PROTECTING THE NUTASHKUAN INNU FIRST NATION COMMUNITY THROUGHOUT FLOOD EVENTS

Localized groundwater solution in Canada safeguards residents situated remotely along the St. Lawrence River

*The image above shows the Nutashkuan Innu First Nation community in Quebec, Canada.

The increasing intensity and frequency of extreme weather events underlines the need to protect communities from the potentially devastating impacts of such phenomena; climate change is expected to worsen heavy precipitation, droughts and other weather occurrences.[1]

In Canada, the Nutashkuan Innu First Nation community, comprising 1,077 residents who live along the Gulf of the St. Lawrence River and at a low elevation above sea level, has been impacted by floods during the annual spring thaw. In 2017, a major thaw and heavy rain resulted in flooding that impacted circa 60 homes, about a quarter of the dwellings in the community.

Following the 2017 spring floods, WSP was commissioned to develop a solution to protect the Nutashkuan Innu First Nation community. The project—a controlled lowering of the regional groundwater table along the land defining the community—involved creating an underground tunnel upstream of the community, to capture and reroute underground water away from the homes vulnerable to flood impact. In a Q&A following the project overview directly below, Project Director Soheil Nakhostin, discusses the challenges of the project, how it was implemented and the benefits the solution brings to the Nutashkuan Innu First Nation community, and potentially to other communities around the world.

Figure 1 – Google Earth image showing the Nutashquan River delta in the St. Lawrence River where the community resides.

Project Overview

Client - Nutashkuan Innu First Nation

Timeframe: Studies started 2018; engineering began in 2019; the lowering of the groundwater table was completed in December 2019; Surface

[1] *Canada's Top Climate Change Risks*, The Expert Panel on Climate Change Risks and Adaptation Potential, Council of Canadian Academies, 2019

drainage (phase 2) was completed in December 2020.

WSP's Responsibilities

- Client representative to different stakeholders
- Funding application and environmental authorizations
- Hydrogeological expertise and modelization
- Engineering design
- Plans and specification
- Tender process for contractors
- Construction supervision

Solution

A regional underground water-lowering system that protects the residents from the impacts of high-water-table-elevation flooding.

Technical Aspects:

- Passive system (no moving element)
- Required hydrological modelization and calibration
- No day-to-day operation required; no associated operations costs
- Minimal maintenance costs – The rising water table will be caught by the underground channel and diverted by gravity toward the outfall
- Designed to counter sand filling and iron ochre issues
- Efficient and limited construction cost
- Designed with climate change in mind
- Monitored through water table piezometers
- 2021 – project Award of Excellence – Canadian Consulting Engineer magazine

Figure 2 - Outfall of the drainage system (summer time)

What was the major challenge of this project?

Soheil Nakhostin: Relatively flat, the region is characterized by vast and very permeable sandy deposits, which directly impact the level of the groundwater table[2] after precipitation or snow melting. Therefore, the flooding situation is a real risk that required a very quick response from WSP with a bold solution proposal. WSP has been the client's engineering team for several consecutive years, a relationship that allowed our team comprehensive understanding of site and soil conditions.

What factors led to the solution?

[2] According to the U.S. Geological Survey (usgs.gov): Groundwater is water that exists in saturated zones beneath the land surface. The upper surface of the saturated zone is called the water table. Groundwater fills the pores and fractures in underground materials such as sand, gravel, and other rock, much the same way that water fills a sponge.

Soheil Nakhostin: There were several key requirements. We needed to develop a cost-effective solution that could be implemented relatively quickly with minimal impact on the environment.

The project's complexity was intensified by the community's remoteness and location along the shores of the Natashquan River and St. Lawrence River. There were no stormwater networks in place, as all of the community's homes were built without footing drains due to lack of suitable slopes to carry the water away by gravity.

How did the team manage the risks associated with lowering the water table?

Soheil Nakhostin: Special attention was given to the potential impacts lowering the groundwater level could have on coastal ecosystems and surrounding hydric and hydrogeological systems. To limit disruptions, an adjustable weir was installed downstream of the drainage system to allow the control of the water table levels. The main objective was to lower the peak of the groundwater level during the spring thaw in May, the period corresponding to the highest water table conditions. Based on observations, a lowering of 400 millimetres was generally sufficient to avoid the flooding problematics.

Since water catchment had to be very efficient over a considerable distance in a flat area, WSP's team developed a new approach—installing underground infiltration chambers, which are traditionally used to hold rainwater under paved surfaces.

Figure 3 - Groundwater table conveyance system with geotextile grid installed underneath

Can you expand upon the technical work of the project?

Soheil Nakhostin: Knowledge of the area's terrain, acquired over several years of collaboration and confirmed by subsequent investigations, informed the technical work to carry out this project. Within six months, the designers worked with hydrogeology experts to implement a groundwater monitoring program and in situ permeability tests, and to generate a computer model to reproduce the hydraulic behaviour of the groundwater table.

A total of 830 metres of catchment chambers were built—each 1.5 metres wide, 0.9 metres high and 3 metres deep—along the main regional road [Route 138]. These chambers were completed with 540 metres of 750-milimeter diameter pipes, creating an underground stream that bypasses the community.

The installation of piezometric probes at several locations, validation of tide levels and analyses of soil were carried out quickly and simultaneously, as were funding applications and environmental authorizations.

In accordance with the hydrogeological study, the solution is a highly efficient underground drainage system capable of intercepting large volumes of groundwater and carrying the water to the gulf despite the absence of an adequate slope. The system also had to withstand the action of iron ochre present in the soil, which could quickly obstruct the holes in conventional perforated pipes.

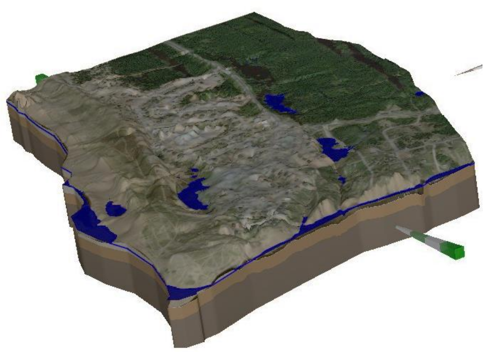

Figure 4 - 3D Modelization of the Nutashkuan topography and hydrogeology; the blue color represents the St. Lawrence River (left) and Natashquan River (lower horizontal)

What are the enduring benefits of this project?

Soheil Nakhostin: The solution maximizes preservation of the natural environment. The locations of the drainage chambers along Route 138 were strategically selected to avoid excavation work in the community's residential area; the selection also avoided unnecessary deforestation, especially as vegetation growth is very slow in the region. The use of trench boxes, instead of conventional excavation methods, also minimized tree felling.

The system is cost-effective, built at 1.8 million dollars [CAN] and has proved efficient in protecting the entire community against flooding, as confirmed by piezometric measurements from 2019 to 2021. The 2017 flood resulted in four million dollars [CAN] worth of damages.

The project also brought social benefits for the community. The hiring and training of local workers and the use of local resources contributed to stimulating the economy.

Another benefit was that this project enabled development of a storm drainage system. As the catchment system in this project ensured the efficient drainage of underground water, a storm drainage system based on the same general principle was built in 2020 to lower water levels and redirect stormwater to the river. In the short term, surface water drainage will allow the community's roads, which are mainly made of gravel, to be paved.

Also significant, as climate change will likely have an increasing impact on variations in different groundwater tables, water experts around the world are increasingly challenged to identify the approach appropriate for each community, enabling the residents to adapt to local conditions.

The innovative solution and design tailored for this community could also provide long-term protection to communities living in areas experiencing similar conditions.

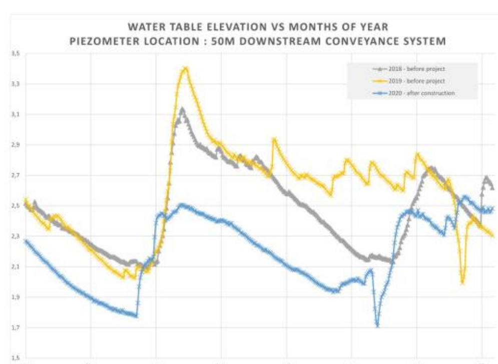

Figure 5 – The chart shows the water table elevation in the Natashkuan Innu First Nation community from 2018 through

2020, the first year after completion of the lowering of the groundwater table (in December 2019). A major thaw and heavy rain occurred in the spring of 2017.

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About WSP

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