Climate Change Impacts on Water and Wastewater Infrastructure at Akwesasne

Final Report

PREPARED FOR

Ontario First Nations
Technical Services Corporation
(OFNTSC)

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June 21, 2017

Ontario First Nations Technical Services Corporation

Stantec

Sign-off Sheet

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Introduction

Severe weather and climate uncertainty represent risks to pubic safety as well as the safety of the service provided by engineered systems in Canada and around the world. 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 – protection of the public interest, which includes life, health, property, economic interests, and the environment.

The impacts of severe weather add to the existing stresses on infrastructure and services it provides. In addition to factors that reduce the capacity and performance of these assets such as 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 the incremental load that causes the asset failure.

Engineers Canada initiated discussions with the Ontario First Nations Technical Services Corporation (OFNTSC) in the Fall of 2015 concerning the impacts of changing climate and extreme weather events on First Nations infrastructure. Of particular interest was to incorporate climate considerations into First Nations asset management planning. Engineers Canada's PIEVC[1] Protocol was considered a promising process to define climate risks and vulnerabilities.

These discussions led to OFNTSC submitting a funding proposal, with support from Engineers Canada, to Indigenous and Northern Affairs Canada (INAC) and the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR). The project was proposed in two phases as follows:

PHASE 1. Mohawk Council of Akwesasne Infrastructure Vulnerability Study (Funded by INAC)

Using Engineers Canada's PIEVC Protocol, evaluate the vulnerability to climate changes of water and wastewater (W/WW) infrastructure of the Mohawk Council of Akwesasne (MCA) and provide recommendations on possible adaptation measures to mitigate risks identified; and

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Use the application of the PIEVC Protocol for Akwesasne water and wastewater infrastructure for knowledge transfer and to build capacity for Akwesasne and OFNTSC staff for future projects by:

[1] PIEVC is the acronym for Engineers Canada's Public Infrastructure Engineering Vulnerability Committee

a) Develop a "FN PIEVC/Asset Management Toolkit" tailored to First Nations communities that includes linkages to infrastructure assets management and leverages existing infrastructure data such as the Asset Condition Reporting System(ACRS) and the Integrated Capital Management System (ICMS); and

b) Provide training on the use of the Toolkit at two locations: Southern and Northern Ontario

This report presents the results of the Phase 1 study, the MCA water and wastewater vulnerability study using Engineers Canada's PIEVC Protocol.

The Akwesasne Community

Akwesasne is a community of approximately 12,300 people (2016) distributed over an area of 11,720 acres and governed by the Mohawk Council of Akwesasne (MCA). The community comprises three districts: Kawehno:ke (Cornwall Island, Ontario), Kana:takon (St. Regis, Quebec) and Tsi Snaihne (Snye, Quebec).

The Mohawk territory of Akwesasne is jurisdictionally unique in that the Akwesasne Territory includes portions that are in Ontario and Quebec within Canada and in New York State of the United States of America. No other First Nation community in Canada has these unique jurisdiction and geographic features. To aid government administration and jurisdiction, the MCA has Political Protocol agreements with the Crown, the Province of Quebec, and is undertaking the development of a Political Protocol with Ontario.

The PIEVC Protocol

Engineers Canada describes the Protocol as a methodology that "systematically reviews historical climate information and projects the nature, severity and probability of future climate changes and events. It also establishes the adaptive capacity of an individual infrastructure as determined by its design, operation and maintenance. It includes an estimate of the severity of climate impacts on the components of the infrastructure (i.e. deterioration, damage or destruction) to enable the identification of higher risk components and the nature of the threat from the climate change impact. This information can be used to make informed engineering judgments on what components require adaptation as well as how to adapt them e.g. design adjustments, changes to operational or maintenance procedures."

The PIEVC Protocol offers the user flexibility in adapting the process to the assessment context and constraints (e.g., time, resources, etc.). For the Akwesasne Water and Wastewater (W/WW) vulnerability and risks assessment, the application of the Protocol did not include the optional Step 4 – Engineering Analysis, since the objective was to develop an overall risk profile of all the infrastructure, buildings and facilities used in providing potable water and wastewater collection and treatment for the community. In addition, although throughout the process social, economic and environmental impacts and benefits were considered, the assessment did not use the triple-bottom-line (TBL) module.

Scope of the Study

The objectives of the project were to:

- Build awareness of the PIEVC Protocol as a risk management tool to MCA and OFNTSC staff;
- Identify infrastructure vulnerabilities to current and future severe weather. The Akwesasne W/WW infrastructure considered in the study included the potable water, and wastewater collection and treatment systems for Cornwall Island (ON), St. Regis (QC) and Snye (QC);
- Establish a risk profile for the Akwesasne W/WW infrastructure; and
- Provide recommendations regarding mitigating risks with the highest consequences to the assets, service, and community.

It is important to note that the project was initially approved in October 2016 and the initial kick-off meeting took place during that month. However, due to schedule constraints and the changes in consulting team, the project's activities resumed mid-January 2017 and substantial completion was achieved at the end of March 2017.

Project Team

The Project Team was composed of key staff from the MCA – Technical Services and Environmental Services Departments, OFNTSC Staff, and the Consulting team. This small but focused group of subject matter experts were supported by a Project Advisory Committee (PAC) from organizations that are knowledgeable or are interested in the area of climate change impacts on public infrastructure.

The strong technical, operational, and environmental expertise of the MCA staff, and their knowledge and experience as long-time residents of Akwesasne, was an essential and invaluable source of infrastructure and climate information to this project.

The members of the Project Team and PAC are listed below.

<table>
<tr><th colspan="2">Project Team</th></tr>
<tr><td><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, Water and Wastewater Manager
Leslie Papineau, Technical Project Manager</td><td><u>Consulting Team</u>
Dr. Guy Félio, Senior Advisor, Stantec (Project Manager)
Amanda Lynch, Water Resources Engineer, Stantec
Eric Dunford, Strategic Management Consultant, Stantec
Alexandre Mineault-Guitard, Environmental Engineering Intern, Stantec
Heather Auld, Climatologist, RSI Inc.</td></tr>
<tr><th colspan="2">Project Advisory Committee</th></tr>
<tr><td>Stephanie Allen, OFNTSC
Ashley Dawn Bach, COO
Marla Desat, SCC
Tom Duncan, INAC
Al Douglas, OCCIAR</td><td>Andréanne Ferland, FNQLSDI
Caroline Larrivée, Ouranos
David Lapp, Engineers Canada
Jamie Ricci, Engineers Canada
Jacqueline Richard, OCCIAR</td></tr>
</table>

Project Definition

Based on the information provided by the MCA Technical Services, the water and wastewater system in Akwesasne can be characterized as two independent systems, as follows:

- Cornwall Island: potable water and wastewater systems
- St. Regis/Snye: potable water and partial wastewater systems (some properties in St. Regis and Snye use private septic systems)

The Project Team, aided by members of the PAC, discussed which infrastructure systems should be considered in the PIEVC study and decided to do an assessment of both systems. Factors considered included the fact that these two systems serve different types of geography and population densities (Cornwall Island being more geographically spread out while St. Regis being similar to a small village), and would be good examples for other First Nations communities.

The time horizons for the study were selected as current conditions (establishing the baseline risks) and 2050 for future conditions. Many of the Akwesasne infrastructure assets were built in the

1990's and early 2000's and will need replacement, undergo rehabilitation or retrofit, or will be at an advanced stage of their service lives within the time horizon selected.

Infrastructure considered

The infrastructure assets considered in this assessment were divided into components to evaluate the impacts from the selected climate events. All the water and wastewater physical infrastructure (for example the intake, treatment plant, pumping stations, RBC's, etc.) were considered in this study. In addition, related support infrastructure (e.g., personnel, suppliers, energy supply, telecommunications, etc.) were included. Details are provided in the report.

Climate information

The climate considerations presented hereafter are the result of discussions of the Project Team and PAC members at the project workshops, research into public information, and the report entitled "Climate Probability Analyses for Mohawk Council of Akwesasne PIEVC Studies" from RSI Inc.

Type of Climate Element	Description
Temperature	Days (per year) with Max Temps > 36°C
	Very warm August Temps Mean >22.5°C (*warmer than August 2012*)
	Combination August warm temperatures & low rainfalls
Fog	Visibilities below ½ statute mile
Precipitation	Days with August total precipitation ≤ ~51mm (*= or < August 2012*)
	Winter snowfall for Jan-Feb-Mar > 200 cm
	Winter rainfall totals (DJF) > 120mm
	March rainfall totals > 60 mm
	Snowfall event > 25 cm/day
	Winter rainfall > 25mm/day
	Severe ice storms (≥ 20 mm freezing rain in one day)
Wind	Days with gusts > 90 km/h
	Days with gusts > 125 km/h
	Days with gusts > 140 km/h
	Tornado frequency within 25 km radius
	Tornado frequency – within 50 km radius

Risk Assessment

In the PIEVC Protocol, Risk is defined as the product of the Probability score multiplied by the Severity score. Since each of the probability and the severity scores are rated from 0 to 7, the maximum risk score will be 49.

For this project, the risk thresholds shown in the Table below were selected by the Project Team:

Selected risk thresholds

Score	Description
<12	**Low**: no action required
12 to 20	**Moderate**: monitoring recommended
21 to 34	**High**: action may be required if threat materialises; a more detailed analysis may be needed.
≥ 35	**Extreme**: 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

The response criteria against which the infrastructure-climate interactions and risks were evaluated are as follows:

<u>Infrastructure response</u>

1. Structural design/capacity
2. Functionality
3. Serviceability
4. Watershed, surface waters and groundwater
5. Operations, maintenance, and materials performance
6. Environmental effects

<u>Community Impacts</u>

7. Emergency response
8. Insurance and legal considerations
9. Policy considerations
10. Social and cultural effects
11. Impacts on the environment
12. Financial/fiscal considerations

The first step in the production of the risk matrix was 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. In the case where an interaction exists, the Project Team identifies with respect to which infrastructure performance considerations the potential risk might exist (for example, impacts on the structural capacity or the functionality of the asset or component).

As the Project Team progressed through the project, it became evident that there were two types of impacts for the climate events: 1) impacts on the performance of the infrastructure itself, and, 2) impacts on the service to the community should the infrastructure fail to deliver as designed. It was therefore decided to establish the risks with respect to the infrastructure assets considering the infrastructure response factors, followed by the consequences on the service and/or the community should the risk materialize and the infrastructure fail to perform. This process is illustrated in Figure 1 next page.

Furthermore, the risks associated with future climate events were evaluated with respect to two (2) asset conditions within the time horizon of the assessment (2017 – 2050): Condition 1 relates to assets that have been replaced at the end of their design life as per the ICMS data; Condition 2 relates to assets that reach the time horizon of this study (2050) beyond their design life. This distinction is important since many assets in the infrastructure systems considered will reach their design life within the time horizon selected. Condition 2 thus presents a higher level of vulnerability for these assets. It should be noted that this analysis is not prescribed in the PIEVC Protocol; however, the Project Team and PAC felt it provides a more realistic assessment of the risks if the assets are not replaced or retrofitted in due time. Only assets characterized as high and extreme risk assets were evaluated with this dual condition process.

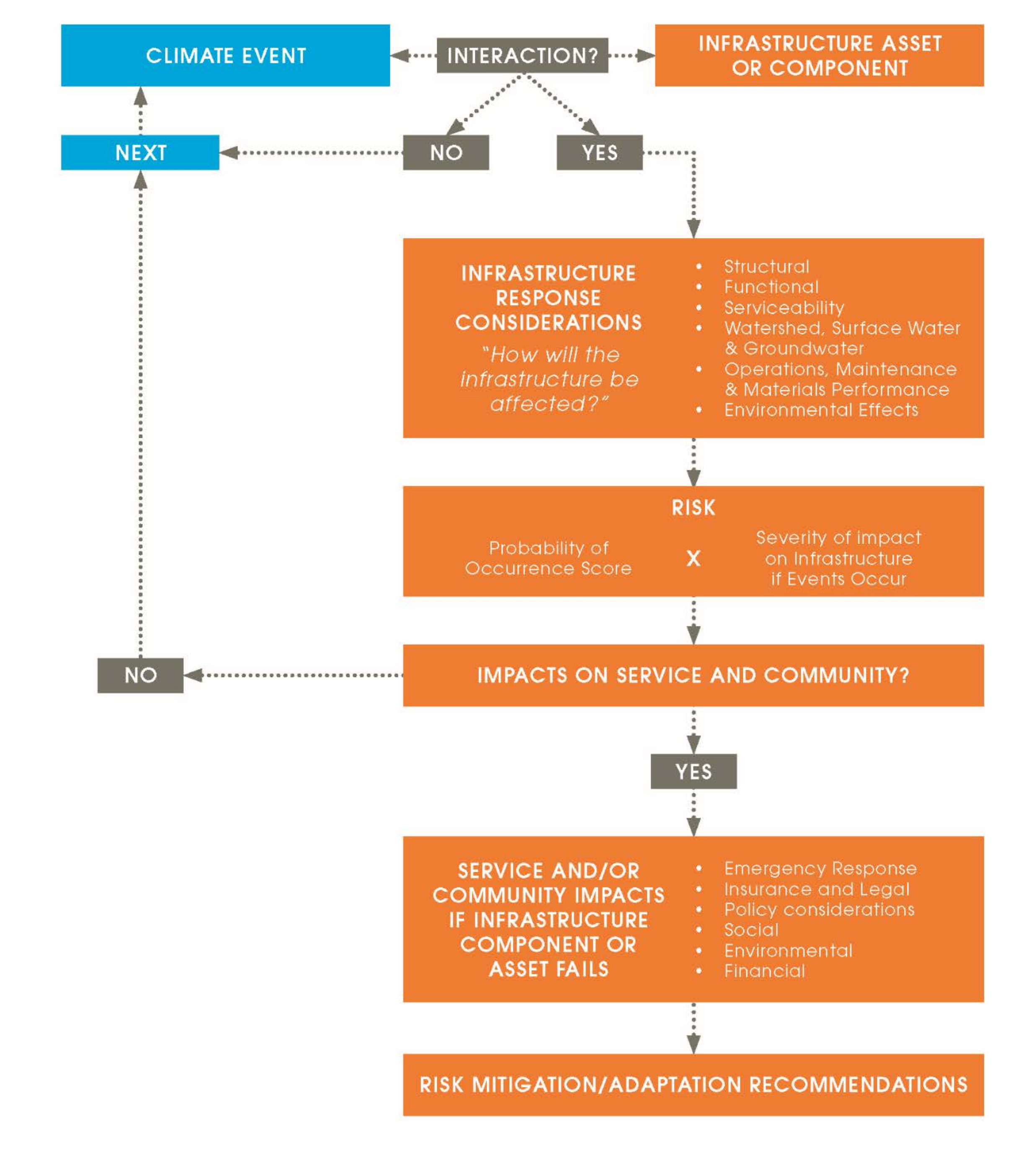

Figure 1: Process used to establish infrastructure risks and impacts on the community

Summary of risks for Cornwall Island infrastructure

Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected	Infrastructure Performance Impacted
Cornwall Island					
Moderate	145	88	• 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	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
High	47	135	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
Extreme	28	34	• Lightning • Tornados	• All infrastructure	• All performance considerations

Summary of risks for St. Regis infrastructure

Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected	Infrastructure Performance Impacted
103					
Moderate	135	103	• Low Precipitation (Aug.) • Combination - Aug. High Temp. with Low precipitation • Snowfall event • Severe Ice Storm • Extreme Ice Storm • Extreme Winds • Rain events	• Environment • Personnel • Suppliers • Electricity • Light buildings • General roadworks • Emergency response • Vehicles and fleet • Communications • Stormwater system	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
High	46	96	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
Extreme	23	28	• Lightning • Tornados	• All infrastructure	• All performance considerations

Summary of risks for Snye infrastructure

Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected	Infrastructure Performance Impacted
Snye					
Moderate	99	60	• Low Precipitation (Aug.) • Combination - Aug. High Temp. with Low precipitation • Snowfall event • Severe Ice Storm • Extreme Ice Storm • Extreme Winds • Rain events	• Environment • Personnel • Suppliers • Electricity • Light buildings • General roadworks • Emergency response • Vehicles and fleet • Communications • Stormwater system	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
High	37	80	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
Extreme	19	36	• Lightning • Tornados	• All infrastructure	• All performance considerations

Influence of infrastructure condition

As indicated earlier, 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. While this analysis is not prescribed in the Protocol, it is worth noting that the Protocol offers flexibility to incorporate additional levels of analysis within its framework, as long as they are documented.

In the context of this study, the summary risk results, and the detailed risk matrices were established considering the infrastructure is in good condition, that is, it is operating at the performance level it was designed for. It was beyond the scope of this project to do an analysis of each component affected based on condition assessment information.

The Project Team and PAC members, during Workshop 4, indicated a useful analysis would be to see the risks assessed in a context where the infrastructure is past its design life and has not been replaced. Information to support this analysis was obtained from the ICMS data provided by INAC.

Without knowledge of long-term capital investment plans for this infrastructure, the worst-case scenario is that none of the assets under consideration will be replaced during the study time horizon and therefore it will be in a more deteriorated condition in the future. This, in turn, results in a higher asset vulnerability to the climate hazards identified. Due to time constraints, only the Cornwall Island infrastructure was assessed using this scenario, which involved increasing the severity scores by one for each of the climate-infrastructure interactions. Also, only the MCA built infrastructure was adjusted, that is the environment, personnel and third-party infrastructure scores remained unchanged. The Table below presents the comparison between the risks to the infrastructure replaced at the end of its design life and the risks with deteriorated infrastructure (not replaced). The analysis did not consider low risks which may become moderate as a result of an increase in severity of the infrastructure.

Summary of risks for Cornwall Island infrastructure replaced at the end of its design life and deteriorated

Risk Rating	Future Climate Risk Score Counts Cornwall Island Infrastructure		Percentage change in risk count
	Infrastructure replaced at end of design life	Infrastructure deteriorated (not replaced)	
Moderate	88	59	- 33%
High	135	143	+ 6%
Extreme	34	44	+29%

The table illustrates the value of maintaining the infrastructure in a state of good repair and capital investments at the end of its service life as an important measure to mitigate risks.

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.

In general, and if maintained in a state of good repair, the water and wastewater infrastructure considered in this study appears in good condition to withstand some increases in frequency and intensity of the climate events retained for this PIEVC analysis. In regard to extreme events, for example tornadoes and ice storms, a loss of function is generally expected and Community risk mitigation and recovery measures are incorporated in Emergency Management and Response Plans. Within their resources constraints, the staff of MCA's Technical Services are providing safe and reliable water to the Akwesasne community, and protecting the health of people and the environment through the wastewater collection and treatment system.

Adaptive and risk mitigation measures were identified by the Project Team and PAC members present during Workshop 4. Since the intent of the study is to provide an overall risk profile of the infrastructure owned and managed by the MCA in Cornwall Island, St. Regis, and Snye, the recommendations do not address specific infrastructure issues. The recommendations below are not listed in a priority order.

- 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 them 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 as roofs, light structures, etc. Select tree locations and species to minimize risks of property damage in case they would fall down.

- Review and improve, as required, policies and procedures – for example:
    - Operations and Maintenance: this could include inspection cycles, practices to maintain the performance of the assets, etc.
    - Climate related events in emergency response measures and plans, etc.

- Install weather stations on Cornwall Island and in St. Regis to ensure relevant local data. These stations should have the capability to at least provide hourly records. Note that the data from the Cornwall station only provides daily averages, thus representing a gap where short duration/high intensity events may be missed. This data will allow an evaluation of whether the climate changes projected in this study have materialized.

- Continue maintaining the high level of staff competencies and the knowledge the MCA staff has about its infrastructure. The knowledge and experience of the MCA staff are critical to continue providing services during normal and severe weather conditions.

- Provide the opportunity to MCA staff to access external subject-matter expertise and advice to deal with specific risk mitigation issues. This could include identifying key climate-infrastructure risks for which a more detailed analysis would be beneficial.

- Review land use planning policies to avoid authorizing construction in high-risk areas of the community.

- Communications, outreach and training to prevent, mitigate and respond to risks, for example: tree pruning to reduce the damage from broken branches; what to do in the case of an extreme event, etc.

- Creative problem solving: use processes such as "key personnel analysis" to bring staff from different services identify risk prevention and mitigation solutions. Use MCA Focus Groups and other community processes as well.

- Ensure lightning protection for sensitive equipment, particularly the SCADA systems.

- Include the risks identified through this study in planning work for infrastructure renewal, future design and construction, and include climate change considerations in best management practices and bylaws. This also involves keeping track of new developments regarding changes to practices and regulations – for example, under the Pan-Canadian Framework on Clean Growth and Climate Change[2].

- Plan for reduced mobility of operators and suppliers due to severe or extreme events, including warning, stock-piling, etc. This could include coordination at border crossings to accelerate passage during emergencies.

- Anticipate and plan collaborations for high risk weather events, such as interactions with emergency and community services, external agencies, and the community itself.

[2] See: https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

Finally, this application of the PIEVC Protocol contributed two new elements to the methodology which should be considered in future versions of the Protocol:

1. The separation of the infrastructure response considerations into two categories as follows (Section 5.6.2):
    a. Impacts on the infrastructure (or service) to assess the risks
    b. Consequences on the community should those risks materialize
2. The analysis of risks based on the future condition and replacement (as guided by asset design life) of the infrastructure (Section 5.6.1).

Abbreviations

ACRS	Asset Condition Reporting System
COO	Chiefs of Ontario
ICLR	Institute for Catastrophic Loss Reduction
FNQLSDI	First Nations of Quebec and Labrador Sustainable Development Institute
ICMS	Integrated Capital Management System
INAC	Indigenous and Northern Affairs Canada
MCA	Mohawk Council of Akwesasne
OCCIAR	Ontario Centre for Climate Impacts and Adaptation Resources
NOAA	US National Oceanic and Atmospheric Administration
OFNTSC	Ontario First Nations Technical Services Corporation
O&M	Operations and maintenance
PAC	Project Advisory Committee
PIEVC	Public Infrastructure Engineering Vulnerability Committee
RBC	Rotating Biological Contactor
RSI	Risk Sciences International Inc.
SCC	Standards Council of Canada
TBL	Triple Bottom Line
WTP	Water Treatment Plant (potable water)
WWTP	Wastewater Treatment Plant

Acknowledgements

This project was made possible by the leadership and dedication of the Ontario First Nations Technical Services Corporation (OFNTSC) in close collaboration with Mohawk Council of Akwesasne (MCA), Engineers Canada and INAC. The Project Team and the members of the Project Advisory Committee are grateful to the MCA and its community for hosting this project and the meetings on their lands.

Stantec wishes to acknowledge and is grateful for the contributions of many individuals that participated in this study.

> The role of Elmer Lickers, Senior O&M Advisor at OFNTSC was crucial in defining the project and obtaining funding. Elmer provided support and leadership in all aspects of this study, and his contributions helped meet tight timelines.
>
> Dr. Henry Lickers, inspiring and knowledgeable in a wide range of fields, was a key champion and participant in all aspects of this project. His passion to bring the knowledge gained in Akwesasne to other First Nations communities in Canada will be critical to the planned development of the FN PIEVC Toolkit
>
> Jay Benedict, Director of MCA Technical Services and his team of dedicated professionals, without whom this project would not have been completed within the short timeline available.
>
> The input and time from the Members of the Project Advisory Committee that participated in the workshops and contributed through their comments enriched the content of this PIEVC study:

Stephanie Allen, OFNTSC
Ashley Dawn Bach, COO
Marla Desat, SCC
Tom Duncan, INAC
Al Douglas, OCCIAR
Andréanne Ferland, FNQLSDI
Caroline Larrivée, Ouranos
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Jacqueline Richard, OCCIAR

INAC funding made this project possible.

1.0 INTRODUCTION

Severe weather and climate uncertainty represent risks to the safety of and service provided by engineered systems and to public safety in Canada and around the world. 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 – protection of the public interest, which includes life, health, property, economic interests, and the environment.

The impacts of severe weather add to the existing stresses on infrastructure and services it provides. In addition to factors that reduce the capacity and performance of these assets such as 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 the incremental load that causes the asset failure.

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

1.1 BACKGROUND

Engineers Canada initiated discussions with the Ontario First Nations Technical Services Corporation (OFNTSC) in the Fall of 2015 concerning the impacts of changing climate and extreme weather events on First Nations infrastructure. Of particular interest was to incorporate climate considerations into First Nations asset management planning. Engineers Canada's PIEVC[3] Protocol was considered a promising process to define climate risks and vulnerabilities.

Improving First Nations awareness, knowledge and internal technical capacity to incorporate climate considerations into asset management was viewed as an important strategy to develop sustainable and cost-effective solutions to address the impacts and costs of future climate and extreme weather events.

These discussions led to OFNTSC submitting a funding proposal, with support from Engineers Canada, to Indigenous and Northern Affairs Canada (INAC) and the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR). The project was proposed in two phases as follows:

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a) Develop a "FN PIEVC/Asset Management Toolkit" tailored to First Nations communities that includes linkages to infrastructure assets management and leverages existing infrastructure data such as the Asset Condition Reporting System(ACRS) and the Integrated Capital Management System (ICMS); and

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This report presents the results of the Phase 1 study, the MCA water and wastewater vulnerability study using Engineers Canada's PIEVC Protocol.

1.2 THE AKWESASNE COMMUNITY

Akwesasne is a community of approximately 12,300 people (2016) distributed over an area of 11,720 acres and governed by The Mohawk Council of Akwesasne (MCA). The community comprises three districts: Kawehno:ke (Cornwall Island, Ontario), Kana:takon (St. Regis, Quebec) and Tsi Snaihne (Snye, Quebec).

The Mohawk territory of Akwesasne is jurisdictionally unique in that the Akwesasne Territory includes portions that are in Ontario and Quebec within Canada and in New York State of the United States of America. No other First Nation community in Canada has these unique jurisdiction and geographic features. To aid government administration and jurisdiction, the MCA has Political Protocol agreements with the Crown, the Province of Quebec, and is undertaking the development of a Political Protocol with Ontario.

1.3 PIEVC PROTOCOL

In August 2005, Engineers Canada partnered with Natural Resources Canada to conduct a national engineering vulnerability assessment of existing and planned public infrastructure to the impacts of climate change. One of the key outcomes from this partnership, completed in April 2008, was a formalized risk assessment procedure or tool, known as the PIEVC Engineering Protocol ("the Protocol"). Since then, more than 45 infrastructure systems have been completed or are in progress for a wide spectrum of assets (a complete list can be found at www.PIEVC.ca)

Engineers Canada describes the Protocol as a methodology that "systematically reviews historical climate information and projects the nature, severity and probability of future climate changes and events. It also establishes the adaptive capacity of an individual infrastructure as determined by its design, operation and maintenance. It includes an estimate of the severity of climate impacts on the components of the infrastructure (i.e. deterioration, damage or destruction) to enable the identification of higher risk components and the nature of the threat from the climate change impact. This information can be used to make informed engineering judgments on what components require adaptation as well as how to adapt them e.g. design adjustments, changes to operational or maintenance procedures."

OFNTSC signed a license agreement with Engineers Canada to use the Protocol for this assessment. The version used was PIEVC Engineering Protocol for Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate, Revision PG-10, May 2012.

The steps in the Protocol application are illustrated in **Figure 1**.

The PIEVC Protocol offers the user flexibility in adapting the process to the assessment context and constraints (e.g., time, resources, etc.). For the Akwesasne W/WW vulnerability and risks assessment, the application of the Protocol did not include Step 4 – Engineering Analysis, since the objective was to develop an overall risk profile of all the infrastructure, buildings and facilities used in providing potable water and wastewater collection and treatment for the community. In addition, although throughout the process social, economic and environmental impacts and benefits were considered, the assessment did not use the TBL module.

A brief description of each step is provided hereafter.

1.3.1 Step 1 – Project Definition

The first step in the application of the Protocol involves setting the general boundary conditions for the project. The Project Team establishes the infrastructure to be assessed and its key attributes such as location, condition, known concerns, etc. The team identifies the overall climatic elements that impact the infrastructure and past weather events that have caused disruptions or failures to the service(s) provided by the asset(s).

This step is used to narrow the focus of the study to allow efficient data collection and vulnerability assessment processes.

1.3.2 Step 2 – Data Gathering and Sufficiency

At this stage of the project, the Team compiles detailed information regarding:

- **The infrastructure, facilities, and buildings part of the assessment**. For example:
    - Detailing physical components of the infrastructure;
        - Number of physical components;
        - Location(s);
    - Other relevant engineering/technical considerations:
        - Material of construction;
        - Age;
        - Importance within the community served;
        - Physical condition;
        - Previous failures causing service disruptions;
    - Operations and maintenance practices;
- **Maintenance and operations logs and reports**;
    - Management practices related to the infrastructure;
        - Insurance considerations;
        - Policies and guidelines;
        - Financial and funding considerations;
        - Regulatory setting; and
        - Legal considerations.

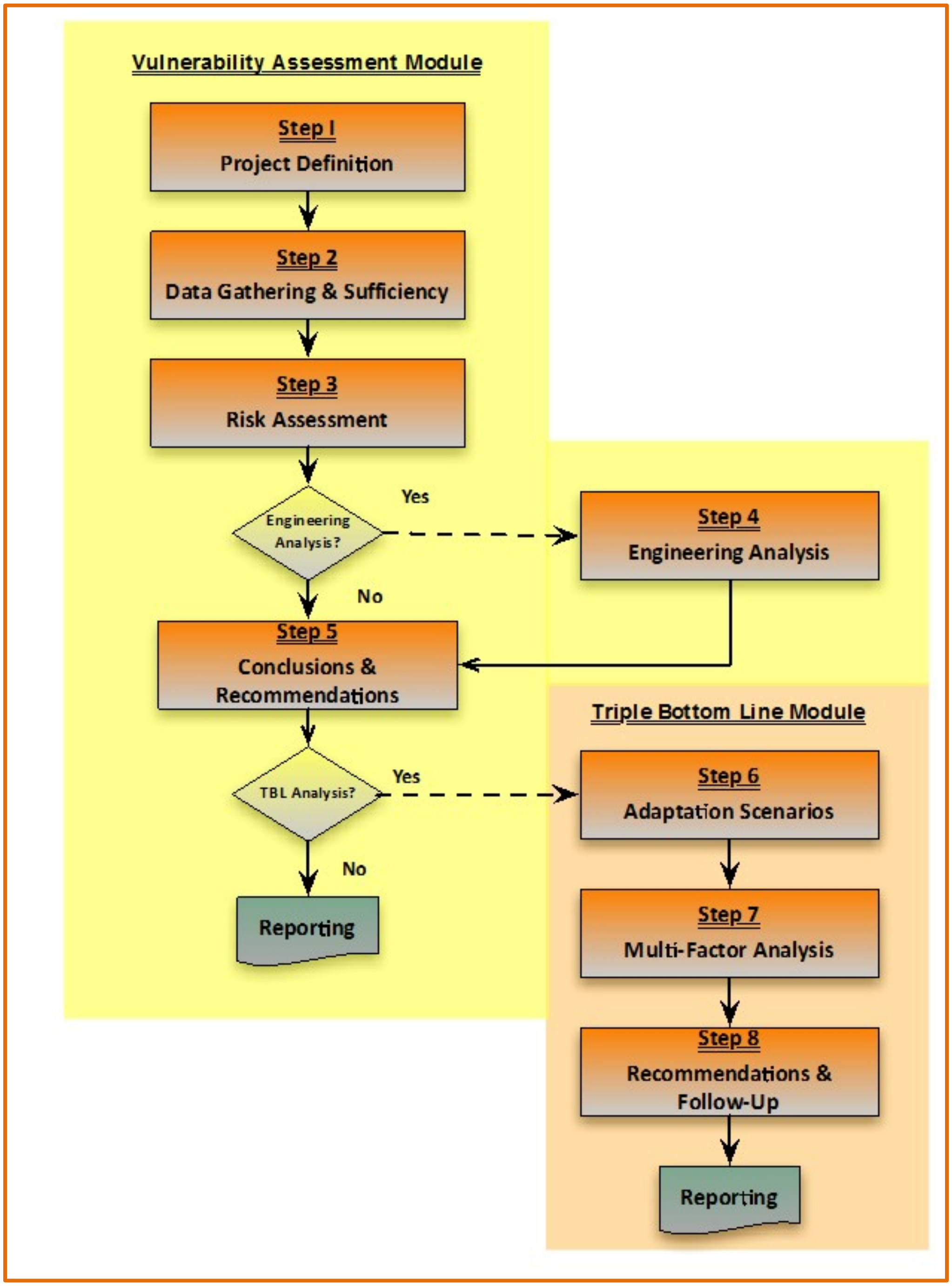


Figure 1: PIEVC Protocol Process Flowchart (Source: Engineers Canada, PIEVC Protocol Revision PG-10, May 2012)

- **Applicable climate information**. Sources of climate information include, but are not limited to:
  - Government agencies (for example: Environment and Climate Change Canada; Ontario Ministry of the Environment and Climate Change)
  - The National Building Code of Canada, Appendix C, Climate Information;
  - Intensity - Duration – Frequency (IDF) curves (for example, from the Ontario Ministry of Transportation or the Ontario Climate Data Portal);
  - Flood plain mapping;
  - Regionally specific climatic modeling and scenario development (IPCC, CCCSN.ca);
  - Historical records of severe weather events (for example: drought reports from conservation authorities and agriculture ministries; US NOAA registries, etc.)
  - Airport weather information (particularly wind patterns)
  - Climate research organizations (for example, ICLR, Ouranos); and
  - Others, as appropriate.

In this project a new element was added to incorporate Traditional Ecological Knowledge (TEK) pertaining to community knowledge of local climate as well as local ecological/environmental concerns.

1.3.3 Step 3 – Risk Assessment

The Project Team first establishes which infrastructure (assets or components) are affected by the selected climate elements; this narrows down the number of interactions the Team will have to assess. These climate-infrastructure interactions are identified in the context of particular response considerations, for example: structural performance, operational impacts, loss of functionality, effects on the environment, etc.

In the Protocol, Risk is defined as the product of two ratings:

- Probability rating: a rating that represents the probability of occurrence of a climate event above a selected threshold, ranging from 0 (not applicable) to 7 (certain to occur)
- Severity rating: a rating of the impacts on the infrastructure asset or component should the climate event occur, ranging from 0 (no impact) to 7 (complete failure)

Risks are evaluated under current climate conditions to establish a baseline; future risks are assessed considering future (projected) climate changes and the projected condition of the infrastructure. The interactions identified are evaluated based on the professional judgement of the assessment team.

In a PIEVC Protocol application, the assessment process does not require that all interactions be subjected to further assessment. In fact, most of the interactions considered will ultimately be eliminated from further consideration. Some interactions may clearly present no, or negligible, risk. Some interactions may clearly indicate a high risk and a need for immediate action. Those interactions that do not yield a clear answer regarding vulnerability may be the subject of a more detailed analysis (for example, refining the relevant climate event projections or improving the knowledge about the condition of the infrastructure and potential impacts of climate events), subjected to the further Engineering Analysis (Step 4 of the Protocol) or recommended for additional study subsequent to the assessment.

1.3.4 [Optional] Step 4 – Engineering Analysis

The optional Step 4 of the Protocol was not performed in this study.

1.3.5 Step 5 – Conclusions and Recommendations

The results of the previous Protocol steps are used to provide recommendations that generally fall into five major categories:

- No further action is required;
- Remedial actions required to mitigate infrastructure performance risks – typically engineering solutions such as upgrades to the infrastructure;
- Management actions required to account for changes in the infrastructure performance - for example, modifying operation and maintenance procedures due to fluctuations in winter precipitation patterns;
- Monitoring activities - for example, performance of the infrastructure or climate data analysis to validate projections; and/or
- Further work required to fill gaps in data availability or data quality.

1.3.6 Steps 6 to 8 – Triple Bottom Line Module

Not performed in this study.

1.4 SCOPE OF THE STUDY, TIMELINE AND LIMITATIONS

1.4.1 Scope of the Study

The objectives of the project were to:

- Build awareness of the PIEVC Protocol as a risk management tool to MCA and OFNTSC staff;
- Identify infrastructure vulnerabilities to current and future severe weather. The Akwesasne W/WW infrastructure considered in the study included the potable water, and wastewater collection and treatment systems for Cornwall Island (ON), St. Regis (QC) and Snye (QC);
- Establish a risk profile for the Akwesasne W/WW infrastructure; and

- Provide recommendations regarding mitigating risks with the highest consequences to the assets, service, and community;

1.4.2 Timeline

Figure 2 below shows the timeline of the project. It is important to note that the project was initially approved in October 2016 and the initial kick-off meeting took place during that month. However, due to schedule constraints and the changes in consulting team, the project's activities resumed mid-January 2017.

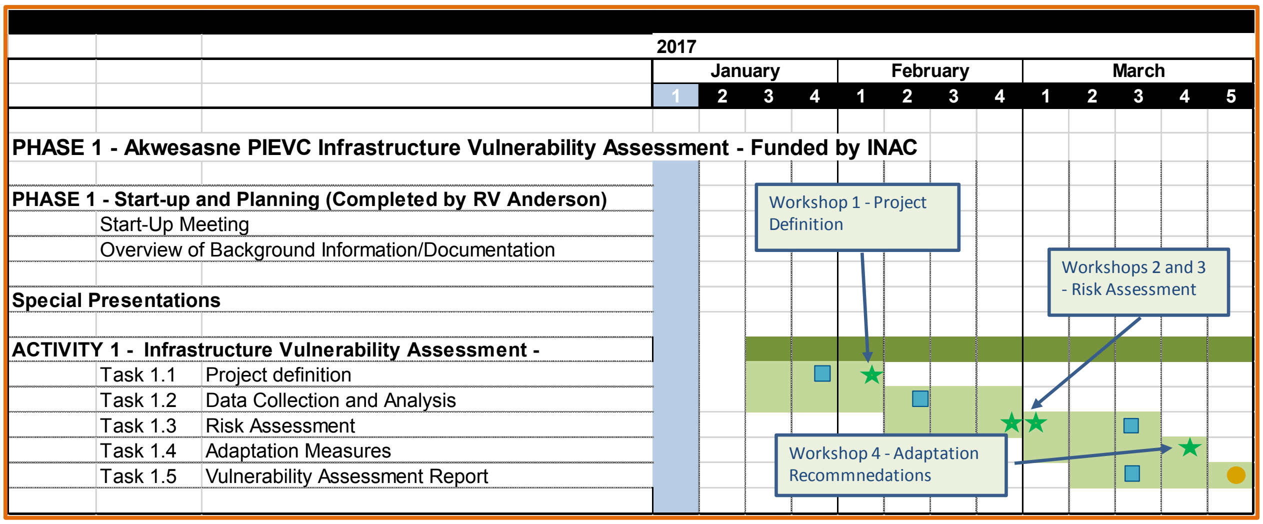


Figure 2: Project Timeline

1.4.3 Limitations

Due to the short timeline of the project, pressure was placed on the Project Team to meet the deadlines while respecting the principles of the PIEVC Protocol in terms of data collection, analysis, and validation.

It is possible that additional infrastructure and climate data exists that was not available at the time of the project or could not be considered.

Further investigation into the availability of infrastructure and climate data and its compilation into sources compiled for this project will form one of the recommendations arising from this assessment.

1.5 PROJECT TEAM AND ADVISORY COMMITTEE

The Project Team was composed of key staff from the MCA – Technical Services and Environmental Services Departments, OFNTSC Staff, and the Consulting team. This small but focused group of subject matter experts were supported by a Project Advisory Committee

(PAC) from organizations that are knowledgeable or are interested in the area of climate change impacts on public infrastructure.

The strong technical, operational, and environmental expertise of the MCA staff, and their knowledge and experience as long-time residents of Akwesasne, was an essential and invaluable source of infrastructure and climate information to this project.

The members of the Project Team and the Project Advisory Committee (PAC) are listed below.

Table 1.1: Project Team and PAC Members

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, Water and Wastewater Manager Leslie Papineau, Technical Project Manager	Consulting Team Dr. Guy Félio, Senior Advisor, Stantec (Project Manager) Amanda Lynch, Water Resources Engineer, Stantec Eric Dunford, Strategic Management Consultant, Stantec Alexandre Mineault-Guitard, Environmental Engineering Intern, Stantec Heather Auld, Climatologist, RSI Inc.
Project Advisory Committee (PAC)	
Stephanie Allen, OFNTSC	Andréanne Ferland, FNQLSDI
Ashley Dawn Bach, COO	Caroline Larrivée, Ouranos
Marla Desat, SCC	David Lapp, Engineers Canada
Tom Duncan, INAC	Jamie Ricci, Engineers Canada
Al Douglas, OCCIAR	Jacqueline Richard, OCCIAR

2.0 STEP 1 - PROJECT DEFINITION

The PIEVC Protocol illustrates the elements that are considered during the Project Definition step as illustrated in **Figure 3** below.

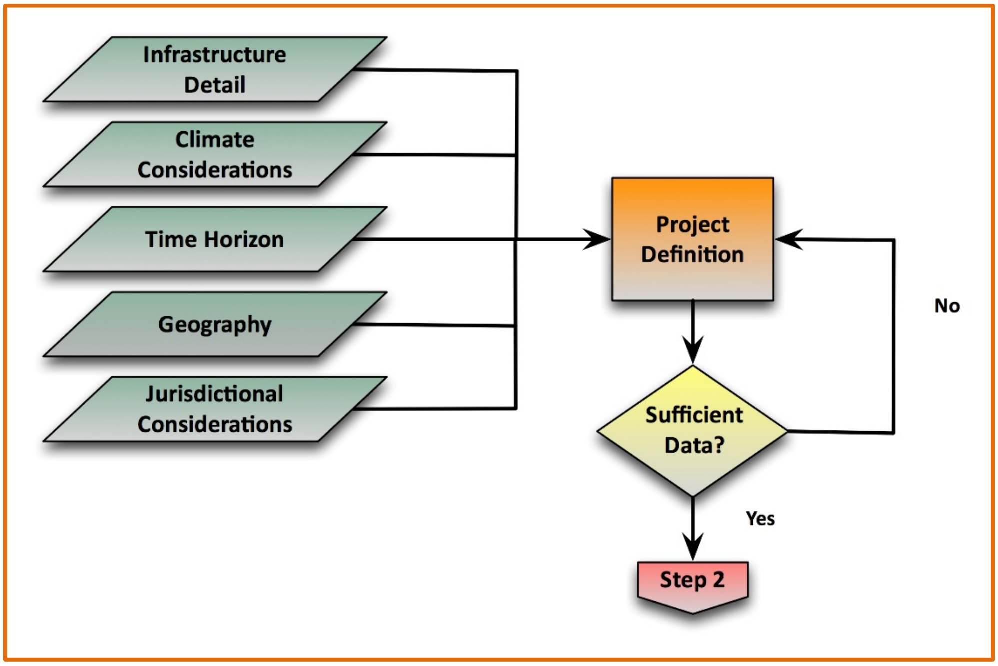


Figure 3: PIEVC Protocol Project Step 1 - Definition Process Flowchart (Source: Engineers Canada, PIEVC Protocol Revision PG-10, May 2012)

The Project Team met at Workshop 1 on February 8, 2017 with some members of the PAC in attendance to define the project parameters.

All participants acknowledged that MCA's Technical Services had very good knowledge of the water and wastewater infrastructure they operate as illustrated by the comprehensive information presented at the Workshop.

Figure 4: Presentation by David Lapp of Engineers Canada at the Project Definition Workshop

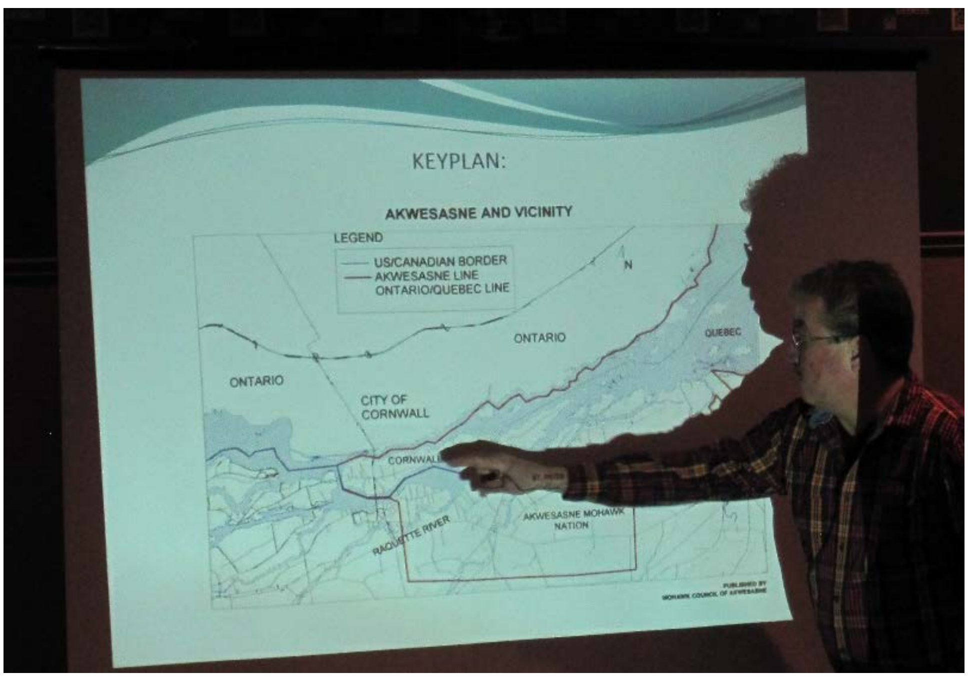


Figure 5: Jay Benedict, Director of MCA Technical Services presents the W/WW Infrastructure of Akwesasne at the Project Definition Workshop

Climate related concerns:

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

- Lightning: has caused disruptions in the SCADA (supervisory control and data acquisition – an IT system for gathering and analyzing real time data to support W/WW operations) and radio signals.
    - A participant noted a shift in when Traditional Lightning Ceremonies took place, In the past, these ceremonies would take place in June/July and September/October. However, in the last 10 years, these ceremonies occur earlier, in March/April and later in the year, November/December. It was also mentioned that lightning was noticeably more intense.
- Mixed winter precipitation events are more common: snow with winter rain, and freezing rain. This has caused problems in buildings with flat roofs (which are common in W/WW facilities), which are susceptible to damage due to these conditions and can cause leaks into the buildings.
- Strong wind events that restrict traffic or close bridges to Cornwall island: this has an impact on operations since the South Channel Bridge is used to access the W/WW facilities in St. Regis and Snye.
- Impacts of extreme high or sustained high temperatures on the operations personnel. The MCA has been pro-active in this area with precautions in place for employees.
- Heavy rains:
    - Concerns with surface run-off that change the turbidity of the raw water. Although the WTPs have some capacity to deal with certain thresholds of turbidity, more frequent or severe run-off may cause turbidity levels that cannot be handled by current plant processes.
    - Increased I/I (infiltration and inflow) into wastewater collection system that impacts the WWTP at St. Regis.
    - Increased flow into the WW collection system from individual properties - for example, sump pumps from houses in St. Regis are connected to the WW collection system.
- Lower water levels in the St. Lawrence River – impacts on the raw water intake:
    - Change in shipping channels, that currently may cause ships to run aground, may cause ships to come close and damage the water intake.
    - Lower water levels and higher temperatures may cause biological changes in the raw water that may not be treated with the current processes in the WTP.
    - Concern about the water transmission main buried in the channel between St. Regis and Snye.
- Freezing rain and ice storms: winter road patterns are changing and during freezing rain events, cars have fallen through near the water intake in St. Regis.
- Insect spreads (and possible new species): for example, Brown Recluse spider and Lyme decease carrying ticks – impacts on personnel operations.

Infrastructure to be considered

Based on the information provided by the MCA Technical Services, the water and wastewater system in Akwesasne can be characterized as two independent systems, as follows:

- Cornwall Island: potable water and wastewater systems
- St. Regis/Snye: potable water and partial wastewater systems (some properties in St. Regis and Snye use private septic systems)

The group discussed which infrastructure should be considered in the PIEVC study and decided to do an assessment of both systems. Factors considered included the fact that these two systems serve different types of geography and population densities (Cornwall Island being more geographically spread out while St. Regis being similar to a small village).

Time Horizon for the study

The time horizons for the study were selected as current conditions (establishing the baseline risks) and 2050 for future conditions. Many of the Akwesasne 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 advance stage into their service lives within the time horizon selected.

3.0 STEP 2 – DATA GATHERING - AKWESASNE W/WW INFRASTRUCTURE

MCA operates the Community's water and wastewater system to service the population of the three districts. As many other communities in Canada, Akwesasne is not immune to extreme weather and climate uncertainty, and has experienced meteorological events that have caused service disruptions and damage to its infrastructure.

3.1 INVENTORY OF INFRASTRUCTURE COMPONENTS

The Akwesasne Mohawk Nation spans the Ontario/Quebec border as well as the Canada/U.S.A. border. The infrastructure systems reviewed in this study includes systems located on Cornwall Island, Ontario and St. Regis and Tsi Snaihne (Snye), Quebec.

In addition to the infrastructure information provided by the MCA Technical Services, the team was given INAC's Asset Condition Rating System (ACRS) and Integrated Capital Management System (ICMS) data for the Akwesasne infrastructure.

3.1.1 Cornwall Island, Ontario

The Cornwall Island infrastructure systems consists of the Cornwall Island West Water Treatment Plant (WTP) and associated distribution pipes and fire hydrants, pump stations and rotating biological contactors (RBC) for treatment of sanitary discharge at various community facilities. Each of the facilities is discussed in the following sections. A key plan of Cornwall Island infrastructure is included in **Figure 6** below.

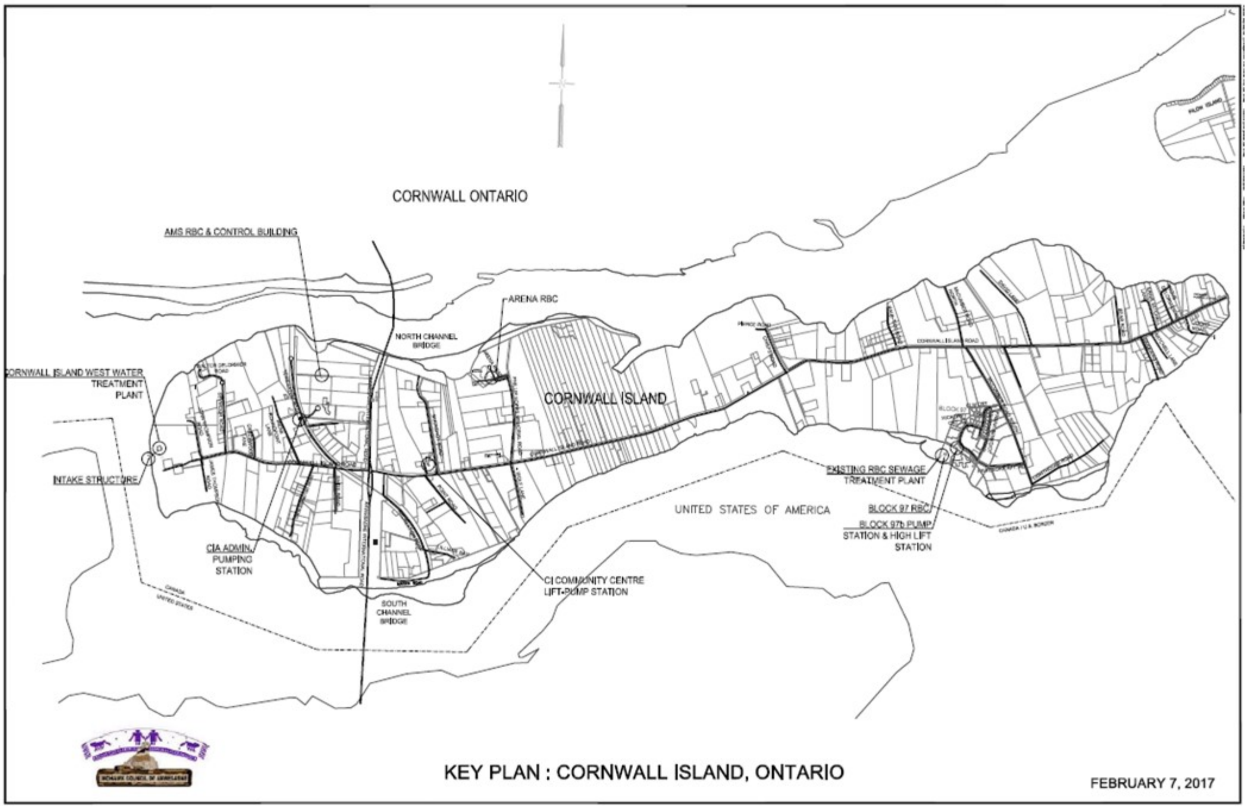


Figure 6:Key Plan of Cornwall Island Water and Waste Water Facilities

3.1.1.1 Cornwall Island West Water Treatment Plant

The Cornwall Island WTP used direct filtration treatment to provide potable water to all of Cornwall Islands' water distribution system. The facility is located on the west end of the island which is the highest elevation location on the island. The facility was constructed in 2006 and designed for a 20-yr population projection of 6,898 persons. The facility is designed to meet average day demand flows of 300Lcpd and provide a fire flow rate of 166.7L/s for 3hours. The WTP also includes 1,400m^3 of reservoir storage.

Figure 7 below shows frontal photo of the building.

Figure 7: Cornwall Island Water Treatment Plant Building

Intake and Low Lift Pump

The intake for the WTP is located in a high-flow reach of the St-Lawrence River approximately 10m from the shoreline and 3m deep. A low lift pump is housed in a control building at the top of the river bank to pump water from the St-Lawrence to the WTP. The pump station includes two low-lift pumps to allow for redundancy.

Figure 8: Intake and Low Lift Pump

<u>Treatment Process Components</u>

The water treatment process at the Cornwall Island WTP relies primarily on direct filtration using sand filter systems. A flocculant agent (alum) is added to the intake water to encourage coagulation of particles to facilitate removal through the filtration system. Filtered water is captured and conveyed to the UV treatment system for disinfection.

Figure 9: Inside View of the Cornwall Island WTP

Filters are backwashed on a regular basis to remove the sediments accumulated in the filters. Backwash water is discharged to settling tanks from which the settled sludge is collected for disposal and clarified water is discharged back to the St-Lawrence River. The backwash discharge is routinely tested for chlorine residual. A cascading outlet system and wetland provides aeration and polishing of the backwash discharge water.

Disinfection of the treated water is provided via an Ultraviolet (UV) disinfection system. For drinking water treatment, UV systems are increasingly common as they provide high levels of disinfection with less production of harmful by-products which are common with chlorine or bromine disinfection processes. Nevertheless, a small amount of chlorine is required to be added to the treated water prior to entering the reservoir to ensure sufficient residual is present in the distributed water to prevent contamination in the distribution system.

Reservoir and High lift pumps

Treated water is stored in the 1400m[3] reservoir for domestic demand and fire-fighting reserve. Water is pumped from the reservoir to the distribution main by high-lift pumps. A total of five (5) high-lift pumps are available to pump to the distribution main however only one pump runs continuously with the other four pumps available during higher demand conditions. If the pressure in the distribution main drops below 80psi a second pump is started to maintain the system pressure.

SCADA System

The entire treatment plant is controlled by a SCADA system that monitors flows and pressures throughout the various system components. They system will initiate back-up pumps as necessary and will also alert the operator of critical issues.

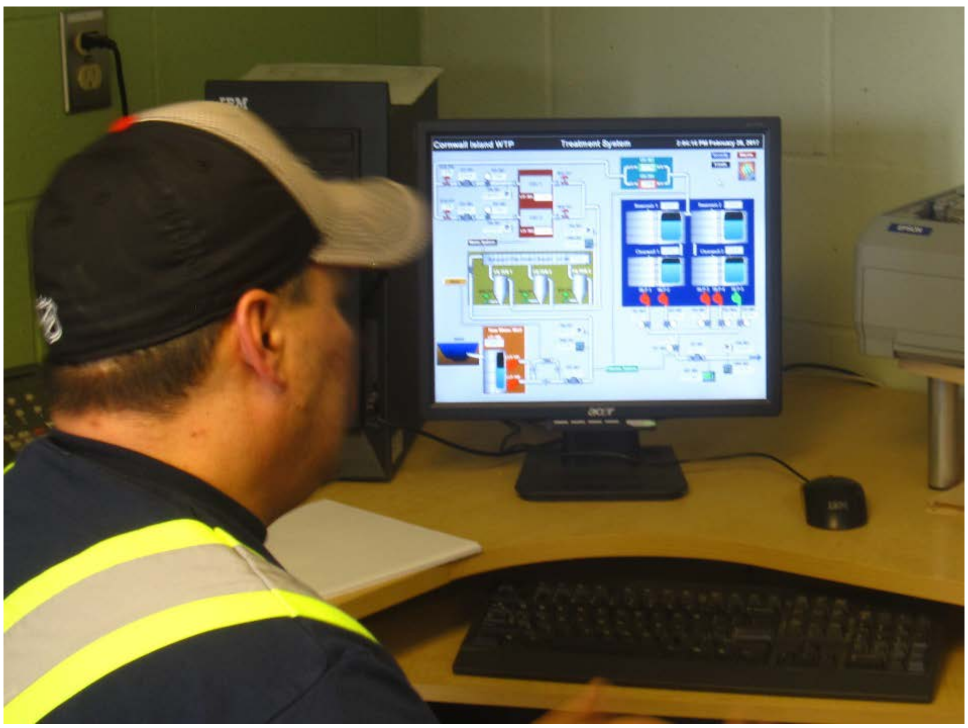


Figure 10: MCA Water Treatment Plant Operator Clayton Barnes Explaining the Plant's SCADA System During the February 28, 2017 Site Visit

Backup Power

A diesel generator provides a back-up power source for the WTP. On-site fuel storage provides sufficient fuel to power the generator continuously for approximately 3 days. The generator is serviced and tested regularly to ensure it is maintained operable in the event of a power failure.

Figure 11: MCA Water Treatment Plant Backup Generator

3.1.1.2 Cornwall Island Water Distribution Systems:

The Cornwall Island Water Treatment Plant serves Kawehnoke with over 9 kilometers of water main and approximately 450 service connections, while the St. Regis Water Treatment Plant serves all of Kanatakon and Tsi Snaihne with 27 kilometers of water main and approximately 950 service connections.

A total of 143 fire hydrants are located on Cornwall Island and are maintained for the Cornwall Island District. Fire hydrants provide a point of connection for fire-fighting as well as a means of flushing the water distribution system to eliminate any stagnated or potentially contaminated water from the distribution main.

3.1.1.3 Rotating Biological Contactors

There are three (3) rotating biological contactors (RBC) that provide waste water treatment to community buildings on Cornwall Island. These RBC units are a form of secondary wastewater treatment which relies on biological decomposition of organic matter in the wastewater. The systems include a primary treatment process that uses pre-screening and settling to remove larger solids.

The RBC unit consists of closely spaced disks that are mounted on a rotating shaft and installed just above the surface of the wastewater. Microorganisms grow on the disks which provide the mechanism for biological decomposition of the organic pollutants in the wastewater.

The following RBC units are in operation on Cornwall Island:

- Cornwall Island Block 97 RBC
  - Built in 2001 to replace a smaller system
  - Services all of Block 97
  - Discharges by gravity to the St-Lawrence River on the shore of the island

Figure 12: Exterior View of Block 97 RBC

Figure 13: Interior View of Block 97 RBC

- Arena RBC
  - Build date is unconfirmed
  - Services the Cornwall Island Arena
  - Discharges by gravity to the St-Lawrence on the north shore of the island
- Akwesasne Mohawk School (AMS) RBC
  - Built in 1991 and services the AMS
  - Gravity outlets to the St-Lawrence River on the north shore of the island
  - Includes a control building which houses power and controls for the RBC unit

3.1.1.4 Pump Stations

<u>Wastewater</u>

There are three wastewater pump station facilities located on Cornwall Island that pump wastewater to nearby RBC units for treatment. These pumps are located below ground with access ports from the surface. Most sites include above ground control panels and air vents.

Cornwall Island Block 97 pump station

- Pumps wastewater from the Block 97 development (consists of 9 apartment buildings, chronic care facility and 30 homes) to the RBC unit.
- Constructed in 1991

Cornwall Island Community Centre Lift Station

- Serves the Community Centre/Daycare and the Tri-district Elders Centre.

Cornwall Island Administration (CIA) complex Pump Station

- Pumps wastewater from the CIA complex to the AMS RBC for treatment.
- Constructed in 2002

Figure 14: Exterior and Interior Views of the Cornwall Island Administration Pump Station

<u>Potable Water</u>

A high-lift water pumping station is also operational at the Block 97 site; this lift station was initially constructed in 1989 to service the development but is now on standby since the construction of the water treatment plant.

Figure 15: Building of the High Lift Station at Block 97

3.1.2 St. Regis, Quebec

The St. Regis infrastructure systems consists of a Water Treatment Plant (WTP) and associated distribution pipes and fire hydrants, pump stations, Waste Water Treatment Plant (WWTP) and wastewater pumping stations for collection of waste water and for discharge of treated effluent. St. Regis village infrastructure also includes a stormwater collection system. Each of the facilities is discussed in the following sections. A key plan of St. Regis infrastructure is included in **Figure 16** below.

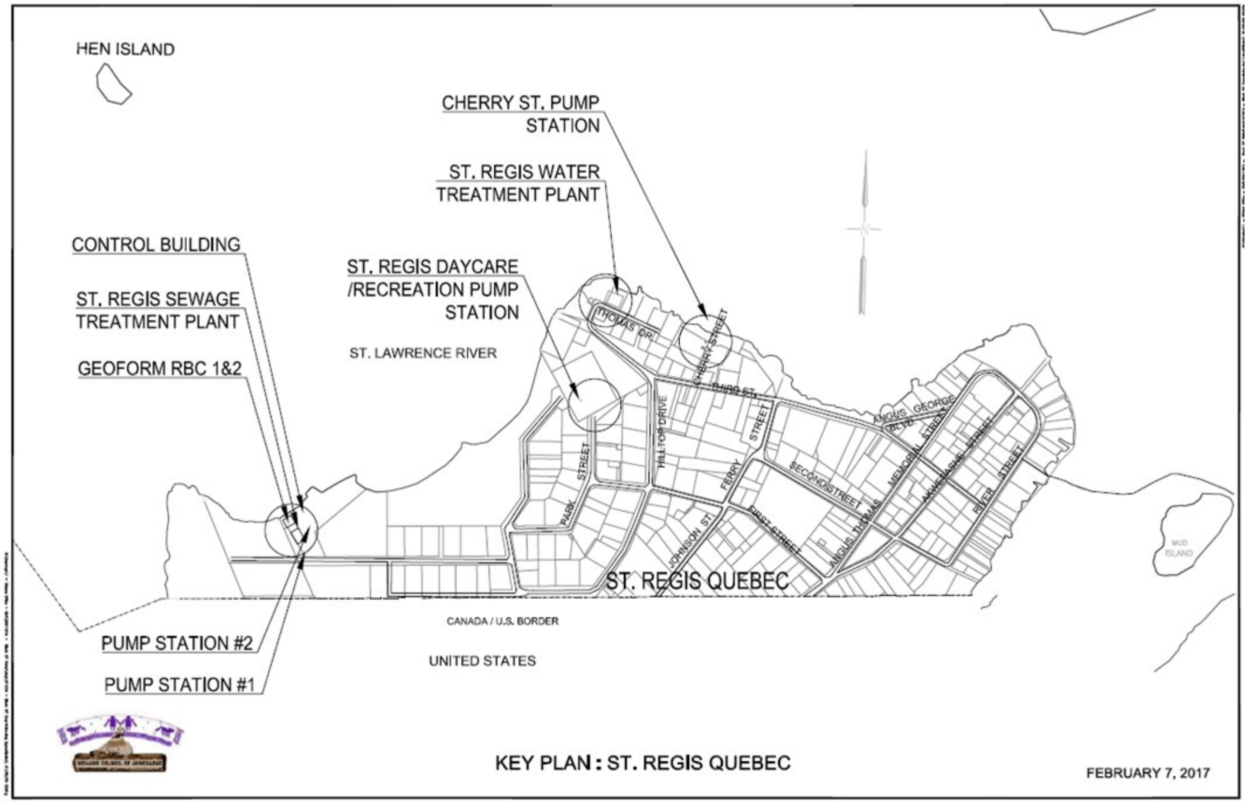


Figure 16: Main Infrastructure Locations in St. Regis (QC)

3.1.2.1 St. Regis Water Treatment Plant

The St. Regis WTP uses direct filtration treatment to provide potable water to all of St. Regis and a portion of Snye's water distribution system. The facility is located on the on the south bank of the St-Lawrence River. The facility was constructed in 1998 and designed for a population projection of 2,500 persons. The facility is designed with a total flow capacity of 2046m3/d and serves to meet average day demand flows of 300Lcpd. The WTP has a total storage capacity of 1,639m^3 within the reservoir which includes a fire flow reserve of 842m^3.

Figure 17: Exterior View of the St. Regis Water Treatment Plant

<u>Intake and Water Treatment Process</u>

The treatment facility draws raw water from an intake of the shore of the St-Lawrence River. Treatment of the raw water is achieved using granular activated carbon (GAC) filters and ultraviolet (UV) system disinfection.

Figure 18: Granular Activated Carbon Tanks at St. Regis WTP

<u>Reservoirs</u>

The reservoirs at the St. Regis WTP includes a total of 5 holding tanks. Two reservoirs are used to store raw water and the remaining three are used to store treated drinking water for distribution and emergency supply.

<u>Water Distribution System</u>

Treated water is distributed from the WTP to St. Regis village and a portion of Snye via a watermain network. The distribution system also includes 39 fire hydrants which are maintained by the St. Regis District.

3.1.2.2 St. Regis Waste Water Collection System

The St. Regis waste water collection system includes two pump stations which pump waste water from the service area to the wastewater collection sewers for conveyance to the wastewater treatment plant. Both facilities are located below ground with control panels located above the ground surface.

<u>Cherry Street Pump Station.</u>

This lift station services the entire lower region of St. Regis Village which consists of approximately 150 homes. Constructed in 1998 the lift station is located near the north central limit of the village.

Figure 19: Exterior of the Cherry Street Pump Station

Figure 20: Interior of the Cherry Street Pump Station

St. Regis daycare/Recreation Centre Pump Station

This lift station services the Kanatakon St. Regis Recreation Building. The facility is located south of the water treatment plant near the centre of the village.

3.1.2.3 St. Regis Waste Water Treatment Plant

The St. Regis waste water treatment plant (WWTP) was constructed in 1991 and services the entire village of St. Regis. While the facility was originally constructed in 1991 the existing treatment system relies on Geoform RBC units installed in 2001. The facility has a design capacity for 2018 population projections of 2,000 persons and uses and has a rated capacity of 1,080m^3/d. The plant's peak hydraulic capacity is 42.7L/s for three hours.

Figure 21: Exterior View of the St. Regis Wastewater Treatment Plant

The treatment facility provides primary and secondary treatment of wastewater. Primary treatment is achieved through settling of solids while secondary treatment is achieved through the four train RBC system composed of four trains of four units. Treated wastewater is pumped from the PS3 lift station for discharge to the St-Lawrence River. The pump station is located underground with a control panel located at the surface. The lift station was constructed in 1999.

Figure 22: RBC Units at St. Regis WWTP

3.1.2.4 Stormwater Collection System

A stormwater collection system services a portion of St. Regis however it is understood that the system provides conveyance only and does not include water quality treatment or flow control.

3.1.3 Snye, Quebec

The Snye infrastructure systems consists of a drinking water storage and distribution system, wastewater pump stations, and a wastewater treatment facility including a lagoon. Each of the facilities is discussed in the following sections. A key plan of Snye water and waste water infrastructure is included in **Figure 23** below.

3.1.3.1 Snye Water Storage Facility/Pump House and High-Lift Station

The Snye Water Treatment Plant is located near the centre of the district and serves only to house the main reservoir for drinking water distributed from the St. Regis WTP. The facility has a storage capacity of 800m3 and was constructed in 1991. As the reservoir is located underground, a high lift station is used to distribute drinking water and to sustain system pressures. The lift station was constructed in 1991 and consists of three high lift pumps; two jockey pumps and one Fire Pump that provides limited service during a power outage. A total of 149 fire hydrants also make up part of the Snye water distribution system.

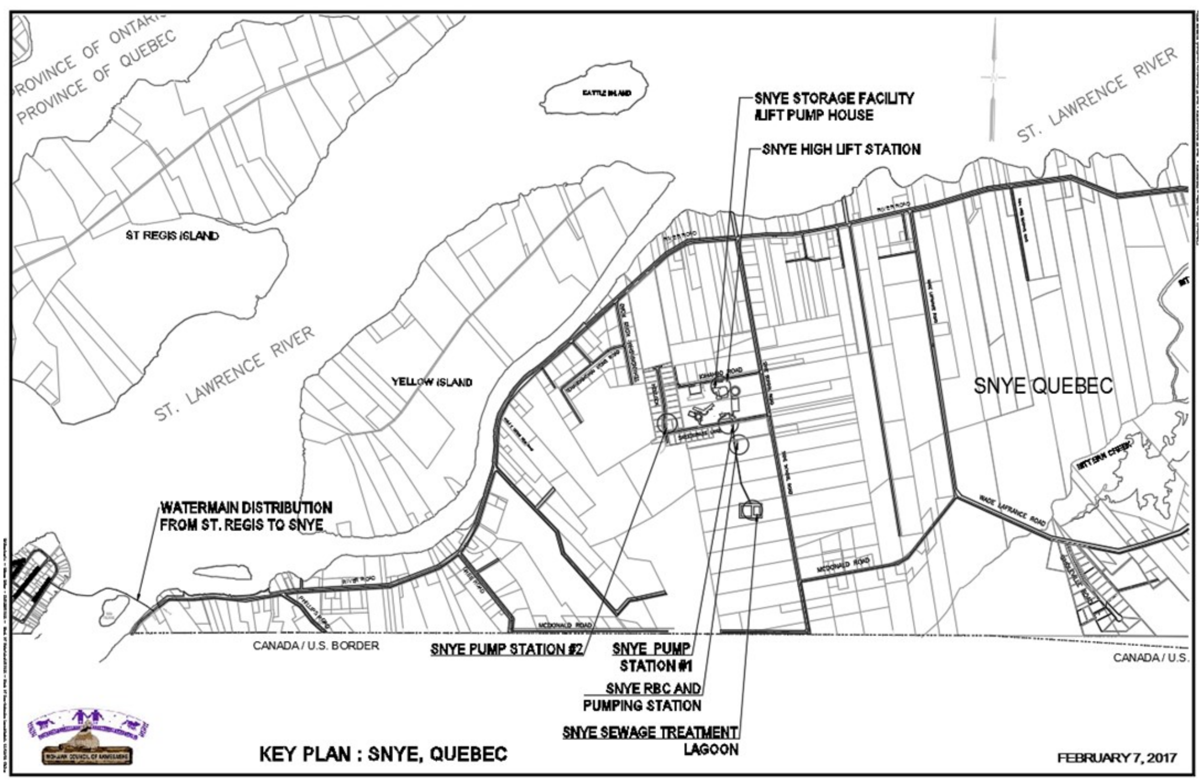


Figure 23: Main Infrastructure Assets at Snye

3.1.3.2 Waste Water Pumping Stations

There are two waste water pumping stations located within the Snye district that pump waste water to the RBC treatment facility.

Snye Pump Station 1

This pump station was constructed in 1960 and is located near Snye School and handles most of the Snye municipal waste water flow. The facility consists of two active pumps located below ground with a control panel located at the surface.

Snye Pump Station 2

Pump station 2 was constructed in 2009 and services the residential subdivision along CH-704 and Sweet Grass Lodge Road. the facility is located below ground with a control panel at the surface.

Figure 24: Snye Pump Station #1 (left) and Pump Station #2 (right)

3.1.3.3 Snye RBC and Waste Water Lagoon

The RBC unit was constructed in 1991 and services the schools, Daycare, Lakhihsotha Lodge and residential subdivision consisting of approximately 30 homes. The facility handles all the municipal waste water for the Snye district.

The waste water treatment lagoon was constructed in 1960 and consists of two ponds downstream of the RBC unit. At initial construction, the lagoon would have provided the primary treatment for the Snye waste water system. Since the construction of the RBC unit, the lagoon provides a final treatment step for the RBC effluent.

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 provided by the MCA Technical Services staff and the ICMS report provided by INAC.

The ICMS data provides an overall condition rating for each infrastructure asset on a scale from 0 to 10, with 10 being a new asset, as shown in **Table 3.1** below. The table also shows, for reference purposes, the Canadian Infrastructure Report Card (see www.CanadaInfrastructure.ca) rating system which is commonly used by municipalities. The table also includes a description of the rating used by the City of Edmonton to illustrate the meaning of the ratings.

Table 3.1: INAC's ICMS, Canadian Infrastructure Report Card (CIRC) Condition Rating Scales and Descriptive (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.

ICMS GENERAL CONDITION RATING		CIRC CONDITION RATING		DESCRIPTION (Source: City of Edmonton)
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 municipal scales present similar ratings but are not comparable on a 1-to-1 basis. **Table 3.2** below presents an extract of the ICMS report provided by INAC which provides information on the condition of infrastructure in Akwesasne.

Table 3.2: INAC's ICMS Condition Rating Scale

	Mohawks of Akwesasne - Water & Wastewater Assets									
	As per ICMS - March 16, 2017									
Site	Sub-Class Description	Asset Code	Asset Name	Year Constructed	Age	Design Life	Estimated Remaining Life	Quantity Number	Unit	General Condition Rating
06210	WATER SUPPLY/TREATMENT	A5A	KAWENOKE WEST LOW LIFT STATION BUILDING	2005	11	40	30	22	sq. m	Good
06210	WATER SUPPLY/TREATMENT	A5A	ST.REGIS SEWAGE TREATMENT	2001	15	20	30	397.3	sq. m	Good
06210	WATER SUPPLY/TREATMENT	A5A	KANEKI:IO WATER PLANT	1998	18	30	25	746.15	sq. m	Good
06210	WATER SUPPLY/TREATMENT	A5A	TSI SNAIHNE WATERPLANT	1978	38	30	25	260	sq. m	Good
06210	WATER SUPPLY/TREATMENT	A5A	KEWENOKE WEST WTP BLDG	2005	11	40	35	906	sq. m	Good
06210	WASTEWATER TREATMENT DISPOSAL	A5B	SEWAGE TREATMENT BUILDING	1991	25	0	25	79.8	sq. m	Good
06210	WASTEWATER TREATMENT DISPOSAL	A5B	RBC CONTROL BUILDING - AMS	1991	25	30	25	8	sq. m	Good
06210	WATER MAINS	B1B	SNYE WATERMAIN EXTENSION	2011	5	50	40	10844	m	Good
06210	WATER MAINS	B1B	WATERMAINS CORNWALL ISLAND	1977	39	0	15	100	m	Good
06210	WATER MAINS	B1B	CI EAST WATERMAIN	2008	8	50	40	7470	m	Good
06210	WATER MAINS	B1B	WATER MAIN SNYE	1996	20	30	25	9600	m	Good
06210	WATER MAINS	B1B	WATER MAINS KAWENOKE APTS.	2001	15	50	30	1310	m	Good
06210	WATER MAINS	B1B	WATER MAINS C.I. WEST	2008	8	50	40	9175	m	Good
06210	WATER MAINS	B1B	WATER MAINS ST-REGIS	1998	18	30	30	6453	m	Good
06210	WATER TREATMENT SYSTEM	B1C	KAWENOKE WEST WATER TREATMENT	2005	11	20	25	1	ea	Good
06210	WATER TREATMENT SYSTEM	B1C	WATER TREATMENT SYSTM@KENEK:IO	1998	18	30	15	1	ea	Good
06210	WATER STORAGE	B1E	RESERVOIR CI WTP	1989	27	25	20	1	ea	Good
06210	WATER STORAGE	B1E	RESERVOIR KANE'KI:IO H20	1997	19	30	20	1	ea	Good
06210	WATER STORAGE	B1E	RESERVOIR	1991	25	0	10	1	ea	Good
06210	WATER STORAGE	B1E	RESERVOIR CI WEST WTP	2005	11	30	20	1	ea	Good
06210	HIGH LEVEL LIFTSTATION	B1H	HIGH LIFT STATION	1991	25	15	15	1	ea	Good
06210	HIGH LEVEL LIFTSTATION	B1H	HIGH LIFT STATION	1991	25	30	15	1	ea	Good
06210	LOW LEVEL LIFTSTATION	B1I	KANE KIIO-LOW LIFT STATION	1998	18	0	25	1	ea	Good
06210	LOW LEVEL LIFTSTATION	B1I	KAWENOKE WEST LOW LIFT PUMPS	2006	10	30	20	1	ea	Good
06210	SANITARY MAIN	B2A	SANITARY MAINS ST. REGIS	1992	24	30	20	5222	m	Good
06210	SANITARY MAIN	B2A	SANIT.MAIN COLLECTION SNYE	1991	25	40	25	1002	m	Good
06210	SANITARY MAIN	B2A	CI ADMIN SANIT.COLLECTION	2002	14	40	25	990	m	Good
06210	SANITARY MAIN	B2A	SANIT.MAIN COLLECTION BLK97	1990	26	25	20	985	m	Good
06210	STORM MAIN	B2B	STORM MAINS - ST. REGIS	1960	56	60	15	2149	m	Fair
06210	STORM MAIN	B2B	STORM MAIN CI EAST	2003	13	30	30	1168	m	Good
06210	STORM MAIN	B2B	STORM MAINS - C.I. WEST	2001	15	0	25	420	m	Good
06210	RBC/TRICKLING FILTER	B2C	RBC UNIT	1991	25	0	5	1	ea	Fair
06210	RBC/TRICKLING FILTER	B2C	16 UNIT RBC ST.REGIS	2001	15	7	10	1	ea	Good
06210	RBC/TRICKLING FILTER	B2C	BLK 97 SEWAGE RBC EXPANSION	2001	15	0	10	1	ea	Good
06210	LAGOON	B2E	LAGOON - CHENAIL SCHOOL	1960	56	0	5	1	ea	Good
06210	CTTY SEPTIC TANK AND FIELD	B2F	COMMUNAL SEPTIC FIELD BED	2001	15	30	15	1	ea	Fair
06210	LIFTSTATION	B2H	SANITARY LIFT STATION SNYE PH. 2	2009	7	40	25	1	ea	Good
06210	LIFTSTATION	B2H	LIFT STATION SEWAGE PS2 CHERRY	1998	18	30	20	1	ea	Good
06210	LIFTSTATION	B2H	SEWAGE LIFT STATION, SR-PS5	1994	22	30	10	1	ea	Good
06210	LIFTSTATION	B2H	PS3 LIFT STATION -SEWAGE	1999	17	30	20	1	ea	Good
06210	LIFTSTATION	B2H	LIFT STATION - SEWAGE	1991	25	0	20	1	ea	Fair
06210	LIFTSTATION	B2H	CI ADMIN.PUMP STATION	2002	14	20	20	1	ea	Good
06210	LIFTSTATION	B2H	LIFT STATION - SEWAGE	1960	56	0	10	1	ea	Fair
06210	LIFTSTATION	B2H	CI COMMUNITY C&R LIFT STATION	2000	16	0	10	1	ea	Good

In general, **Table 3.2** shows the water and wastewater assets in Akwesasne are in good condition, with some infrastructure, particularly for wastewater and stormwater management, exhibiting signs of deterioration or performing at lower levels than originally intended.

Additional information on the condition and needs of the Akwesasne water and wastewater infrastructure was provided by the MCA Technical Services as follows:

- SCADA at St. Regis WWTP not working at this time
- Snye RBC needs replacing due to age
- Snye Pump Station 1 needs replacing
- Pumps need to be replaced at Cherry ST. Pump Station 1 (Snye)
- Three pumps at Snye WWTP need replacement
- St. Regis water intake: Zebra mussels and freezing problems
- All Fuel tanks need replacing due to age/condition
- Leaks in distribution system in St. Regis / Snye

- Infiltration/sump pumps in stormwater collection system in St. Regis and Snye
- Piping needs replacing in Blk 97 pump station
- Need grinder or shredder pumps in Blk 97 Pumping Station
- Need new grinder in PS 1 St. Regis

Other problems identified by the MCA Technical Services in the operations, maintenance and capital improvements for their W/WW infrastructure include:

- Wait times / travel at both border crossings
- Contracted service personnel sometimes have trouble or refuse to cross border
- Cost of equipment has increased, and/or there is limited availability in Canada, therefore the only source is to purchase in the United States where the exchange rate for the US dollar is high.

4.0 CLIMATE CONSIDERATIONS

The climate considerations presented hereafter are the result of discussions of the Project Team and PAC members at the project workshops, research into public information and the report entitled "Climate Probability Analyses for Mohawk Council of Akwesasne PIEVC Studies" from RSI Inc. is attached in **Appendix A**.

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.

4.1 TRADITIONAL CLIMATE KNOWLEDGE

Information gathered from long-time residents of Akwesasne on the Project Team, complemented by the report below, were critical to guide the climate analysis and define the infrastructure thresholds this vulnerability assessment.

4.1.1 Climate Change Adaptation Plan for Akwesasne (2013)

The Project Team and PAC members were provided a 2013 report produced by the St. Regis Mohawk Tribe entitled *Climate Change Adaptation Plan for Akwesasne*. This report describes climate trends, for example:

> "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 flows."

The report makes particular reference to the weather events of 2012, as follows:

> "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."

> "Thunderstorm warnings were also issued. As a result of the dry conditions, residents who planted gardens needed to work extra hard to keep gardens from drying up. Heavy rainfall has been more frequent, downing corn stalks

> and other tall plants, and heavy cloud cover and cloud formations with high winds have been observed to have become more frequent as well."
>
> "A tornado hit in Summerstown in summer 2012, just miles from Akwesasne. Akwesasne had high winds on that day."
>
> "On December 27th, 2012, there was a winter storm warning in Akwesasne and many businesses and offices were closed. Schools were out on Christmas vacation. Thirteen to 17 inches of snow fell within 24 hours."

Climate trends indicate these patterns may continue in the future. The climate analysis revealed:

- Mid-late summers appear to be changing: increasing rainfall totals for June, July and September, while decreasing in August (see **Figure 25** below).
- Climate change models for future are not clear – slight summer increases.
- Spring and summer 2012 were very dry – Level 2 Low Water in Raisin River Conservation Authority and Level 3 in parts South Nation Conservation Authority; accompanied with hot temperatures.

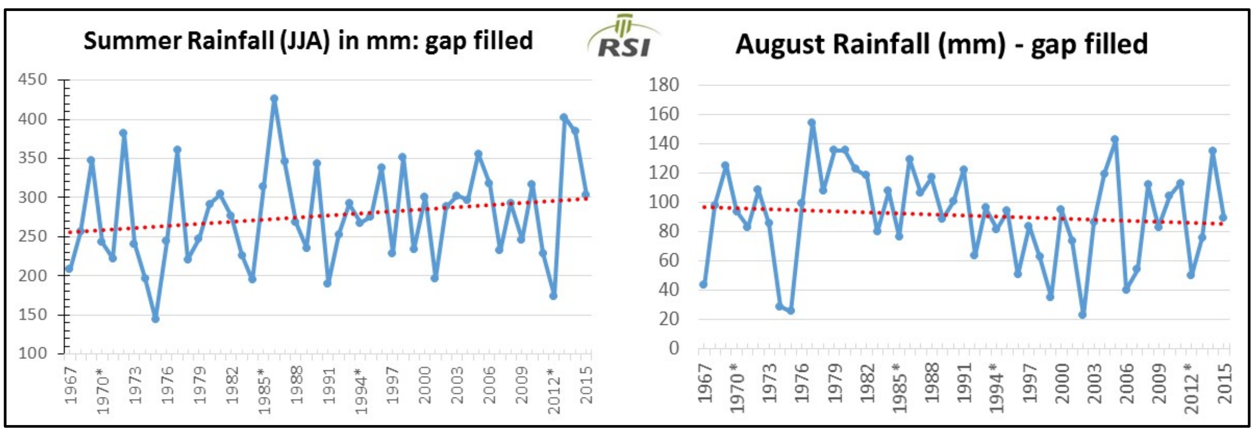


Figure 25: Comparison of Summer Rainfall Averages and August Rainfall Averages for Cornwall (* indicates incomplete data)

4.1.2 Lightning and Hail

Two additional meteorological events were included in the analysis as they may have impacts on the infrastructure assessed:

> Lightning which has caused SCADA failures in the past and for which the season of occurrence, based on local observations, is now longer. As indicated earlier, a member of the Project Team noted a shift in when Traditional Lightning Ceremonies took place, and that lightning was noticeably more intense.

Although hard to predict, the NOAA storm events database reports a strong lightning event in Massena (NY) in May 2007 that caused in excess of US $250,000 in damages at the time.

Hail up to between 3/4in (19mm) and 1in (25mm) diameter has been reported in the NOAA storm events database in July 2008 and 2016 in the Massena (NY) area.

4.2 GENERAL OVERVIEW

Akwesasne's unique and challenging climate can be characterized by:

- Many storm tracks meet in the area – even an Atlantic Ocean influence
- Unique valley climate – St Lawrence River, some Ottawa valley influence
- Summer heat & humidity; air quality issues; drought some years (observed and projected – IPCC AR5 RCP 8.5[4]) August mean temperatures illustrated on **Figure 22** below).

Which potentially result in:

- Severe thunderstorms/ tornadoes; heavy downpours, soggy periods
- Windy – winds mainly up and down the valley, funnelling
- Potential for big ice storms, snow storms

[4] The Representative Concentration Pathways (RCPs), which are used for making projections, describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5). RCP2.6 is representative of a scenario that aims to keep global warming likely below 2°C above pre-industrial temperatures. Source: http://www.ipcc.ch/index.htm

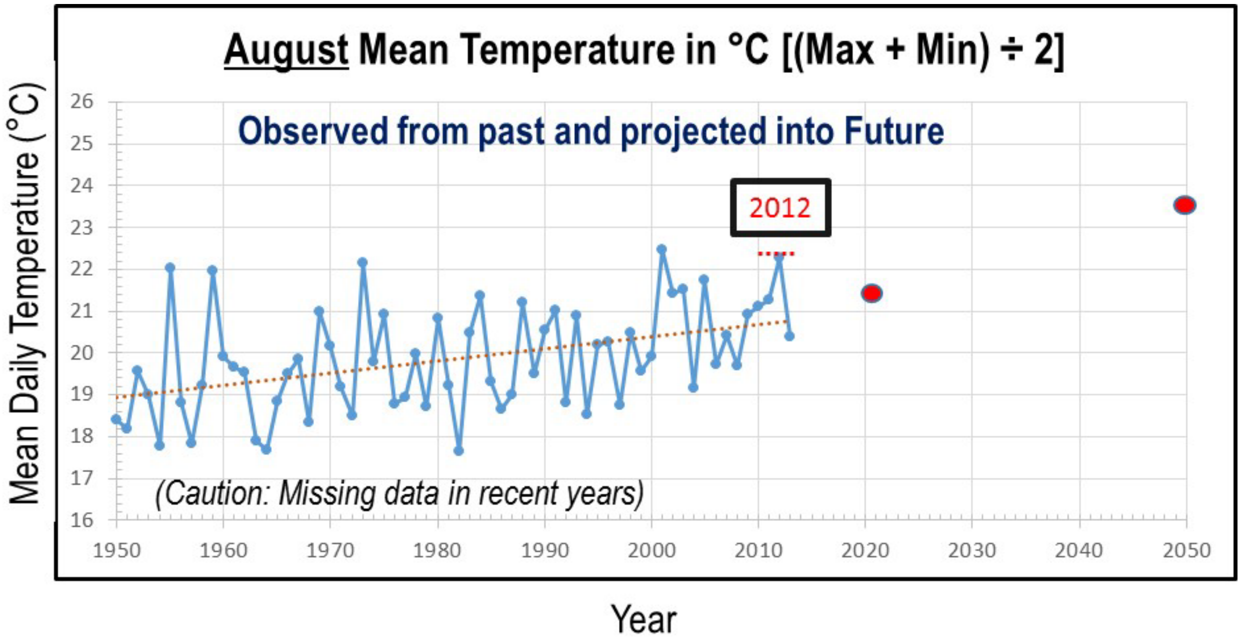


Figure 26: Historical and Projected August Mean Temperatures for Cornwall (ON)

Climate elements were part of the discussions at each of the four workshops of the project. In Workshop 1 – Project Definition, MCA staff was to recall weather events that may have caused disruptions in the water or wastewater services or failures of assets.

During Workshops 2 and 3, the Project Team and PAC members present reviewed the list of suggested weather elements by the PIEVC Protocol (**Appendix B** – March 1, 2017 Workshop #4 Presentation) and selected those relevant to the infrastructure under assessment and local/regional climate conditions.

Figure 27: Heather Auld of RSI Inc. Presenting Climate Information to the Participants at Workshop 4 on March 21, 2017

In Workshop 4, prior to finalizing the risk assessment and discussing potential adaptation measures, the Project Team and PAC members present were provided further information on climate elements, thresholds and probabilities (See **Appendix A** for climate presentation by Heather Auld, RSI Inc.)

4.3 SOURCES OF INFORMATION

The main sources of climate information for this study are listed below:

- 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

In general, the changes in climate in the Akwesasne area are projected to result in a climate similar to Syracuse (NY) in the 2020's and to Columbus (OH) in the 2050's as illustrated in **Figure 28** below.

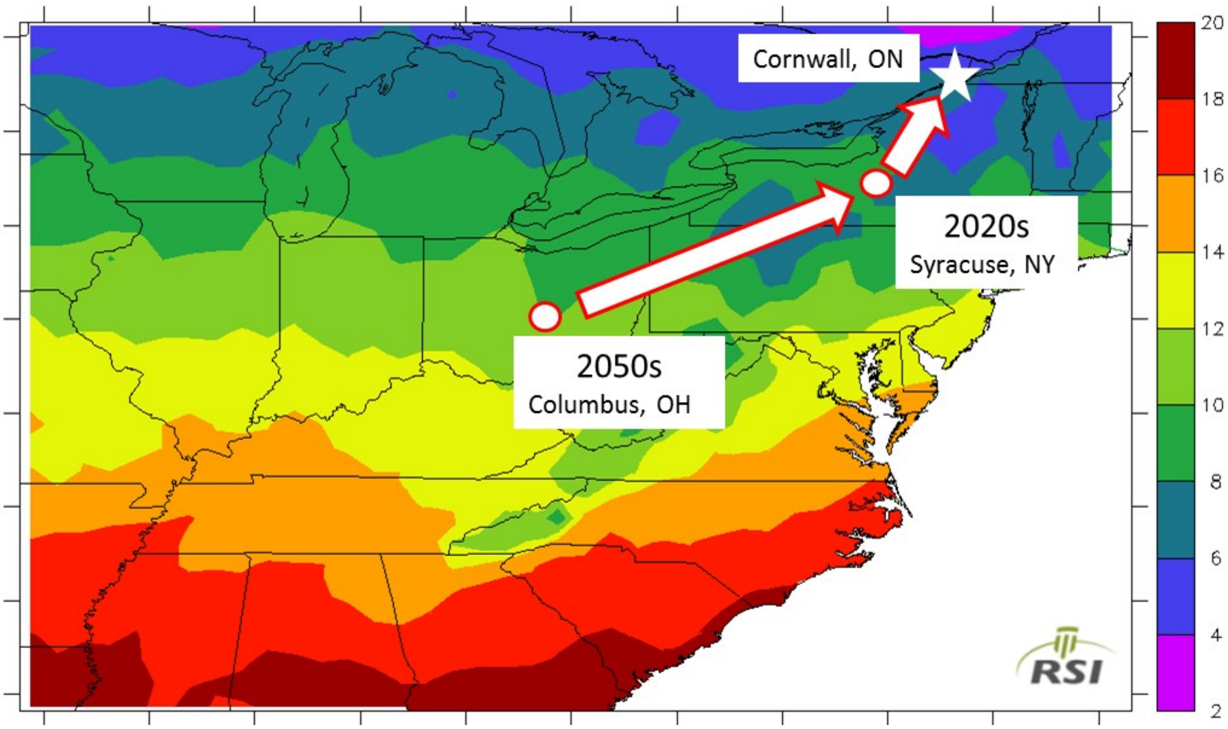


Figure 28: Projected Future Mean Annual Temperatures for Cornwall – 2020's (2010-40) and 2050's (2040-70): (IPCC AR5, RCP8.5)

4.4 CLIMATE ELEMENTS

The selected climate elements for the exposure, vulnerability and risk assessments are shown in **Table 4.1** below.

Several extreme weather events were observed locally in 2012 (see section 4.4 Other Considerations) and thus was used as a reference year to establish baseline climate thresholds.

Table 4.1: Principal Climate Elements Considered in the Analysis

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)	
Fog	Visibilities below ½ statute mile	Reference impacts to shipping
Wind	Days with gusts > 90 km/h	i.e., NBC 50-year return period design steady wind
	Days with gusts > 125 km/h	i.e., NBC 50-year return period climatic design gust with wind gust factor applied
	Days with gusts > 140 km/h	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

5.0 STEP 3 - VULNERABILITY AND RISK ASSESSMENT

5.1 PIEVC PROTOCOL PROCESS

Step 3 of the Protocol instructs the Project Team to perform the following steps, illustrated in **Figure 29** below.

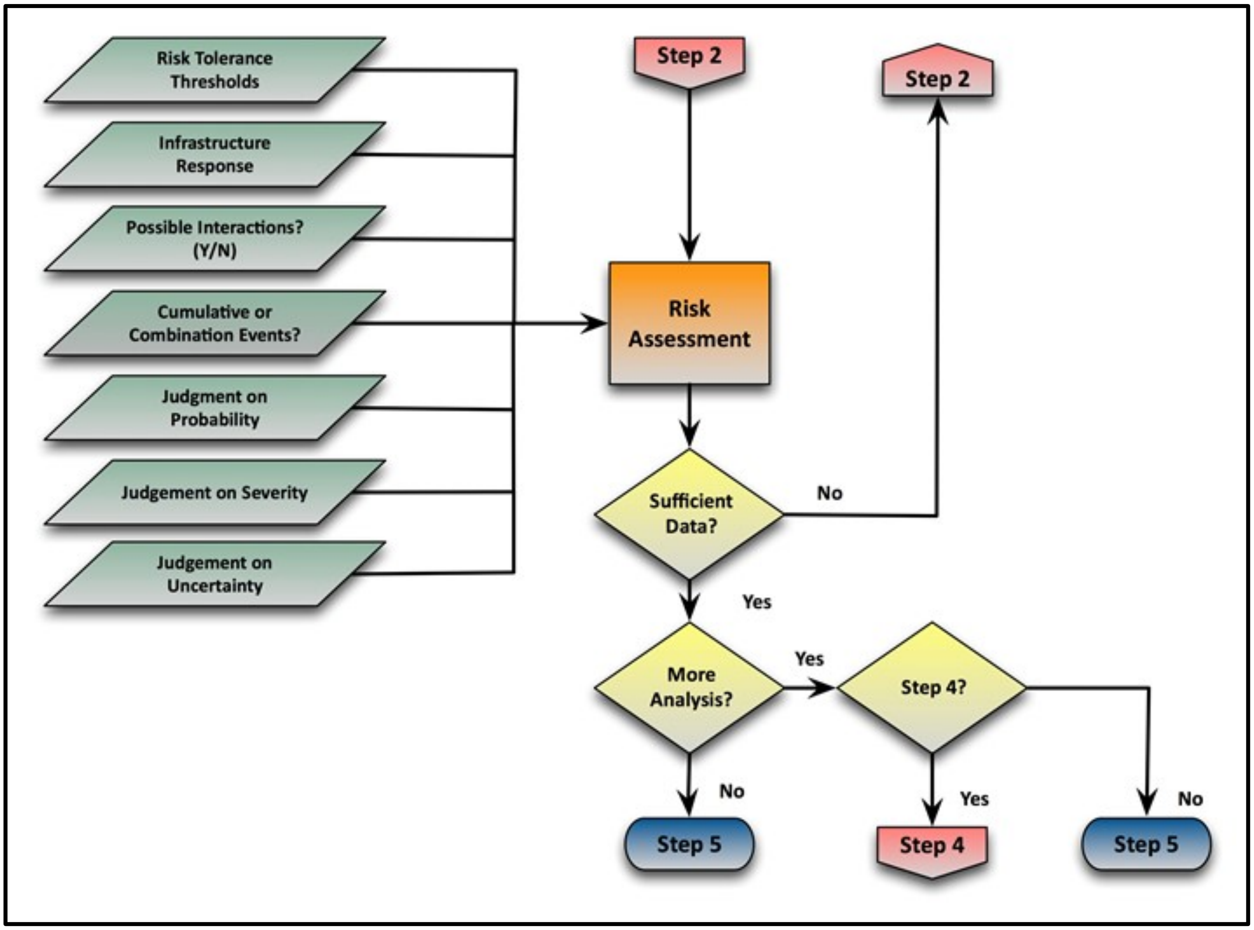


Figure 29: PIEVC Protocol Risk Assessment Process Flowchart

5.2 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 7, the maximum risk score will be 49.

For this project, the risk thresholds shown in **Table 5.1** below were selected by the Project Team:

Table 5.1: Selected Risk Thresholds

Score	Description
<12	**Low**: no action required
12 to 20	**Moderate**: monitoring recommended
21 to 34	**High**: action may be required if threat materialises; a more detailed analysis may be needed.
≥ 35	**Extreme**: 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**

5.3 INFRASTRUCTURE RESPONSE

During Workshop 2, the Project Team and PAC members present 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 that are provided in **Appendix B**. They are summarized below:

<u>Infrastructure response</u>

1. Structural design/capacity
2. Functionality
3. Serviceability
4. Watershed, surface waters and groundwater
5. Operations, maintenance and materials performance
6. Environmental effects

<u>Community Impacts</u>

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

5.4 CLIMATE PROBABILITY SCORING

Since statistical information for historical and projected event frequencies was available for most climate parameters, PIEVC's Method B (**Table 5.2**) was used to develop probability scores for each parameter. The climate probabilities are converted from numerical probabilities, where possible, into PIEVC score categories ranging from 0 or "unlikely", to 7, or "highly likely."

Table 5.2: PIEVC Probability Scoring Method B

Score	Probability	
0	<0.1%	< 1 in 1,000
1	1%	1 in 100
2	5%	1 in 20
3	10%	1 in 10
4	20%	1 in 5
5	40%	1 in 2.5
6	70%	1 in 1.4
7	>99%	>1 in 1.01

Table 5.3 to **Table 5.5** present the results of the climate analysis (current trends and future projections), and the corresponding PIEVC probability scores used in the risk assessment.

Table 5.3: Probability Scores for Temperature and Fog

Climate Element	Current (data to 2014 in some cases)	Score (Current)	Future climate to 2050s	Score (Future)
Temperatures				
Days (per year) with Max Temps > 36°C	0.03 or once every 30+ years	2	0.9 or Once every 1-2 years	5
Very warm **August** Temps Mean >22.5°C (*warmer than August 2012*)	0.06 or 3 times in last 50 years (1973, 2001, 2012)	3	Almost every year (mean of 23.3°C)	6
Days with **August** total precipitation ≤ ~51mm (*equal to or less than August 2012*	0.16 or 8 times in last 50 years (every 6-7 years)	4	Slightly more often	5
Combination August Warm Temperatures & low rainfalls	<< 0.16	3	Common – Temps frequent; rainfall prob. ≥ 0.16	4
Fog				
Visibilities below ½ statute mile	~ 6-7% probability during shipping season (for Massena)	3	Unknown, although some decreasing trends in parts of North America	3

Table 5.4: Probability Scores for Precipitation

Climate Element	Current (data to 2014 in some cases)	Score (Current)	Future climate to 2050s	Score (Future)
Precipitation				
> 120 mm rainfall in 7 days	0.04 or once every 20+ years (2 in 45 years)	2	Likely continue to increase	3
Winter snowfall for Jan-Feb-Mar > 200 cm	0.1 or once every 9+ years (4 years out of 35)	3	Winter snowfall amounts appear to be increasing – but likely to decrease into future	2
Winter rainfall totals (DJF) > 120mm	0.2 or once every 5 years (6 years out of 30)	4	? Might have decreased since 1981 – lots of missing data	4
March rainfall totals > 60 mm	0.1 or once every 10 years (3 times in recent 30 years)	3	Increasing	4
Snowfall event > 25 cm/day	0.36 or once every 3+ years (18 years out of 50)	5	Snowstorms may increase in intensity but shorter winters	6
Winter rainfall > 25mm/day	0.4 or once every 2-3 years (20 years out of 50)	5	Increase; shorter snow season, warming winters	6
Severe ice storms (≥ 20 mm freezing rain in one day)	~ Once every 10 years	3	Expected to increase (~40+%), based on Cheng et al	4
Extreme ice storms (≥ 40 mm freezing rain that isn't easily shed)	~ Once every 50 years	2	Expected to increase (assume ~40%)	3

Table 5.5: Probability Scores for Winds, Hail and Lightning

Climate Element	Current (data to 2014 in some cases)	Score (Current)	Future climate to 2050s	Score (Future)
Winds				
Days with gusts > 90 km/h (i.e., NBC 50-year return period design steady wind)	0.8 or ~ once every year – Based on recent 11 years of data for Massena	7	Estimate ~25% increase	7
Days with gusts > 125 km/h (i.e., NBC 50-year return period climatic design gust with wind gust factor applied)	0.45 or once every ~2 years – Based on recent 11 years of data for Massena	5	Likely increase (assume 25%)	6
Days with gusts > 140 km/h (Massena, 50-year return period wind gust)	0.05 or once every 50 years based on U.S. wind extremes study	2	Likely increase	3
Tornado frequency within 25 km area (Note: only have data for Canadian territory within 25 km. Probability doubled if considering US)	~0.1 or once every ~10 years (4 in 30 years)	3	? Could increase; Longer convective season	4
Tornado frequency – within 50 km area (Note: only have data for Canadian territory within 50 km.	0.3 or once every ~3+ years (9 in 30 years)	5	? Could increase; Longer convective season	6
Hail				
Hail storm >19mm diameter	~0.2 or 2 events in 10 years in Massena	4	? Could increase; Longer convective season	5
Lightning				
Greatest yearly density for Cornwall area	~ 2 strikes /sq.km/yr.	7	Unknown	7

5.5 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 took place.

Table 5.6: Infrastructure Severity Scoring

Score	Severity of Consequences and Effects
0	Negligible Not Applicable
1	Very Low Some Measurable Change
2	Low Slight Loss of Serviceability
3	Moderate Loss of Serviceability
4	Major Loss of Serviceability Some Loss of Capacity
5	Loss of Capacity Some Loss of Function
6	Major Loss of Function
7	Extreme Loss of Asset

5.6 RISK ASSESSMENT

5.6.1 Infrastructure components evaluated

The infrastructure assets considered in this assessment where divided into components to evaluate the impacts from the selected climate events. **Table 5.7** to **Table 5.9** below show the detailed lists of assets/components for each of the three districts: Cornwall Island, St. Regis and Snye.

Table 5.7: Cornwall Island Infrastructure Assessed

Cornwall Island	
Water Supply System	**Wastewater System**
Water Treatment Plant	Akwesasne Mohawk School - RBC and Control Building Outfall in St. Lawrence River
Building structure	Building
Building envelope	Equipment
Roof	Environment
Process equipment	Cornwall Island Administration Complex - Pump Station
HVAC system	Building
Foundations	Equipment
Site services	Environment
Storage and/or alternate use	Cornwall Island Community Centre - Lift Station Raised tile bed septic system
Access road	Building
Environment (plants, trees, animals)	Equipment
Environment (soil conditions)	Environment
Backwater disposal	Block 97 - RBC
Biosolids/sludge disposal	Building
Communications / SCADA/Telemetry	Equipment
Back-up power (generator, fuel storage)	Environment
WTP - High Lift Pumps	Arena - RBC
WTP - Reservoir	Building
WTP - Intake	Equipment
WTP - Low Lift Pump	Environment
Block 97b - Pump Station	Biosolids/sludge disposal
Building	Portable backup generators
Equipment	**Administration/Operations**
Environment	Vehicles and fleet
Block 97b - High Lift Station	Personnel
Building	Records
Equipment	Suppliers
Environment	Communications
Distribution pipes	Emergency procedures/personnel
Fire Hydrants	Electricity
Back-up power (generator, fuel storage)	General road network
Water source (St. Lawrence)	Bridges

Table 5.8: St. Regis Infrastructure Assessed

St. Regis	
Water Supply System	**Wastewater System**
Water Treatment Plant	Waste Water Treatment Plant
Building structure	Building structure
Building envelope	Building envelope
Roof	Roof
Process equipment	Process equipment
HVAC system	HVAC system
Foundations	Foundations
Site services	Site services
Storage and/or alternate use	Storage and/or alternate use
Access road	Access road
Environment (plants, trees, animals)	Environment (plants, trees, animals)
Environment (soil conditions)	Environment (soil conditions)
Backwater disposal	Biosolids/sludge disposal
Biosolids/sludge disposal	Communications / SCADA/Telemetry
Communications / SCADA/Telemetry	Sewage Treatment Building Lab & Shop
WTP - GAC Tanks & Reservoir	St. Regis - Geoform RBC's units
Distribution Pipes	Building
Fire hydrants	Equipment
Water transmission line to Snye	Environment
Back-up power (generator, fuel storage)	PS3 Lift Station Waste Water Sewage
Administration/Operations	Building
Vehicles and fleet	Equipment
Personnel	Environment
Records	Cherry St. Pump Station
Suppliers	Building
Communications	Equipment
Emergency procedures/personnel	Environment
Electricity	St. Regis Daycare / Recreation Pump Station
General road network	Building
Bridges	Equipment
	Environment
	Collection pipes
	Back-up power (generator, fuel storage)
	Portable backup generators
	Stormwater collection System

Table 5.9: Snye Infrastructure Assessed

Snye	
Water Supply System	**Wastewater System**
WTP - Storage Facility / Lift Station House	Pump Station 1
Building	Building
Equipment	Equipment
Environment	Environment
WTP Reservoir	Sanitaty Lift Station 2
High Lift Station	Building
Building	Equipment
Equipment	Environment
Environment	RBC
Distribution pipes	Building
Environment (plants, trees, animals)	Equipment
Fire Hydrants	Environment
Administration/Operations	Lagoon
Vehicles and fleet	Outfall
Personnel	Collection pipes
Records	Portable backup generators (from St Regis)
Suppliers	Back-up power (generator, fuel storage) - supports the Water supply and wastewater system
Communications	Wetland - treament for sub-division (flow from septic tanks --> wetland --> marsh)
Emergency procedures/personnel	
Electricity	
General road network	
Bridges	

5.6.2 Risk screening process

The first step in the production of the risk matrix 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. In the case an interaction exists, the Project Team identifies with respect to which infrastructure performance considerations the potential risk might exist (for example, impacts on the structural capacity or the functionality of the asset or component. The infrastructure performance considerations selected for this study were described in Section 5.3 of this report.

As the Project Team progressed through the project, it became evident that there were two types of impacts for the climate events: impacts on the performance of the infrastructure itself, and impacts on the service and the community should the infrastructure fail to deliver as designed. It was therefore decided to establish the risks with respect to the infrastructure assets considering the following performance factors:

1. Structural design/capacity
2. Functionality
3. Serviceability
4. Watershed, surface waters and groundwater
5. Operations, maintenance and materials performance

The analysis then considers the consequences on the service and/or the community should the risk materialize and the infrastructure fail to perform, using the remaining selected performance factors:

1. Emergency response
2. Insurance and legal considerations
3. Policy considerations
4. Social and cultural effects
5. Environmental effects
6. Financial impacts

This process is illustrated in Figure 30 following.

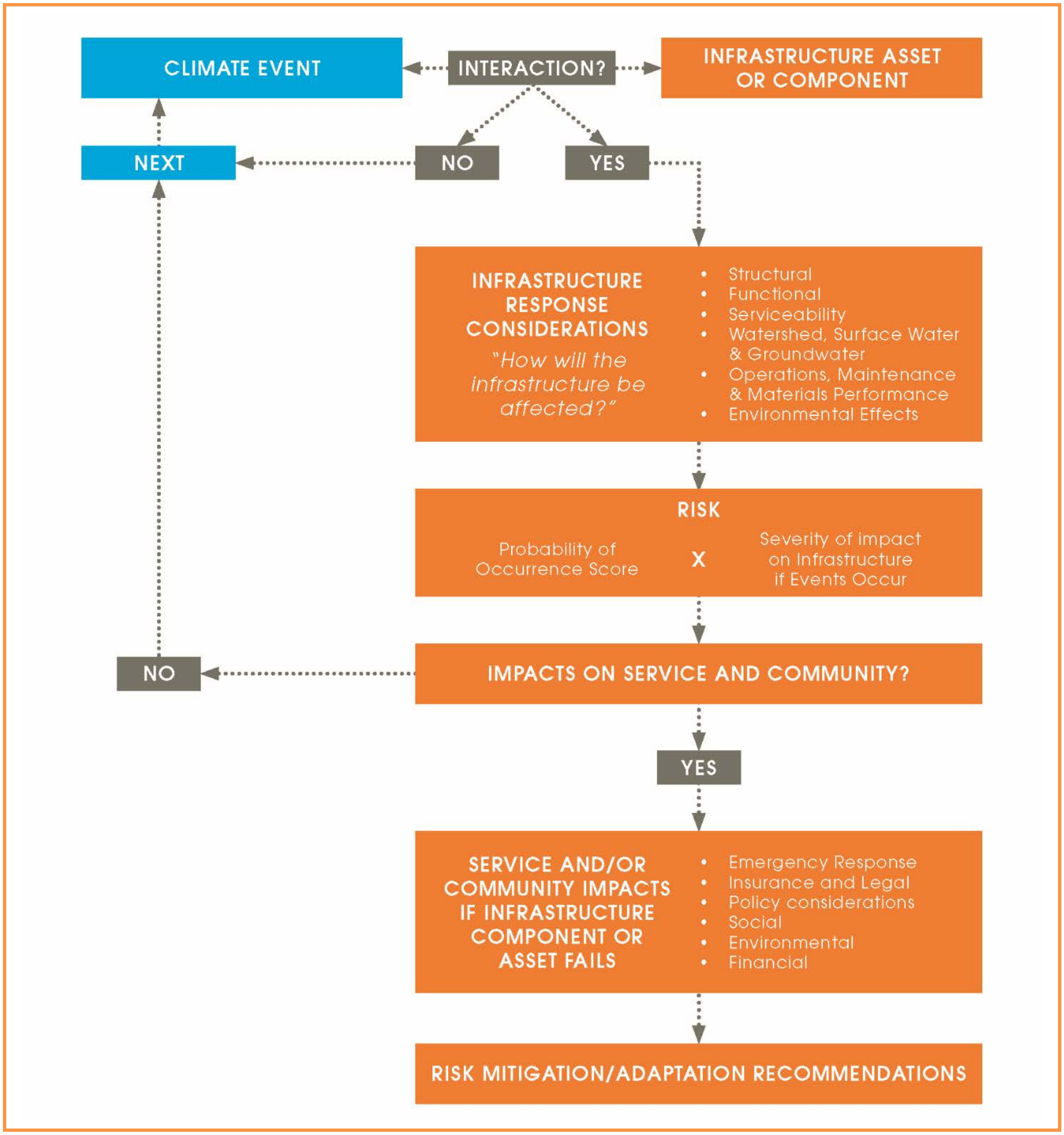


Figure 30: Process Used to Establish Infrastructure Risks and Impacts on the Community

Furthermore, the risks associated with future climate events were evaluated with respect to two (2) asset conditions: Condition 1 relates to assets that have been replaced at the end of their design life as per the ICMS data; Condition 2 relates to assets that reach the time horizon of this study (2050) beyond their design life. This distinction is important since, as shown by the ICMS data illustrated in **Table 3.2**, many assets in the infrastructure system will reach their design life within the time horizon selected; Condition 2 thus presents a higher level of vulnerability for these assets. It should be noted that this analysis is not prescribed in the PIEVC Protocol; however, the Project Team felt it provides a more realistic assessment of the risks if the assets are not replaced or retrofitted in due time. Only assets for which high and extreme risks were evaluated with this dual condition process.

5.6.3 Summary of risk results

Table 5.10 to **Table 5.12** below present a summary of the risk counts (moderate, high and extreme), 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 it was designed for. This is addressed in **Section 5.6.1**.

Following are observations regarding the risks identified:

1. The highest risks are related to wind and precipitation events.

   Tornados could be considered in the special risk category. The data analyzed shows a number of incidents within 25km and 50km of Akwesasne, although no site events have been recorded. Tornados can have devastating effects on the infrastructure located on their path, but generally cause "surgical" damage to above-ground infrastructure. The Project Team also identified downbursts and microbursts (strong convective downdrafts resulting in an outward burst of often damaging winds at or near the surface) as threats that can cause similar damage to tornadoes but over a wider area. Although members of the team indicated records of such events could be obtained from area farmers and forestry officials, this research was not completed as part of the project.

   Long duration rain events can cause stormwater and wastewater problems in St. Regis and Snye, particularly due to the high groundwater level conditions in the area.

   Hail greater than 19mm (0.75in) diameter can have damaging impacts on a number of infrastructure elements, including: building envelopes; light buildings such as the RBC shells, pumping stations buildings, etc.; vehicles; communication systems; etc. Although the data regarding hail under current and future climate is not conclusive, nearby (Massena, NY) hail storms warranted including this hazard and its impacts.

2. Lightning is a threat to communications and the environment.

   MCA staff indicated past damage to the SCADA and communications systems in Akwesasne. Local knowledge indicates that the lightning season is becoming longer and thus the risk of more cloud-to-ground strikes is expected to increase. Another infrastructure element susceptible of being affected by lightning are trees surrounding buildings and facilities. Indirectly, tall trees hit by lightning strikes may fall on a building or facility, potentially causing significant damage or disruptions.

3. Ice storms can cause severe disruptions and damage.

   The Akwesasne community lived through the 1998 Eastern Ontario and Western Quebec that impacted electricity, communications, and transportation networks. Although the probability for similar events (>40mm of freezing rain) is low, the potential for less severe events (>20mm of freezing rain) can impact a wide range of infrastructure assets causing disruptions to services, response times, communications and electrical interruptions, etc.

4. Reliance on third-party services.

   It is rare for a community to own and operate all the assets needed to provide services. Example of third-party services include: electricity (Cornwall Island is supplied by Cornwall Power; St. Regis and Snye are supplied by Hydro Quebec); communications (whether land lines or cellular); fuel and chemical supplies; etc. Risks to the MCA infrastructure will generally apply to those third-party organizations as well. It is therefore important that the community's risk management plan consider and involve those organizations.

5. Long periods of hot weather and low precipitation.

   The summer of 2012 – and particularly August, was used as a reference since the extended hot temperatures and drought (low precipitation) conditions, particularly associated with high relative humidity, are likely to happen more often in the future. Consequences of such weather can include: damage to the environment (with potentially more wild fires); stress on the water system (higher demand, possible impacts on the water source and supply); personnel and indoor environment (HVAC) impacts; stress on the electricity supply (due to higher demand for cooling); etc. Furthermore, it is not unusual that these weather conditions are followed by intense and/or large rain events, thus potentially causing significant runoff that can lead to surcharging the drainage systems.

6. The St. Lawrence water source.

   The St. Lawrence River is a vast and reliable water source for the Akwesasne community. Fluctuations in the water levels, caused by natural events of human controls, may affect the intakes to the MCA water supply. For example, MCA staff indicated lower water levels in the River could expose the intake structures to boats and larger ships if there are changes in shipping channel corridors.

Table 5.10: Summary of risks for Cornwall Island infrastructure

Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected	Infrastructure Performance Impacted
Cornwall Island					
Moderate	145	88	• 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	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
High	47	135	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
Extreme	28	34	• Lightning • Tornados	• All infrastructure	• All performance considerations

Table 5.11: Summary of Risks for St. Regis infrastructure

Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected	Infrastructure Performance Impacted
103					
Moderate	135	103	• Low Precipitation (Aug.) • Combination - Aug. High Temp. with Low precipitation • Snowfall event • Severe Ice Storm • Extreme Ice Storm • Extreme Winds • Rain events	• Environment • Personnel • Suppliers • Electricity • Light buildings • General roadworks • Emergency response • Vehicles and fleet • Communications • Stormwater system	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
High	46	96	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
Extreme	23	28	• Lightning • Tornados	• All infrastructure	• All performance considerations

Table 5.12: Summary of Risks for Snye infrastructure

Risk Score Counts	Current Climate	Future (2050s) Climate	Main Climate Events	Principal Infrastructure Affected	Infrastructure Performance Impacted
Snye					
Moderate	99	60	• Low Precipitation (Aug.) • Combination - Aug. High Temp. with Low precipitation • Snowfall event • Severe Ice Storm • Extreme Ice Storm • Extreme Winds • Rain events	• Environment • Personnel • Suppliers • Electricity • Light buildings • General roadworks • Emergency response • Vehicles and fleet • Communications • Stormwater system	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
High	37	80	• Hail • Tornados • Strong winds • Ice storms • Snowfall events	• Light buildings • Communications • SCADA • Environment • Personnel • Vehicles and fleet • Electricity • Suppliers • General road works	• Structural capacity • Functionality • Serviceability • Operations • Environmental effects
Extreme	19	36	• Lightning • Tornados	• All infrastructure	• All performance considerations

5.6.4 Influence of the Infrastructure Condition

As indicated earlier in this report, 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. While this analysis is not prescribed in the Protocol, it is worth noting that the Protocol offers flexibility to incorporate additional levels of analysis within its framework, as long as they are documented.

In the context of this study, the summary risk results, and the detailed risk matrices were established considering the infrastructure is in good condition, that is it is operating at the performance level it was designed for. It was beyond the scope of this project to do an analysis of each component affected based on condition assessment information.

The Project Team and PAC members, during Workshop 4, indicated a useful analysis would see risks assessed in a context where the infrastructure is past its design life and has not been replaced.

Table 5.13 below present information extracted from the ICMS report provided by INAC. Note that the Project Team did not verify or validate this data and that blank cells indicate missing or inconsistent data. The purpose of this table is to illustrate the current condition of the infrastructure, its year of construction and the year of replacement if it were to end its service life at the same time as its design life. The Table shows that all assets would be due to be replaced within the time horizon of this risk assessment, i.e., the 2050s.

Without knowledge of long-term capital investment plans for this infrastructure, the worst-case scenario is that none will be replaced during the study time horizon and therefore it will be in worst condition in the future. This in turn results of a higher vulnerability to the climate hazards identified. Due to time constraints, only the Cornwall Island infrastructure was assessed using this scenario, which involved increasing the severity scores by one for each of the climate-infrastructure interactions. Also, only the MCA built infrastructure was adjusted, that is the environment, personnel and third-party infrastructure scores remained unchanged. **Table 17** presents the comparison between the risks to the infrastructure replaced at the end of its design life and the risks with deteriorated infrastructure (not replaced). The analysis did not consider low risks which may become moderate as a result of an increase in severity of the infrastructure.

Table 5.13: Summary of Asset Information from ICMS

Asset Category	Asset Name	Year Constructed	Design Life	Date Replacement required	Estimated Remaining Life	General Condition Rating
WATER SUPPLY/TREATMENT						
	KAWENOKE WEST LOW LIFT STATION BUILDING	2005	40	2045	30	Good
	ST. REGIS SEWAGE TREATMENT	2001	20	2021	30	Good
	KANEKI:IO WATER PLANT	1998	30	2028	25	Good
	TSI SNAIHNE WATERPLANT	1978	30	2008	25	Good
	KEWENOKE WEST WTP BLDG	2005	40	2045	35	Good
WASTEWATER TREATMENT DISPOSAL						
	SEWAGE TREATMENT BUILDING	1991			25	Good
	RBC CONTROL BUILDING - AMS	1991	30	2021	25	Good
WATER TREATMENT SYSTEM						
	KAWENOKE WEST WATER TREATMENT	2005	20	2025	25	Good
	WATER TREATMENT SYSTM@KENEK:IO	1998	30	2028	15	Good
WATER STORAGE						
	RESERVOIR CI WTP	1989	25	2014	20	Good
	RESERVOIR KANE'KI:IO H20	1997	30	2027	20	Good
	RESERVOIR	1991			10	Good
	RESERVOIR CI WEST WTP	2005	30	2035	20	Good
HIGH LEVEL LIFT STATION						
	HIGH LIFT STATION 1	1991	15	2006	15	Good
	HIGH LIFT STATION 2	1991	30	2021	15	Good
LOW LEVEL LIFTSTATION						
	KANE KIIO-LOW LIFT STATION	1998			25	Good
	KAWENOKE WEST LOW LIFT PUMPS	2006	30	2036	20	Good

Asset Category	Asset Name	Year Constructed	Design Life	Date Replacement required	Estimated Remaining Life	General Condition Rating
STORM MAIN						
	STORM MAINS - ST. REGIS	1960	60	2020	15	Fair
	STORM MAIN CI EAST	2003	30	2033	30	Good
	STORM MAINS - C.I. WEST	2001	0		25	Good
RBC/TRICKLING FILTER						
	RBC UNIT	1991			5	Fair
	16 UNIT RBC ST. REGIS	2001	7	2008	10	Good
	BLK 97 SEWAGE RBC EXPANSION	2001	0	2001	10	Good
LIFTSTATION						
	SANITARY LIFT STATION SNYE PH. 2	2009	40	2049	25	Good
	LIFT STATION SEWAGE PS2 CHERRY	1998	30	2028	20	Good
	SEWAGE LIFT STATION, SR-PS5	1994	30	2024	10	Good
	PS3 LIFT STATION -SEWAGE	1999	30	2029	20	Good
	LIFT STATION - SEWAGE	1991			20	Fair
	CI ADMIN.PUMP STATION	2002	20	2022	20	Good
	LIFT STATION - SEWAGE	1960			10	Fair
	CI COMMUNITY C&R LIFT STATION	2000			10	Good
OTHER						
	LAGOON - CHENAIL SCHOOL	1960			5	Good
	COMMUNAL SEPTIC FIELD BED	2001	30	2031	15	Fair

Table 5.14: Summary of Risks for Cornwall Island Infrastructure Replaces at the End of its Design Life and Deteriorated

Risk Rating	Future Climate Risk Score Counts Cornwall Island Infrastructure		Percentage change in risk count
	Infrastructure replaced at end of design life	Infrastructure deteriorated (not replaced)	
Moderate	88	59	- 33%
High	135	143	+ 6%
Extreme	34	44	+29%

The table illustrates the value of maintaining the infrastructure in a state of good repair and capital investments at the end of its service life, an important measure to mitigate risks.

5.7 COMMUNITY IMPACTS FROM INFRASTRUCTURE RISKS

Infrastructure loss of performance or function has impacts on the community as a whole. 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 to 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 Community may have to take extraordinary measures to address its financial situation. This could be in the form, for example, of lowering levels of services.

6.0 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, as illustrated in **Figure 31** below.

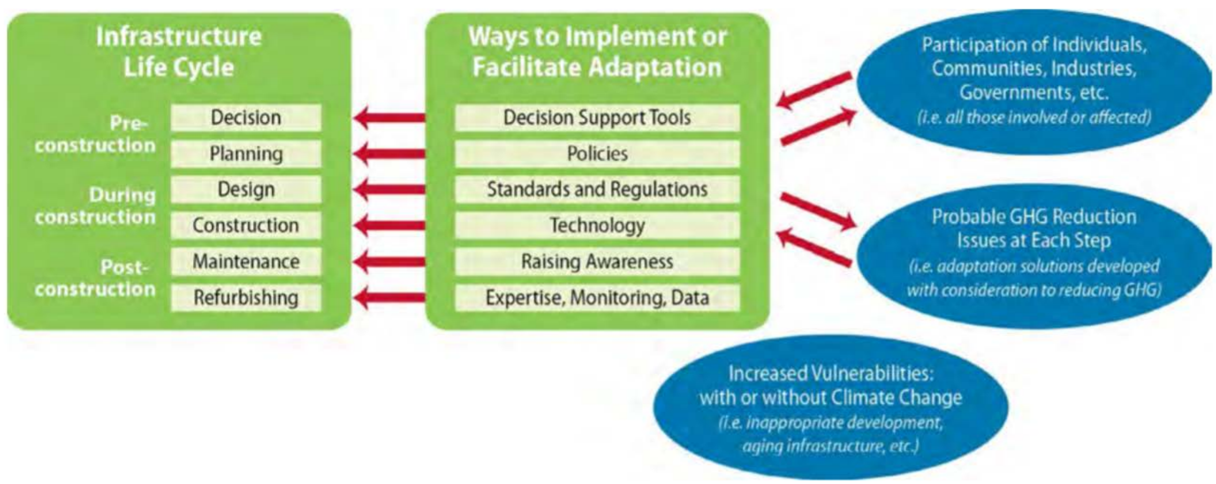


Figure 31: Adaptation in the Infrastructure Life Cycle (Source: Larrivée and Simonet, 2007)

In general, and if maintained in a state of good repair, the water and wastewater infrastructure considered in this study appears to be in sufficiently good condition to withstand some increases in frequency and intensity of the climate events retained for this PIEVC analysis. In regard to extreme events, for example tornadoes and ice storms, a loss of function is generally expected and Community risk mitigation and recovery measures are incorporated in Emergency Management and Response Plans. Within their resources constraints, the staff of MCA's Technical Services are providing safe and reliable water to the Akwesasne community, and protecting the health of people and the environment through the wastewater collection and treatment system.

Adaptive and risk mitigation measures were identified by the Project Team and PAC members present during Workshop 4. Since the intent of the study is to provide an overall risk profile of the infrastructure owned and managed by the MCA in Cornwall Island, St. Regis, and Snye, the recommendations do not address specific infrastructure issues. The recommendations below are not listed in a priority order.

- 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 them 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 as roofs, light structures, etc. Select tree locations and species to minimize risks of property damage in case they would fall.

- Review and improve, as required, policies and procedures – for example:
    - Operations and Maintenance: this could include inspection cycles, practices to maintain the performance of the assets, etc.
    - Climate related events in emergency response measures and plans, etc.

- Install weather stations on Cornwall Island and in St. Regis to ensure relevant local data. These stations should have the capability to at least provide hourly records. Note that the data from the Cornwall station only provides daily averages, thus representing a gap where short duration/high intensity events may be missed. This data will allow an evaluation of whether the climate changes projected in this study have materialized.

- Continue maintaining the high level of staff competencies and the knowledge the MCA staff has about its infrastructure. The knowledge and experience of the MCA staff are critical to continue providing services during normal and severe weather conditions.

- Provide the opportunity to MCA staff to access external subject-matter expertise and advice to deal with specific risk mitigation issues. This could include identifying key climate-infrastructure risks for which a more detailed analysis would be beneficial.

- Review land use planning policies to avoid authorizing construction in high-risk areas of the community.

- Communications, outreach and training to prevent, mitigate and respond to risks, for example: tree pruning to reduce the damage from broken branches; what to do in the case of an extreme event, etc.

- Creative problem solving: use processes such as “key personnel analysis” to bring staff from different services identify risk prevention and mitigation solutions. Use MCA Focus Groups and other community processes as well.

- Ensure lightning protection for sensitive equipment, particularly the SCADA systems.

- Include the risks identified through this study in planning work for infrastructure renewal, future design and construction, and include climate change considerations in best management practices and bylaws. This also involves keeping track of new developments regarding changes to practices and regulations – for example, under the Pan-Canadian Framework on Clean Growth and Climate Change[5].

- Plan for reduced mobility of operators and suppliers due to severe or extreme events, including warning, stock-piling, etc. This could include coordination at border crossings to accelerate passage during emergencies.

- Anticipate and plan collaborations for high risk weather events, such as interactions with emergency and community services, external agencies, and the community itself.

Finally, this application of the PIEVC Protocol contributed two new elements to the methodology which should be considered in future versions of the Protocol:

3. The separation of the infrastructure response considerations into two categories as follows (Section 5.6.2):
    a. Impacts on the infrastructure (or service) to assess the risks
    b. Consequences on the community should those risks materialize
4. The analysis of risks based on the future condition and replacement (as guided by asset design life) of the infrastructure (Section 5.6.1).

[5] See: https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

Appendix A CLIMATE CONSIDERATIONS – PRESENTATION BY RSI

RISK SCIENCES INTERNATIONAL

Climate Change Guidance for the Akwesasne Water and Wastewater PIEVC Vulnerability Assessment

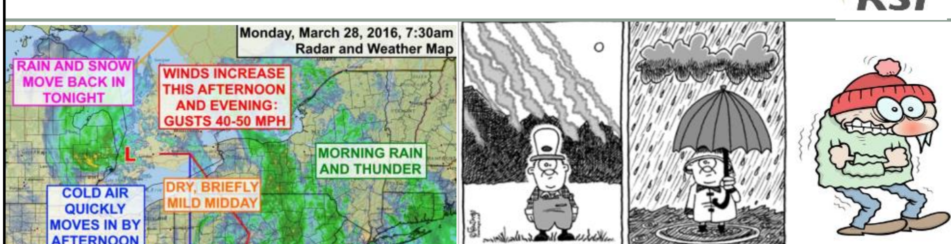
Cornwall, May 25, 2012Chris Derouchie

Heather Auld

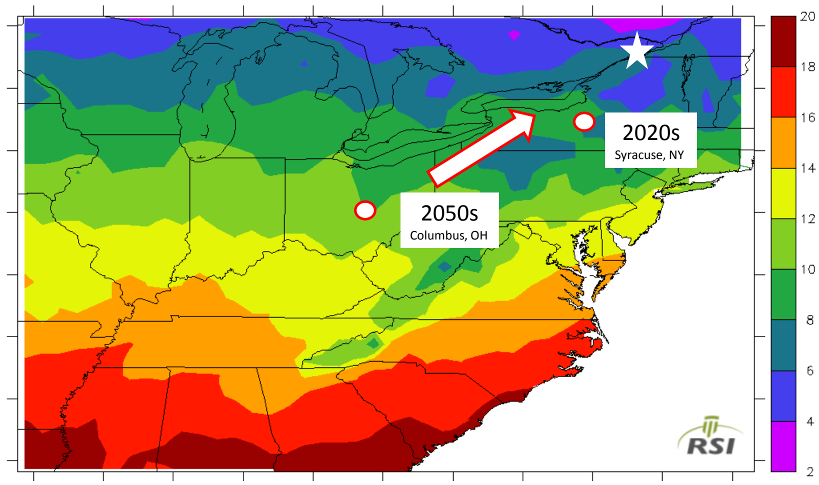
Risk Sciences International

Akwesasne Area's Unique & Challenging Climate

- Many storm tracks meet here – even an Atlantic Ocean influence
- Unique valley climate – St Lawrence River, some Ottawa valley influence
- Summer heat & humidity; air quality issues; drought some years
- *Severe thunderstorms/ tornadoes; heavy downpours, soggy periods*
- *Windy – winds mainly up and down the valley, funnelling*
- *Potential for big ice storms, snow storms*



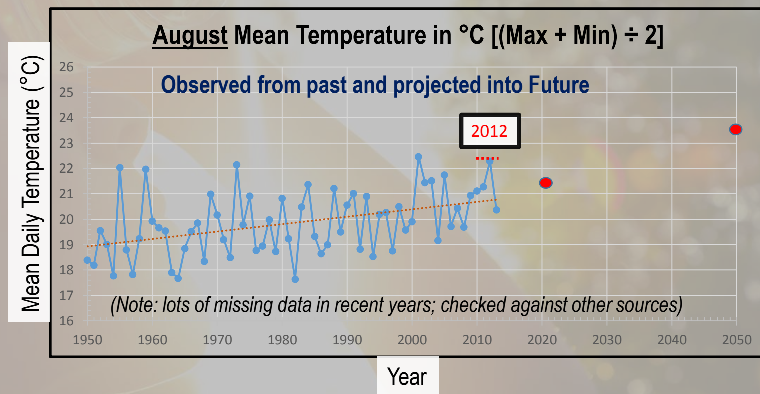
2020s (2010-40) and 2050s (2040-70): Projected Future Mean Annual Temperatures for Cornwall (IPCC AR5, RCP8.5)



Equivalent Climate Patterns (Columbus, OH → Syracuse → Cornwall

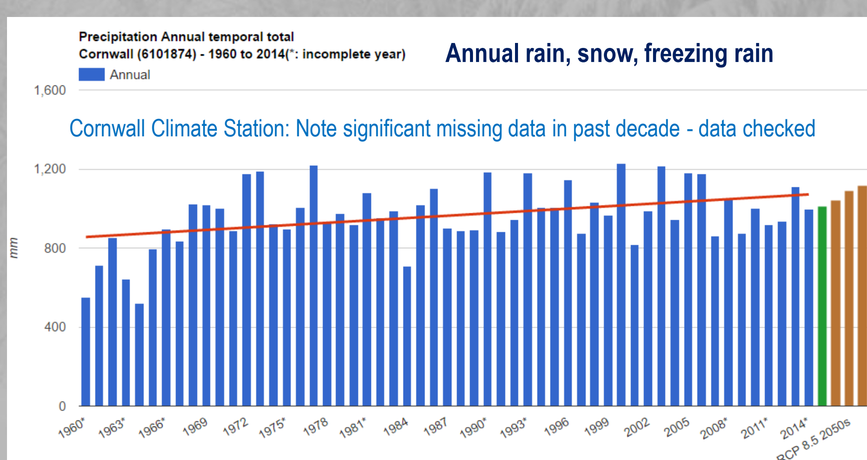
Warmer Temperatures, Wetter and Drier too

Warmer Seasons – Risks from heavy downpours and more summer drought?



Implications:
- Warmer temperatures, longer summers; drought risks
- Some signs Great Lakes warming at faster rate than land temperatures

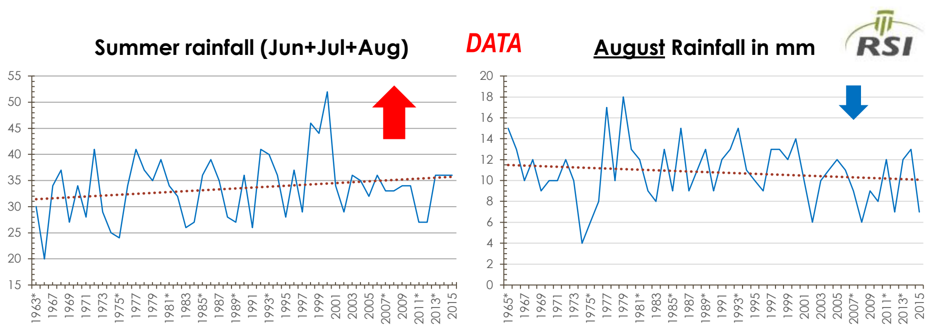
Likely Increasing Total Precipitation of all Types…. AND variable



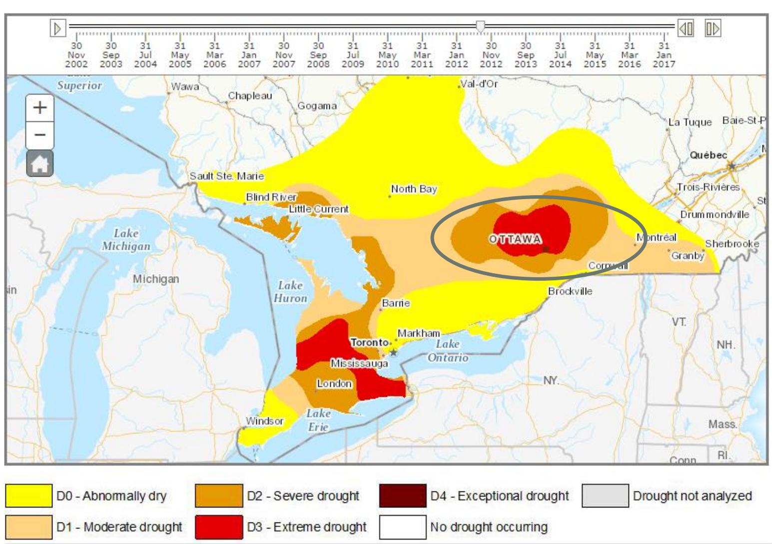
Extremes expected to increase faster than the averages or totals

August rainfalls decreasing?? BUT other rainfall amounts increasing *(Note: missing data in recent years, record checked)*

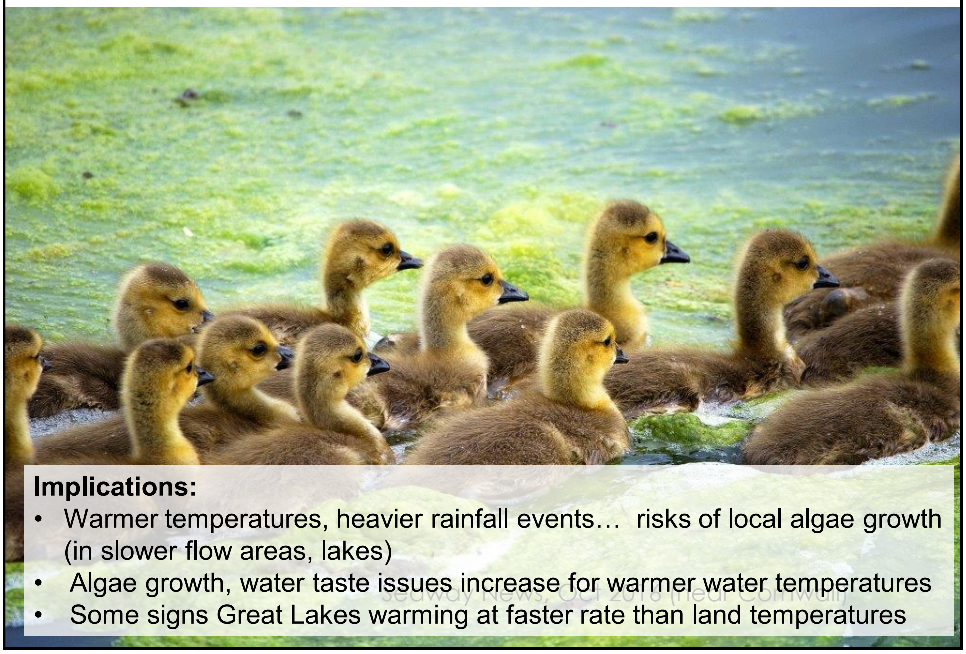
- Mid-late summers appear to be changing – less rainfall some summers? drier?
- Meanwhile, increasing rainfall totals for June, July and September
- Climate change models for future not clear – slight summer increases
- Take spring and summer 2012: ; very dry – Level 2 Low Water in Raisin River CA and Level 3 in parts South Nation CA; hot



Mixed with Drought Seasons (Summer, 2012)



Warming Temperatures, Runoff… Local Algae Growth Risks



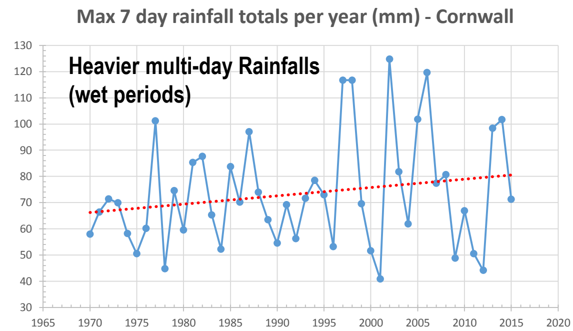
Seaway News, Oct 2016 (Neil Cornwall)

Implications:

- Warmer temperatures, heavier rainfall events… risks of local algae growth (in slower flow areas, lakes)
- Algae growth, water taste issues increase for warmer water temperatures
- Some signs Great Lakes warming at faster rate than land temperatures

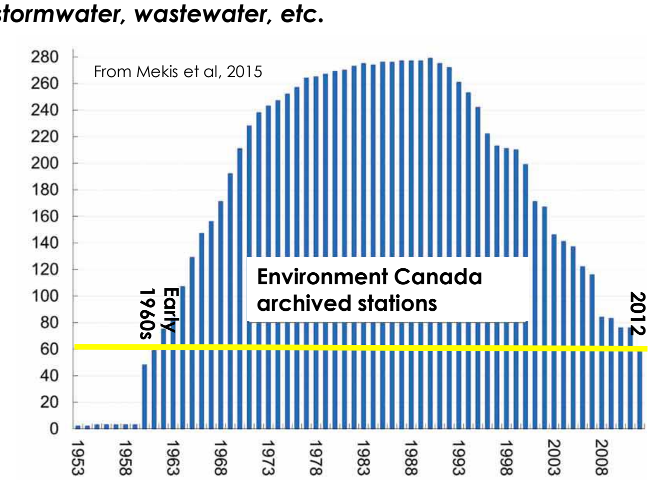
Heavy Rain Downpour, Snowfalls, More Winter Melting, Rain on Snow

Multi-day Rainfalls: Rainfalls Totals over 7-days (mm)



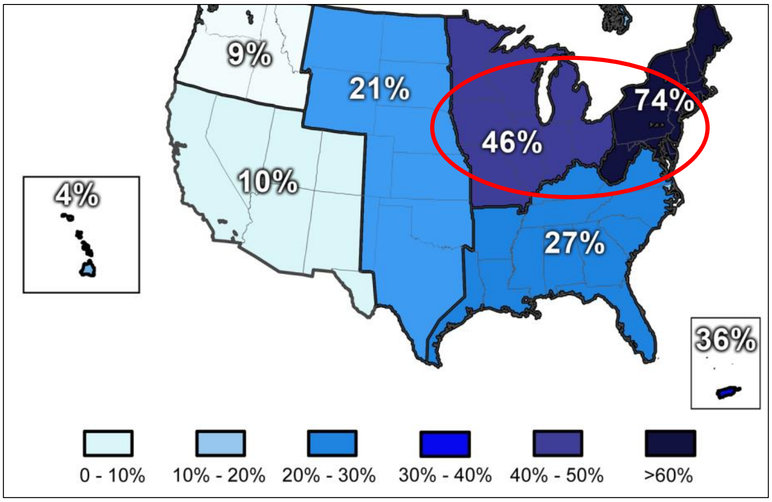
Declines in Rainfall Data: Difficult to Detect Trends

Rate of Rainfall Data Networks – used for drainage, reservoirs, roads, stormwater, wastewater, etc.



Municipalities, province have additional climate data – Need to integrate with Environment and Climate Change Canada (ECCC) Network of

U.S. Evidence of More Intense Rainfalls – Not as Strong in Canada
Significant Data Issues in Canada

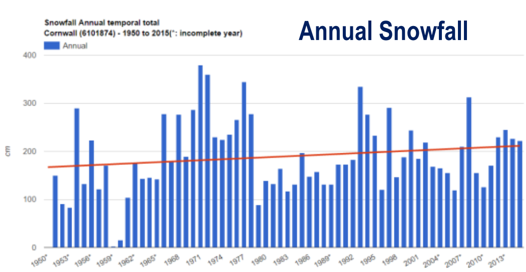


Trends in intense daily rainfall amounts

Trends in Cornwall snowfall totals/year

(note * indicate missing data in recent years)

- Winter snowfalls – variable each year; Annual totals may be increasing
- Winter rainfall amounts also increasing
- Warmer winter air holds more moisture – whether snow, rain, freezing rain
- Under climate change – shorter winters, more winter rain, snowfall totals should decrease, BUT…
- *Potential for bigger snowstorms*
- *Potential for more ice storms (damaging type, could increase ~40% by 2050s)*
- *Potential for more winter flooding*



More Thunderstorms, Longer Seasons

- Longer thunderstorm seasons likely
- Heavy downpours, high winds, lightning, risk of tornadoes
- Frequency of heavy rainfall downpours … increasing

Total of 9 tornadoes within 50 km (Canadian side) from 1980-2009; 4 within 25 km

Weakest F0 = 3 tornadoes
Damaging F1 = 4 tornadoes
Stronger F2 = 2 tornadoes

Manufactured building:
F0 … loss roof deck, roofs
F1 … complete destruction of roofs, some walls
F2 … complete destruction of unit

High Winds

- Winds typically blow up and down the St Lawrence River valley; Funnelling
- Windy area – Many causes of extreme winds
- Best dataset – Massena Airport, New York State
- Wind Gusts at Massena A > 90 kph occur almost every year
- Wind Gusts > 100 kph occur almost every other year
- Could increase in future (one study, ~25% by 2050s)
- National Building Code (Cornwall)… ~ 125kph designs may not be high enough – needs more study

Casselman, May 29, 2013

Droughts, Heavy rainfall, Snow storms, Ice storms…

Range of Climate Adaptation Options

RSI

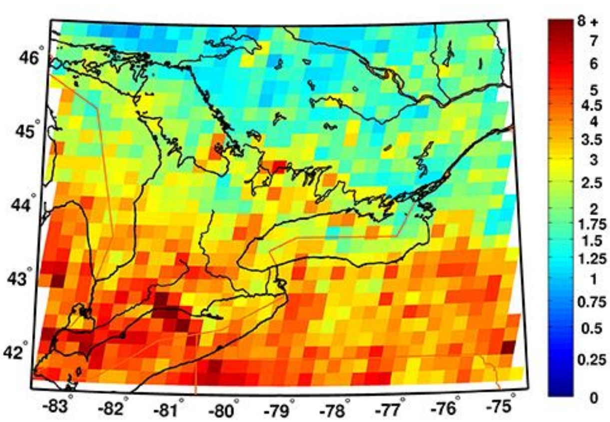
Current Climate

- Do nothing
- Low regrets (*e.g. data, maintenance, disaster plans*)
- Strengthen existing & new *(e.g. asset management; retrofits to existing; replacement)*
- Identify & Manage vulnerabilities *(e.g. PIEVC risk assessment)*
- Monitor; Improve science
- New approaches *(e.g. new designs)*

Incl.Changing Climate

- DESIGN (new structures?)
  - Include future climate (*PIEVC*)
  - Safety Factors; Stage; Flexible
- OPERATIONS (existing/new)
  - Improve (*Repair & retrofit; maintenance)*
  - Financial *(insurance; Mun. reserves)*

Greatest single-year lightning flash density (flashes per square kilometre per year) for southern Ontario



Appendix B WORKSHOP #3 PRESENTATION – MARCH 1, 2017

Ontario First Nations Technical Services Corporation

Mohawk Council of Akwesasne

PIEVC Vulnerability Assessment Process

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

Wednesday March 1, 2017
OFNTSC-MCA PIEVC Vulnerability Study
Infrastructure Risk Workshop

Stantec

Ontario First Nations Technical Services Corporation

Mohawk Council of Akwesasne

Yesterday - Workshop #2

Time	Description	
9:00am – 9:15am	Welcome and introductions	Mohawk Council of Akwesasne OFNTSC
9:15am – 10:00am	Review of PIEVC Protocol steps and discussion	Engineers Canada and Consultant
10:00am – 10:30am	Review and validation of infrastructure components to assess	All
10:30am – 10:45am	Health break	
10:45am – 12:00noon	Description, identification and selection of performance criteria	All participants
12:00pm – 12:45pm	Lunch	
12:45pm – 3:15pm	Site visit	All participants
3:15pm – 3:30pm	Review of Workshop # 3 agenda	Consultant
3:30pm	Adjourn	

Stantec

Ontario First Nations Technical Services Corporation

Mohawk Council of Akwesasne

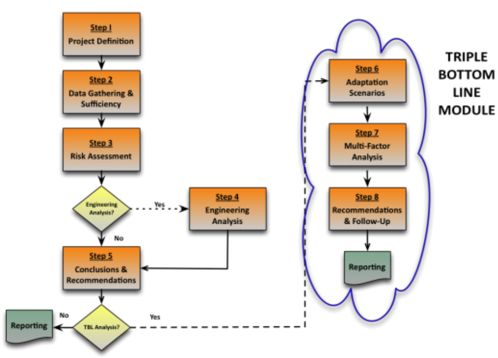
Today - Workshop #3

Time	Description	
9:00am – 9:15am	Welcome and introductions	Mohawk Council of Akwesasne OFNTSC
9:15am – 9:45am	Review of Workshop # 2 findings, site visit 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	

Stantec

Ontario First Nations Technical Services Corporation

Mohawk Council of Akwesasne



engineerscanada

GENERAL DESCRIPTION OF THE PIEVC PROCESS

Stantec

Ontario First Nations Technical Services Corporation

Mohawk Council of Akwesasne

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

Severity								
7	0	7	14	21	28	35	42	
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

6 x 7 = 42

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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The PIEVC Risk Matrix

Infrastructure Components	Infrastructure Response Considerations									
	Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Emergency Response	Insurance Considerations	Policy Considerations	Social Effects	Environmental Effects
	Mark Relevant Responses with ✓									
Storm Sewer / Culvert Sections (Banner --> Leslie Park)										
Manholes										
Catchbasins										
Open Channel Sections										
Outfalls into Graham's Creek										
Road Crossings										
Canfield Rd										
Banner Rd										
Monterey Drive										
Pathway near Leslie Park Public School										
Pathway near Leslie Park										

Infrastructure Components	1					2				3			
	Rain 1					Rain 2				Temperature Extremes (H/L)			
	Infrastructure Threshold Value				Rationale for Infrastructure Threshold.	Infrastructure Threshold Value				Infrastructure Threshold Value			
	Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Y/N	P	S	R
Storm Sewer / Culvert Sections (Banner --> Leslie Park)													
Manholes													
Catchbasins													
Open Channel Sections													
Outfalls into Graham's Creek													
Road Crossings													
Canfield Rd													
Banner Rd													
Monterey Drive													
Pathway near Leslie Park Public School													
Pathway near Leslie Park													

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PERFORMANCE CRITERIA WORKSHOP #2 FEBRUARY 28, 2017

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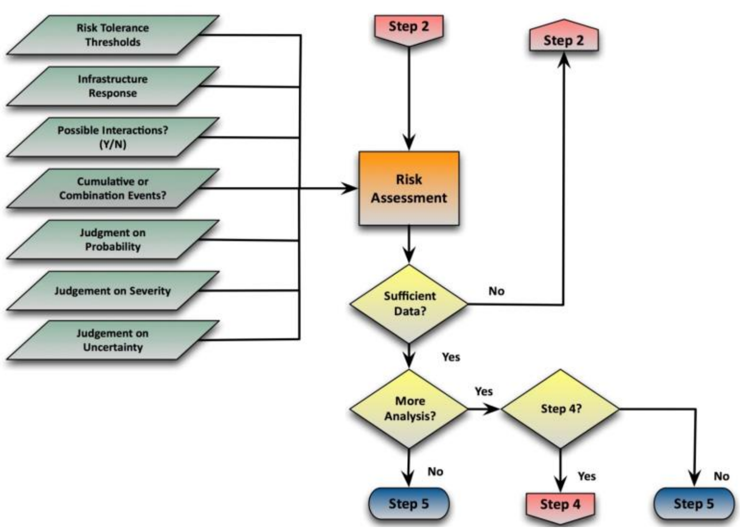
Step 3 - Risk Assessment



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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. 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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7. 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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8. 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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9. 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

10. 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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11. 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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RISK ASSESSMENT – CLIMATE CONSIDERATIONS
MARCH 1, 2017

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Some climate information

MOTHER EARTH

"We are all thankful to our Mother, the Earth, for she gives us all that we need for life. She supports our feet as we walk about upon her. It gives us joy that she continues to care for us as we walk about upon her. It gives us joy that she continues to care for us as she has from the beginning of time. To our Mother, we send greetings and thanks. Now our minds are one."

Climate Change Adaptation Plan for Akwesasne

Draft August 30, 2013

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Climate Change Adaptation Plan for Akwesasne

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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.

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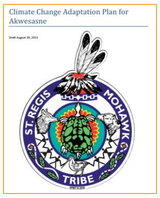

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- Thunderstorm warnings were also issued. As a result of the dry conditions, residents who planted gardens needed to work extra hard to keep gardens from drying up. Heavy rainfall has been more frequent, downing corn stalks and other tall plants, and heavy cloud cover and cloud formations with high winds have been observed to have become more frequent as well.
- A tornado hit in Summerstown in summer 2012, just miles from Akwesasne. Akwesasne had high winds on that day.
- On December 27th, 2012, there was a winter storm warning in Akwesasne and many businesses and offices were closed. Schools were out on Christmas vacation. Thirteen to 17 inches of snow fell within 24 hours.

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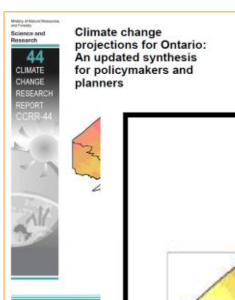

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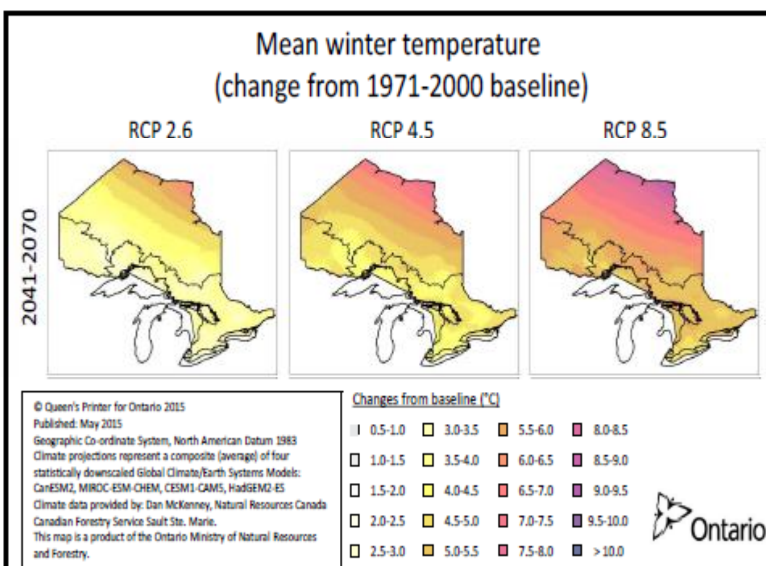
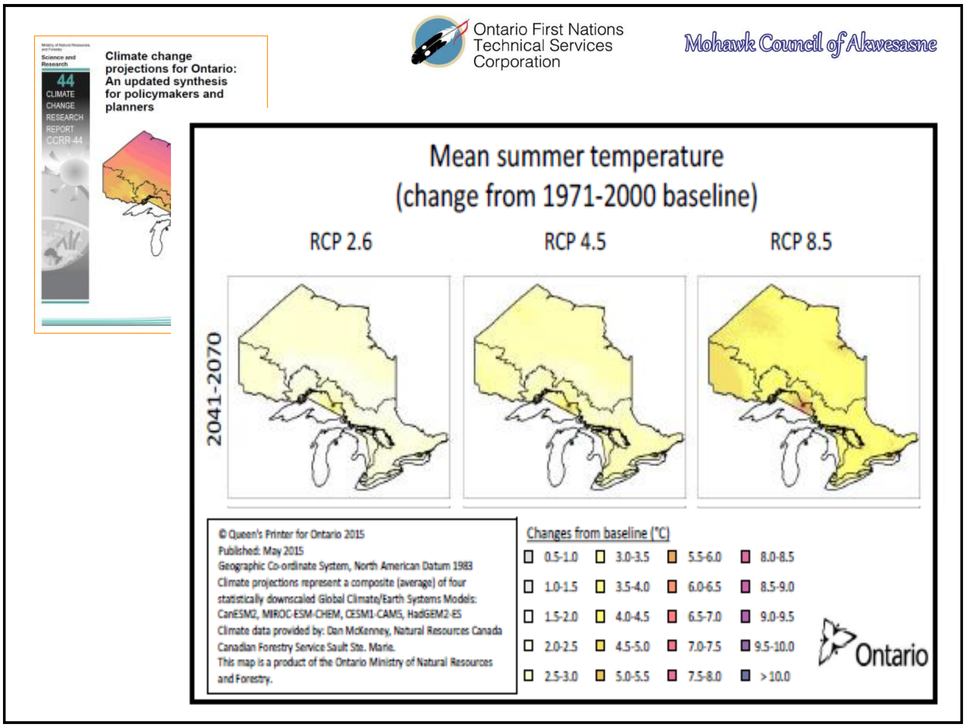
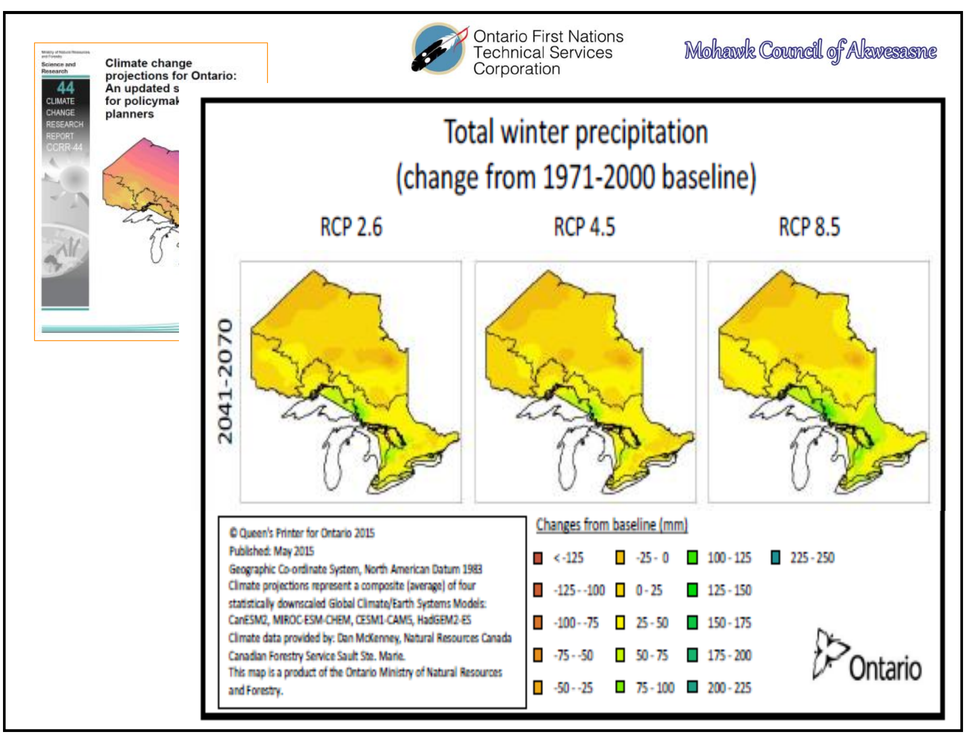



Climate change projections for Ontario: An updated synthesis for policymakers and planners
44
CLIMATE CHANGE RESEARCH REPORT
CCRR-44
Ontario First Nations Technical Services Corporation
Mohawk Council of Akwesasne
Mean summer temperature
(change from 1971-2000 baseline)
RCP 2.6
RCP 4.5
RCP 8.5
2041-2070
© Queen's Printer for Ontario 2015
Published: May 2015
Geographic Co-ordinate System, North American Datum 1983
Climate projections represent a composite (average) of four statistically downscaled Global Climate/Earth Systems Models: CanESM2, MIROC-ESM-CHEM, CESM1-CAM5, HadGEM2-ES
Climate data provided by: Dan McKenney, Natural Resources Canada Canadian Forestry Service Sault Ste. Marie.
This map is a product of the Ontario Ministry of Natural Resources and Forestry.
Changes from baseline (°C)
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
4.5-5.0
5.0-5.5
5.5-6.0
6.0-6.5
6.5-7.0
7.0-7.5
7.5-8.0
8.0-8.5
8.5-9.0
9.0-9.5
9.5-10.0
> 10.0
Ontario


Climate change projections for Ontario: An updated s for policymak planners
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CLIMATE CHANGE RESEARCH REPORT
CCRR-44
Ontario First Nations Technical Services Corporation
Mohawk Council of Akwesasne
Total winter precipitation
(change from 1971-2000 baseline)
RCP 2.6
RCP 4.5
RCP 8.5
2041-2070
© Queen's Printer for Ontario 2015
Published: May 2015
Geographic Co-ordinate System, North American Datum 1983
Climate projections represent a composite (average) of four statistically downscaled Global Climate/Earth Systems Models: CanESM2, MIROC-ESM-CHEM, CESM1-CAM5, HadGEM2-ES
Climate data provided by: Dan McKenney, Natural Resources Canada Canadian Forestry Service Sault Ste. Marie.
This map is a product of the Ontario Ministry of Natural Resources and Forestry.
Changes from baseline (mm)
< -125
-125 - -100
-100 - -75
-75 - -50
-50 - -25
-25 - 0
0 - 25
25 - 50
50 - 75
75 - 100
100 - 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
Ontario

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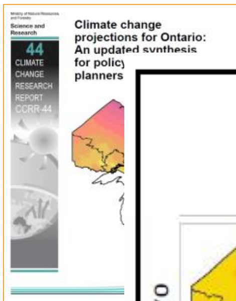

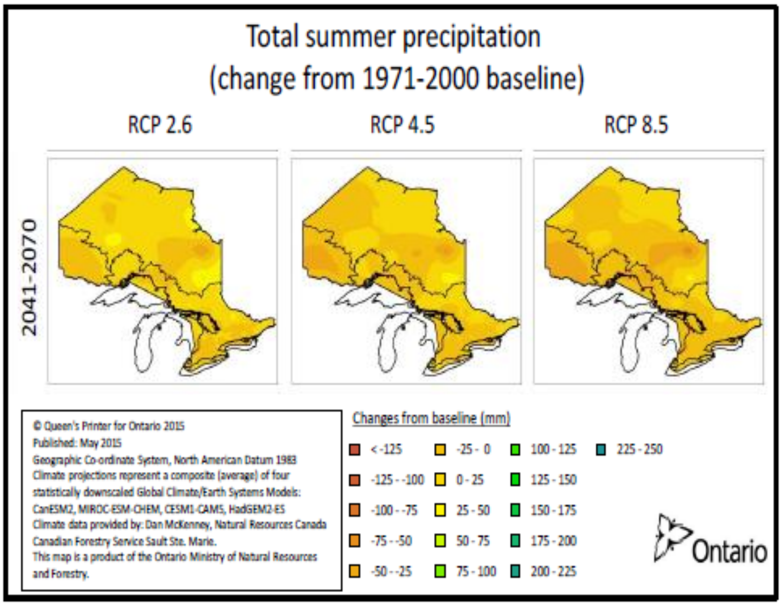

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Western University - ICLR

IDF for: CORNWALL ONT HYDRO ID:6101901

Station Info | IDF, historical data | IDF under climate change

Station name: **CORNWALL ONT HYDRO**

ID: **6101901**

Latitude: **45.03**

Longitude: **-74.80**

Starting year: **1957**

Ending year: **1992**

Number of years (with data): **33**

- https://www.idf-cc-uwo.ca/

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IDF for: CORNWALL ONT HYDRO ID:6101901

Current

Station Info | IDF, historical data | IDF under climate change

Tables | Plots | Interpolation Equations

Total precipitation amounts are presented in mm and precipitation intensity rates are presented in mm/h for different return periods (T) presented in years

(●) Total PPT (mm) ( ) Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	7.94	11.03	13.08	15.66	17.58	19.49
10 min	11.58	16.49	19.74	23.85	26.90	29.92
15 min	14.11	19.51	23.09	27.61	30.97	34.29
30 min	17.90	24.35	28.62	34.02	38.02	41.99
1 h	21.74	28.61	33.16	38.91	43.18	47.41
2 h	26.95	35.92	41.86	49.36	54.92	60.45
6 h	36.19	49.54	58.38	69.55	77.84	86.07
12 h	42.51	60.65	72.66	87.84	99.09	110.27
24 h	47.02	66.46	79.33	95.60	107.66	119.64

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IDF for: CORNWALL ONT HYDRO ID:6101901

2050

Station Info | IDF, historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different ret periods (T) presented in years

(●) Total PPT (mm) ( ) Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	9.56	12.97	15.30	18.18	20.29	22.48
10 min	14.21	19.58	23.25	27.77	31.13	34.56
15 min	17.01	22.92	26.95	31.92	35.62	39.39
30 min	21.48	28.49	33.28	39.13	43.59	48.01
1 h	25.34	32.95	38.15	44.59	49.31	54.19
2 h	31.51	41.51	48.34	56.84	62.96	69.40
6 h	43.15	57.91	67.98	80.46	89.59	99.07
12 h	51.92	71.99	85.69	102.68	115.07	127.98
24 h	57.33	78.67	93.25	111.24	124.54	138.20

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Some references

- http://www.farmzone.com/statistics/suncloud/cl6101874/so071
- http://www.eldoradocountyweather.com/canada/climate2/Cornwall.html
- https://www.timeanddate.com/weather/canada/cornwall/climate
- https://www.worldweatheronline.com/cornwall-weather-averages/ontario/ca.aspx
- https://en.climate-data.org/location/3545/
- Ontario Climate Data Portal: http://www.ontarioccdp.ca/

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Selecting the Climate Parameters

- Modified from the suggested PIEVC Protocol list

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Suggested Climate and Infrastructure Threshold Parameters

Climate Parameter	Infrastructure Threshold Parameter
Temperature	▪ Rate of change ▪ Mean values ▪ Extremes o High summer o Low winter
Precipitation as Rain	▪ Frequency (One-Day, Short Duration Less than 24 hours, Multi-Day) ▪ Total annual/seasonal precipitation and rain ▪ Intensity of rain events (One-Day, Short Duration Less than 24 hours) ▪ Proportion of annual and seasonal precipitation as rainfall ▪ Drought conditions ▪ Winter rain
Precipitation as Snow	▪ Frequency ▪ Total annual/seasonal precipitation and snow ▪ Magnitude of snow events (e.g., blizzards) ▪ Proportion of annual and seasonal precipitation as snowfall ▪ Frequency and intensity of rapid snow melt events ▪ Rain on snow events
Wind Speed	▪ Mean values (one hour mean winds) o Monthly o Seasonal o Annual ▪ Extremes/gusts ▪ Thunderstorm winds ▪ General wind patterns/gradients ▪ Changes in hurricane and/or tornado event frequency/intensity

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Suggested Climate and Infrastructure Threshold Parameters

Climate Parameter	Infrastructure Threshold Parameter
St Lawrence Water Levels	▪ Change in mean value
Fog	▪ Frequency ▪ Visibility
Ice	▪ River or lake ice build up ▪ Changes in ice build up patterns
Hail	▪ Frequency of events ▪ Magnitude of events
Frost	▪ Freeze thaw cycles ▪ Change in frost season
Lightning	▪ Density/frequency of lightning strikes ▪ Change patterns
Ice Accretion	▪ Change in frequency/intensity of ice storm events ▪ Ice build up on infrastructure components
Freezing rain and ice storms	▪ Freezing rain events: frequency and magnitude ▪ Ice storms
Other	▪ Other climate factors as relevant to the infrastructure under consideration

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PIEVC Ratings

- Climate occurrence
- Severity of impacts

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

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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 Loss of Asset

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Identification of interactions

	Infrastructure Response Considerations										1					2				3			
											Rain 1					Rain 2				Temperature Extremes (H/L)			
Infrastructure Components	Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Emergency Response	Insurance Considerations	Policy Considerations	Social Effects	Environmental Effects	Infrastructure Threshold Value				Rationale for Infrastructure Threshold.	Infrastructure Threshold Value				Infrastructure Threshold Value			
	Mark Relevant Responses with ✓										Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Y/N	P	S	R
Storm Sewer / Culvert Sections (Banner --> Leslie Park)																							
Manholes																							
Catchbasins																							
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Monterey Drive																							
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Pathway near Leslie Park																							

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Selection of Response Considerations

											1					2				3			
	Infrastructure Response Considerations										Rain 1					Rain 2				Temperature Extremes (H/L)			
Infrastructure Components	Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Emergency Response	Insurance Considerations	Policy Considerations	Social Effects	Environmental Effects	Infrastructure Threshold Value				Rationale for Infrastructure Threshold	Infrastructure Threshold Value				Infrastructure Threshold Value			
	Mark Relevant Responses with ✓										Y/N	P	S	R	Rationale For Severity Score	Y/N	P	S	R	Y/N	P	S	R
Storm Sewer / Culvert Sections (Banner --> Leslie Park)																							
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Pathway near Leslie Park Public School																							
Pathway near Leslie Park																							

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Probability, Severity and Risks

											1					2				3			
	Infrastructure Response Considerations										Rain 1					Rain 2				Temperature Extremes (H/L)			
Infrastructure Components	Structural Design	Functionality	Serviceability	Watershed, Surface Water & Groundwater	Operations, Maintenance & Materials Performance	Emergency Response	Insurance Considerations	Policy Considerations	Social Effects	Environmental Effects	Infrastructure Threshold Value				Rationale for Infrastructure Threshold	Infrastructure Threshold Value				Infrastructure Threshold Value			
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