	19.8	24.7
EC-IDF	1994	2.2	3.6	4.4	6.0	10.1	16.2	37.5	43.5	59.6
EC-IDF	1997	1.4	1.9	2.6	3.7	6.0	10.4	19.4	31.1	49.8
EC-IDF	1998	3.7	5.4	7.6	9.5	11.7	13.7	25.2	42.2	47.1
EC-IDF	1999	6.5	7.0	7.2	8.3	12.7	19.0	25.2	39.0	50.5
EC-IDF	2000	-99.9	-99.9	-99.9	-99.9	-99.9	16.0	25.5	29.1	32.8
EC-IDF	2001	1.9	2.5	2.7	4.1	6.9	10.6	18.4	30.1	33.7
EC-IDF	2002	3.1	5.6	6.2	6.8	8.8	15.1	27.5	45.7	59.4
EC-IDF	2003	2.5	4.8	5.8	6.2	8.7	11.7	15.9	26.6	38.7
EC-IDF	2004	3.6	5.0	6.9	8.5	11.9	12.7	-99.9	-99.9	31.4
EC-IDF	2005	2.1	2.3	2.9	5.4	8.1	14.8	29.9	31.4	35.2
EC-IDF	2006	2.1	2.8	3.6	4.8	7.8	10.4	17.2	28.9	46.0
EC-IDF	2007	2.1	2.8	3.5	5.0	7.5	12.9	25.3	38.7	43.7
EC-IDF	2008	2.6	4.8	7.1	12.9	17.6	24.8	46.9	53.3	54.5
EC-IDF	2009	1.2	1.4	2.0	3.7	5.7	9.8	19.0	24.5	32.5
EC-IDF	2010	2.7	3.9	5.8	7.8	8.0	13.3	-99.9	-99.9	58.0
EC-IDF	2011	3.3	4.4	4.6	7.4	11.5	18.5	33.0	39.8	41.6
EC-IDF	2012	3.8	6.0	7.2	9.0	15.2	18.8	23.0	30.2	47.4
EC-IDF	2013	3.2	4.8	5.6	8.8	9.8	9.8	19.2	21.6	27.8
	# Yrs. Années	18	18	18	18	18	19	17	17	19
	Mean Moyenne	2.9	4.2	5.1	7.0	9.8	14.2	25.1	33.9	42.9
	Std. Dev. Écart-type	1.2	1.6	1.8	2.4	3.1	4.0	8.1	9.2	10.9
	Skew. Dissymétrie	1.48	-0.13	-0.29	0.65	1.03	1.11	1.36	0.44	0.04
	Kurtosis	7.05	2.51	2.11	4.10	4.28	4.60	5.32	3.08	2.32

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	2.7	3.7	4.5	5.1	5.3	6.0	6.7	18
EC-IDF 10 min	3.9	5.3	6.3	7.1	7.4	8.3	9.2	18
EC-IDF 15 min	4.8	6.4	7.5	8.6	8.9	9.9	10.9	18
EC-IDF 30 min	6.6	8.7	10.1	11.4	11.8	13.1	14.4	18
EC-IDF 1 h	9.3	12.1	13.9	15.7	16.2	18.0	19.7	18
EC-IDF 2 h	13.6	17.1	19.4	21.6	22.3	24.5	26.6	19
EC-IDF 6 h	23.8	31.0	35.7	40.3	41.8	46.2	50.7	17
EC-IDF 12 h	32.3	40.4	45.8	50.9	52.6	57.6	62.6	17
EC-IDF 24 h	41.1	50.7	57.1	63.2	65.1	71.1	77.0	19

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	32.2	45.0	53.5	61.6	64.2	72.1	80.0	18
	+/- 6.1	+/- 10.4	+/- 14.0	+/- 17.7	+/- 18.9	+/- 22.6	+/- 26.3	18
EC-IDF 10 min	23.4	31.9	37.5	42.9	44.6	49.9	55.1	18
	+/- 4.1	+/- 6.9	+/- 9.3	+/- 11.7	+/- 12.5	+/- 14.9	+/- 17.4	18
EC-IDF 15 min	19.2	25.7	30.1	34.2	35.5	39.6	43.6	18
	+/- 3.1	+/- 5.3	+/- 7.1	+/- 9.0	+/- 9.6	+/- 11.5	+/- 13.4	18
EC-IDF 30 min	13.1	17.3	20.1	22.8	23.7	26.3	28.9	18
	+/- 2.0	+/- 3.4	+/- 4.6	+/- 5.8	+/- 6.2	+/- 7.4	+/- 8.6	18
EC-IDF 1 h	9.3	12.1	13.9	15.7	16.2	18.0	19.7	18
	+/- 1.3	+/- 2.2	+/- 3.0	+/- 3.8	+/- 4.1	+/- 4.9	+/- 5.7	18
EC-IDF 2 h	6.8	8.5	9.7	10.8	11.2	12.2	13.3	19
	+/- 0.8	+/- 1.4	+/- 1.9	+/- 2.3	+/- 2.5	+/- 3.0	+/- 3.5	19
EC-IDF 6 h	4.0	5.2	6.0	6.7	7.0	7.7	8.4	17
	+/- 0.6	+/- 1.0	+/- 1.3	+/- 1.7	+/- 1.8	+/- 2.2	+/- 2.5	17
EC-IDF 12 h	2.7	3.4	3.8	4.2	4.4	4.8	5.2	17
	+/- 0.3	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.0	+/- 1.2	+/- 1.4	17
EC-IDF 24 h	1.7	2.1	2.4	2.6	2.7	3.0	3.2	19
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.5	+/- 0.6	+/- 0.7	+/- 0.8	19

****

Table 3 : Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	20 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	12.5	16.8	19.7	22.4	23.3	25.9	28.6
Std. Dev. /Écart-type (RR)	10.5	14.7	17.5	20.1	21.0	23.6	26.2
Std. Error/Erreur-type	0.4	0.4	0.4	0.4	0.4	0.5	0.6
Coefficient (A)	9.4	12.3	14.2	16.0	16.6	18.4	20.2
Exponent/Exposant (B)	-0.510	-0.529	-0.538	-0.544	-0.546	-0.550	-0.554
Mean % Error/% erreur moyenne	2.9	2.8	3.0	3.2	3.2	3.4	3.5

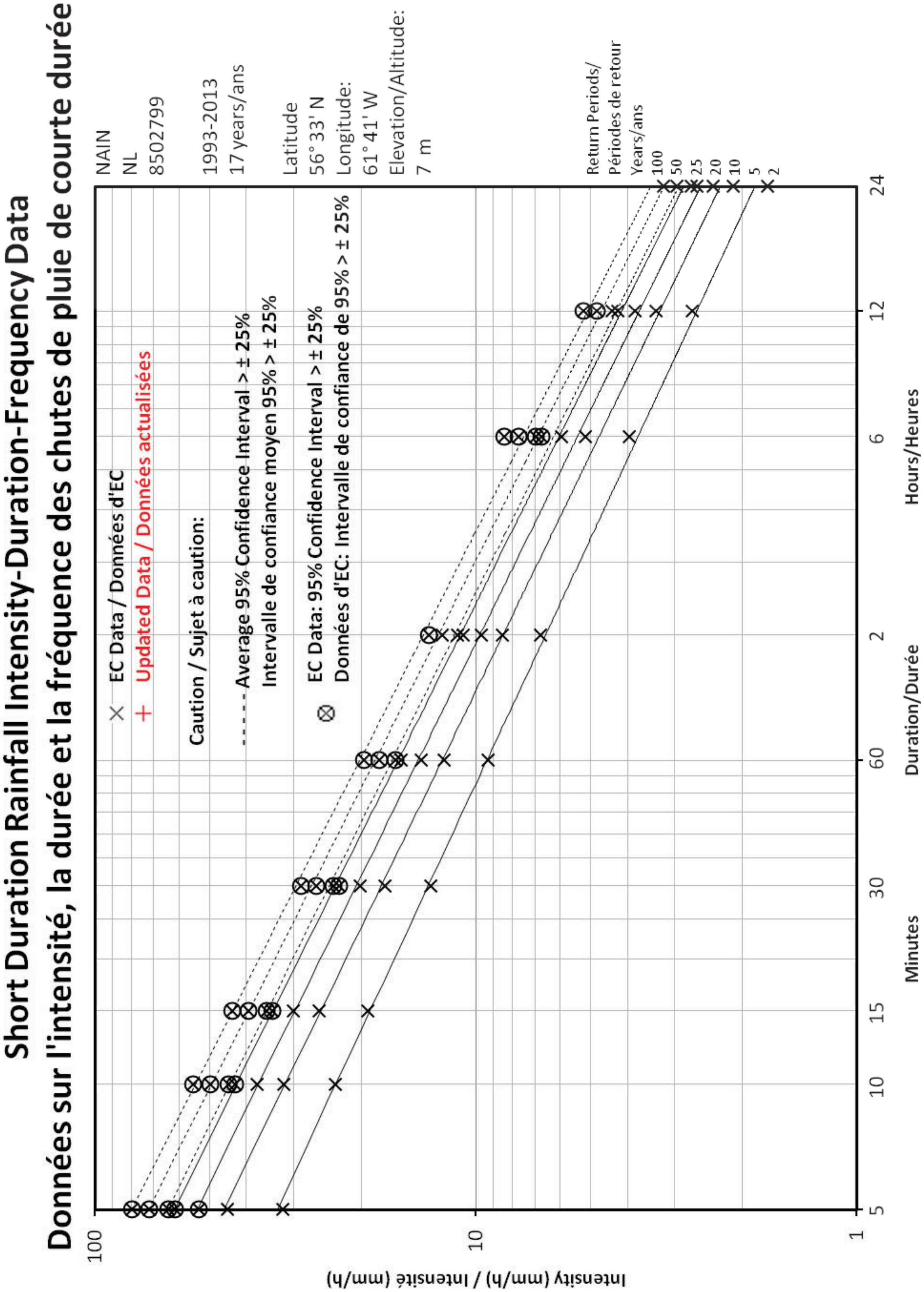

Figure 18.1 Nain IDF Curve – EC IDF V2.3

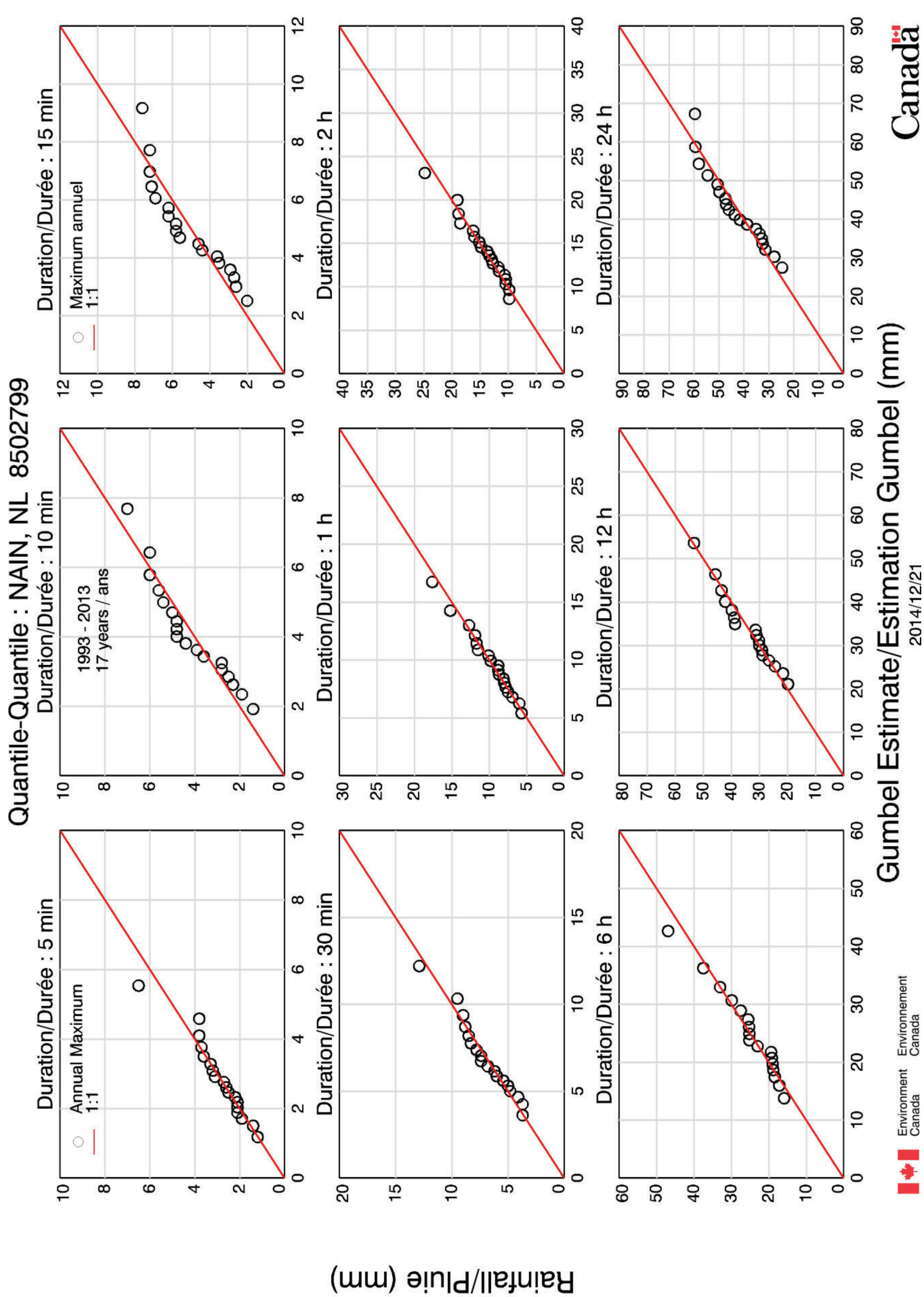

Figure 18.2 Nain Quantile-Quantile Plot – EC IDF V2.3

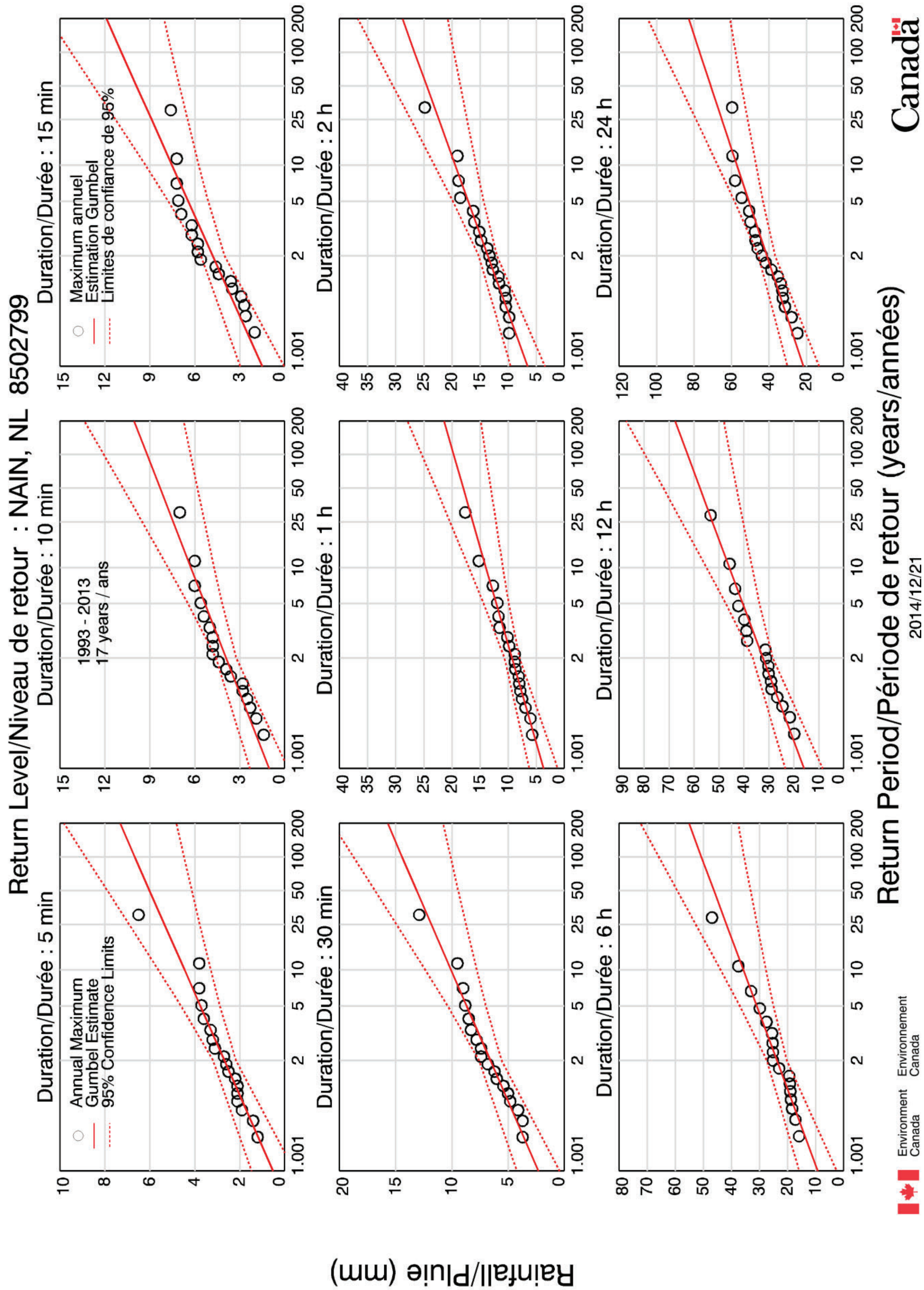

Figure 18.3 Nain Return Level Plot – EC IDF V2.3

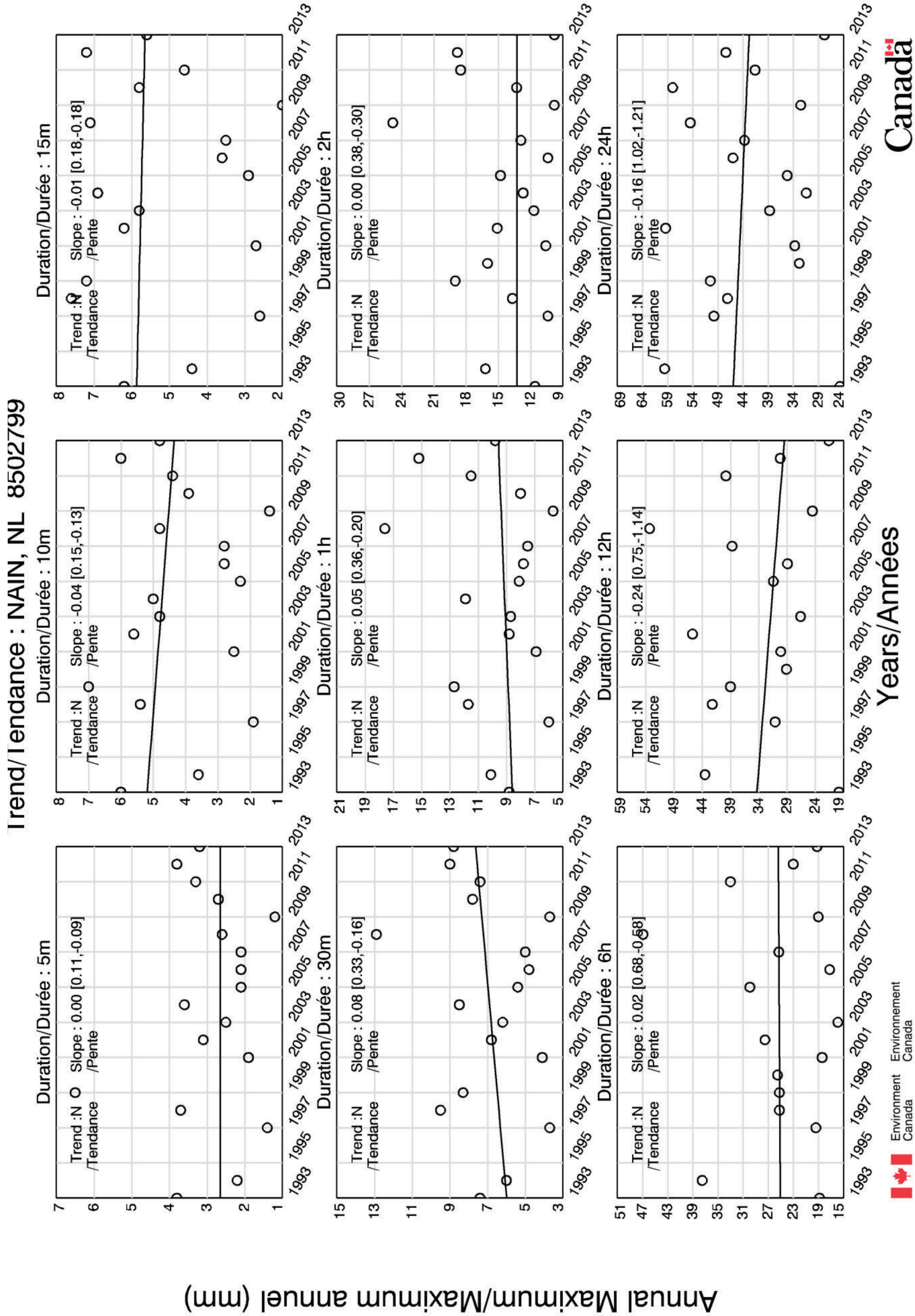

Figure 18.4 Nain Trend Plot – EC IDF V2.3

APPENDIX I

INTENSITY DURATION FREQUENCY (IDF) CURVES INCLUDING CLIMATE CHANGE

Table 1.43 Future Climate IDF Curves for Churchill Falls A (8501132) – 2011-2040 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.6	6.0	7.0	7.8	8.1	9.0	9.9
10-min	6.2	8.3	9.6	11.0	11.4	12.7	14.0
15-min	7.4	9.9	11.5	13.1	13.6	15.1	16.6
30-min	9.4	12.2	14.0	15.8	16.3	18.1	19.8
1-hr	11.0	13.6	15.2	16.8	17.4	18.9	20.5
2-hr	13.9	16.3	17.9	19.3	19.8	21.3	22.7
6-hr	20.9	26.0	29.3	32.6	33.6	36.8	39.9
12-hr	29.4	34.8	38.5	41.9	43.0	46.4	49.8
24-hr	36.5	42.5	46.5	50.3	51.5	55.2	58.9
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.2	7.4	8.6	9.9	10.4	11.7	13.0
10-min	7.2	10.3	12.0	13.9	14.6	16.4	18.3
15-min	8.5	12.3	14.4	16.7	17.5	19.8	22.0
30-min	10.6	14.9	17.3	19.9	20.7	23.3	25.9
1-hr	12.2	16.1	18.2	20.6	21.4	23.8	26.1
2-hr	15.0	18.6	20.6	22.9	23.6	25.8	27.9
6-hr	22.4	29.6	34.0	38.1	39.5	43.9	48.2
12-hr	31.0	38.6	43.1	47.6	49.1	53.7	58.3
24-hr	38.4	47.0	52.1	57.2	58.9	64.1	69.3
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.5	8.5	9.8	11.4	12.0	13.7	15.3
10-min	8.9	11.9	13.9	16.3	17.1	19.6	22.0
15-min	10.7	14.1	16.5	19.3	20.3	23.3	26.2
30-min	13.0	17.0	19.7	22.9	24.0	27.3	30.6
1-hr	14.4	18.0	20.4	23.3	24.3	27.4	30.4
2-hr	17.0	20.4	22.7	25.4	26.3	29.1	31.9
6-hr	25.3	32.7	37.7	42.4	43.9	49.3	54.7
12-hr	34.2	41.8	46.8	52.0	53.8	59.5	65.2
24-hr	42.1	50.8	56.5	62.4	64.5	71.0	77.5

Table 1.44 Future Climate IDF Curves for Churchill Falls A (8501132) – 2041-2070 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.2	7.0	8.2	9.3	9.7	10.8	11.9
10-min	7.0	9.7	11.5	13.1	13.7	15.3	16.9
15-min	8.4	11.6	13.7	15.6	16.3	18.2	20.1
30-min	10.5	14.1	16.4	18.7	19.4	21.5	23.7
1-hr	12.0	15.4	17.5	19.5	20.1	22.1	24.1
2-hr	14.9	18.0	19.9	21.8	22.4	24.3	26.1
6-hr	22.3	28.6	32.7	36.6	37.9	41.7	45.5
12-hr	30.9	37.5	41.8	45.9	47.3	51.3	55.3
24-hr	38.3	45.7	50.6	55.2	56.7	61.2	65.7
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.8	8.0	9.5	10.8	11.2	12.5	13.8
10-min	7.9	11.2	13.4	15.3	15.9	17.8	19.7
15-min	9.4	13.4	16.0	18.2	18.9	21.2	23.4
30-min	11.7	16.1	19.1	21.6	22.4	24.9	27.5
1-hr	13.1	17.2	19.9	22.2	22.9	25.2	27.5
2-hr	15.9	19.7	22.1	24.3	25.0	27.1	29.3
6-hr	23.7	31.4	36.5	41.4	42.9	47.4	51.9
12-hr	32.4	40.4	45.8	50.7	52.3	56.9	61.6
24-hr	40.0	49.2	55.3	60.9	62.7	68.0	73.2
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.6	9.2	11.0	12.5	13.1	14.8	16.4
10-min	9.1	13.0	15.6	17.9	18.7	21.2	23.6
15-min	10.8	15.5	18.6	21.3	22.2	25.2	28.1
30-min	13.2	18.5	22.0	25.1	26.1	29.4	32.7
1-hr	14.5	19.4	22.5	25.3	26.3	29.3	32.3
2-hr	17.2	21.7	24.6	27.2	28.1	30.9	33.7
6-hr	25.6	34.6	41.1	46.8	48.6	54.0	59.3
12-hr	34.4	43.9	50.7	56.4	58.2	63.7	69.4
24-hr	42.4	53.2	61.1	67.6	69.7	76.1	82.5

Table 1.45 Future Climate IDF Curves for Churchill Falls A (8501132) – 2071-2100 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.1	6.6	7.5	8.5	8.8	9.7	10.6
10-min	6.9	9.1	10.5	11.9	12.3	13.6	15.0
15-min	8.3	10.8	12.5	14.1	14.7	16.2	17.8
30-min	10.3	13.2	15.1	17.0	17.6	19.3	21.1
1-hr	11.9	14.5	16.3	18.0	18.5	20.1	21.7
2-hr	14.8	17.2	18.8	20.4	20.9	22.4	23.9
6-hr	22.1	27.4	31.0	34.4	35.5	38.8	42.1
12-hr	30.7	36.3	40.0	43.6	44.7	48.2	51.7
24-hr	38.1	44.3	48.4	52.4	53.6	57.5	61.3
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.1	8.4	10.0	11.5	12.0	13.4	14.8
10-min	8.4	11.8	14.2	16.4	17.1	19.2	21.2
15-min	10.0	14.1	16.9	19.5	20.3	22.8	25.2
30-min	12.3	16.9	20.1	23.1	24.0	26.8	29.5
1-hr	13.7	17.9	20.8	23.5	24.4	26.9	29.4
2-hr	16.5	20.3	23.0	25.5	26.3	28.7	31.0
6-hr	24.5	32.4	37.9	43.1	44.7	49.8	54.8
12-hr	33.3	41.6	47.1	52.4	54.1	59.3	64.5
24-hr	41.0	50.5	57.0	63.2	65.1	71.2	77.2
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	7.3	10.0	11.9	13.7	14.3	16.2	18.0
10-min	10.1	14.1	16.9	19.7	20.5	23.3	25.9
15-min	12.0	16.8	20.1	23.4	24.4	27.6	30.8
30-min	14.6	20.0	23.7	27.4	28.6	32.2	35.8
1-hr	15.8	20.7	24.1	27.5	28.6	31.9	35.2
2-hr	18.4	23.0	26.1	29.2	30.2	33.3	36.4
6-hr	27.2	37.0	43.5	49.8	51.8	58.1	64.4
12-hr	36.1	46.3	53.0	59.7	61.8	68.4	74.9
24-hr	44.3	56.1	63.8	71.5	73.9	81.5	89.0

Table 1.46 Future Climate IDF Curves for Goose A (8501900) – 2011-2040 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.0	5.5	6.4	7.2	7.5	8.3	9.2
10-min	5.7	8.1	9.5	10.9	11.3	12.6	14.0
15-min	6.9	9.9	11.7	13.4	13.9	15.6	17.3
30-min	8.8	12.5	14.8	16.9	17.6	19.7	21.8
1-hr	11.2	14.7	16.8	18.8	19.5	21.5	23.4
2-hr	14.3	18.1	20.3	22.4	23.1	25.2	27.2
6-hr	23.4	28.6	31.6	34.6	35.5	38.4	41.2
12-hr	31.6	38.1	41.9	45.6	46.8	50.4	54.0
24-hr	40.8	50.0	55.6	60.9	62.6	67.8	73.0
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.6	6.4	7.6	8.8	9.2	10.4	11.5
10-min	6.8	9.7	11.7	13.6	14.2	16.2	18.1
15-min	8.2	11.9	14.2	16.6	17.4	19.8	22.2
30-min	10.5	15.1	18.2	21.2	22.2	25.3	28.3
1-hr	12.9	17.3	20.2	23.2	24.2	27.2	30.1
2-hr	16.3	21.1	24.3	27.5	28.6	31.9	35.1
6-hr	26.1	33.0	37.4	42.0	43.5	48.1	52.7
12-hr	34.7	43.0	48.5	54.0	55.7	61.3	66.8
24-hr	45.0	56.2	63.5	71.0	73.4	81.0	88.4
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.1	7.6	9.2	10.8	11.3	12.8	14.3
10-min	7.6	11.8	14.5	17.1	18.0	20.5	23.1
15-min	9.3	14.4	17.7	20.9	21.9	25.0	28.1
30-min	11.9	18.4	22.7	26.7	28.0	32.0	36.0
1-hr	14.2	20.6	24.7	28.7	30.0	33.9	37.7
2-hr	17.7	24.8	29.4	33.8	35.2	39.5	43.8
6-hr	28.2	38.2	44.8	51.1	53.1	59.2	65.4
12-hr	37.2	49.1	56.9	64.4	66.7	74.1	81.3
24-hr	48.2	63.9	74.1	83.9	87.1	96.7	106.2

Table 1.47 Future Climate IDF Curves for Goose A (8501900) – 2041-2070 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.5	6.1	7.2	8.2	8.6	9.6	10.5
10-min	6.5	9.2	11.0	12.6	13.2	14.8	16.4
15-min	7.9	11.2	13.4	15.5	16.2	18.2	20.1
30-min	10.1	14.3	17.1	19.7	20.5	23.0	25.5
1-hr	12.5	16.5	19.1	21.6	22.4	24.8	27.1
2-hr	15.8	20.1	23.0	25.7	26.6	29.2	31.7
6-hr	25.4	31.6	35.6	39.5	40.7	44.5	48.1
12-hr	34.0	41.5	46.4	51.1	52.6	57.2	61.7
24-hr	43.9	54.2	60.9	67.4	69.4	75.6	81.6
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.7	6.7	8.0	9.2	9.6	10.7	11.9
10-min	6.9	10.3	12.4	14.4	15.0	16.9	18.9
15-min	8.4	12.5	15.1	17.5	18.3	20.7	23.1
30-min	10.8	16.0	19.3	22.3	23.3	26.3	29.4
1-hr	13.1	18.2	21.3	24.3	25.2	28.1	31.1
2-hr	16.5	22.1	25.5	28.8	29.8	33.0	36.2
6-hr	26.4	34.4	39.4	44.0	45.5	50.0	54.5
12-hr	35.1	44.6	50.7	56.3	58.0	63.5	68.9
24-hr	45.5	58.2	66.2	73.6	76.0	83.3	90.7
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.6	8.1	9.9	11.6	12.1	14.0	15.9
10-min	8.4	12.7	15.7	18.5	19.4	22.6	25.8
15-min	10.2	15.5	19.1	22.6	23.7	27.6	31.5
30-min	13.1	19.8	24.5	28.9	30.4	35.4	40.4
1-hr	15.5	22.0	26.5	30.9	32.4	37.3	42.2
2-hr	19.1	26.4	31.4	36.2	37.8	43.3	48.7
6-hr	30.1	40.5	47.7	54.6	56.8	64.3	71.9
12-hr	39.4	51.7	60.3	68.5	71.1	79.9	88.9
24-hr	51.2	67.3	78.4	89.1	92.7	104.7	116.6

Table 1.48 Future Climate IDF Curves for Goose A (8501900) – 2071-2100 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.5	5.8	6.7	7.5	7.8	8.6	9.4
10-min	6.5	8.6	10.0	11.4	11.8	13.1	14.5
15-min	7.9	10.5	12.3	14.0	14.5	16.2	17.8
30-min	10.1	13.4	15.6	17.7	18.4	20.4	22.5
1-hr	12.5	15.5	17.6	19.6	20.2	22.1	24.0
2-hr	15.8	19.1	21.2	23.3	24.0	26.0	28.0
6-hr	25.4	30.0	33.1	36.1	37.0	39.9	42.8
12-hr	33.9	39.8	43.6	47.3	48.5	52.1	55.7
24-hr	43.9	52.1	57.5	62.7	64.4	69.5	74.6
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.9	6.8	8.1	9.4	9.8	11.0	12.2
10-min	7.3	10.4	12.6	14.7	15.3	17.4	19.4
15-min	8.8	12.7	15.3	17.9	18.7	21.2	23.7
30-min	11.3	16.2	19.6	22.8	23.9	27.1	30.2
1-hr	13.7	18.4	21.7	24.8	25.8	28.9	31.9
2-hr	17.0	22.3	25.9	29.3	30.4	33.8	37.2
6-hr	27.2	34.8	39.8	44.8	46.3	51.2	55.9
12-hr	36.0	45.1	51.2	57.1	59.0	64.8	70.5
24-hr	46.7	58.8	66.9	74.8	77.3	85.0	92.6
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.8	8.9	11.1	13.3	14.0	16.0	18.1
10-min	8.8	14.0	17.8	21.4	22.6	26.1	29.6
15-min	10.7	17.1	21.7	26.1	27.5	31.8	36.1
30-min	13.8	21.9	27.9	33.5	35.3	40.8	46.3
1-hr	16.1	24.1	29.9	35.5	37.3	42.7	48.1
2-hr	19.8	28.7	35.2	41.4	43.3	49.4	55.4
6-hr	31.1	43.8	53.0	61.8	64.6	73.2	81.8
12-hr	40.5	55.6	66.4	76.8	80.1	90.2	100.3
24-hr	52.7	72.3	86.4	100.0	104.3	117.5	130.7

Table 1.49 Future Climate IDF Curves for Mary's Harbour A (8502591) – 2011-2040 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	2.7	3.7	4.2	4.6	4.8	5.3	5.7
10-min	3.8	4.8	5.3	5.8	6.0	6.5	7.0
15-min	4.5	5.7	6.3	6.8	7.0	7.6	8.2
30-min	6.5	7.9	8.6	9.3	9.5	10.2	10.8
1-hr	9.1	10.7	11.5	12.2	12.5	13.2	13.9
2-hr	13.4	16.2	17.7	19.1	19.6	21.0	22.3
6-hr	23.7	29.5	32.7	35.8	36.7	39.7	42.7
12-hr	32.7	42.6	48.0	53.1	54.7	59.7	64.7
24-hr	39.9	51.9	58.2	64.3	66.3	72.3	78.2
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.2	4.3	5.1	5.8	6.0	6.8	7.5
10-min	4.3	5.5	6.3	7.1	7.4	8.2	8.9
15-min	5.1	6.4	7.4	8.3	8.6	9.4	10.3
30-min	7.2	8.8	9.9	10.9	11.3	12.3	13.3
1-hr	9.9	11.7	12.9	14.1	14.5	15.6	16.7
2-hr	14.8	18.1	20.3	22.4	23.1	25.2	27.2
6-hr	26.4	33.2	37.7	42.2	43.6	48.1	52.2
12-hr	37.3	49.0	56.8	64.5	67.0	74.6	81.7
24-hr	45.7	60.0	69.5	78.9	81.9	91.2	99.9
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.9	5.2	6.2	7.0	7.3	8.2	9.0
10-min	5.0	6.5	7.5	8.4	8.7	9.7	10.6
15-min	5.9	7.6	8.7	9.8	10.1	11.1	12.2
30-min	8.2	10.1	11.5	12.7	13.1	14.3	15.6
1-hr	10.9	13.1	14.6	16.0	16.5	17.8	19.2
2-hr	16.7	20.7	23.4	25.9	26.7	29.2	31.7
6-hr	30.1	38.5	44.0	49.3	50.9	56.1	61.2
12-hr	43.8	58.2	67.8	76.9	79.9	88.8	97.7
24-hr	53.8	71.5	83.3	94.5	98.1	109.1	120.1

Table 1.50 Future Climate IDF Curves for Mary's Harbour A (8502591) – 2041-2070 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.1	3.7	4.1	4.5	4.6	5.0	5.3
10-min	4.2	4.8	5.2	5.7	5.8	6.2	6.6
15-min	5.0	5.7	6.2	6.6	6.8	7.2	7.7
30-min	7.1	7.9	8.5	9.0	9.2	9.7	10.3
1-hr	9.7	10.7	11.3	11.9	12.1	12.8	13.4
2-hr	14.5	16.3	17.5	18.6	19.0	20.1	21.3
6-hr	25.7	29.7	32.4	34.9	35.7	38.2	40.6
12-hr	36.3	42.9	47.4	51.6	52.9	57.1	61.2
24-hr	44.4	52.2	57.3	62.3	63.9	68.7	73.5
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.5	4.8	5.6	6.4	6.6	7.4	8.1
10-min	4.6	6.0	6.9	7.7	8.0	8.8	9.5
15-min	5.5	7.0	8.0	9.0	9.3	10.2	11.0
30-min	7.7	9.5	10.6	11.8	12.1	13.2	14.2
1-hr	10.4	12.4	13.7	15.0	15.4	16.5	17.6
2-hr	15.7	19.4	21.7	24.1	24.8	26.9	28.9
6-hr	28.3	35.9	40.7	45.5	47.1	51.5	55.9
12-hr	40.6	53.8	62.0	70.4	73.1	80.7	88.3
24-hr	49.7	65.9	76.0	86.3	89.6	98.9	108.2
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.4	6.0	7.0	8.0	8.4	9.3	10.2
10-min	5.6	7.3	8.4	9.5	9.9	10.9	11.8
15-min	6.6	8.5	9.7	11.0	11.3	12.5	13.6
30-min	8.9	11.2	12.7	14.1	14.6	16.0	17.2
1-hr	11.8	14.3	16.0	17.6	18.1	19.7	21.1
2-hr	18.2	22.8	25.9	28.8	29.7	32.5	35.1
6-hr	33.1	42.7	49.0	55.1	57.0	62.9	68.8
12-hr	49.1	65.6	76.6	87.1	90.5	100.8	111.0
24-hr	60.3	80.7	94.3	107.3	111.4	124.1	136.7

Table 1.51 Future Climate IDF Curves for Mary's Harbour A (8502591) – 2071-2100 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.1	3.9	4.4	4.9	5.0	5.5	5.9
10-min	4.2	5.0	5.6	6.1	6.2	6.7	7.2
15-min	5.0	5.9	6.5	7.1	7.3	7.9	8.3
30-min	7.1	8.2	8.9	9.6	9.8	10.5	11.1
1-hr	9.8	11.0	11.8	12.6	12.8	13.5	14.2
2-hr	14.6	16.8	18.3	19.7	20.2	21.5	22.7
6-hr	26.0	30.8	33.9	37.0	37.9	40.9	43.6
12-hr	36.7	44.8	50.1	55.3	56.9	61.9	66.7
24-hr	45.0	54.6	61.0	67.1	69.0	75.0	80.6
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.7	4.9	5.6	6.3	6.5	7.2	7.9
10-min	4.9	6.1	6.9	7.6	7.8	8.6	9.4
15-min	5.7	7.1	8.0	8.8	9.1	9.9	10.8
30-min	8.0	9.6	10.6	11.6	11.9	12.9	13.9
1-hr	10.7	12.5	13.7	14.8	15.1	16.3	17.4
2-hr	16.3	19.6	21.7	23.7	24.3	26.4	28.5
6-hr	29.4	36.2	40.7	45.0	46.3	50.4	54.7
12-hr	42.6	54.7	62.7	69.7	72.0	79.1	86.6
24-hr	52.2	66.6	76.0	85.1	87.8	96.4	105.4
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.4	6.3	7.6	8.9	9.3	10.5	11.7
10-min	5.6	7.7	9.1	10.4	10.9	12.2	13.5
15-min	6.6	8.9	10.5	12.0	12.5	14.0	15.4
30-min	8.9	11.7	13.6	15.3	15.9	17.7	19.4
1-hr	11.8	14.8	16.9	18.9	19.6	21.5	23.5
2-hr	18.2	23.8	27.6	31.2	32.4	35.9	39.5
6-hr	33.2	44.6	52.4	59.9	62.2	69.5	76.8
12-hr	49.1	68.9	82.5	95.4	99.5	112.2	124.8
24-hr	60.3	84.9	101.6	117.7	122.8	138.5	154.1

Table 1.28 Future Climate IDF Curves for St. Anthony (8403401) – 2011-2040 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.5	5.0	5.9	6.8	7.1	7.9	8.6
10-min	5.4	7.6	9.1	10.5	10.9	12.1	13.3
15-min	6.9	9.4	11.0	12.5	13.0	14.4	15.7
30-min	9.5	11.8	13.4	14.8	15.3	16.6	17.8
1-hr	12.8	15.1	16.6	18.1	18.6	19.9	21.1
2-hr	18.2	21.1	23.0	24.8	25.4	27.0	28.5
6-hr	31.1	35.7	38.8	41.7	42.6	45.2	47.6
12-hr	40.9	46.9	51.0	54.8	56.1	59.4	62.6
24-hr	51.9	61.4	67.7	73.7	75.7	80.9	85.9
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.3	6.2	7.6	9.1	9.6	11.0	12.3
10-min	6.5	9.5	11.8	14.1	14.8	17.0	19.1
15-min	8.1	11.5	14.0	16.5	17.3	19.8	22.2
30-min	10.6	13.8	16.2	18.6	19.3	21.7	23.9
1-hr	13.8	17.1	19.5	21.9	22.6	25.0	27.2
2-hr	19.5	23.6	26.6	29.5	30.4	33.3	36.1
6-hr	33.2	39.7	44.5	49.2	50.7	55.3	59.8
12-hr	43.7	52.2	58.5	64.7	66.7	72.8	78.8
24-hr	56.3	69.6	79.5	89.2	92.3	101.8	111.1
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.0	7.8	9.6	11.5	12.0	13.9	15.6
10-min	7.7	12.0	14.9	17.8	18.7	21.5	24.3
15-min	9.5	14.2	17.4	20.6	21.7	24.8	27.9
30-min	12.0	16.4	19.4	22.4	23.4	26.4	29.3
1-hr	15.2	19.7	22.7	25.8	26.7	29.7	32.6
2-hr	21.2	26.8	30.5	34.3	35.5	39.2	42.8
6-hr	36.0	44.9	50.9	56.9	58.8	64.7	70.5
12-hr	47.3	59.0	66.9	74.9	77.4	85.2	92.9
24-hr	61.9	80.3	92.6	105.1	109.0	121.1	133.2

Table 1.29 Future Climate IDF Curves for St. Anthony (8403401) – 2041-2070 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.1	5.4	6.1	6.9	7.1	7.8	8.5
10-min	6.2	8.2	9.4	10.6	10.9	12.1	13.2
15-min	7.9	10.1	11.4	12.7	13.1	14.3	15.5
30-min	10.4	12.5	13.8	14.9	15.3	16.5	17.7
1-hr	13.7	15.8	17.0	18.2	18.6	19.8	21.0
2-hr	19.3	21.9	23.5	25.0	25.4	26.9	28.3
6-hr	32.9	37.1	39.6	42.0	42.7	45.0	47.3
12-hr	43.2	48.7	52.0	55.1	56.2	59.2	62.3
24-hr	55.6	64.2	69.3	74.2	75.8	80.6	85.3
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.8	7.0	8.4	9.8	10.2	11.6	12.9
10-min	7.4	10.8	13.0	15.2	15.9	18.0	20.1
15-min	9.2	12.9	15.4	17.8	18.5	20.9	23.2
30-min	11.5	15.2	17.5	19.7	20.5	22.7	24.9
1-hr	14.7	18.5	20.8	23.0	23.8	26.0	28.2
2-hr	20.6	25.3	28.2	30.9	31.8	34.6	37.4
6-hr	35.0	42.5	47.1	51.5	52.9	57.4	61.8
12-hr	46.0	55.8	61.9	67.8	69.7	75.5	81.4
24-hr	59.9	75.3	84.8	93.9	96.9	106.1	115.2
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.9	9.9	11.9	13.8	14.4	16.3	18.1
10-min	10.6	15.3	18.5	21.5	22.4	25.3	28.2
15-min	12.7	17.9	21.4	24.7	25.8	29.0	32.2
30-min	15.0	19.9	23.2	26.3	27.3	30.3	33.4
1-hr	18.3	23.2	26.5	29.6	30.6	33.7	36.7
2-hr	25.0	31.2	35.2	39.1	40.3	44.1	47.9
6-hr	42.0	51.9	58.3	64.6	66.5	72.6	78.7
12-hr	55.3	68.2	76.8	85.0	87.6	95.6	103.6
24-hr	74.4	94.6	108.0	120.9	125.0	137.5	150.0

Table 1.30 Future Climate IDF Curves for St. Anthony (8403401) – 2071-2100 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.0	5.4	6.4	7.3	7.6	8.4	9.3
10-min	6.1	8.3	9.8	11.2	11.7	13.1	14.4
15-min	7.7	10.1	11.8	13.4	13.9	15.4	16.9
30-min	10.2	12.6	14.1	15.6	16.1	17.5	18.9
1-hr	13.5	15.8	17.4	18.9	19.4	20.8	22.2
2-hr	19.1	22.0	23.9	25.8	26.4	28.2	29.9
6-hr	32.5	37.2	40.3	43.3	44.2	47.1	49.8
12-hr	42.7	48.9	53.0	56.9	58.1	61.9	65.6
24-hr	54.8	64.4	70.8	76.9	78.9	84.8	90.5
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.2	7.4	8.9	10.3	10.8	12.3	13.7
10-min	8.0	11.5	13.7	16.0	16.7	19.0	21.3
15-min	9.8	13.7	16.2	18.7	19.5	22.0	24.6
30-min	12.3	15.9	18.2	20.6	21.4	23.8	26.1
1-hr	15.5	19.2	21.5	23.9	24.7	27.1	29.5
2-hr	21.6	26.1	29.0	32.0	33.0	36.0	38.9
6-hr	36.6	43.8	48.5	53.2	54.8	59.5	64.3
12-hr	48.1	57.6	63.8	70.0	72.1	78.3	84.6
24-hr	63.2	78.0	87.7	97.4	100.6	110.5	120.2
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.4	9.5	11.3	13.0	13.5	15.2	16.9
10-min	9.8	14.6	17.5	20.1	21.0	23.6	26.2
15-min	11.8	17.2	20.3	23.3	24.2	27.1	30.2
30-min	14.2	19.2	22.1	24.9	25.8	28.6	31.5
1-hr	17.4	22.5	25.4	28.2	29.1	31.9	34.9
2-hr	24.0	30.2	33.9	37.4	38.5	41.9	45.6
6-hr	40.4	50.4	56.2	61.8	63.6	69.1	74.9
12-hr	53.1	66.3	74.0	81.4	83.7	90.9	98.7
24-hr	70.9	91.6	103.7	115.2	118.9	130.1	142.2

Table 1.55 Future Climate IDF Curves for Wabush Lake A (8504175) – 2011-2040 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.2	6.3	7.5	8.5	8.8	9.7	10.7
10-min	5.9	8.8	10.4	11.9	12.3	13.6	14.9
15-min	7.1	10.6	12.5	14.3	14.8	16.4	17.9
30-min	9.8	14.4	16.9	19.2	19.9	22.0	24.0
1-hr	11.9	17.5	20.7	23.5	24.3	26.8	29.4
2-hr	14.9	20.7	23.9	26.8	27.7	30.3	32.9
6-hr	21.5	27.3	30.6	33.7	34.6	37.4	40.2
12-hr	28.8	36.6	41.2	45.5	46.8	50.7	54.6
24-hr	35.9	45.3	50.7	55.7	57.2	61.8	66.3
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.0	7.2	8.6	9.8	10.2	11.5	12.7
10-min	7.0	10.0	12.0	13.7	14.3	16.0	17.7
15-min	8.4	12.0	14.4	16.5	17.2	19.2	21.3
30-min	11.5	16.3	19.3	22.1	23.0	25.7	28.5
1-hr	14.1	19.9	23.6	27.1	28.1	31.5	34.8
2-hr	17.1	23.1	27.0	30.5	31.6	35.1	38.5
6-hr	23.2	29.2	33.1	36.7	37.8	41.2	44.8
12-hr	31.0	39.0	44.3	49.2	50.7	55.3	60.1
24-hr	38.6	48.2	54.4	60.2	62.0	67.6	73.3
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.4	9.3	11.6	13.7	14.4	16.5	18.6
10-min	9.0	13.1	16.2	19.1	20.1	23.0	25.9
15-min	10.8	15.7	19.4	23.0	24.2	27.7	31.1
30-min	14.7	21.1	26.0	30.7	32.2	36.8	41.4
1-hr	17.9	25.7	31.8	37.5	39.4	45.0	50.6
2-hr	21.1	29.2	35.4	41.3	43.2	49.1	54.8
6-hr	26.3	34.2	40.1	45.8	47.6	53.1	58.6
12-hr	35.0	45.4	53.1	60.5	62.9	70.1	77.3
24-hr	43.5	56.0	65.4	74.3	77.2	85.9	94.6

Table 1.56 Future Climate IDF Curves for Wabush Lake A (8504175) – 2041-2070 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.0	5.5	6.5	7.5	7.8	8.7	9.7
10-min	5.6	7.7	9.1	10.5	10.9	12.2	13.5
15-min	6.7	9.2	10.9	12.6	13.1	14.7	16.3
30-min	9.2	12.6	14.8	17.0	17.6	19.7	21.8
1-hr	11.2	15.3	18.1	20.7	21.5	24.1	26.7
2-hr	14.2	18.4	21.3	24.0	24.8	27.5	30.1
6-hr	21.0	25.6	28.6	31.6	32.5	35.4	38.2
12-hr	28.0	34.5	38.8	42.9	44.2	48.2	52.2
24-hr	35.0	42.6	47.7	52.5	54.0	58.8	63.5
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.8	7.9	9.4	10.8	11.2	12.5	13.8
10-min	8.1	11.1	13.2	15.1	15.7	17.5	19.3
15-min	9.7	13.3	15.8	18.1	18.8	21.0	23.2
30-min	13.2	17.9	21.3	24.2	25.2	28.1	30.9
1-hr	16.1	21.9	26.0	29.6	30.8	34.4	37.9
2-hr	19.2	25.2	29.4	33.2	34.4	38.0	41.7
6-hr	24.9	31.0	35.1	39.0	40.2	44.0	47.7
12-hr	33.2	41.3	46.8	52.0	53.7	58.7	63.6
24-hr	41.3	51.0	57.6	63.8	65.7	71.7	77.6
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.9	9.6	11.7	13.8	14.4	16.4	18.4
10-min	9.7	13.4	16.4	19.2	20.1	22.9	25.7
15-min	11.6	16.1	19.7	23.1	24.2	27.6	30.9
30-min	15.7	21.6	26.3	30.8	32.3	36.7	41.0
1-hr	19.2	26.4	32.2	37.7	39.5	44.9	50.2
2-hr	22.4	29.9	35.8	41.5	43.3	48.9	54.4
6-hr	27.3	34.8	40.6	46.1	47.8	53.2	58.5
12-hr	36.3	46.2	53.7	60.9	63.2	70.2	77.2
24-hr	45.1	57.0	66.0	74.7	77.5	86.0	94.4

Table 1.57 Future Climate IDF Curves for Wabush Lake A (8504175) – 2071-2100 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.9	7.0	8.1	9.1	9.4	10.4	11.4
10-min	6.8	9.8	11.3	12.7	13.2	14.6	16.0
15-min	8.2	11.8	13.6	15.3	15.8	17.5	19.2
30-min	11.2	16.0	18.3	20.6	21.3	23.5	25.7
1-hr	13.6	19.5	22.4	25.1	26.0	28.7	31.4
2-hr	16.7	22.7	25.7	28.5	29.4	32.2	35.0
6-hr	22.9	28.9	32.1	35.1	36.1	39.1	42.0
12-hr	30.6	38.8	43.1	47.3	48.6	52.7	56.8
24-hr	38.0	47.8	53.0	57.9	59.4	64.2	69.0
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	6.1	8.5	9.9	11.3	11.8	13.3	14.7
10-min	8.5	11.9	13.9	15.8	16.4	18.5	20.5
15-min	10.2	14.2	16.7	19.0	19.7	22.3	24.7
30-min	13.9	19.2	22.4	25.4	26.4	29.7	32.9
1-hr	16.9	23.4	27.4	31.1	32.3	36.3	40.2
2-hr	20.1	26.7	30.8	34.6	35.9	40.1	44.1
6-hr	25.6	32.2	36.5	40.5	41.7	45.6	49.7
12-hr	34.0	42.8	48.6	53.8	55.5	60.7	66.1
24-hr	42.3	52.7	59.7	66.0	68.0	74.1	80.8
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	7.8	11.2	13.5	15.7	16.4	18.5	20.6
10-min	10.9	15.7	18.9	21.9	22.9	25.8	28.8
15-min	13.1	18.8	22.7	26.3	27.5	31.1	34.6
30-min	17.6	25.2	30.2	35.0	36.5	41.2	45.9
1-hr	21.5	30.8	37.0	42.9	44.7	50.5	56.2
2-hr	24.8	34.4	40.7	46.8	48.8	54.7	60.6
6-hr	29.2	38.8	45.2	51.3	53.2	59.2	65.2
12-hr	38.7	51.2	59.5	67.5	70.0	77.8	85.5
24-hr	48.0	63.2	73.2	82.9	85.9	95.3	104.7

Table 1.52 Future Climate IDF Curves for Nain (8502799) – 2011-2040 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	2.5	3.6	4.1	4.7	4.8	5.3	5.8
10-min	3.7	5.1	5.8	6.5	6.7	7.4	8.1
15-min	4.6	6.2	7.0	7.8	8.1	8.8	9.6
30-min	6.3	8.4	9.5	10.5	10.8	11.8	12.8
1-hr	8.9	11.7	13.1	14.4	14.9	16.2	17.5
2-hr	13.1	16.6	18.4	20.0	20.6	22.2	23.9
6-hr	22.8	30.0	33.6	37.1	38.2	41.6	45.0
12-hr	31.2	39.3	43.4	47.3	48.6	52.4	56.2
24-hr	39.7	49.4	54.2	58.9	60.4	64.9	69.4
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.3	4.6	5.4	6.1	6.4	7.1	7.8
10-min	4.7	6.4	7.5	8.5	8.8	9.7	10.6
15-min	5.7	7.7	8.9	10.1	10.4	11.5	12.6
30-min	7.7	10.3	11.9	13.4	13.8	15.2	16.6
1-hr	10.8	14.2	16.4	18.3	18.9	20.7	22.5
2-hr	15.5	19.8	22.4	24.9	25.6	28.0	30.2
6-hr	27.7	36.5	42.0	47.0	48.6	53.4	58.1
12-hr	36.8	46.7	52.9	58.5	60.3	65.7	70.9
24-hr	46.4	58.1	65.5	72.1	74.2	80.7	86.9
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.8	5.4	6.4	7.4	7.8	8.7	9.7
10-min	5.4	7.4	8.9	10.2	10.6	11.9	13.2
15-min	6.5	8.9	10.5	12.1	12.6	14.1	15.6
30-min	8.8	11.8	13.9	15.9	16.6	18.5	20.5
1-hr	12.2	16.3	19.0	21.7	22.5	25.1	27.6
2-hr	17.2	22.3	25.8	29.1	30.2	33.4	36.7
6-hr	31.3	41.8	48.9	55.8	58.0	64.6	71.3
12-hr	40.8	52.6	60.7	68.4	70.8	78.3	85.8
24-hr	51.1	65.2	74.7	83.9	86.8	95.7	104.6

Table 1.53 Future Climate IDF Curves for Nain (8502799) – 2041-2070 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	2.8	3.7	4.2	4.7	4.9	5.4	5.9
10-min	4.1	5.2	5.9	6.6	6.8	7.5	8.2
15-min	5.0	6.3	7.2	7.9	8.2	9.0	9.7
30-min	6.8	8.6	9.6	10.6	10.9	11.9	12.9
1-hr	9.6	11.9	13.3	14.6	15.1	16.4	17.7
2-hr	14.0	16.9	18.6	20.3	20.8	22.5	24.1
6-hr	24.6	30.5	34.1	37.6	38.7	42.1	45.4
12-hr	33.3	40.0	44.0	47.9	49.1	53.0	56.7
24-hr	42.2	50.1	54.9	59.6	61.0	65.6	70.0
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.4	4.6	5.5	6.3	6.6	7.5	8.3
10-min	4.8	6.4	7.6	8.7	9.1	10.3	11.4
15-min	5.9	7.7	9.1	10.4	10.8	12.1	13.4
30-min	8.0	10.3	12.1	13.8	14.3	16.0	17.7
1-hr	11.1	14.3	16.6	18.8	19.5	21.8	23.9
2-hr	15.9	19.8	22.7	25.6	26.5	29.3	32.0
6-hr	28.5	36.6	42.6	48.4	50.3	56.2	61.7
12-hr	37.7	46.8	53.5	60.1	62.2	68.8	75.0
24-hr	47.4	58.2	66.2	74.0	76.6	84.4	91.8
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	4.3	6.1	7.3	8.4	8.8	9.9	11.0
10-min	6.1	8.4	10.0	11.5	11.9	13.4	14.9
15-min	7.3	10.0	11.8	13.5	14.1	15.8	17.5
30-min	9.8	13.2	15.6	17.8	18.6	20.8	22.9
1-hr	13.6	18.1	21.2	24.2	25.1	28.0	30.9
2-hr	19.0	24.6	28.5	32.3	33.5	37.1	40.8
6-hr	34.9	46.5	54.6	62.3	64.7	72.3	79.7
12-hr	44.9	58.0	67.0	75.7	78.4	86.9	95.3
24-hr	55.9	71.5	82.2	92.5	95.8	105.9	115.9

Table 1.54 Future Climate IDF Curves for Nain (8502799) – 2071-2100 Time Horizon

Minimum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.1	4.0	4.4	4.8	5.0	5.4	5.8
10-min	4.4	5.6	6.2	6.7	6.9	7.5	8.0
15-min	5.4	6.8	7.5	8.1	8.3	8.9	9.5
30-min	7.3	9.1	10.0	10.8	11.1	11.9	12.7
1-hr	10.3	12.7	13.8	14.9	15.2	16.3	17.3
2-hr	14.8	17.8	19.3	20.6	21.0	22.4	23.7
6-hr	26.4	32.6	35.5	38.3	39.1	41.9	44.6
12-hr	35.3	42.2	45.5	48.6	49.6	52.7	55.7
24-hr	44.6	52.8	56.7	60.4	61.6	65.2	68.9
Median Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	3.4	4.7	5.5	6.2	6.4	7.2	7.9
10-min	4.9	6.5	7.6	8.6	8.9	9.8	10.8
15-min	6.0	7.8	9.1	10.2	10.6	11.7	12.7
30-min	8.1	10.5	12.1	13.5	14.0	15.4	16.8
1-hr	11.3	14.5	16.6	18.5	19.1	21.0	22.8
2-hr	16.0	20.1	22.7	25.1	25.9	28.3	30.6
6-hr	28.9	37.1	42.6	47.6	49.2	54.0	58.8
12-hr	38.1	47.4	53.6	59.1	60.9	66.3	71.7
24-hr	47.9	58.9	66.3	72.9	75.0	81.5	87.9
Maximum Projected Precipitation Amount (mm)							
Duration	Return Interval (years)						
	2	5	10	20	25	50	100
5-min	5.3	7.0	8.1	9.2	9.6	10.6	11.7
10-min	7.3	9.6	11.1	12.6	13.0	14.4	15.8
15-min	8.8	11.4	13.1	14.8	15.3	17.0	18.6
30-min	11.7	15.1	17.3	19.5	20.1	22.2	24.3
1-hr	16.0	20.5	23.5	26.3	27.2	30.0	32.7
2-hr	22.1	27.7	31.4	35.0	36.1	39.6	43.1
6-hr	41.2	52.8	60.5	67.8	70.2	77.3	84.5
12-hr	52.0	65.0	73.6	81.9	84.5	92.6	100.6
24-hr	64.4	79.9	90.1	99.9	103.1	112.7	122.2

APPENDIX J

LIST OF ENDANGERED SPECIES (NL ENDANGERED SPECIES REGULATION)

Appendix I – Endangered Species of Newfoundland and Labrador

Wildlife Group (Taxon)	Species (Common name)	COSEWIC status	SARA status	Newfoundland and Labrador Regulation 57/02: Endangered Species List Regulations (under Endangered Species Act)	TEK, population objectives and notes
Birds	American Golden-Plover				Assess/Maintain
	Bank Swallow	Threatened	Threatened	Schedule B: Threatened	
	Barn Swallow	Special Concern	Threatened	Schedule C: Vulnerable	
	Barrow's Goldeneye	Special Concern	Special Concern	Schedule C: Vulnerable	
	Bobolink	Special Concern	Threatened	Schedule C: Vulnerable	
	Canada Goose (North Atlantic)				Increase 50%
	Common Loon				Assess/Maintain
	Common Nighthawk	Special Concern	Special Concern	Schedule C: Vulnerable	
	Common Nighthawk			Schedule C: Vulnerable	
	Eskimo Curlew	Endangered	Endangered	Schedule A: Endangered	
	Evening Grosbeak	Endangered	Endangered	Schedule C: Vulnerable	
	Golden Eagle	Not at Risk			Maintain current
	Gray-cheeked Thrush				Assess/Maintain
	Great Auk	Extinct			
	Gyrfalcon				Maintain current
	Harlequin Duck (Eastern)	Special Concern	Special Concern	Schedule C: Vulnerable	Assess /Maintain
	Hudsonian Godwit	Threatened		Schedule B: Threatened	
	Ivory Gull	Endangered	Endangered	Schedule A: Endangered	

	Leach's Storm Petrel	Threatened		Schedule B: Threatened	
	Least Sandpiper				Assess/Maintain
	Lesser Yellowlegs	Threatened		Schedule B: Threatened	Presently confirmed area of occupancy range in Newfoundland, no observations within proposed road area in Labrador
	Long-tailed Duck				Assess/Maintain
	Newfoundland Gray-cheeked Thrush			Schedule B: Threatened	
	Northern Wheatear				Maintain current
	Olive-sided Flycatcher	Special Concern	Special Concern	Schedule C: Vulnerable	
	Peregrine Falcon (anatum/tundrius)		Special Concern	Schedule C: Vulnerable	Assess/Maintain
	Piping Plover (melodus subspecies)	Endangered	Endangered	Schedule A: Endangered	
	Red Crossbill (perna subspecies)	Threatened	Threatened	Schedule B: Threatened	
	Red Knot (rufa subspecies)	Endangered	Endangered	Schedule A: Endangered	
	Red-necked Phalarope	Special Concern	Special Concern	Schedule C: Vulnerable	
	Red-throated Loon				Assess/Maintain
	Ross's Gull	Endangered	Threatened		
	Rough-legged Hawk				Maintain current
	Rusty Blackbird	Special Concern	Special Concern	Schedule C: Vulnerable	
	Semipalmated Sandpiper				Assess/Maintain
	Short-billed Dowitcher				Revision to final report, current species range not in Labrador, but is in Newfoundland
	Short-eared Owl	Threatened	Special Concern	Schedule B: Threatened	Assess/Maintain
	Snow Bunting				Maintain current
	Snowy Owl				Maintain current

Mammals	American Marten (*Newfoundland population)	Special Concern	Threatened	Schedule C: Vulnerable	
	Eastern Red Bat	Endangered			
	Hoary Bat	Endangered			
	Little Brown Myotis	Endangered	Endangered	Schedule A: Endangered	
	Northern Myotis	Endangered	Endangered	Schedule A: Endangered	

	Polar Bear	Special Concern	Special Concern	Schedule C: Vulnerable	TEK report, three FN hunting stations (Postville, Hopedale, Nain)
	Silver-haired Bat	Endangered			
	Wolverine	Special Concern	Special Concern	Schedule A: Endangered	
	Woodland Caribou (Lac Joseph herd)	Threatened		Schedule B: Threatened	TEK report
	Woodland Caribou (Mealy Mountain herd)	Threatened		Schedule B: Threatened	
	Woodland Caribou (Red Wine herd)	Threatened		Schedule B: Threatened	
	Woodland Caribou (Torngat Mountains Population)	Endangered			

Fish	Atlantic Salmon				TEK report, Inhabits ocean, spawns in freshwater
	American Eel	Threatened		Schedule C: Vulnerable	Inhabits freshwater, spawns in ocean
	Arctic Char				TEK report, Inhabits ocean, spawns in freshwater
	Atlantic sturgeon	Threatened			Revision to initial report
	Banded Killifish	Special Concern	Special Concern	Schedule C: Vulnerable	Limited areas of occupancy/range subject species to increased risk. Road development noted as threat. Data limited in Labrador
	Mummichog			Schedule C: Vulnerable	Occasionally found in freshwater

Insects	Gypsy Cockoo Bumble Bee	Endangered	Endangered	Schedule A: Endangered	
	Suckley's Cuckoo Bumble Bee	Threatened		Schedule B: Threatened	
	Transverse Lady Beetle	Special Concern	Special Concern	Schedule C: Vulnerable	
	Yellow-banded Bumble Bee	Special Concern	Special Concern	Schedule C: Vulnerable	

Vegetation	Alaska Rein Orchid			Schedule A: Endangered	
	Barrens Willow	Endangered	Endangered	Schedule A: Endangered	
	Black Ash	Threatened	Not listed	Schedule B: Threatened	
	Blue Felt Lichen	Special Concern	Special Concern	Schedule C: Vulnerable	
	Bodin’s Milkvetch			Schedule B: Threatened	
	Boreal Felt Lichen	Special Concern	Special Concern	Schedule C: Vulnerable	
	Crowded Wormseed Mustard			Schedule A: Endangered	

	Cutleaf Fleabane			Schedule A: Endangered	
	Dense Draba	Special Concern	Under consideration	Schedule C: Vulnerable	
	Feathery False Solomon's Seal			Schedule A: Endangered	
	Fernald's Braya	Endangered	Endangered	Schedule A: Endangered	
	Fernald's Milk-vetch	Special Concern	Special Concern	Schedule C: Vulnerable	
	Gmelin's Watercrowfoot			Schedule A: Endangered	
	Graceful Felt Lichen (Voles Ears Lichen)			Schedule A: Endangered	
	Griscom's Arnica	Threatened	Threatened	Schedule A: Endangered	
	Lindley's Aster			Schedule A: Endangered	
	Long's Braya	Endangered	Endangered	Schedule A: Endangered	
	Low Northern Rockcress			Schedule A: Endangered	
	Mackenzie's Sweetvetch			Schedule B: Threatened	
	Mountain Bladder Fern			Schedule A: Endangered	
	Mountain Fern			Schedule C: Vulnerable	
	Mountain Holly Fern	Threatened	Threatened		
	Northern Bog Aster			Schedule A: Endangered	
	Northern Twayblade			Schedule A: Endangered	
	Oval-leaved Creeping Spearwort			Schedule A: Endangered	
	Porsild's Bryum	Threatened	Threatened	Schedule B: Threatened	
	Rattlesnakeroot			Schedule A: Endangered	
	Red Pine (Island of Newfoundland Population)			Schedule B: Threatened	
	Rock Dwelling Sedge			Schedule A: Endangered	
	Sharpleaf Aster			Schedule B: Threatened	
	Tradescant's Aster			Schedule B: Threatened	
	Vole Ear's Lichen	Endangered	Endangered		
	Vreelands's Striped Coralroot			Schedule A: Endangered	
	Water Pygmyweed			Schedule C: Vulnerable	
	Wooly Arnica			Schedule A: Endangered	
	Wrinkled Shingle Lichen	Threatened	Threatened	Schedule B: Threatened	