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CLIMATE CHANGE VULNERABILITY AND RISK ASSESSMENT OF AKWESASNE WATER AND WASTEWATER INFRASTRUCTURE

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1 Context

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. Figure 1 below shows the Mohawk Council of Akwesasne territory.

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.

In 2016, Akwesasne in collaboration with the Ontario First Nations Technical Services Corporation (OFNTSC) and Engineers Canada, obtained funding from Indigenous and Northern Affairs Canada (INAC) to conduct a vulnerability assessment of its water and wastewater (W/WW) infrastructure using the PIEVC Protocol.

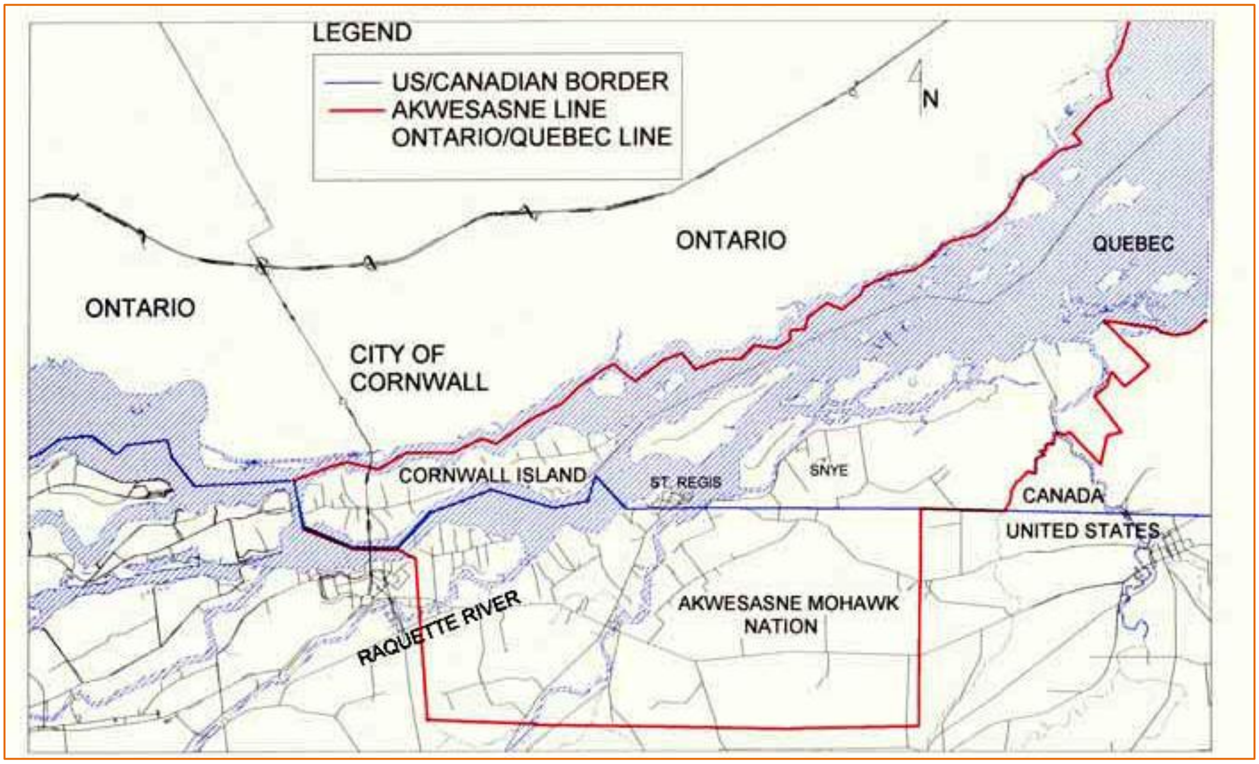

Figure 1: Akwesasne and Vicinity (Source: Mohawk Council of Akwesasne)

2 Overview of the PIEVC Protocol

Engineers Canada developed the PIEVC Protocol in 2007 as a result of concerns of the profession regarding risks associated with climate changes that may impact the safety and performance of infrastructure over its life-cycle. To date, the Protocol has been used or is currently being used (2017) in more than 45 projects. Engineers Canada (see: www.PIEVC.ca) describes this tool as:

"The Protocol 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."

3 Description of the Infrastructure

The infrastructure assessed in this project is typical of water and wastewater systems found in small to medium size communities. It is particular however because of the geography of the territory served and the presence of the St. Lawrence River. This represents two challenges:

- Independent systems for Cornwall Island and St. Regis/Snye
- Access to St. Regis and Snye requiring crossing through the USA.

The W/WW system of the Mohawk Council of Akwesasne is maintained by 8 operators, and comprises the following elements:

Potable Water:

- 2 water plants (Cornwall Island and St. Regis)
- 41 km of watermains (including a watermain under the St. Regis river to provide water to Snye)
- 1400 service connections

Wastewater

- Sewage treatment plant
- 6 sewage treatment units (Rotating Biological Contactors – RBCs)
- 8.2 km of wastewater collection pipes
- 452 service connections (St. Regis)

Figure 2 shows some of the infrastructure in Akwesasne.

Figure 2: Akwesasne Cornwall Island Water Treatment Plant (Source: Mohawk Council of Akwesasne)

4 Climate Considerations

In general, future climate projections for the area show rising temperature trends higher in winter than summer. Although total annual or seasonal precipitation projections do not show definite trends up or down, recent weather and climate models indicate changes in precipitation patterns, for example: increased number of freezing rain events; winter rain; drought and heat waves followed by short duration/high intensity rain events.

The following climate parameters were selected for the vulnerability assessment:

Table 1: Examples of Climate Parameters

Climate Parameter*	Description	Comments
Temperature	Annual mean	Potential impact on raw water source
	Extreme high	Impacts on operations and equipment
	Extreme low	Impacts on equipment and operations in a context of short term extreme temperature variations
	Heat wave	Three or more consecutive days at temperatures greater or equal to 32 degrees C – potential impacts on water demand and supply
Precipitation	Short duration / High intensity events	Potential flooding; potential run-off impacts on water quality at intake
	Lack of precipitation over extended periods (drought)	Potential damage to the environment around infrastructure facilities; increased potential of run-off during rain events following the drought; increase susceptibility to wild fires; surcharge of combined sewer in St. Regis.
	Extended periods of rain	Potential for flooding around W/WW infrastructure; rise in ground water level in St. Regis with potential impacts on storm and wastewater collection system
	Winter rain	Rain on snow events potentially causing flat roof surcharges
	Freezing rain / ice storms	Potential damage to flat roofs; possible loss of electrical power; difficult mobility of operational staff
Wind	Extreme winds	Annual instances of > 50 knots winds within a 100km radius of Akwesasne
	Tornado	Two instances of tornados in last 12 years within a 100km radius of Akwesasne
Lightning		Increase in thunderstorm and lightning season duration. Potential damage to SCADA system as experienced in the past

5 Overview of Risk Assessment Process and Results

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 use the process illustrated on Figure 3 below which is a slight variation of the traditional PIEVC process.

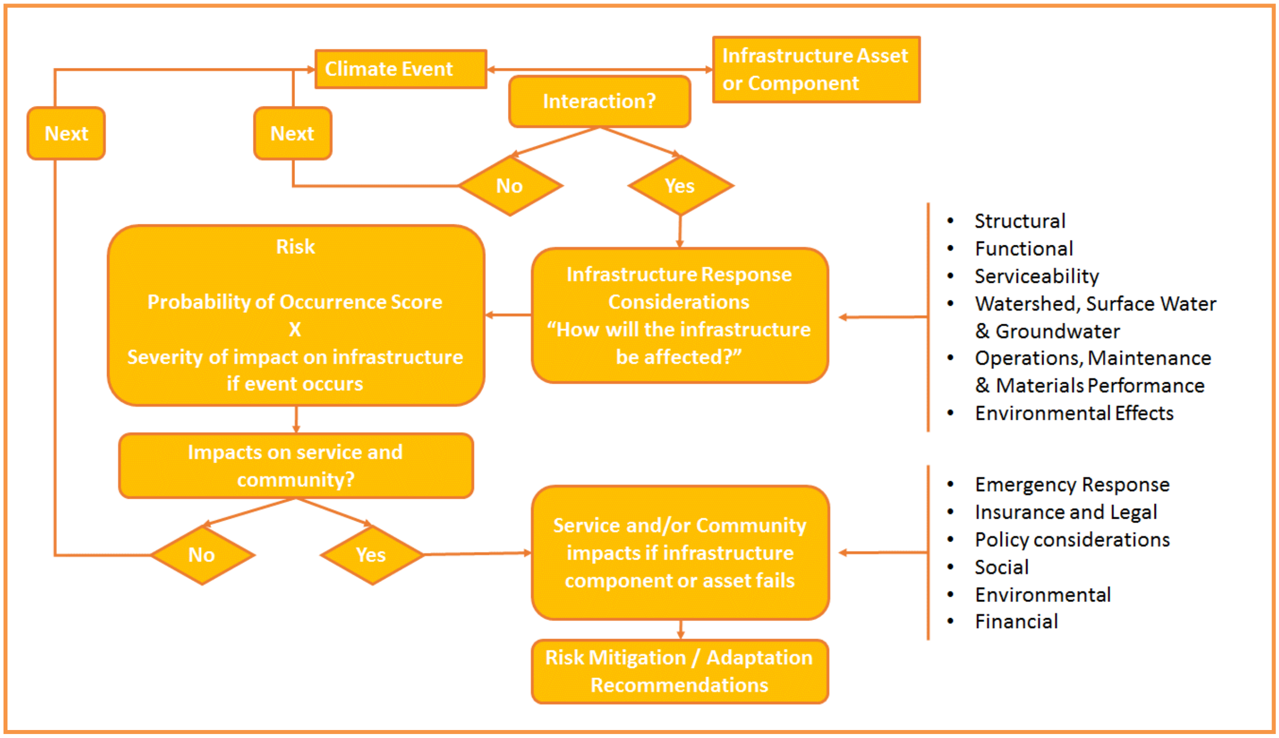

Figure 3: Process used to establish infrastructure risks and impacts on the community

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. Alhtough 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 strong rain events, thus potentially causing significant runoff that can lead to surcharging the drainage systems.

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 2 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 2: Summary of risk counts for Cornwall Island infrastructure replaced at the end of its design life and deteriorated

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

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.

6 Conclusion

In general, although many of the infrastructure components of the W and WW system in Akwesasne are in acceptable condition, long term vulnerability of these systems in view of increased extreme weather events need to be considered in the asset management plan of the community. Pressures on operations and maintenance budgets, common not only in First Nations communities but in Canadian municipalities as well, can result in accelerated deterioration – thus increased vulnerability, of these infrastructure systems.