Climate Change Impacts on Water and Wastewater Infrastructure at Moose Factory

Final Report

July 24, 2018

Project No. 163401448

Prepared by: Stantec

Developed in partnership with: Ontario First Nations Technical Services Corporation

Sign-off Sheet

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Executive Summary

This report presents the results of the Climate Risk Assessment (CRA) study conducted for Moose Factory using the Ontario First Nations Technical Services Corporation (OFNTSC) First Nations PIEVC Protocol; a methodology adapted from Engineers Canada's Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering Protocol [https://pievc.ca/protocol]. The report identifies infrastructure vulnerabilities to current and future severe weather; focusing on Moose Factory's Water and Wastewater systems. The report establishes a risk profile for the identified infrastructure and provides recommendations regarding mitigating the risks with the highest consequences.

The methods utilized to develop the report include reviewing background information (such as climate data, infrastructure drawings and existing infrastructure condition reports) and consultation with local personnel (such as Moose Factory Public Works staff and the Water Treatment Plant operators). The input from local expertise regarding the infrastructure is combined with the background information to develop a risk profile, in the form of a matrix, highlighting infrastructure that may be most at risk under current climate conditions, with respect to specific weather events. The findings under current climate conditions are then re-evaluated against the demands that may be placed on them under future climate scenarios, with respect to the expected change of frequency or intensity of specific weather events.

The results of this process suggest that, for the infrastructure identified under current climate conditions, there are 22 interactions between a selected infrastructure item and a particular weather event that are categorized with a "Moderate" risk threshold rating. Another 9 interactions are categorized with a "High" risk threshold rating. When evaluated against projected future climate conditions, the count of these categories of risk threshold become 34 for "Moderate" and remain at 9 for "High". When exploring the potential for inadequate future maintenance practices, there are even more interactions between a selected infrastructure item and a particular weather event that become Moderate or High.

The water and wastewater infrastructure of Moose Factory is well maintained and provides safe drinking water and sanitation services. The Public Works Department, under budget pressures, has managed to maintain the infrastructure in a state of good repair; the maintenance practices they have adopted and implemented have resulted in resilient infrastructure.

The findings reinforce the need for regular maintenance practices and for sound asset management planning for infrastructure; including financial and engineering planning for replacing infrastructure at the end of its intended lifecycle. The specific Risk Mitigation and Adaptation Measures recommended for Moose Factory generally fall into the following categories:

- Considerations to include future climate impacts in the design of replacement infrastructure
- Expanding capacity of existing infrastructure
- Additional monitoring, inspection and maintenance of infrastructure conditions by Operations personnel

- Emergency preparedness in case of infrastructure failures, such as system redundancies or back-up power/supplies
- Additional training of Operations personnel
- Continuation of existing infrastructure upgrade programs

This report also acknowledges the fact that the analysis conducted has limitations. The intent of the study is to provide an overall risk profile of the infrastructure owned and managed by the Moose Cree First Nation, the recommendations do not address specific infrastructure issues. This report should not be solely relied upon as a plan to make the infrastructure of Moose Factory more resilient to changes in climate. Rather this report provides a starting point for identifying specific infrastructure that presents the greatest risks in terms of service to the community, and helps identify infrastructure that deserves a detailed analysis to ensure it can continue effectively and safely serving Moose Factory in the coming decades.

Abbreviations

ACRS	Asset Condition Reporting System
CRA	Climate Risk Assessment
COO	Chiefs of Ontario
GCR	General Condition Rating
GHG	Green House Gas
ICMS	Integrated Capital Management System
INAC	Indigenous and Northern Affairs Canada
IPCC	Intergovernmental Panel on Climate Change
MCFN	Moose Cree First Nation
O&M	Operations and Maintenance
OCCIAR	Ontario Centre for Climate Impacts and Adaptation Resources
OCWA	Ontario Clean Water Agency
OFNTSC	Ontario First Nations Technical Services Corporation
PIEVC	Public Infrastructure Engineering Vulnerability Committee
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
WTP	Water Treatment Plant (potable water)
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

Severe weather and climate uncertainty represent risks to public safety in Canada and around the world, as well as to the safety of engineered systems and the services they provide. In this context, an increasing number of public agencies and organizations that provide public services address climate change adaptation as part of their primary mandate—protecting the public interest, which includes life, health, property, economy, culture and the environment.

The impacts of severe weather add to the existing stresses on infrastructure and the services it provides. In addition to factors that reduce the capacity and performance of these assets (e.g. age, increased demand, material weathering, design and construction inadequacies, lack of maintenance, or extension of service life beyond design), the increased intensity of weather events can produce an incremental load that would cause asset failure.

Infrastructure vulnerability and risk assessments are the foundations to ensure climate change is considered in engineering design, operations and maintenance of community infrastructure, buildings, and facilities. When one takes the time to identify the services and related assets that are highly vulnerable to climate change impacts, one can plan and implement cost-effective solutions to adapt to these new weather patterns.

Creating infrastructure that is resilient to climate change is of particular concern in some of Canada's more remote communities, given that these communities already operate infrastructure under extreme weather conditions. Additionally, access to these remote communities can result in difficulty addressing and repairing infrastructure failures, should they occur. For these reasons, Moose Factory is a community that will benefit from having a sound climate change adaptation strategy.

This report presents the results of the Climate Risk Assessment (CRA) study conducted for Moose Cree First Nation using the First Nations PIEVC Protocol, a methodology adapted from Engineers Canada's Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering Protocol [https://pievc.ca/protocol].

1.1 COMMUNITY DESCRIPTION

Moose Factory is a community located on Moose Factory Island, near the mouth of the Moose River, at the southern end of James Bay[1]. The Island has an area of approximately 5.25 sq.km. This community is associated with the entire island, but politically, the island is divided into two entities:

- Factory Island 1 - Indian reserve that makes up the northern two-thirds of the island, belonging to the Moose Cree First Nation (MCFN) (population: 1451).
- Unorganized Cochrane District - Unincorporated southern third, home to the old Hudson's Bay Company post and government services, governed by the provincial Local Services Board and the federal Weeneebayko Health Ahtuskaywin that administers the hospital (population: 1007).

Moose Factory lies in the Hudson Bay Lowlands physiographic region, which is flat and underlain by sedimentary rocks, mainly limestone, dolomite, and shale. The extreme flatness of the terrain, the moisture holding quality of

[1] Source: https://web.archive.org/web/20120316073824/http://www.wakenagun.ca/Adobe/moosefactory.pdf

marine clay, and the presence of permafrost has resulted in poor drainage: thus, the lowlands are waterlogged. The high banks of the of the Moose River present better drainage and the shelter provided by the banks permits the growth of trees such as black spruce and balsam poplar.

Being situated so close to James Bay, the island of Moose Factory is affected by the Arctic Ocean tides which rise and fall twice daily, varying as much as 2.5 metres from high to low tide.

Figure 1: Satellite view of Moose Factory and Surrounding Area (Source: Google Earth).

The weather in the region is characterized as having warm summers and cold winters. Summer temperatures range from 10 - 35 degrees Celsius. Winter temperatures can range from -10 to -40 degrees Celsius. With the frigid Arctic winds from the north, these temperatures feel more drastic due to the wind chill factor.

1.2 SCOPE OF THE STUDY

The objectives of the study are to:

- Identify infrastructure vulnerabilities to current and future severe weather. Moose Factory infrastructure considered in the study included the community's Water (W) and Wastewater (WW) systems.
- Establish a risk profile for the identified infrastructure
- Provide recommendations regarding mitigating risks with the highest consequences to the assets, service, and community

1.3 PROJECT TIMELINE

Table 1 shows the timeline for the project.

Table 1: Timeline for the Project

Phase	Completion Date
Start-up meeting	September 7, 2017
Workshop 1: Define the project	September 26, 2017
Workshop 2: Gather the data	September 28, 2017
Workshop 3: Complete the risk assessment	November 21, 2017
Request engineering analysis (optional)	N/A
Workshop 4: Prepare recommendations for action	November 23, 2017
Produce Climate Risk Assessment Report (this document)	July 24, 2018

The workshops listed above correspond with the four steps of the First Nations PIEVC Protocol by the same name. The details of what each of these steps involves are summarized in their respective sections of this report.

1.4 PROJECT TEAM

The Project Team included key staff from Moose Factory, Ontario First Nations Technical Services Corporation (OFNTSC), the Mushkegowuk Council Technical Services, supported by subject matter experts from Stantec and Risk Sciences International (RSI). The members of the Project Team are listed below.

Table 2: Project Team

Project Team	
Moose Factory • Abel Wapachee, Director of Public Works • Stan Kapashesit, Director of Economic Development Mushkegowuk Council • Chris Seguin, Project Officer, Mushkegowuk Council Technical Services	OFNTSC • Elmer Lickers, Senior O&M Advisor Subject Matter Experts Support Team • Guy Félio, Senior Advisor (Stantec) • Wayne Penno, Senior Engineer (Stantec) • Heather Auld, Climatologist (RSI)

2.0 STEP 1: PROJECT DEFINITION

This first step of the Climate Risks Assessment (CRA) using the FN PIEVC Protocol involves setting the general boundary conditions for the project. The CRA project team identifies the infrastructure to be assessed and its key attributes, such as location, condition, known concerns, etc. The team identifies the overall climatic elements that affect the infrastructure and past weather events that have caused disruptions or failures to the service(s) provided by the asset(s).

The Project Team met at Workshop 1 on September 26 2017 to define the project parameters.

Following a presentation on the objectives of the project, an overview of the methodology for the climate risk assessment, and the Mohawk Council of Akwesasne W/WW CRA project, the team discussed the assets to include in the study.

The Project Team decided to assess the climate (current and future) risks for the Moose Factory water supply and wastewater collection and treatment systems. For the water supply, all components from source (intake) to distribution were included. The infrastructure included in the wastewater system included collection, treatment, and release into the environment. Support assets (e.g., storage and public works buildings) and third-party suppliers (e.g., fuel, electricity, chemicals) were also included.

2.1 CLIMATE RELATED CONCERNS

Discussions focused on current concerns on meteorological events that have or are causing infrastructure and operations disruptions and/or failures, and on observations of changes in climate patterns. Following are the main points raised and discussed during Workshop 1.

- Moose Factory usually experiences three winter storms per year: February (typically a blizzard), early and late March.
- May 2013 ice jam and a “not normal” tidal event caused flooding. Flooding also occurred in Fort Albany and Kashechewan (example, Figure 2)
- Rapid snow melt in April causes road flooding (example, Figure 3)
- Gravel hauling using the winter road (the annually cleared road on frozen Moose River) could historically be done until mid or the end of March. In recent years, gravel hauling ends earlier in the year.
- The sand bars in the Moose River build up in different locations due to changes in river flow and velocity. This usually occurs in the Spring, causing increased raw water turbidity and possible damage, to the water intake.

Ice jam puts Moosonee, Moose Factory on alert

Spring breakup on Moose River prompts concerns about flooding

CBC News · Posted: May 03, 2013 10:16 AM ET | Last Updated: May 3, 2013

Ice jams up on the Moose River in Moosonee, Ont. The town anticipates there may be severe flooding and has requested assistance from Emergency Management Ontario. (Facebook)

Spring breakup has started in the far north, and an ice jam on the Moose River is threatening to flood both Moose Factory and Moosonee.

Moose Factory Island Fire and Rescue officials said the community's hospital is on alert in case patients need to be moved.

Figure 2: Article from CBC News regarding the flooding of May 2013

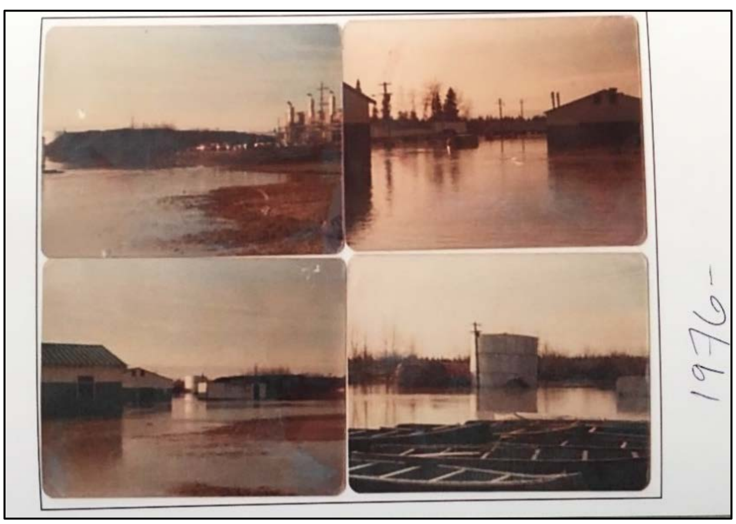

Figure 3: Photo of 1976 Flooding in Moose Factory provided by Project Team Member

2.2 INFRASTRUCTURE TO BE CONSIDERED

Figure 4 below shows an example of notes taken during Workshop 1 to identify the infrastructure components that will be considered in the assessment. During the Workshop, the Project Team listed the following preliminary infrastructure to be assessed.

- Water Supply system
    - Intake
    - Transmission from intake to plant
    - Water treatment plant
    - Distribution system (including hydrants, valves, watermains, the reservoir and other accessories)
- Wastewater System
    - Collection – sanitary mains (including lift stations)
    - Treatment (lagoons)
- Support buildings
- Operations personnel
- Third-party services

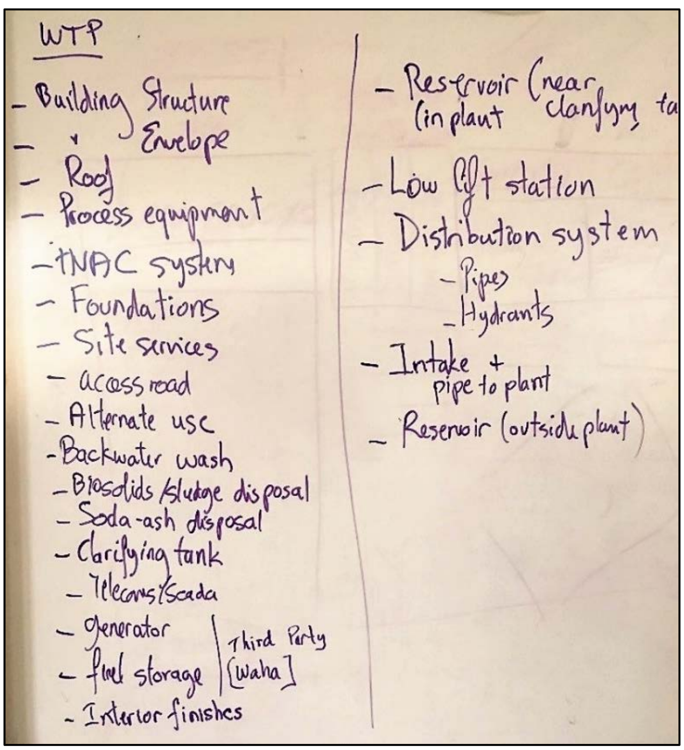

Figure 4: Working List of Components of Water Treatment Plant Components Developed at Workshop 1

Figure 5: Photo of Water Treatment Plant Building and Reservoir taken during the September 26, 2017 Site Visit as part of Workshop 1

2.3 TIME HORIZON FOR THE STUDY

The time horizons for the study were selected as current conditions (establishing the baseline risks) and 2050s (2035 to 2065[2]) for future conditions. Many of the infrastructure assets were built in the 1990's and early 2000's and will have to be replaced, undergo rehabilitation, or retrofit, or will be at an advanced stage into their service lives within the time horizon selected.

[2] Climate is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of meteorological variables such as temperature, precipitation and wind over a period of time, typically 30 years. (Source: World Meteorological Organization). The "2050s" projected climate is therefore the projected average over the 30-year period from 2035 to 2065.

3.0 STEP 2: DATA COLLECTION

3.1 INVENTORY OF INFRASTRUCTURE COMPONENTS

The water and wastewater infrastructure systems service all the inhabitants on Moose Factory Island, including the Moose Cree First Nations and Mocreebec First Nations (Local Services Board), as well as services the Weeneebayko General Hospital.

In addition to the infrastructure information provided by the Ontario Clean Water Agency (OCWA) and MCFN Public Works Department, the team was provided additional information from Indigenous and Northern Affairs Canada's (INAC) Asset Condition Rating System (ACRS) – latest report dated 2016[3], and the Integrated Capital Management System (ICMS) for water and wastewater infrastructure.

3.1.1 Potable Water System

The Moose Factory potable water system is comprised of the Moose Factory Water Treatment Plant (WTP), inground and above ground water storage tanks, low lift pump station, and associated distribution pipes and fire hydrants (see Figure 6). The WTP was first constructed in early 1950 and upgraded in 1978. The plant capacity was upgraded again in 1995, with the addition of two treatment process trains, to meet the increasing water demands resulting from the growing population on the island.

The original WTP uses an Ecodyne Reactivator Clarifier and two self-backwashing filters to treat the raw water from the Moose River. Additional treated water is provided by two Napier Reid package treatment trains, consisting of two-stage flocculation, settling and filtration. The filter water from both treatment systems is disinfected through the addition of chlorine gas, before entering the in-ground clear well. Both the Ecodyne and Napier Reid treatment systems operate together to produce the daily potable water demands for the residents and businesses on Moose Factory Island.

Raw Water Intake Structure

The raw water from the Moose River flows by gravity through the raw water intake pipe into the low lift pump well (Figure 7). Four low lift pumps housed in the low lift pump building, transfer water through two separate pipes from the pump well to each water treatment system (Ecodyne and Napier-Reed) in the water treatment plant.

In 2006, spring ice flows on the river damaged the raw water pipe and intake box structure, reducing the ability of water to flow into the pump well during extreme low water events (Figure 8). As a temporary emergency measure to assure an adequate supply of raw water during ice-free conditions, water is pumped to the low lift pump well using a portable raft equipped with two submersible water pumps.

[3] Asset Condition Reporting System, Final Report, All On-Reserve at Moose Cree First Nation. Report to Indigenous and Northern Affairs Canada, Saulteaux Consulting and Engineering. Inspected Summer 2016.

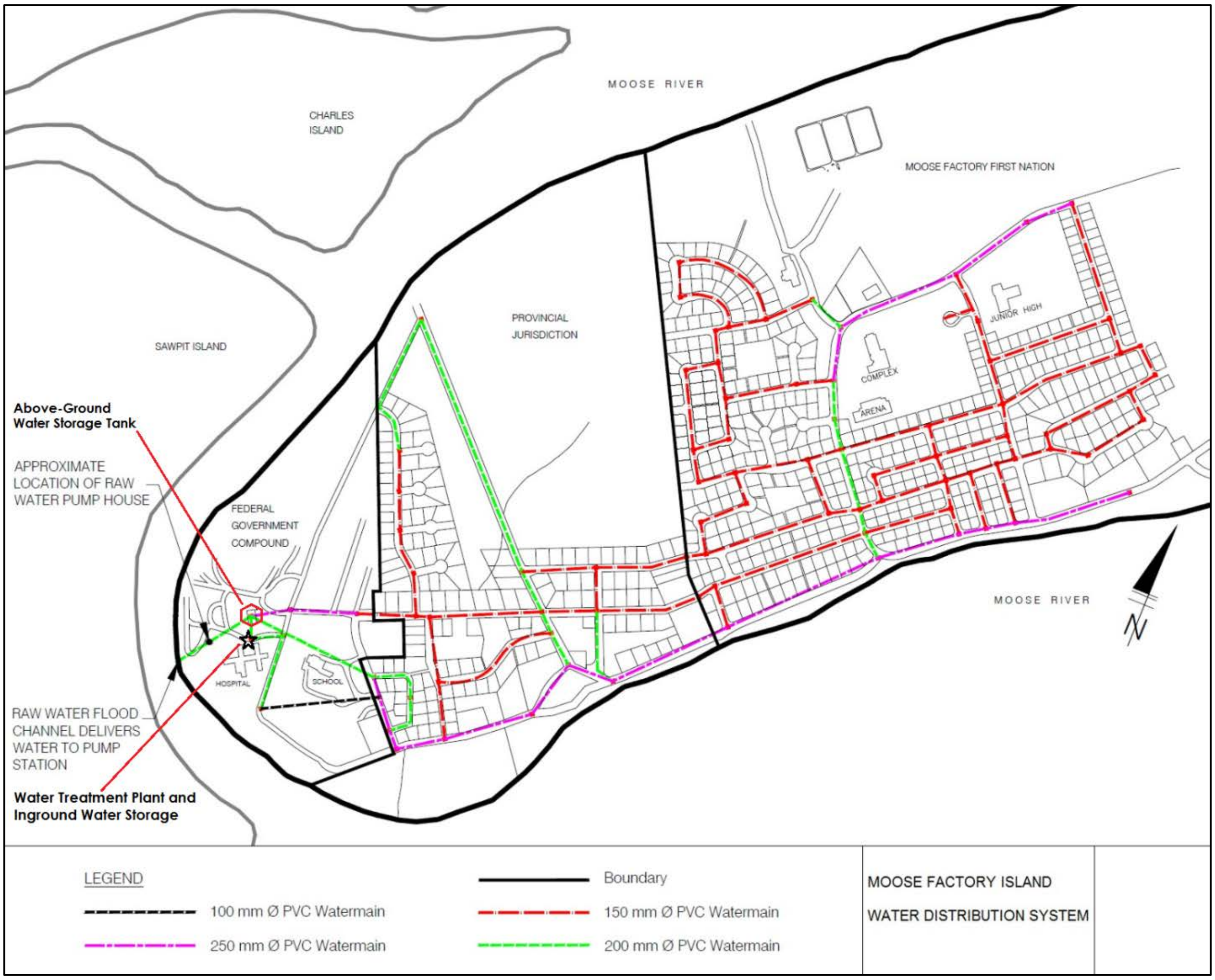

Figure 6: Moose Factory Water Treatment, Storage and Distribution Piping System (Source: Moose Factory Water Treatment Plant – Feasibility Study, OCWA 2015)

Figure 7: Raw Water Intake and Low Lift Pump Building

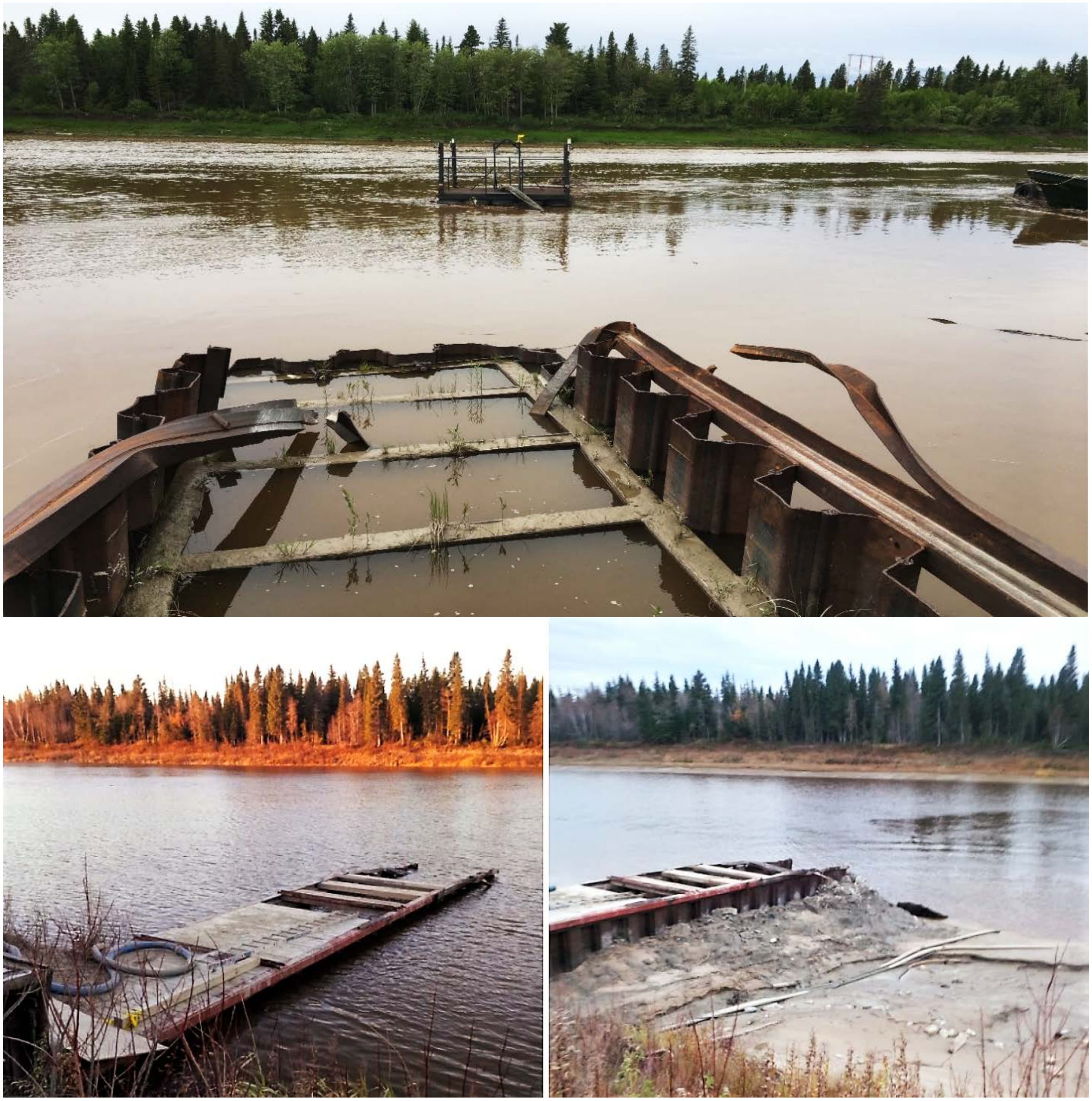

Figure 8: Raw Water Intake Structure – River Level Fluctuations

Water Treatment Plant - Building

The water treatment systems are housed in the water treatment plant building, a steel framed aluminum sided building structure constructed on a poured concrete foundation. Annexed to the water plant is a separate building that houses the hot water heating system equipment for the hospital.

The Ecodyne and Napier Reid treatment units along with the chemical treatment equipment and chemical storage areas are all located on the main floor of the building. The high lift treated water pumps and fire water pumps are located in the building basement. Treated water, fire water and steam heat piping are connected to the hospital through an underground concrete tunnel.

Figure 9: Filter System Inside the WTP

Treated Water Storage

Treated and disinfected water from the Ecodyne and Napier-Reed treatment equipment is stored in an underground concrete clearwell adjacent to the water treatment building. Four transfer pumps pump water from the clearwell to an above ground storage tank. Total treated water storage for the Moose Factory WTP is approximately 1,350 m^3 (410m^3 underground and 940m^3 above ground storage).

High lift Pumps and Water Distribution Piping

Water is pumped from the above ground storage tank into the distribution system by four high-lift pumps. The pumps are controlled through the WTP Programmable Logic Controller (PLC)/Supervisory Control and Data Acquisition (SCADA) system to maintain a set pressure in the distribution system. If the pressure in the distribution main drops below the low pressure set point, additional high lift pumps will start to raise the pressure in the distribution system to above the low pressure set point.

Emergency/Back-up Generator and SCADA System

Back-up electrical power is provided by two 1.5 MW diesel generators owned and operated by the Weeneebayko General Hospital. The generators are located outside the WTP building.

The WTP operations are monitored and controlled by a SCADA system as shown in **Figure 10**.

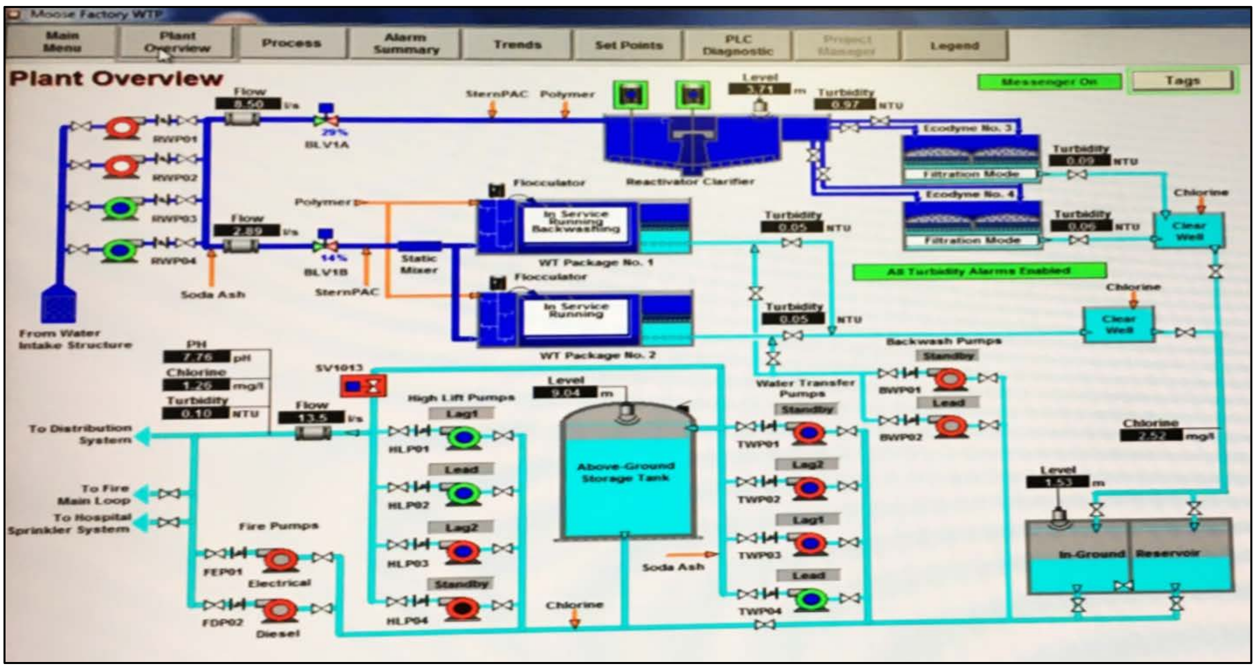

Figure 10: SCADA Screen Showing the WTP Operations

3.1.2 Wastewater System

The Moose Factory wastewater system is comprised of four lift stations that convey raw sewage to a three-cell lagoon located on the western side of the island. Raw sewage is collected and conveyed through the wastewater system by a network of underground sanitary sewer pipes. Operation and maintenance access to the pipes is possible through a series of manholes. **Figure 11** shows the layout of the wastewater system at Moose Factory.

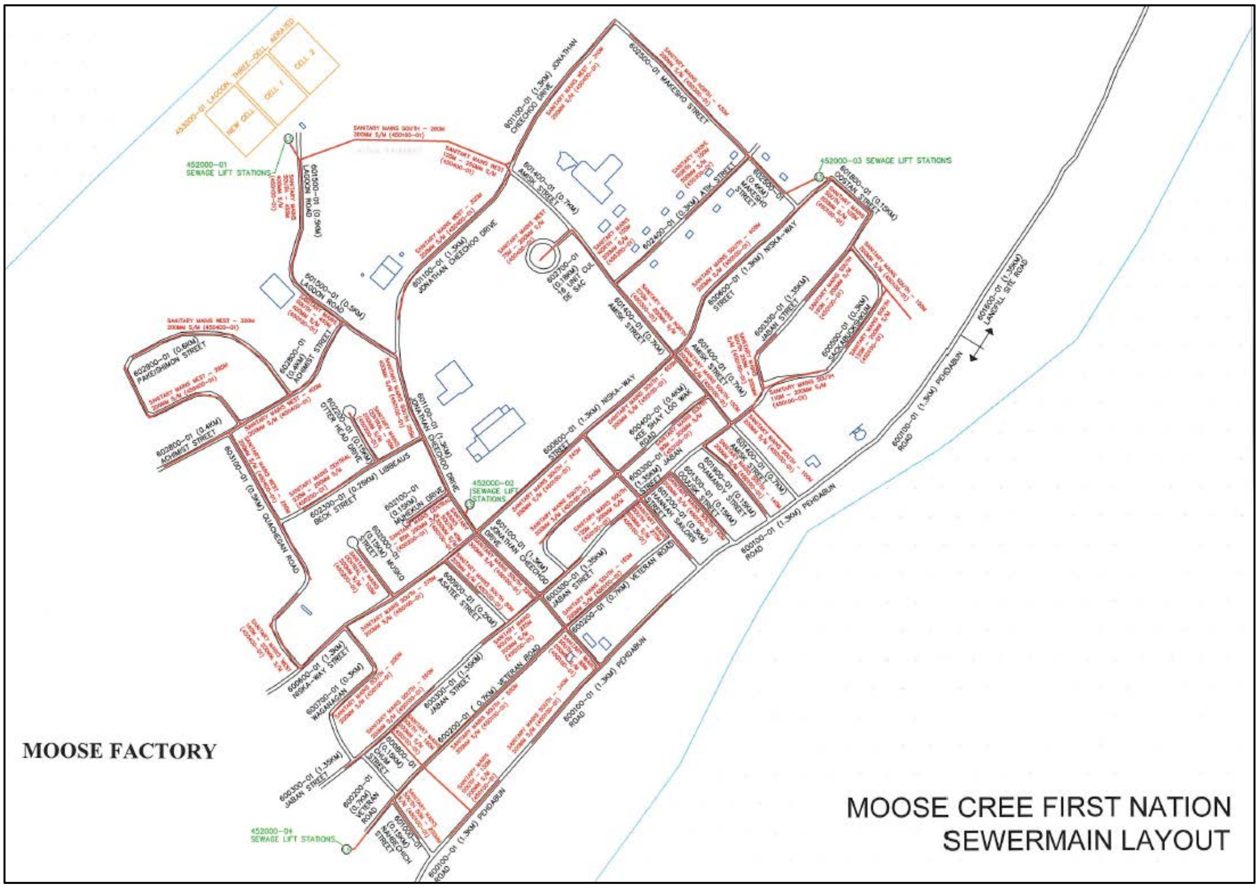

Figure 11: Moose Factory – Sewer Main and Treatment Lagoons Layout (Source: ACRS Report by Saulteaux Consulting and Engineering. Inspected Summer 2016)

<u>Sewage Lift Stations</u>

Each sewage lift station is comprised of submersible pumps within a buried fiberglass tank wet well with steel access hatches and vent piping in the lid, a davit crane for removal and installation of the pumps, and an electrical control panel. With the exception of one station, each lift station is equipped with two pumps that operate on a duty and standby system. Each station is equipped with an autodialer that automatically calls the operator's cell phone when a problem with the pump station occurs.

<u>Lagoon and Blower Building</u>

The lagoon site is comprised of three treatment cells, a blower building and a valve chamber. The site is fully fenced. Access is by a gravel road through a locked gate.

A valve chamber at the lagoon site is used to direct raw sewage as well as control the aeration treatment system to the different cells. Blowers inside the blower building provide aeration to the raw sewage through underground piping to assist the treatment process. Final treated effluent flows from the northeast most cell through the outfall into a creek which discharges into the Moose River.

Figure 12: Typical Lift Station, Lagoon Cell, Valve Chamber and Blower Building

3.2 CONDITION OF INFRASTRUCTURE COMPONENTS

In terms of condition/performance rating, no field inspection was carried out by the Project Team, and we relied exclusively on the asset condition and performance data provided by the ACRS inspection report (2016) and the Public Works and OCWA staff on the Project Team.

The ICMS data provides an overall general condition rating (GCR) for each infrastructure asset on a scale from 0 to 10, with 10 being a new asset, as shown in Table 4. The ICMS rating does not provide a description of the performance, deterioration or needs for the asset or its components. As a reference, Table 4 also shows the Canadian Infrastructure Report Card (CIRC) (see www.CanadaInfrastructure.ca) rating system commonly used by municipalities. The right-most column of the table includes a description of the rating used by the City of Edmonton to illustrate the meaning of the ratings.

Table 3: INAC's ICMS, Canadian Infrastructure Report Card (CIRC) Condition Rating Scales and Description (from City of Edmonton)

ICMS GENERAL CONDITION RATING		CIRC CONDITION RATING		DESCRIPTION (Source: City of Edmonton)
0	Closed or Critical	1	Very Poor	• The element is physically unsound and/or not performing as originally intended. • Element has higher probability of failure or failure is imminent. • Maintenance costs are unacceptable and rehabilitation is not cost effective. • Replacement/major refurbishment is required.
1 – 3	Poor	2	Poor	• The element is showing significant signs of deterioration and is performing to a much lower level than originally intended. • A major portion of the element is physically deficient. • Required maintenance costs significantly exceed acceptable standards and norms. • Typically, element is approaching the end of its expected life.
4 – 6	Fair	3	Fair	• The element is showing signs of deterioration and is performing at a lower level than originally intended. Some components of the element are becoming physically deficient. • Required maintenance costs exceed acceptable standards and norms but are increasing. • Typically, element has been used for a long time and is within the later stage of its expected life.
7 - 9	Good	4	Good	• The element is physically sound and is performing its function as originally intended. • Required maintenance costs are within acceptable standards and norms but are increasing. • Typically, element has been used for some time but is within mid-stage of its expected life.
10	New	5	Very Good	• The element is physically sound and is performing its function as originally intended. • Required maintenance costs are well within standards and norms. Typically, element is new or recently rehabilitated.
99	Not Inspected			

The INAC and CIRC scales present similar ratings but are not comparable on a 1-to-1 basis.

Table 4 presents an extract of the ICMS report which provides information on the condition of infrastructure considered in this climate risks assessment.

Table 4: ICMS Data on Assets to be considered in the Climate Risks Assessment

Asset Name	Asset No.	Ext. No.	Asset Code	Quantity	Units	Gen Con	Use	Mtc by	Year of Construction
LAGOON BLOWER BLDG	003200	01	A5B	50.76	SQ.M.	7	1	1	1986
WATER TREATMENT PLANT	003500	01	A5A	522.3	SQ.M.	7	1	1	1990
LOW LEVEL LIFTSTATION BUILDING	003600	01	A5A	56.48	SQ.M.	5	1	1	1990
WAREHOUSE 2	007000	01	A2C	295.2	SQ.M.	5	1	1	1975
GARAGE	009000	01	A2B	227.11	SQ.M.	5	1	1	1976
PUBLIC WORKS GARAGE	009000	02	A2B	937.6	SQ.M.	8	1	1	2001
STORAGE BUILDING - OLD FIRE HALL	016000	01	A2C	184.8	SQ.M.	6	1	1	1956
WATER MAINS	400000	02	B1B	1423	M.	7	1	1	1990
WATERMAINS SOUTH	400100	01	B1B	7365	M.	7	1	1	1987
WATERMAINS CENTRAL	400200	01	B1B	580	M.	7	1	1	1991
WATERMAINS NORTH	400300	01	B1B	1165	M.	7	1	1	1997
WATERMAINS WEST	400400	01	B1B	2525	M.	7	1	1	2002
UNDERGROUND STORAGE RESERVIOR #1	405000	01	B1E	1	EA.	7	1	1	1990
ABOVE GROUND STORAGE RESERVOIR #2	405000	02	B1E	1	EA.	6	1	1	1990
LOW LEVEL LIFTSTATION	408000	01	B1I	1	EA.	6	1	1	1990
WATER TREATMENT SYSTEM	410000	01	B1C	1	EA.	7	1	1	1990
SANITARY MAINS SOUTH	450100	01	B2A	6905	M.	7	1	1	1987
SANITARY MAINS CENTRAL	450200	01	B2A	525	M.	7	1	1	1991
SANITARY MAINS NORTH	450300	01	B2A	955	M.	7	1	1	1997
SANITARY MAINS WEST	450400	01	B2A	2275	M.	7	1	1	2001
SEWAGE LIFT STATIONS	452000	01	B2H	1	EA.	8	1	1	1987
SEWAGE LIFT STATIONS #2	452000	02	B2H	1	EA.	7	1	1	1987
SEWAGE LIFT STATIONS	452000	03	B2H	1	EA.	8	1	1	1987
SEWAGE LIFT STATIONS	452000	04	B2H	1	EA.	7	1	1	1987
LAGOON,THREE•CELL,AERATED	453000	01	B2I	1	EA.	4	1	1	1987
LAGOON ROAD	601500	01	D1B	0.5	KM.	7	1	1	1985

Details of the condition of these assets are available in the 2016 ACRS report. In general, assets listed are mostly in Good to Fair condition, some at the lower end of the Fair range, indicating that the assets or some of their critical components are showing signs of deterioration and are performing at a lower level than originally intended. Some components of the asset are likely becoming physically deficient and have maintenance costs that are increasing and/or exceed acceptable standards and norms.

Following are observations on the water and wastewater systems reported in the Moose Factory 2016 ACRS report.

General observations on the condition of assets considered in this climate risks assessment
(Source: Asset Condition Reporting System, Final Report, All On-Reserve at Moose Cree First Nation. Report to Indigenous and Northern Affairs Canada, Saulteaux Consulting and Engineering. Inspected Summer 2016)

Water Treatment

The water treatment system consists of two separate water treatment systems located in Moose Factory. The systems are both conventional treatment systems and the oldest system has extensive rusting. There are two reservoirs, and a low lift station.

The system is aged and is separated in two different buildings and is operating well. The system is operated by OCWA but two community members operate under the employment of OCWA. The fire pump is not working in Auto due to a broken watermain. The watermain is scheduled for repair but due to the pressure loss, the operators have the system in manual.

Watermains are in good condition but there are a number of hydrants not working.

Sewage

Sewage is disposed via a gravity sewage collection system, 4 liftstations, and a facultative lagoon. Presently the blowers for the aeration system in the lagoon is not in operation and have not been working for a number of years.

All four (4) of the liftstations are working and in good condition.

For the size of the population the lagoons seem undersized. The operator has had no formal training on operating the system and should be trained. The valve chamber was half full of ground water and the valves do not operate. A study should be initiated on the system to determine proper operation, treatment efficiency, and life expectancy. At the time of inspection, sewage was making its way through the 3 cells and then going out through the overflow.

Buildings

The Public Works and Housing Warehouse are well maintained; however, the other garages and warehouses are in need of repairs/upgrades and are only in fair condition.

3.3 CLIMATE CONSIDERATIONS

The general temperature and precipitation annual average profile for the closest Environment Canada weather station (Moosonee UA, Station ID 6075425) is shown in **Figure 13** below.

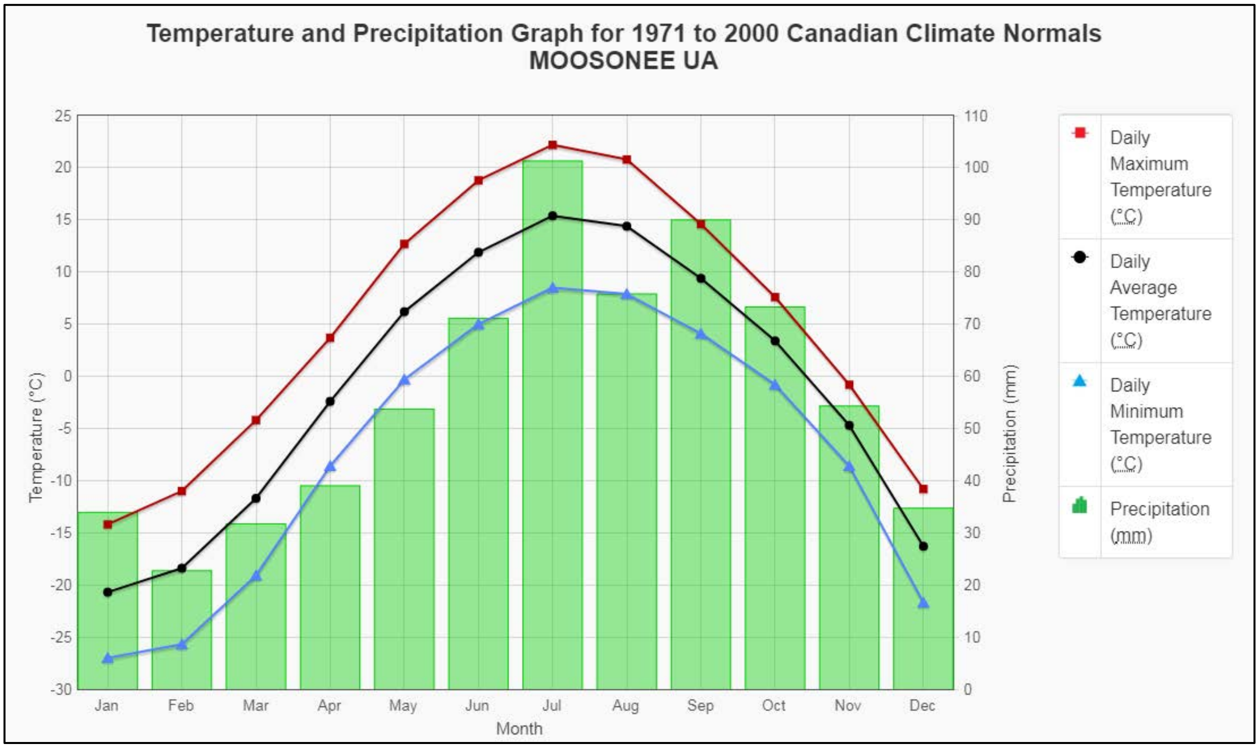

Figure 13: Average Monthly Temperature and Precipitation from Moosonee UA Station

Climate elements were part of the discussions at each of the four workshops of the project. In Workshop 1, participants were asked to recall weather events that may have caused damage/disruptions to the water and wastewater infrastructure. During Workshops 2 and 3, the Project Team members reviewed the list of weather elements suggested by the FN PIEVC Protocol and selected those relevant to the infrastructure under assessment given local/regional climate conditions.

The climate considerations presented hereafter are the result of discussions amongst team members at the project workshops, research into public information and news reports, and the following reports:

- *Climate change projections for Ontario: An updated synthesis report for policymakers and planners.* Ontario Ministry of Natural Resources and Forestry, Climate Change Research Report CCRR-44, 2015
- *Climate Change Impacts and Adaptation in Northern Ontario.* Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR), 2010

The selection of climate parameters and infrastructure thresholds was the result of the workshops during which the history of infrastructure-weather interactions that have caused structural or functional failures, or service disruptions were discussed.

3.3.1 Climate Trends and Projections

The main source of climate data was the Environment Canada weather station at Moosonee (Station ID: 6075425)

The figures below provide examples of data used for the study; details are provided in the Workshop presentations in Appendix A. Initial future climate projections were based on the Intergovernmental Panel on Climate Change (IPCC) RCP[4] 4.5 scenario - a stabilization scenario in which total radiative forcing is stabilized shortly after 2100[5]. The analysis of global green house gas (GHG) emissions in recent years led to the decision by the Project Team to use the RCP 8.5 emissions scenario for the future climate analysis.

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

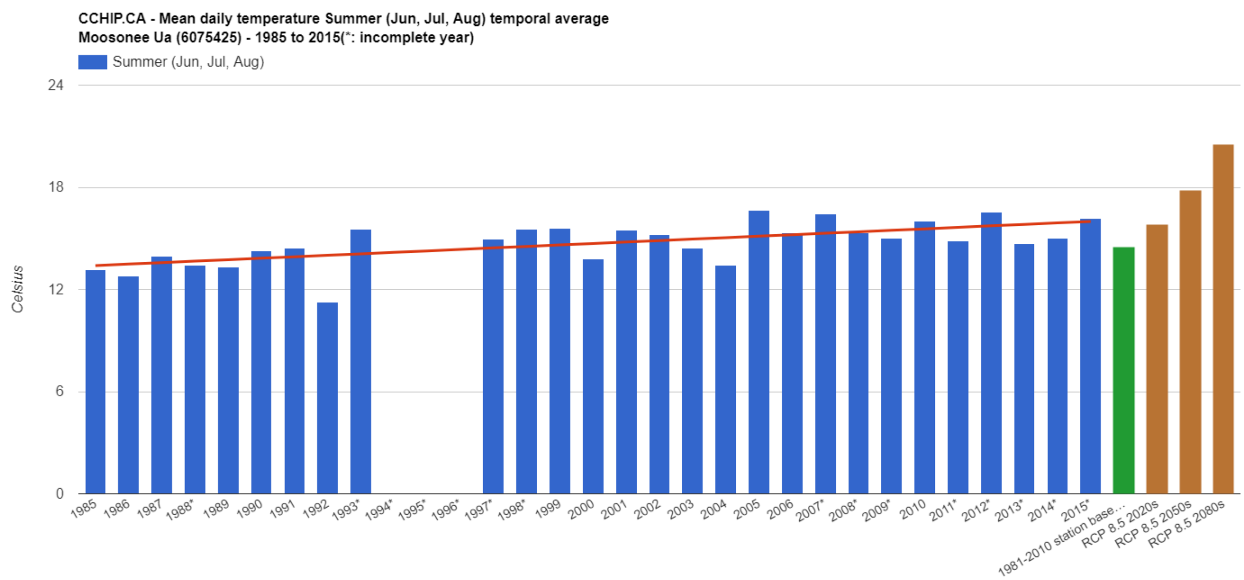

Figure 14: Mean Daily Temperature for Summer - Historical Trend and Future Climate Projection (Moosonee Weather Station, RCP 8.5)

[4] RCP: Representative Concentration Pathways – a greenhouse gas concentration (not emissions) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2014.
[5] By comparison, RCP 8.5 is characterized by increasing greenhouse gas emissions over time, representative of scenarios in the literature that lead to high greenhouse gas concentration levels, while RCP 2.6 emission pathway is representative of scenarios that lead to very low greenhouse gas concentration levels.

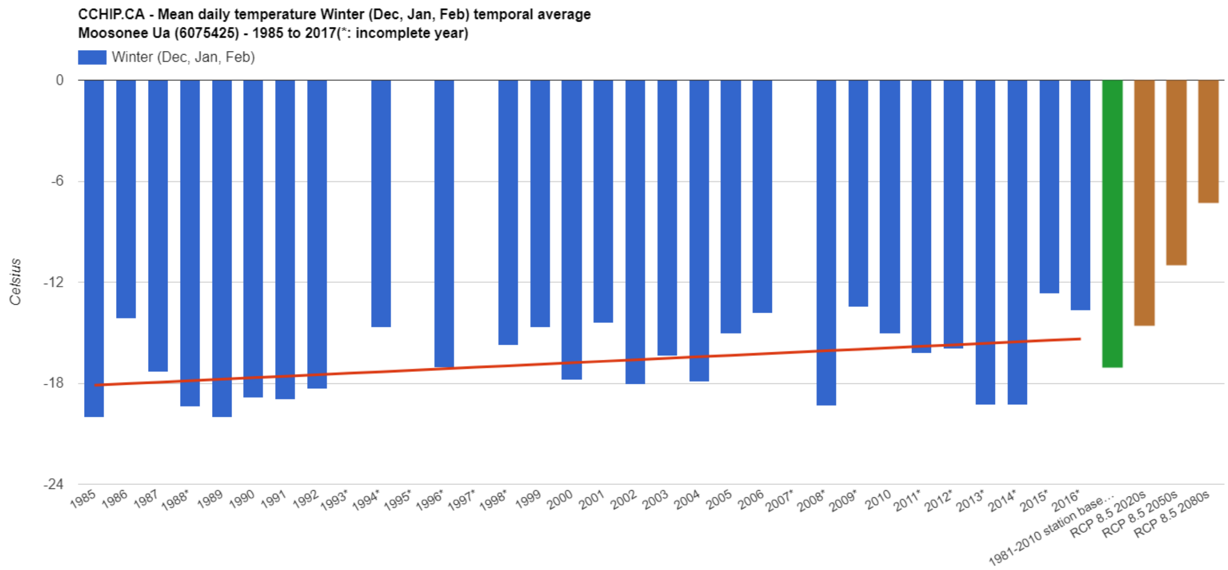

Figure 15: Mean Daily Temperature for Winter - Historical Trend and Future Climate Projection (Moosonee Weather Station, RCP 8.5)

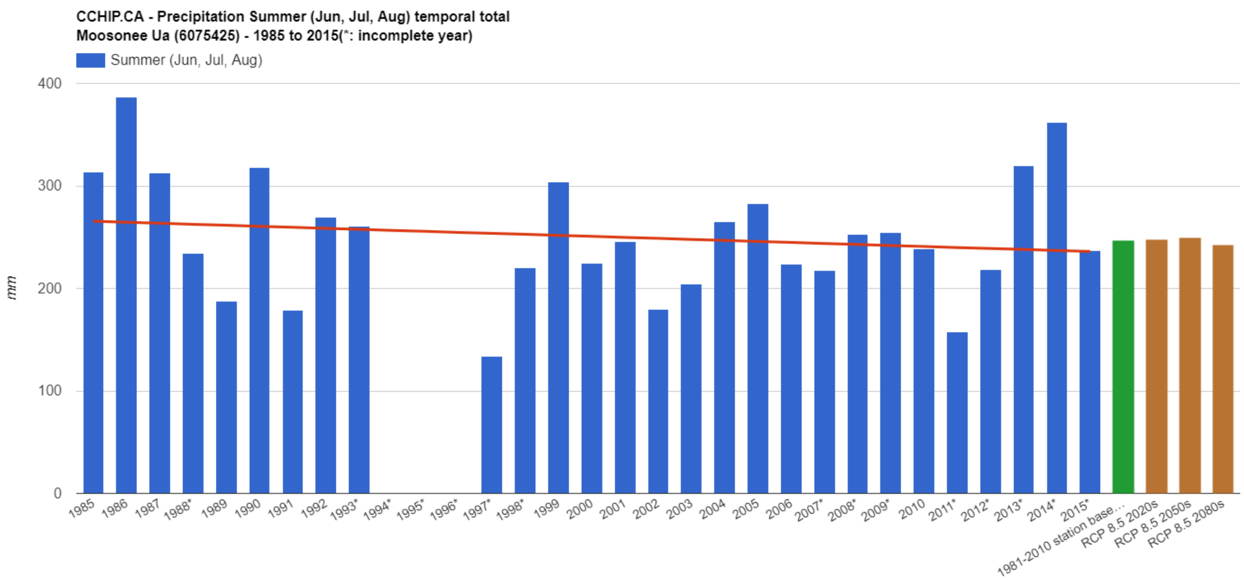

Figure 16: Summer Precipitation - Historical Trend and Future Climate Projection (Moosonee Weather Station, RCP 8.5)

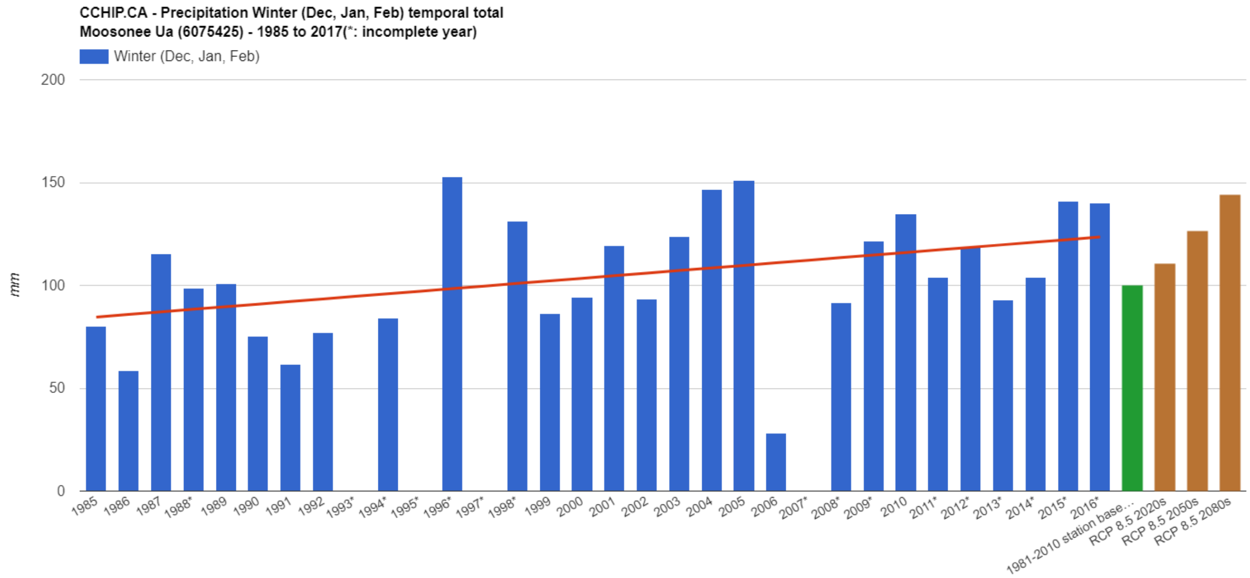

Figure 17: Winter Precipitation - Historical Trend and Future Climate Projection (Moosonee Weather Station, RCP 8.5)

3.3.2 Climate Elements Considered to Affect the Infrastructure

The selected climate elements for the exposure, vulnerability, and risk assessments are shown in **Table 5** below.

Table 5: Principal Climate Elements Selected by the Project Team for the Analysis

Type of Climate Element	Description	Comment
Temperature	High Temperatures	Occurrence of 10 days/year with Temp. >30°C
	Extreme High Temperatures	Occurrence of 1-3 days/year with Max Temp. >35°C
	Seasonal temperature variations	Heating and cooling degree days
	Extreme cold	Occurrence of Temp. of -40°C or less without windchill factor
	Shift in seasonal temperatures	Increase in air-only access due to ice road thaw
Precipitation	3 consecutive days of winter rain	Southern Ontario Threshold for weather warning causing flood of 25 mm (May be different for Northern Ontario)
	Freezing rain	Estimated 15 mm causing local power line damage
	Short duration - High Intensity rainfall	20 mm in one hour
	Shift in seasonal precipitation	Flow variability
	3 consecutive days of rain	Selected based on past precipitation events that have caused disruptions and/or failures, for example, rainfall July 6/86 - 122mm in approximately 12 hours
	Heavy snowfall	100 cm in 3 days

4.0 STEP 3: COMPLETE THE RISK ASSESSMENT

Step 3 of the Protocol instructs the Project Team to perform the following steps, illustrated in **Figure 18**. Details of the process are provided in Section 4.5.2.

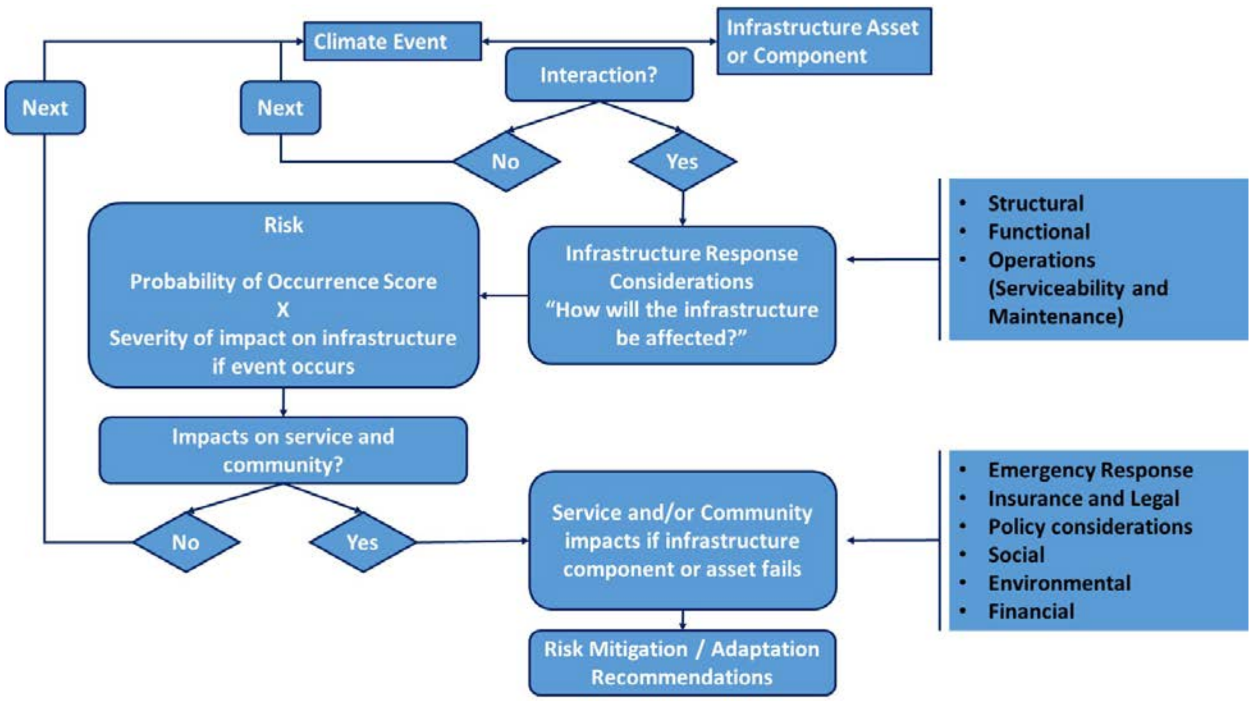

Figure 18: FN PIEVC Protocol Risk Assessment Process Flowchart

4.1 RISK THRESHOLDS

Risk is defined as the product of the **Probability** score multiplied by the **Severity** score. Since the probability and the severity scores are each rated from 0 to 5, the maximum risk score will be 25 as illustrated below. For this project, the Project Team selected the risk thresholds shown in **Table 6** below.

Table 6: Risk Thresholds

Score	Description
≤5	**Low:** No action required
6 to 14	**Moderate:** Monitoring recommended; action may be required if threat materialises; a more detailed analysis may be needed
≥ 15	**Hight:** Action required; immediate attention if risk occurs in current climate; adaptation planning necessary if risk occurs in future climate projections
Special Cases	• Frequently recurring events, low single event impacts but accumulated effects • Low probability, high impact events (for example, tornados)

4.2 INFRASTRUCTURE RESPONSE

During Workshop 2, the Project Team members selected the infrastructure response criteria against which the infrastructure-climate interactions and risks would be evaluated. The reader is encouraged to study the details of the infrastructure responses selected in Workshop 3 and summarized in Workshop 4, that are provided in **Appendix A**. They are summarized below:

Infrastructure response:

1. Structural capacity
2. Functionality
3. Operations, maintenance, and materials performance

Community impacts:

1. Emergency response
2. Insurance and legal considerations
3. Policy considerations
4. Social and cultural effects
5. Impacts on the environment
6. Financial/fiscal impacts

4.3 CLIMATE PROBABILITY SCORING

The FN PIEVC Protocol rates the probability of the climate events occurring (current and future climate) as follows:

Table 7: FN PIEVC Probability Scoring

Score	Description
0	Negligible Not applicable
1	Highly unlikely Improbable
2	Remotely possible
3	Possible Occasional
4	Somewhat likely Normal
5	Likely Frequent

The following table presents the results of the climate analysis (current trends and future projections), and the corresponding FN PIEVC probability scores used in the risk assessment.

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Table 8: Probability Scores for Selected Climate Events

Climate Event	Description	Comment	Rating	
			Current	Future
Temperature				
Maximum temperature	High Temperatures	Occurrence of 10 days/year with Temp. >30°C (Current climate = 6.1 days/year >30°C without humidex)	4	5
	Extreme High Temperatures	Occurrence of 1-3 days/year with Max Temp. >35°C (Current climate = 0.26 days/year >35°C without humidex)	5	5
Temperature Variations	Seasonal Temp. Variations	Heating and cooling degree days.(Current climate cooling = 77 degree days)	4	5
Minimum temperature	Extreme cold	Temp. of -40°C or less without windchill factor (Current climate = 0.5 days/year)	5	3
Seasonal	Shift in seasonal temperatures. Late freeze and or early thaw	Lengthening of air only access season due to ice road thaw and other impacts on river. Professional judgement of the Project Team.	5	5
Precipitation				
Winter rain	3 consecutive days of winter rain	Southern Ontario Threshold for weather warning causing flood of 25 mm. May be different for Northern Ontario	2	3
Freezing rain	Accumulation of freezing rain	Estimated 15 mm causing local power line damage and damage to trees	4	5
Short Duration Rain	Short Duration - High Intensity (20 mm in one hour)	Only 3 years of IDF data (2004 to 2006). Approx. equivalent to a 1:5 rain event	4	5
Precipitation Variations	Shift in seasonal precipitation. Changes in Moose River flow patterns	"Quick response" of flow in river to changes in air temperature in the Spring as evidenced from comparison of temperature and river flow data.	5	5
Long Duration Rain	3 consecutive days of rain	Selected based on past precipitation events that have caused distruptions and/or failures, for example, rainfall July 6/86 - 122mm in 12 hours or less	2	4
Precipitation (snow)	Heavy snowfall	100 cm or more in 3 days	4	5

4.4 INFRASTRUCTURE SEVERITY SCORING

The following rating system was used for the assessment of the severity of impacts on the infrastructure should a selected climate event occur.

Table 9: Infrastructure Severity Scoring Developed by the Project Team

Score and Description	Consequence [Structural, Functional, Operations]
0 No effect	• No service interruption • No budget impacts • Fully operational – normal • No additional complaints about the service
1 Insignificant	• Can be corrected through the regular maintenance cycle
2 Minor	• Require minor repairs but have the internal capacity and inventory of parts to do those repairs • No impact on O&M and capital budget – no additional budget required • May need further assessment
3 Moderate	• Have the capacity to do repairs but need to order parts • May need to have certified staff (e.g., electrician) do repairs • Need inspection with possibly external expertise
4 Major	• Partial loss of equipment and/or components • Loss of function of asset, several assets, or critical components • Requires detailed assessment with external expertise • Requires major repairs and possibly complete replacement of components/equipment • Impacts on O&M and capital budget that may require additional funding • Requires implementing alternative service delivery
5 Catastrophic	• Total loss of equipment and service that requires full replacement of asset, several assets and major components • Impacts on other elements of asset or other assets • May have impacts on the public health and safety • Significant impacts on capital budget requiring additional funding • Consider declaring state of emergency

4.5 RISK ASSESSMENT

This section of the report presents the infrastructure components that were evaluated, describes the risk screening process, summarizes the results of the risk assessment, and discusses the influence of the infrastructure condition on the risk assessment.

4.5.1 Infrastructure Components Evaluated

The infrastructure assets considered in this assessment were divided into components to evaluate the impacts from the selected climate events. Table 10 shows the detailed lists of assets/components.

Table 10: Infrastructure Assessed

Wastewater System Lagoons Cell 1 Cell 2 Cell 3 Lagoon blower building Lagoon Road Sanitary mains South Sanitary mains Central Sanitary mains North Sanitary mains West Sewage lift stations (#1-4) Sewage lift station #5 **Third party services** Electricity Telecommunications Fuel supply WTP chemical supply **River** Raw Water Supply Transportation Corridor	**Potable water system** Intake Structure Water treatment plant - Building Building envelope Building structure Roof Foundations Heating/Cooling system Fuel- Heating oil (backup for heat) Backup generator Water treatment system Underground reservoir (#1) Above-ground reservoir (#2) Low level lift station Building Low level lift station equipment Watermains South Watermains Central Watermains North Watermains West Hydrants	**Administration and operations** Operations personnel **Support buildings** Old Fire Hall Building envelope Building structure Roof Foundations Heating system Public works garage Building envelope Building structure Roof Heating system Garage Building envelope Building structure Roof Foundations Heating system

4.5.2 Risk Screening Process

The first step in the production of the risk matrix (illustrated in Figure 18) is to evaluate whether there is an interaction between an infrastructure component and a climate event, also referred to as establishing the exposure of the infrastructure to the climate hazards. Where an interaction exists, the Project Team identifies with respect to which infrastructure performance considerations the potential risk might exist (e.g. impacts on the structural capacity or the functionality of the asset or component) - see Section 4.2 of this report for a description of the infrastructure performance considerations selected for this study.

Furthermore, the risks associated with future climate events were evaluated with respect to two asset conditions: **Condition 1** relates to the scenario where assets, over the study period (i.e., 2050s) have been maintained in a state of good repair; **Condition 2** relates to the scenario where the assets have reached or passed their design life, or have not been maintained in a state of good repair. Condition 2 thus presents a higher level of vulnerability for these assets.

4.5.3 Summary of Risk Results

Table 11 presents a summary of the risk counts for the number of infrastructure-climate interactions in each risk threshold category (Moderate, and High). The table also presents the infrastructure assets or components affected, and the performance impacted if the risks occur. The general risk matrices created for this project consider infrastructure in a good state of repair, operating at the performance level for which it was designed.

The highest risks to the infrastructure and community identified by the study are:

1. **Observed and projected seasonal shifts in temperature and precipitation.** They impact the Moose River which is the source of raw water for the community and is an essential transportation link to the mainland.

2. **Extreme cold** was also identified as a threat to several infrastructure assets and services: electricity, heating systems (particularly the Old Fire Hall) and hydrants. Although annual and seasonal temperature averages are projected to increase in the future, changes in climate are projected to increase the extremes (high and low), and therefore continue to pose a threat in the future.

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Table 11: Summary of Moderate and High Risks

Risk Score Counts				Main Climate Events	Principal Infrastructure Affected
		Future (2050s) Climate			
Risk Threshold Category	Current Climate	Condition 1 Infrastructure replaced at end of design life and well maintained	Condition 2 Infrastructure deteriorated (not replaced or poorly maintained)		
Moderate	22	34	36	• Maximum temperatures • Freezing rain • Precipitation (Rain) – short duration/high intensity • Extreme cold • Heavy snow fall	• Heating and cooling systems in buildings • Operations personnel • Old Fire Hall roof • Telecommunications • Fuel supply • WTP chemicals supply • Sewage lift-stations • Fuel- Heating oil (backup for heat) • Backup generators • Roof WTP and Old Fire Hall • Operations Personnel • Fuel and WTP chemicals supplies
High	9	9	10	• Extreme cold • Freezing rain • Seasonal shift in temperatures • Seasonal shift in precipitation	• Electricity • Heating system – Old Fire Hall • Hydrants • Electricity • Water intake • Transportation corridor • Water intake • Raw water supply • Transportation Corridor

4.5.4 Influence of the Infrastructure Condition

The condition of the infrastructure is a key element to establishing risks. Estimating the future condition of the infrastructure is a complex process that requires predicting the operations, maintenance, and capital investments to maintain the infrastructure in a state of good repair and replacing it when it has reached the end of its service life. This is the realm of sound asset management practices.

Without knowledge of long-term capital investment plans for this infrastructure, the worst-case scenario (Condition 2) is that none will be replaced during the study time horizon and current maintenance procedures cannot be sustained due to funding pressures. This results in a higher vulnerability to the climate hazards identified, which is completed by increasing the severity scores by one for each of the climate-infrastructure interactions. **Table 12** presents the comparison between the risks to the infrastructure replaced at the end of its design life and maintained in a state of good repair, and the risks with deteriorated infrastructure.

Table 12: Summary of Risks for Infrastructure Replaced at the End of its Design Life and is Well Maintained vs. Infrastructure that is Deteriorated

Future Climate Risk Score Counts | Moose Factory W/WW Infrastructure			
Risk Threshold Category	Condition 1 Infrastructure replaced at end of design life and well maintained	Condition 2 Infrastructure deteriorated (not replaced or poorly maintained)	Percentage change in risk count
Moderate	34	36	+ 6%
High	9	10	+ 11%

4.6 COMMUNITY IMPACTS FROM INFRASTRUCTURE RISKS

Infrastructure loss of performance or function affects the whole community. Resilient infrastructure is necessary to provide resilient services that, in turn, contribute to the resilience of the community. The community impacts selected for this study are as follows:

1. **Emergency response services** can be impacted in following manners:
   a. Increased demand due to higher number of emergencies or broad area covered by the event;
   b. Impacts to the facilities, equipment and personnel that are used to provide emergency services; and
   c. Loss of functionality of roads or other routes to access the locations where emergencies occur

2. **Insurance and legal impacts** may result from a failure in the services or damages from the collapse of public assets. For example: basement flooding due to loss of stormwater system capacity; fallen public trees on private property; failure of wastewater systems resulting in temporary facilities' closures or environmental damage; etc.

3. **Policy considerations** relate to the processes, procedures and guidelines that affect the performance of the infrastructure in providing services. As indicated in the previous section, maintaining and operating the infrastructure in a state of good repair and re-capitalizing the assets in a timely manner can be part of a risk mitigation strategy.

4. **Social and cultural effects** result from the loss of services provided by the infrastructure. In the particular case of water and wastewater services, the impacts are multiple and varied, and can range from mere inconvenience to health and safety issues. These will compound the hardships experienced by the community in the event of extreme climate events.

5. **Environmental impacts** may result in short or long-term stress to the community, for example, in the event of the loss of key environmental features on a temporary or permanent basis.

6. **Financial impacts** may redirect resources from other planned investments or priority areas in the community. With limited sources of funding available, the Moose Cree First Nation may have to take extraordinary measures to address its financial situation. This could be in the form, for example, of lowering levels of services.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Infrastructure in a community exists to provide a service. Since many of the components or assets within infrastructure systems have long service lives, there are many opportunities to introduce climate change adaptation measures throughout this life-cycle.

The water and wastewater infrastructure of Moose Factory is well maintained and provides safe drinking water and sanitation services. The Public Works Department, under budget pressures, has managed to maintain the infrastructure in a state of good repair; the maintenance practices they have adopted and implemented have resulted in resilient infrastructure.

The Project Team identified adaptive and risk mitigation measures during Workshop 4. Since the intent of the study is to provide an overall risk profile of the infrastructure owned and managed by Moose Factory, the recommendations do not address specific infrastructure issues. The recommendations listed on the following page are not listed in a priority order.

As described in section 4.5.4, if infrastructure is not maintained in a state of good repair or is not replaced when it has reached at the end of its intended service life, it can become more vulnerable to the effects of climate change. The analysis for climate-infrastructure interactions for unmaintained infrastructure, yielded an increase in Moderate and High risk ratings. This reinforces the importance of proper asset management planning, including the sufficient funding of maintenance practices and proper training for operations and maintenance staff.

The impacts of severe climate events on infrastructure is shown to have far reaching consequences in many aspects of a community beyond the infrastructure itself, as detailed in section 4.6. It is recommended all these potential community impacts are considered as reinforcement for policy decisions regarding the creation of sound asset management plans.

Climate Event	Risk Mitigation and Adaptation Measures
Shift in seasonal precipitation	Water intake in Moose River • Consider seasonal shifts in new water intake design • Monitor river levels to adjust operations • Explore an alternative secondary water intake • Increase water storage capacity – to include fire protection
Shift in seasonal temperature	Water treatment • Impact on transportation of chemicals needed for treatment when river transport is not possible • Ensure four months of chemical supply for the Plant
Extreme High Temperature	Water Treatment Plant • Increase ventilation in the plant • Increase cooling in the office area for staff
Freezing Rain	Buildings • Inspect after freezing rain events • Clear debris and branches that can pause safety hazards Personnel: • Provide personnel with proper safety equipment • Apply sand and salt in working areas • Train/refresh training staff in safe operating practices Third party services • Include potential loss of service in emergency planning • Involve treatment plant service provider in emergency planning Back-up electricity (also to mitigate Extreme Cold risks) • Plan for long term WTP operations back-up system (the Hospital back-up generators will still be available in the short to medium turn - until the Hospital is moved to Moosonee). • Ensure portable back-up generators are available for lift stations in case of power failure • Engage the electricity provider (Hydro One) in discussions about reinforcing and expanding the capacity of the local grid
Heavy snowfall	Low Lift Station • In the new design for the WTP, the station will be in a new building. Meanwhile, ensure proper winter maintenance such as clearing snow on the roof when accumulations are greater than 50cm. alternatively explore a new roof Back-up electricity • Plan for long term WTP operations back-up system (the Hospital back-up generators will still be available in the short to medium turn - until the Hospital is moved to Moosonee). • Ensure portable back-up generators are available for lift stations in case of power failure • Engage the electricity provider (Hydro One) in discussions about reinforcing and expanding the capacity of the local grid
Extreme cold	Hydrants • Continue the program of insulating hydrants • Replace the anti-freeze in hydrants when used for fire protection or flushed Old Fire Hall heating system • The building is currently under-used because of heating problems but the storage space provided by the building is needed. • Explore increasing the capacity of the heating system • Explore increasing the insulation in the building, considering that the roof contains asbestos products.

Appendix A WORKSHOP PRESENTATIONS

Ontario First Nations Technical Services Corporation

Moose Cree First Nation

FN PIEVC Infrastructure Vulnerability Assessment OFNTSC-Moose Cree W/WW Vulnerability Study Infrastructure Exposure Workshop

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
Senior Advisor, Stantec

Tuesday September 25, 2017

Funded by: Canada

In Collaboration with: engineerscanada

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Safety Moment

What do you see on your site related to safety?

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"Turning Words Into Action"
Improving First Nations Infrastructure Resilience to our Changing Climate

David Lapp FEC, P.Eng.
Practice Lead, Globalization and Sustainable Development

and

Jamie Ricci, MS
Practice Lead, Research

PIEVC Akwasasne Workshop
February 8, 2017

engineerscanada
ingénieurscanada

What is Engineers Canada?

STRUCTURE

- National organization for the engineering profession in Canada
- Members - 12 engineering regulators that regulate the practice of engineering e.g. Professional Engineers Ontario (PEO)
- Over 290,000 professional members in Canada

FUNCTIONS

- Common approaches for professional qualifications, professional practice and ethical conduct
- Accredits all undergraduate engineering programs in Canada– 271 programs in 43 universities
- National and international voice of the profession
- Climate change work since 2001- focus on infrastructure adaptation and resilience

Civil Infrastructure and Engineered Buildings

The services provided by these engineering works touch all of us in many ways

Services

Shelter
Sanitation
Safety and security
Water
Heat, Light and Power
Mobility for people, goods and services
Health and recreation

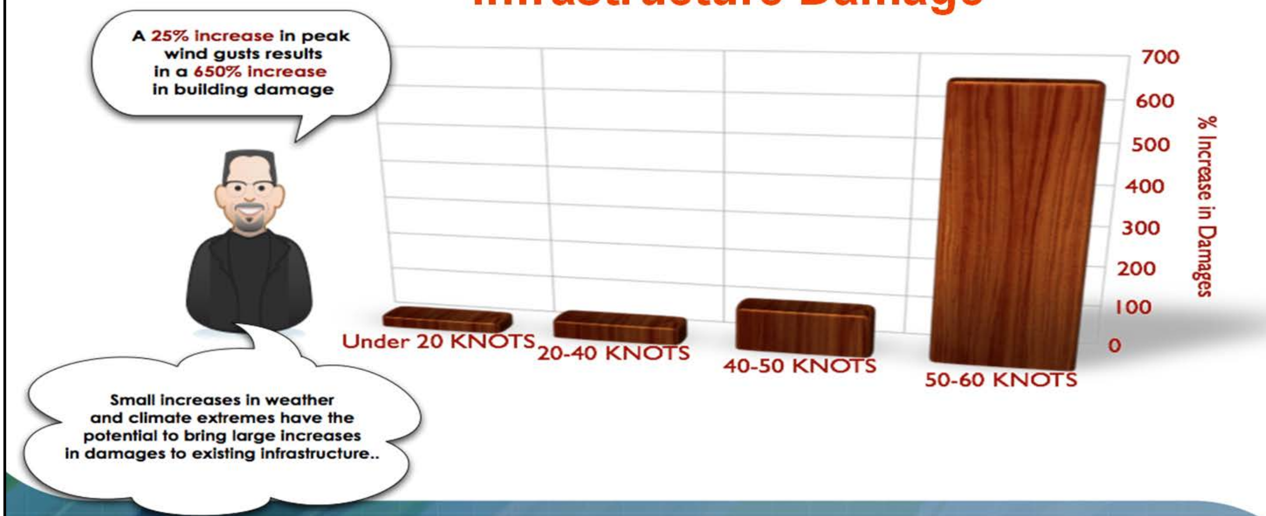
Categories

Homes & Buildings
Transportation networks
Energy networks
Water, Waste, & Storm water networks
Industrial structures
Communications networks
Landfills and waste depots

Why Define Infrastructure Risks?

- Minimize service disruptions
- Protect people, property and the environment
- Optimize service
  - Manage lifecycle
  - Manage operations
  - Avoid surprises
  - Reduce/avoid costs
- To deal with the uncertainties of future climate
- First step in risk reduction planning to improve (climate) resilience

Small Increases Lead to Escalating Infrastructure Damage



Areas for Action: Achieving First Nations Climate Resilient Infrastructure

1. Understand climate risks and vulnerabilities
2. Integrate into First Nations social context (Elder's knowledge)
3. Support asset management in a changing climate
4. First Nations' operation and management of on-reserve assets
5. Cost effective
6. Economic opportunities
7. Engage community
8. Capacity-building

Thank you!

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Ontario First Nations Technical Services Corporation

Moose Cree First Nation

Workshop Objectives

- Overview to the PIEVC vulnerability assessment process
- Description of water and wastewater infrastructure in Moose Factory and past weather related performance issues and concerns
- Definition of the global project parameters and boundary conditions for the vulnerability assessment.
  - Which infrastructure is being assessed;
  - Its location;
  - General climatic, geographic considerations; and
  - Uses of the infrastructure.
- Roles and responsibilities of the team members.
- Identify participants for the Special Project Advisory Committee
- Next steps

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Moose Cree First Nation

Workshop Agenda

Time	Description	
9:00am – 9:30am	Welcome and introductions	Moose Cree First Nation and OFNTSC
9:30am – 10:30am	Description of the PIEVC Protocol	Stantec
10:30am – 10:45am	Health break	
10:45am – 11:45am	Description of Moose Factory W and WW infrastructure	Moose Cree First Nation
11:45am – 12:15pm	Discussion: infrastructure concerns related to current climate	All participants
12:15pm – 1:00pm	Lunch	
1:00pm – 2:30pm	Facilitated discussion: selection of infrastructure for vulnerability assessment	All participants
2:30pm – 3:00pm	Roles and responsibilities of the team members.	All participants
3:00pm – 3:30pm	Next steps	
3:30pm	Adjourn	

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Mohawk Council of Akwesasne

Canada

engineerscanada

OCCIAR
Ontario Centre for Climate Impacts and Adaptation Resources

Project Objectives

Moose Cree First Nation

Oneida of the Thames

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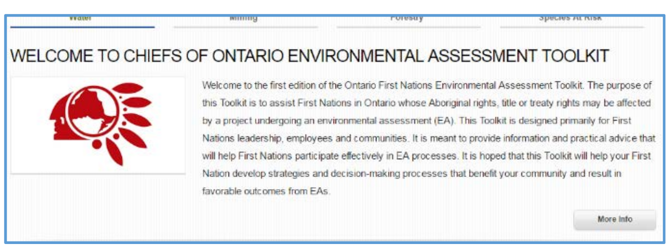
- **Phase 1:** Vulnerability to climate change assessment of the W/WW infrastructure at Akwesasne (completed)
- **Phase 2a:** Development of draft FN PIEVC/Asset Management (AM) toolkit (current)
- **Phase 2b:** Pilot testing draft FN PIEVC/AM Toolkit (Fall 2017):
  - Moose Cree FN (W/WW infrastructure – Moose Factory)
  - Oneida Nation of the Thames (Housing)
- **Phase 2c:** Revise FN PIEVC/AM Toolkit; develop training material; offer training at 2 locations in Southern and Northern Ontario (Early 2018)
- **Phase 3 (to be confirmed):** deployment of FN PIEVC/AM Toolkit to other First Nations in Canada

FN PIEVC/AM Toolkit

- Adapt the current PIEVC Protocol and develop a FN CC Vulnerability Assessment Toolkit
  - Link to asset management
  - Use local and existing resources (e.g., Elders' knowledge, ACRS and ICMS data, etc.)



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FN PIEVC/AM Toolkit Framework

- Work in progress
- Common elements to PSAB 3150 Asset Accounting requirements, Asset Management, and Risk Management:
  - Asset inventory
  - Condition
  - Service life/remaining life
  - Value of assets
- Considerations over the life-cycle of the asset

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TCA Reporting (PS 3150)	Asset Management	Risk Management
Inventory	Inventory	Inventory
Condition Assessment (Physical Condition)	Condition Assessment (Physical Condition, Capacity, Functionality)	Condition Assessment (Physical Condition, Capacity, Functionality)
Residual Life Prediction	Residual Life Prediction	Residual Life Prediction
Valuation (Historical)	Valuation (Replacement)	Valuation (Replacement)
	Analysis: Needs: Capacity, Physical Condition, O&M Cost-Benefit	Analysis: Threats Exposure Vulnerability Risks
	Life-cycle Management Plans Additions and Upgrades Replacement and Refurbishment Operations and Maintenance Risk Management	
TCA Report	Investment Plan (Capital, O&M)	Risk Management plan
	Monitor, Report, Revise	Monitor, Report, Revise

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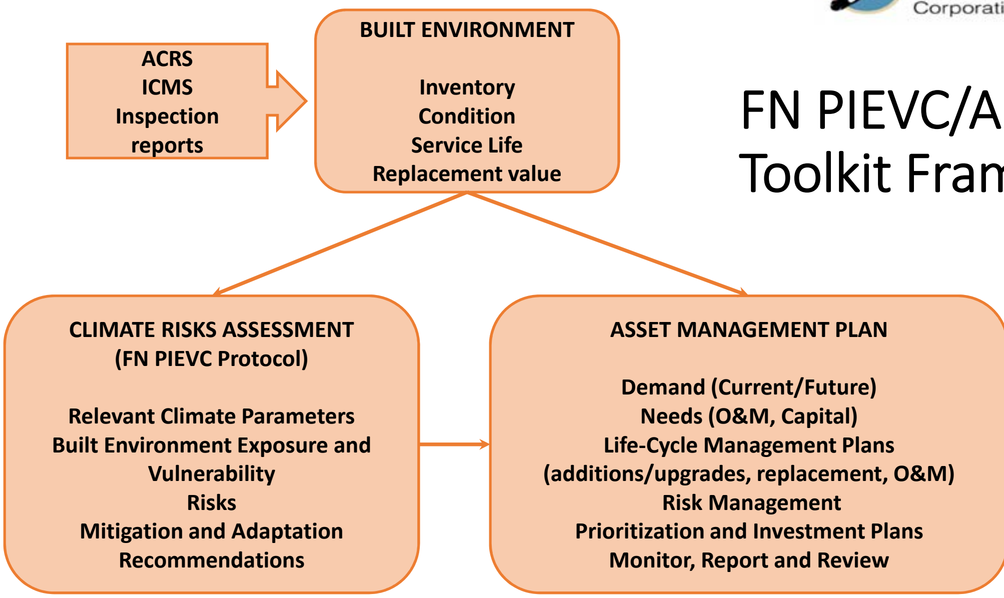
FN PIEVC/AM Toolkit Framework



Examples of Climate Elements and Consequences

- **Oneida Nation of the Thames - Housing**
  - Precipitation, wind, temperatures, relative humidity, environment, insects and pests, etc.
- **Moose Cree First Nation – Moose Factory W/WW systems**
  - Precipitation, winds, temperatures, environment, permafrost, sea ice, ice roads, sea level changes, etc.

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Moose Cree First Nation

- **Pilots will focus on the Climate Change Risks – but link to asset management**
- Next Steps:
  - Finalize Draft FN PIEVC/AM Toolkit
  - Schedule Kick-off meetings with Communities + Workshop
    - Team introductions
    - Project schedule
    - Infrastructure data
    - Preliminary climate considerations

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FN PIEVC Climate Change Infrastructure Vulnerability Assessment - Process

Based on Engineers Canada's PIEVC Protocol

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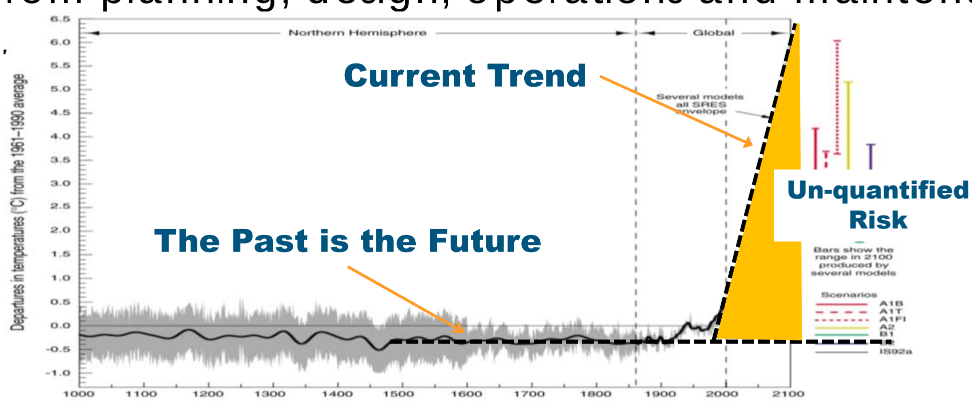
Infrastructure Vulnerability to CC

From planning, design, operations and maintenance

..



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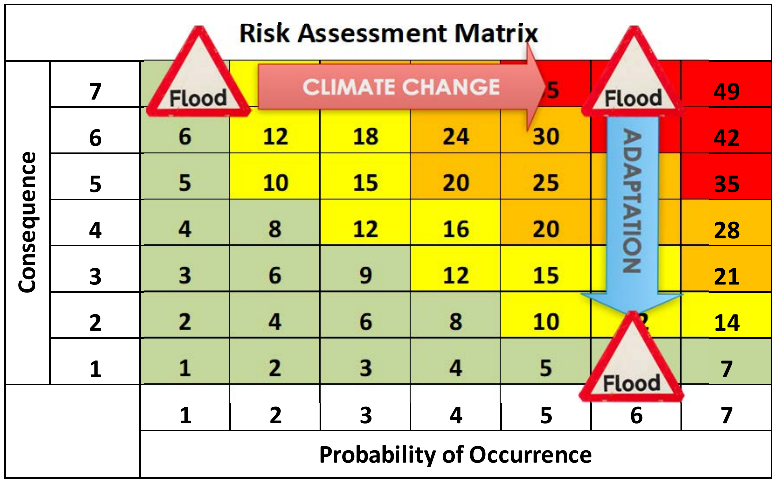

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Public Infrastructure Engineering Vulnerability Committee (PIEVC)

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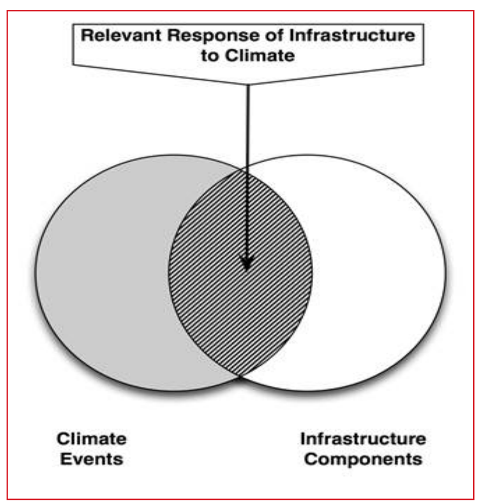
The PIEVC Protocol

- Five step evaluation process
- A tool derived from standard risk management methodologies
- Intended for use by qualified engineering professionals
- Requires contributions from those with pertinent local knowledge and experience
- Focused on the principles of vulnerability and resiliency



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Public Infrastructure Engineering Vulnerability Committee (PIEVC)

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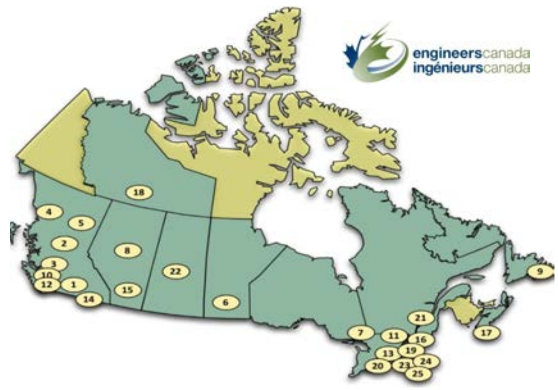
Not a theoretical methodology

Has been or currently applied to
45+ projects in Canada:

- Water resources systems
- Storm & waste water systems
- Roads & bridges
- Buildings (residential, ICI)
- Urban transportation infrastructure
- Energy Infrastructure
- Airport infrastructure
- Hospital
- Three projects in central America



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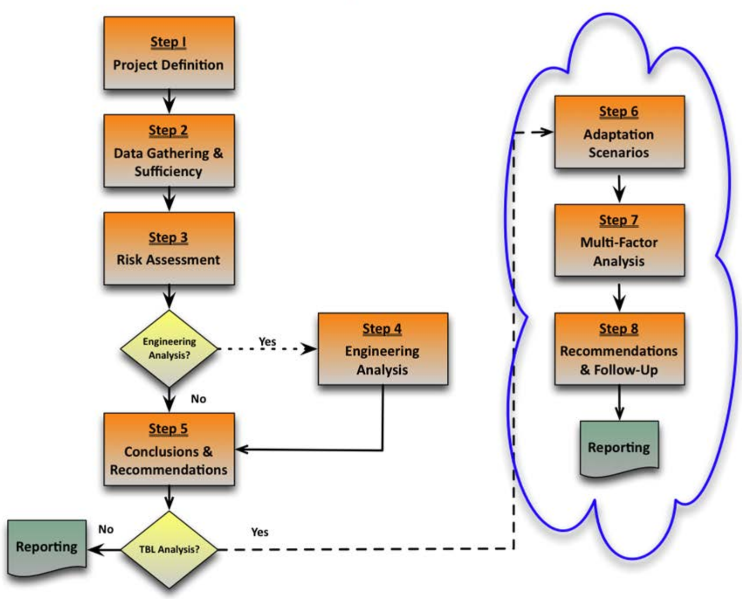
General description of the PIEVC process



TRIPLE BOTTOM LINE MODULE

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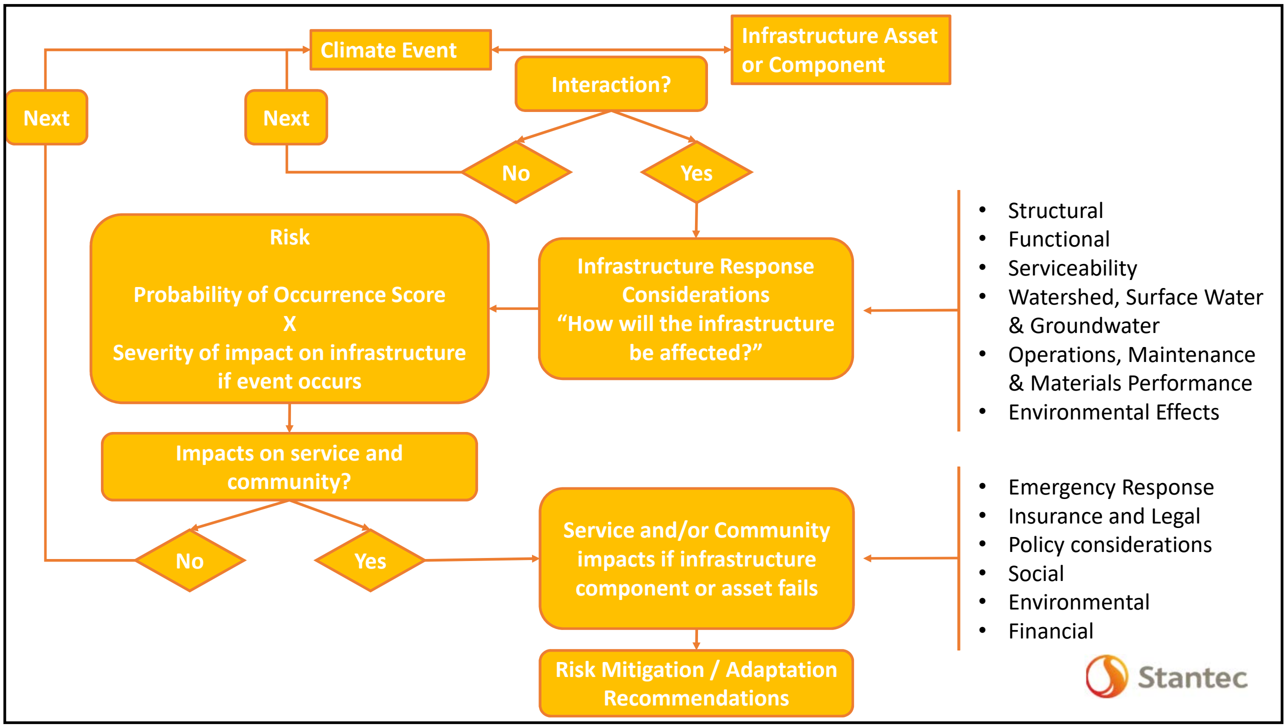

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Score	Severity of Consequences and Effects	
	Method D	Method E
0	No Effect	Negligible Not Applicable
1	Measurable	Very Low Some Measurable Change
2	Minor	Low Slight Loss of Serviceability
3	Moderate	Moderate Loss of Serviceability
4	Major	Major Loss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

Risk

6 X 7 = 42

Severity								
7	0	7	14	21	28	35	42	49
6	0	6	12	18	24	30	36	42
5	0	5	10	15	20	25	30	35
4	0	4	8	12	16	20	24	28
3	0	3	6	9	12	15	18	21
2	0	2	4	6	8	10	12	14
1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
	0	1	2	3	4	5	6	7

Probability

Special Case	Low Risk	Medium Risk	High Risk

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

Using Severity and Probability Ratings in a Risk Matrix

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Phase 1 - PIEVC Protocol Vulnerability Assessment of Akwesasne's W/WW Infrastructure

Funded by

Canada

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Akwesasne W/WW Climate Change Vulnerability Assessment Objectives

- Identify **nature and severity of risks to components in a life-cycle context** – compatible with asset management plans
- **High level assessment of the predominant vulnerabilities** to climate change and optimize more detailed engineering analysis
- **Recommendations** for adjustments to design, operations and maintenance to maintain / improve levels of service
- Provide a **structured, documented approach** that ensures consistency and accountability.

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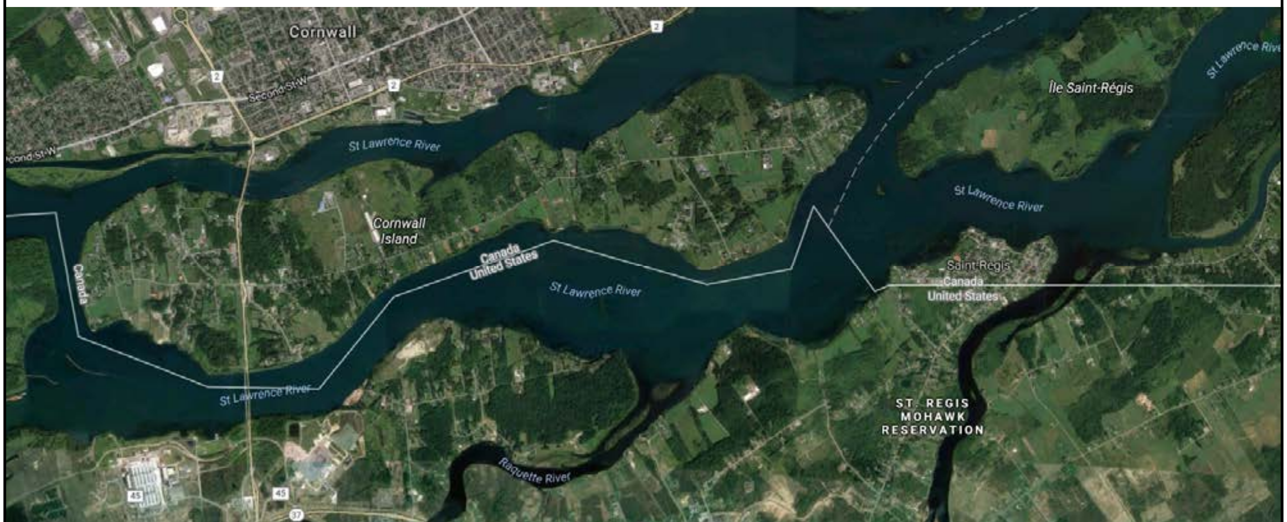

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Project Team

<u>Ontario First Nations Technical Services Corporation</u>

- Elmer Lickers, Senior O&M Advisor (Project Director)
- Bill Maloney, Climate Change Officer

<u>Mohawk Council of Akwesasne</u>

- Jay Benedict, Director Technical Services
- Dr. Henry Lickers, Director Environmental Services
- John Tate Lazore, W/WW Manager
- Leslie Papineau, Technical Project Manager

<u>Consulting Team</u>

- Dr. Guy Félio, Senior Advisor, Stantec (Project Manager)
- Amanda Lynch, Water Resources Engineer, Stantec
- Eric Dunford, Sustainability Consultant, Stantec
- Alexandre Mineault-Guitard, Environmental Engineering Intern, Stantec
- Heather Auld, Climatologist, RSI Inc

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Project Advisory Committee

- Stephanie Allen, OFNTSC
- Ashley Dawn Bach, COO
- Marla Desat, SCC
- Tom Duncan, INAC
- Al Douglas, OCCIAR
- Andréanne Ferland, FNQLSDI
- Caroline Larrivée, Ouranos
- David Lapp, Engineers Canada
- Jamie Ricci, Engineers Canada
- Jacqueline Richard, OCCIAR

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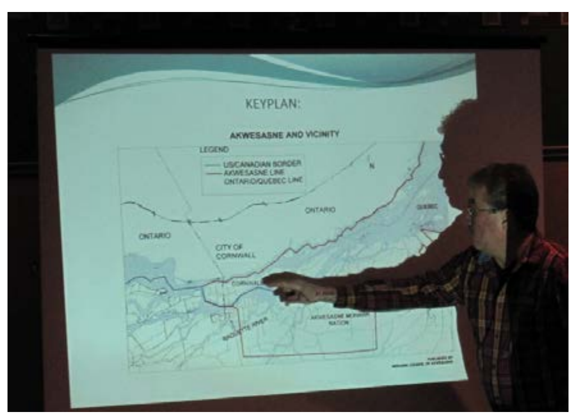
Project Definition - Infrastructure Components

- Three Districts
  - Cornwall Island
  - St. Regis
  - Snye
- All W/WW infrastructure in each district
- Infrastructure Information:
  - MCA Technical Services
  - ACRS and ICMS Data



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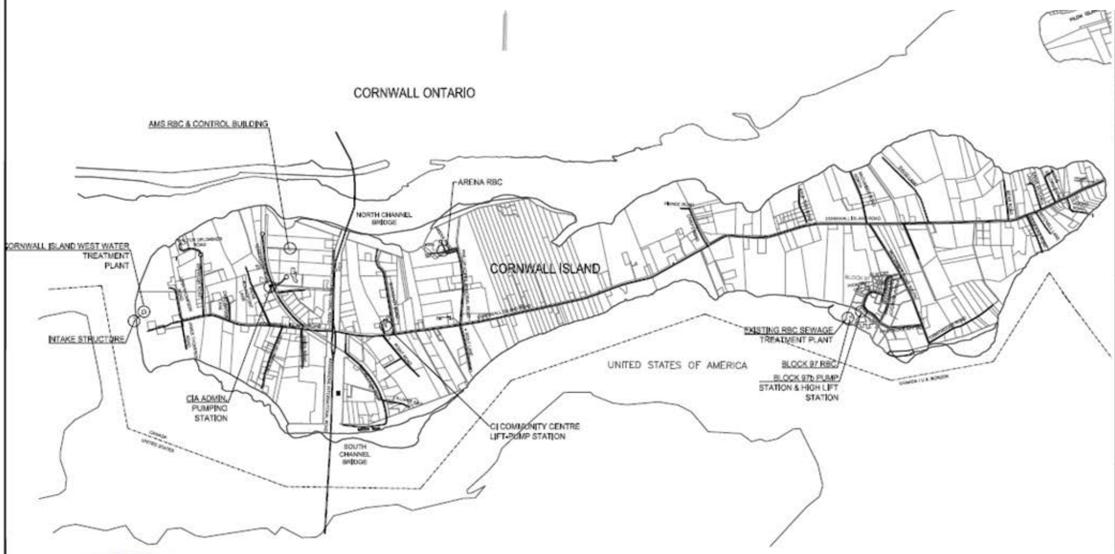

KEY PLAN : CORNWALL ISLAND, ONTARIO

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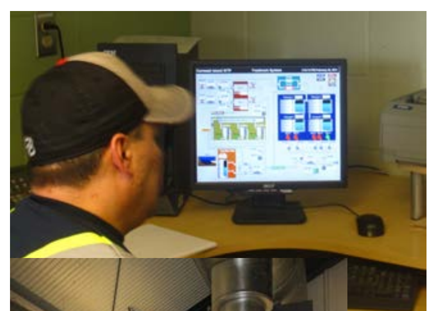

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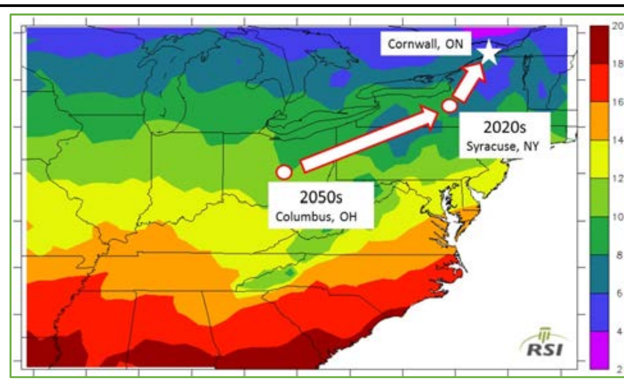
Climate Elements

- Sources of information:
  - Environment Canada – Cornwall Weather Station; Climate ID: 6101872
  - US National Oceanic and Atmospheric Administration
    - Massena (NY) Weather Station
    - Storm Events Data Base for St. Lawrence County (NY)
  - Ontario Tornado Watch



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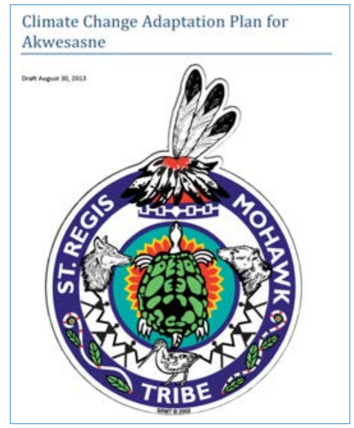
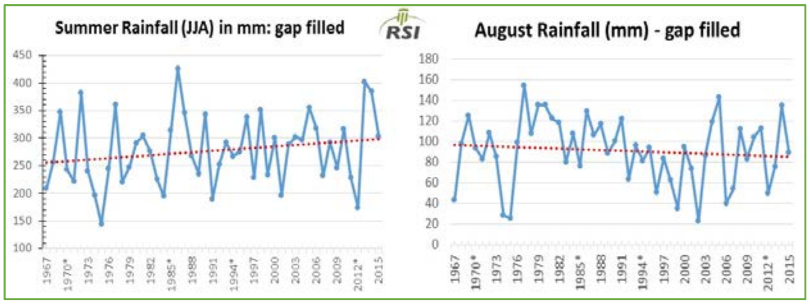
- Observed climate trends over the past few decades indicate a changing climate. Since 1970, trends that have been observed include **rising temperatures, more frequent hot days, longer growing seasons, less snowfall and more winter rain, reduced snowpack, and earlier ice and snowmelt resulting in earlier peak river flo**ws.
- At Akwesasne, the **drought of summer 2012** affected many of nature's cycles on all of creation. The changes came about in the way of hot and humid temperatures, high winds, heavy rainfall, hail, low water levels, and fish and wildlife reproductive cycles were out of sync. The downpour of rainfall, hail, and strong high winds destroyed gardens at a time when it was late to restart gardens to get a good crop. Some areas had 6 inches of hail in July. Thunderstorm warnings were also issued.



Type of Climate Element	Description	Comment
Temperature	Days (per year) with Max Temps > 36°C	Significant missing data over past decade
	Very warm August Temps Mean >22.5°C (*warmer than August 2012*) (	Significant missing data over past decade
	Combination August warm temperatures & low rainfalls	
Precipitation	Days with August total precipitation ≤ ~51mm (*equal to or less than August 2012*)	Significant missing data over past decade
	Winter snowfall for Jan-Feb-Mar > 200 cm	Gap filled dataset used
	Winter rainfall totals (DJF) > 120mm	Significant missing data over past decade
	March rainfall totals > 60	Significant missing data over past decade
	Snowfall event > 25 cm/day	Significant missing data over past decade
	Winter rainfall > 25mm/day	Significant missing data over past decade
	Severe ice storms (≥ 20 mm freezing rain in one day)	
	Extreme ice storms (≥ 40 mm freezing rain that isn't easily shed)	



Type of Climate Element	Description	Comment
Fog	Visibilities below ½ statute mile	Reference impacts to shipping
Wind	Days with gusts > 90 kph	i.e., NBC 50 year return period design steady wind
	Days with gusts > 125 kph	i.e., NBC 50 year return period climatic design gust with wind gust factor applied
	Days with gusts > 140 kph	Massena A, 50 year return period wind gust
	Tornado frequency within 25 km radius	Only have data for Canadian territory. Probability 2x if considering US side
	Tornado frequency – within 50 km radius	Only have data for Canadian territory. Probability 2x if considering US side

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Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected
Cornwall Island				
Moderate	140	77	• Low Precipitation (Aug.) • Combination - Aug. High Temp. with Low precipitation • Snowfall event • Severe Ice Storm • Extreme Ice Storm • Extreme Winds	• Environment • Personnel • Suppliers • Electricity • Light buildings • General roadworks • Emergency response • Vehicles and fleet • Communications
High	45	124	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works
Extreme	28	34	• Lightning • Tornados	• All infrastructure

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Influence of Infrastructure Condition

Future Climate Risk Score Counts Cornwall Island Infrastructure			
Risk Rating	Infrastructure replaced at end of design life	Infrastructure deteriorated (not replaced)	Percentage change in risk count
High	124	140	+ 13%
Extreme	34	43	+26%

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Some recommendations

- **Evaluate the financial constraints and resources** needed to maintain the infrastructure in a state of good repair and to invest in a timely manner in the replacement of infrastructure when it reaches the end of its service life, which can effectively decrease the extreme risks by more than 25%. This can be done through the life-cycle analysis and investment planning processes of an asset management plan.
- **Improve the weather alert system** to support operational staff and emergency first responders allowing to be pro-active in anticipation of severe weather, for example, ensuring back-up power (fixed and portable) units are ready for use.
- **Identify risk mitigation or risk avoidance measures for strong to extreme wind events,** such as securing (anchoring) asset components such roofs, light structures, etc. Select tree locations and species to minimize risks of property damage in case they would fall down.

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- **Review and improve O&M practices and policies** as required. This could include inspection cycles, maintenance to maintain the performance of the assets, etc.
- **Install weather stations on Cornwall Island and in St. Regis** to ensure relevant local data. These stations should have the capability of hourly records, a gap in the data from the Cornwall station which only provides daily averages, thus missing short duration/high intensity events.
- **Ensure lightning protection** for sensitive equipment, particularly the SCADA systems.
- **Plan for reduced mobility** of operators and suppliers due to severe or extreme events, including warning, stock-piling, etc.

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"The Protocol is straight forward but detailed. While the instruments of protocol look complicated, they could be utilized by many different peoples at various levels of understanding with a little assistance from a more knowledgeable expert.

As the protocol is used, it becomes apparent to the community that this will be very useful for evaluating the adaptability of the community infrastructure. It also helps to clarify gaps and shortcomings of the community infrastructure and processes."

Henry Lickers
Director, Environmental Services
Mohawk Council of Akwesasne

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Assessment of the CC Vulnerability of the W/WW of Moose Factory

Infrastructure Definition Process

The FN PIEVC Risk Matrix

Infrastructure Components	Infrastructure Response Considerations						Max. Daily Temp.				Hotest Month (Aug.) Temp.				Low Precipitation (Aug.)				Combination - Aug. High Temp. with Low				Fog				Rain - 7 day period			
	Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Environmental Effects	Days (per year) with Max Temps > 36°C				Very warm August Temps Mean >22.5°C (warmer than August 2012)				Days with August total precipitation ≤ ~50mm (equal to or less than August 2012)				Combination August Warm Temperatures & low rainfalls				Fog visibilities below ½ statute mile (for shipping)				> 120 mm rainfall in 7 days			
	Mark Relevant Responses with ✓						Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Cornwall Island								5				6				5				4				3				3		
Water Supply System																														
Water Treatment Plant																														
Building structure	✓	✓	✓		✓																									
Building envelope	✓	✓	✓		✓																									
Roof	✓	✓	✓		✓																									
Process equipment		✓	✓		✓												4	20			5	20								
HVAC system	✓	✓	✓		✓								3	18							3	12								
Foundations	✓																												1	3
Site services	✓	✓	✓		✓	✓																								
Storage and/or alternate use	✓	✓	✓		✓																								3	9
Access road	✓	✓	✓		✓																									
Environment (plants, trees, animals)						✓							3	18			5	25			6	24								
Environment (soil conditions)																	2	10			3	12							3	9
Backwater disposal	✓	✓	✓	✓	✓																									
Biosolids/sludge disposal			✓		✓																									
Communications / SCADA/Telemetry	✓	✓	✓		✓																									
Back-up power (generator, fuel storage)	✓	✓	✓		✓																									
WTP - High Lift Pumps	✓	✓	✓		✓																									
WTP - Reservoir		✓															5	25			5	20								
WTP - Intake	✓	✓	✓		✓																									
WTP - Low Lift Pump	✓	✓	✓		✓																									

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Water/Wastewater Infrastructure at Moose Factory

Identify the components of the infrastructure to be assessed in general terms

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Infrastructure Definition

- Define the global project parameters and boundary conditions for the engineering vulnerability assessment. :
  - Which infrastructure is being assessed;
  - Its location;
  - Climatic, geographic considerations;
  - Define performance criteria; and
  - Uses of the infrastructure.
- First step of narrowing the focus to allow efficient data acquisition and vulnerability assessment.

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Infrastructure Performance Criteria

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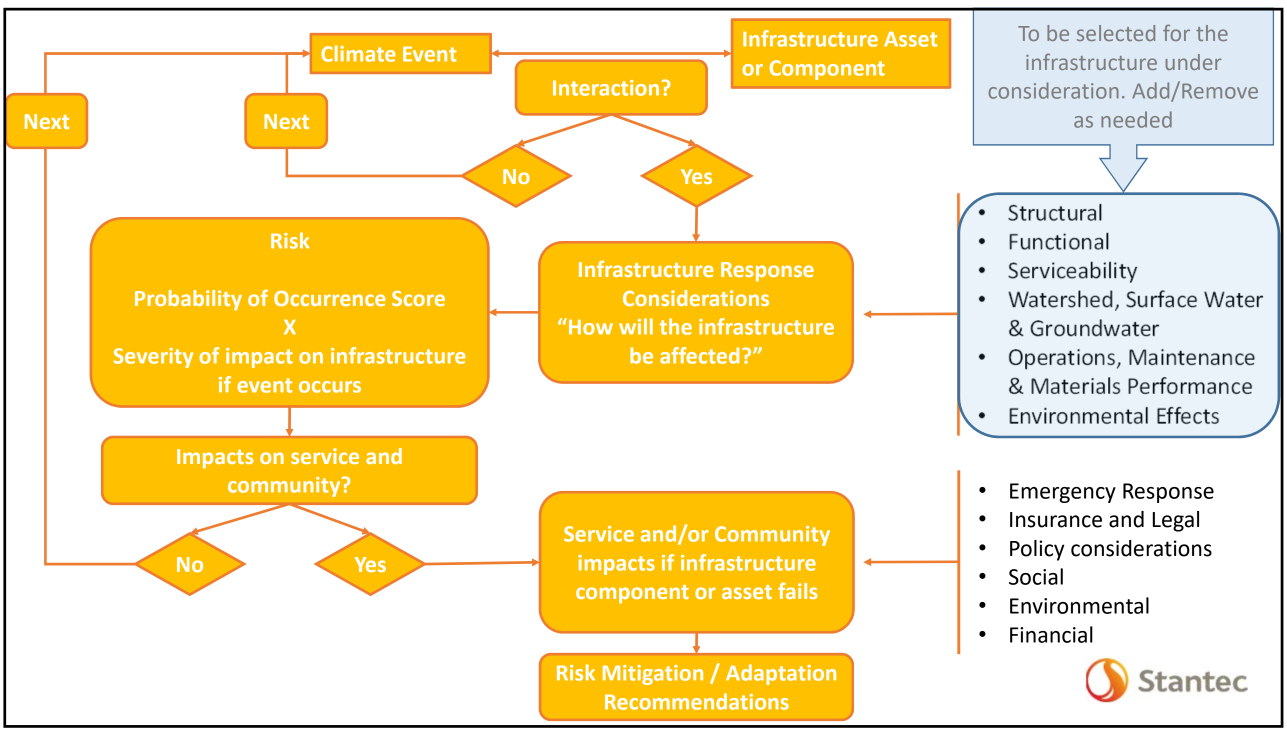

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1. Structural Design/Capacity

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Load carrying capacity
- Fracture / Collapse
- Fatigue
- Access
- Deflection / Permanent deformation
- Cracking and deterioration
- Foundations

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2. Functionality

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Effective Capacity of the infrastructure to provide the intended service
  - Short term
  - Medium term
  - Long term

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3. Serviceability

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

Ability to conduct routine and/or planned maintenance and refurbishment activities

- Short term
- Medium term
- Long term

- Equipment service life - component replacement frequencies

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4. Watershed, Surface Water, and Groundwater

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Erosion along streams, rivers, and ditches
- Erosion scour of associated or supporting earthworks
- Slope stability of embankments
- Sediment transport and sedimentation
- Channel realignment / meandering
- Water quality
- Water quantity
- Run off

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5. Operations, Maintenance, and Materials Performance

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Occupational safety
- Access to worksite
- Equipment performance
- Maintenance and replacement cycles
- Electricity demand
- Fuel use
- Materials Performance
- Changes from design expectation

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6. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

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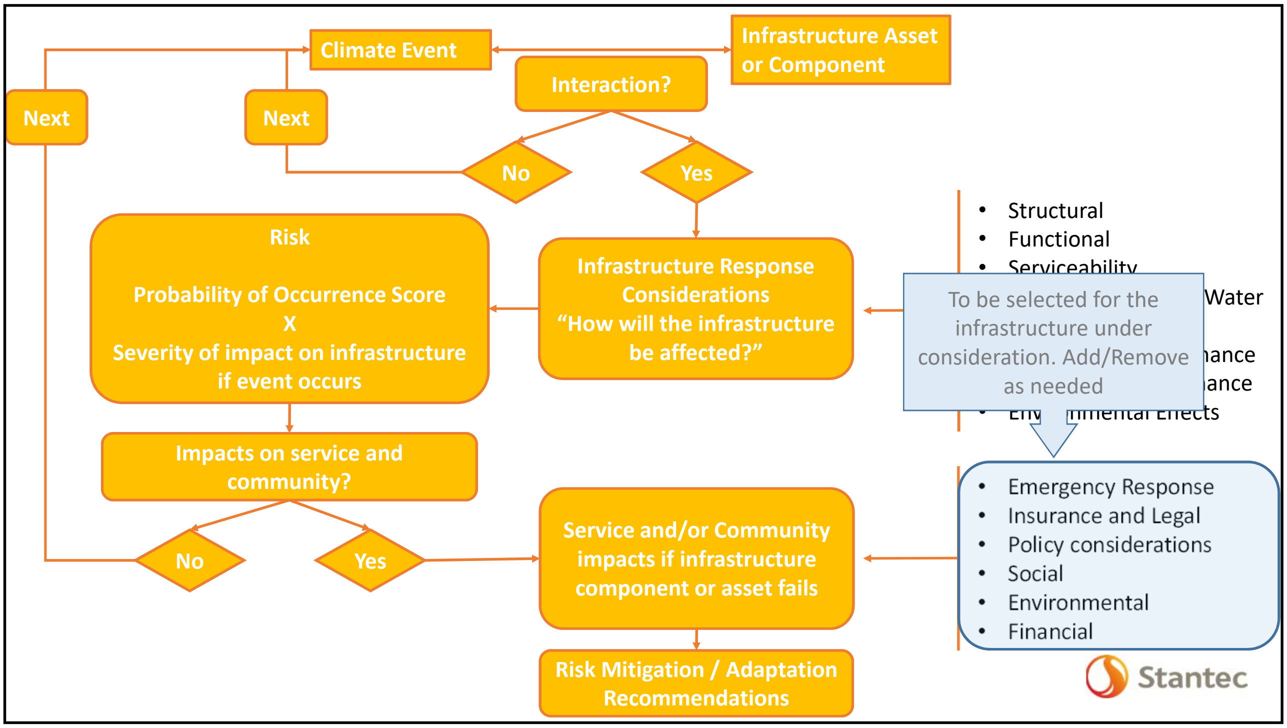

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1. Emergency Response

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Procedures and systems to address:
  - Severe storm events
  - Flooding
  - Ice dams
  - Water damage

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2. Insurance and Legal Considerations

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Insurance rates
- The ability to acquire insurance
- Insurance policy limitations and exclusions
- Legal impacts and liability

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3. Policy Considerations

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Codes
- Guidelines
- Standards
- Internal operations and maintenance policies and procedures
- Levels of Service policy
- Land use planning

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4. Social Effects

With respect to the infrastructure or infrastructure component, being assessed climate loading may affect:

- Accessibility to critical facilities such as hospitals, fire and police services
- Energy supply to a community
- Dislocation of affected populations
- Provision of basic services such as potable water distribution and wastewater collection
- Closure of schools and other public services
- Destruction or damage to heritage buildings, monuments, etc. or historically important resources

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5. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

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6. Fiscal Considerations

With respect to the infrastructure or infrastructure component being assessed, climate loading may cause:

- Drain on current/future financial resources to deal with unplanned repairs, maintenance and/or replacements
- Shifting financial resources from other community priorities
- Impacts on services and/or levels of service
- Community economic impacts and/or hardships

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Dr. Guy Felio, P.Eng., FCSCE, IRP[Climate]
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FN PIEVC Infrastructure Vulnerability Assessment OFNTSC-Moose Cree W/WW Vulnerability Study Overview

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
Senior Advisor, Stantec

September 28, 2017

Funded by: Canada

In Collaboration with: engineerscanada

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Ontario First Nations Technical Services Corporation

Mohawk Council of Akwesasne

Canada

engineerscanada

OCCIAR
Ontario Centre for Climate Impacts and Adaptation Resources

Project Objectives

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Oneida of the Thames

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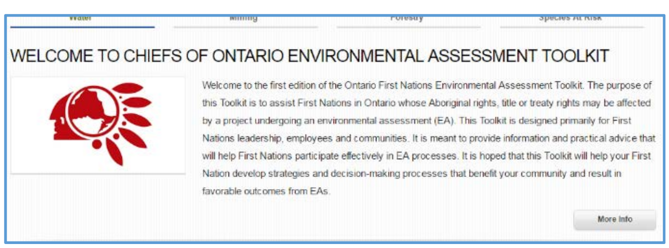
- **Phase 1:** Vulnerability to climate change assessment of the W/WW infrastructure at Akwesasne (completed)
- **Phase 2a:** Development of draft FN PIEVC/Asset Management (AM) toolkit (current)
- **Phase 2b:** Pilot testing draft FN PIEVC/AM Toolkit (Fall 2017):
  - Moose Cree FN (W/WW infrastructure – Moose Factory)
  - Oneida Nation of the Thames (Housing)
- **Phase 2c:** Revise FN PIEVC/AM Toolkit; develop training material; offer training at 2 locations in Southern and Northern Ontario (Early 2018)
- **Phase 3 (to be confirmed):** deployment of FN PIEVC/AM Toolkit to other First Nations in Canada

FN PIEVC/AM Toolkit

- Adapt the current PIEVC Protocol and develop a FN CC Vulnerability Assessment Toolkit
  - Link to asset management
  - Use local and existing resources (e.g., Elders' knowledge, ACRS and ICMS data, etc.)



FN PIEVC/AM Toolkit Framework

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- Work in progress
- Common elements to PSAB 3150 Asset Accounting requirements, Asset Management, and Risk Management:
  - Asset inventory
  - Condition
  - Service life/remaining life
  - Value of assets
- Considerations over the life-cycle of the asset

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TCA Reporting (PS 3150)	**Asset Management**	**Risk Management**
Inventory	Inventory	Inventory
Condition Assessment (Physical Condition)	Condition Assessment (Physical Condition, Capacity, Functionality)	Condition Assessment (Physical Condition, Capacity, Functionality)
Residual Life Prediction	Residual Life Prediction	Residual Life Prediction
Valuation (Historical)	Valuation (Replacement)	Valuation (Replacement)
	Analysis: Needs: Capacity, Physical Condition, O&M Cost-Benefit ←	Analysis: Threats Exposure Vulnerability Risks
↓	Life-cycle Management Plans Additions and Upgrades Replacement and Refurbishment Operations and Maintenance Risk Management	↓
TCA Report	Investment Plan (Capital, O&M) ←	Risk Management plan
	Monitor, Report, Revise	Monitor, Report, Revise

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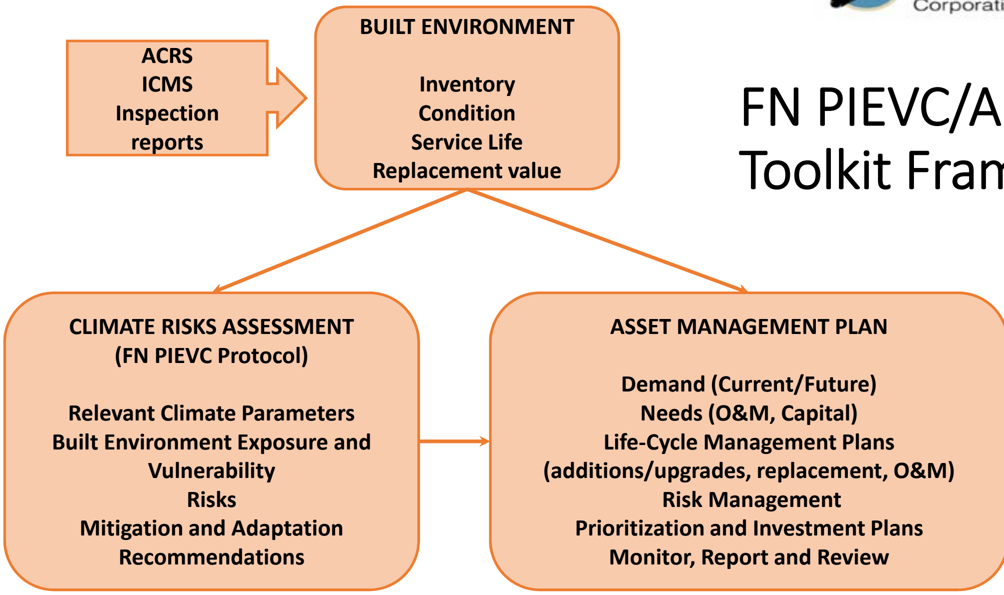
FN PIEVC/AM Toolkit Framework



Examples of Climate Elements and Consequences

- **Oneida Nation of the Thames - Housing**
  - Precipitation, wind, temperatures, relative humidity, environment, insects and pests, etc.
- **Moose Cree First Nation – Moose Factory W/WW systems**
  - Precipitation, winds, temperatures, environment, permafrost, sea ice, ice roads, sea level changes, etc.

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- **Pilots will focus on the Climate Change Risks – but link to asset management**
- Next Steps:
  - Finalize Draft FN PIEVC/AM Toolkit
  - Schedule Kick-off meetings with Communities + Workshop
    - Team introductions
    - Project schedule
    - Infrastructure data
    - Preliminary climate considerations

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FN PIEVC Climate Change Infrastructure Vulnerability Assessment - Process

Based on Engineers Canada's PIEVC Protocol

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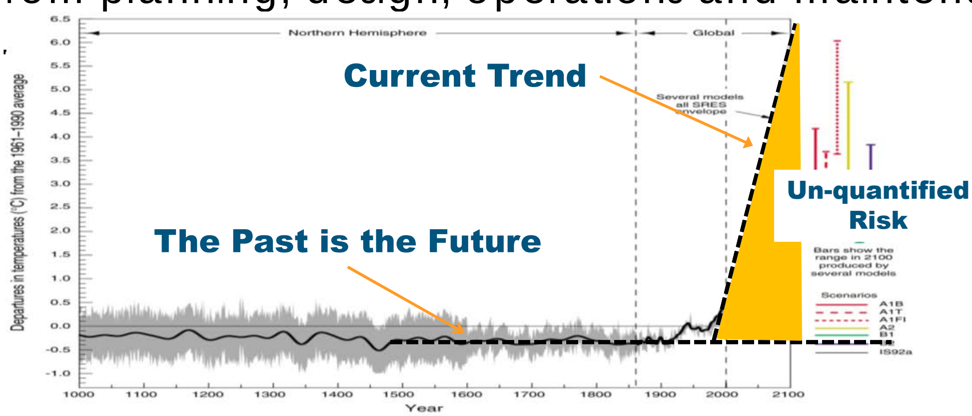
Infrastructure Vulnerability to CC

From planning, design, operations and maintenance ..



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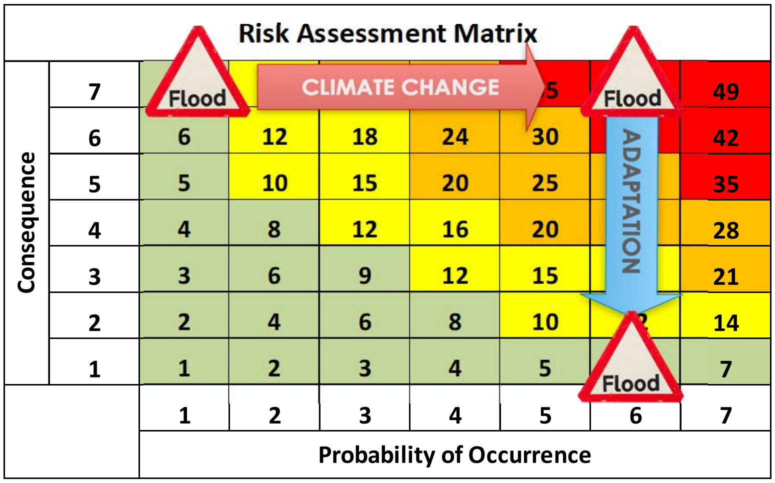

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Public Infrastructure Engineering Vulnerability Committee (PIEVC)

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The PIEVC Protocol

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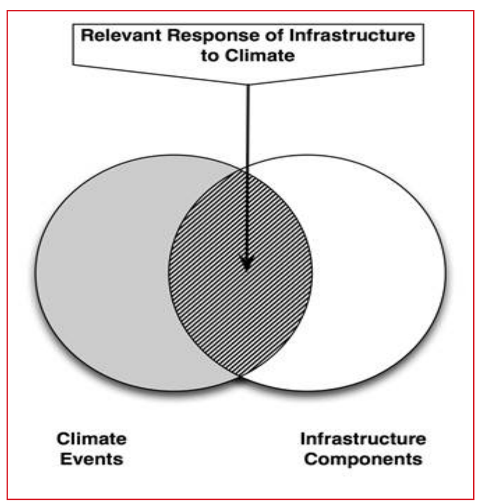
- Five step evaluation process
- A tool derived from standard risk management methodologies
- Intended for use by qualified engineering professionals
- Requires contributions from those with pertinent local knowledge and experience
- Focused on the principles of vulnerability and resiliency



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Public Infrastructure Engineering Vulnerability Committee (PIEVC)

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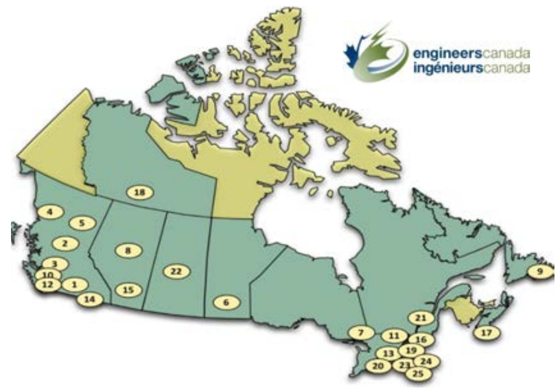
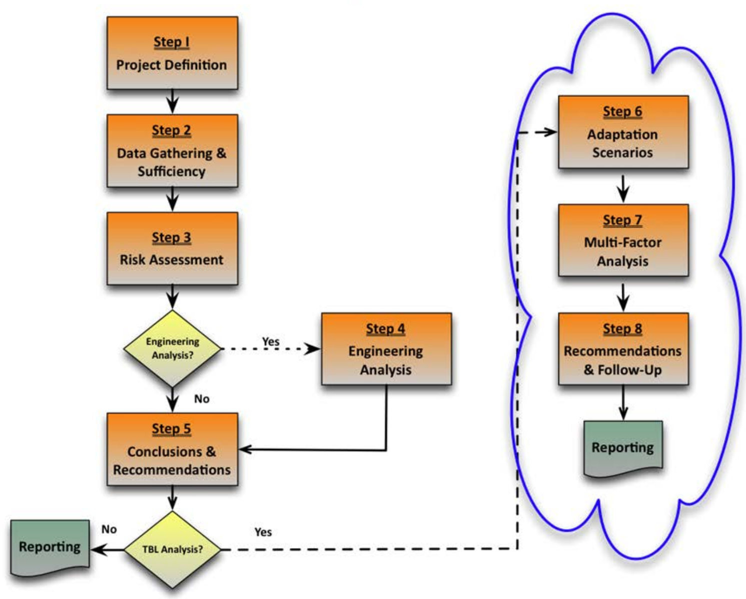
Not a theoretical methodology

Has been or currently applied to
45+ projects in Canada:

- Water resources systems
- Storm & waste water systems
- Roads & bridges
- Buildings (residential, ICI)
- Urban transportation infrastructure
- Energy Infrastructure
- Airport infrastructure
- Hospital
- Three projects in central America



General description of the PIEVC process



TRIPLE BOTTOM LINE MODULE

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

Severity								
7	0	7	14	21	28	35	42	49
6	0	6	12	18	24	30	36	42
5	0	5	10	15	20	25	30	35
4	0	4	8	12	16	20	24	28
3	0	3	6	9	12	15	18	21
2	0	2	4	6	8	10	12	14
1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
	0	1	2	3	4	5	6	7

Probability

Special Case | Low Risk | Medium Risk | High Risk

Risk

6 X 7 = 42

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

Using Severity and Probability Ratings in a Risk Matrix

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Phase 1 - PIEVC Protocol Vulnerability Assessment of Akwesasne's W/WW Infrastructure

Funded by

Canada

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Akwesasne W/WW Climate Change Vulnerability Assessment Objectives

- Identify **nature and severity of risks to components in a life-cycle context** – compatible with asset management plans
- **High level assessment of the predominant vulnerabilities** to climate change and optimize more detailed engineering analysis
- **Recommendations** for adjustments to design, operations and maintenance to maintain / improve levels of service
- Provide a **structured, documented approach** that ensures consistency and accountability.

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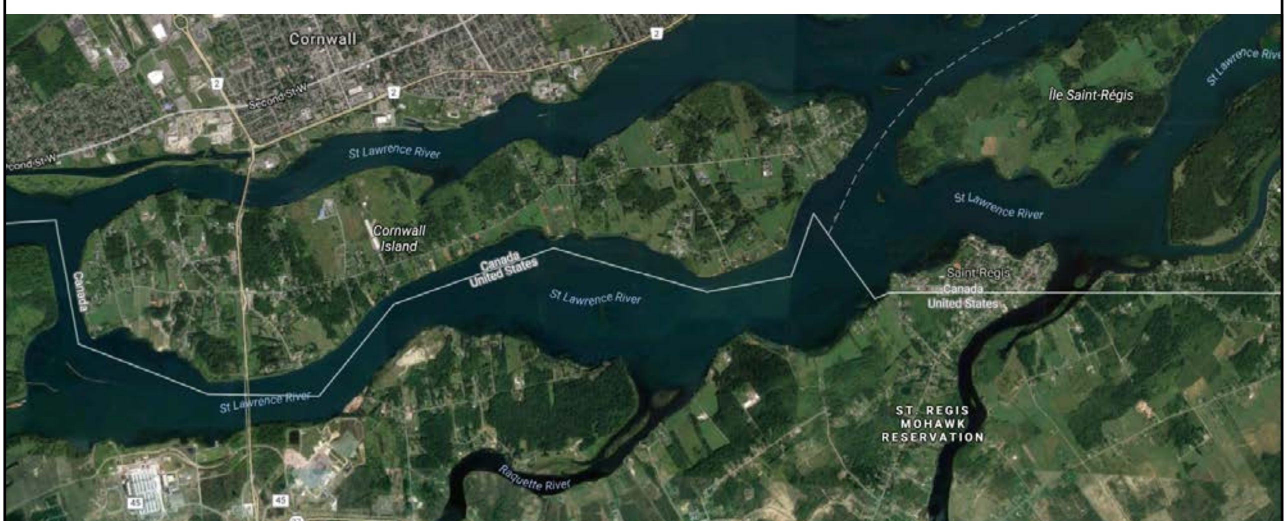

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Project Team

Ontario First Nations Technical Services Corporation

- Elmer Lickers, Senior O&M Advisor (Project Director)
- Bill Maloney, Climate Change Officer

Mohawk Council of Akwesasne

- Jay Benedict, Director Technical Services
- Dr. Henry Lickers, Director Environmental Services
- John Tate Lazore, W/WW Manager
- Leslie Papineau, Technical Project Manager

Consulting Team

- Dr. Guy Félio, Senior Advisor, Stantec (Project Manager)
- Amanda Lynch, Water Resources Engineer, Stantec
- Eric Dunford, Sustainability Consultant, Stantec
- Alexandre Mineault-Guitard, Environmental Engineering Intern, Stantec
- Heather Auld, Climatologist, RSI Inc

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Project Advisory Committee

- Stephanie Allen, OFNTSC
- Ashley Dawn Bach, COO
- Marla Desat, SCC
- Tom Duncan, INAC
- Al Douglas, OCCIAR
- Andréanne Ferland, FNQLSDI
- Caroline Larrivée, Ouranos
- David Lapp, Engineers Canada
- Jamie Ricci, Engineers Canada
- Jacqueline Richard, OCCIAR

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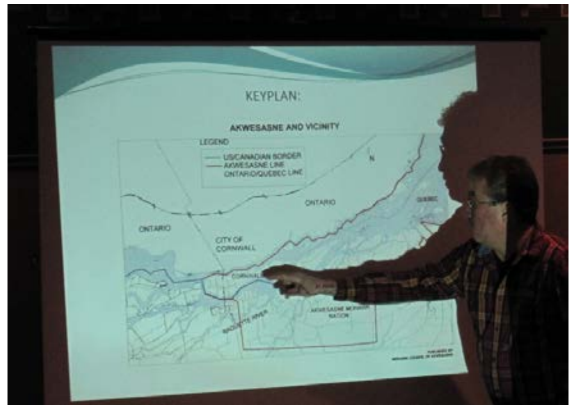
Project Definition - Infrastructure Components

- Three Districts
  - Cornwall Island
  - St. Regis
  - Snye
- All W/WW infrastructure in each district
- Infrastructure Information:
  - MCA Technical Services
  - ACRS and ICMS Data



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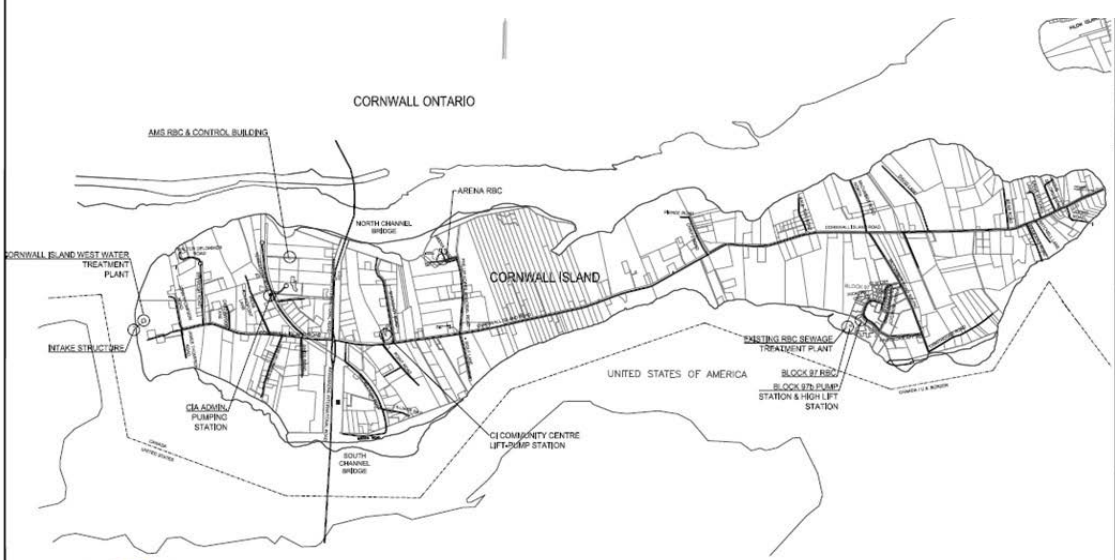

KEY PLAN : CORNWALL ISLAND, ONTARIO

FEBRUARY

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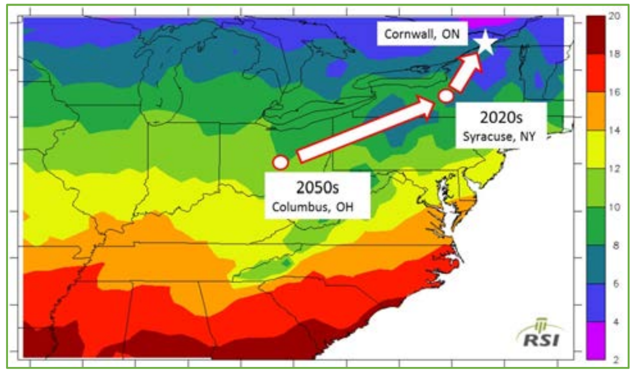
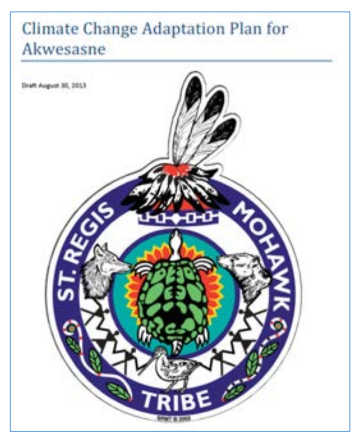
Climate Elements

- Sources of information:
  - Environment Canada – Cornwall Weather Station; Climate ID: 6101872
  - US National Oceanic and Atmospheric Administration
    - Massena (NY) Weather Station
    - Storm Events Data Base for St. Lawrence County (NY)
  - Ontario Tornado Watch



- Observed climate trends over the past few decades indicate a changing climate. Since 1970, trends that have been observed include **rising temperatures, more frequent hot days, longer growing seasons, less snowfall and more winter rain, reduced snowpack, and earlier ice and snowmelt resulting in earlier peak river flo**ws.
- At Akwesasne, the **drought of summer 2012** affected many of nature's cycles on all of creation. The changes came about in the way of hot and humid temperatures, high winds, heavy rainfall, hail, low water levels, and fish and wildlife reproductive cycles were out of sync. The downpour of rainfall, hail, and strong high winds destroyed gardens at a time when it was late to restart gardens to get a good crop. Some areas had 6 inches of hail in July. Thunderstorm warnings were also issued.


Climate Change Adaptation Plan for Akwesasne

Type of Climate Element	Description	Comment
Temperature	Days (per year) with Max Temps > 36°C	Significant missing data over past decade
	Very warm August Temps Mean >22.5°C (*warmer than August 2012*) (	Significant missing data over past decade
	Combination August warm temperatures & low rainfalls	
Precipitation	Days with August total precipitation ≤ ~51mm (*equal to or less than August 2012*)	Significant missing data over past decade
	Winter snowfall for Jan-Feb-Mar > 200 cm	Gap filled dataset used
	Winter rainfall totals (DJF) > 120mm	Significant missing data over past decade
	March rainfall totals > 60	Significant missing data over past decade
	Snowfall event > 25 cm/day	Significant missing data over past decade
	Winter rainfall > 25mm/day	Significant missing data over past decade
	Severe ice storms (≥ 20 mm freezing rain in one day)	
	Extreme ice storms (≥ 40 mm freezing rain that isn't easily shed)	

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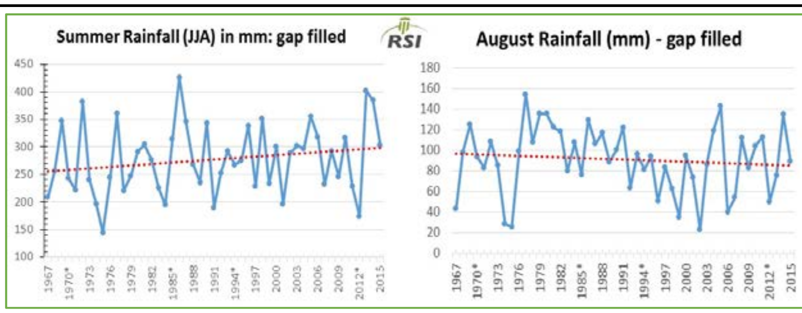

Type of Climate Element	Description	Comment
Fog	Visibilities below ½ statute mile	Reference impacts to shipping
Wind	Days with gusts > 90 kph	i.e., NBC 50 year return period design steady wind
	Days with gusts > 125 kph	i.e., NBC 50 year return period climatic design gust with wind gust factor applied
	Days with gusts > 140 kph	Massena A, 50 year return period wind gust
	Tornado frequency within 25 km radius	Only have data for Canadian territory. Probability 2x if considering US side
	Tornado frequency – within 50 km radius	Only have data for Canadian territory. Probability 2x if considering US side

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Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected
Cornwall Island				
Moderate	140	77	• Low Precipitation (Aug.) • Combination - Aug. High Temp. with Low precipitation • Snowfall event • Severe Ice Storm • Extreme Ice Storm • Extreme Winds	• Environment • Personnel • Suppliers • Electricity • Light buildings • General roadworks • Emergency response • Vehicles and fleet • Communications
High	45	124	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works
Extreme	28	34	• Lightning • Tornados	• All infrastructure

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Influence of Infrastructure Condition

Future Climate Risk Score Counts Cornwall Island Infrastructure			
Risk Rating	**Infrastructure replaced at end of design life**	**Infrastructure deteriorated (not replaced)**	**Percentage change in risk count**
High	124	140	+ 13%
Extreme	34	43	+26%

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Some recommendations

- **Evaluate the financial constraints and resources** needed to maintain the infrastructure in a state of good repair and to invest in a timely manner in the replacement of infrastructure when it reaches the end of its service life, which can effectively decrease the extreme risks by more than 25%. This can be done through the life-cycle analysis and investment planning processes of an asset management plan.
- **Improve the weather alert system** to support operational staff and emergency first responders allowing to be pro-active in anticipation of severe weather, for example, ensuring back-up power (fixed and portable) units are ready for use.
- **Identify risk mitigation or risk avoidance measures for strong to extreme wind events,** such as securing (anchoring) asset components such roofs, light structures, etc. Select tree locations and species to minimize risks of property damage in case they would fall down.

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- **Review and improve O&M practices and policies** as required. This could include inspection cycles, maintenance to maintain the performance of the assets, etc.
- **Install weather stations on Cornwall Island and in St. Regis** to ensure relevant local data. These stations should have the capability of hourly records, a gap in the data from the Cornwall station which only provides daily averages, thus missing short duration/high intensity events.
- **Ensure lightning protection** for sensitive equipment, particularly the SCADA systems.
- **Plan for reduced mobility** of operators and suppliers due to severe or extreme events, including warning, stock-piling, etc.

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"The Protocol is straight forward but detailed. While the instruments of protocol look complicated, they could be utilized by many different peoples at various levels of understanding with a little assistance from a more knowledgeable expert.

As the protocol is used, it becomes apparent to the community that this will be very useful for evaluating the adaptability of the community infrastructure. It also helps to clarify gaps and shortcomings of the community infrastructure and processes."

Henry Lickers
Director, Environmental Services
Mohawk Council of Akwesasne

Dr. Guy Felio, P.Eng., FCSCE, IRP[Climate]
Guy.Felio@Stantec.com

FN PIEVC Infrastructure Vulnerability Assessment
OFNTSC-Moose Cree W/WW Vulnerability Study
Infrastructure Exposure and Climate Considerations Workshop #2

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
Senior Advisor, Stantec

Thursday September 28, 2017

Funded by: Canada

In Collaboration with: engineerscanada

Agenda

- Project Overview
- FN PIEVC infrastructure vulnerability to climate change process
- Infrastructure to be considered in study
- Infrastructure performance considerations
- Relevant climate events
- Next steps
  - Project Advisory Committee
  - Workshops 3 (Risk Assessment) and 4 (Adaptation Measures)
- Wrap-up and close

Infrastructure Components	ACRS	Performance Considerations					Climate Elements																			
		Structural	Operational	Functionality	Environment (Land)	Environment (Water)	Temperature 5 consecutive days with temp. > 30 deg.				Temperature 10 consecutive days with temp. < -35 deg.				Blizzard > 50cm snow in 24 hour period				Rain 3 consecutive days with total rainfall of > 100mm				Climate event 5			
							Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y				Y				N				N							
- SCADA																										
- Communications																										
- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

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Moose Cree First Nation

Rating scales

Climate

Score	Probability Method A	Probability Method B
0	Negligible Not Applicable	< 1 in 1,000
1	Highly Unlikely Improbable	1 in 100
2	Remotely Possible	1 in 20
3	Possible Occasional	1 in 10
4	Somewhat Likely Normal	1 in 5
5	Likely Frequent	>1 in 2.5

Impacts on Infrastructure

Score	Descriptor	Provide Example
0	No Effect	
1	Insignificant	
2	Minor	
3	Moderate	
4	Major	
5	Catastrophic	

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Infrastructure Components	ACRS	Performance Considerations: Structural	Operational	Functionality	Environment (Land)	Environment (Water)	(Current) Climate Elements: Temperature – 5 consecutive days with temp. > 30 deg.: Y/N	P	S	R	Temperature – 10 consecutive days with temp. < -30 deg.: Y/N	P	S	R	Blizzard – > 50cm snow in 24 hour period: Y/N	P	S	R	Rain – 3 consecutive days with total rainfall of > 100mm: Y/N	P	S	R	Climate event 5: Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y	1	3	3	Y	3	2	6	N				N							
- SCADA																										
- Communications																										
- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

Current Climate

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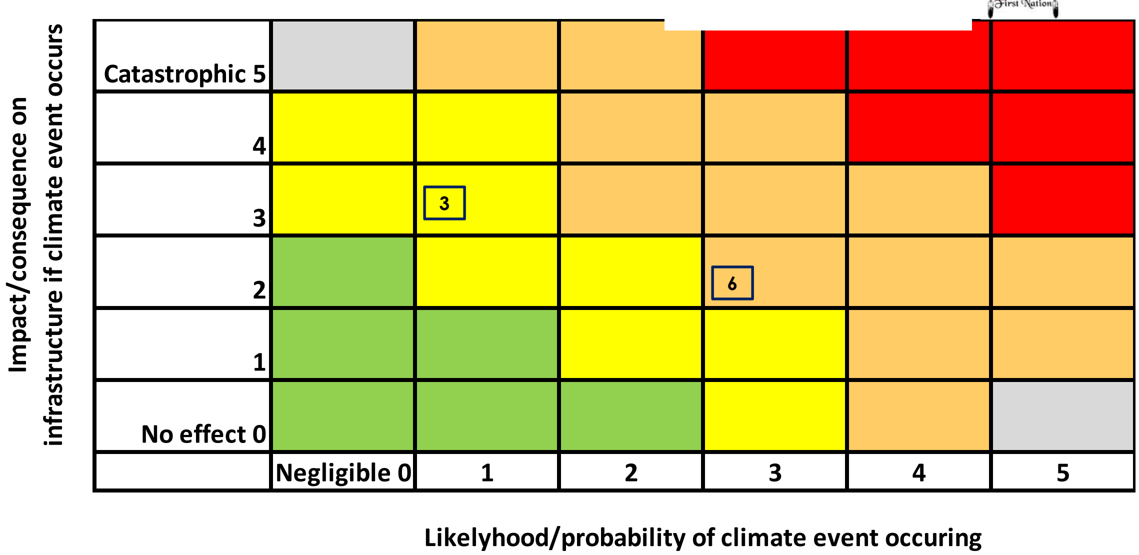

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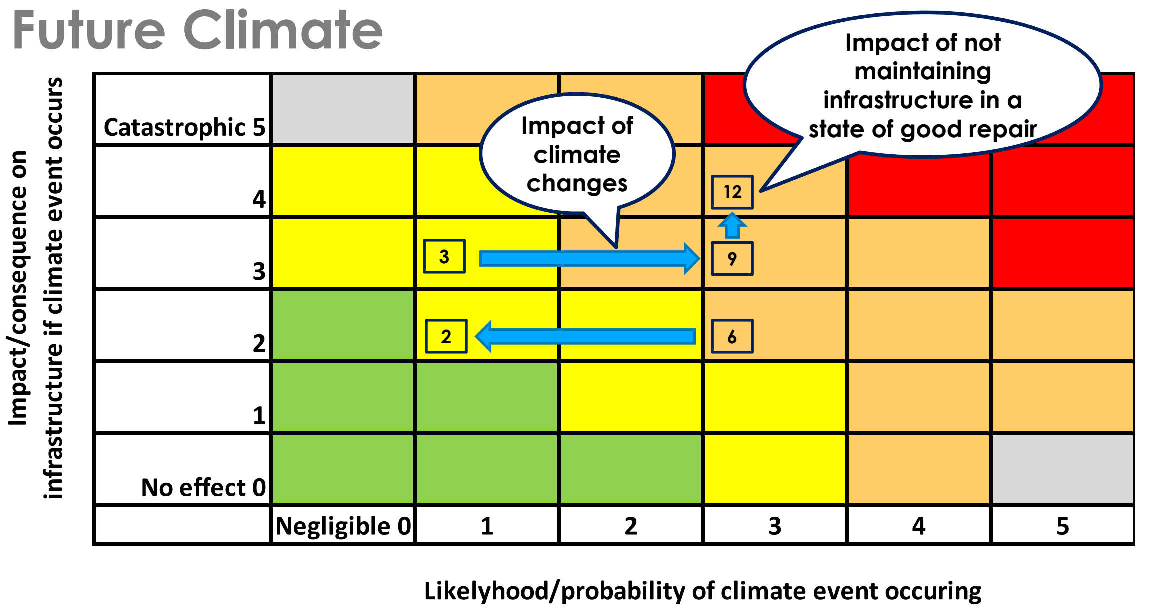
Infrastructure Components	ACRS	Performance Considerations: Structural	Operational	Functionality	Environment (Land)	Environment (Water)	(Future) Climate Elements: Temperature – 5 consecutive days with temp. > 30 deg. Y/N	P	S	R	Temperature – 10 consecutive days with temp. < -30 deg. Y/N	P	S	R	Blizzard – > 50cm snow in 24 hour period Y/N	P	S	R	Rain – 3 consecutive days with total rainfall of > 100mm Y/N	P	S	R	Climate event 5 Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y	3	3	9	Y	1	2	2	N				N							
- SCADA																										
- Communications																										
- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

Future Climate



The FN PIEVC Risk Matrix

Infrastructure Components	Infrastructure Response Considerations: Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Environmental Effects
	Mark Relevant Responses with ✓					
Cornwall Island						
Water Supply System						
Water Treatment Plant						
Building structure	✓	✓	✓		✓	
Building envelope	✓	✓	✓		✓	
Roof	✓	✓	✓		✓	
Process equipment		✓	✓		✓	
HVAC system	✓	✓	✓		✓	
Foundations	✓					
Site services	✓	✓	✓		✓	✓
Storage and/or alternate use	✓	✓	✓		✓	
Access road	✓	✓	✓		✓	
Environment (plants, trees, animals)						✓
Environment (soil conditions)						
Backwater disposal	✓	✓	✓	✓	✓	
Biosolids/sludge disposal			✓		✓	
Communications / SCADA/Telemetry	✓	✓	✓		✓	
Back-up power (generator, fuel storage)	✓	✓	✓		✓	
WTP - High Lift Pumps	✓	✓	✓		✓	
WTP - Reservoir		✓				
WTP - Intake	✓	✓	✓		✓	
WTP - Low Lift Pump	✓	✓	✓		✓	

Infrastructure Components	Max. Daily Temp. — Days (per year) with Max Temps > 36°C				Hotest Month (Aug.) Temp. — Very warm August Temps Mean >22.5°C (warmer than August 2012)				Low Precipitation (Aug.) — Days with August total precipitation ≤ ~50mm (equal to or less than August 2012)				Combination - Aug. High Temp. with Low — Combination August Warm Temperatures & low rainfalls				Fog — Fog visibilities below ½ statute mile (for shipping)				Rain - 7 day period — > 120 mm rainfall in 7 days			
	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Cornwall Island		5				6				5				4				3				3		
Water Supply System																								
Water Treatment Plant																								
Building structure																								
Building envelope																								
Roof																								
Process equipment											4	20			5	20								
HVAC system							3	18							3	12								
Foundations																							1	3
Site services																								
Storage and/or alternate use																							3	9
Access road																								
Environment (plants, trees, animals)							3	18			5	25			6	24								
Environment (soil conditions)											2	10			3	12							3	9
Backwater disposal																								
Biosolids/sludge disposal																								
Communications / SCADA/Telemetry																								
Back-up power (generator, fuel storage)																								
WTP - High Lift Pumps																								
WTP - Reservoir											5	25			5	20								
WTP - Intake																								
WTP - Low Lift Pump																								

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Assessment of the CC Vulnerability of the W/WW of Moose Factory

Infrastructure Definition Process

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Water/Wastewater Infrastructure at Moose Factory

Identify the components of the infrastructure to be assessed in general terms

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Infrastructure Definition

- Define the global project parameters and boundary conditions for the engineering vulnerability assessment. :
  - Which infrastructure is being assessed;
  - Its location;
  - Climatic, geographic considerations;
  - Define performance criteria; and
  - Uses of the infrastructure.
- First step of narrowing the focus to allow efficient data acquisition and vulnerability assessment.

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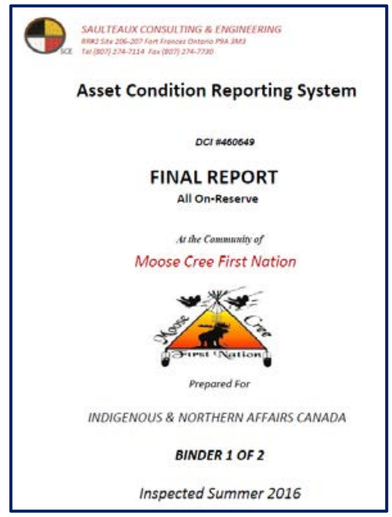
Confirm the Infrastructure List

Main components

- Potable Water
  - Intake and transmission to plant
  - WTP
  - Distribution and appurtenances
- Wastewater
  - Collection
  - Treatment
  - Receiving environment
- Administration and operations


SAULTEAUX CONSULTING & ENGINEERING
RR#2 Site 206-207 Fort Frances Ontario P9A 3M3
Tel (807) 274-7114 Fax (807) 274-7730

Asset Condition Reporting System

DCI #460649

FINAL REPORT
All On-Reserve

At the Community of
Moose Cree First Nation

Prepared For

INDIGENOUS & NORTHERN AFFAIRS CANADA

BINDER 1 OF 2

Inspected Summer 2016

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Potable Water System

- Intake
- Underground reservoir
- Above ground reservoir
- Low level lift station
  - Building
  - Equipment
- Watermains
- Hydrants
- Others?

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Water Treatment Plant

- Building Structure
- Building Envelope
- Roof
- Foundations
- Process equipment
- HVAC
- Electrical systems
- Scada/communications
- Storage
- Site services
- Access road
- Backup generator

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Wastewater Collection and Treatment System

- Sanitary Mains
- Sewage lift stations
  - Building
  - Equipment
- Lagoons
  - Cells
  - Blower building and equipment
- Storage building (old fire hall)?
- Others?

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Administration and Operations

- Vehicles and fleet
- Personnel
- Records
- Supplier
- Emergency procedures/personnel
- Electricity
- Island access
- General road network
- Others?
- Garage ? Public works yard?
- Others?

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Establish the Infrastructure Performance Criteria

"If a climate event impacts the infrastructure, how will the condition and performance be affected?"

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Infrastructure Components	ACRS	Performance Considerations					Climate Elements																			
		Structural	Operational	Functionality	Environment (Land)	Environment (Water)	Temperature 5 consecutive days with temp. > 30 deg.				Temperature 10 consecutive days with temp. < -35 deg.				Blizzard > 50cm snow in 24 hour period				Rain 3 consecutive days with total rainfall of > 100mm				Climate event 5			
							Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y				Y				N				N							
- SCADA																										
- Communications																										
- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

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Moose Cree First Nation

1. Structural Design/Capacity

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Load carrying capacity
- Fracture / Collapse
- Fatigue
- Access
- Deflection / Permanent deformation
- Cracking and deterioration
- Foundations

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2. Functionality

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Effective Capacity of the infrastructure to provide the intended service
  - Short term
  - Medium term
  - Long term

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3. Serviceability

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

Ability to conduct routine and/or planned maintenance and refurbishment activities

- Short term
- Medium term
- Long term

- Equipment service life - component replacement frequencies

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4. Watershed, Surface Water, and Groundwater

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Erosion along streams, rivers, and ditches
- Erosion scour of associated or supporting earthworks
- Slope stability of embankments
- Sediment transport and sedimentation
- Channel realignment / meandering
- Water quality
- Water quantity
- Run off

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5. Operations, Maintenance, and Materials Performance

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Occupational safety
- Access to worksite
- Equipment performance
- Maintenance and replacement cycles
- Electricity demand
- Fuel use
- Materials Performance
- Changes from design expectation

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6. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

Impacts on the service or the community if the infrastructure fails

1. Emergency Response

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Procedures and systems to address:
  - Severe storm events
  - Flooding
  - Ice dams
  - Water damage

2. Insurance and Legal Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Insurance rates
- The ability to acquire insurance
- Insurance policy limitations and exclusions
- Legal impacts and liability

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3. Policy Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Codes
- Guidelines
- Standards
- Internal operations and maintenance policies and procedures
- Levels of Service policy
- Land use planning

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4. Social Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Accessibility to critical facilities such as hospitals, fire and police services
- Energy supply to a community
- Dislocation of affected populations
- Provision of basic services such as potable water distribution and wastewater collection
- Closure of schools and other public services
- Destruction or damage to heritage buildings, monuments, etc. or historically important resources

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5. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

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6. Fiscal Impacts

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Drain on current/future financial resources to deal with unplanned repairs, maintenance and/or replacements
- Shifting financial resources from other community priorities
- Impacts on services and/or levels of service
- Community economic impacts and/or hardships

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Climate Elements to Consider

General information on projections

Discussion on past events that have caused infrastructure disruptions and/or damage

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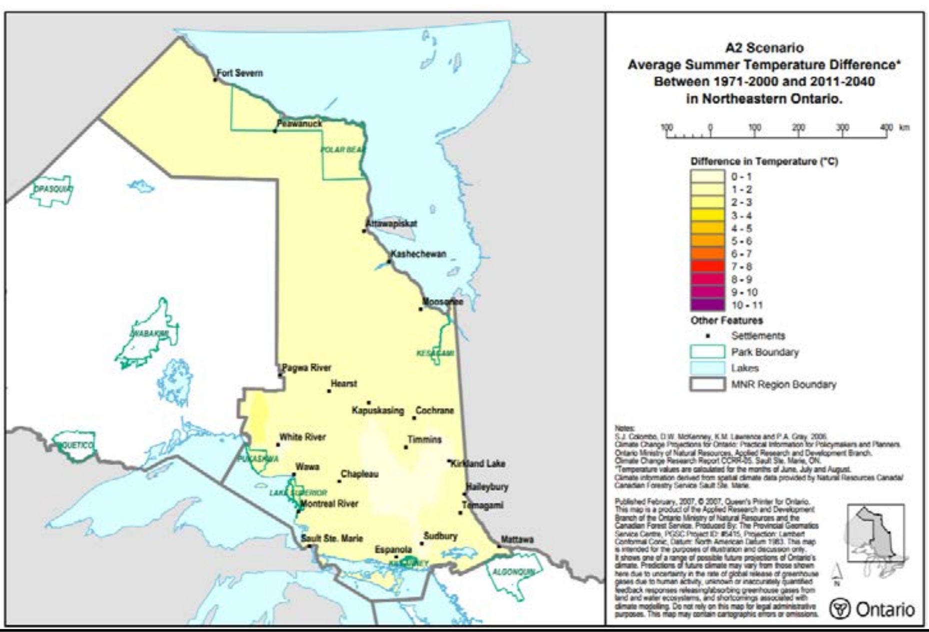

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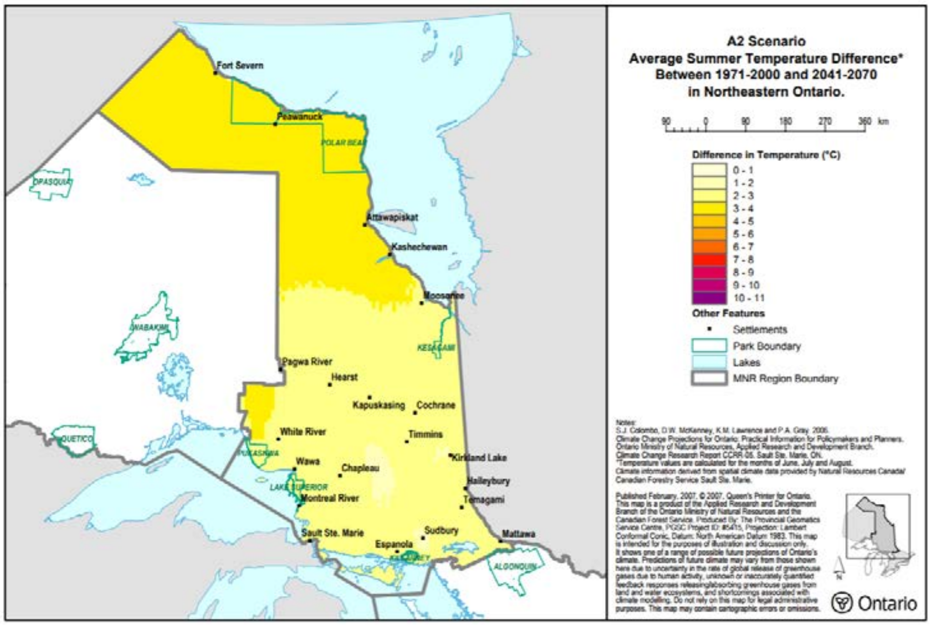

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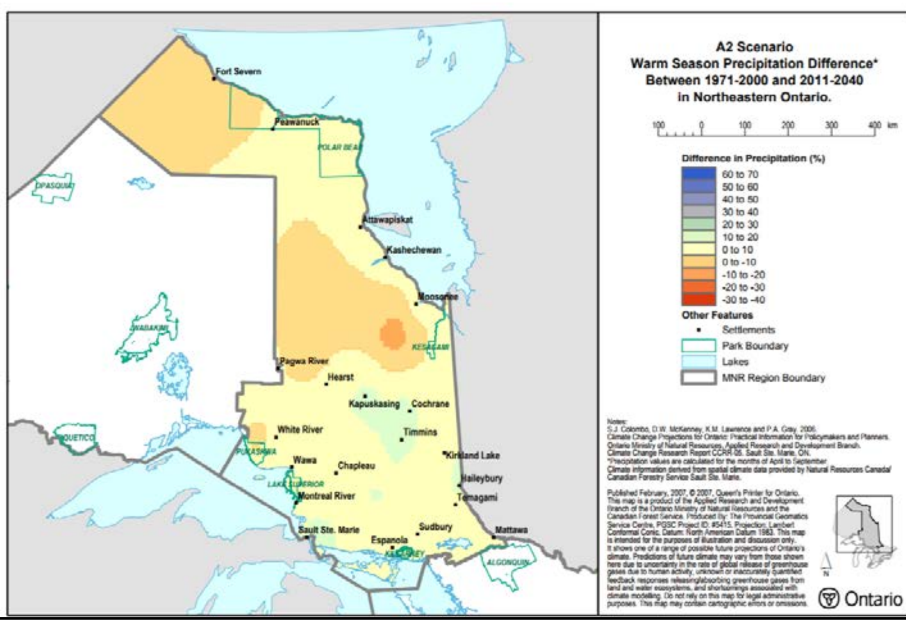

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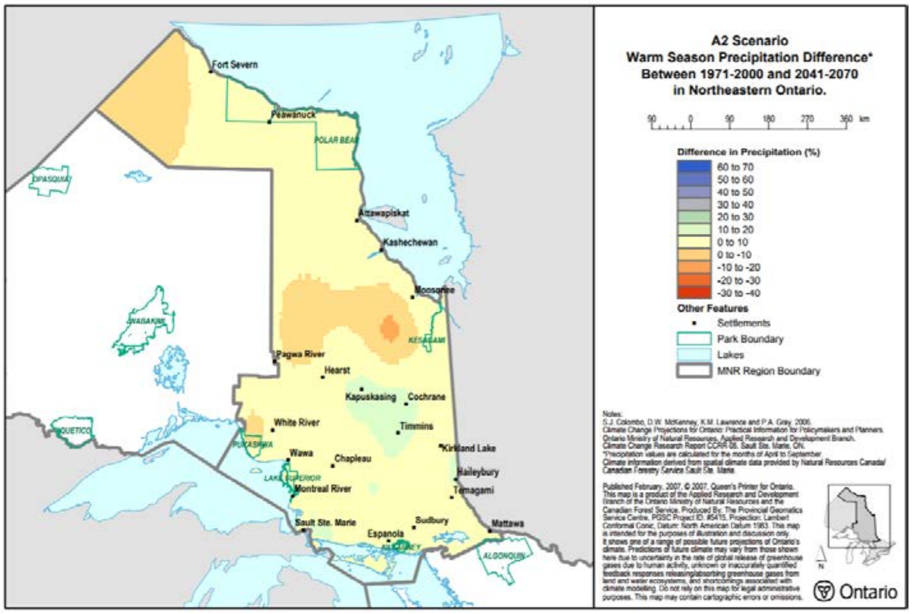

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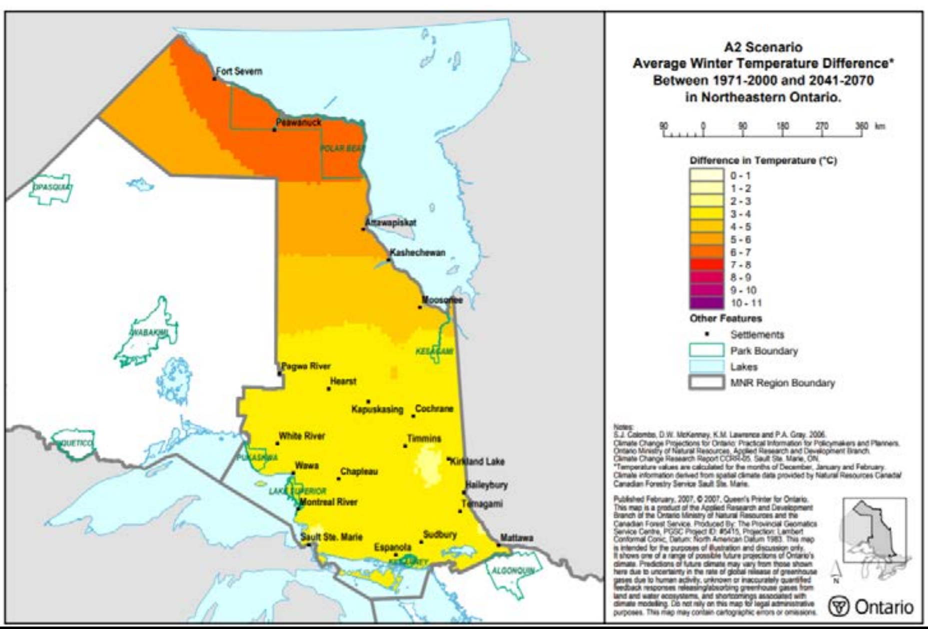

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Moose Factory WTP

Project Status Update Report

Asim Masaud, M.Sc., P.Eng., PMP

Elvio Zaghi, MBA, P.Eng

Wed, July 25 2017

ONTARIO CLEAN WATER AGENCY
AGENCE ONTARIENNE DES EAUX

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2 Climate Change

Extreme river conditions are and will continue to occur more frequently and will severely impact the function and integrity of Plant's Water Intake

i. **Extreme low liquid levels** – recent tidal effects have jeopardized plant operation. The river liquid level was too low for the existing intake to draw water

ii. **Extreme Ice Flows** – spring thaws have caused extreme ice floe events that severely damaged the intake structure

iii. **Extreme Flooding** – extreme flooding events during spring thaw have caused flooding of plant's site and jeopardized the low lift pump building at the intake structure

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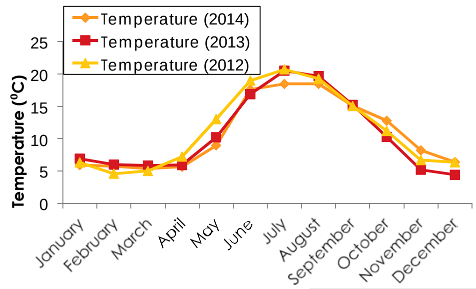
Slide 40

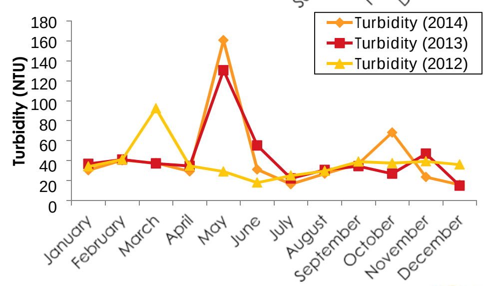
2 Raw Water Quality Impacts

ONTARIO CLEAN WATER AGENCY
AGENCE ONTARIENNE DES EAUX

Climate Considerations

- **Seasonality**
  - Ice dams
  - Turbidity spikes (>140 NTU) during spring melt
- **Tidal Effects**
  - Semi-diurnal tide (low tide occurs twice per day)
  - Enhanced by wind speed and direction
  - Strong winds have been linked to extremely low water levels at Moose Factory Island Intake
  - Flow reversals are common





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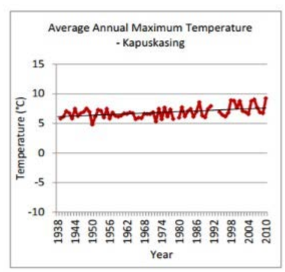
Slide 41

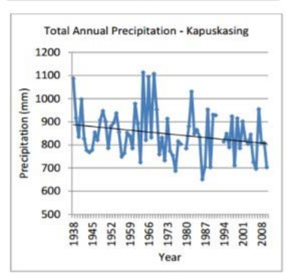
2 Raw Water Quality Impacts

ONTARIO CLEAN WATER AGENCY
AGENCE ONTARIENNE DES EAUX

Climate Change Impacts

- **Warmer winter and spring temperatures**
  - Reduced ground frost, snow
  - Increased freezing rain
- **Temperature variability**
  - Late September: 4ºC in morning and 25ºC in afternoon is common
- **Changes in precipitation**
  - Lower water levels
- **Increasing intensity of storms and wind**
  - Flooding
- **Potential increases in upstream agriculture**
  - 1 million acres of underutilized land in the clay belt in the watershed (near Kapuskasing)
  - Longer growing seasons
  - Greater potential for algae growth





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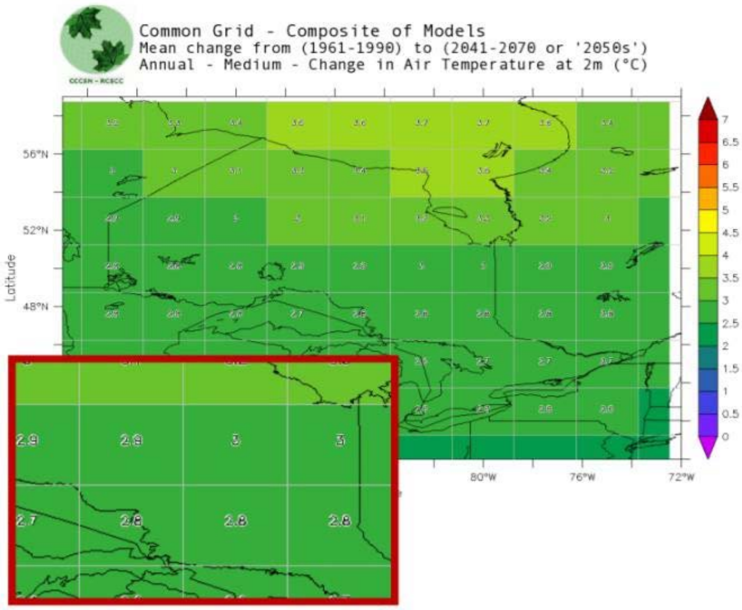
Slide 42

2 Raw Water Quality Impacts

Change in Annual Air Temperature (°C) from 1961/1990 to 2050



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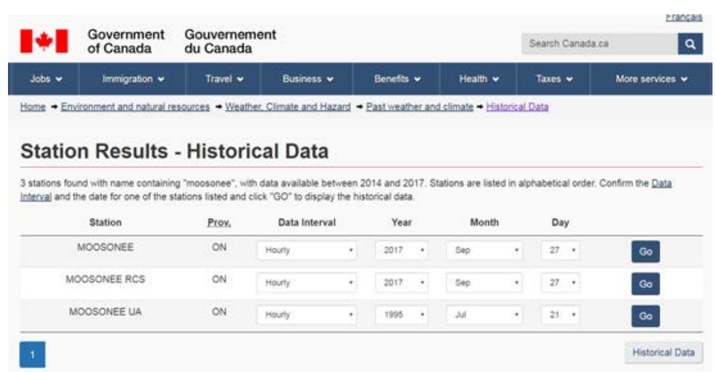
Other sources

- Ontario Climate Data Portal
- Western Ontario U. IDF curves



But MOST IMPORTANTLY …

… YOUR knowledge of local climate!

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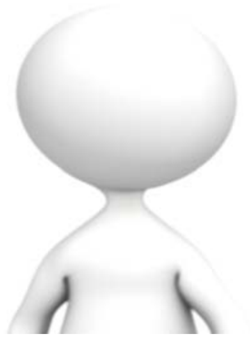

Dr. Guy Felio, P.Eng., FCSCE, IRP[Climate]
Guy.Felio@Stantec.com

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Moose Cree First Nation

FN PIEVC Infrastructure Vulnerability Assessment
OFNTSC-Moose Cree W/WW Vulnerability Study
Risk Assessment Workshop #3

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
Senior Advisor, Stantec

Tuesday November 21, 2017

Funded by: Canada

In Collaboration with engineerscanada

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Safety Moment

STOP & TALK: GET PREPARED

Health, Safety, Security and Environment

If a disaster occurs in your community, it may take emergency workers some time to get to you as they are helping others in need. That is why it is important to always be prepared to take care of yourself and your family for a minimum of 72 hours.

Things to have in your Emergency Preparedness Kit:

- Water(6L/l.5 gal. per person)
- Food that won't spoil(canned good, energy bars, etc.)
- Manual can opener
- Flashlight and batteries
- Battery powered radio
- Extra batteries
- First aid kit
- Cash
- Emergency plan and legal documents
- Special needs items (e.g., prescription medications, baby formula)
- Whistle
- Blankets
- Change of clothing
- Candles and matches or a lighter

If you have questions, please contact your supervisor, Office Safety and Environment Coordinator (OSEC), or local HSSE representative

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Objectives

- Review of Workshop 3
- Identification and validation of the climate parameters for the study
- Risk matrix: infrastructure-climate interactions
- Risk Matrix: climate probability ratings, severity of impacts scores and risk calculations
- Summary
- Next steps - Workshop 4

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Agenda

Time	Description	
9:00am – 9:15am	Welcome and introductions	Moose Factory and OFNTSC
9:15am – 9:45am	Review of Workshop # 2 findings and PIEVC Protocol steps and discussion	Consultant
9:45am – 10:30am	Presentation of preliminary climate parameters and selection	Consultant; All
10:30am – 10:45am	Health break	
10:45am – 12:00noon	Risk matrix: infrastructure and climate interactions	All participants
12:00pm – 12:45pm	Lunch	
12:45pm – 3:15pm	Risk matrix: climate events' probabilities, severity rating and risk scores	All participants
3:15pm – 3:30pm	Review and next steps	Consultant
3:30pm	Adjourn	

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Infrastructure Components	ACRS	Performance Considerations					Climate Elements																			
		Structural	Operational	Functionality	Environment (Land)	Environment (Water)	Temperature 5 consecutive days with temp. > 30 deg.				Temperature 10 consecutive days with temp. < -35 deg.				Blizzard > 50cm snow in 24 hour period				Rain 3 consecutive days with total rainfall of > 100mm				Climate event 5			
							Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y				Y				N				N							
- SCADA																										
- Communications																										
- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

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Moose Cree First Nation

Rating scales

Climate

Score	Probability	
	Method A	Method B
0	Negligible Not Applicable	< 1 in 1,000
1	Highly Unlikely Improbable	1 in 100
2	Remotely Possible	1 in 20
3	Possible Occasional	1 in 10
4	Somewhat Likely Normal	1 in 5
5	Likely Frequent	>1 in 2.5

Impacts on Infrastructure

Score	Descriptor	Provide Example
0	No Effect	
1	Insignificant	
2	Minor	
3	Moderate	
4	Major	
5	Catastrophic	

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Infrastructure Components	ACRS	Performance Considerations					(Current) Climate Elements																			
		Structural	Operational	Functionality	Environment (Land)	Environment (Water)	Temperature 5 consecutive days with temp. > 30 deg.				Temperature 10 consecutive days with temp. < -30 deg.				Blizzard > 50cm snow in 24 hour period				Rain 3 consecutive days with total rainfall of > 100mm				Climate event 5			
							Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y	1	3	3	Y	3	2	6	N				N							
- SCADA																										
- Communications																										
- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

Current Climate

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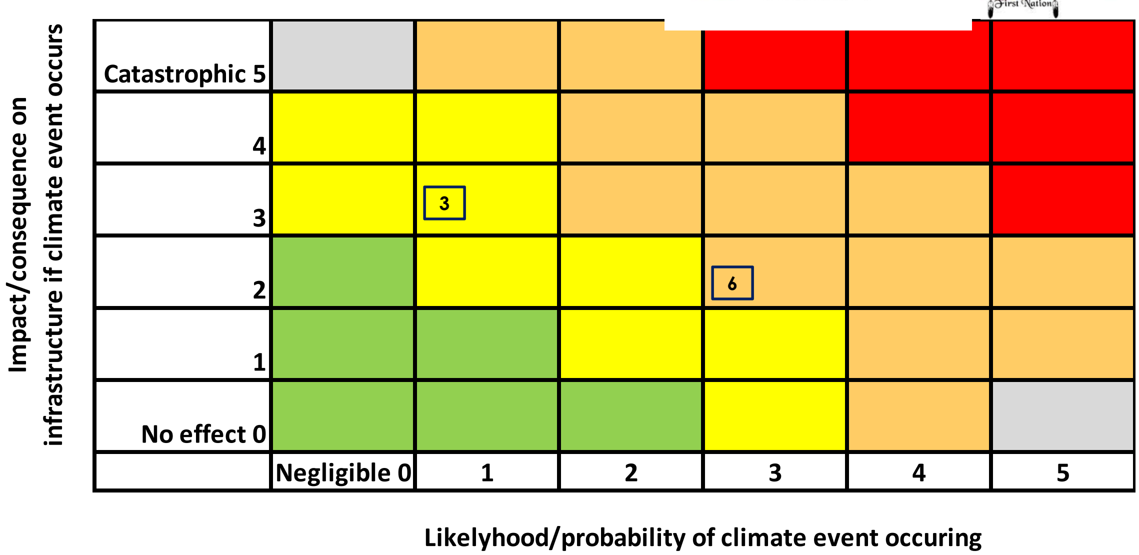

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Infrastructure Components	ACRS	Performance Considerations					(Future) Climate Elements																			
		Structural	Operational	Functionality	Environment (Land)	Environment (Water)	Temperature 5 consecutive days with temp. > 30 deg.				Temperature 10 consecutive days with temp. < -30 deg.				Blizzard > 50cm snow in 24 hour period				Rain 3 consecutive days with total rainfall of > 100mm				Climate event 5			
							Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Water Treatment Plant																										
- Building structure																										
- Building envelope																										
- Roof																										
- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y	3	3	9	Y	1	2	2	N				N							
- SCADA																										
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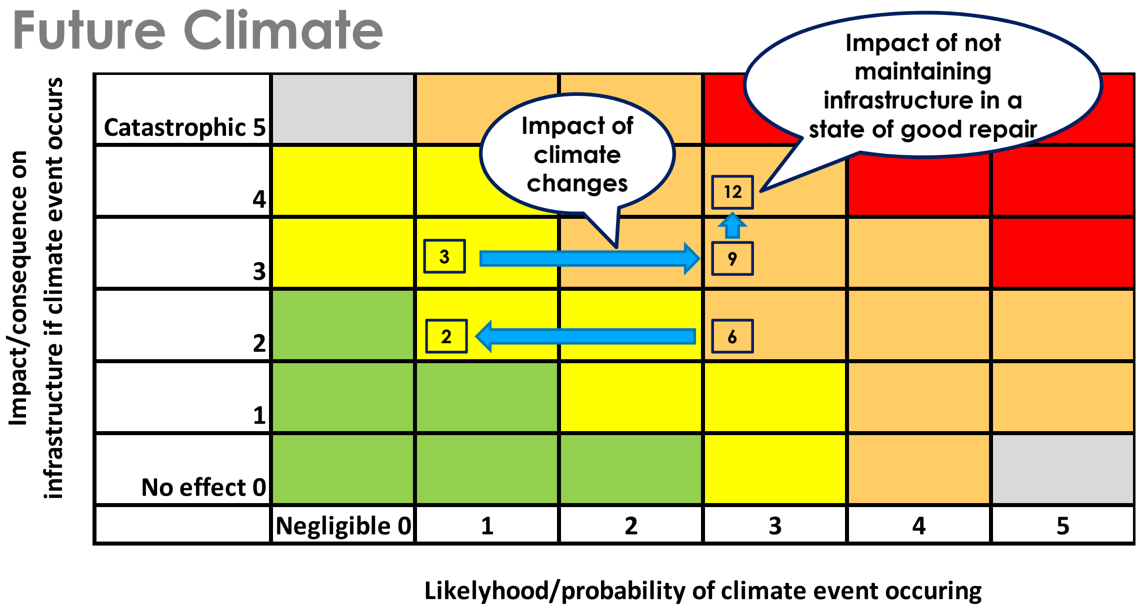
Future Climate



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The FN PIEVC Risk Matrix

Infrastructure Components	nfrastructure Response Considerations: Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Environmental Effects	Max. Daily Temp.: Days (per year) with Max Temps > 36°C				Hotest Month (Aug.) Temp.: Very warm August Temps Mean >22.5°C (warmer than August 2012)				Low Precipitation (Aug.): Days with August total precipitation ≤ ~50mm (equal to or less than August 2012)				Combination - Aug. High Temp. with Low: Combination August Warm Temperatures & low rainfalls				Fog: Fog visibilities below ½ statute mile (for shipping)				Rain - 7 day period: > 120 mm rainfall in 7 days			
	Mark Relevant Responses with ✓						Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Cornwall Island								5				6				5				4				3				3		
Water Supply System																														
Water Treatment Plant																														
Building structure	✓	✓	✓		✓																									
Building envelope	✓	✓	✓		✓																									
Roof	✓	✓	✓		✓																									
Process equipment		✓	✓		✓												4	20			5	20								
HVAC system	✓	✓	✓		✓								3	18							3	12								
Foundations	✓																												1	3
Site services	✓	✓	✓		✓	✓																								
Storage and/or alternate use	✓	✓	✓		✓																								3	9
Access road	✓	✓	✓		✓																									
Environment (plants, trees, animals)						✓							3	18			5	25			6	24								
Environment (soil conditions)																	2	10			3	12							3	9
Backwater disposal	✓	✓	✓	✓	✓																									
Biosolids/sludge disposal			✓		✓																									
Communications / SCADA/Telemetry	✓	✓	✓		✓																									
Back-up power (generator, fuel storage)	✓	✓	✓		✓																									
WTP - High Lift Pumps	✓	✓	✓		✓																									
WTP - Reservoir		✓															5	25			5	20								
WTP - Intake	✓	✓	✓		✓																									
WTP - Low Lift Pump	✓	✓	✓		✓																									

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Assessment of the CC Vulnerability of the W/WW of Moose Factory

Infrastructure Definition Process

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Water/Wastewater Infrastructure at Moose Factory

Identify the components of the infrastructure to be assessed in general terms

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Infrastructure Definition

- Define the global project parameters and boundary conditions for the engineering vulnerability assessment. :
  - Which infrastructure is being assessed;
  - Its location;
  - Climatic, geographic considerations;
  - Define performance criteria; and
  - Uses of the infrastructure.
- First step of narrowing the focus to allow efficient data acquisition and vulnerability assessment.

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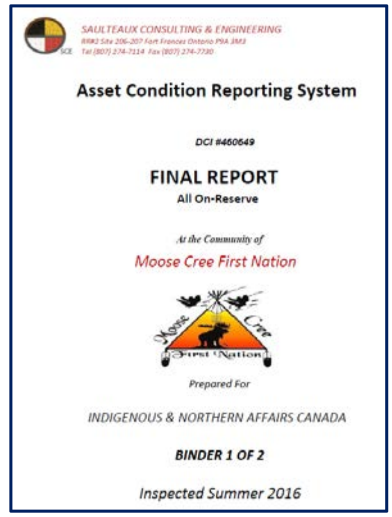
Infrastructure to be Assessed

Main components

- Potable Water
- Wastewater
- Administration and operations
- Third party services
  - Telecommunications
  - Electricity
  - Fuel supply


SAULTEAUX CONSULTING & ENGINEERING

Asset Condition Reporting System

DCI #460649

FINAL REPORT

All On-Reserve

At the Community of

Moose Cree First Nation

Prepared For

INDIGENOUS & NORTHERN AFFAIRS CANADA

BINDER 1 OF 2

Inspected Summer 2016

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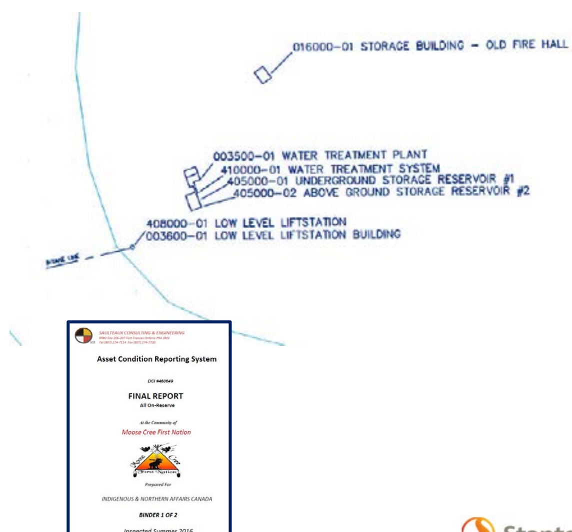
Potable Water System

- Intake
- Low lift station (at intake)
- Water treatment plant
- Storage tanks (underground and above-ground)
- Transmission main (250mm)
- Distribution mains (150mm)
- Hydrants



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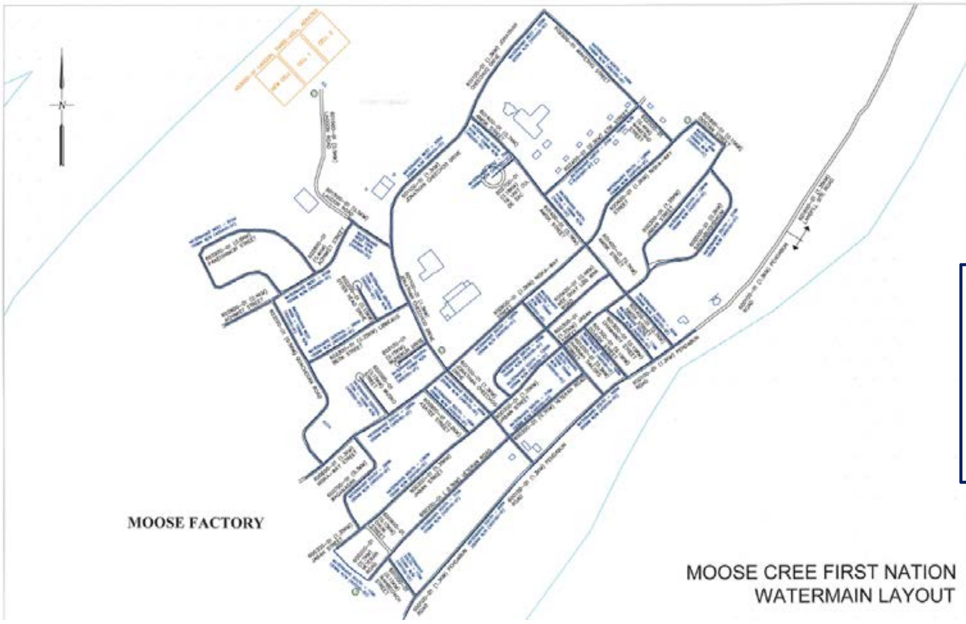

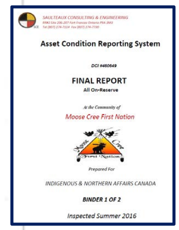

MOOSE CREE FIRST NATION
WATERMAIN LAYOUT

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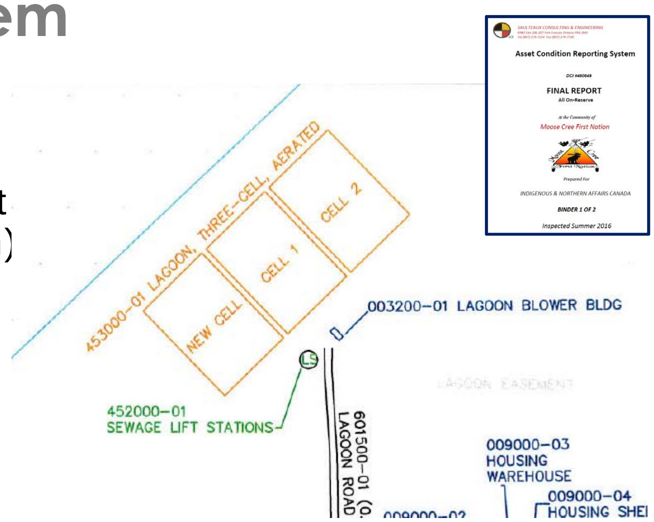
Moose Cree First Nation

Wastewater System

- Collection (sewer mains) from 200mm to 400mm
- Sewage lift stations (#1 at lagoons, #2 to #4 in town)
- Aerated lagoon cells (3)
- Blower system



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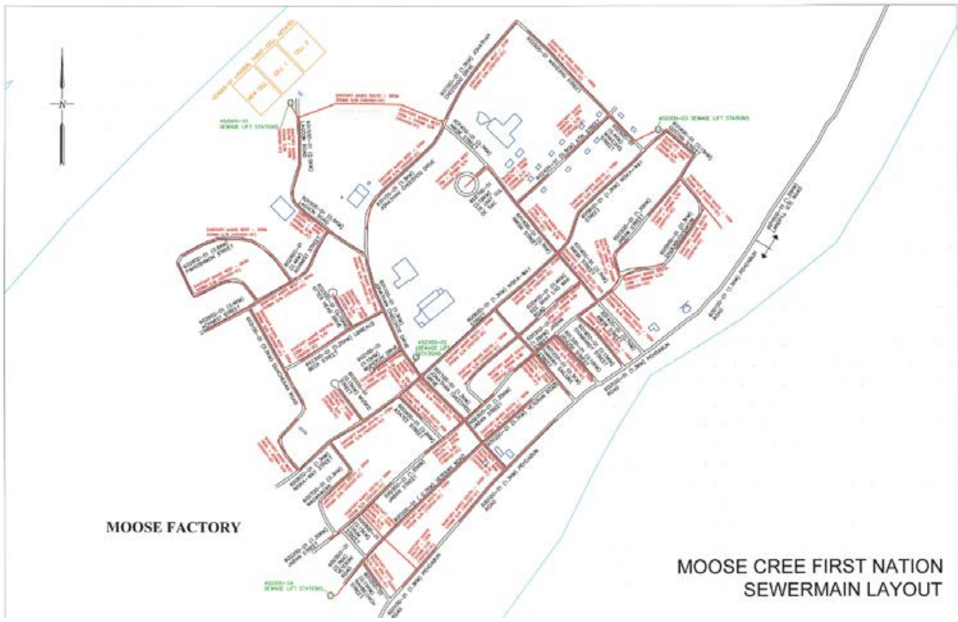

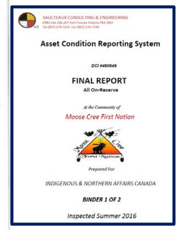

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Administration and Operations

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- Other buildings and yards
  - Public works garage and shed
- Vehicles and fleet
- Personnel
- Third party suppliers
- Island access
- General road network

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Buildings – general breakdown (not all apply)

- Building Structure
- Building Envelope
- Roof
- Foundations
- Process equipment
- HVAC
- Electrical systems
- Scada/communications
- Storage
- Site services
- Access road
- Backup generator

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Establish the Infrastructure Performance Criteria

"If a climate event impacts the infrastructure, how will the condition and performance be affected?"

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Infrastructure Components	ACRS	Performance Considerations					Climate Elements																			
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- Building envelope																										
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- Foundations																										
- Process equipment																										
- HVAC system			✓	✓			Y				Y				N				N							
- SCADA																										
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- Electricity																										
- Site services																										
- Access road																										
- Third party supplies																										
Administration and Operations																										

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1. Structural Capacity

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Load carrying capacity
- Fracture / Collapse
- Fatigue
- Access
- Deflection / Permanent deformation
- Cracking and deterioration
- Foundations

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2. Functionality

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Effective Capacity of the infrastructure to provide the intended service
  - Short term
  - Medium term
  - Long term

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3. Operations

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Occupational safety
- Access to worksite
- Equipment performance
- Maintenance and replacement cycles
- Electricity demand
- Fuel use
- Materials Performance
- Changes from design expectation

4. Environment (Land)

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With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Vegetation cover
- Absorption properties
- Trees
- External elements (not attached to building)
- Erosion

5. Environment (Water)

With respect to the infrastructure or infrastructure component being assessed, climate loading may affect:

- Erosion along streams, rivers, and ditches
- Erosion scour of associated or supporting earthworks
- Slope stability of embankments
- Sediment transport and sedimentation
- Channel realignment / meandering
- Water quality
- Water quantity
- Run off

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Confirm Rating scales

Climate

Score	Probability	
	Method A	Method B
0	Negligible Not Applicable	< 1 in 1,000
1	Highly Unlikely Improbable	1 in 100
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Impacts on Infrastructure

Score	Descriptor	Provide Example
0	No Effect	
1	Insignificant	
2	Minor	
3	Moderate	
4	Major	
5	Catastrophic	

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Example - Oneida

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Moose Cree First Nation

Score and Description	Consequence
0 No effect	No Damage Fully functional – continues to perform as intended
1 Insignificant	Can be corrected through the regular maintenance cycle
2 Minor	Requires sending repair crew No replacement of major components or asset Repair parts usually stocked and readily available May need further assessment
3 Moderate	Needs attention Requires repair crew and replacement of components Repair parts may not be available and require ordering Will need further assessment
4 Major	Collapse. Total loss that requires full replacement. Little or no impacts on other elements of asset or other assets
5 Catastrophic	Collapse. Total loss that requires full replacement. Will require relocating people and/or functions Impacts on other elements of asset or other assets May have impacts on health and safety

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Impacts on the service or the community if the infrastructure fails

1. Emergency Response

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Procedures and systems to address:
  - Severe storm events
  - Flooding
  - Ice dams
  - Water damage

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Moose Cree First Nation

2. Insurance and Legal Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Insurance rates
- The ability to acquire insurance
- Insurance policy limitations and exclusions
- Legal impacts and liability

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3. Policy Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Codes
- Guidelines
- Standards
- Internal operations and maintenance policies and procedures
- Levels of Service policy
- Land use planning

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4. Social Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Accessibility to critical facilities such as hospitals, fire and police services
- Energy supply to a community
- Dislocation of affected populations
- Provision of basic services such as potable water distribution and wastewater collection
- Closure of schools and other public services
- Destruction or damage to heritage buildings, monuments, etc. or historically important resources

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5. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

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6. Fiscal Impacts

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Drain on current/future financial resources to deal with unplanned repairs, maintenance and/or replacements
- Shifting financial resources from other community priorities
- Impacts on services and/or levels of service
- Community economic impacts and/or hardships

Application of the Draft FN PIEVC/AM Toolkit: Moose Factory

Climate Considerations – Weather Station Data and Projections

From Workshop #2

- 2013 – 2014 - end of March ?
  - Tidal event: Fort Albany flooding; "ramp dropped"; not a "normal" tide
- 3 winter storms a year:
  - February: blizzard
  - Early and end of March
- April: snowmelt causing flooding
- Gravel hauling: use to be until end of March; now finish earlier because of winter road not available

From Workshop #2 (continued)

- Sand bars in the river shifting: occurs in early May causes clogging in the spring → increase in raw water turbidity
- 2015: power failure due to an ice storm
  - Ice storms occurring every 3-5 years
  - February to April?
- Extreme cold → power lines "snapped" around 2008 – Temp around -50°C
- Wind? To check with tidal events
- Ice break-up (ice backs-up water causing flooding)

From Workshop #2 (continued)

- Occurrence of winter lightning – unusual but more frequent now
- Increase occurrences of winter rain events: increases loads on roofs; fire hydrants [ice cover?]
- Winters getting warmer

What we also heard

Trevor Koostachin, Public Works Manager of Attawapiskat First Nation

- During the past 10 years cold weather has been occurring later in the calendar year while warmer weather has been occurring earlier in the Spring. Shorter winter season overall.
- Usually the area would receive 1 instance of warm weather in March followed by colder weather to carry out in the Spring until late April. The past few years the area has received 2-3 instances of warm weather in the winter as early as January.
- Generally experienced high winds from 2015-2016.
- Rainfall was extremely low Summer of 2017.

What we also heard

Leo Metatawabin , Environmental Steward - Fort Albany

- Occasions of thunder in 2016 generally high. Lightning occurred February 2016.
- Summer 2017 unusually dry. The area has generally been receiving continuously less rainfall year after year.
- 2006 Kashechewan flooding.
- Shortened winter road seasons. Late winter, early spring.

Climate Elements to Consider

General information on projections

Discussion on past events that have caused infrastructure disruptions and/or damage

Moose Factory WTP

Project Status Update Report

Asim Masaud, M.Sc., P.Eng., PMP

Elvio Zaghi, MBA, P.Eng

Wed, July 25 2017

ONTARIO CLEAN WATER AGENCY
AGENCE ONTARIENNE DES EAUX

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2 Climate Change

Extreme river conditions are and will continue to occur more frequently and will severely impact the function and integrity of Plant's Water Intake

i. **Extreme low liquid levels** – recent tidal effects have jeopardized plant operation. The river liquid level was too low for the existing intake to draw water

ii. **Extreme Ice Flows** – spring thaws have caused extreme ice floe events that severely damaged the intake structure

iii. **Extreme Flooding** – extreme flooding events during spring thaw have caused flooding of plant's site and jeopardized the low lift pump building at the intake structure

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2 Raw Water Quality Impacts

ONTARIO CLEAN WATER AGENCY
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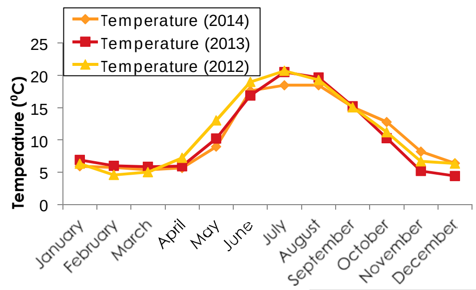
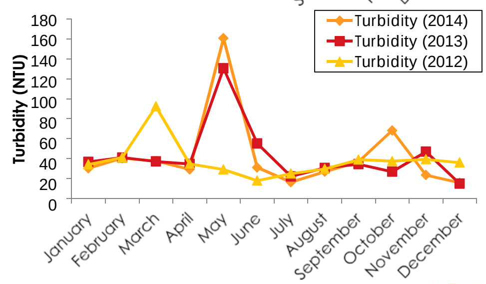
Climate Considerations

- **Seasonality**
  - Ice dams
  - Turbidity spikes (>140 NTU) during spring melt
- **Tidal Effects**
  - Semi-diurnal tide (low tide occurs twice per day)
  - Enhanced by wind speed and direction
  - Strong winds have been linked to extremely low water levels at Moose Factory Island Intake
  - Flow reversals are common





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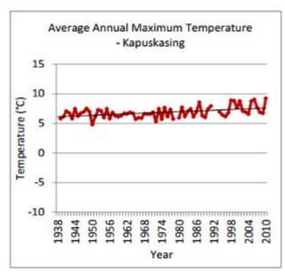
Slide 47

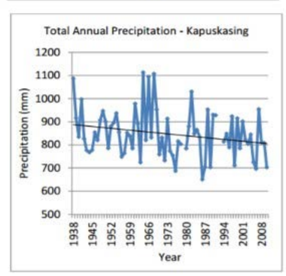
2 Raw Water Quality Impacts

ONTARIO CLEAN WATER AGENCY
AGENCE ONTARIENNE DES EAUX

Climate Change Impacts

- **Warmer winter and spring temperatures**
  - Reduced ground frost, snow
  - Increased freezing rain
- **Temperature variability**
  - Late September: 4ºC in morning and 25ºC in afternoon is common
- **Changes in precipitation**
  - Lower water levels
- **Increasing intensity of storms and wind**
  - Flooding
- **Potential increases in upstream agriculture**
  - 1 million acres of underutilized land in the clay belt in the watershed (near Kapuskasing)
  - Longer growing seasons
  - Greater potential for algae growth





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Slide 48

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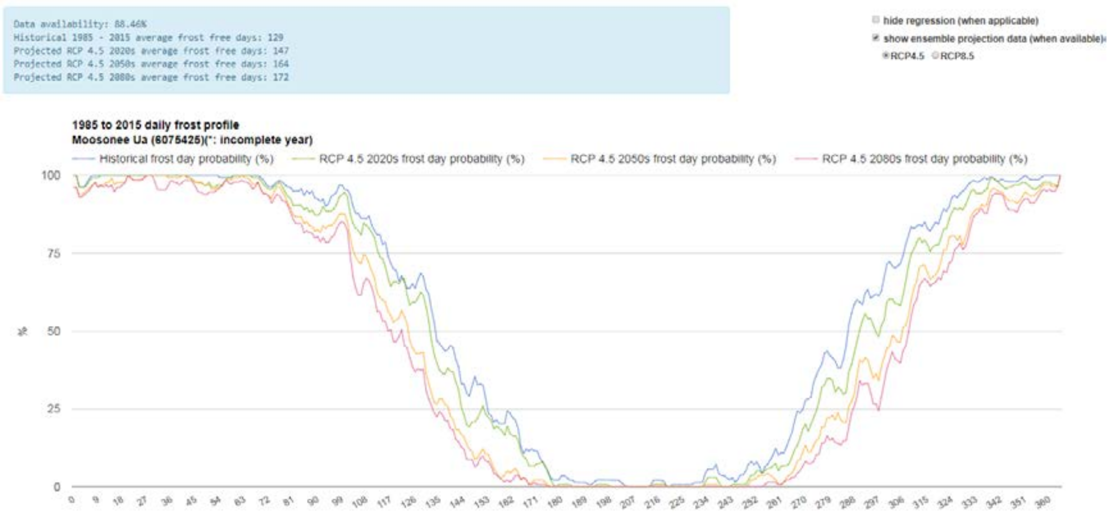
Moose Cree First Nation



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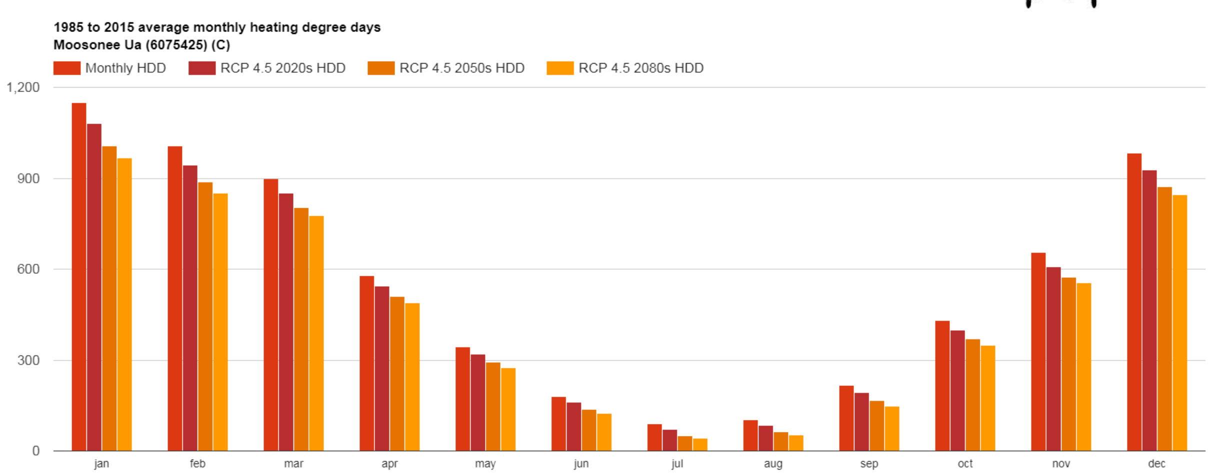
Moose Cree First Nation



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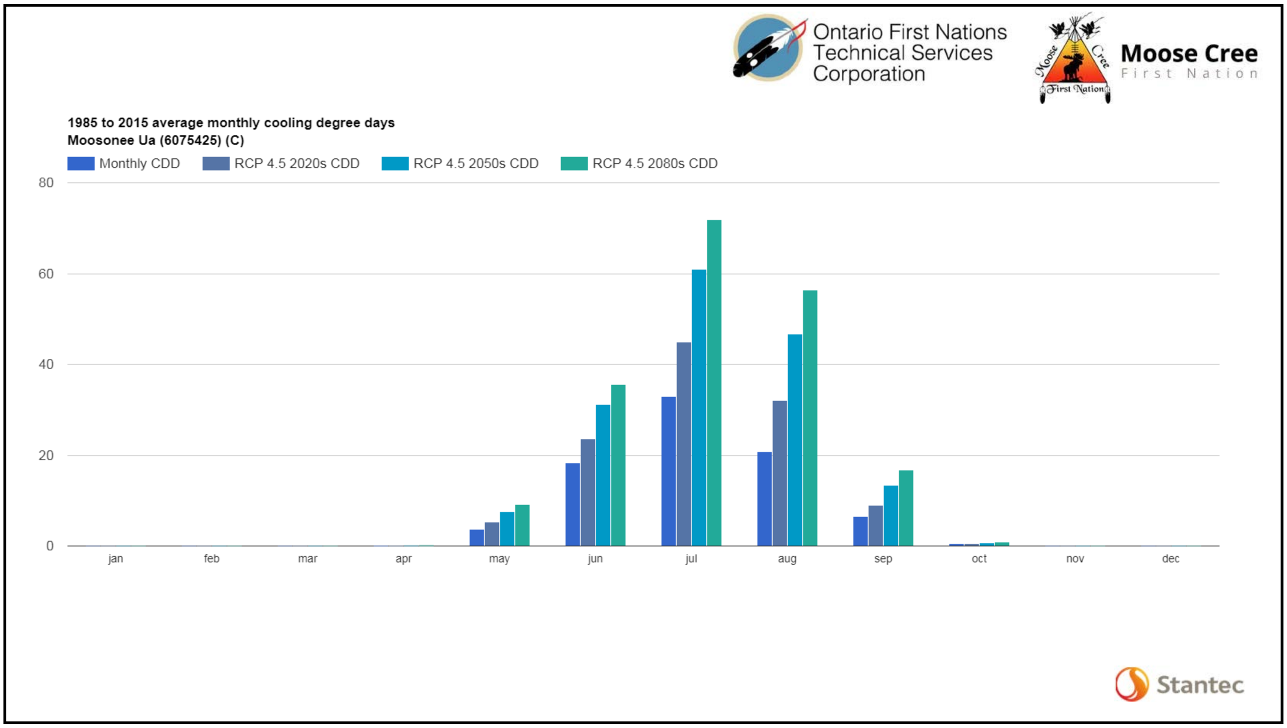

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
1985 to 2015 average monthly cooling degree days
Moosonee Ua (6075425) (C)
Monthly CDD
RCP 4.5 2020s CDD
RCP 4.5 2050s CDD
RCP 4.5 2080s CDD
80
60
40
20
0
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
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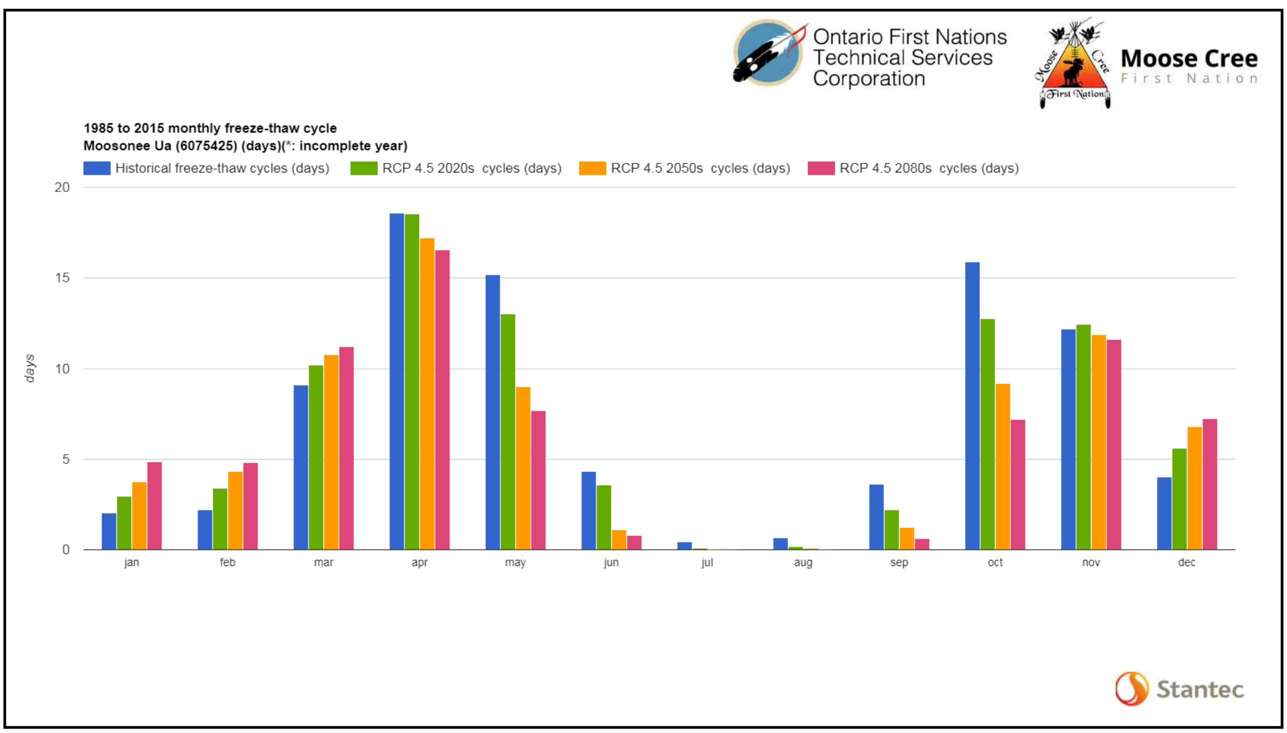

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Moose Cree First Nation
1985 to 2015 monthly freeze-thaw cycle
Moosonee Ua (6075425) (days)(*: incomplete year)
Historical freeze-thaw cycles (days)
RCP 4.5 2020s cycles (days)
RCP 4.5 2050s cycles (days)
RCP 4.5 2080s cycles (days)
days
20
15
10
5
0
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
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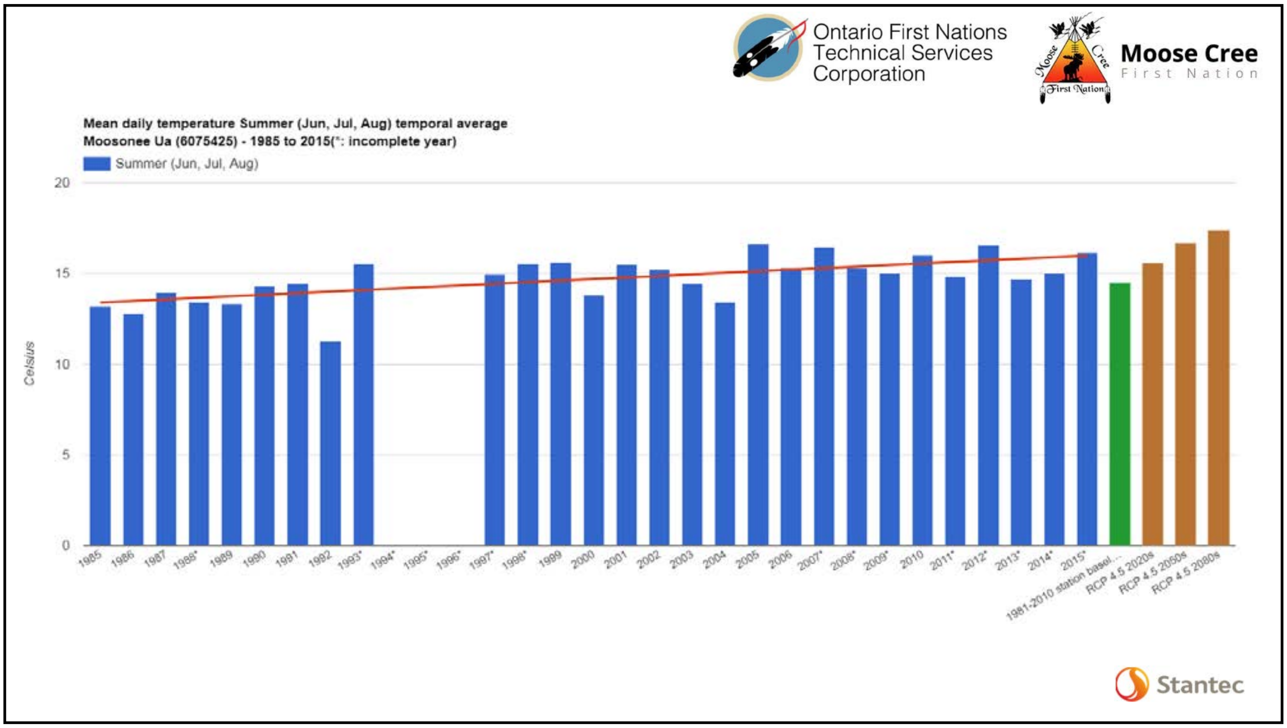

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Mean daily temperature Summer (Jun, Jul, Aug) temporal average
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
Summer (Jun, Jul, Aug)
Celsius
1981-2010 station basel...
RCP 4.5 2020s
RCP 4.5 2050s
RCP 4.5 2080s
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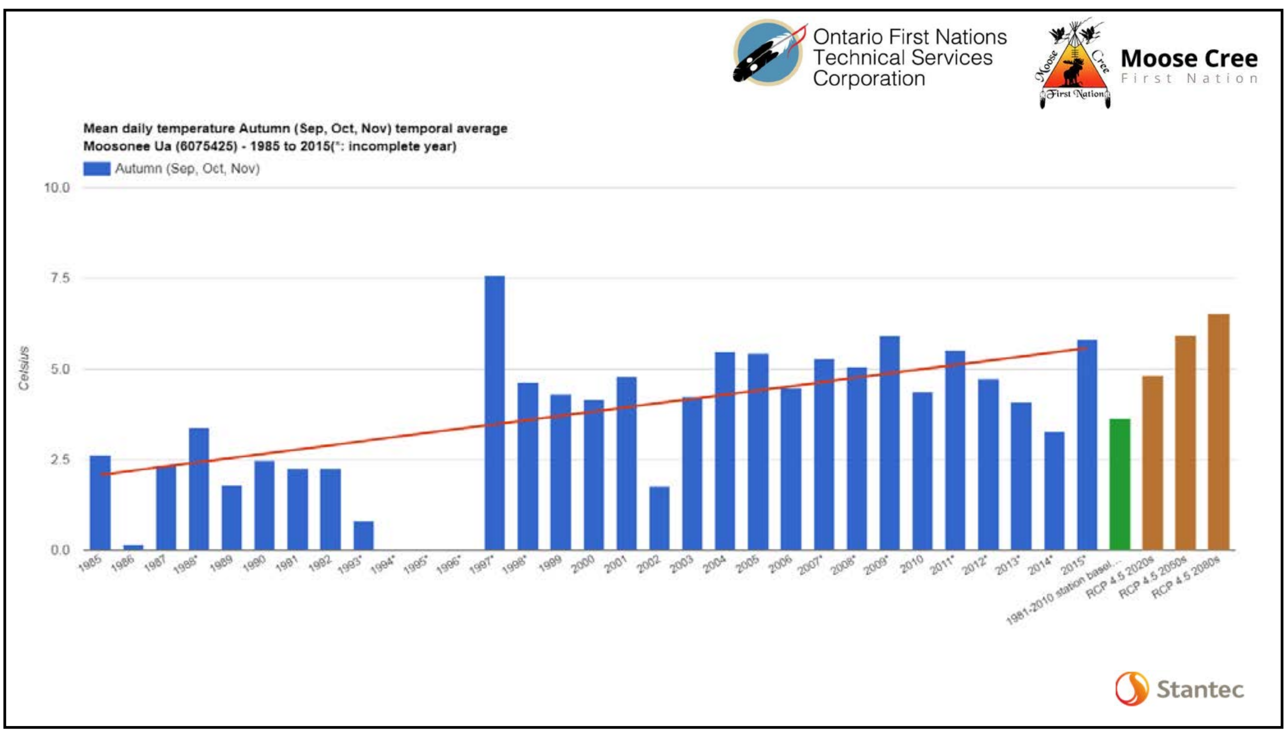

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Mean daily temperature Autumn (Sep, Oct, Nov) temporal average
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
Autumn (Sep, Oct, Nov)
Celsius
1981-2010 station basel...
RCP 4.5 2020s
RCP 4.5 2050s
RCP 4.5 2080s
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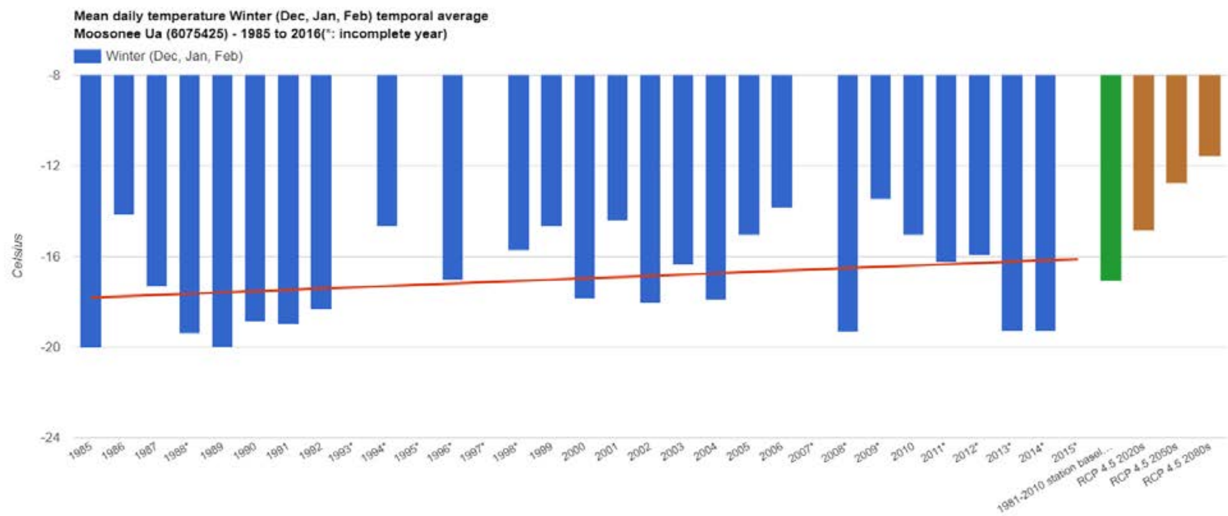
Ontario First Nations Technical Services Corporation

Moose Cree First Nation



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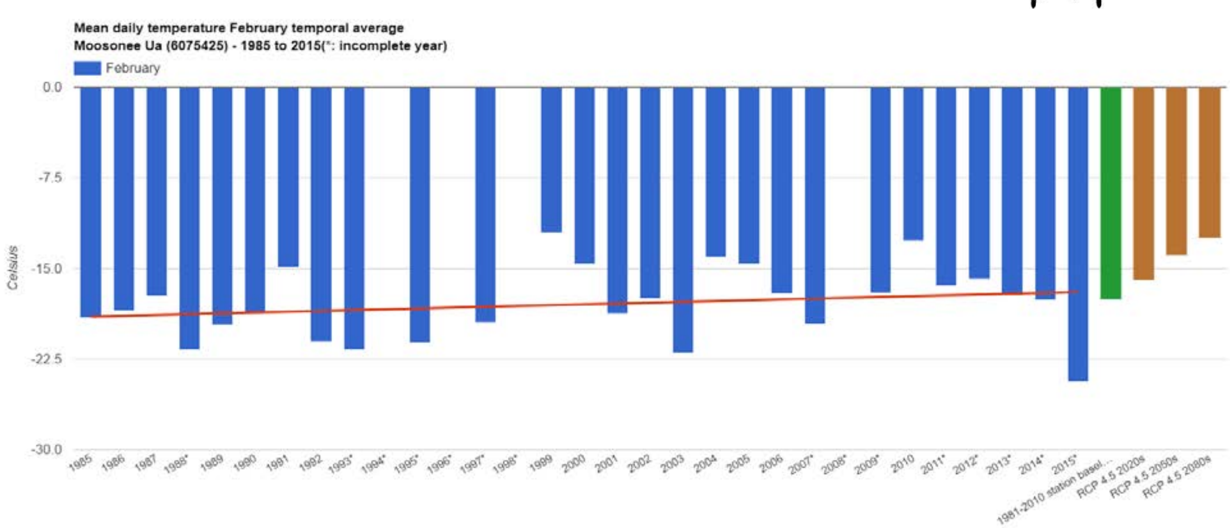
Moose Cree First Nation



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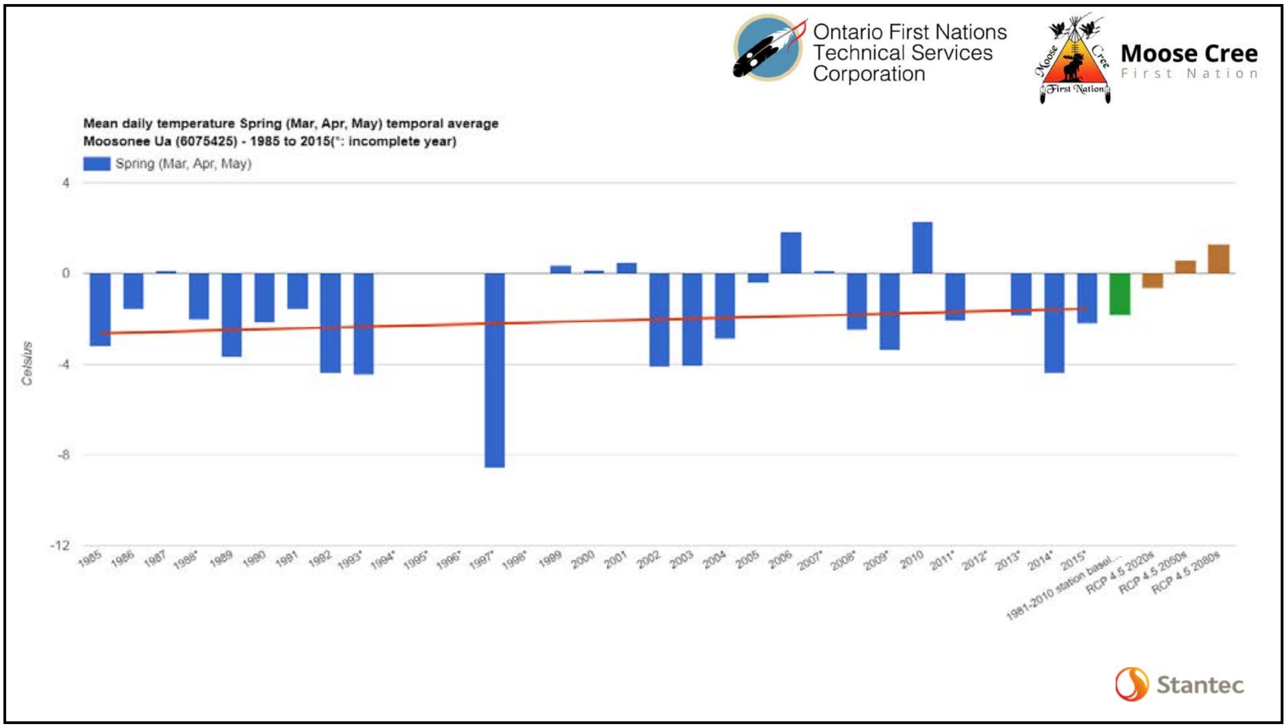
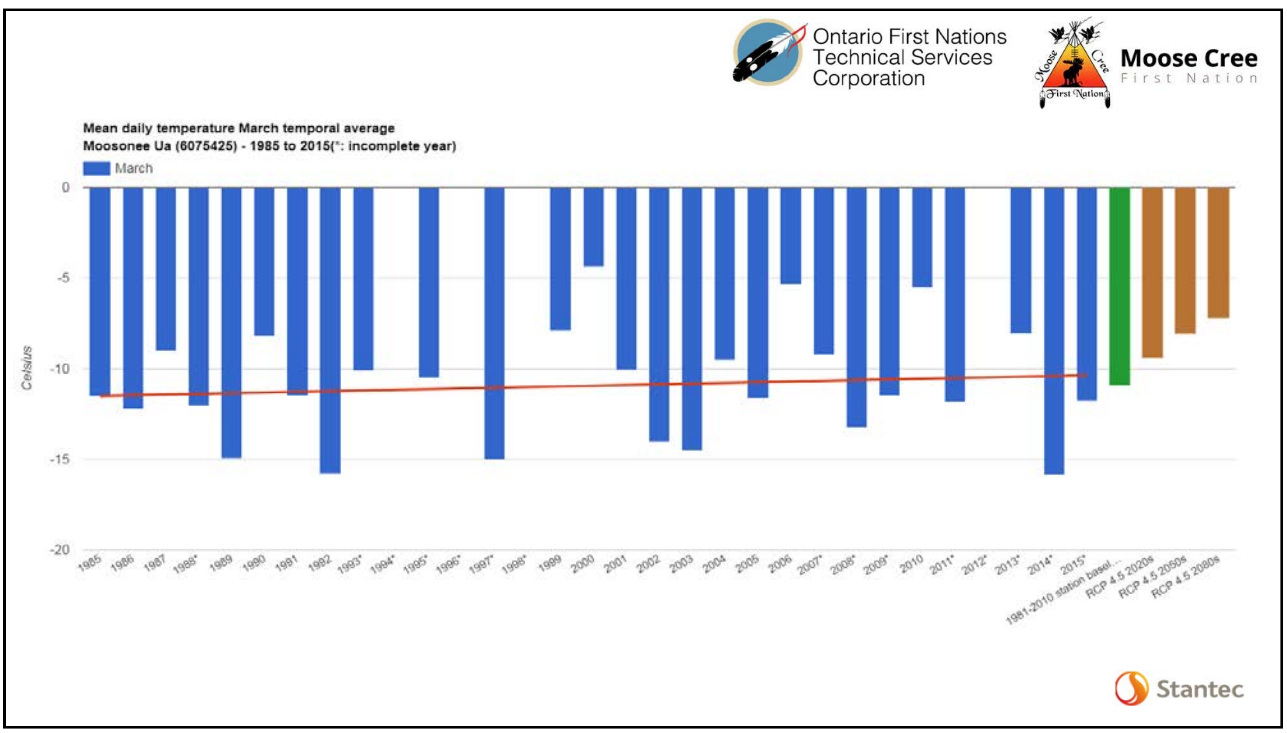
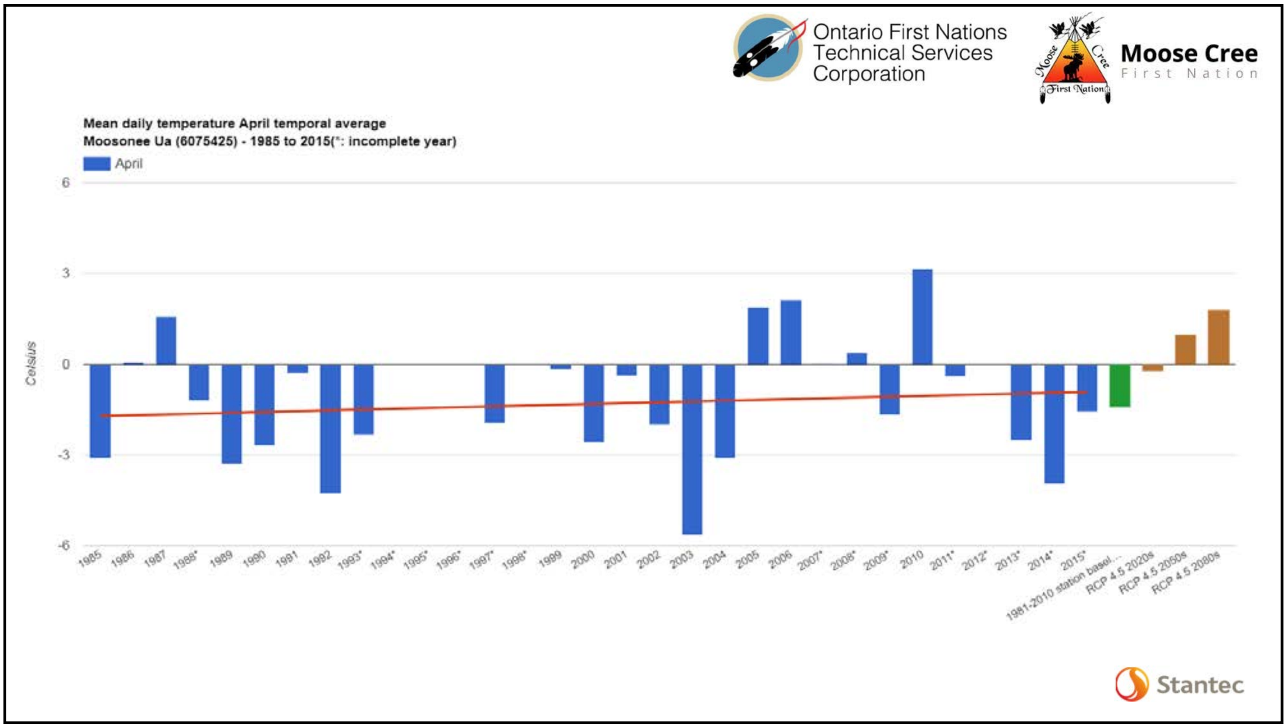
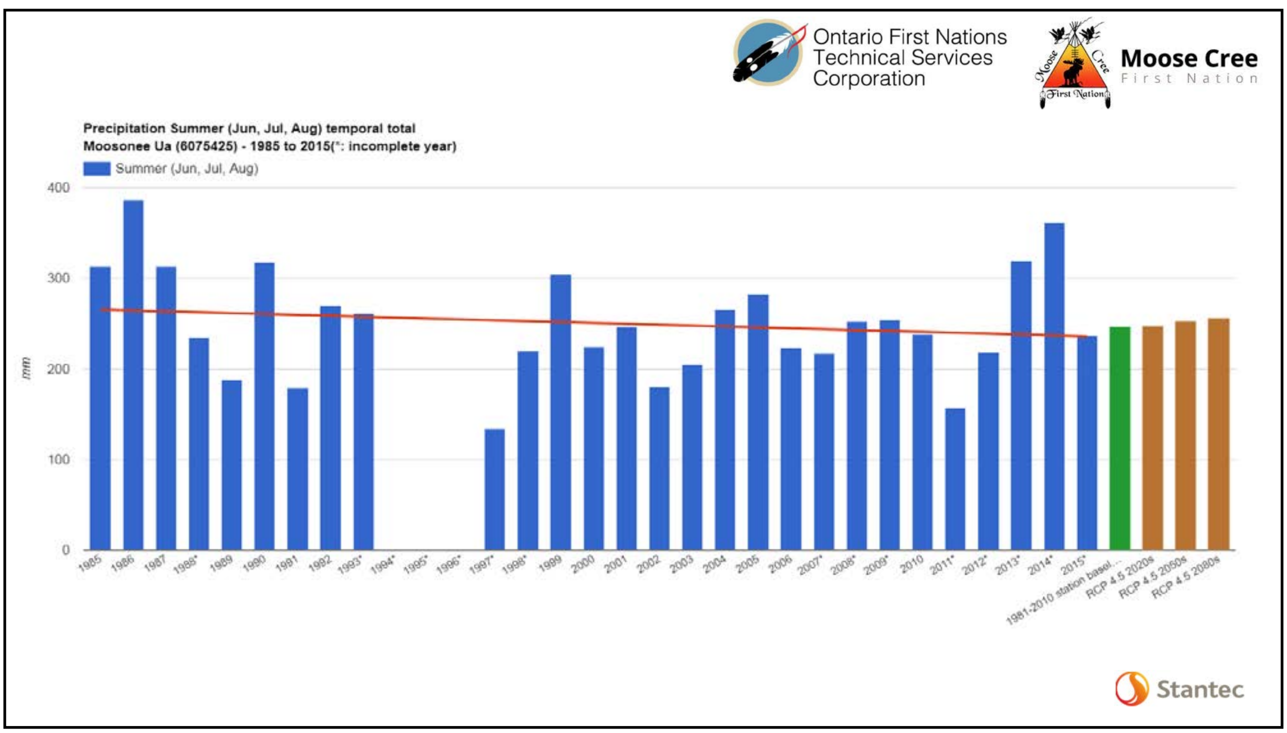

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Mean daily temperature Spring (Mar, Apr, May) temporal average
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
Spring (Mar, Apr, May)
Celsius
Stantec

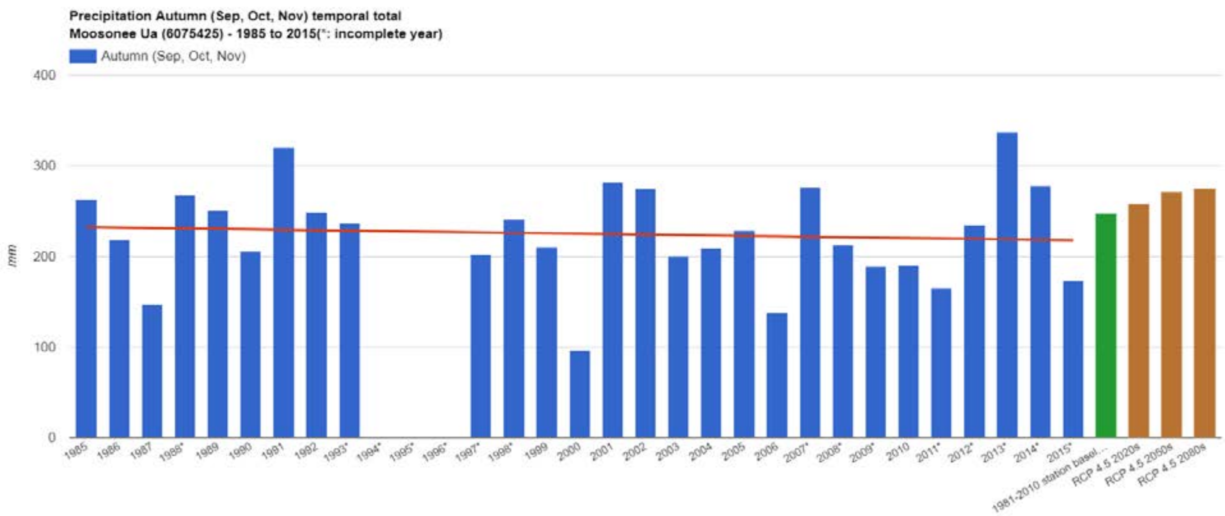

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Mean daily temperature March temporal average
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
March
Celsius
Stantec


Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Mean daily temperature April temporal average
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
April
Celsius
Stantec


Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Precipitation Summer (Jun, Jul, Aug) temporal total
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
Summer (Jun, Jul, Aug)
mm
Stantec

Ontario First Nations Technical Services Corporation

Moose Cree First Nation



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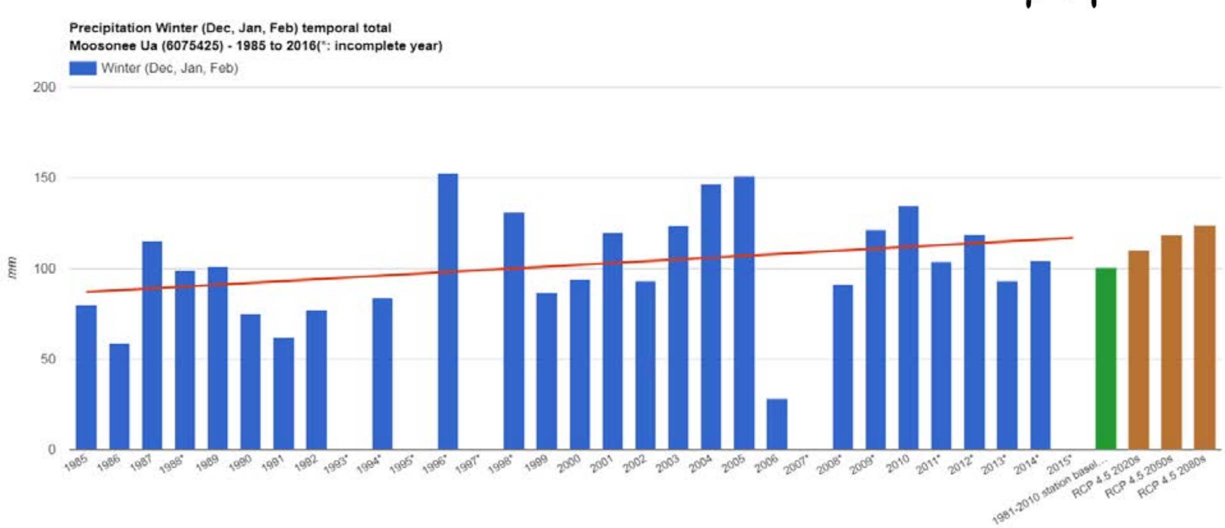
Moose Cree First Nation



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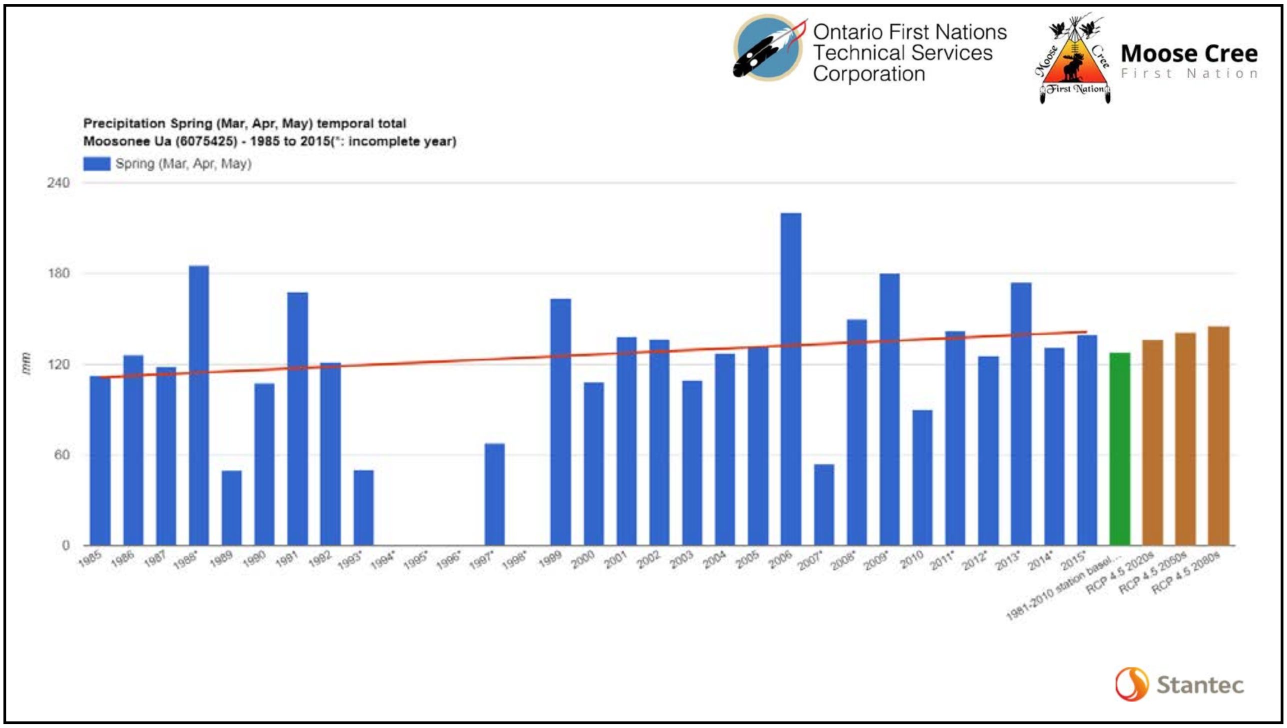

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Precipitation Spring (Mar, Apr, May) temporal total
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
Spring (Mar, Apr, May)
mm
1981-2010 station basel...
RCP 4.5 2020s
RCP 4.5 2050s
RCP 4.5 2080s
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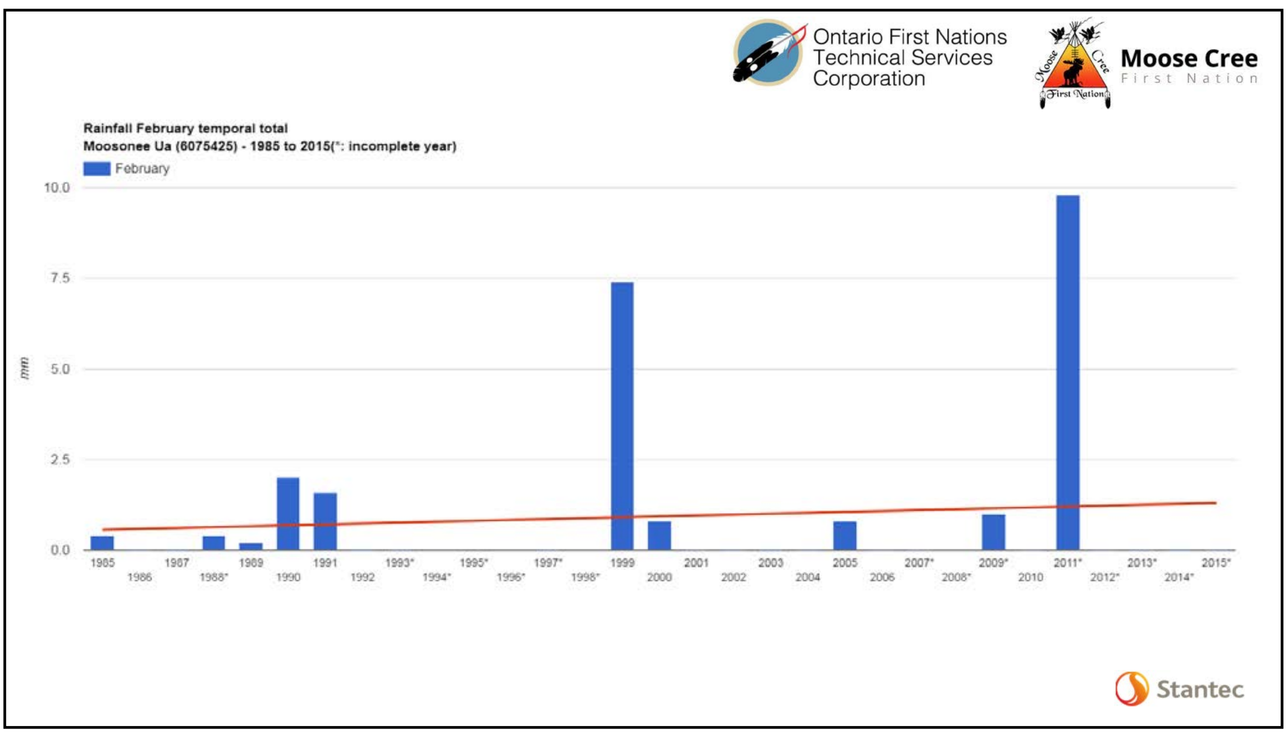

Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Rainfall February temporal total
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
February
mm
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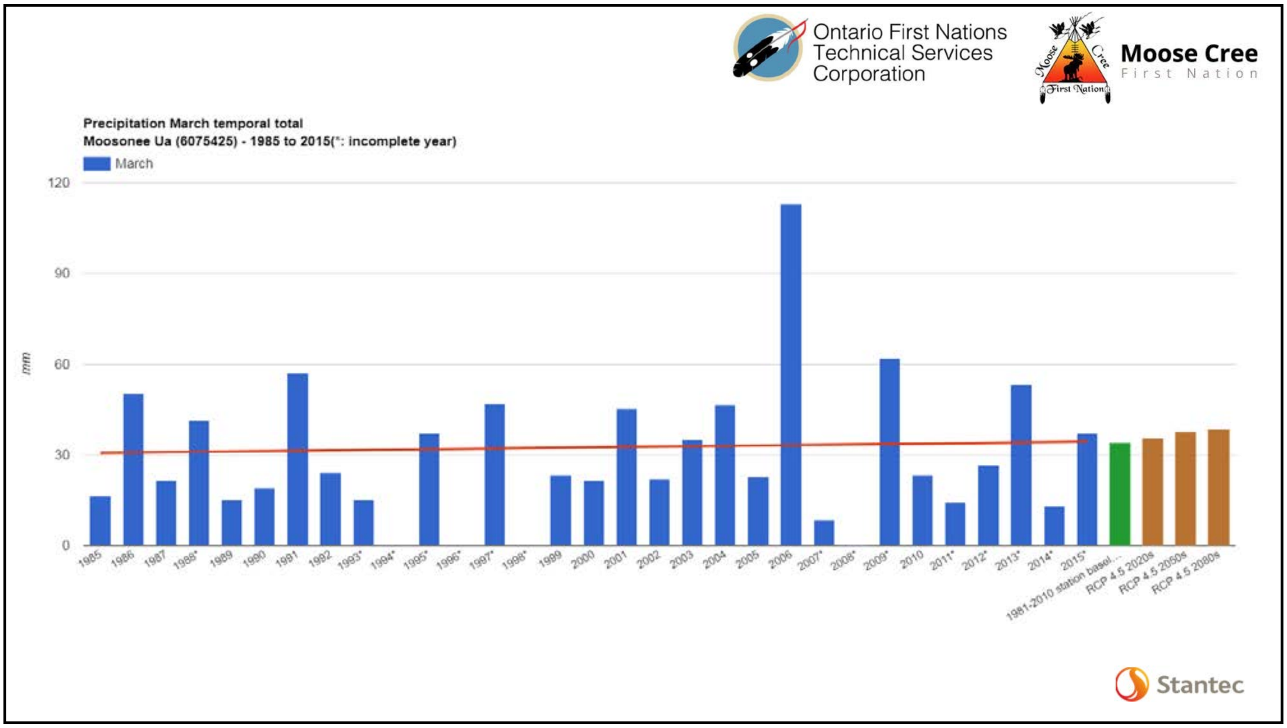
Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Precipitation March temporal total
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
March
mm
1981-2010 station basel...
RCP 4.5 2020s
RCP 4.5 2050s
RCP 4.5 2080s
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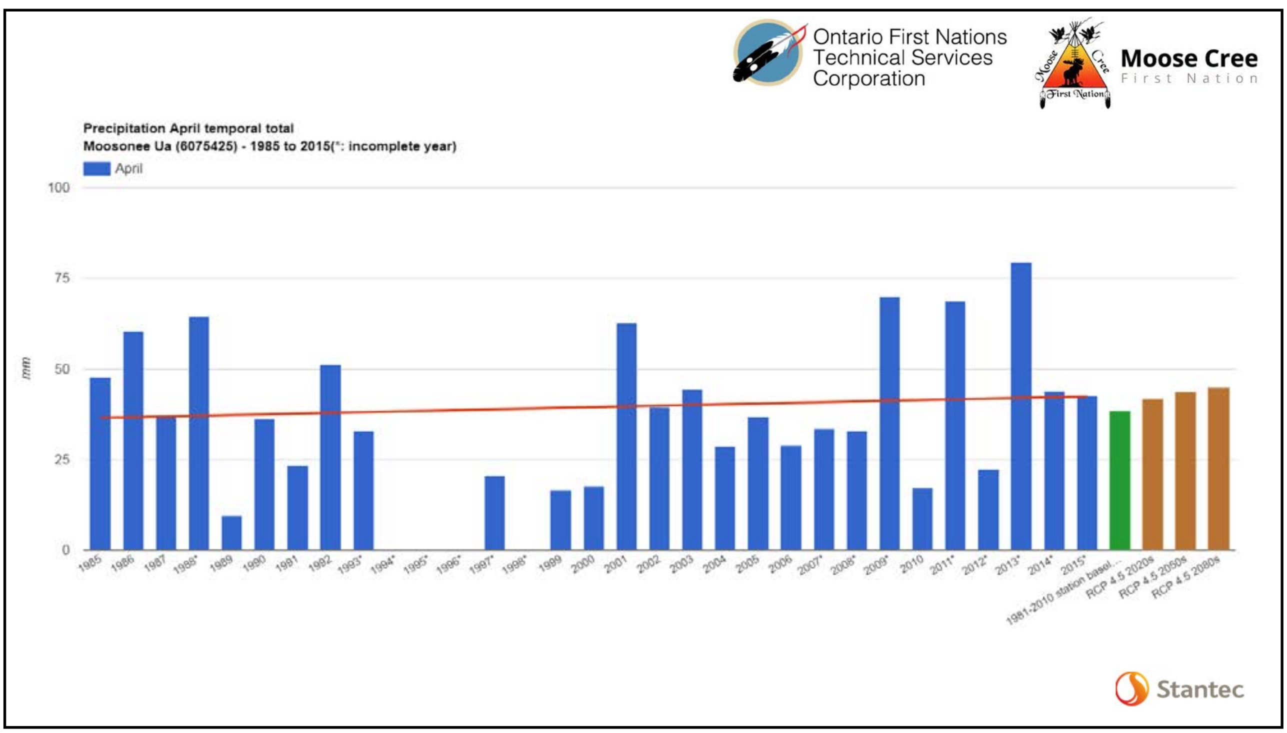
Ontario First Nations Technical Services Corporation
Moose Cree First Nation
Precipitation April temporal total
Moosonee Ua (6075425) - 1985 to 2015(*: incomplete year)
April
mm
1981-2010 station basel...
RCP 4.5 2020s
RCP 4.5 2050s
RCP 4.5 2080s
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IDF – ICLR (not for design)

Current Climate

T (years)	2	5	10	25	50	100
5 min	7.62	10.41	12.15	14.24	15.71	17.11
10 min	9.26	12.50	14.68	17.47	19.56	21.66
15 min	11.22	14.83	17.08	19.75	21.62	23.38
30 min	14.01	18.17	21.04	24.78	27.66	30.59
1 h	16.82	21.26	24.00	27.26	29.53	31.68
2 h	20.24	26.69	31.44	38.06	43.45	49.25
6 h	27.04	36.99	46.97	65.45	85.22	112.07
12 h	32.30	43.50	55.09	77.25	101.65	135.62
24 h	37.94	51.73	65.01	88.69	113.15	145.35

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IDF – ICLR (not for design)

Future (2050's) Climate – RPC 4.5

T (years)	2	5	10	25	50	100
5 min	8.67	12.08	14.26	17.23	19.58	22.00
10 min	10.56	14.49	17.16	21.00	24.22	27.66
15 min	12.76	17.21	20.04	23.90	26.98	30.13
30 min	15.99	21.04	24.54	29.72	34.19	39.08
1 h	19.15	24.64	28.13	32.97	36.90	40.94
2 h	23.14	30.88	36.55	45.28	53.17	62.06
6 h	31.09	42.14	52.99	72.90	94.85	124.86
12 h	37.18	50.28	62.62	86.12	112.15	147.53
24 h	43.64	59.32	74.01	100.11	128.50	165.26

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Moose Cree First Nation

Work on the Risk Matrix

- Infrastructure list
- Performance considerations
- Climate parameters and probabilities
- Interactions: Y/N
- Severity if climate event occurs
- Risk

Asset/Infrastructure Elements	ACRS/ICMS Information					Performance Considerations					1 Max. Temp				2 Seasonal Temp variaions				3 Wind			
	Asset #	Quantity	Units	Year constructed	General condition	Structural	Operations	Functional	Environment (Land)	Environment (Water)	Days with Temp >XX deg. C				Heating and cooling degree days				Exceeding XX km.p.h			
											Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Wastewater System																						
Lagoons	453000			1987	4																	
Lagoon blower building	003200			1986	7																	
Lagoon Road	601500			1985	7																	
Sanitary mains South	450100			1987	7																	
Sanitary mains Central	450200			1991	7																	
Sanitary mains North	450300			1997	7																	
Sanitary mains West	450400			2001	7																	
Sewage lift stations (4)	452000			1987	7-8																	
Potable water system																						
Intake structure																						
Water treatment plant - Building	003500			1990	7																	
Building envelope																						

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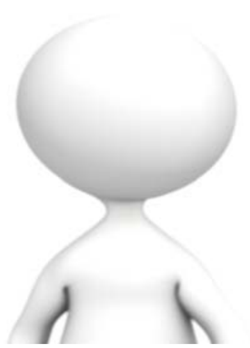
Moose Cree First Nation



Dr. Guy Felio, P.Eng., FCSCE, IRP[Climate]
Guy.Felio@Stantec.com

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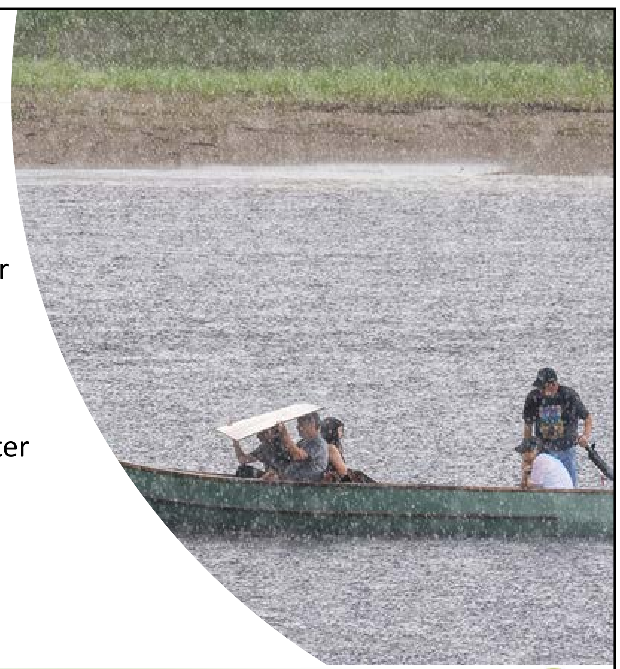
The Changing Climate of the Moose River Area

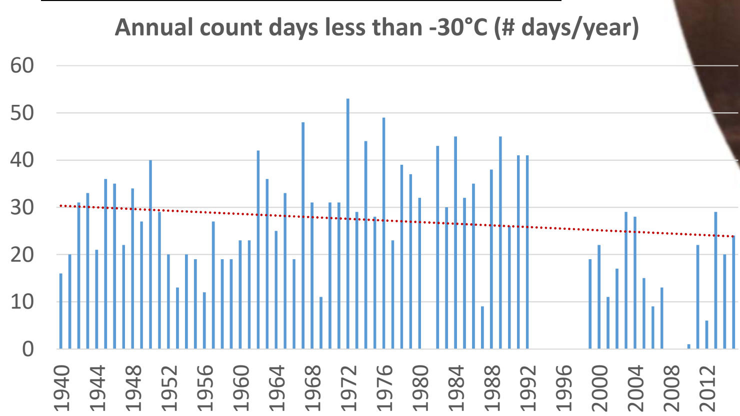
Heather Auld
Risk Sciences International

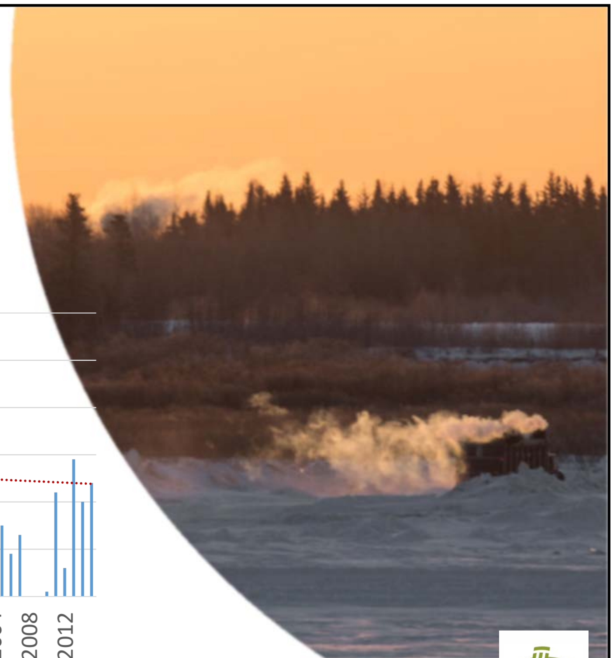
The Changing Climate of the Moose River Area

- Warming over recent decades
- Fewer cold days – but falls and winters likely more variable
- More hots days > 30°C and 35°C; more summer humidity
- Summer rainfall – varying; may be more of the heavy rainfall days. thunderstorms
- Later fall freeze-up and earlier spring break-up
- Shorter winter road seasons – bridging the water taxi and winter road seasons
- More ice jam potential in spring?? More warm days in April, heavier rainfall events
- Winter snowfall varies from year-to-year
- Bigger snow storms? Ice storms

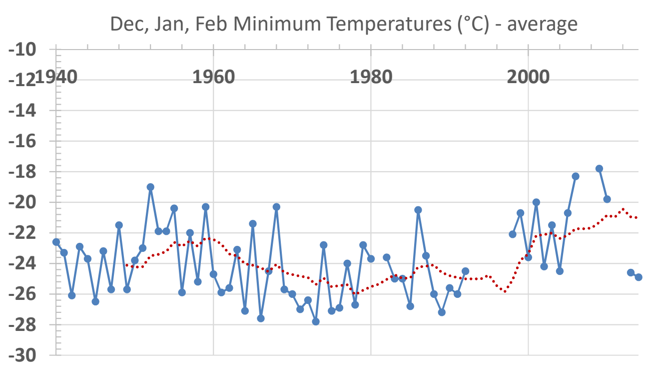


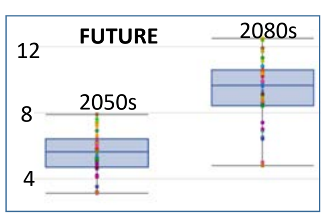
Fewer Very Cold Winter Days and Shorter Winters … Days below -30°C decreasing





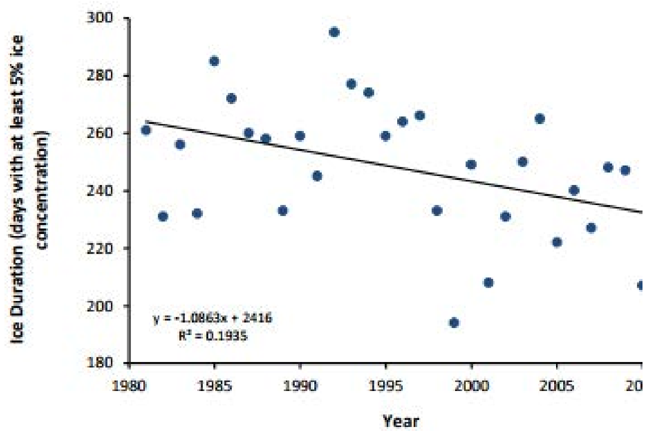
BUT Winters are Variable … Average Winter Minimum Temperatures





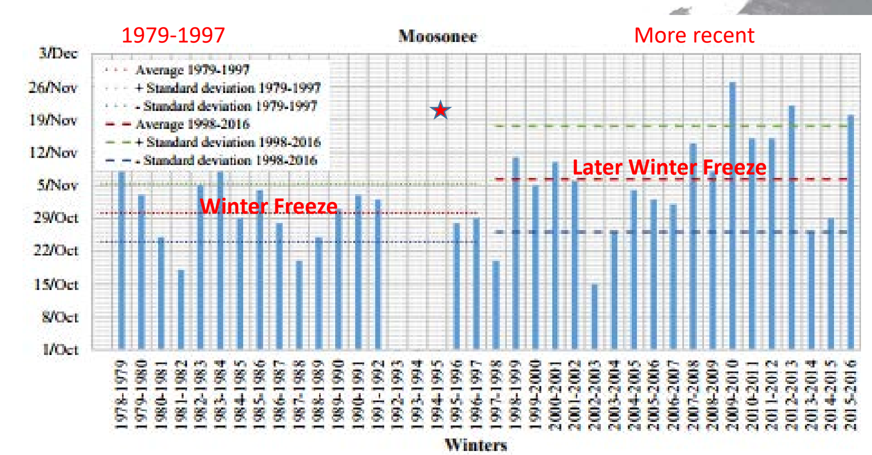
- Winters expected to warm in future by average 6°C
- Sudbury winter temperatures?

Shorter Ice Seasons over James Bay (with 5% or more ice cover)

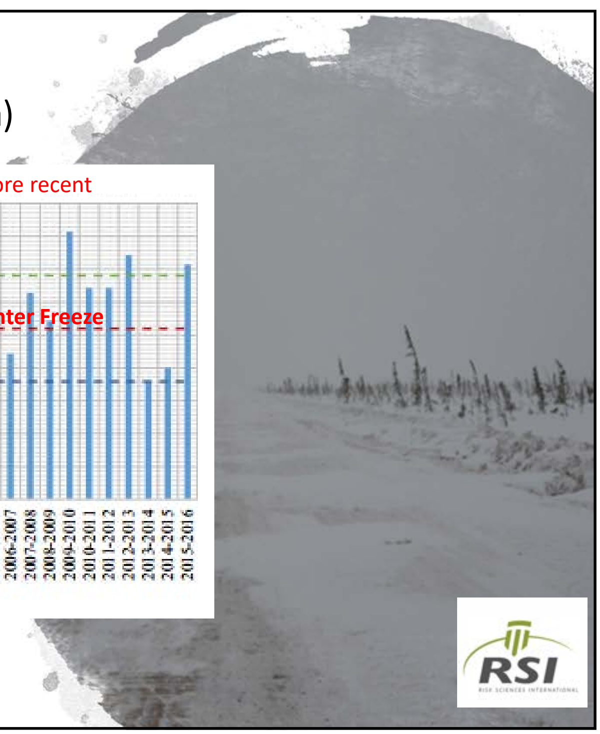


- Every 1°C increase in air temperature = about a 14% decrease in its ice extent (Hudson Bay Basin)
- Every 1°C increase in air temperature = delays freeze-up by nearly a week (0.7-.9)

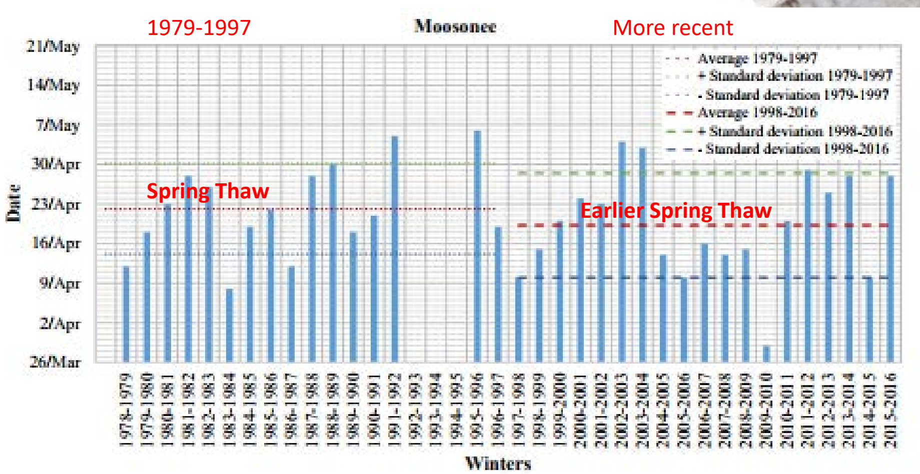
Southern James Bay Winter Freeze-Up … Starts about one week later compared to 1979-1997 period (based on Moosonee data)

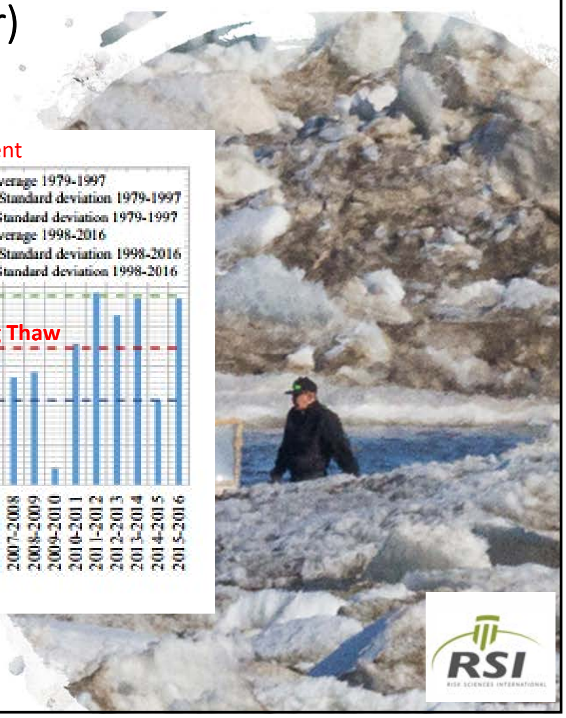


But, can be variable from one year to the next



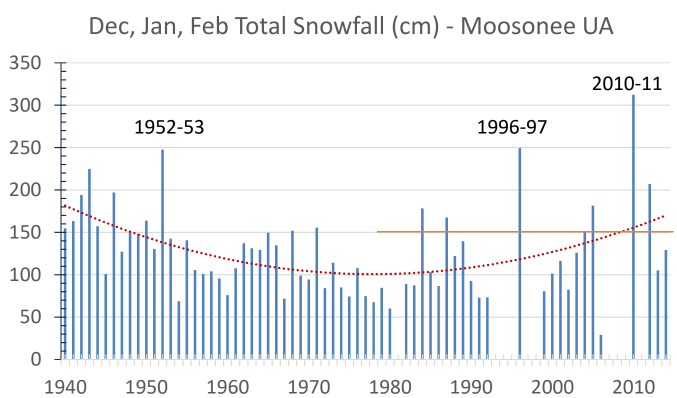
Earlier Spring Break-up (shallow water) … Estimated from Moosonee data





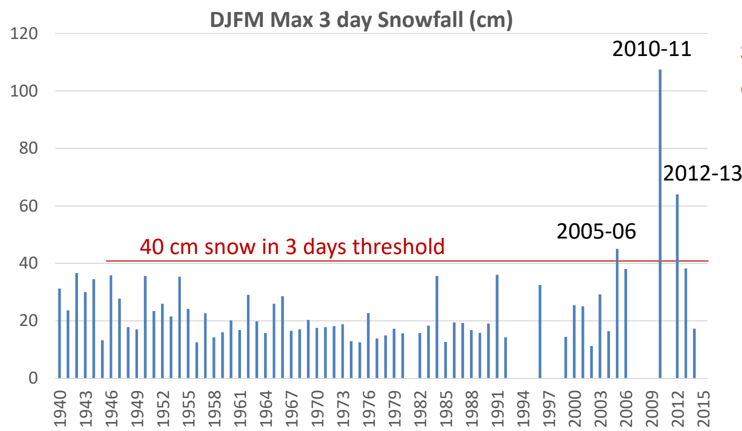
But, can be variable from one year to the next

Dec-Jan-Feb Snowfall Totals/year … James Bay open longer? Variable?



Recent mix of low snowfall and some heavier snow years.

Snow Storms – Max 3-Day Snowstorm Events in cm (DJFM)

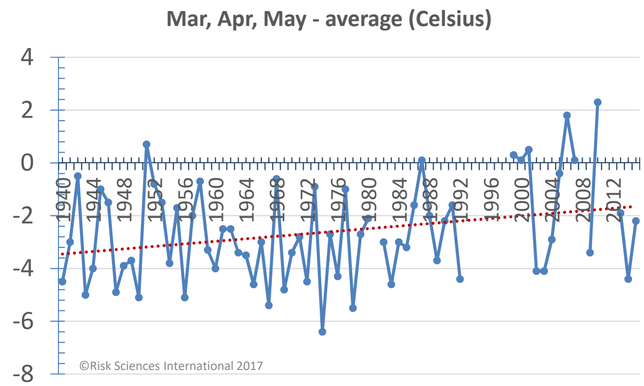


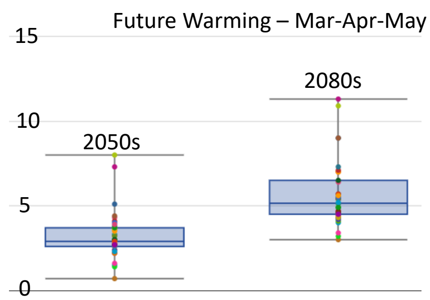
More of the big snowstorm events?

Freezing rain… Ice Storms in future?

- Warmer air can hold more moisture
- With warming winters – more moisture?
- Bigger snow, freezing rain/drizzle, rain events
- With warming winters, potential for more freezing rain, especially in early and late winter

March-April-May Warming … with more to come





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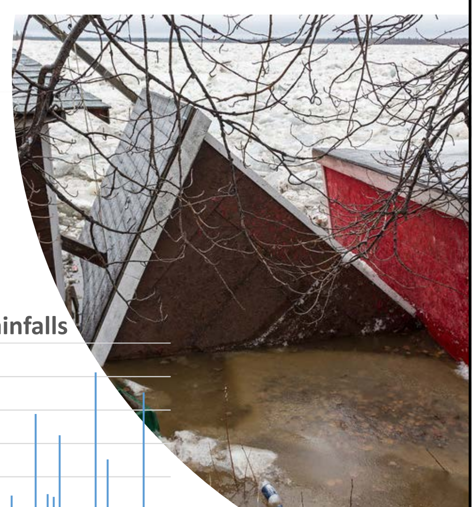
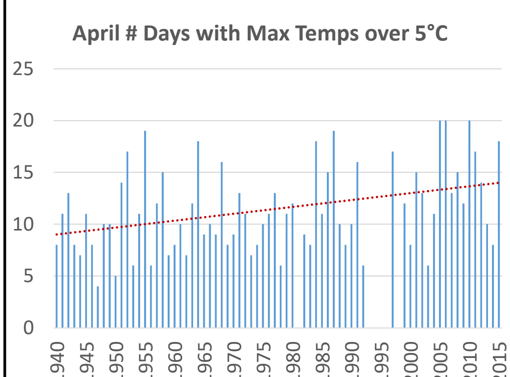
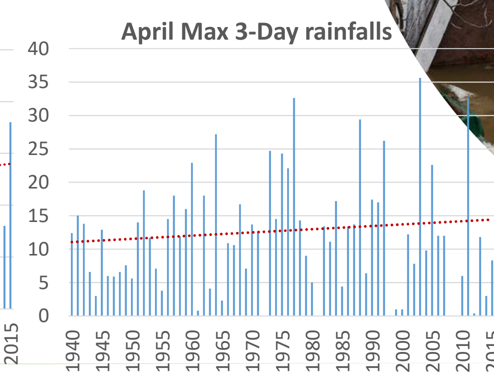
Climate and Ice Jams on the Moose River?

- Weather triggers include rapid warming and melting, intense rainfalls, heavy snowpacks, previous high water
- Potential to increase under changing climate?







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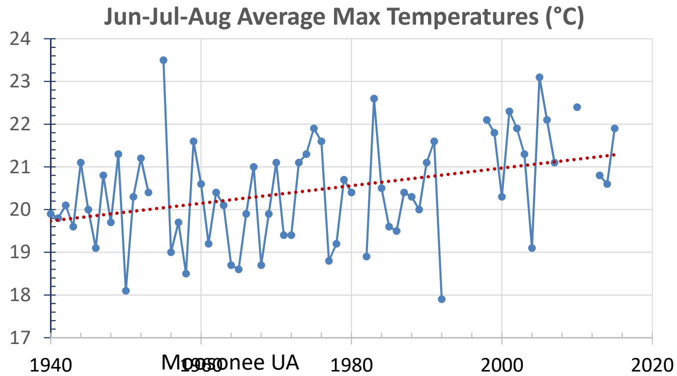
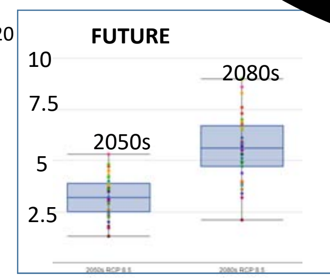
Summer Max Temperatures Warming since 1940: … more to come



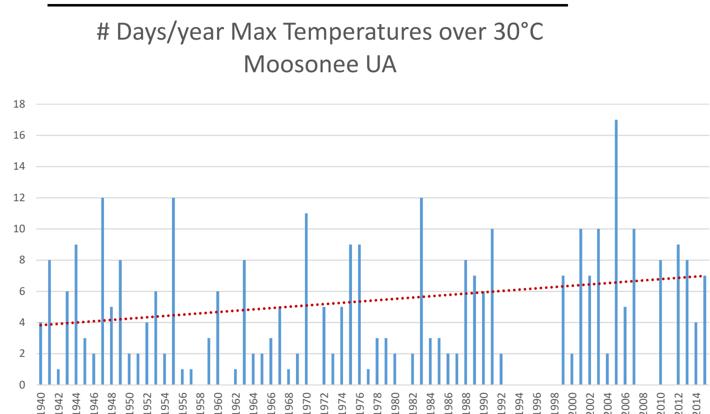


Future North Bay summer temperatures by 2050s?

RSI

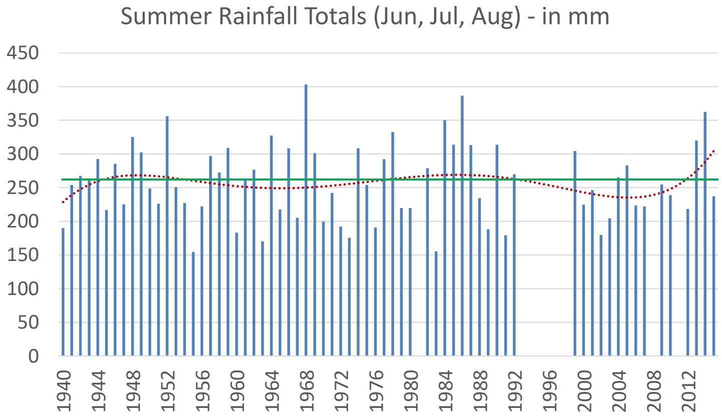
More Hot Days: Days hotter than 30°C increasing

Days > 35°C increasing too (1-3 days many years)



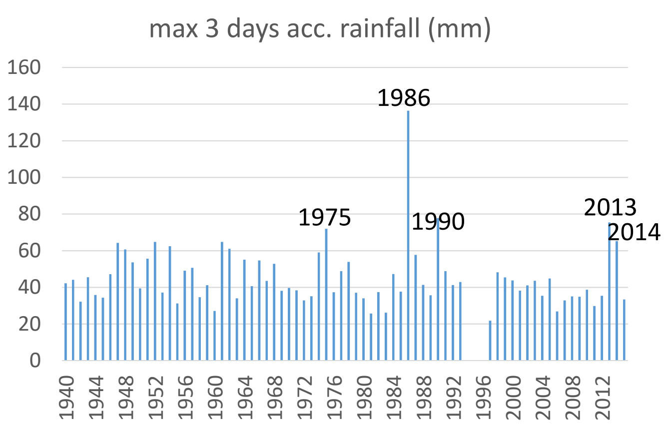
RSI

Summer Rainfall (June-July-Aug)



- Summer rainfall totals are variable over time.
- 2013 and 2014 summers were wetter than usual
- Forest fire risks during dry years - projected to increase

Annual Maximum Three-Day Rainfalls: Moosonee UA

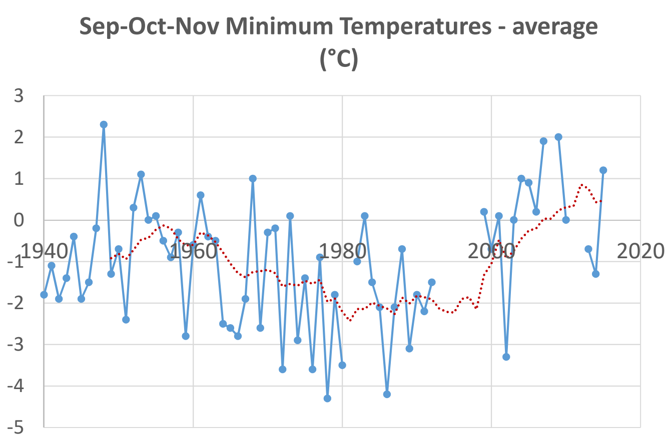


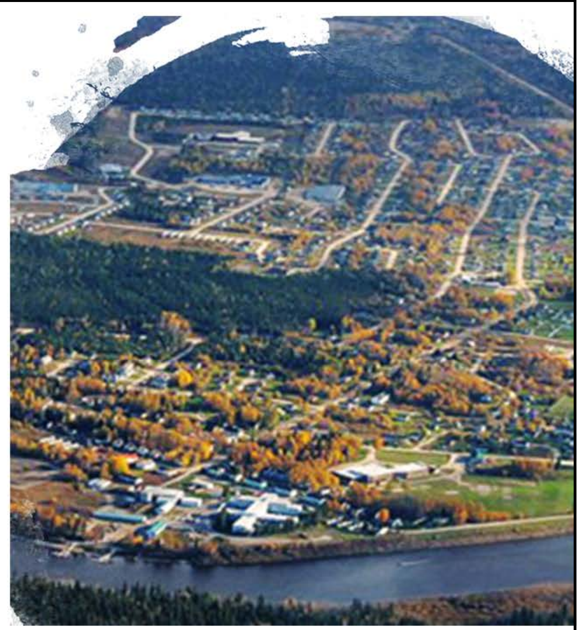
Heavier rainfall events…? More thunderstorms?

Summer Thunderstorms, Lightning

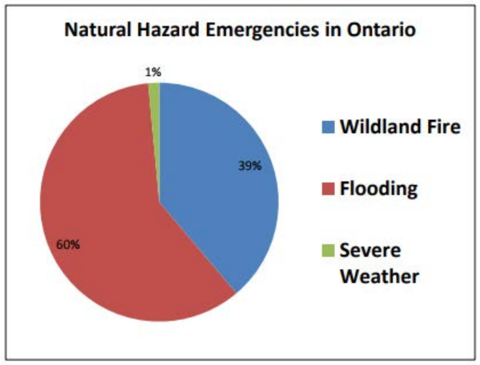
- Average of 24 days/year with lightning with 25 Km (less over James Bay) – similar to Edmonton, and more than northwestern Ontario
- Likely to increase – Longer thunderstorm season
- Slight evidence of higher winds in summer?
- Warmer air can hold more moisture, potential for heavier rainfall events

Fall (Sept-Oct-Nov) Temperatures – Variable over the years





73% of fires require evacuation



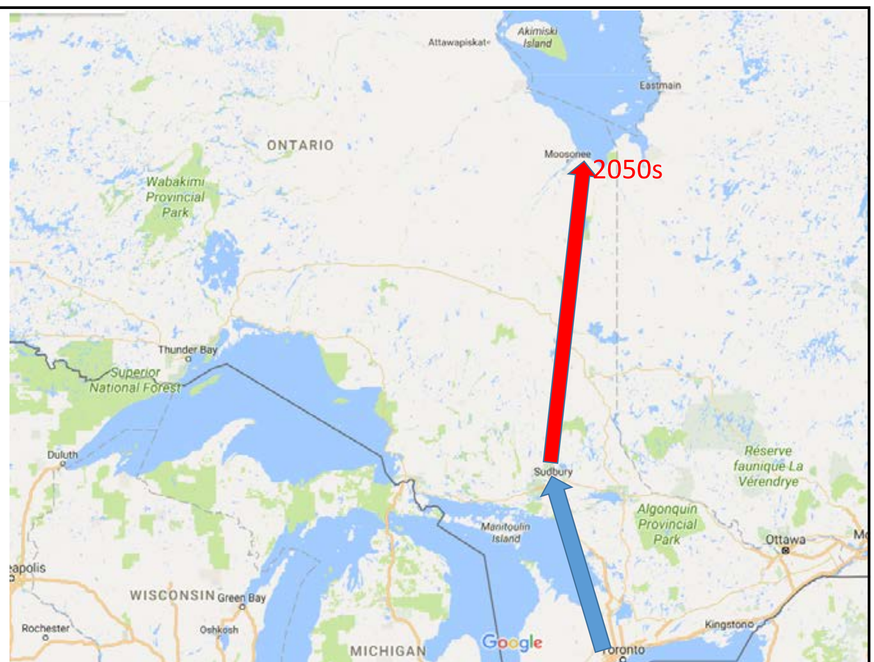
Weather-related Emergencies

50% of floods require evacuation

Under climate change:

- **Forest fire potential in northeastern Ontario to increase (as much as 300% northwestern Ontario)**
- **Heavy rainfall events to increase; Ice jamming (?)**

Moose Factory's Climate in the next few decades



More like Sudbury, North Bay for temperatures?

Hudson Bay could slow the warming in some seasons.

Uncertainties in Climate Change Projections

Most Confident — **Least / Less Confident**

More CERTAINTY ⟷ Less CERTAINTY

- Longer growing season
- Warmer winters
- More heat waves
- More winter precipitation
- More intense rainfall
- More severe ice, snow storms
- Increase in wind extremes

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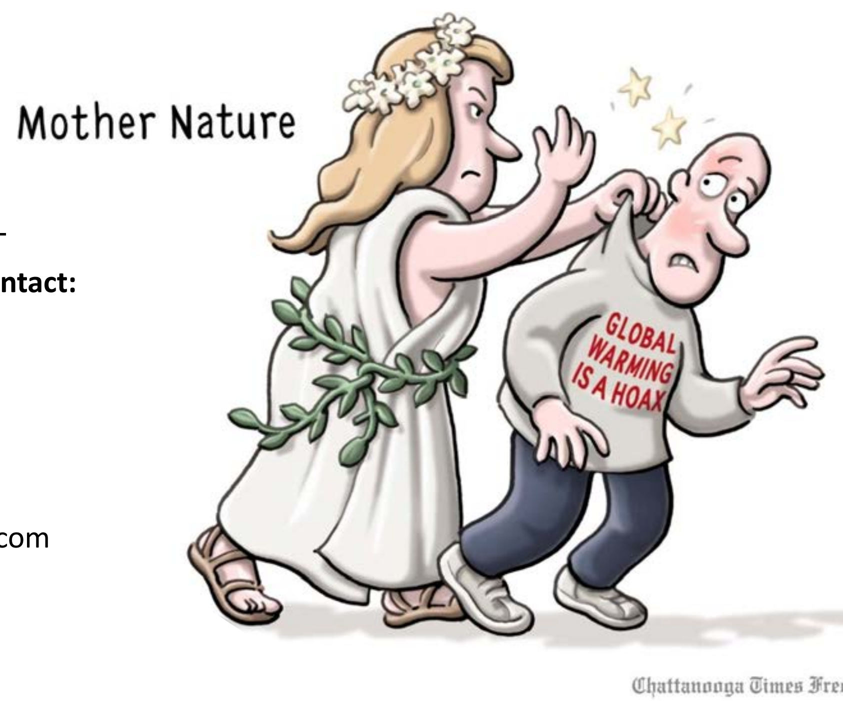
RSI

Thank You!!



For further information, contact:

Heather Auld
Principal Climate Scientist
Risk Sciences International

Email: hauld@risksciences.com
Tel: 905-737-6026

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FN PIEVC Infrastructure Vulnerability Assessment
OFNTSC-Moose Cree W/WW Vulnerability Study
Mitigation of Risks and Adaptation Measures
Workshop #4

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
Senior Advisor, Stantec

Thursday November 23, 2017

Funded by: Canada

In Collaboration with: engineerscanada

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Moosonee, ON

Moosonee,ON ▶ Alerts in Effect

ALERTS IN EFFECT

Special Weather Statement

Issued at 05:15 Thursday 23 November 2017

Snow and freezing rain expected overnight and Friday.

Snow is expected to begin overnight. Total snowfall amounts of 5 to 10 cm are possible before the snow changes to freezing rain Friday morning or afternoon. Freezing rain may continue for several hours before changing to rain Friday afternoon or evening. Ice accretion and slippery conditions are possible with this event.

This precipitation will be the result of a low pressure centre and warm front crossing Northern Ontario tonight and Friday.

###

Please continue to monitor alerts and forecasts issued by Environment Canada. To report severe weather, send an email to ec.cpio-tempetes-ospc-storms.ec@canada.ca or tweet reports using #ONStorm.

Environment Canada

Safety Moment

STOP & TALK: COLD AND FLU SEASON

Health, Safety, Security and Environment

As cold and flu season quickly approaches, check out these tips to see how you can avoid it!

- Eat healthy and well-balanced meals
- Open a window – letting a little fresh air in keeps airborne viral particles on the move, making them harder to pick up
- Don't touch your face, especially your lips
- Wash your hands often
- Exercise and get a good night sleep
- Load up on liquids – drinking at least 2L (1/2 gal.) of water a day with help clear out your system
- If you feel a sore throat coming on gargle with warm salt water

If you have questions, please contact your supervisor, Office Safety and Environment Coordinator (OSEC), or local HSSE representative

HSSE Stop & Talk are written for educational purposes and are not intended to replace safe work practices or procedures.
ver. November 2017

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Objectives

- Review, revise as necessary, and agree on the current and future climate risk (risk matrices)
- Identify risk mitigation measures for the highest risks
- Recommend actions for immediate risks
- Discuss potential adaptation measures to attenuate the risks under future climate conditions
- Next steps

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Agenda

Time	Description	
9:00am – 9:15am	Welcome and introductions	Moose Factory and OFNTSC
9:15am – 10:30am	Review of risk matrices	All participants
10:30am – 10:45am	Health break	
10:45am – 12:00noon	Review of risk matrices	All participants
12:00pm – 12:45pm	Lunch	
12:45pm – 3:15pm	Risk mitigation and adaptation measures	All participants
3:15pm – 3:30pm	Review	Consultant
3:30pm	Adjourn	

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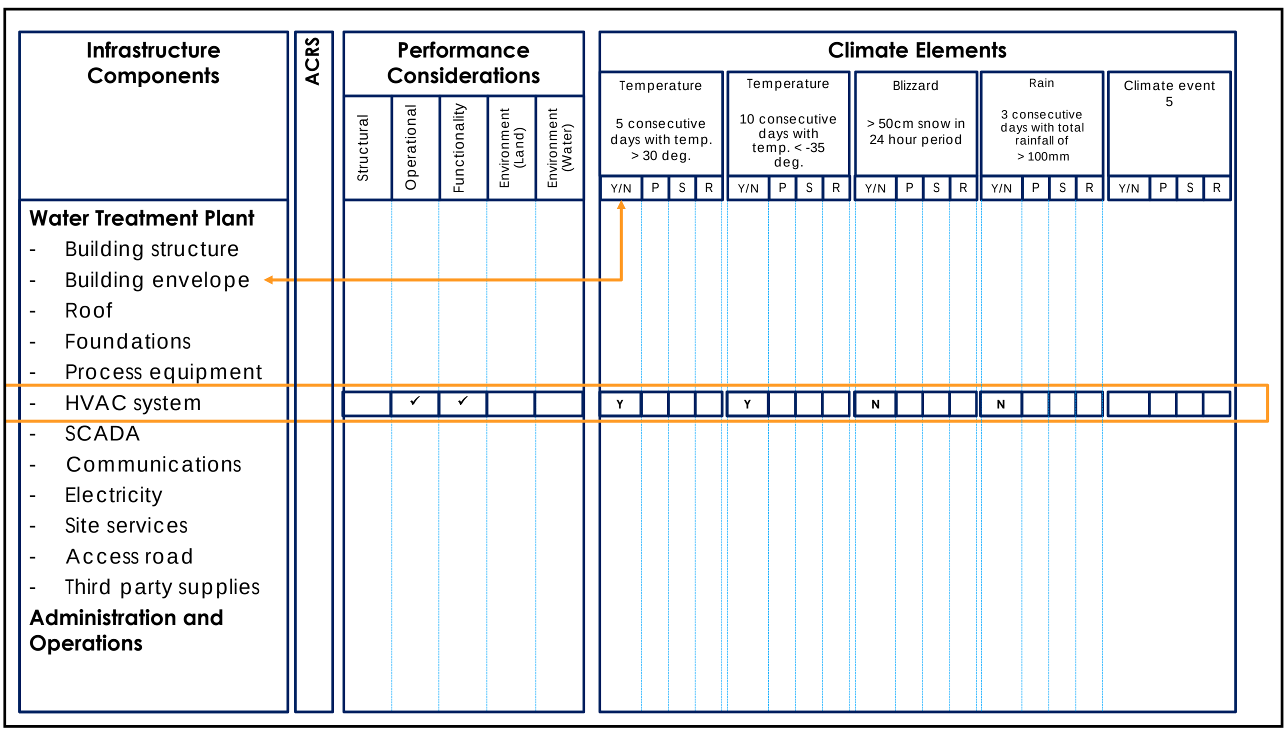

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Infrastructure

Potable water system

- Intake Structure
- Water treatment plant - Building
  - Building envelope
  - Building structure
  - Roof
  - Foundations
  - Heating/Cooling system
  - Fuel (oil Heat)
  - Backup generator
- Water treatment system
- Underground reservoir (#1)
- Above-ground reservoir (#2)
- Low level lift station Building
- Low level lift station equipment
- Watermains
- Watermains South
- Watermains Central
- Watermains North
- Watermains West
- Hydrants

Wastewater System

- Lagoons
- Lagoon blower building
- Lagoon Road
- Sanitary mains South
- Sanitary mains Central
- Sanitary mains North
- Sanitary mains West
- Sewage lift stations (5)
- Administration and operations
- Operations personnel

Third party services

- Electricity
- Telecommunications
- Fuel supply
- WTP chemical supply

River

- Raw Water Supply
- Transportation Corridor

Administration and operations

- Operations personnel

Support buildings

- Warehouse 2
  - Building envelope
  - Building structure
  - Roof
  - Foundations
- Public works garage
  - Building envelope
  - Building structure
  - Roof
  - Heating/Cooling system
- Garage
  - Building envelope
  - Building structure
  - Roof
  - Foundations

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Rating scales

Climate

Score	Probability	
	Method A	Method B
0	Negligible Not Applicable	< 1 in 1,000
1	Highly Unlikely Improbable	1 in 100
2	Remotely Possible	1 in 20
3	Possible Occasional	1 in 10
4	Somewhat Likely Normal	1 in 5
5	Likely Frequent	>1 in 2.5

Impacts on Infrastructure

Score	Descriptor	Provide Example
0	No Effect	
1	Insignificant	
2	Minor	
3	Moderate	
4	Major	
5	Catastrophic	

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Score and Description	Consequence [Structural, Functional, Operations]
0 No effect	• No service interruption • No budget impacts • Fully operational – normal • No additional complaints about the service
1 Insignificant	• Can be corrected through the regular maintenance cycle
2 Minor	• Require minor repairs but have the internal capacity and inventory of parts to do those repairs • No impact on O&M and capital budget – no additional budget required • May need further assessment
3 Moderate	• Have the capacity to do repairs but need to order parts • May need to have certified staff (e.g., electrician) do repairs • Need inspection with possibly external expertise
4 Major	• Partial loss of equipment and/or components • Loss of function of asset, several assets, or critical components • Requires detailed assessment with external expertise • Requires major repairs and possibly complete replacement of components/equipment • Impacts on O&M and capital budget that may require additional funding • Requires implementing alternative service delivery • May have impacts on public health and safety
5 Catastrophic	• Total loss of equipment and service that requires full replacement of asset, several assets and major components • Impacts on other elements of asset or other assets • Impacts on public health and safety

Impacts on Infrastructure

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Climate Events

RCP 8.5 scenario for future climate

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Climate Event	Description	Comment	Rating Current	Rating Future
Maximum temperature	• 10 days/year with Temp. > 30°C • Occurrences of Days with Temp. >35°C (1-3 days)		4 5	5 5
Seasonal Temp. Variations	• Heating and cooling degree days	Current cooling = 77 degree days	4	5
3 consecutive days of winter rain	• Southern Ontario Threshold for weather warning causing flood of 25 mm	May be different for Northern Ontario	2	3
Freezing rain	• Estimated 15 mm causing local power line damage and damage to trees		4	5
Precipitation (rain)	• Short Duration - High Intensity (20 mm in one hour)	Only 3 years of IDF data (2004 to 2006). Approx. equivalent to a 1:5 rain event	4	5

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Climate Events (cont'd)

RCP 8.5 scenario for future climate

Climate Event	Description	Comment	Rating Current	Rating Future
Precipitation (rain)	• >100 mm rain in 12 hours	July 6/86 - 122mm in 12 hours or less	2	4
Minimum temperature	• Extreme cold: - 40°C without windchill		5	3
Shift in seasonal temperatures	• Lengthening of air only access season	?	?	?
Shift in seasonal precipitation	• Low flow	? See following slides "Quick response" of low in river to changes in air temperature	?	?
Precipitation (snow)	• Heavy snow: 100 cm in 3 days		4	5

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CRIPE

CGU HS Committee on River Ice Processes and the Environment
19th Workshop on the Hydraulics of Ice Covered Rivers
Whitehorse, Yukon, Canada, July 9-12, 2017.

Near Real-Time Monitoring of Ice Breakup in the Far North of Ontario Using RADARSAT-2 in Support of Provincial Flood Forecasting and Warning

Andy Beaton[1], Joost Van Der Sanden[2], Ken Corston[3] Alice Deschamps[2] and Simon Tolszczuk-Leclerc[2]
[1]*Ontario Ministry of Natural Resources and Forestry, 300 Water Street, Peterborough, Ontario K9J 8M5*
andy.beaton@ontario.ca

[2]*Natural Resources Canada, 560 Rochester Street, Ottawa, Ontario, K1S 5K2*
joost.vandersanden@canada.ca, alice.deschamps@canada.ca, simon.tolszczuk-leclerc@canada.ca

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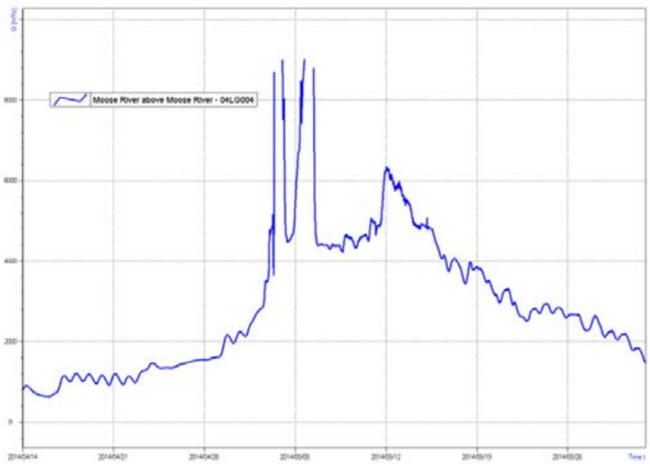

Figure 2. Spikes in hydrograph indicating ice breakup occurrence around the 04LG004 streamflow gauge on the Moose River around May 5th 2014. Note: Discontinuous data at the peaks of the hydrograph are a result of the flow exceeding the rating curve.

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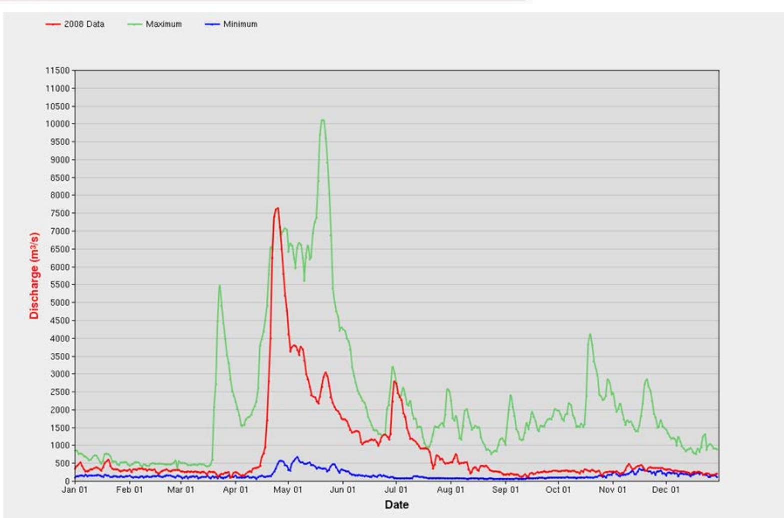
Government of Canada | Gouvernement du Canada

Jobs | Immigration | Travel | Business | Benefits | Health | Taxes | More services

Home → Environment and natural resources → Water level and flow → Historical Data → Hydrometric Data Search

Daily Discharge Graph for MOOSE RIVER ABOVE MOOSE RIVER (04LG004) [ON]



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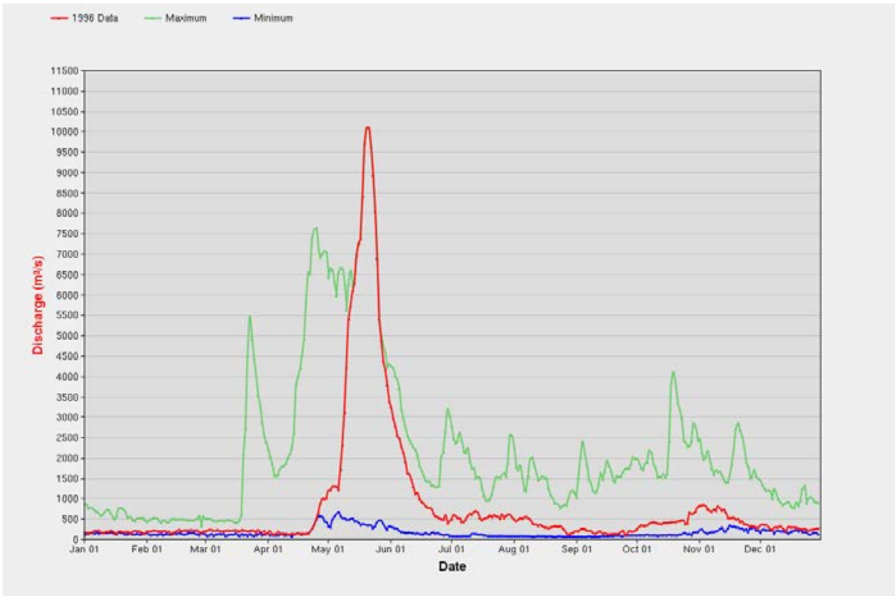

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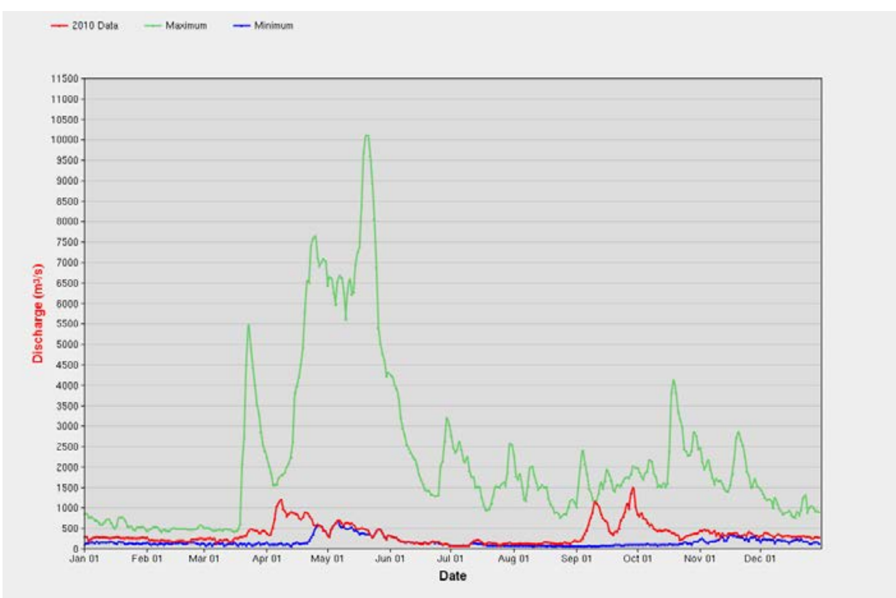

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Proposed risk rating

Impact/consequence on infrastructure if climate event occurs						
	Catastrophic 5					HIGH
	4					
	3			MEDIUM		
	2					
	Insignificant 1	LOW				
		1 Highly unlikely	2	3	4	5 Likely / Frequent
		Likelyhood/probability of climate event occuring				

High: >= 15

Medium: 6 – 12

Low: =< 4

Special:

- P=1 and S=5
- P=5 and S=1

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Review of the Risk Matrix

Infrastructure list

Performance considerations

Climate parameters and probabilities

Interactions: Y/N

Severity if climate event occurs

Risk

Asset/Infrastructure Elements	ACRS/ICMS Information					Performance Considerations					1 Max. Temp				2 Seasonal Temp variaions				3 Wind			
	Asset #	Quantity	Units	Year constructed	General condition	Structural	Operations	Functional	Environment (Land)	Environment (Water)	Days with Temp >XX deg. C				Heating and cooling degree days				Exceeding XX km.p.h			
											Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R
Wastewater System																						
Lagoons	453000			1987	4																	
Lagoon blower building	003200			1986	7																	
Lagoon Road	601500			1985	7																	
Sanitary mains South	450100			1987	7																	
Sanitary mains Central	450200			1991	7																	
Sanitary mains North	450300			1997	7																	
Sanitary mains West	450400			2001	7																	
Sewage lift stations (4)	452000			1987	7-8																	
Potable water system																						
Intake structure																						
Water treatment plant - Building	003500			1990	7																	
Building envelope																						

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Risk Summary

Risk Rating	Current Climate	Future Climate	Future Climate + Infrastructure in worse condition
Low	12	0	
Medium	24	34	
High	4	6	

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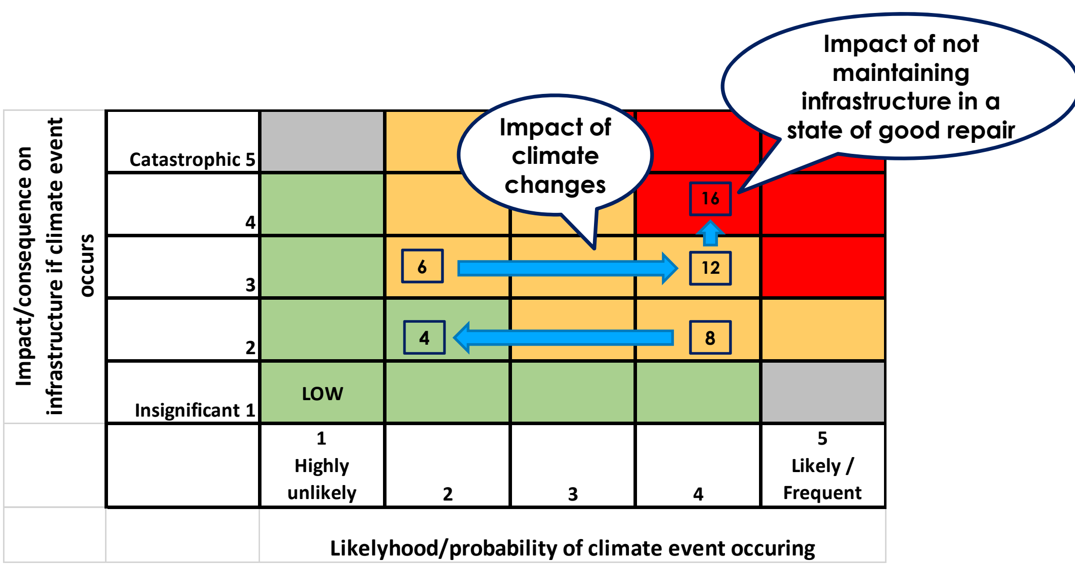
Future Climate



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Impacts on the service or the community if the infrastructure fails

1. Emergency Response

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Procedures and systems to address:
  - Severe storm events
  - Flooding
  - Ice dams
  - Water damage

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2. Insurance and Legal Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Insurance rates
- The ability to acquire insurance
- Insurance policy limitations and exclusions
- Legal impacts and liability

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3. Policy Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Codes
- Guidelines
- Standards
- Internal operations and maintenance policies and procedures
- Levels of Service policy
- Land use planning

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4. Social Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Accessibility to critical facilities such as hospitals, fire and police services
- Energy supply to a community
- Dislocation of affected populations
- Provision of basic services such as potable water distribution and wastewater collection
- Closure of schools and other public services
- Destruction or damage to heritage buildings, monuments, etc. or historically important resources

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5. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

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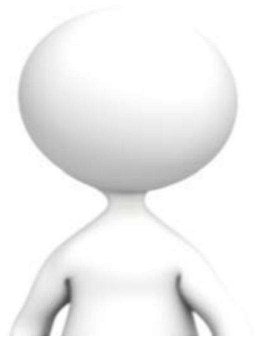
6. Fiscal Impacts

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Drain on current/future financial resources to deal with unplanned repairs, maintenance and/or replacements
- Shifting financial resources from other community priorities
- Impacts on services and/or levels of service
- Community economic impacts and/or hardships

Mitigating Risks and Adaptation Measures



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