Real-Time Water Quality Deployment Report

Lower Churchill River Network

May 31 to July 5, 2017

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Municipal Affairs & Environment
Water Resources Management Division

Contents

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Real Time Water Quality Monitoring

- Staff members with the Department of Municipal Affairs & Environment monitor real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at one station on the Lower Churchill River: Churchill River below Muskrat Falls.
- On May 31, 2017, a real-time water quality monitoring instrument was deployed at the Churchill River below Muskrat Falls station for a period of 36 days.
- The station at English Point was not deployed due to inaccessibility. Heavy ice during Spring break-up caused significant damage to the landing pad, which prevented the helicopter from landing. Due to the large amounts of shrubs and bushes, the helicopter was unable to land anywhere near this site.
- The station at Grizzle Rapids was not deployed due to inaccessibility. This area consistently experiences heavy ice build-up that does not abate until late spring. An area near the below Grizzle Rapids station (which contained both water quality and quantity monitoring capabilities) experienced a landslide in September 2016 and therefore a decision was made to relocate the water quality component of this station to the existing above Grizzle Rapids hydrometric station as soon as the ice conditions improve. The below Grizzle Rapids stations will be discontinued.
- The station at above Muskrat Falls was not able to be deployed during this deployment period. This station was relocated in October 2016 as it was situated in the flood zone of the Muskrat Falls Reservoir and needed to be moved back to ensure the station did not flood as the reservoir water levels were raised (as was planned in the fall of 2016). However, due to unforeseen issues, water levels were raised and decreased again. As a result, the newly located above Muskrat Falls station is now situated approximately 650 feet from the edge of the reservoir (i.e. at current water levels) making it impractical to install monitoring equipment. Additionally, safety requirements with regards to working in and around the reservoir for the Muskrat Falls project further hindered the ability to deploy the instrument at this station.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.
- At deployment and removal, a QA/QC instrument is temporarily deployed alongside the field instrument. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the field instrument and QA/QC instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Instrument Performance Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/l) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

- It should be noted that the temperature sensor on any instrument is the most important. All other parameters can be broken down into three groups: temperature dependant, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the instrument the entire instrument must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.

- Deployment and removal comparison rankings for the Lower Churchill River stations deployed from May 31 to July 5, 2017 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, May 31 to July 5, 2017

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Muskrat Falls	May 31, 2017	Deployment	Good	Poor	Excellent	Poor	Fair
	July 5, 2017	Removal	Excellent	Good	Excellent	Excellent	Excellent
English Point	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A
Grizzle Rapids	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A
Above Muskrat Falls	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A

- **Churchill River below Muskrat Falls**
  - At deployment, conductivity was ‘excellent’, temperature was ‘good’, turbidity was ‘fair, and both pH and dissolved oxygen were ‘poor’. The discrepancies observed between the field instrument and QA/QC instrument are attributed to a failure with the QA/QC instrument.
  - At removal, temperature, conductivity, dissolved oxygen and turbidity were all ‘excellent’, while pH was ‘good’.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from May 31 to July 5, 2017 at the Churchill River below Muskrat Falls site.
- With the exception of water quantity data (stage & flow), all data used in the preparation of graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.
- The Grizzle Rapids station was inaccessible due to spring ice.
- The English Point station was inaccessible due to damages to the landing pad.
- The above Muskrat Falls station was inaccessible due to having been moved a significant distance from the water (i.e. outside of flood zone) and due to safety concerns associated with working in and around the reservoir.

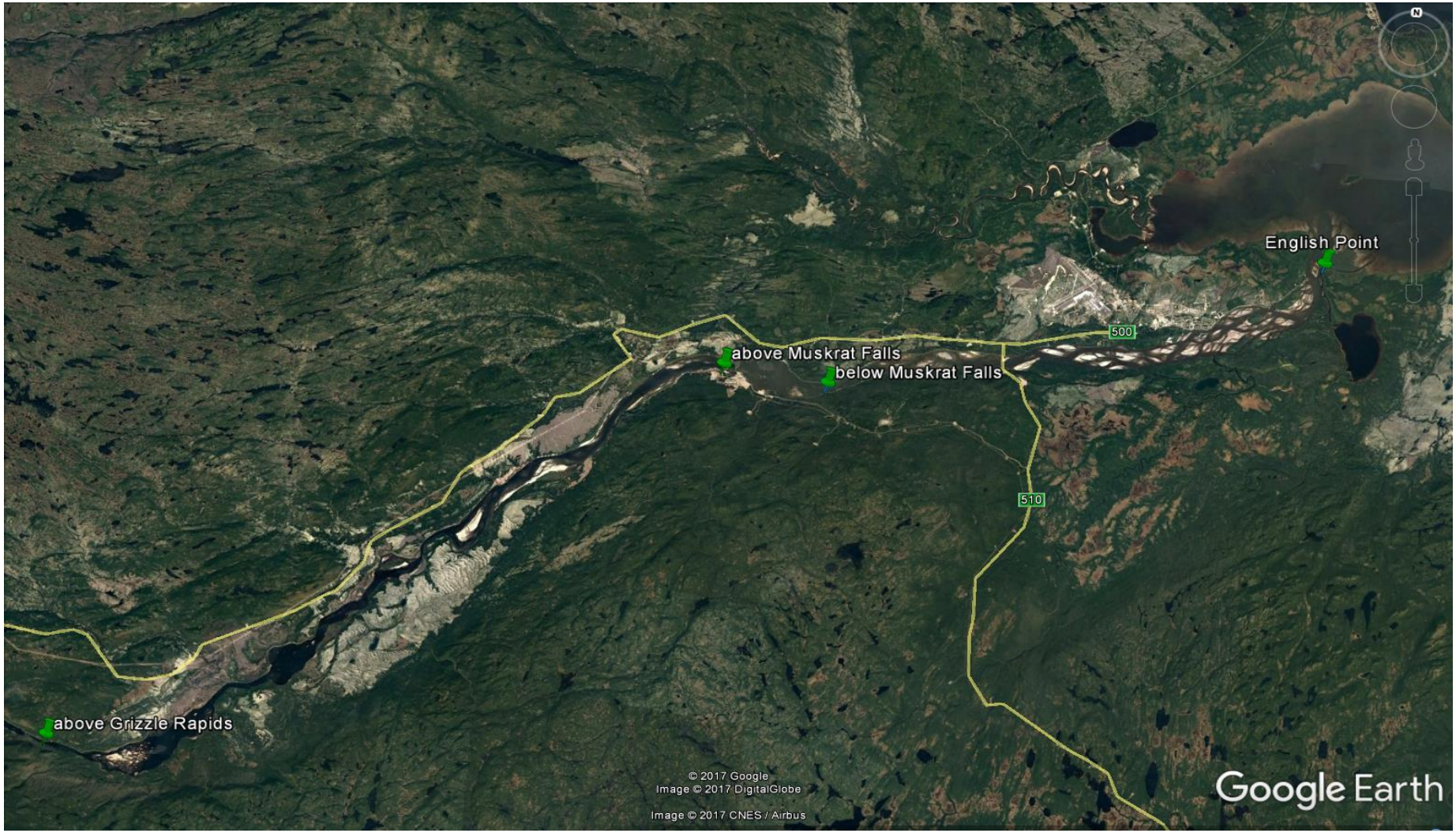

Figure 1: Lower Churchill Network of Real-Time Water Quality Stations

Churchill River below Muskrat Falls

Water Temperature

- Water temperature ranges from 3.20°C to 13.90°C during deployment, with a median value of 8.20°C (Figure 2).
- Water temperature is gradually increasing throughout the deployment period with the exception of a stable period from June 18th through June 25th. This warming trend is to be expected as air temperatures warm into the spring and summer months. Air temperature data was obtained from the Muskrat Falls MET Station.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

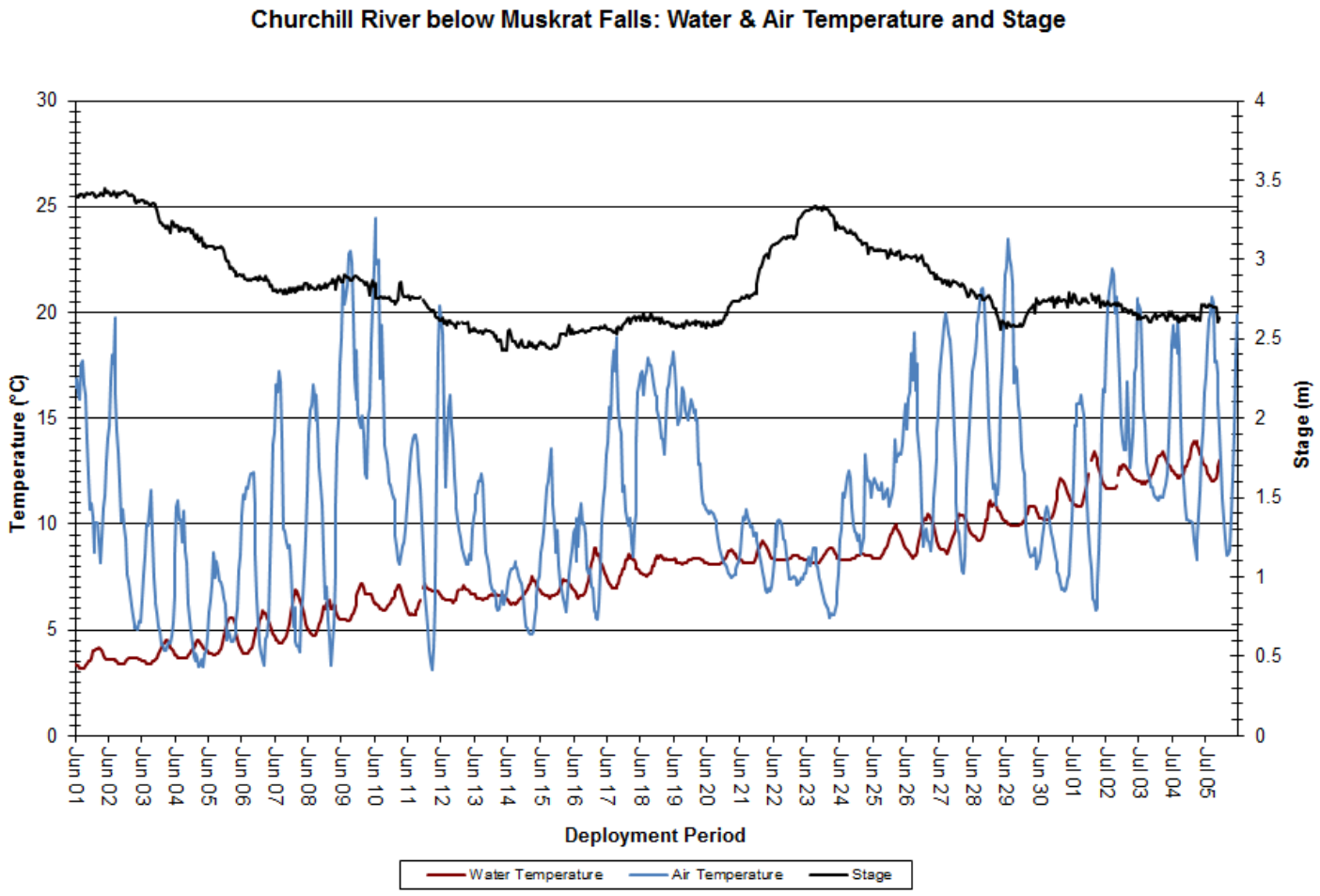

Figure 2: Water & Air Temperature and Stage at Churchill River below Muskrat Falls

pH

- pH ranges between 6.63 and 6.84 pH units, with a median value of 6.73 (Figure 3).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

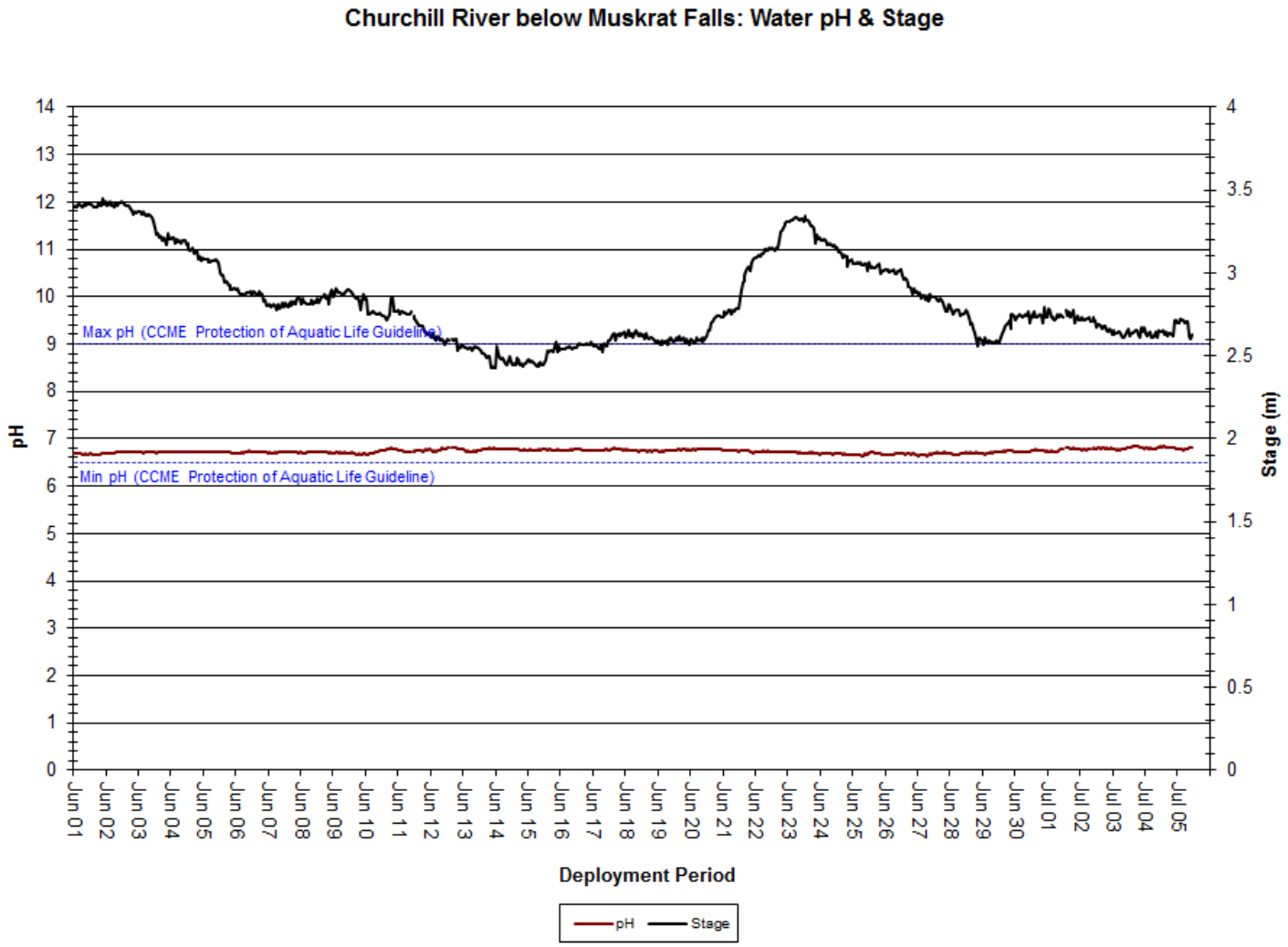

Figure 3: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Specific conductivity ranges from 11.0µS/cm to 15.5µS/cm, with a median value of 13.7µS/cm. (Figure 4).
- The relationship between conductivity and stage are inversed. When stage level rises, specific conductance levels drop in response as increased amounts of water in the river system dilute solids that are present.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

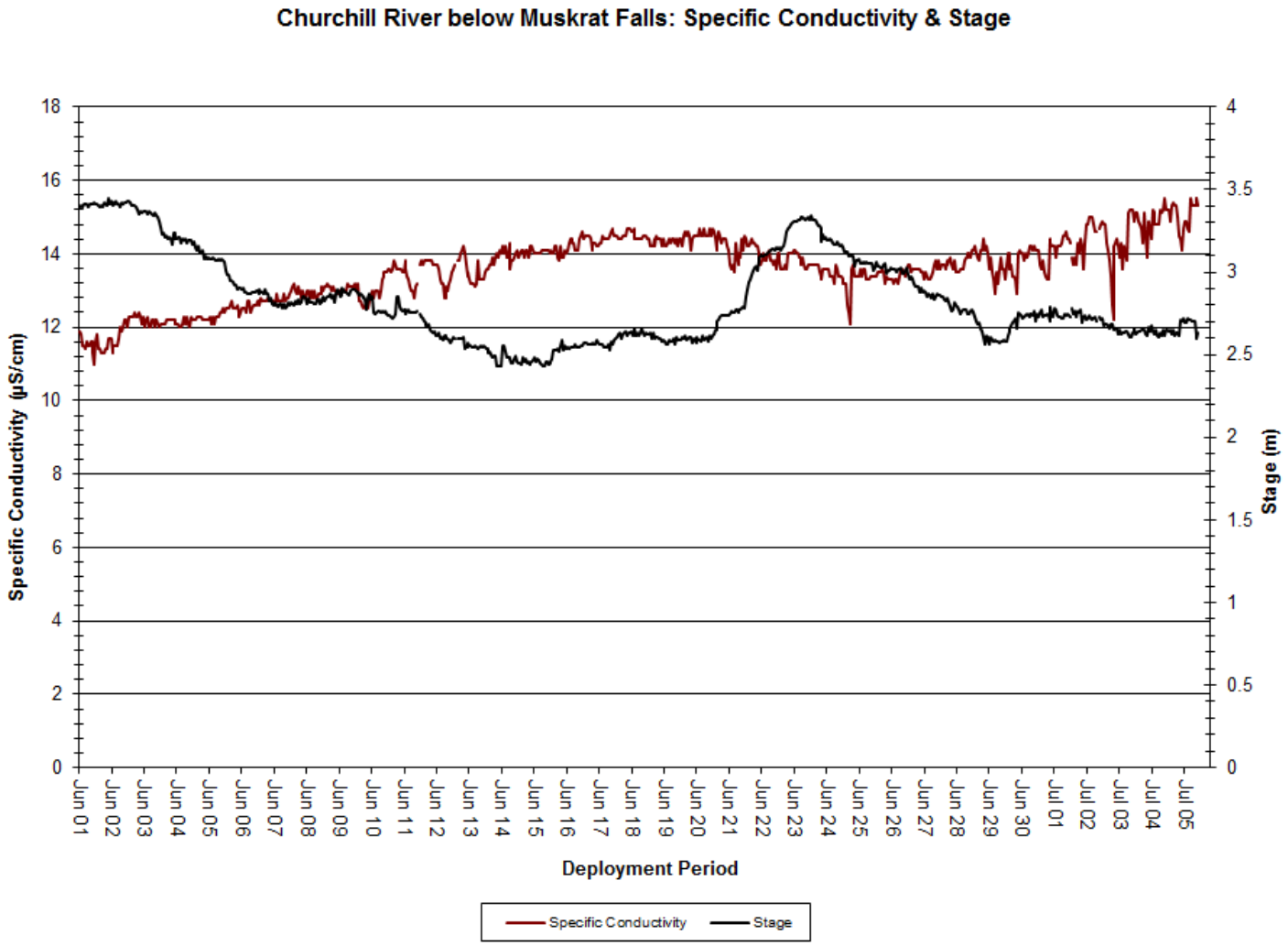

Figure 4: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges from 11.36mg/L to 14.62mg/L, with a median value of 12.60mg/L. The saturation of dissolved oxygen ranges from 96.3% to 114.1%, with a median value of 106.4% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels are slowly falling as temperatures rise into the spring and summer season. Generally, dissolved oxygen levels are higher in a waterbody during periods of cooler temperatures.
- Dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early Life Stages and Other Life Stages for the duration of this deployment period.

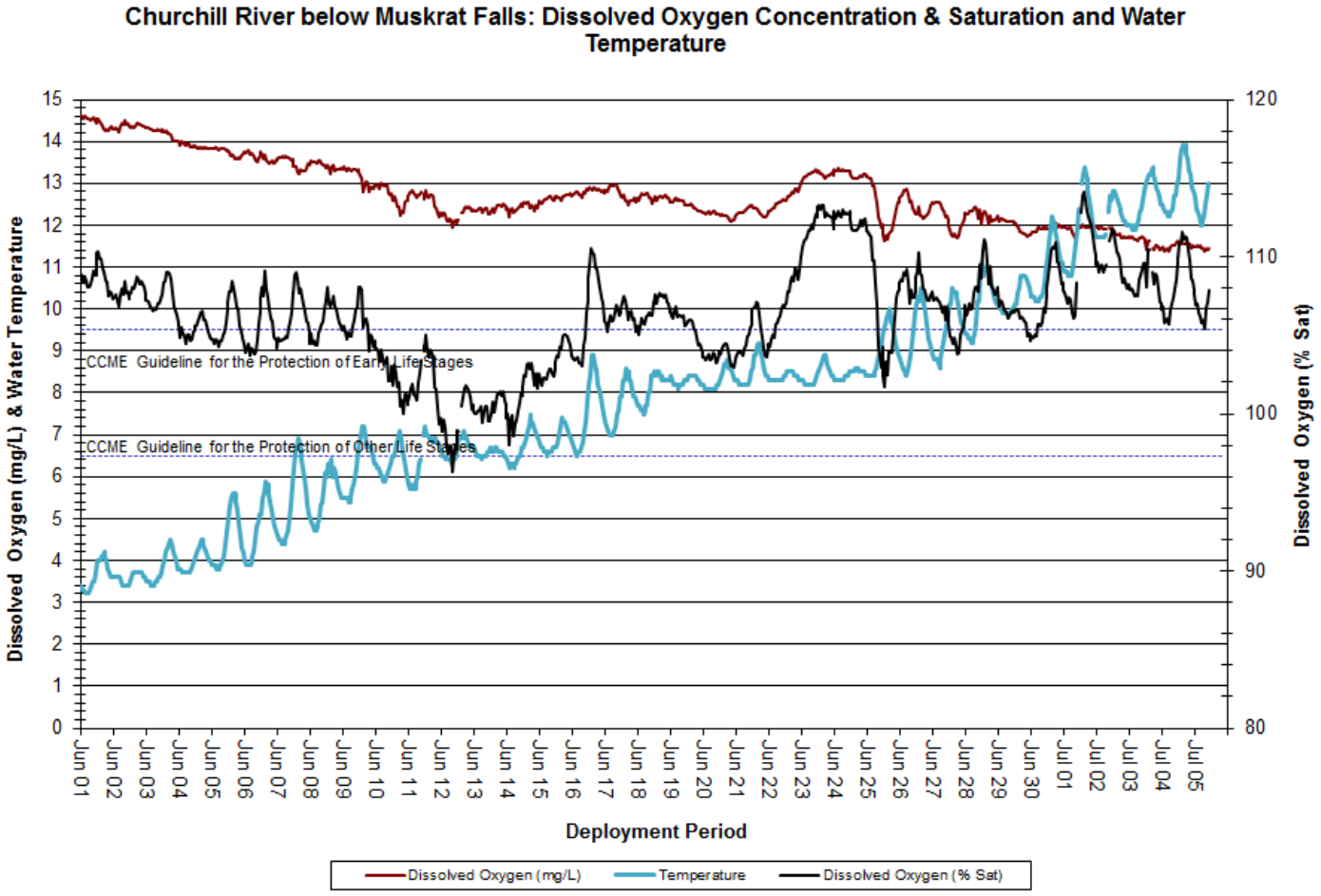

Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Turbidity ranges from 0.0NTU to 105.5NTU, with a median value of 10.0NTU (Figure 6).
- The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events (Figure 7). Precipitation can increase the presence of suspended material in water.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

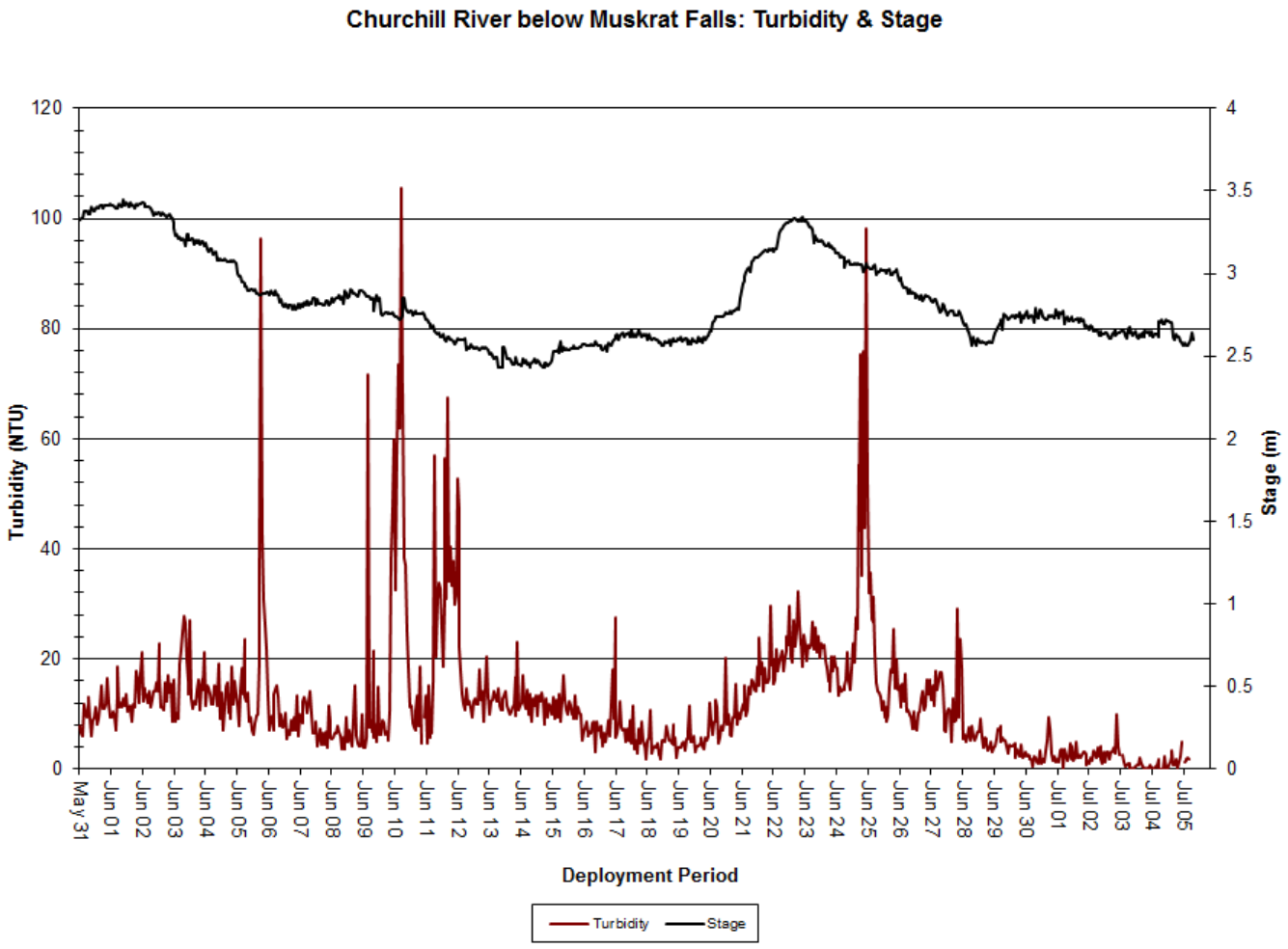

Figure 6: Turbidity & Stage at Churchill River below Muskrat Falls

Stage and Precipitation

- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 7).
- Stage is generally variable across the deployment period. As expected, precipitation events correlate with temporary increases in stage.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

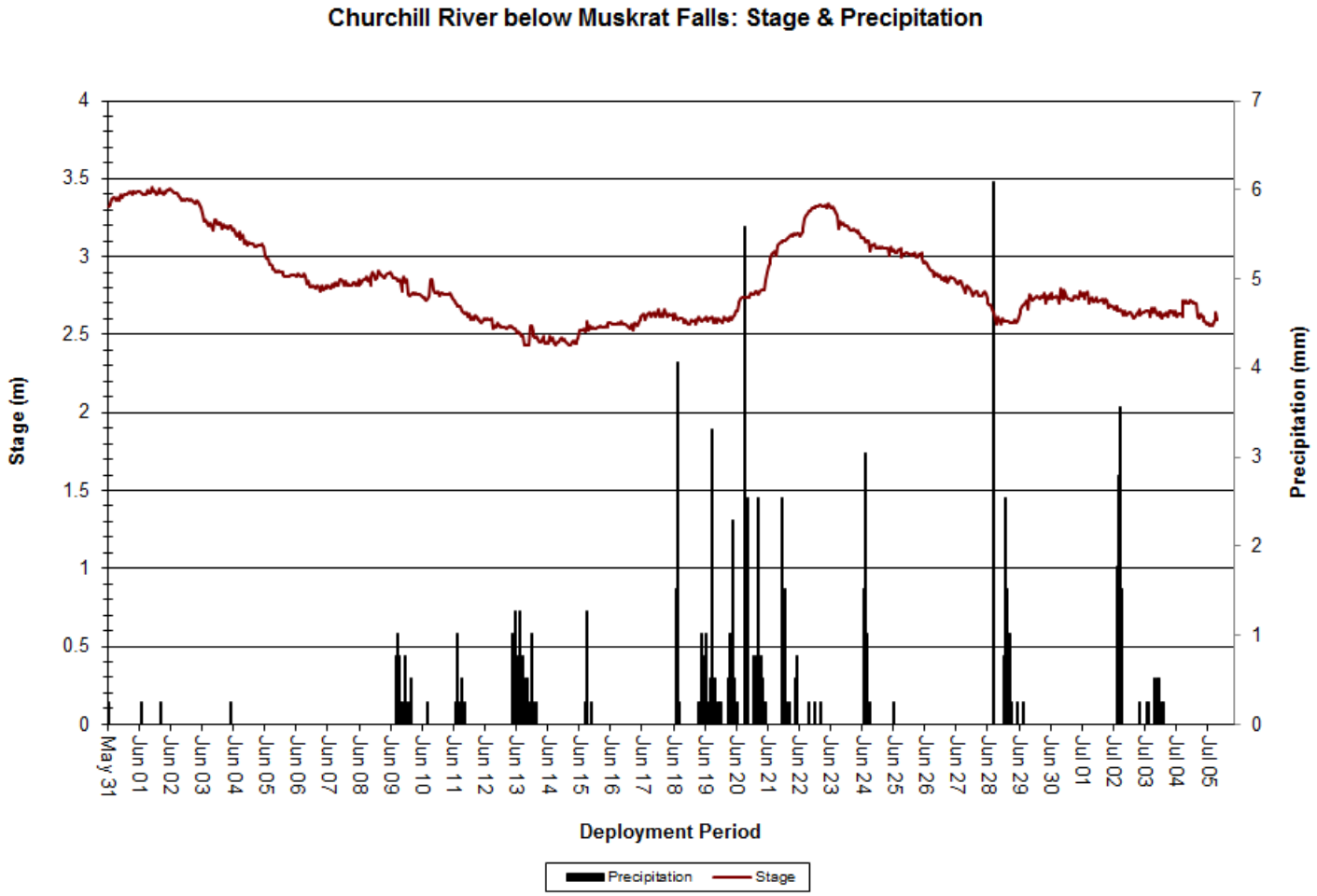

Figure 7: Stage & Precipitation (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

Conclusions

- An instrument was deployed at the Churchill River below Muskrat Falls water quality monitoring station on the Lower Churchill River from May 31st to July 5th, 2017. The stations at Grizzle Rapids and English Point could not be deployed due to seasonal conditions, but will be deployed during the next site visit. The station above Muskrat Falls could not be deployed due to location and accessibility concerns.
- Water temperature was increasing at the Churchill River below Muskrat Falls station throughout the deployment period due to the increasing ambient air temperatures in the region as summer approaches.
- pH was stable at the Churchill River below Muskrat Falls station, remaining within the recommended CCME Guidelines for the Protection of Aquatic Life.
- Specific conductivity showed some variation at the Churchill River below Muskrat Falls station, demonstrating an expected inverse relationship with stage.
- Dissolved oxygen was decreasing throughout the deployment period at the Churchill River below Muskrat Falls station. This is to be expected as water temperatures increase with the changing seasons.
- Turbidity data at the Churchill River below Muskrat Falls station showed several turbidity events related to precipitation. There is known consistent background turbidity at this station due to high levels of sediment and precipitation events.

References

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APPENDIX A

Water Parameter Description

Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l or % saturation) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (USGS, 2017).

Flow - Flow (m3/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.

pH - pH is a measure of the relative amount of free hydrogen and hydroxyl ions in water. pH is an important indicator of chemically changing water, and determines the solubility and biological availability of nutrients and heavy metals in the water (USGS, 2017).

Specific conductivity - Specific conductivity (µs/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25°C. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Fondriest Environmental Inc, 2016).

Stage - Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature - Essential to the measurement of most water quality parameters, temperature (°C) controls most aquatic processes. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth. In turn, water temperature has an influence on the metabolic rates and biological activity of aquatic organisms (Fondriest Environmental Inc, 2016b).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Swenson and Baldwin, 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Swenson and Baldwin 1965).

APPENDIX B

Grab Sample Results

Maxxam Job #: B7B6092
Report Date: 2017/06/15

Department of Municipal Affairs and Environment
Site Location: CHURCHILL RIVER
Your P.O. #: 215062145-3

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
EMW241 CR below MF								
Sampling Date 2017/05/31 11:40								
Matrix W								
Sample # 2017-6300-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	12	1.0	mg/L	N/A	2017/06/13	2017/06/13		5014642
Hardness (CaCO3)	7.1	1.0	mg/L	N/A	2017/06/09	2017/06/09		5014638
Nitrate (N)	<0.050	0.050	mg/L	N/A	2017/06/13	2017/06/13		5014641
Inorganics								
Conductivity	13	1.0	uS/cm	N/A	2017/06/08	2017/06/08	JMV	5018471
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2017/06/13	2017/06/13	FD	5019736
Total Alkalinity (Total as CaCO3)	6.9	5.0	mg/L	N/A	2017/06/12	2017/06/12	NRG	5018680
Dissolved Chloride (Cl)	1.0	1.0	mg/L	N/A	2017/06/12	2017/06/12	NRG	5018686
Colour	46	5.0	TCU	N/A	2017/06/12	2017/06/12	NRG	5018702
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2017/06/08	2017/06/08	JMV	5018472
Total Kjeldahl Nitrogen (TKN)	0.17	0.10	mg/L	+/- <RDL	2017/06/09	2017/06/09	BMO	5021185
Nitrite (N)	<0.010	0.010	mg/L	N/A	2017/06/12	2017/06/12	NRG	5018714
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2017/06/12	2017/06/12	NRG	5019167
Dissolved Organic Carbon (C)	4.9	0.50	mg/L	N/A	2017/06/12	2017/06/12	SMT	5020734
Total Organic Carbon (C)	5.2	0.50	mg/L	N/A	2017/06/12	2017/06/12	SMT	5020758
pH	6.72	N/A	pH	N/A	2017/06/08	2017/06/08	JMV	5018470
Total Phosphorus	0.026	0.004	mg/L	+/- 0.006	2017/06/09	2017/06/12	ASP	5021047
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2017/06/12	2017/06/12	NRG	5018688
Turbidity	12	0.10	NTU	N/A	2017/06/08	2017/06/08	JMV	5018490
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2017/06/09	2017/06/12	ARS	5020959
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.60	0.0050	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Barium (Ba)	0.012	0.0010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Boron (B)	<0.050	0.050	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Calcium (Ca)	1.6	0.10	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Chromium (Cr)	0.0012	0.0010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Iron (Fe)	0.68	0.050	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Magnesium (Mg)	0.74	0.10	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Manganese (Mn)	0.020	0.0020	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Potassium (K)	0.42	0.10	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732

Maxxam Analytics International Corporation o/a Maxxam Analytics 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.maxxamanalytics.com

Maxxam Job #: B7B6092
Report Date: 2017/06/15

Department of Municipal Affairs and Environment
Site Location: CHURCHILL RIVER
Your P.O. #: 215062145-3

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
EMW241 CR below MF								
Sampling Date 2017/05/31 11:40								
Matrix W								
Sample # 2017-6300-00-SI-SP								
Registration # WS-S-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Sodium (Na)	0.54	0.10	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Strontium (Sr)	0.0099	0.0020	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732
Total Zinc (Zn)	0.0072	0.0050	mg/L	N/A	2017/06/08	2017/06/09	BAN	5018732

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Maxxam Job #: B7B6044
Report Date: 2017/06/12

Department of Municipal Affairs and Environment
Site Location: CHURCHILL RIVER
Your P.O. #: 217000610

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
EMW045 CR below MF								
Sampling Date 2017/05/31 11:40								
Matrix W								
Sample # 2017-6300-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	26	2.0	mg/L	N/A	2017/06/07	2017/06/12	LPW	5016398

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