Real-Time Water Quality Deployment Report

Lower Churchill River Network

May 25 to June 29, 2016

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Climate Change
Water Resources Management Division

Contents

Prepared by:
Kyla Brake – Environmental Scientist
Department of Environment and Climate Change
Water Resources Management Division
Phone: 709.729.3899
Fax: 709.729.0320

Newfoundland Labrador

Real-Time Water Quality Deployment Report

Lower Churchill River Network

May 25 to June 29, 2016

Real Time Water Quality Monitoring

- Staff of the Department of Environment and Climate Change monitor real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at four stations on the Lower Churchill River: below Grizzle Rapids, above and below Muskrat Falls and at English Point.
- On May 25, 2016, real-time water quality monitoring instruments were deployed at two of the Lower Churchill River Stations for a period of 34 & 35 days. The station below Lower Muskrat Falls was not deployed due to inaccessibility as water levels were extremely high, preventing the helicopter from landing. The station below Grizzle Rapids was not deployed as the station was inaccessible due to spring ice.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QAQC), 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 QAQC Instrument is temporarily deployed along side 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 QAQC 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 25 to June 29, 2016 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, May 25 to June 29, 2016

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below 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 upper Muskrat Falls (47590)	May 25, 2016	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	June 29, 2016	Removal	N/A	N/A	N/A	N/A	N/A
Below 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
At English Point (45042)	May 25, 2016	Deployment	Good	Excellent	Excellent	Excellent	Poor
	June 30, 2016	Removal	Good	Excellent	Good	Excellent	Poor

Upon deployment at above Muskrat Falls, pH, specific conductivity and dissolved oxygen, temperature and turbidity all rank 'excellent'. At removal the instrument was out of the water due to the rapid drop in spring water levels, thus the QAQC comparisons could not be completed.

- During deployment at English Point, conductivity, pH and dissolved oxygen ranked 'excellent', while temperature ranked 'good' and turbidity ranked 'poor' at deployment. The field turbidity value was 77.3NTU and the QA/QC value was 130.9NTU, while the grab sample value was 390NTU. This discrepancy is likely due to sediment being suspended and disturbed around the QA/QC and field sonde as the value was being recorded.
- At removal, dissolved oxygen and pH ranked 'excellent', temperature and conductivity ranked 'good' while turbidity ranked 'poor' upon removal. The field turbidity value was 72.6NTU and the QA/QC value was 32.9NTU. This discrepancy is likely due to sediment being suspended and disturbed around the QA/QC and field sonde as the value was being recorded.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from May 25 to June 29, 2016 on the Lower Churchill River Network.
- With the exception of water quantity data (stage & flow), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- The below Grizzle Rapids station was inaccessible due to spring ice.
- The below Muskrat Falls station was inaccessible due to extremely high water levels which prevented the helicopter from landing in the area.

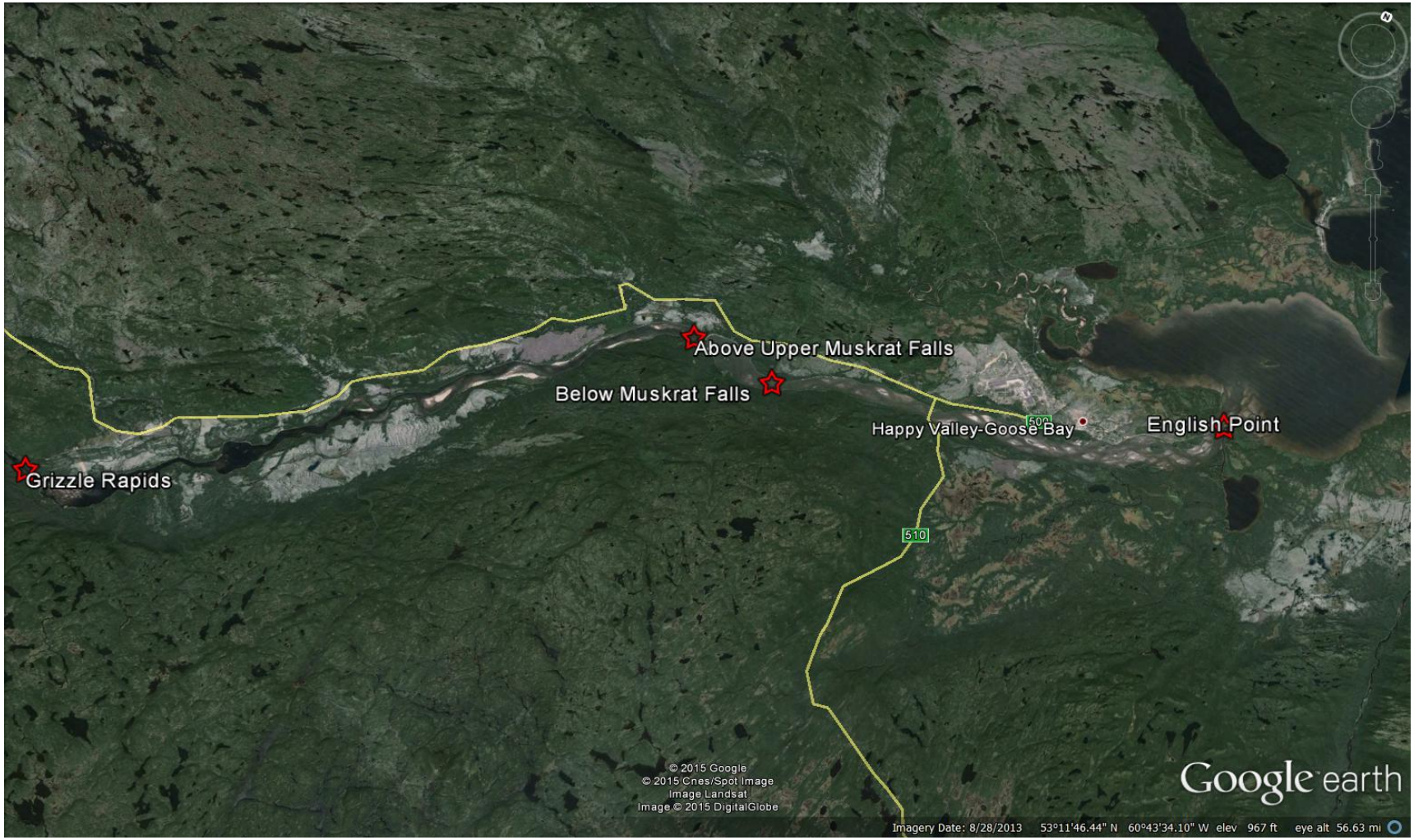

Figure 1: Lower Churchill Network-Station Locations

Churchill River below Grizzle Rapids

- This station was inaccessible on May 25th due to the presence of significant winter ice along the shoreline. It will be deployed in June 2016.
- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 2). Overall, stage decreases during the deployment period. Precipitation occurs on 26 of the days in the deployment period and amounts are generally low, with the exception of the largest event June 14-15 with 60.71mm of rain over 48 hours. Stage ranged between 34.46m and 33.43m, with a decrease of 1.03m over the deployment period.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

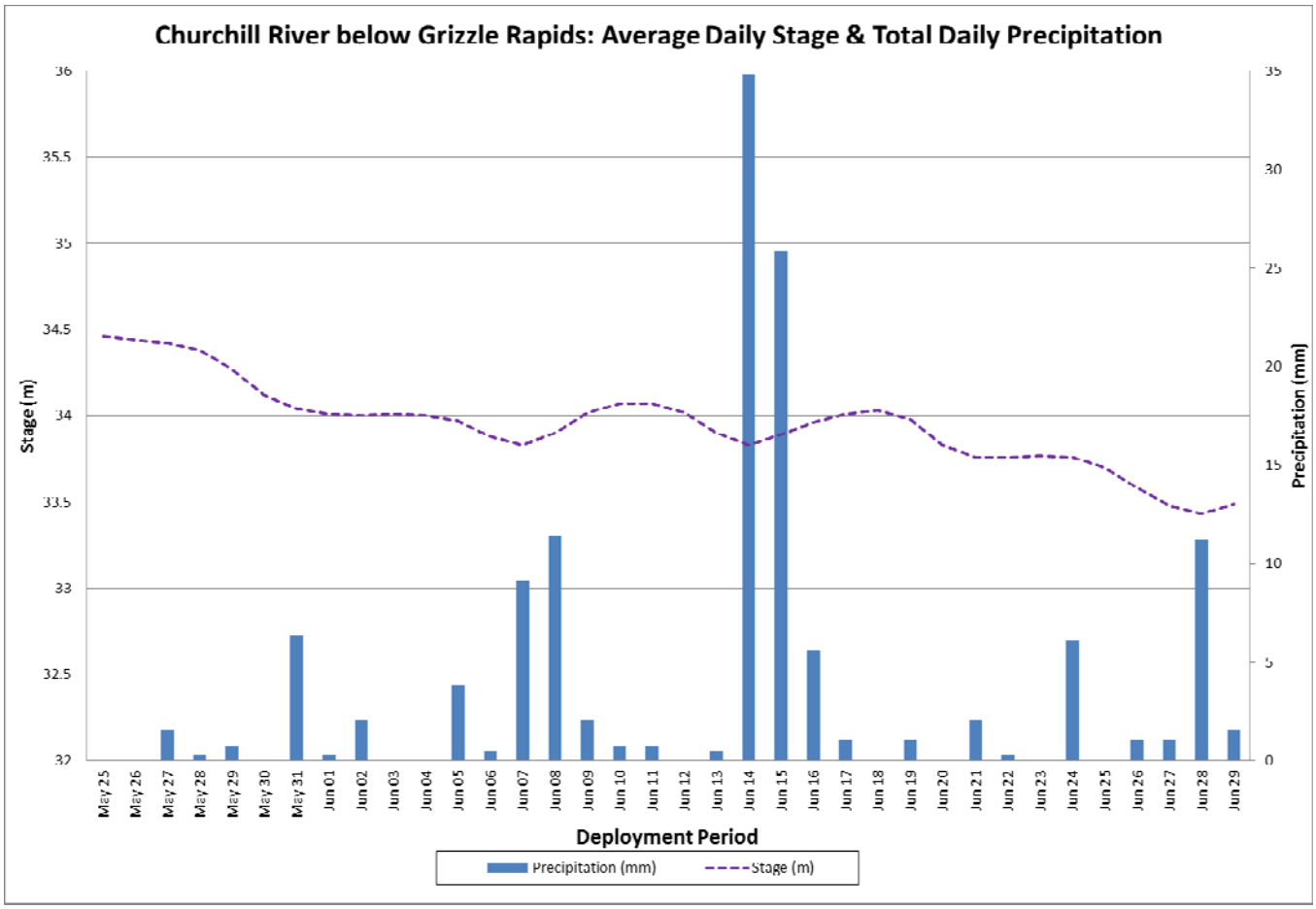

Figure 2: Average Stage & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids Station

Figure 3: May 2016 – Grizzle Rapids ice build-up: inaccessible May 25 2016

Churchill River above upper Muskrat Falls

Water Temperature

- Water temperature ranges from 2.79°C to 12.59°C with a median value of 5.51°C (Figure 4).
- Water temperature is gradually increasing throughout the deployment period with the exception of a cold period around June 13th, which is reflected in both air and water temperatures. The warming trend is expected as air temperatures warm into the spring and summer months.
- The instrument was found out of the water upon removal; the data between June 22 and 29 is not reflective of the aquatic environment and has been removed from the dataset.

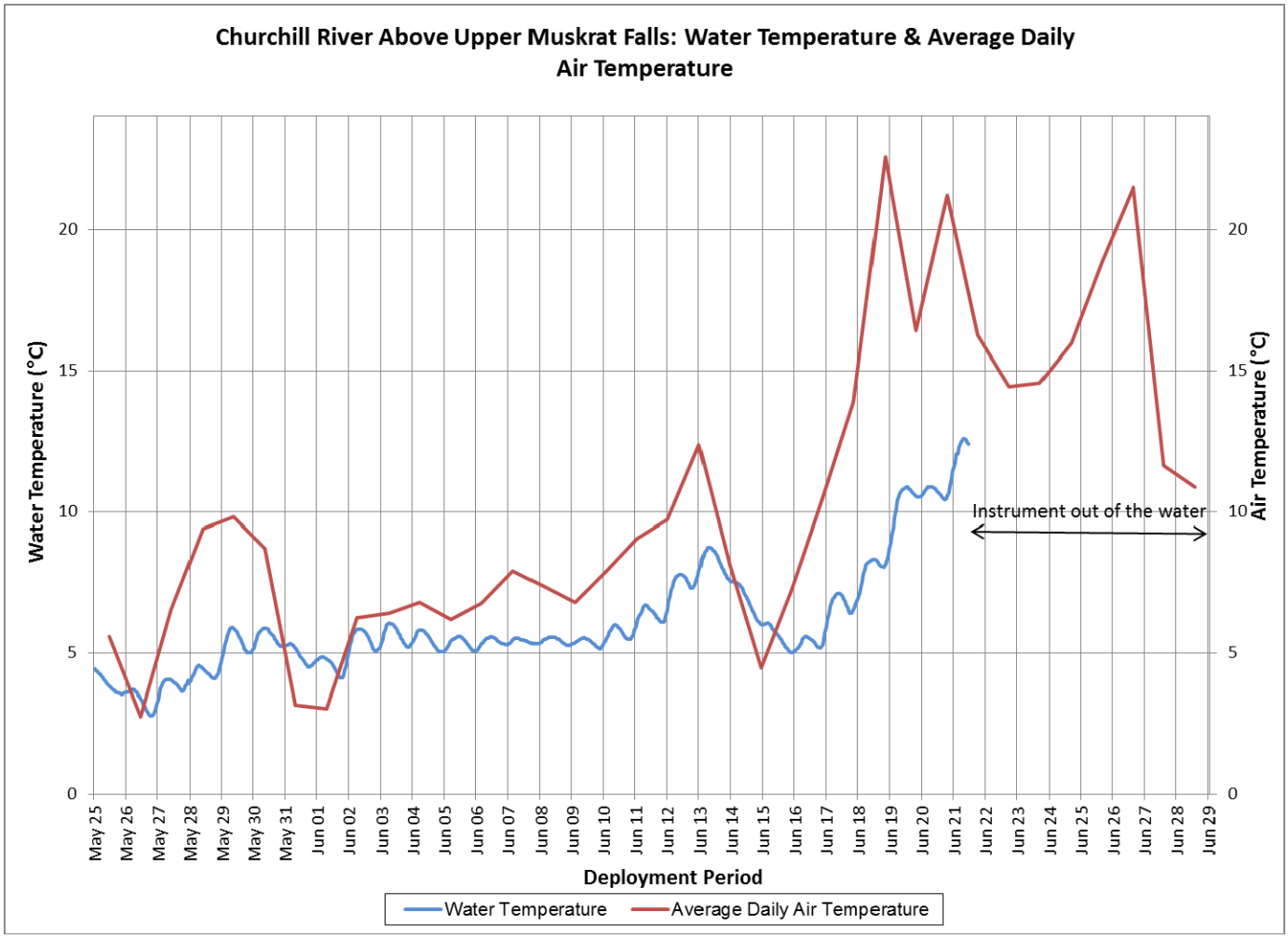

Figure 4: Water temperature and daily average air temperature (Muskrat Falls Weather Station) at Churchill River above upper Muskrat Falls Station

pH

- pH ranges between 6.51 and 6.77 pH units with a median value of 6.64 (Figure 5).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines.
- The instrument was found out of the water upon removal; the data between June 22 and 29 is not reflective of the aquatic environment and has been removed from the dataset.

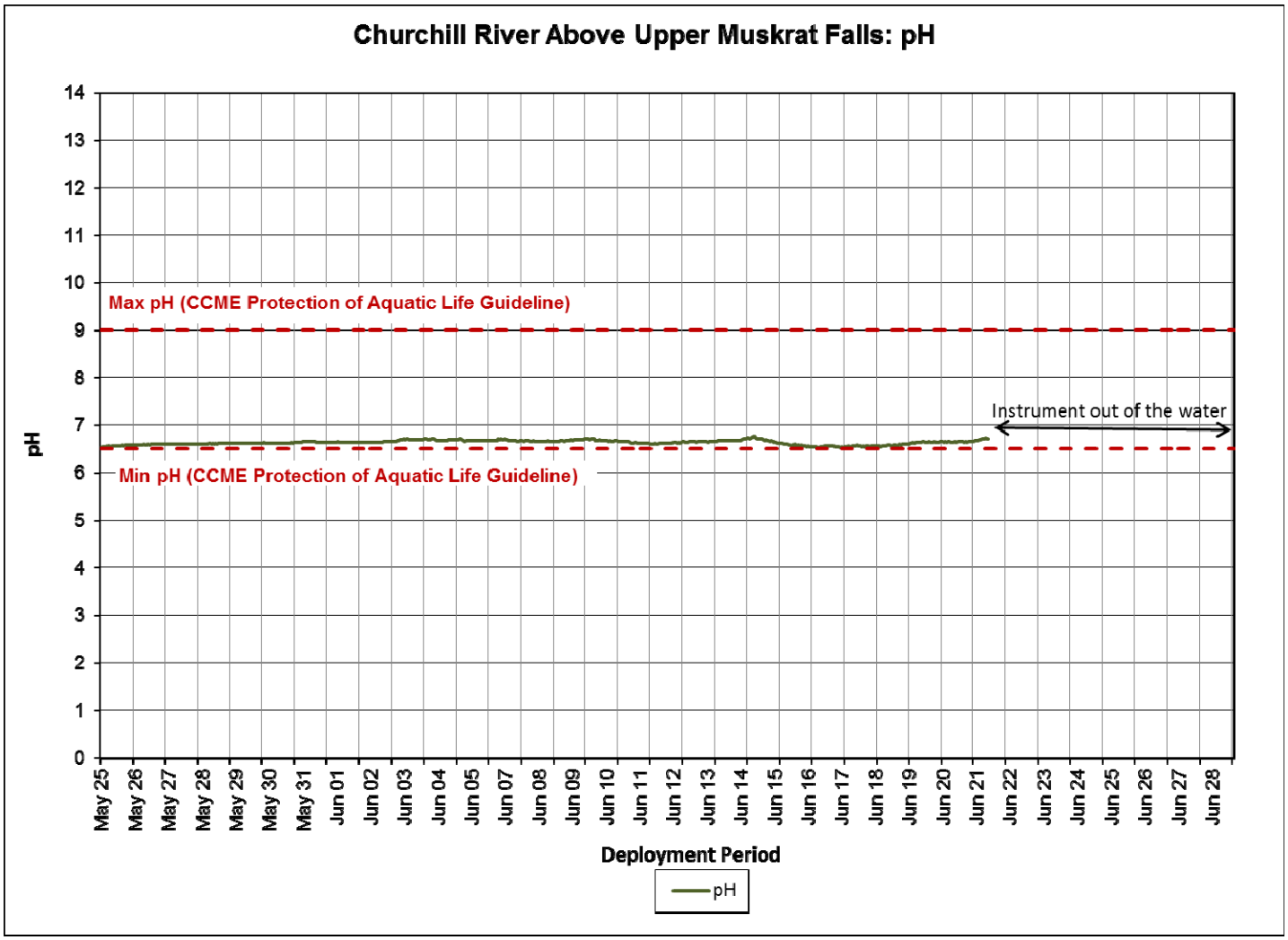

Figure 5: pH values at Churchill River above upper Muskrat Falls Station

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 9.3µS/cm to 11.2µS/cm with a median of 10.4µS/cm. (Figure 6).
- TDS (total dissolved solids) ranges from 0.0060 g/L to 0.0072 g/L with a median of 0.0066 g/L (Figure 6).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inversed. When stage level rises, the specific conductance levels drops in response as the increased amount of water in the river system dilutes the solids that are present.
- The instrument was found out of the water upon removal; the data between June 22 and 29 is not reflective of the aquatic environment and has been removed from the dataset.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

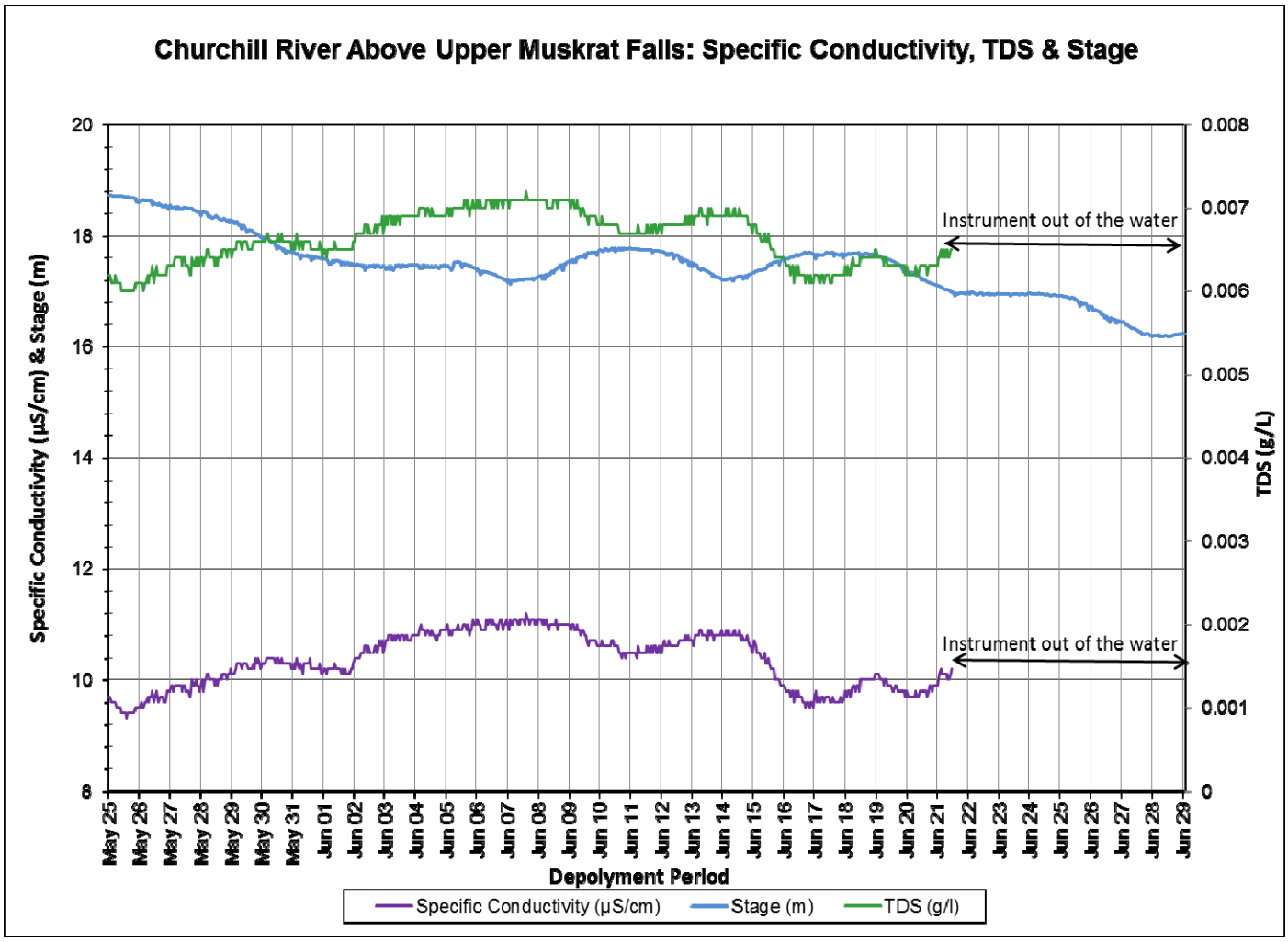

Figure 6: Specific Conductivity & TDS at Churchill River above upper Muskrat Falls Station

Dissolved Oxygen

- Dissolved oxygen content ranges between 10.21mg/l and 12.80mg/l with a median value of 11.99mg/l. The saturation of dissolved oxygen ranges from 93.6% to 100.3% with a median value of 95.9% (Figure 7).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the spring and summer season. Generally there is more dissolved oxygen present in a waterbody during periods of cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early Life Stages and Other Life Stages.
- The instrument was found out of the water upon removal; the data between June 22 and 29 is not reflective of the aquatic environment and has been removed from the dataset.

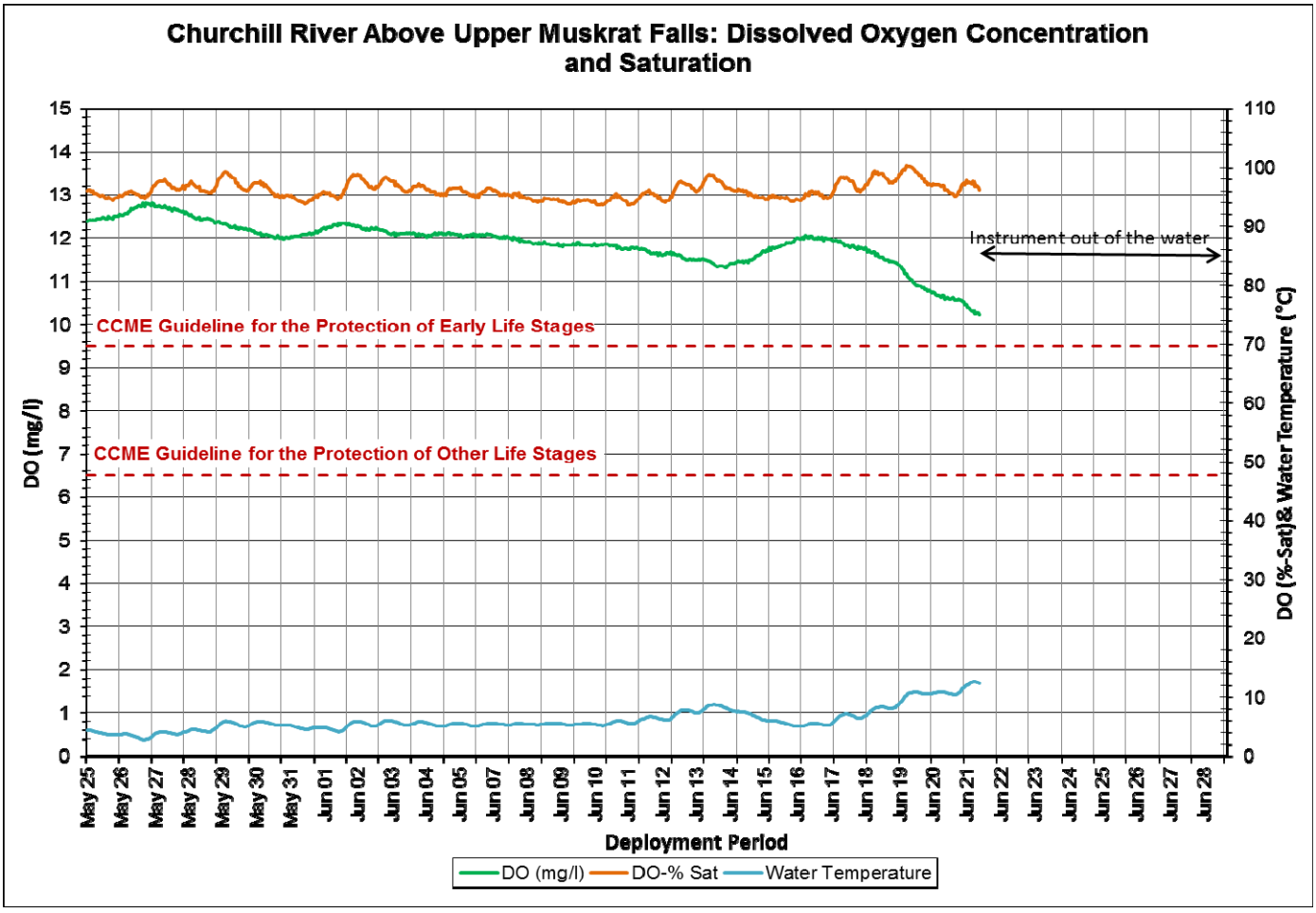

Figure 7: Dissolved Oxygen at Churchill River above upper Muskrat Falls Station

Chlorophyll

- Chlorophyll ranges between 11ug/L and 25.2 ug/L with a median value of 18.3 ug/L (Figure 8).
- Chlorophyll is found within living cells of photosynthetic organisms like phytoplankton and cyanobacteria. The amount of chlorophyll found in water can be used to understand the general biological health of an ecosystem. Chlorophyll can also be used to identify algal bloom events and is an indicator of nutrient loading in ecosystems.
- The chlorophyll values fluctuated slightly during the deployment period.
- The instrument was found out of the water upon removal; the data between June 22 and 29 is not reflective of the aquatic environment and has been removed from the dataset.

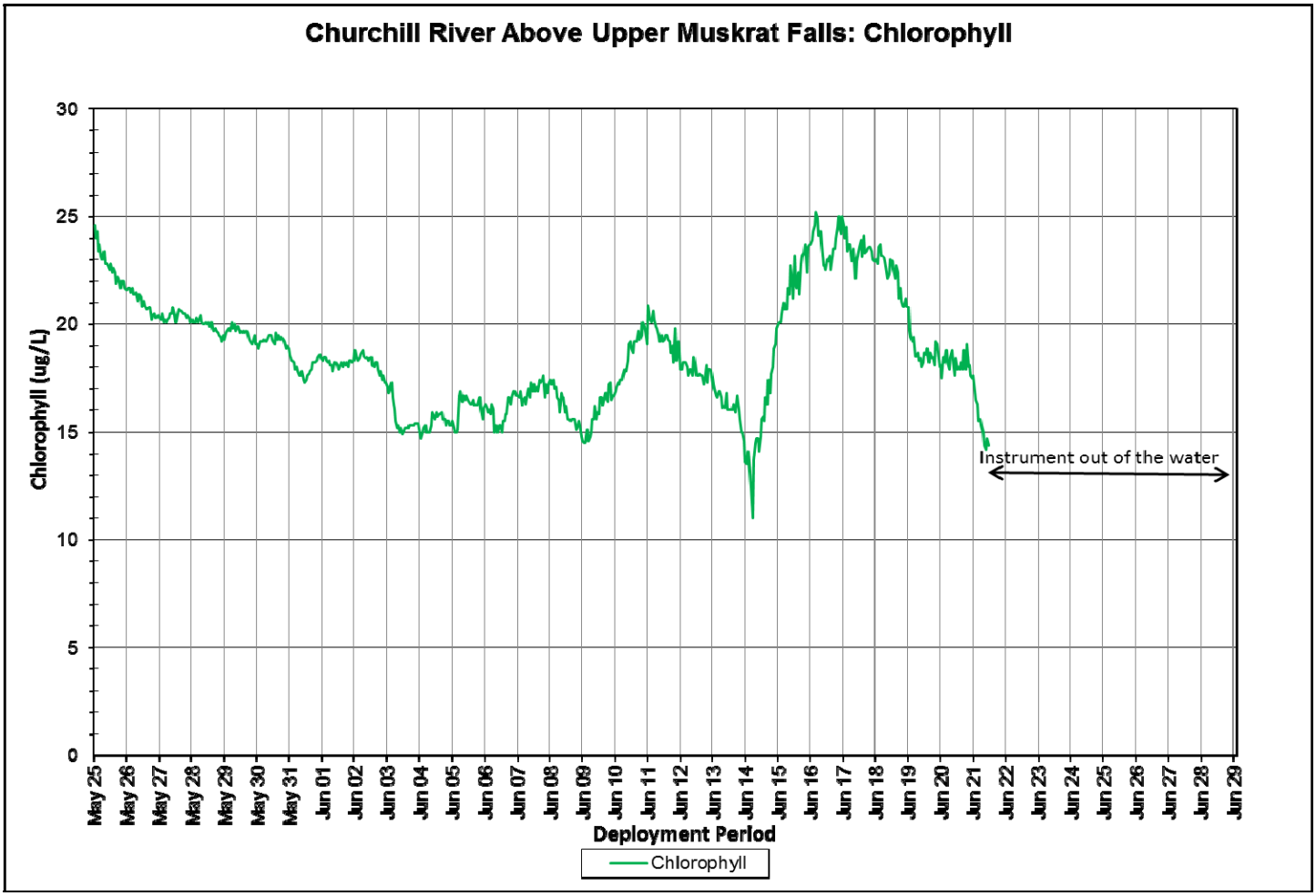

Figure 8: Chlorophyll at Churchill River above upper Muskrat Falls Station

Stage, Flow, Turbidity and Precipitation

- Turbidity ranges between 47.1NTU and 83.8NTU with a median value of 60.4NTU (Figure 9).
- The turbidity sensor on this instrument can read values between 0NTU and 3000NTU. However a reading of 3000 NTU is always identified as an error reading and should not be used as a valid reading or included in any statistical analysis.
- The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events. Precipitation can increase the presence of suspended material in water.
- The instrument was found out of the water upon removal; the data between June 22 and 29 is not reflective of the aquatic environment and has been removed from the dataset.

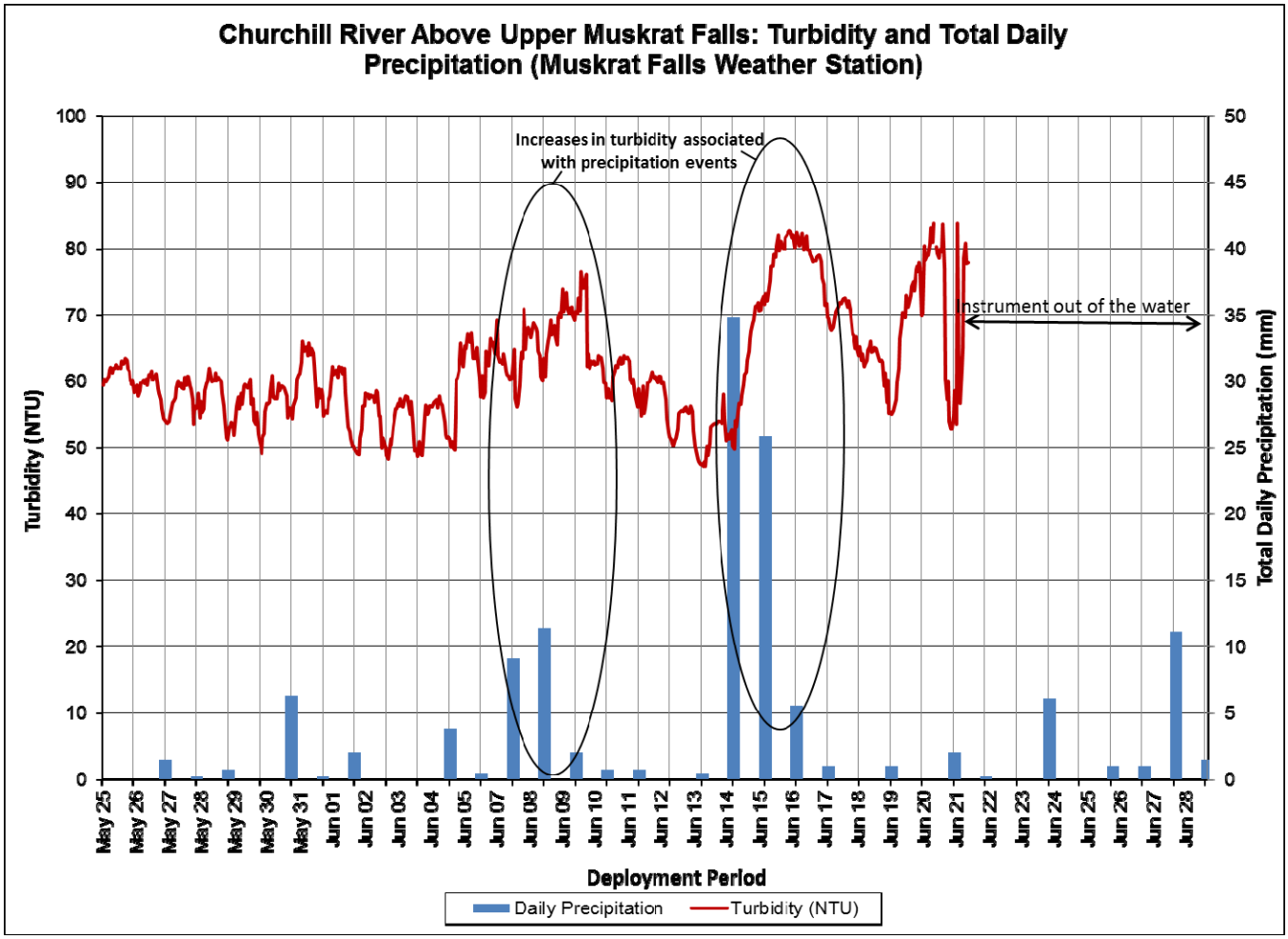

Figure 9: Turbidity and Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level (Figure 10).
- Stage is generally decreasing throughout the deployment period. This is common during this time of the year after the spring melt.
- Precipitation events led to temporary increases in stage. Precipitation occurs on 26 of the days in the deployment period and amounts are generally low, with the exception of the largest event on June 14-15 with 60.71mm of rain over 48 hours.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

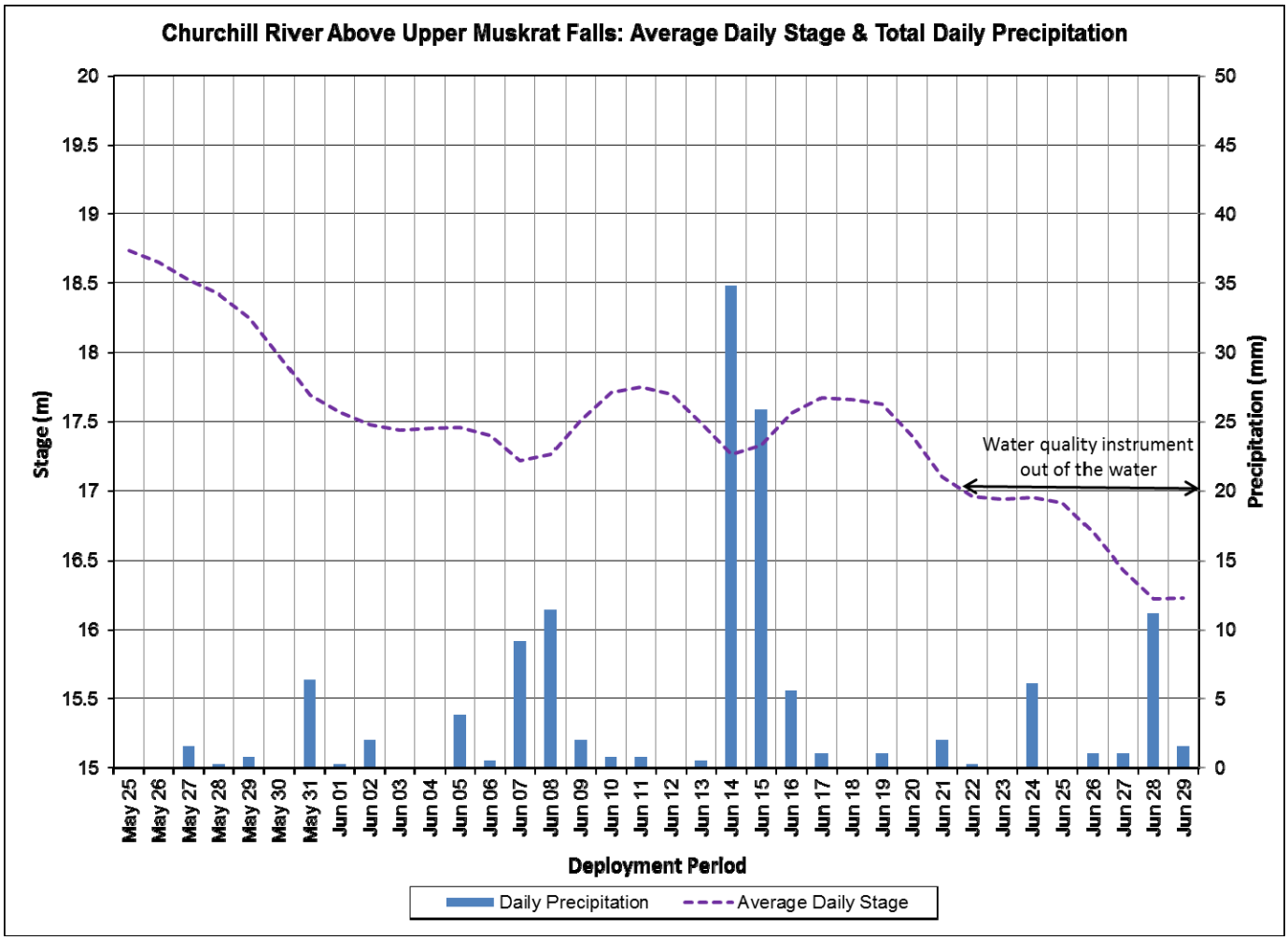

Figure 10: Total Daily Precipitation (Muskrat Falls Weather Station) and Average Daily Stage at Churchill River above upper Muskrat Falls Station

- Stage ranges between 16.18m to 18.74m resulting in a drop in stage of 2.56m over the course of the deployment period. This drop in water level shows why the field instrument deployed was found out of the water at the time of removal. Dramatic decreases in stage at this time of year are common after the spring melt.
- Flow ranges from 1411.60m^3/s to 3169.56m^3/s; a lower stage results in less flow through the river (Figure 11).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

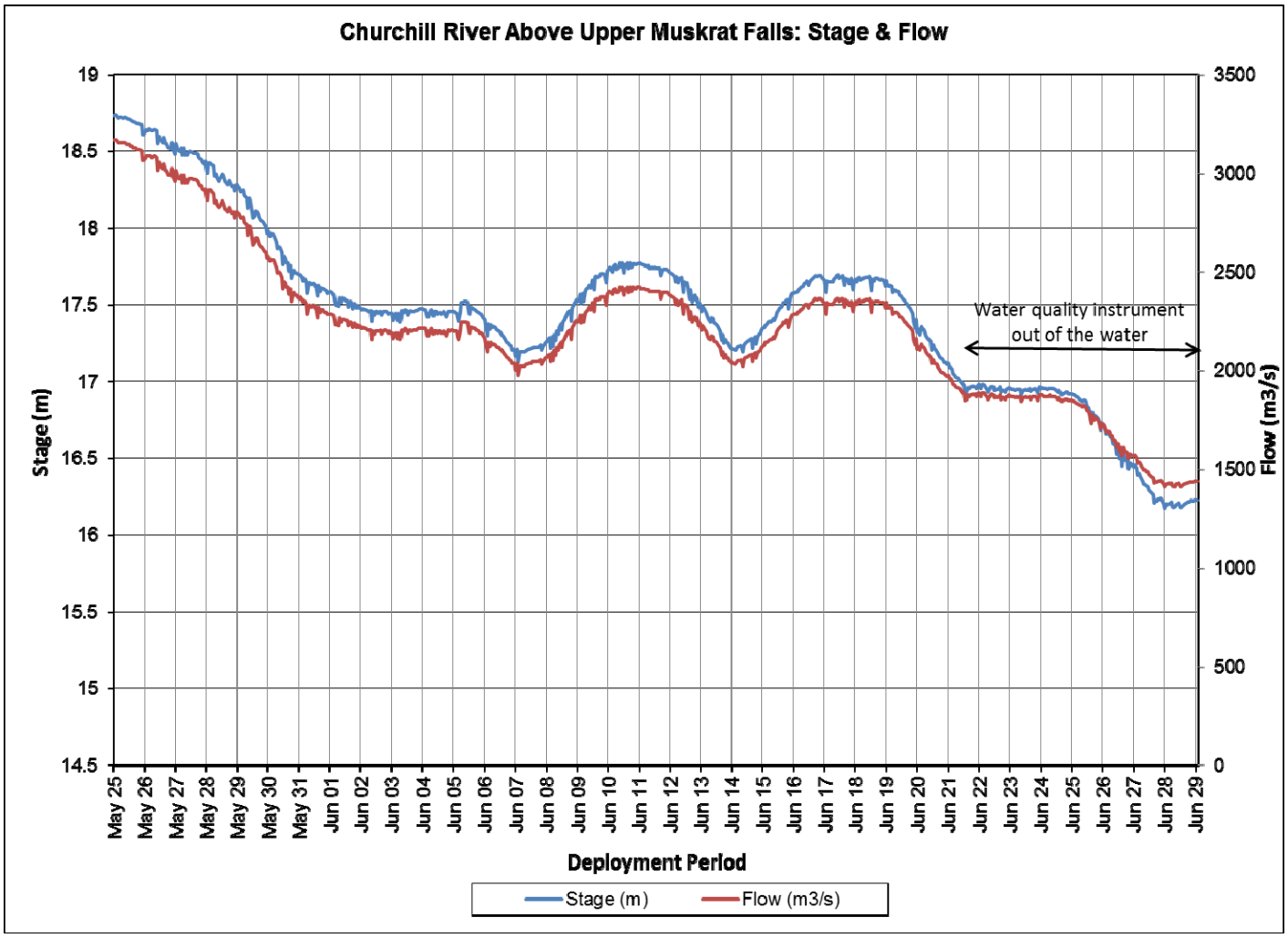

Figure 11: Stage & Flow at Churchill River above upper Muskrat Falls Station

Churchill River below Muskrat Falls

- The sonde located at this station has been repeatedly buried in sand during 2014. The decision to not redeploy the sonde until sand conditions in the area improve was made in August 2014. The station was deployed during September 2015 for a trial run before being removed again for winter. During the site visit on May 25, 2016, water levels were very high, preventing safe access to the site and deployment.
- Stage and precipitation (Muskrat Falls Weather Station) are graphed below to show the relationship between rainfall and water level. Stage decreases during the deployment period. Precipitation occurs on 26 of the days in the deployment period and amounts are generally low, with the exception of the largest event on June 14-15 with 60.71mm of rain over 48 hours. Stage ranged between 2.60m and 4.25m, resulting in a decrease of 1.65m over this period (Figure 12).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

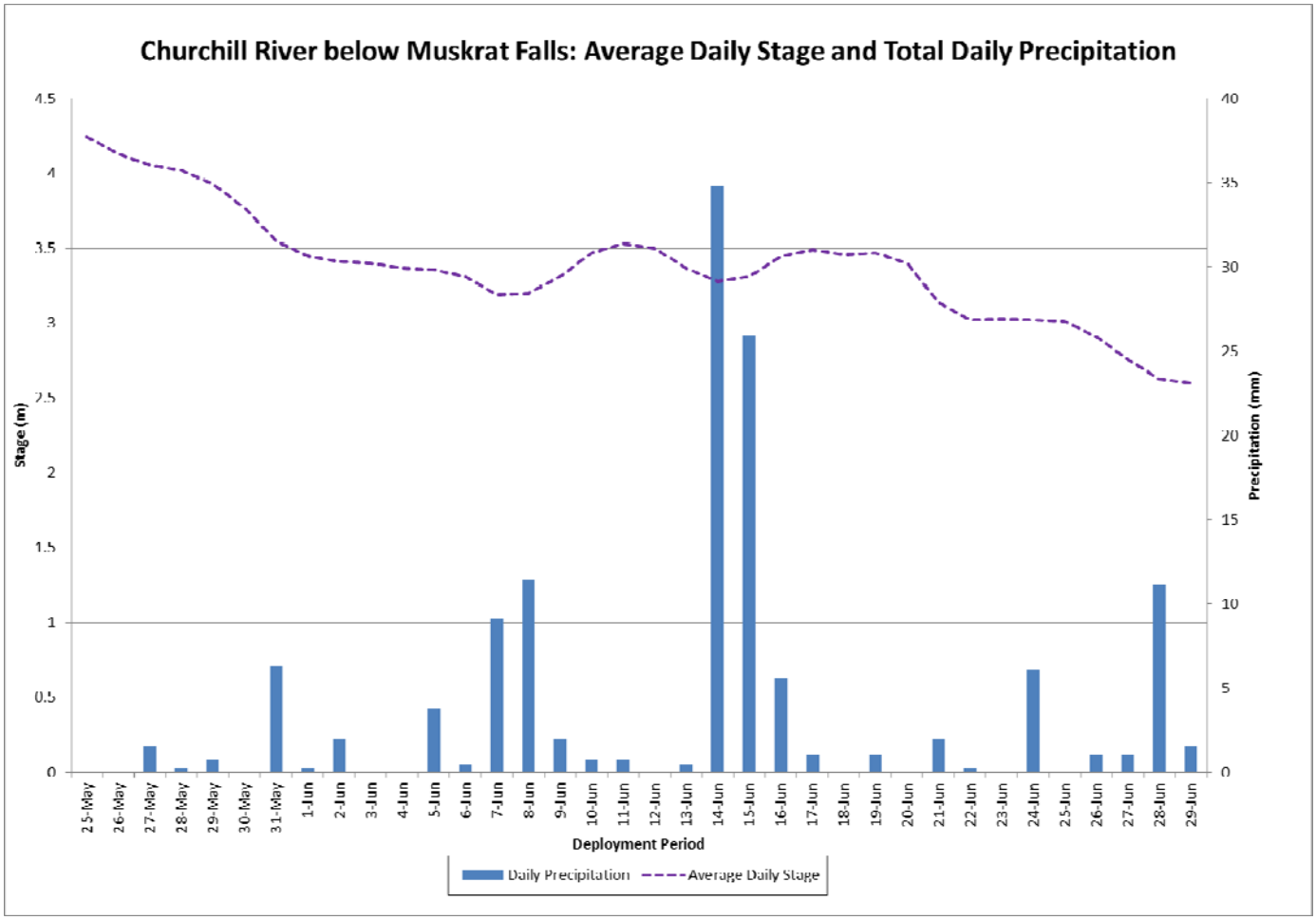

Figure 12: Total Daily Precipitation (Muskrat Falls Weather Station) & Average Daily Stage at Churchill River below Muskrat Falls Station

Figure 13: Photos of Churchill River below Muskrat Falls Station (May 25, 2016)

Churchill River at English Point

Water Temperature

- Water temperature ranges from 2.10°C to 18.00°C with a median value of 7.20°C (Figure 14).
- Water temperature is gradually increasing throughout the deployment period with the exception of a cold period around June 13th, which is reflected in both air and water temperatures. The warming trend is expected as air temperatures warm into the spring and summer months. Water temperature fluctuates diurnally.

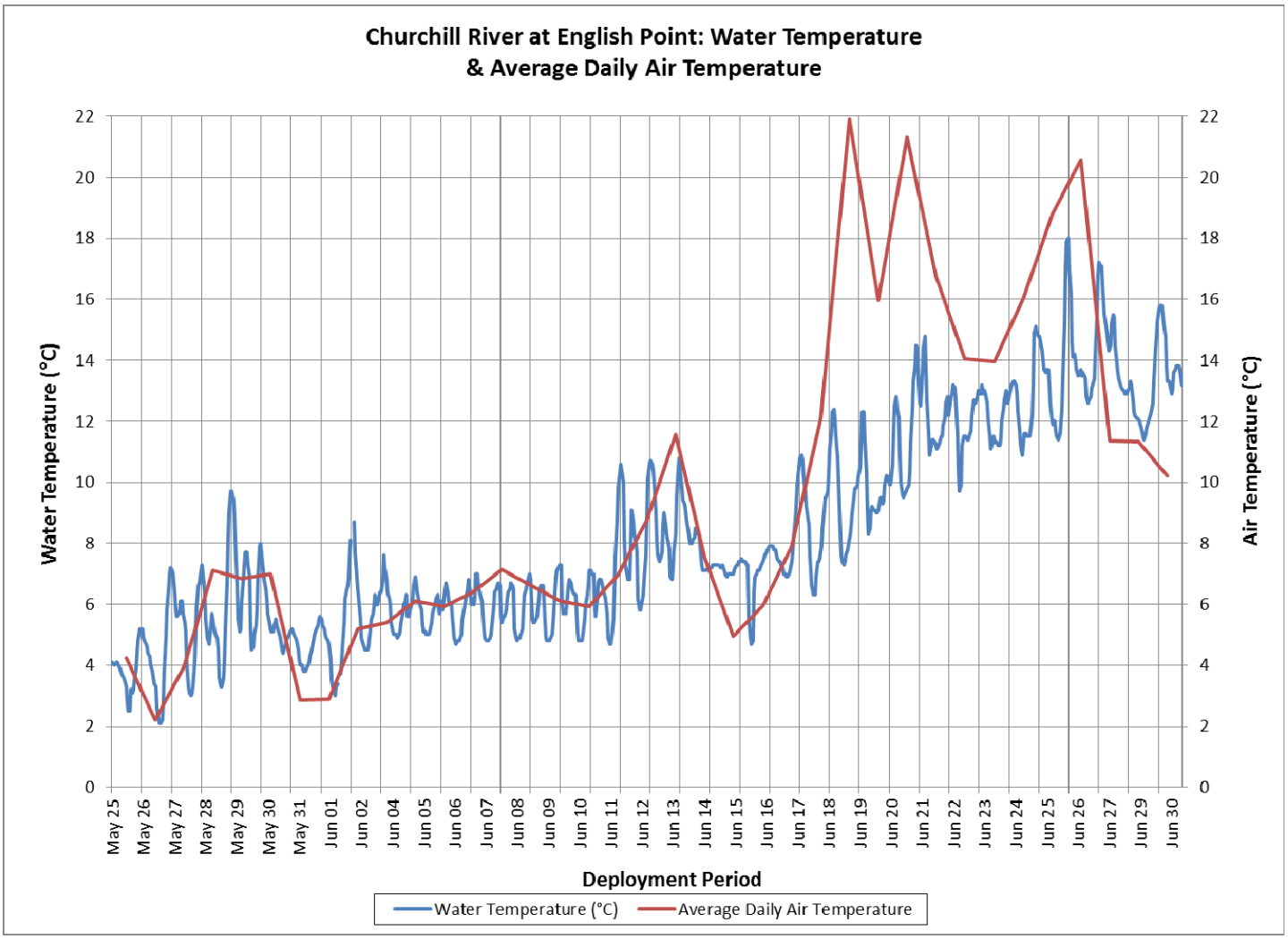

Figure 14: Water Temperature & Average Daily Air Temperature (Mud Lake Weather Station) at Churchill River at English Point Station

pH

- pH ranges between 6.26 and 6.99 pH units with a median value of 6.61 (Figure 15)
- All pH values recorded during this deployment period hovered around the Min pH CCME protection of Aquatic Life Guidelines of 6.5.

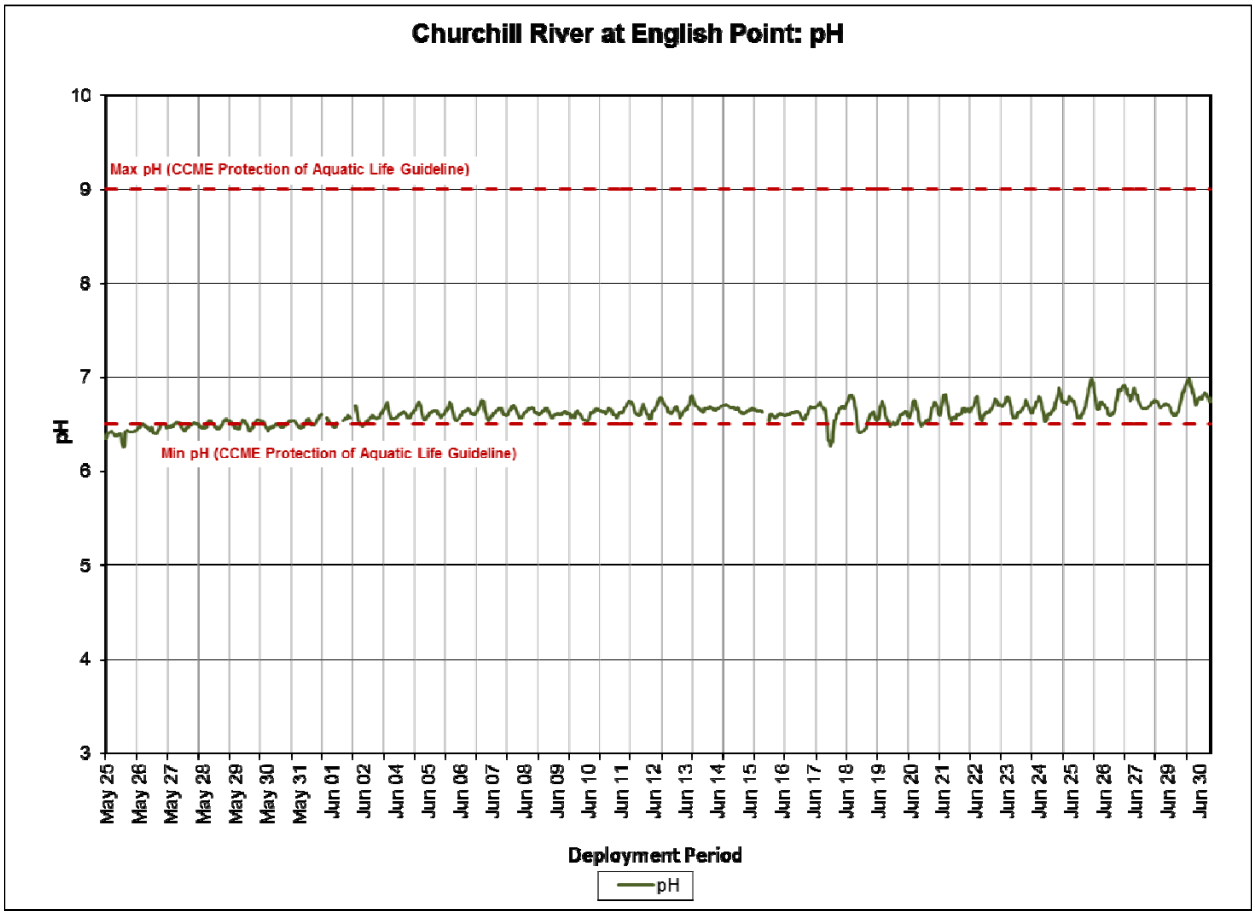

Figure 15: pH at Churchill River at English Point Station

Specific Conductivity and TDS

- Specific conductance ranges between 12.2µS/cm and 45.0µs/cm during the deployment period, with a median of 27.5µS/cm (Figure 16).
- TDS ranges between 0.0078 g/mL to 0.0288 g/mL during the deployment period, with a median of 0.0176 g/mL (Figure 16).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, the specific conductivity increases as the dissolved solids and salinity increase, and vice versa as the tide goes out. This increase and decrease in specific conductivity and stage occurs twice daily. This pattern is generally consistent throughout the deployment period (Figure 16).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

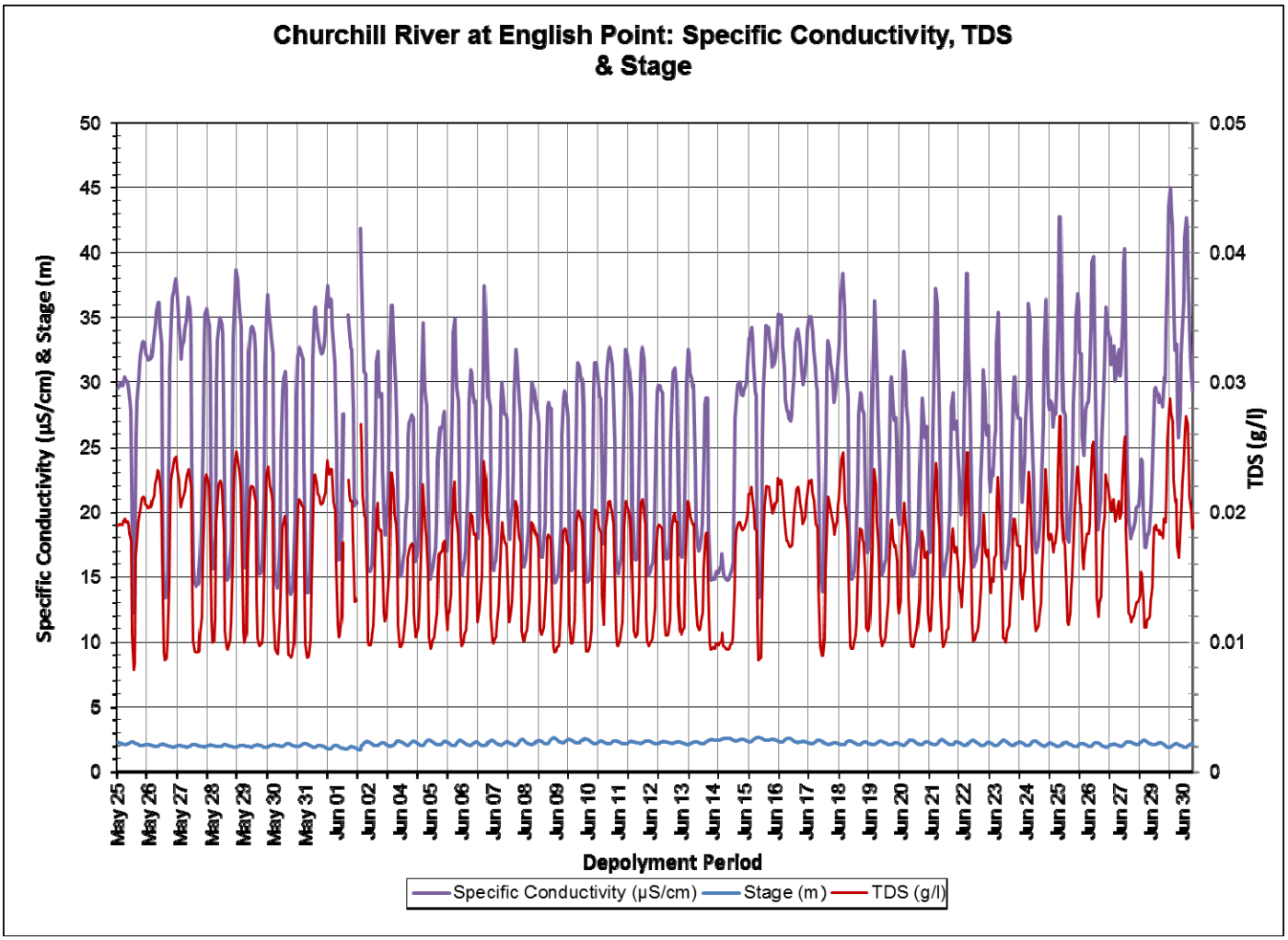

Figure 16: Specific Conductivity and Stage at Churchill River at English Point Station

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.41mg/l and 13.83mg/l during the deployment period. The saturation of dissolved oxygen ranges from 86.3% to 109.2% (Figure 17).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly decreasing as temperatures rise into the summer months. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guideline for the Protection of Other Life Stages. However, the levels dipped slightly below the minimum CCME Guideline for the Protection of Early Life Stages for a short time near the end of the deployment. The guidelines are indicated in red on Figure 17.

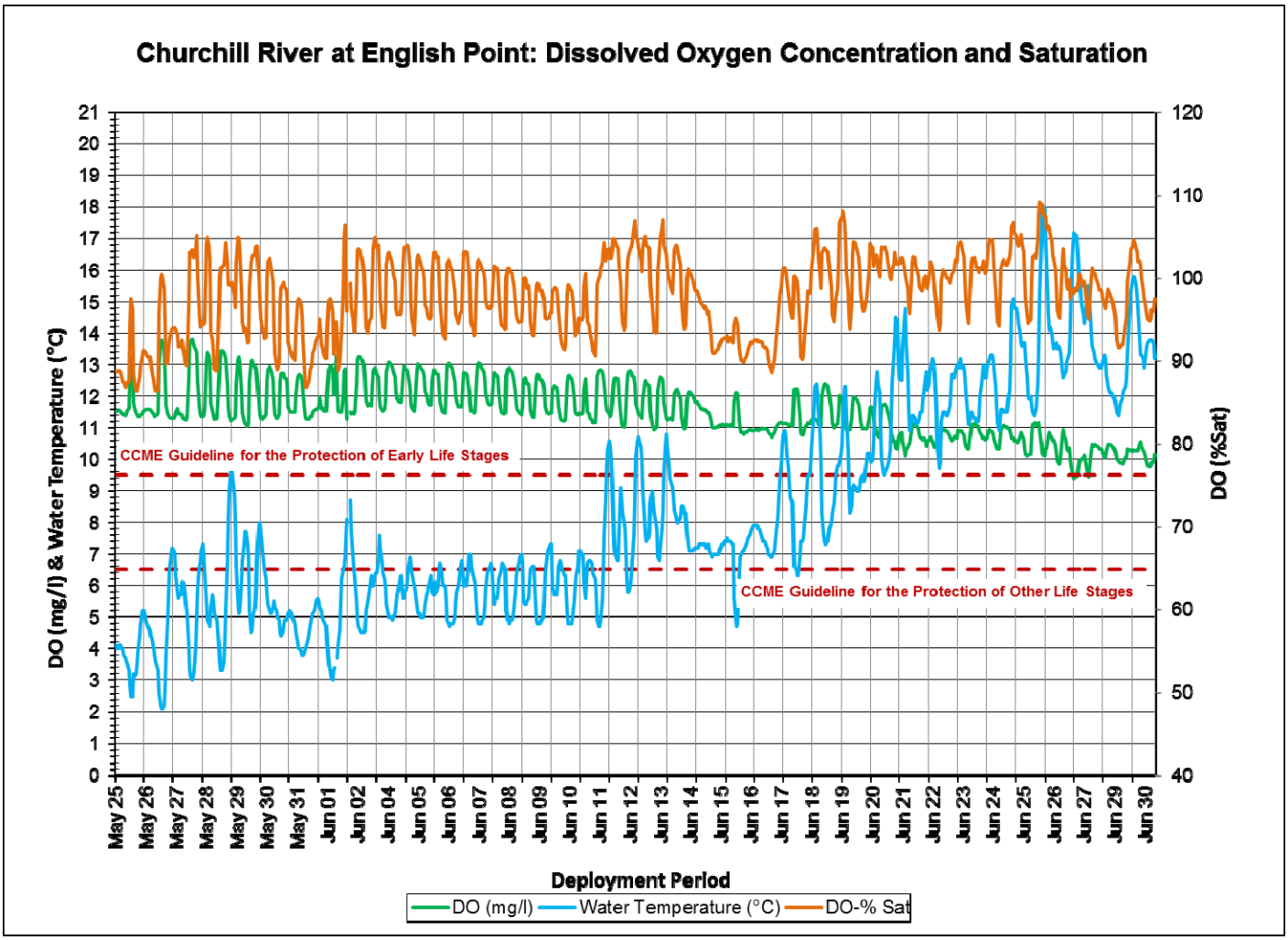

Figure 17: Dissolved Oxygen at Churchill River at English Point Station

Stage, Turbidity and Precipitation

- Turbidity ranges from 9.9NTU to 322.9NTU during the deployment period, with a median value of 28.3NTU (Figure 18). The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events. Precipitation can increase the presence of suspended material in water (Figure 18).This location is known to have background turbidity, some sensor fouling and sediment that can bury an instrument. This is likely what caused the increased turbidity during the second half of the deployment.
- Precipitation occurs on 23 days during the deployment period and amounts are small in magnitude, with the largest on June 14-15 with 48.77mm of rain (Figure 18).
- Stage ranges between 1.70m and 2.66m, with a median value of 2.18m. Stage fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, the stage level increases causing tide related turbidity events, and vice versa as the tide goes out. This pattern is generally consistent throughout the deployment period (Figure 19).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

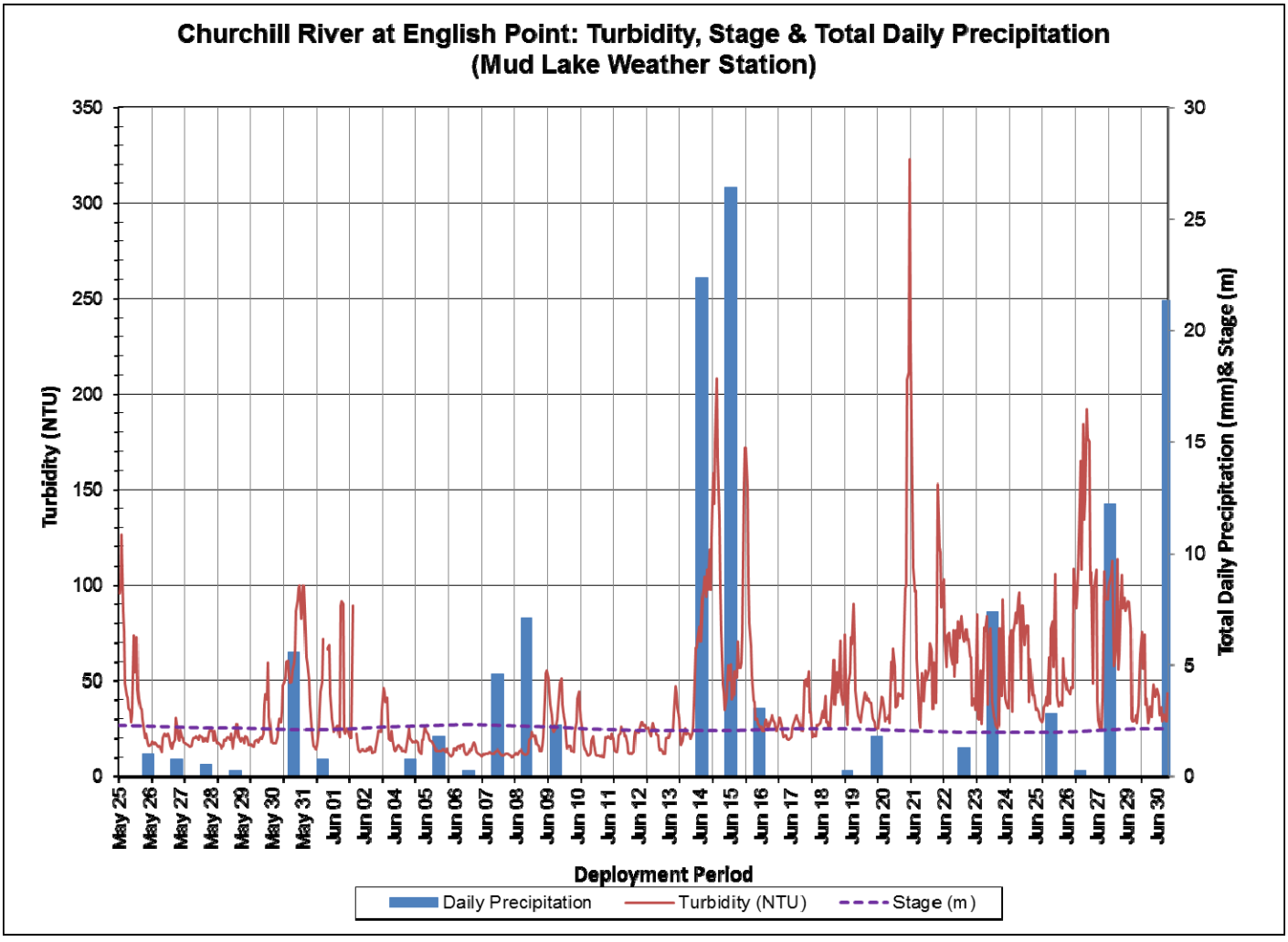

Figure 18: Turbidity, Stage & Total Precipitation (Mud Lake Weather Station) at Churchill River at English Point Station

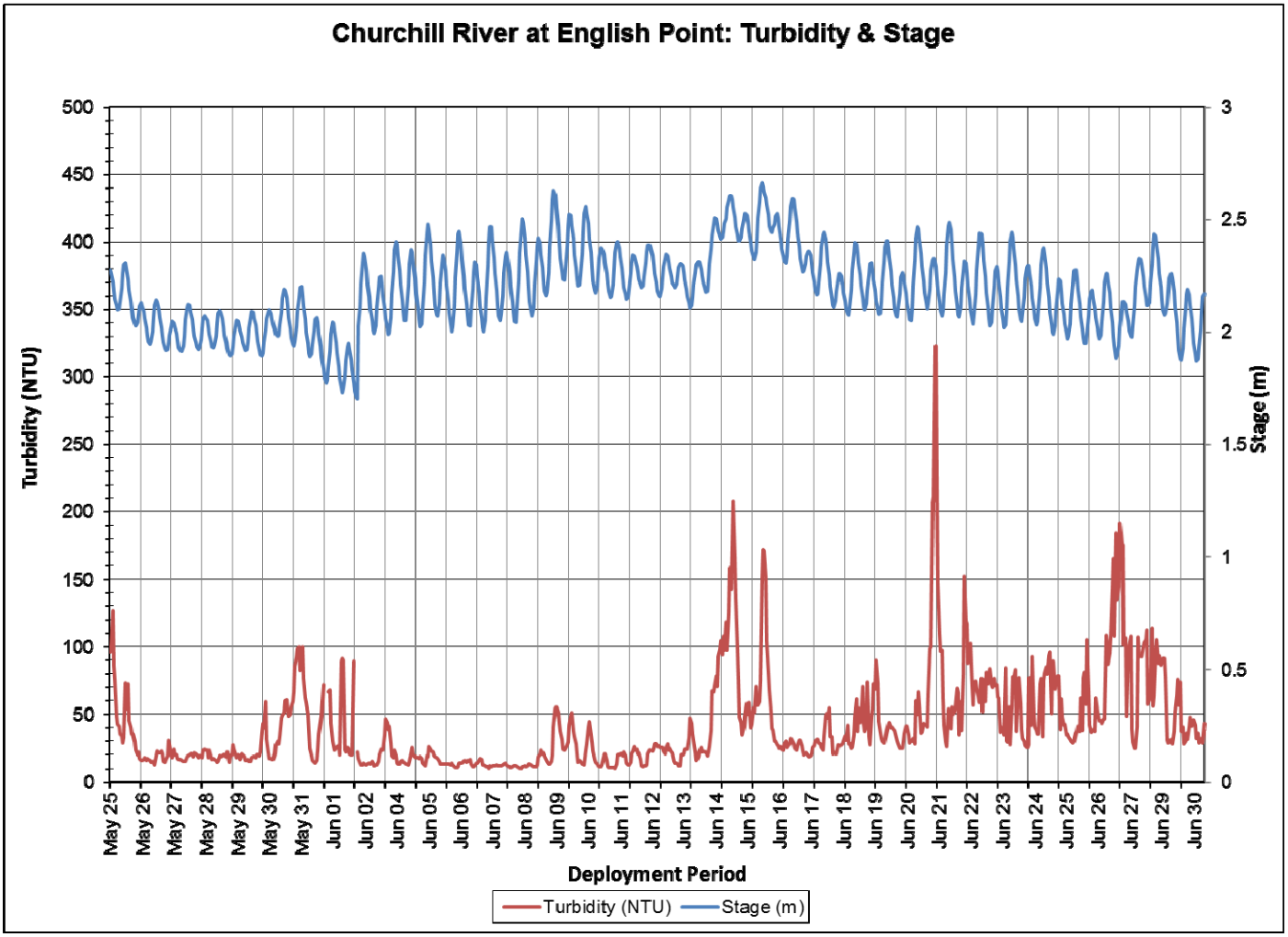

Figure 19: Turbidity & Stage at Churchill River at English Point Station

Conclusions

- Instruments were deployed at the above Upper Muskrat Falls and English Point water quality monitoring stations on the Lower Churchill River from May 25 to June 29/30, 2016. The below Grizzle Rapids station and below Lower Muskrat Falls station were not deployed, but will be deployed during the next site visit.
- Stage levels are generally decreasing at all stations throughout the deployment as the spring melt ends heading into the summer months. Water level changes at the each of the stations ranged between 0.90m and 2.56m.
- Water temperature was increasing at all stations throughout the deployment period due to the increasing ambient air temperatures in the region as summer approaches. Water temperature typically ranged between 2.10°C and 18.00°C.
- pH is generally neutral and stable at stations along the Lower Churchill River ranging between 6.26 and 6.99 pH units. The majority of pH values at all stations were within the recommended CCME Guidelines for the Protection of Aquatic Life.
- Specific conductivity was relatively stable at the station above upper Muskrat Falls regardless of the fluctuating stage levels. All stations showed little variation in values except at English Point, which is influenced by the tides in Lake Melville. Specific conductivity ranged between 9.3µS/cm and 11.42µS/cm at the station above upper Muskrat Falls. Specific conductivity values at the station at English Point ranged higher at 12.2µS/cm to 45.0µS/cm.
- Dissolved oxygen was relatively stable throughout the deployment period at above upper Muskrat Falls. Since the instrument was not in the water for the entire deployment we cannot see the effect of increased water temperature on the dissolved oxygen at this location. Dissolved oxygen was decreasing at English Point with the increase of ambient air and water temperatures. Values ranged between 9.41mg/l and 13.83mg/l.
- Turbidity data at above upper Muskrat Falls experienced several turbidity events related to precipitation events. In addition, due to the spring melt and changing of stage the instrument was likely exposed to mixing sediment. A median value of 60.4NTU was recorded during the deployment period. English Point experienced a median value of 28.3NTU during the deployment period. There is known consistent background turbidity at this station due to the substrate at the location, tidal wave action, and precipitation events.

References

- Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

  Online: http://st-ts.ccme.ca/en/index.html?chems=154,162&chapters=1

- Swanson, H.A., and Baldwin, H.L., 1965. A Primer on Water Quality, U.S. Geological Survey.

  Online: http://ga.water.usgs.gov/edu/characteristics.html

- Environment Canada. Water Quality. Fresh Water Quality Monitoring Date modified: 2016-11-26

  Online:https://www.ec.gc.ca/eaudouce-freshwater/default.asp?lang=En&n=8C50C138-1&printfullpage=true#wsA92C85CB

APPENDIX A

Station Comparisons

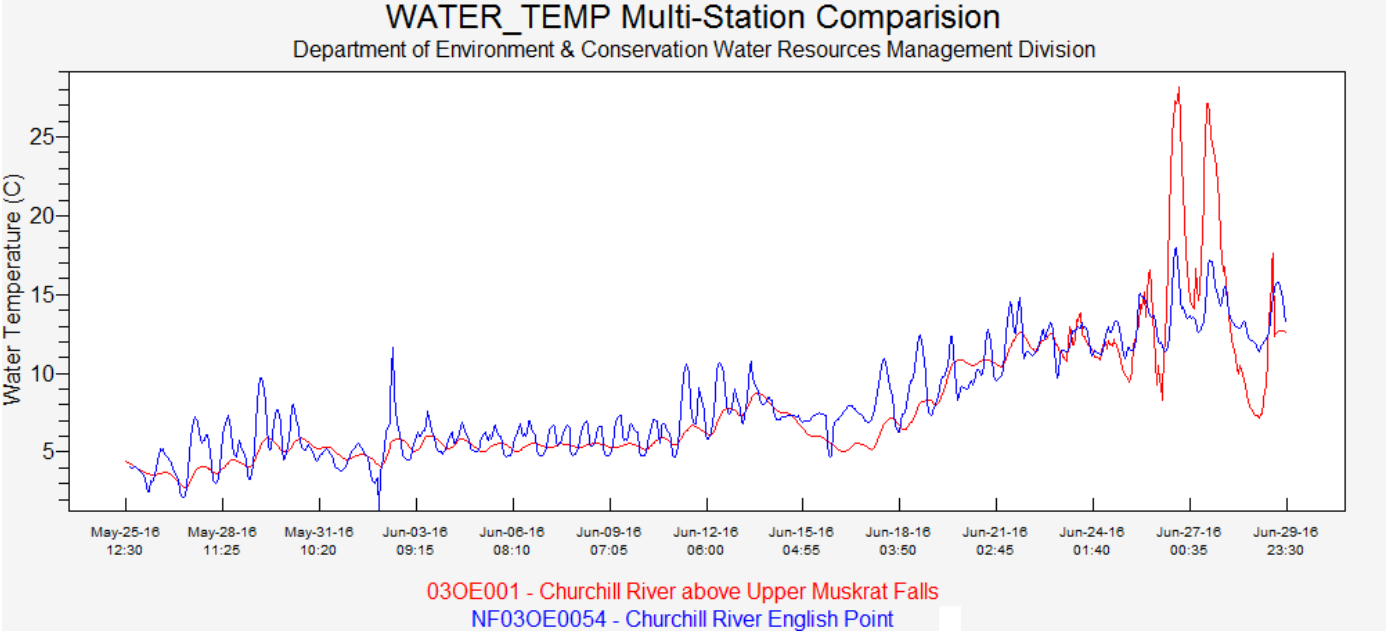

Figure A1: Comparison of Water Temperature at the Real-Time Stations on Churchill River

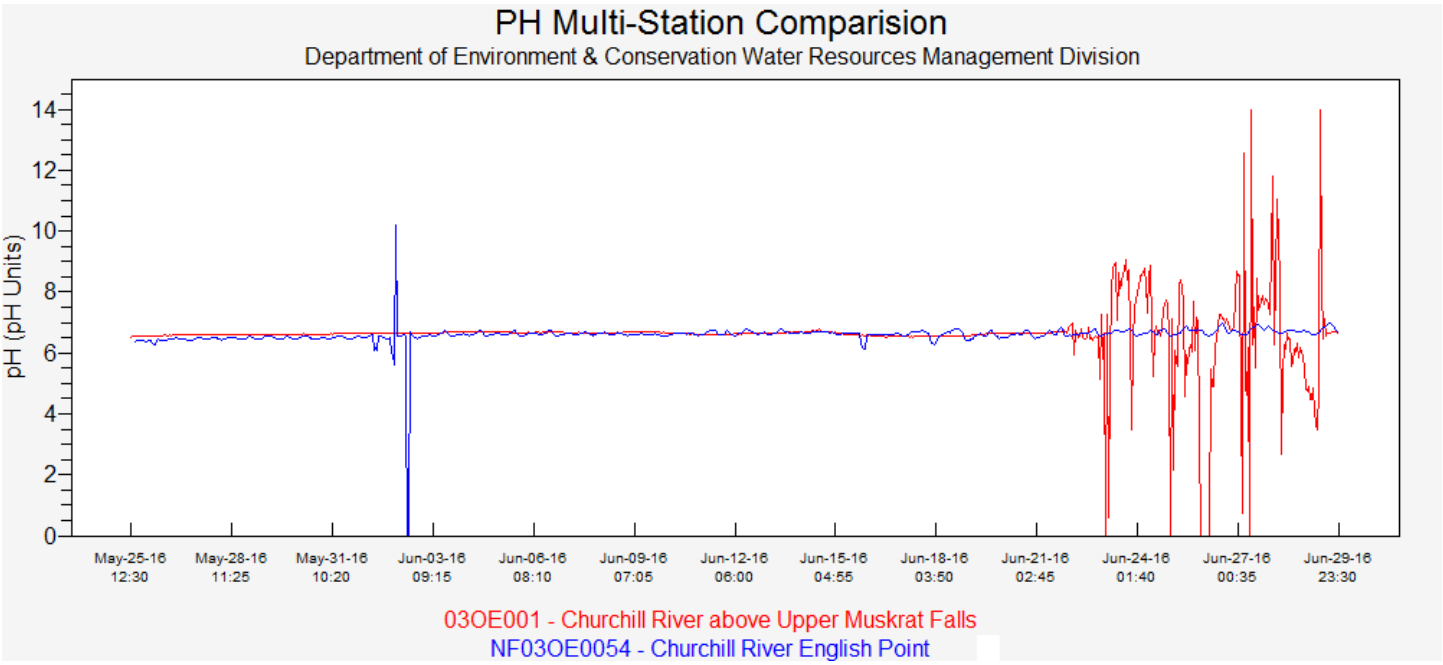

Figure A2: Comparison of pH at the Real-Time Stations on Churchill River

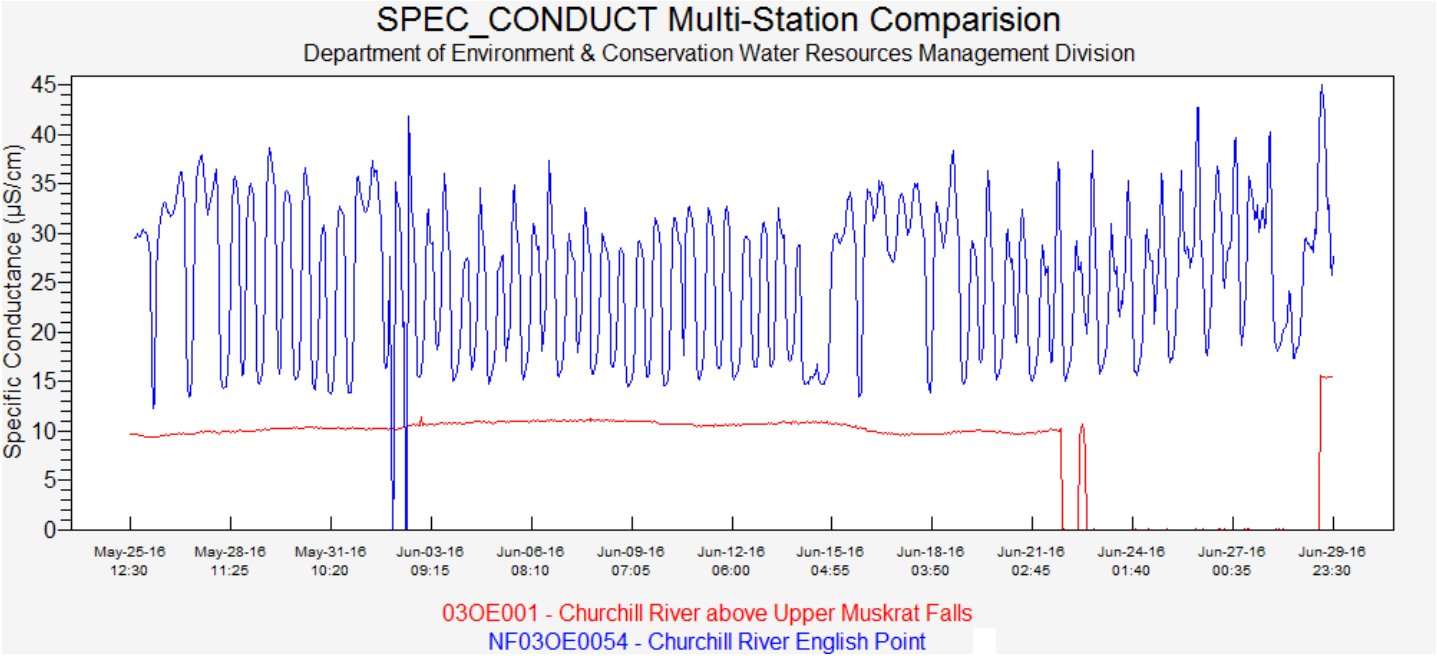

Figure A3: Comparison of Specific Conductivity at the Real-Time Stations on Churchill River

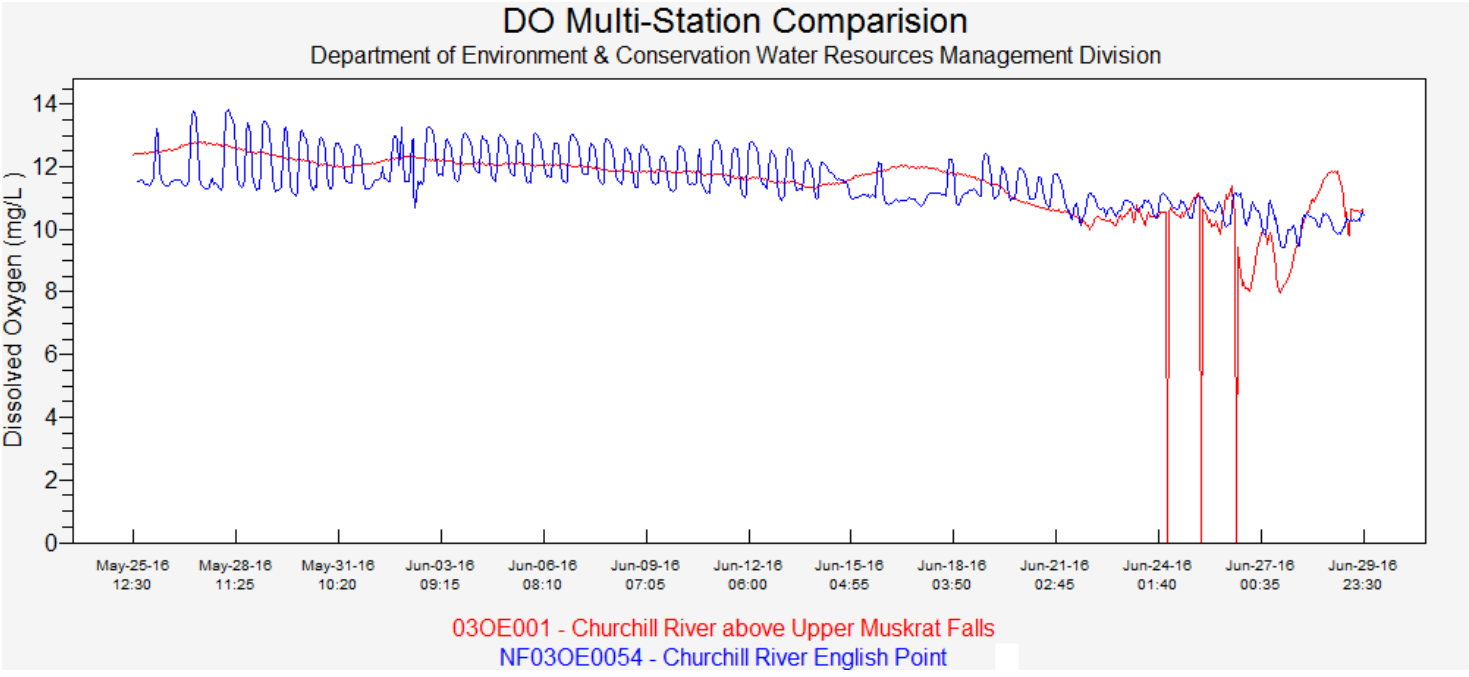

Figure A4: Comparison of Dissolved Oxygen at the Real-Time Stations on Churchill River

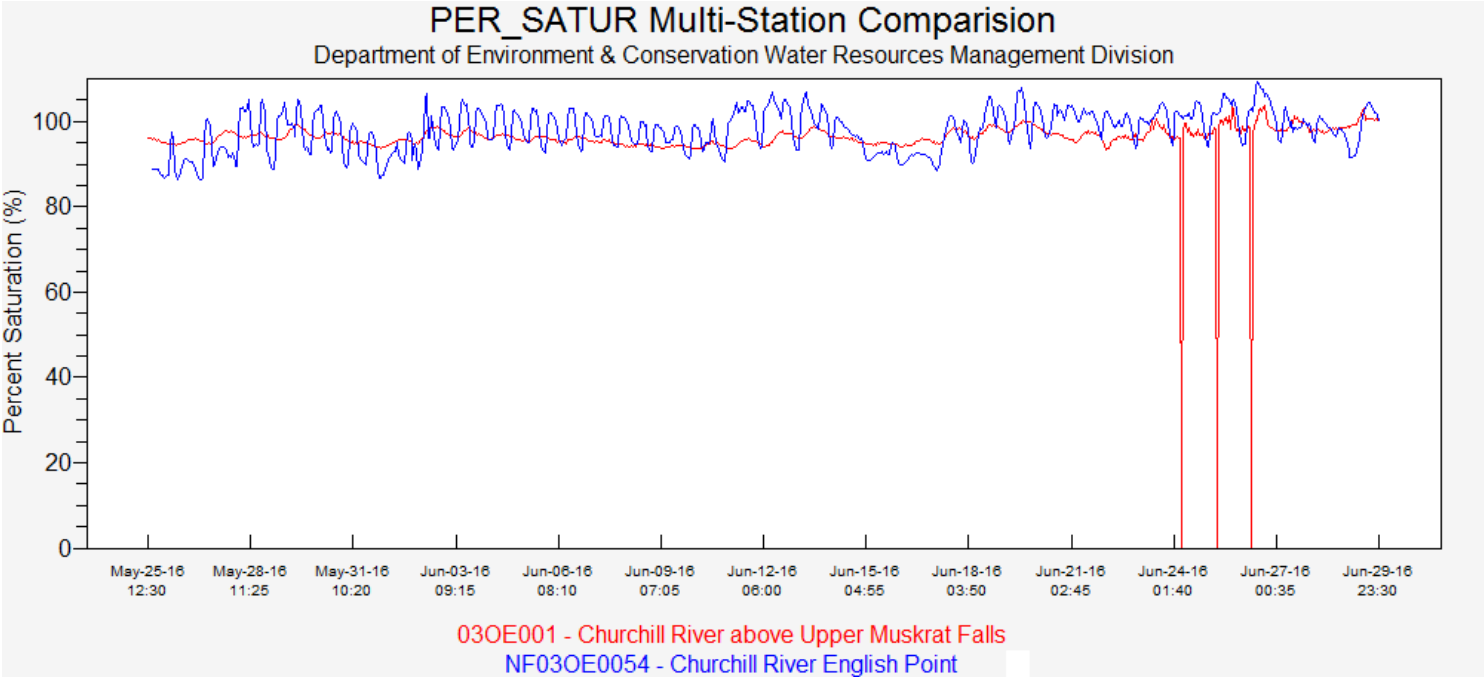

Figure A5: Comparison of Dissolved Oxygen (% Saturation) at the Real-Time Stations on Churchill River

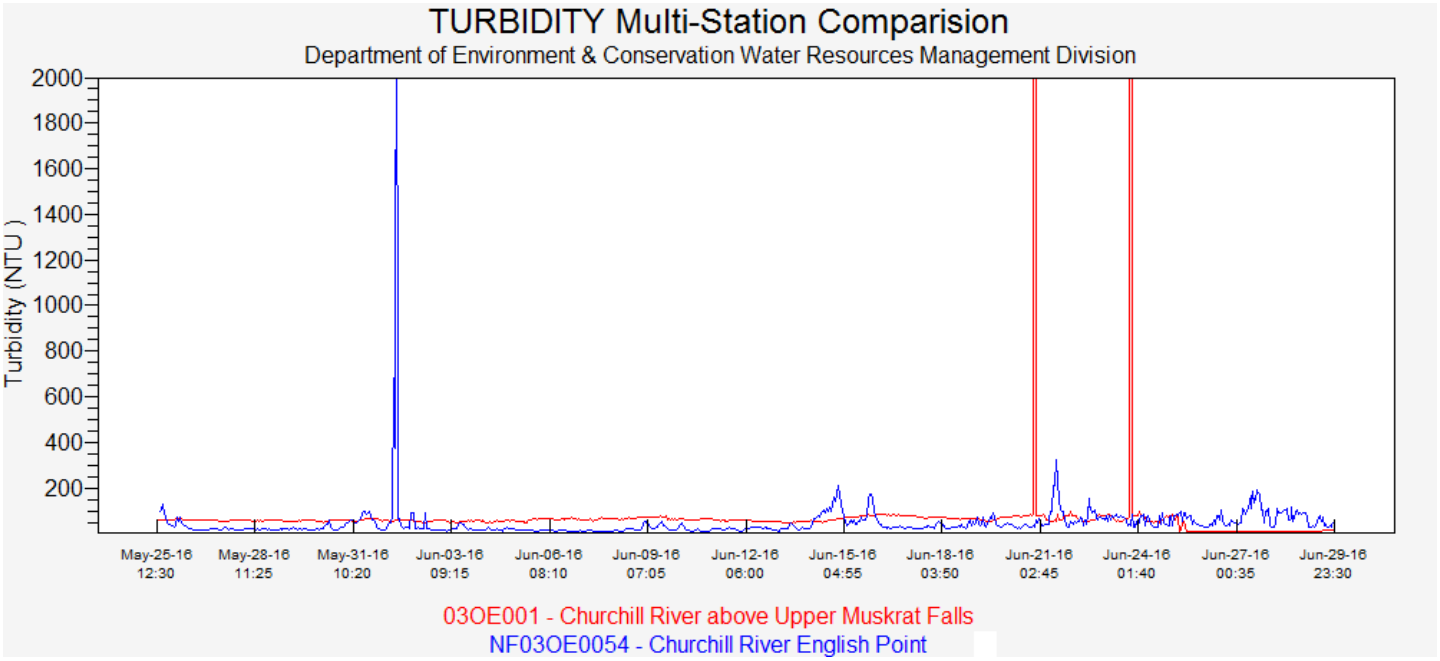

Figure A6: Comparison of Turbidity at the Real-Time Stations on Churchill River

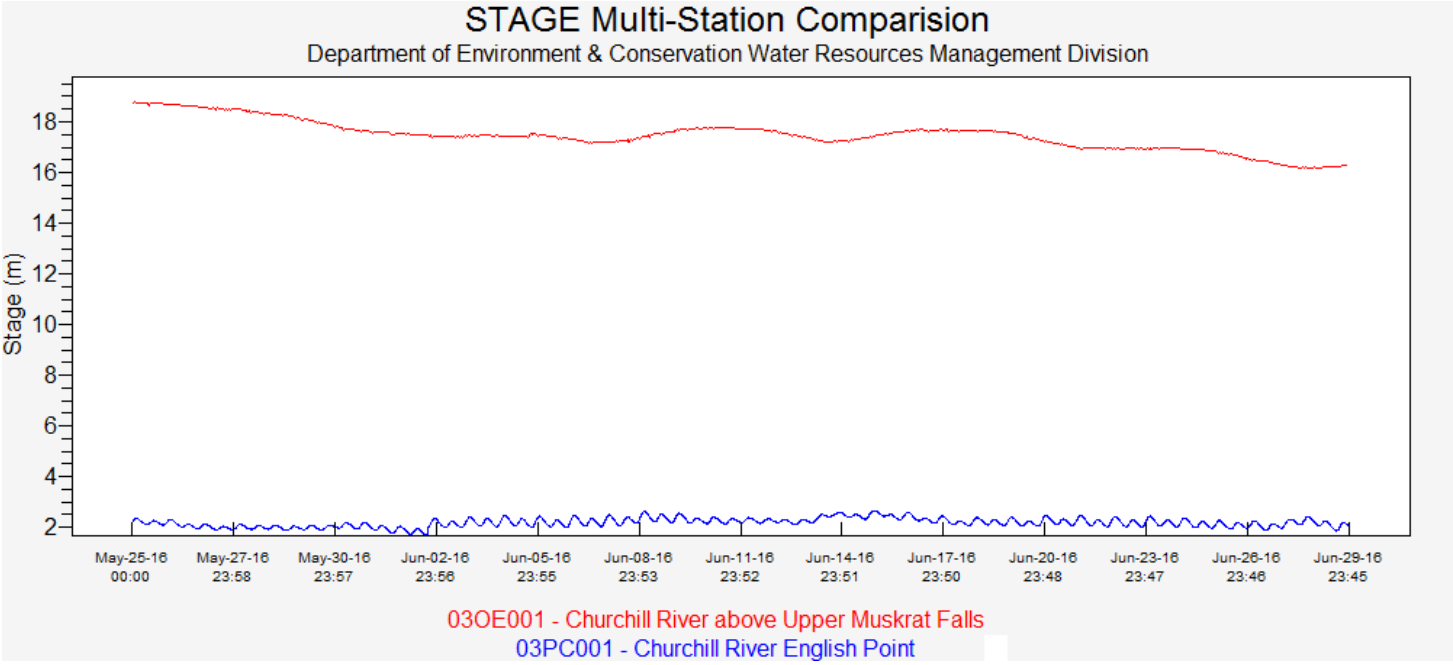

Figure A7: Comparison of Stage at the Real-Time Stations on Churchill River

APPENDIX B

Quality Assurance / Quality Control Procedures

- As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the beginning and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].
- At the beginning of the deployment period, a newly calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is temporarily deployed *in-situ* and alongside the newly calibrated Field Sonde. A grab sample is also taken from the water body at this time and sent away to a laboratory for analysis. Field Sonde performance ratings for *temperature (^oC)* and *Dissolved Oxygen (% saturation)* are based on differences recorded by the Field Sonde and QA/QC Sonde. Field Sonde performance ratings for *specific conductivity (µS/cm), pH (unit)* and *turbidity (NTU)* are based on differences between Field Sonde readings and grab sample results.
- At the end of the deployment period, water quality parameters are recorded by the Field Sonde before and after a thorough cleaning of its probes. Error caused by *bio-fouling* (E_f) is assessed by comparing these readings with readings made by a newly calibrated QA/QC Sonde, which is temporarily deployed *in-situ* and along side the Field Sonde. An assessment of *instrument drift error* (E_d) is made during laboratory calibration of the Field Sonde, and the two error values are added to give an estimate of total error ($E_t = E_f + E_d$). If E_t exceeds a predetermined data correction criterion, a correction factor is applied to the dataset based on linear interpolation of E_t. The Field Sonde performance is also rated at the end of the deployment period, based on the E_t value.
- Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (^oC)	≤ ±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 > 35 µS/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

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at *http://pubs.water.usgs.gov/tm1d3*

APPENDIX C

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 (Allan 2010).
- ***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 the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).
- ***Specific conductivity*** - Specific conductivity (μS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. 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 (Allan 2010; Swanson and Baldwin 1965).
- ***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 (oC) controls most processes and dynamics of limnology. 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 (Allan 2010; Hach 2006).
- ***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 (Allan 2010; Swanson 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 (Allan 2010; Hach 2006; Swanson and Baldwin 1965).

APPENDIX D

Grab Sample Results

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Maxxam Job #: B6A9243
Report Date: 2016/07/22

Department of Environment & Conservation
Site Location: GOOSE BAY, NL
Your P.O. #: 215062145-02
Sampler Initials: MM

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CLE335 CR Above Upper MF								
Sampling Date 2016/05/25 12:00								
Matrix W								
Sample # 2016-6300-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	12	1.0	mg/L	N/A	2016/06/08	2016/06/08		4518293
Hardness (CaCO3)	7.8	1.0	mg/L	N/A	2016/06/06	2016/06/06		4518286
Nitrate (N)	<0.050	0.050	mg/L	N/A	2016/06/08	2016/06/08		4518289
Inorganics								
Conductivity	15	1.0	uS/cm	N/A	2016/06/08	2016/06/08	JMV	4529902
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/06/06	2016/06/06	FD	4525260
Total Alkalinity (Total as CaCO3)	6.0	5.0	mg/L	N/A	2016/06/08	2016/06/08	NRG	4528780
Dissolved Chloride (Cl)	1.0	1.0	mg/L	N/A	2016/06/08	2016/06/08	NRG	4528786
Colour	47	5.0	TCU	N/A	2016/06/08	2016/06/08	MCN	4528808
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/06/08	2016/06/08	JMV	4529903
Total Kjeldahl Nitrogen (TKN)	0.11	0.10	mg/L	+/- <RDL	2016/06/03	2016/06/03	AAY	4524087
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/06/08	2016/06/08	MCN	4528812
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/06/07	2016/06/07	NRG	4528236
Dissolved Organic Carbon (C)	5.0	0.50	mg/L	N/A	2016/06/06	2016/06/06	SMT	4526875
Total Organic Carbon (C)	4.8	0.50	mg/L	N/A	2016/06/07	2016/06/07	SMT	4528162
pH	6.90	N/A	pH	N/A	2016/06/08	2016/06/08	JMV	4529900
Total Phosphorus	0.025	0.004	mg/L	+/- 0.005	2016/06/05	2016/06/06	SNR	4526222
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/06/08	2016/06/08	NRG	4528792
Turbidity	7.8	0.10	NTU	N/A	2016/06/08	2016/06/08	JMV	4530163
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/06/02	2016/06/02	ARS	4522095
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.47	0.0050	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Barium (Ba)	0.012	0.0010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Calcium (Ca)	1.9	0.10	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Iron (Fe)	0.57	0.050	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Magnesium (Mg)	0.73	0.10	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Manganese (Mn)	0.019	0.0020	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Potassium (K)	0.43	0.10	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Sodium (Na)	0.59	0.10	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Strontium (Sr)	0.011	0.0020	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2016/06/03	2016/06/03	BAN	4523969

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
A Bureau Veritas Group Company

Success Through Science®

Maxxam Job #: B6A9268
Report Date: 2016/07/22

Department of Environment & Conservation
Site Location: GOOSE BAY, NL
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CLE450 CR Above Upper MF								
Sampling Date 2016/05/25 12:00								
Matrix W								
Sample # 2016-6300-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	23	1.0	mg/L	N/A	2016/06/01	2016/06/02	LPW	4520938

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
A Bureau Veritas Group Company

Success Through Science®

Maxxam Job #: B6A9243
Report Date: 2016/07/22

Department of Environment & Conservation
Site Location: GOOSE BAY, NL
Your P.O. #: 215062145-02
Sampler Initials: MM

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CLE337 CR@ English Point								
Sampling Date 2016/05/25 15:00								
Matrix W								
Sample # 2016-6302-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	65	1.0	mg/L	N/A	2016/06/08	2016/06/08		4518293
Hardness (CaCO3)	65	1.0	mg/L	N/A	2016/06/07	2016/06/07		4518286
Nitrate (N)	<0.050	0.050	mg/L	N/A	2016/06/08	2016/06/08		4518289
Inorganics								
Conductivity	34	1.0	uS/cm	N/A	2016/06/07	2016/06/07	JMV	4528108
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2016/06/06	2016/06/06	FD	4525644
Total Alkalinity (Total as CaCO3)	9.0	5.0	mg/L	N/A	2016/06/07	2016/06/07	NRG	4528780
Dissolved Chloride (Cl)	4.6	1.0	mg/L	N/A	2016/06/08	2016/06/08	NRG	4528786
Colour	65	10	TCU	N/A	2016/06/08	2016/06/08	MCN	4528808
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2016/06/07	2016/06/07	JMV	4528111
Total Kjeldahl Nitrogen (TKN)	0.14	0.10	mg/L	+/- <RDL	2016/06/02	2016/06/06	AAY	4523643
Nitrite (N)	<0.010	0.010	mg/L	N/A	2016/06/08	2016/06/08	MCN	4528812
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2016/06/07	2016/06/07	NRG	4528236
Dissolved Organic Carbon (C)	5.9	0.50	mg/L	N/A	2016/06/06	2016/06/06	SMT	4526875
Total Organic Carbon (C)	5.0(1)	5.0	mg/L	N/A	2016/06/07	2016/06/07	SMT	4528162
pH	6.77	N/A	pH	N/A	2016/06/07	2016/06/07	JMV	4528107
Total Phosphorus	0.62	0.04	mg/L	+/- 0.08	2016/06/05	2016/06/06	SNR	4526222
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2016/06/08	2016/06/08	NRG	4528792
Turbidity	390	0.10	NTU	N/A	2016/06/07	2016/06/07	JMV	4528344
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2016/06/02	2016/06/02	ARS	4522095
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	18	0.0050	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Arsenic (As)	0.0015	0.0010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Barium (Ba)	0.20	0.0010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Boron (B)	<0.050	0.050	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Cadmium (Cd)	0.000040	0.000010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Calcium (Ca)	7.2	0.10	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Chromium (Cr)	0.029	0.0010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Copper (Cu)	0.027	0.0020	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Iron (Fe)	19	0.050	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Lead (Pb)	0.0053	0.00050	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Magnesium (Mg)	11	0.10	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Manganese (Mn)	0.44	0.0020	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Nickel (Ni)	0.025	0.0020	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Potassium (K)	7.3	0.10	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Sodium (Na)	5.7	0.10	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Strontium (Sr)	0.065	0.0020	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Uranium (U)	0.00077	0.00010	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431
Total Zinc (Zn)	0.066	0.0050	mg/L	N/A	2016/06/06	2016/06/06	BAN	4526431

(1) Reporting limit was increased due to turbidity.

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
A Bureau Veritas Group Company

Success Through Science®

Maxxam Job #: B6A9268
Report Date: 2016/07/22

Department of Environment & Conservation
Site Location: GOOSE BAY, NL
Your P.O. #: 216009736

Sample Details/Parameters	Result	RDL	UNITS	MU	Extracted	Analyzed	By	Batch
CLE453 CR @ English Point								
Sampling Date 2016/05/25 15:00								
Matrix W								
Sample # 2016-6302-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	230	5.0	mg/L	N/A	2016/06/01	2016/06/02	LPW	4520938

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