Drinking Water Quality (July 2013)
Preliminary Results
Pond Inlet, NU.

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Summary

This report describes the preliminary results obtained from the environmental assessment of the drinking water supply in Pond Inlet, which was conducted from July 18 to 22, 2013. In close collaboration with community members, inhabitants were interviewed regarding their views on the drinking water supply and habits of water usage. The interviews were held in both public buildings (8) and private homes (9). Samples of raw untreated water from the water reservoir, the adjacent river, and treated drinking water samples from water trucks and taps were also obtained to undergo chemical and microbiological testing for a panel of parameters, including chlorine and the content fecal indicator bacteria (i.e., total coliforms and *Escherichia coli*). Not included in this report are results from the on-going metal and in-depth microbiological testing and the findings from the interviews.

The main finding presented in this preliminary is that the levels of chlorine residuals were very low in the drinking water, meaning that there was no residual protection of the water. Coliform bacteria and *E. coli* were absent from all drinking water samples with the exception of the "brown" water sample obtained from the tap in a public building where the water tank had run dry. This result indicates that potentially harmful bacteria may be lodged in the precipitate found in water tanks and in premise plumbing.

The majority of samples from the water reservoir contained low levels of coliform bacteria but only one sample contained *E. coli*. The fecal indicator bacteria were absent in the water being pumped into the water treatment plant (WTP), however, coliform bacteria were consistently found in repeated samples of the river water. Although no *E. coli* bacteria were found in the river water, it is not recommended that this water be consumed without prior treatment.

In conclusion, it is recommended that the treated drinking water leaving the WTP contains free chlorine levels of at least 0.2 mg/L to provide the water with some residual protection as it is being transported and delivered to the community. Also, it is recommended that the water tanks be cleaned on a regular basis to ensure that a resident microbial biofilm population does not develop. As fecal indicator bacteria (i.e., coliform bacteria and *E. coli*) were detected in the source water it would also be prudent to advise against the intake of untreated water from the water reservoir and adjacent river.

1.0 Introduction

The typical model of potable water delivery in most Northern communities is fundamentally different than in Southern communities. In the North, water is extracted from lakes, rivers or glacier streams and either piped or trucked to reservoirs within the town, from where it is trucked to community households and public buildings and stored in tanks. Depending on the community, chlorination for microbial control is performed either on discharge from the reservoir, or directly within the water delivery truck. There are several points along the delivery train where water may become contaminated. Contaminants may be either microbial (bacteria, viruses, protozoa) or chemical (heavy metals, organics, disinfection by-products) in nature. The management and

maintenance of municipal as well as in-home infrastructures will presumably play a large role in the potential for water contamination.

The overall objective of this project is to monitor and better understand drinking water quality and potential sources of contamination from the original source (e.g., lake, river, glacier) to the tap (the point of human use) within Nunavut communities, including Pond Inlet.

This project was initiated in response to the interest in drinking water quality research voiced by Nunavut communities while team members from the Centre for Water Resource Studies (CWRS) at Dalhousie University and Nunavut Research Institute in Iqaluit were originally in the communities working on wastewater related research projects. It is important to note this is an exploratory research project designed to assess the drinking water quality and water delivery methods rather than to address known water quality issues.

2.0 Material and Methods

Water samples from the source-to-tap continuum in the drinking water supply in Pond Inlet, which is located on Baffin Island, NU, were collected over four days from July 19 to 22, 2013.

The source water in Pond Inlet comes from a man-made water reservoir located approximately 5 km south of the hamlet. The reservoir lake is mainly fed by water percolating through the hill slope and snow/ice melt water (Figure 1). On occasion, when the water level in the water reservoir runs low, water from the river located to the south-west of the water reservoir is pumped to stock the water reservoir to an adequate level before freeze-up. As is indicated in Figure 1, water samples were obtained from the water reservoir at the intake to the water treatment plant (WTP) and across from the intake. The river was similarly sampled in two locations close to where the water would be pumped to the water reservoir. Both of these locations were sampled twice on two separate days. A sample of raw source water was also obtained directly from the pipe in the WTP, prior to chlorination.

Treated (chlorinated) drinking water samples were obtained from three water trucks and taps in seven public buildings and nine private homes. In the case of the public buildings, two different taps were sampled in the same building, while in another public building the same tap was sampled immediately after the tank had been refilled after running dry and then 6 hours later. The nine private homes represented both private and public housing units of different ages and locations.

At the time of sampling, household inhabitants and public building managers were interviewed about their views on the drinking water supply and habits of water usage to aid in contextualizing the water quality data. Also, the Acting Municipal Water Foreman and several Water Truck Drivers were consulted regarding their typical work routines, the chlorination injection process that occurs at the WTP, and their chlorine monitoring and record keeping protocol. The results of these interviews are not included in this preliminary report.

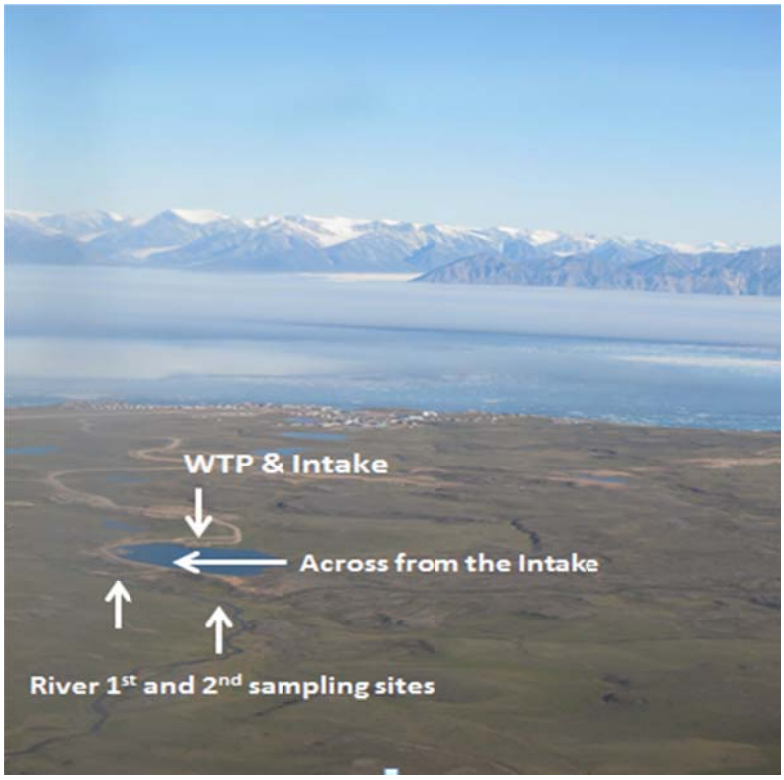

Figure 1. Aerial photo of Pond Inlet showing the location of the water reservoir, the water treatment plant (WTP) and sampling sites by the intake to the WTP, across the intake and on the adjacent the river which serves as an alternative water source.

2.1 Sample collection and analysis of water temperature, pH, conductivity and contents of chlorine (free and total)

Water samples were collected in 4 L plastic containers following rinsing of the container three times with the water sample.

Water reservoir and stream samples were obtained using a sampling pole with a sampling bottle strapped to the pole. Care was taken to obtain samples below the water surface in the case of the water reservoir and in "runs" of the stream.

Before sampling the drinking water taps, the aerators were first removed followed by disinfection of the taps with a sanitizing napkin (Antibacterial Wipes, Life brand, Shoppers Drug Mart, Canada). The tap was then run for approximately one minute before sampling the drinking water.

On site measurements of the water temperature and pH were done using a handheld YSI sonde (Yellow Springs, OH, USA). All water samples were brought back to the field laboratory in Pond Inlet. Here, the contents of chlorine (free and total) were measured using a HACH Pocket Colorimeter II for Chlorine (HACH, Ames, IA, USA) and DPD pillows according to the manufacturer's instructions. The conductivity was measured using a calibrated Thermo Orion 5-Star apparatus (Fisher Scientific, Nepean, ON, Canada) equipped with a conductivity electrode.

Microbial cells from one litre of the water sample was concentrated onto a filter with a pore size of 0.45 µm to be subjected to DNA extraction in Iqaluit in our laboratory located at the Nunavut Research Institute. Sample volumes of approximately 40-50 mL were preserved with nitric acid for future metal analysis.

Following processing all samples were stored at 5°C and shipped to Iqaluit the next day for storage or analyses. The metal samples (5°C) and DNA extracts (-20°C) were finally transferred to our laboratory at Dalhousie University in Halifax, Nova Scotia for the final analyses which are still on-going at the time of writing this preliminary report.

2.2 Enumeration of coliforms and Escherichia coli

For determination of the total coliform and *E. coli* content, a sub-set of each sample was aseptically transferred to two sterile bottles (*ca*. 100 mL in each) with thiosulfate to inactivate any chlorine residues. The samples were stored at 5°C overnight and shipped to Iqaluit where they were analyzed within 24 hours of being sampled.

One hundred mL of the water samples were added directly to the Idexx Colilert Quanti-Trays (Westbrook, ME, USA), sealed and incubated for 18 hours at 37°C. Following incubation, yellow wells were enumerated for the determination of coliforms while presumptive *E. coli* were counted as the light blue fluorescing wells. Using the manufacturer's conversion table, the number of positive wells was converted into the most probable number (MPN) per 100 mL of water. Each water sample was done in duplicate.

3.0 Results

3.1 Water Quality in Public Buildings

The temperature of the drinking water varied widely in the seven public buildings with temperatures from 14 to 26.2°C. The pH levels were consistently close to neutral (pH=7), while conductivity ranged from 63.1 to 98.2 µS/cm. The level of chlorine (free and total) was very low with concentrations of 0-0.07 mg/L. None of the ordinary tap samples contained any coliforms or *E. coli* in the duplicate 100 ml sample volumes.

The water obtained from Building 4 immediately after the tank had been refilled, came from the empty tank and as the pipes were full of air, precipitated corrosion and biofilm products likely contributed to the water's aesthetically unpleasant brown colour as well as the high conductivity (117.4 µS/cm). This water sample also contained coliforms (18.7 MPN/100 mL) and *E. coli* (1 MPN/100 mL), indicating the presence of these bacteria in the water tank and premise plumbing. Sampling of the same tap six hours later showed a return to normal conductivity levels (83.0 µS/cm)and absence of coliforms/*E. coli* (Table 1).

Table 1. Water Quality in Public Buildings in Pond Inlet.

Building		Temperature (°C)	pH	Conductivity (µS/cm)	Chlorine (mg/L)		Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
					Free	Total		
1		17.8	6.93	63.1	0	0	<1	<1
2		26.2	7.00	96.2	0.01	0.01	<1	<1
3	Tap 1	23.6	7.22	94.6	0.01	0.01	<1	<1
	Tap 2	21.4	7.03	98.6	0.01	0.01	<1	<1
4	Refill	22.0	7.24	117.4	0.03	0	18.7	1
	Later	20.2	7.36	83.0	0.04	0.07	<1	<1
5		22.5	7.42	78.3	0.01	0.02	<1	<1
6		20.9	7.43	91.9	0.01	0.01	<1	<1
7		14.0	7.49	84.25	0.02	0.01	<1	<1

3.2 Water Quality in Private Homes

The water quality in the private homes showed similar trends as those presented above for the public buildings.

It is worth noting that the chlorine levels were consistently low with the exception of Home 9, where a free chlorine concentration of 0.16 mg/L was detected in the water (Table 2). Interestingly, the owner of that home indicated that his tank had not recently been filled.

The average temperature and conductivity of the drinking water coming directly from the domestic drinking taps were 22.6°C and 73.5 µS/cm, respectively. Coliform bacteria and *E. coli* were absent in both of the 100 mL samples analyzed from each home (Table 2).

Table 2. Water Quality in Private Homes in Pond Inlet.

Home	Temperature (°C)	pH	Conductivity (µS/cm)	Chlorine (mg/L)		Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
				Free	Total		
1	25.7	7.12	69.9	0.01	0.01	<1	<1
2	17.4	7.36	63.2	0.01	0.01	<1	<1
3	23.0	7.26	68.3	0.00	0.01	<1	<1
4	24.0	7.27	71.8	0.01	0.01	<1	<1
5	19.0	7.30	64.9	0.02	0.02	<1	<1
6	20.8	7.30	79.8	0.01	0.02	<1	<1
7	23.0	7.33	78.3	0.01	0.01	<1	<1
8	26.6	7.30	84.3	0.01	0.02	<1	<1
9	24.0	7.38	81.1	0.16	0.17	<1	<1

3.3 Raw Source Water Quality in Pond Inlet

The temperature of the untreated source water was constant (11.8-12.8°C) over the sampling period (Table 3). The water was slightly alkaline (pH 7.12-7.58). The water reservoir samples exhibited a much higher conductivity (72.8-76.0 µS/cm) compared to the water samples from the adjacent river, where conductivity averaged 21.5 µS/cm. This difference probably reflects the different origin of the water, as in groundwater vs. surface water. The raw source water from the water reservoir was found to contain low levels of coliform bacteria and one sample also contained *E. coli* (Table 3). The river water contained higher levels of coliform bacteria (230-320 MPN/100 mL) at both sampling sites and events, however, none of the samples contained *E. coli* indicating this bacteria is not widespread in the catchment draining into the river.

Table 3. Raw Source Water Quality in Pond Inlet.

Water Source	Tempera-ture (°C)	pH	Conductivity (µS/cm)	Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
WTP 1st Sample	12.3	7.38	76.0	<1	<1
WTP 2nd Sample	11.8	7.50	75.9	<1	<1
WR Intake 1st Sample	12.6	7.58	nt	1	<1
WR Intake 2nd Sample	12.8	7.31	72.8	1	<1
WR Across from Intake 1st Sample	12.6	7.40	nt	4.6	1
WR Across from Intake 2nd Sample	12.8	7.35	73.5	<1	<1
River 1 1st sampling	12.5	7.37	nt	293	<1
River 1 2nd sampling	12.3	7.28	22.05	320	<1
River 2 1st sampling	12.6	7.22	nt	230	<1
River 2 2nd sampling	12.0	7.12	21.02	233	<1

WTP – Water Treatment Plant, WR – Water Reservoir, nt – not tested (see also Figure 1 for specification of sampling locations)

3.4 Treated Drinking Water Quality in Pond Inlet

Freshly treated water samples were obtained from three water trucks that had just been filled at the WTP (Table 4). The truck samples were obtained on two different days. The water quality parameter values (pH, temperature, and conductivity) resembled those obtained in the raw water from the water reservoir (see Table 3).

Notably the freshly treated water contained very low levels of chlorine. It is normally recommended that water is chlorinated to levels between 0.2-2.0 mg/L at the WTP to provide the drinking water with a chlorine residual for downstream protection against microbial contamination and regrowth.

Total coliform bacteria and *E. coli* were absent in duplicate 100 mL samples of the fresh drinking water.

Table 4. Water Quality in Freshly Treated Drinking Water Samples in Pond Inlet.

Water Truck	Temperature (°C)	pH	Conductivity (µS/cm)	Chlorine (mg/L)		Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
				Free	Total		
1	12.1	7.37	77.4	0.02	0.05	<1	<1
2	13.2	7.28	80.1	0.02	0.05	<1	<1
3	11.5	7.40	77.8	0.04	0.05	<1	<1

4.0 Summary of Results

A total of 21 drinking water samples obtained from public buildings, homes and water delivery trucks were analyzed for basic water quality parameters (temperature, pH and conductivity), levels of free and total chlorine and the presence of coliform bacteria and *E. coli*. The temperature of the drinking water obtained from taps in public buildings and homes tended to be above 20°C which can potentially cause issues around biofilm regrowth in premise plumbing structures. The levels of chlorine residuals were very low in the drinking water, meaning that there was no residual protection of the water. Coliform bacteria and *E. coli* were absent from all drinking water samples with the exception of the "brown" water sample obtained from the tap in a public building where the water tank had run dry. This result indicates that potentially harmful bacteria may be lodged in the water tank and premise plumbing biofilm populations.

Three out of four raw source water samples from the water reservoir contained low levels of coliform bacteria but only one sample contained *E. coli*. The fecal indicator bacteria were absent in the water being pumped into the WTP, however, coliform bacteria were consistently found in repeated samples of the river water. Although no *E. coli* bacteria were found in the river water, it is not recommended that this water be consumed without prior treatment.

In conclusion, it is recommended that the treated drinking water leaving the WTP contains free chlorine levels of at least 0.2 mg/L to provide the water with some residual protection during transportation and delivery to the community. Also, it is recommended that the water tanks are cleaned on a regular basis to ensure that a resident microbial biofilm population does not develop. As fecal indicator bacteria (i.e., coliform bacteria and *E. coli*) were detected in the source water it would also be prudent to advise against the intake of untreated water from the water reservoir and adjacent river.

5.0 Acknowledgements

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