Building a water treatment plant for remote communities in cold environments:

THE CASE OF KUGAARUK, NUNAVUT

By Cheryl Gomes, M. Eng.

Located within the Arctic Circle, Kugaaruk, Nunavut has the record for the coldest wind chill ever recorded in Canada (-92°C, 1975). Besides July and August, temperatures fall below 0°C all year in Kugaaruk. Which begs the question: How do the 800 residents of this remote community with year-round freezing conditions obtain drinking water?

The process of designing, building, operating, and maintaining a water treatment plant (WTP) for cold, remote regions has a unique set of challenges, which may not arise for large urban centers in other regions of Canada. Here is a look at the case of Kugaaruk, Nunavut.

Click here to return to Table of Contents

THE FIRST WATER TREATMENT PLANT IN KUGAARUK

Kugaaruk is a predominantly Inuit community on the shore of Pelly Bay in Nunavut. The first water treatment plant (WTP) in Kugaaruk was completed in 1988, when its population was 300.

HIGHLY VARIABLE RAW WATER SOURCE

The WTP draws raw water from a small, shallow man-made reservoir along a river. The surface is frozen most of the year, which reduces the depth of raw water available and can increase turbidity. When the frozen surface thaws for a few months of the year, the reservoir is no longer protected from surface run off. This significantly alters the raw water quality and can result in high levels of sediments. In January 2010, a saltwater surge contaminated the reservoir, which is located only 2km northeast of the Arctic Ocean. The plant was temporarily shut down; forcing the Hamlet of Kugaaruk to manually draw water from farther upstream and use sleds to transport water vessels to the residents. In other words, the raw water source is highly variable, which can make it considerably difficult to design a WTP. Furthermore, water quality data is not readily available for Arctic regions.

TRUCKS DELIVER CHLORINATED WATER TO EVERY HOME

Extensive permafrost and frost heaving make it impossible to install underground infrastructure, which is typically used to deliver potable water from a WTP to end-users. Aboveground distribution networks are sometimes used in Arctic communities; however, all infrastructure must be insulated and water must constantly be circulated to avoid freezing. This can become costly to install and maintain. A truckfill system is an appealing alternative for a small ($5km^2$) community like Kugaaruk. Plant operators fill trucks with potable water and deliver the water to the community, by filling hundreds of water storage tanks that are located outside every house or public building. Each storage tank is connected to the facility to transport water inside. The original WTP treated the water using chlorine only and the water was then delivered to every home using the truckfill system.

THE URGENT NEED FOR A PLANT UPGRADE

As decades passed, the WTP became inadequate for a number of reasons:

- Useful life: The WTP was designed to last 20 years. By 2014, the WTP was in operation for 26 years. Physical deterioration of the equipment was significant.
- Flow rate: The WTP was designed to serve up to 450 residents by producing water at a rate of 17L/s (260GPM). While this was meant to accommodate the future growth of the community, the population increase was significantly underestimated, with a population of nearly 800 by 2014. Furthermore the flow rate could not meet the fire demand if an emergency fire occurred.
- Treatment technology: The WTP treated the raw water using chlorine only. As Canadian standards for drinking water quality became higher, further treatment would become necessary to provide potable water.
- Public perception: Residents believed their health was at risk if they consumed the water produced from the original WTP and instead they relied on filtered or bottled water.

The WTP was in desperate need of an upgrade. In 2014, BI Pure Water and Williams Engineering teamed up to deliver a new WTP for the Government of Nunavut. Team work and constant problem solving was critical to ensure project success.

DESIGNING THE NEW WATER TREATMENT PLANT

In 2013, a new system was designed to treat the highly variable reservoir water and provide potable water to the community, using the truckfill delivery method already in place. Resilience was a key design parameter so that the plant could withstand freezing conditions throughout the year. The plant walls were insulated with (10cm) polyurethane panels, and bullet proofed with (0.3cm) steel lining to accommodate the local hunting lifestyle. Plant mobility was another key design parameter.

Click here to return to Table of Contents

The community intended on eventually building a new water reservoir farther from the Arctic Ocean, to prevent recontamination by saltwater. The plant was manufactured as a fully portable unit so it could easily be relocated to the new reservoir in the future. The treatment system included a custom filtration system, ultraviolet (UV) for primary disinfection and chlorine for secondary disinfection. This schematic was duplicated to have two independent treatment trains, providing redundancy and allowing two trucks to be filled simultaneously. Water could be produced at 40L/s (600GPM), which could meet the fire demand if needed. The plant was manufactured and tested in Surrey to minimize work required on site.

WORKING ON SITE WITH LIMITED RESOURCES

Resources for industrial activity are limited in Kugaaruk, which can make site work very costly. At the time, the only excavator in town was rented at approximately $1000 per day. Instead an excavator was purchased in Surrey, shipped to Kugaaruk for site work, and later offered to the community at cost, for future use. Shipping supplies to Kugaaruk may be the most difficult compared to any other Canadian Arctic community. Kugaaruk is situated on a rock outcrop and its geographic location is subject to ice jams. Cargo delivery ships cannot access the community. Airfreight can be used to deliver goods to Kugaaruk, but it is expensive and flights are often cancelled due to blizzards or high winds. Sometimes it takes months to clear the backlog of goods to be shipped by airfreight. Alternatively, the Canadian Coast Guard delivers goods to Kugaaruk using massive icebreaker vessels. Economically, this is the most attractive option. However, deliveries are only made once a year, meaning extensive planning and commitment to schedule are crucial. Any small delay could cause a one-year setback. The plant was delivered via the Canadian Coast Guard in September 2013, and commissioned by October 2014 (Figure 1). The previous WTP from the '80s was refurbished to provide chlorine storage and supplied power from a backup generator.

PROJECT OUTCOMES AND OVERCOMING ONGOING CHALLENGES

The community was pleased with the new WTP. However, when the ice melted in August 2014, spring run off affected the quality of the reservoir water. The filters needed to be replaced earlier than expected. A depleted filter supply was not ideal for Kugaaruk, since the specialty filters took months to produce and shipping items from factory to Kugaaruk is no quick task. In January 2015, BI Pure modified the plant design by changing the filter arrangement from a series to parallel configuration, which significantly extended the useful life of the filters. A large supply of replacement filters was also kept on hand in Kugaaruk to ensure the community would not run out. Additionally, remote monitoring capabilities were installed to collect water quality data and troubleshoot any future concerns, minimizing the need for service visits to Kugaaruk.

Although there were many weather related and logistic challenges, thanks to the support from the Hamlet of Kugaaruk, local workers and the Government of Nunavut, the new WTP proved to be a successful project and the pride of the community. Locals informed us that they no longer rely on filtered or bottled water and have confidence in their new WTP.

ABOUT THE AUTHOR

Cheryl Gomes, M. Eng., completed her B. Sc. in Chemistry at McGill and M. Eng. in Chemical and Biological Engineering, with an Engineering Management sub-specialization at UBC. Both degrees focused on water chemistry, water/wastewater engineering and economics. After completing her UBC thesis, she worked as a project engineer and sales engineer in the water treatment manufacturing industry.