Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 27/29 to November 1/2, 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 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 four stations on the Lower Churchill River: Churchill River below Metchin River, Churchill River above Grizzle Rapids, Churchill River below Muskrat Falls and Churchill River at English Point.
- This is the first deployment period for the station at Churchill River below Metchin River. This station had been decommissioned at the end of the 2014 field season, but was brought back online this year to allow for more complete monitoring of the Churchill River.
- Real-time water quality monitoring instruments were deployed at all stations on the Lower Churchill River on September 27th and September 29th. The instrument at Churchill River above Grizzle Rapids was removed on November 1st, for a deployment period of 33 days. Instruments at Churchill River below Muskrat Falls and Churchill River at English Point were also removed on November 1st, for a deployment period of 35 days. The instrument at Churchill River below Metchin River was removed on November 2nd, for a deployment period of 34 days.
- 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. This 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 dependent, 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 September 27/29 to November 1/2, 2017 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations September 27/29 to November 1/2, 2017

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	Sept 29, 2017	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	November 2, 2017	Removal	Good	Excellent	Excellent	Good	Excellent
Above Grizzle Rapids	Sept 29, 2017	Deployment	Good	Good	Excellent	Excellent	Poor
	November 1, 2017	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
Below Muskrat Falls	Sept 27, 2017	Deployment	Good	Fair	Excellent	Excellent	Poor
	November 1, 2017	Removal	Fair	Good	Excellent	Good	Fair
At English Point	Sept 27, 2017	Deployment	Good	Good	Marginal	Excellent	Poor
	November 1, 2017	Removal	Good	Excellent	Excellent	Excellent	Poor

- **Churchill River below Metchin River**
    - At deployment, temperature ranked as 'good', while all other parameters were 'excellent'.
    - At removal, temperature and dissolved oxygen were 'good', while all other parameters were 'excellent'.
- **Churchill River above Grizzle Rapids**
    - At deployment, temperature and pH were 'good', conductivity and dissolved oxygen were 'excellent', but turbidity was 'poor'. Given that two other stations experienced 'poor' turbidity rankings at deployment, this discrepancy is due to a sensor failure with the QA/QC sonde. This conclusion is supported by an 'excellent' ranking for turbidity between the field sonde and grab sample.
    - At removal, comparison rankings could not be determined due to a power failure with the instrument. The internal log file was unable to record any water quality parameters after October 22, 2017.

- **Churchill River below Muskrat Falls**
    - At deployment, conductivity and dissolved oxygen were 'excellent', temperature was 'good', pH was 'fair', and turbidity was 'poor'. Given that two other stations experienced 'poor' turbidity rankings at deployment, this discrepancy is due to a sensor failure with the QA/QC sonde. This conclusion is supported by an 'excellent' ranking for turbidity between the field sonde and grab sample.
    - At removal, conductivity was 'excellent', pH and dissolved oxygen were 'good', while temperature and turbidity were 'fair'.
- **Churchill River at English Point**
    - At deployment, dissolved oxygen was 'excellent', temperature and pH were 'good', conductivity was 'marginal', and turbidity was 'poor'. Given that two other stations experienced 'poor' turbidity rankings at deployment, this discrepancy is due to a sensor failure with the QA/QC sonde. This conclusion is supported by a 'good' ranking for turbidity between the field sonde and grab sample.
    - At removal, pH, conductivity and dissolved oxygen were all 'excellent', temperature was 'good' and turbidity was 'poor'. Considering the rough aquatic conditions at the time of removal, this discrepancy could be attributed to either the QA/QC instrument not being placed in close enough proximity to the field instrument, or the QA/QC instrument disturbing sediment on the river bed resulting in a higher-than-expected turbidity reading.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from September 27/29 to November 1/2, 2017 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 QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.
- The station at Churchill River above Grizzle Rapids was deployed on July 12th, 2017. Since an area near the below Grizzle Rapids station (which contained both water quality and quantity monitoring capabilities) experienced a landslide in September 2016, a decision was made to relocate the water quality component of this station to the existing above Grizzle Rapids hydrometric station. Unforeseen power issues prevented transmission of data from this station; however, internal log file data is available for analysis in this report. Unforeseen power issues prevented transmission of data from this station and led to an instrument failure partway through this deployment period. Internal log file data is available for analysis in this report up to and including 6:00pm on October 22nd, 2017.
- 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.

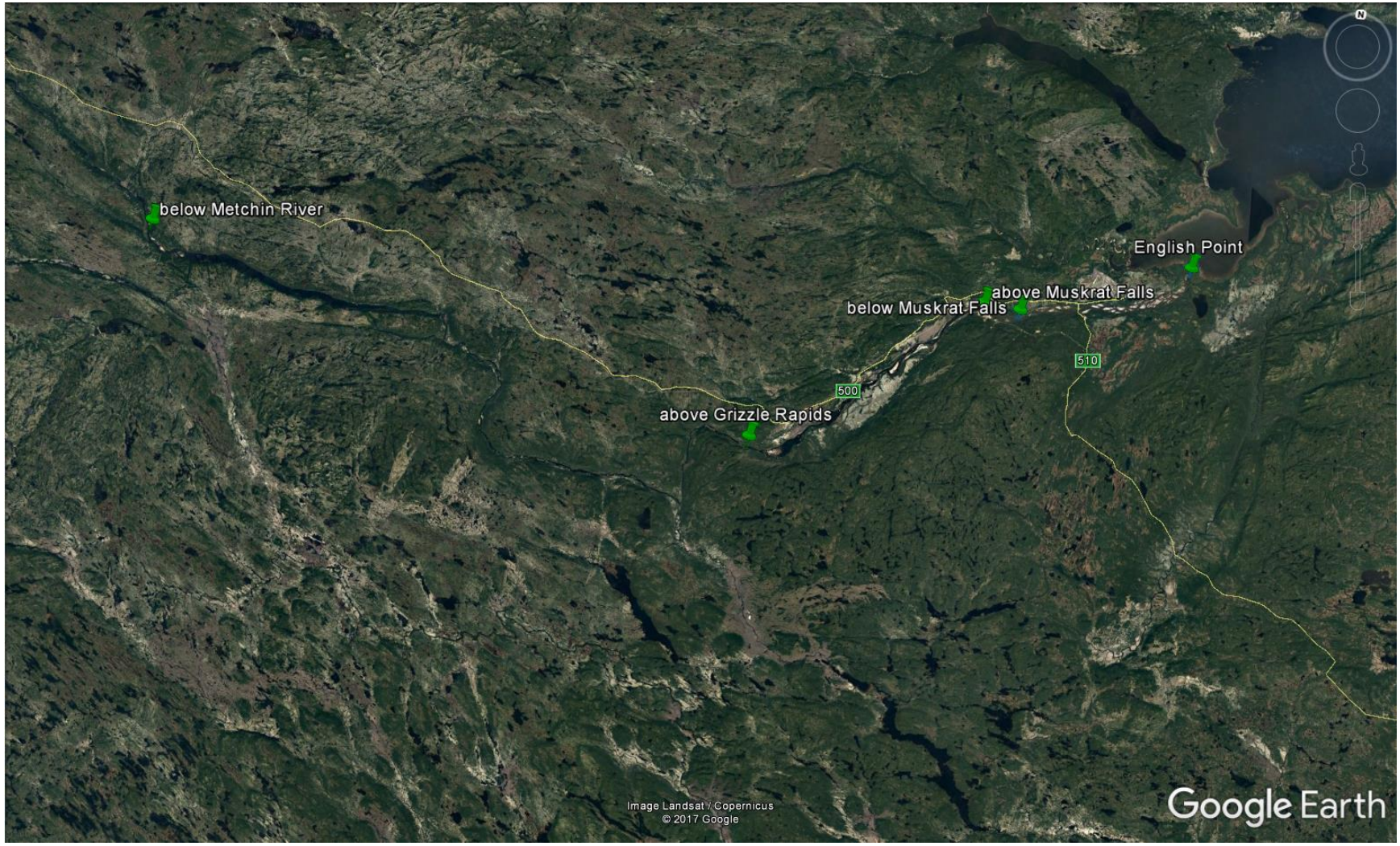

Figure 1: Lower Churchill Network of Real-Time Water Quality Stations

Churchill River below Metchin River

Water Temperature

- Water temperature ranged from 2.90°C to 8.90°C, with a median value of 5.40°C (Figure 2).
- Water temperature slowly decreased over the course of this deployment – a trend that is expected as air temperatures cool through the fall season. Water temperature data exhibits a diurnal pattern as expected, and closely correlates with ambient air temperatures. There was a notable increase in water temperature from October 25th through October 27th, which correlates with higher-than-expected ambient air temperatures in the region.
- 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.

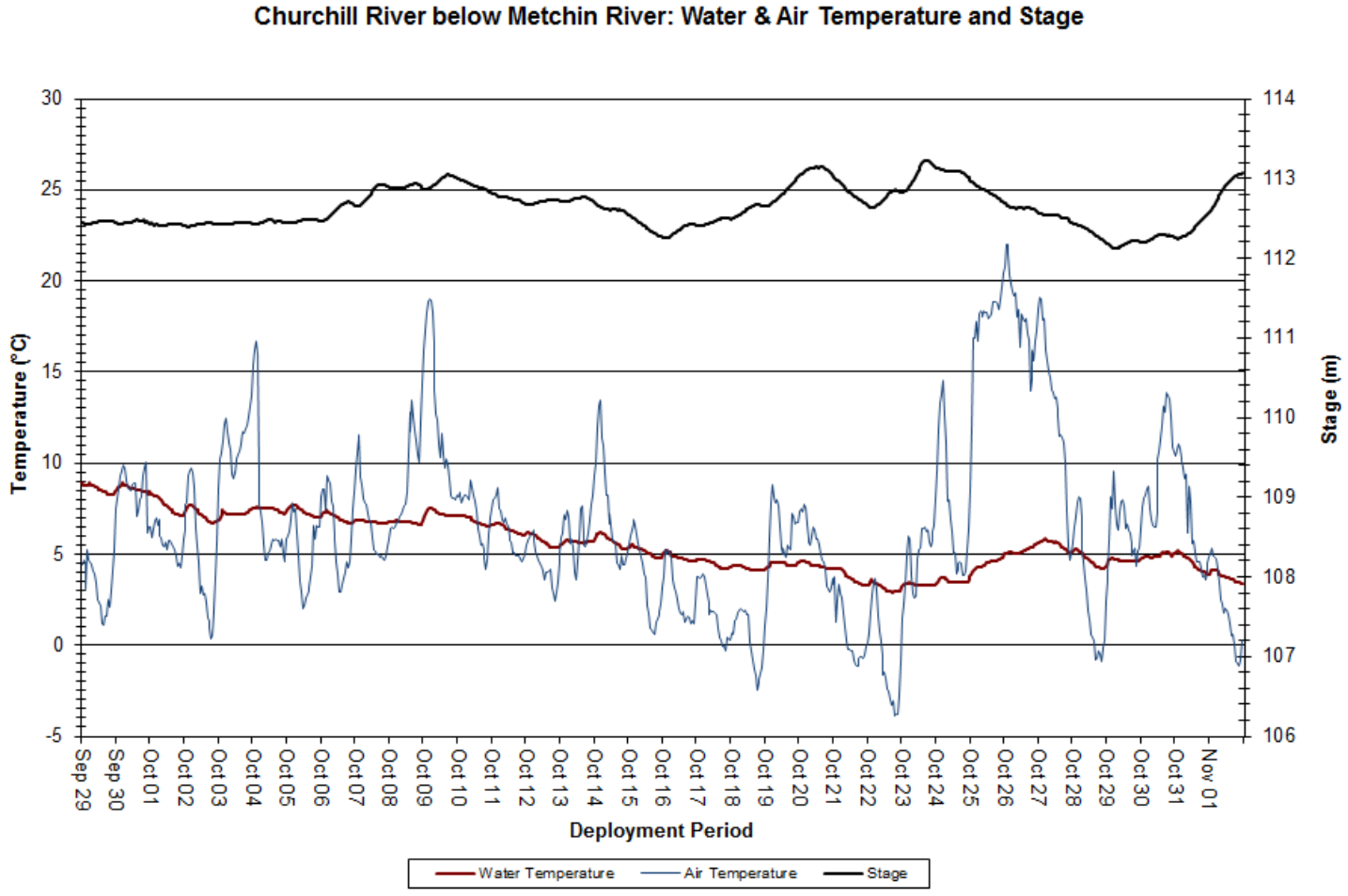

Figure 2: Water & Air Temperature (Muskrat Falls Weather Station) and Stage at Churchill River below Metchin River

pH

- pH values ranged from 6.58 to 6.95 pH units, with a median value of 6.75 (Figure 3).
- pH values were stable over the course of deployment and fall within the CCME Protection of Aquatic Life Guidelines.
- Photosynthesis uses up hydrogen molecules; this causes the concentration of hydrogen ions to decrease, which in turn causes pH to increase. For this reason, pH may be higher during daylight hours and during the growing season when photosynthesis is at a maximum. This is illustrated by the diurnal fluctuations in pH values (Figure 3).
- 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.

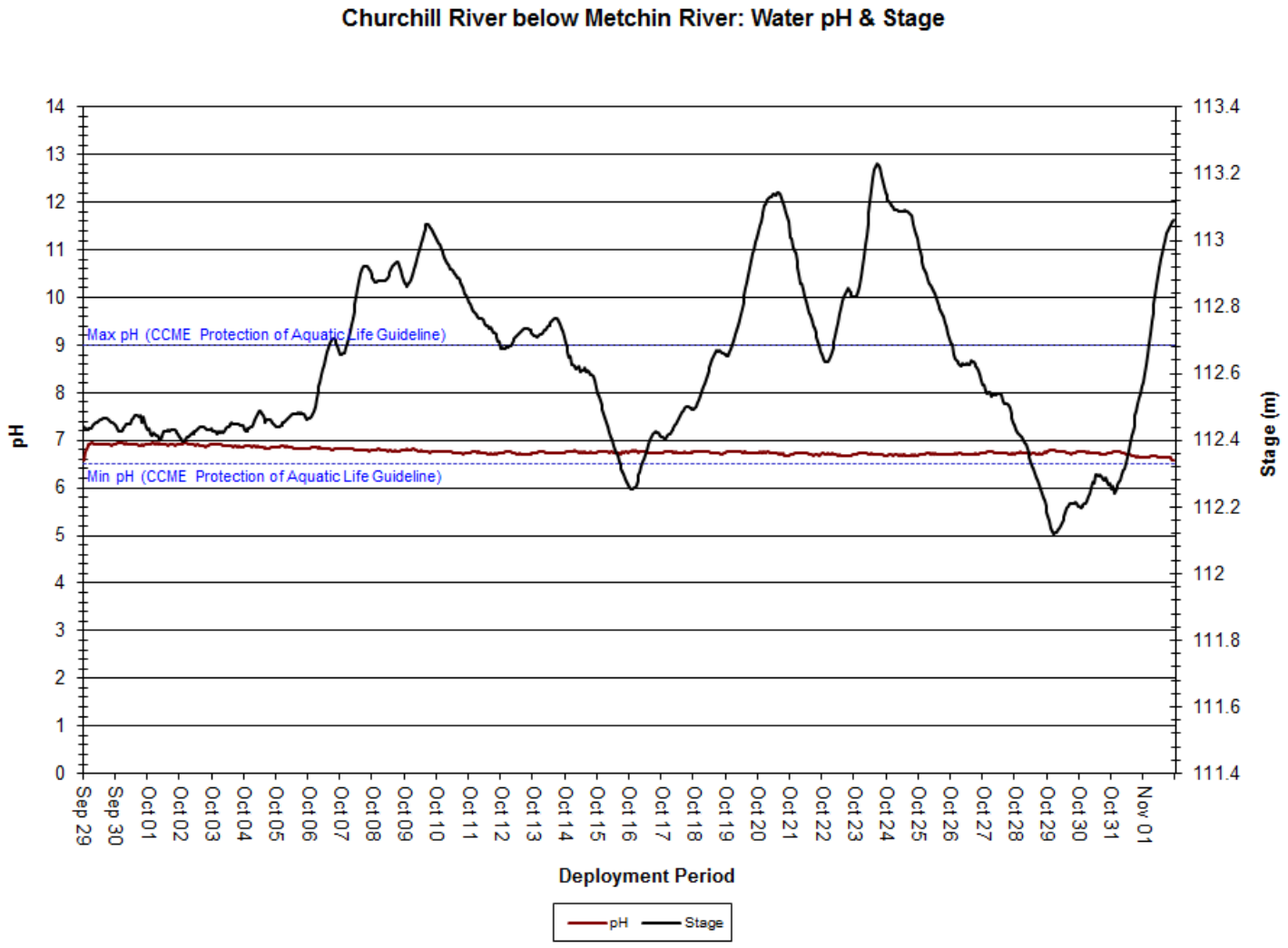

Figure 3: pH & Stage at Churchill River below Metchin River

Specific Conductivity

- Specific conductivity ranges from 18.7µS/cm to 21.5µS/cm, with a median value of 19.9µS/cm (Figure 4).
- The relationship between conductivity and stage is inversed. When stage levels increase, specific conductance levels decrease as the increased amount of water in the river system dilutes 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.

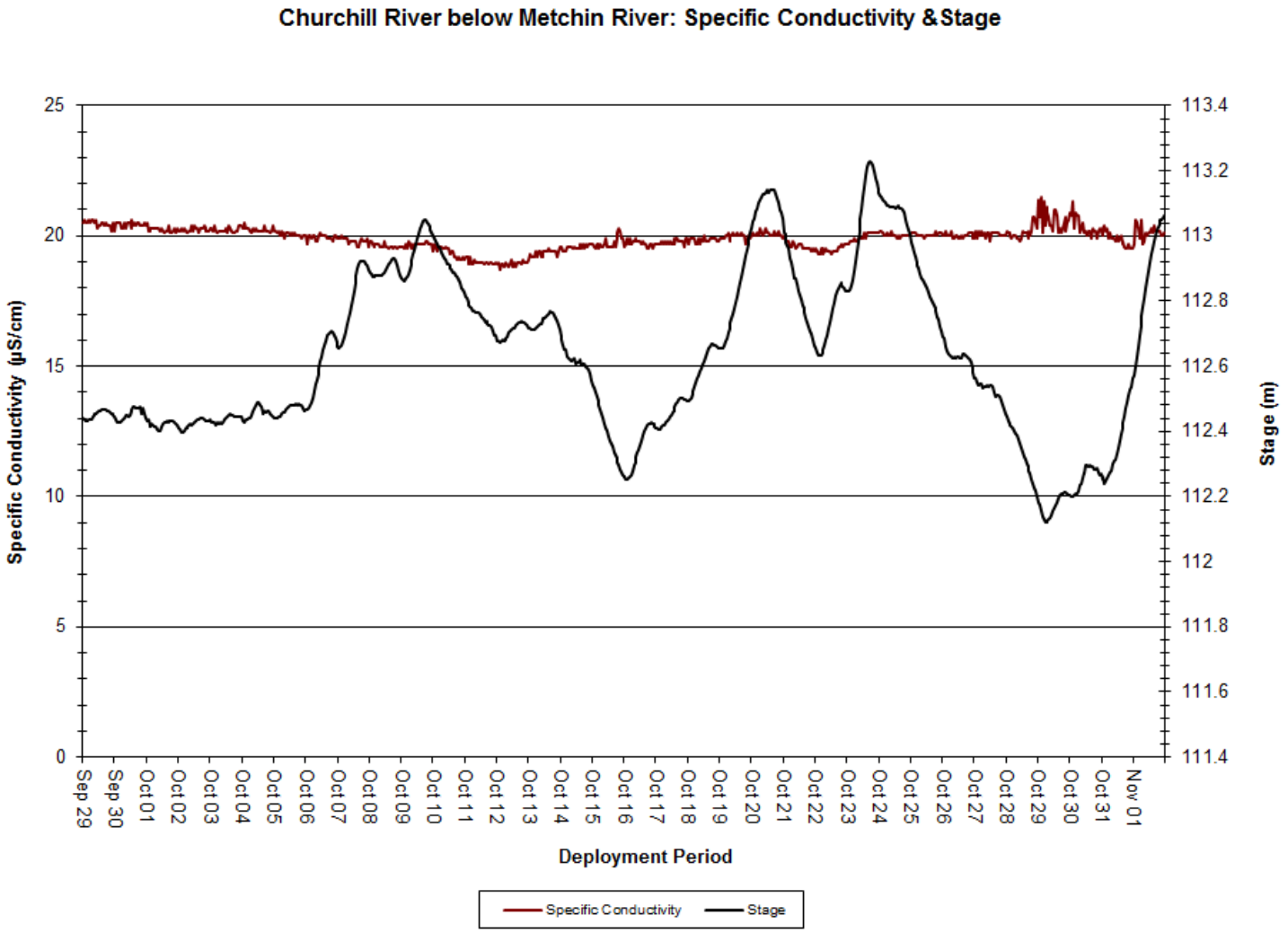

Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River

Dissolved Oxygen

- Dissolved oxygen content ranged from 10.67mg/L to 12.48mg/L, with a median value of 11.87mg/L. The saturation of dissolved oxygen ranged from 90.8% to 95.5%, with a median value of 92.4% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels are gradually increasing as temperatures decrease through the fall season. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels remained above the CCME Guideline for the Protection of Early Life Stages for the majority of the deployment period, with the exception of a few instances early in the deployment period.

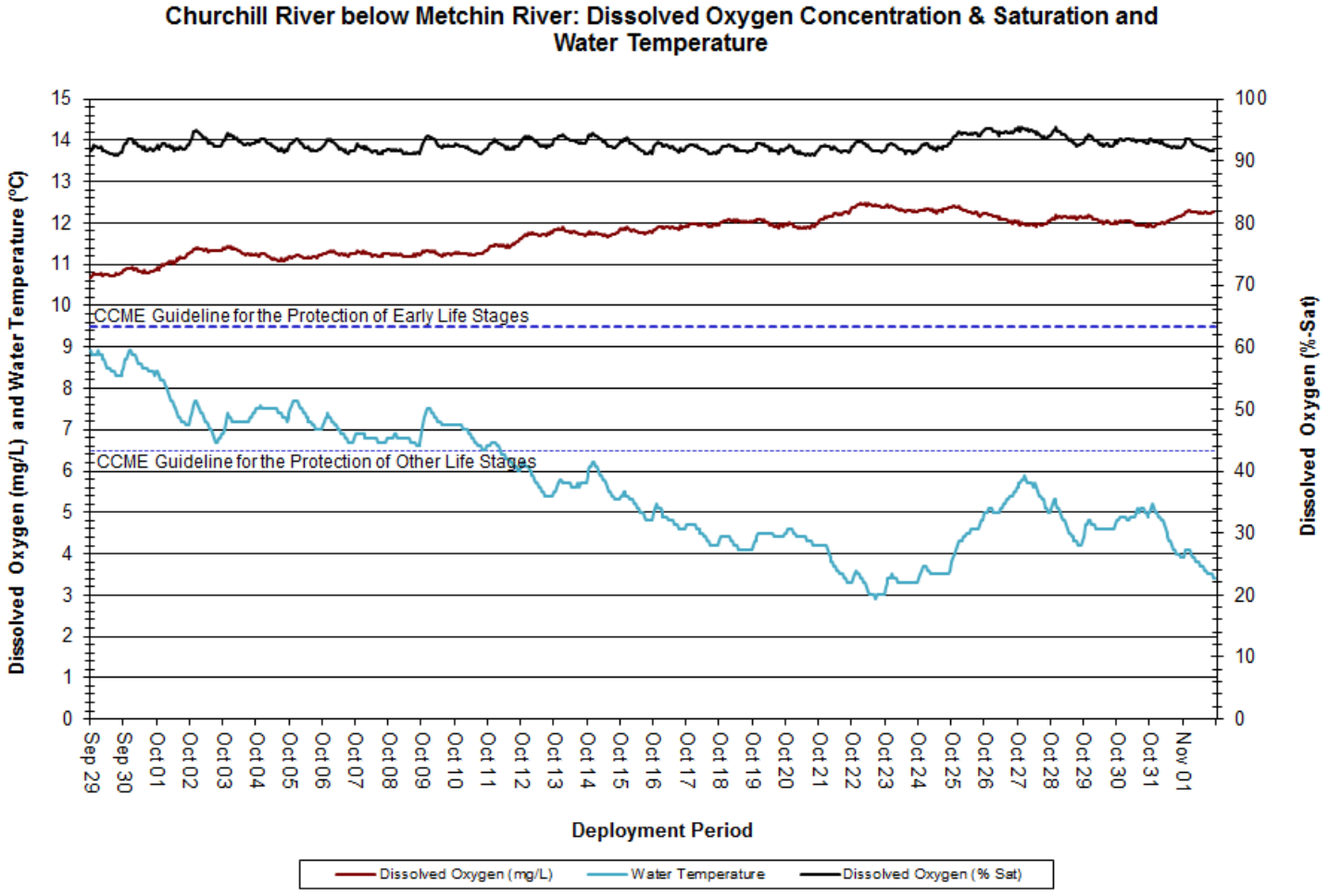

Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Turbidity

- Turbidity ranged from 0.0NTU to 59.2NTU, with a median value of 0.0NTU (Figure 6). A median value of 0.0NTU indicates a very low level of natural background turbidity in the waterbody.
- Many of the turbidity spikes correlate with precipitation events (Figure 6); however, some turbidity events do not coincide with any precipitation. This station is located at a wide and deep section of the Churchill River and therefore turbidity levels are likely less susceptible to precipitation events as compared to other areas. Turbidity levels returned to background levels following each observed increase.
- Precipitation data was obtained from the Muskrat Falls Weather 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.

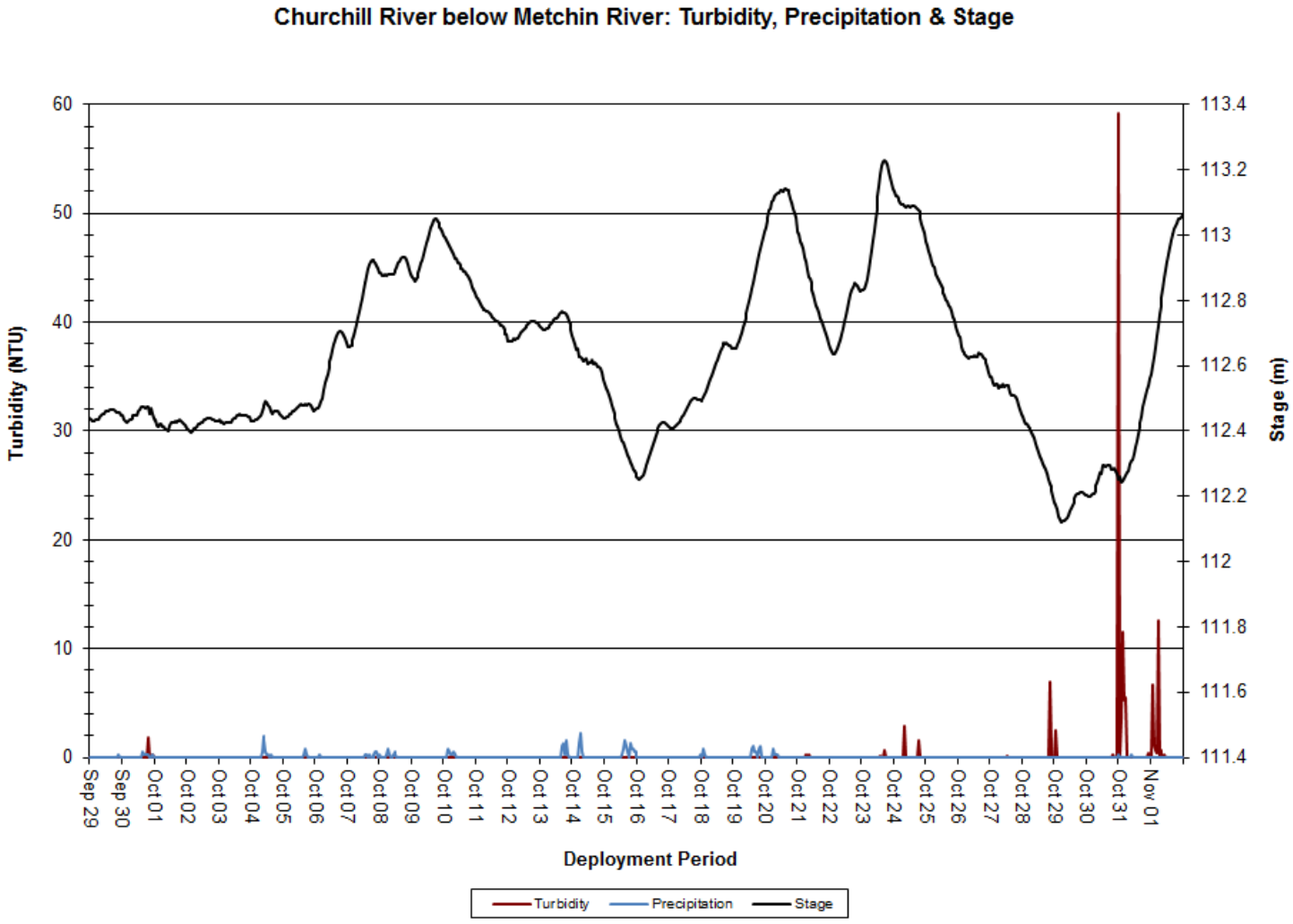

Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River

Stage and Flow

- Stage levels ranged from 112.12m to 113.23m, with a median value of 112.62m (Figure 7).
- Flow ranged from 855.12m^3/s to 1308.85m^3/s, with a median value of 1106.56m^3/s (Figure 7).
- Stage was slightly variable across the course of deployment, with flow following a similar trend.
- 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.

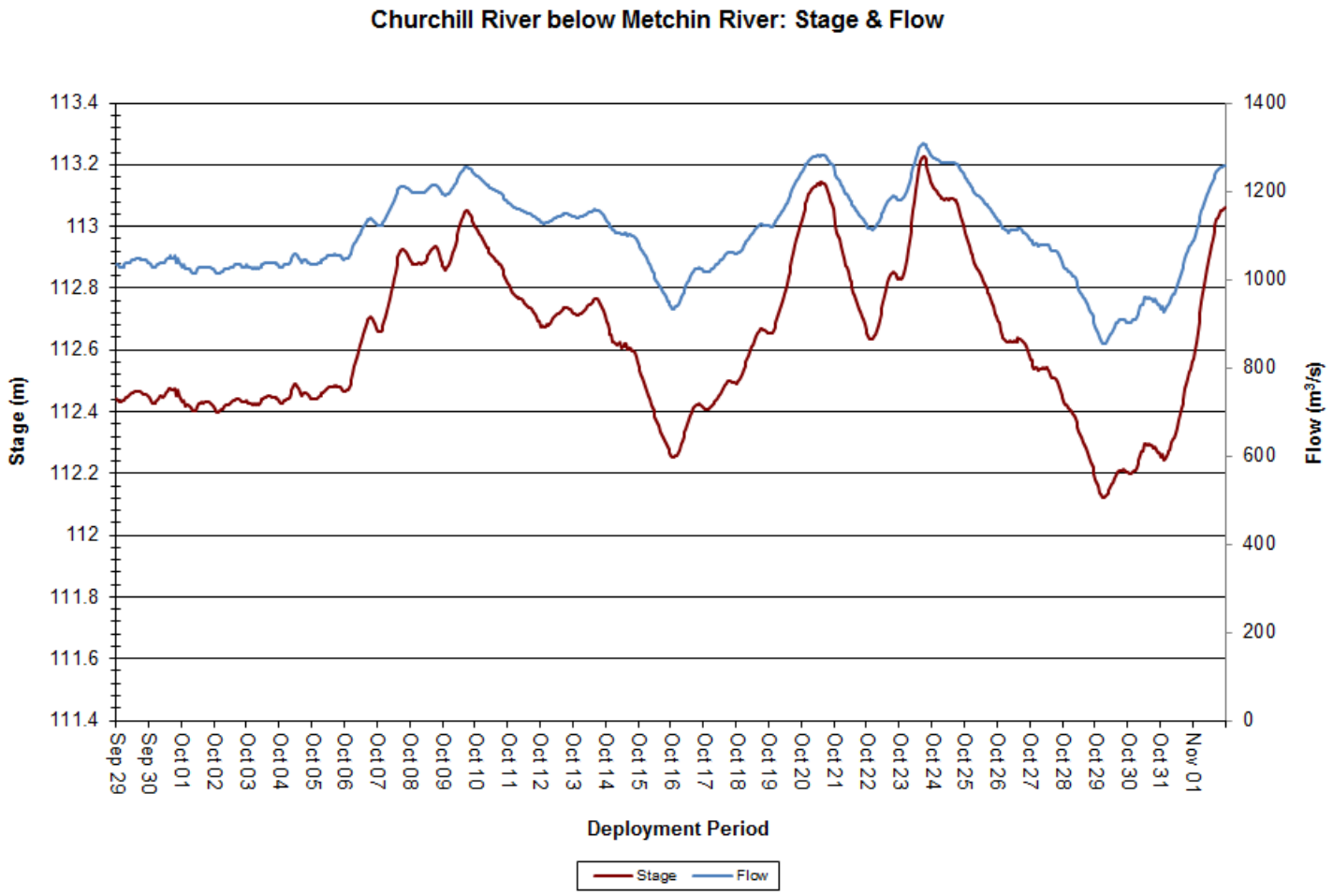

Figure 7: Stage & Flow at Churchill River below Metchin River

Churchill River above Grizzle Rapids

Water Temperature

- Water temperature ranged from 5.58°C to 10.56°C, with a median value of 8.95°C (Figure 8).
- Water temperature gradually decreases across the deployment period - a trend that is expected as air temperatures also decrease. Water temperatures closely correlate with ambient air temperatures (Muskrat Falls Weather 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.

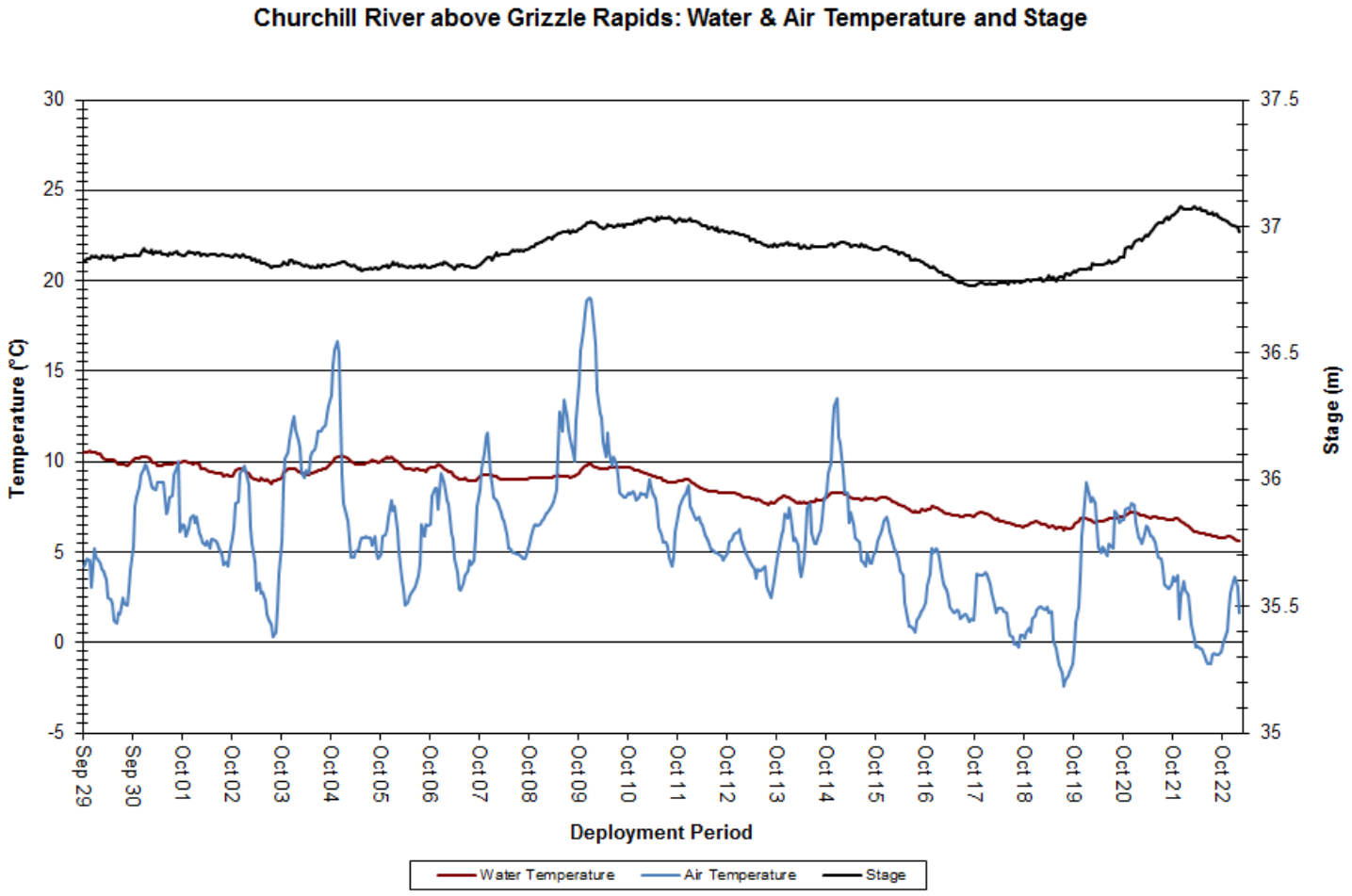

Figure 8: Water & Air Temperature (Muskrat Falls Weather Station) and Stage at Churchill River above Grizzle Rapids

pH

- pH ranged from 6.45 to 7.01 pH units, with a median value of 6.70 (Figure 9).
- pH values were slowly decreasing and stayed within the CCME Protection of Aquatic Life Guidelines for the majority of the deployment period, with the exception of several instances around October 22nd.
- 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.

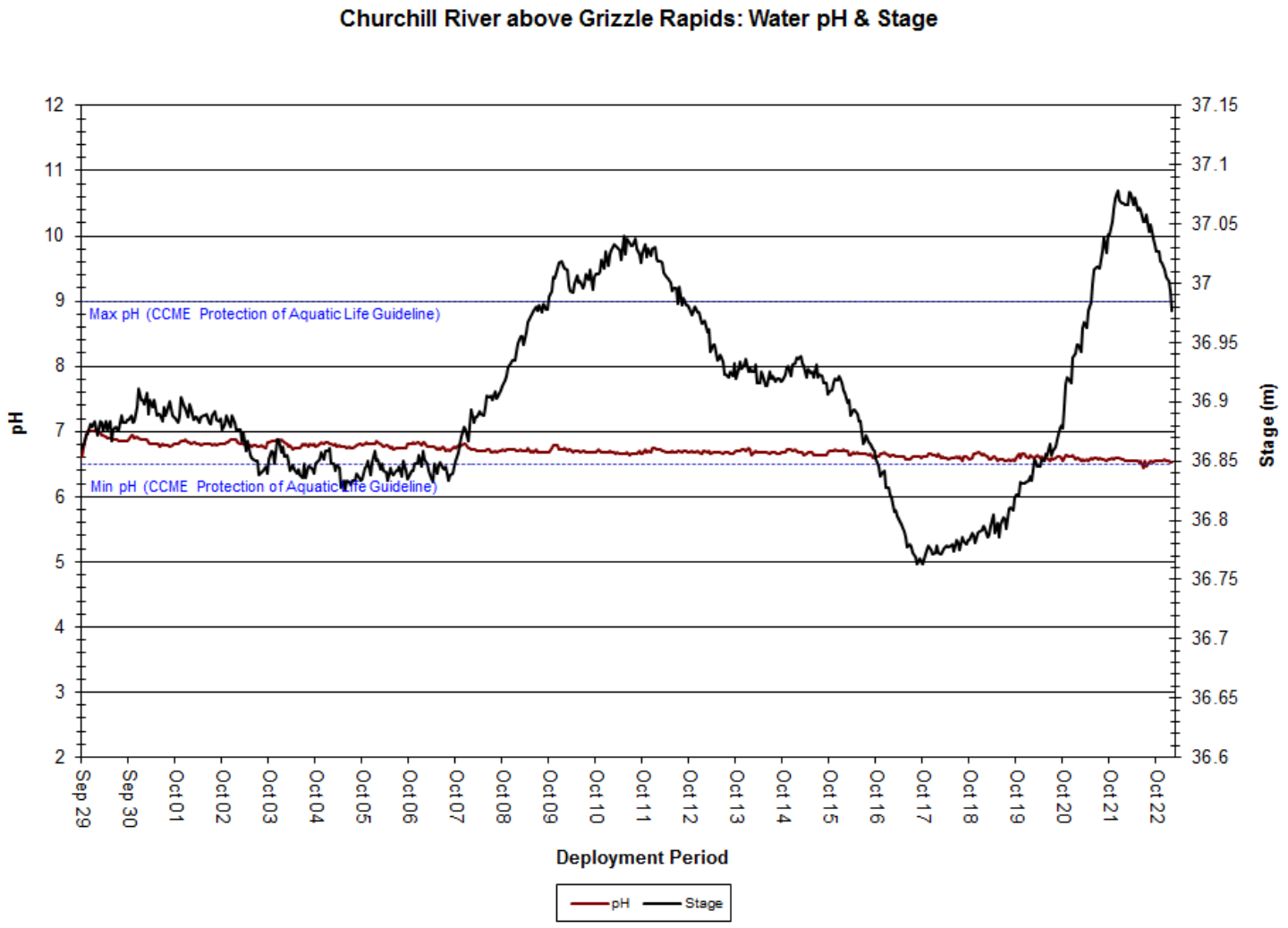

Figure 9: pH & Stage at Churchill River above Grizzle Rapids

Specific Conductivity

- Specific conductivity ranged from 18µS/cm to 19µS/cm, with a median value of 18µS/cm (Figure 10).
- The relationship between conductivity and stage is generally inversed. When stage levels decrease, specific conductance levels increase as the decreased amount of water in the river system concentrates solids that are present. This relationship is difficult to see in the graph below due to the internal log file recording specific conductance values as integers as opposed to decimals.
- 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.

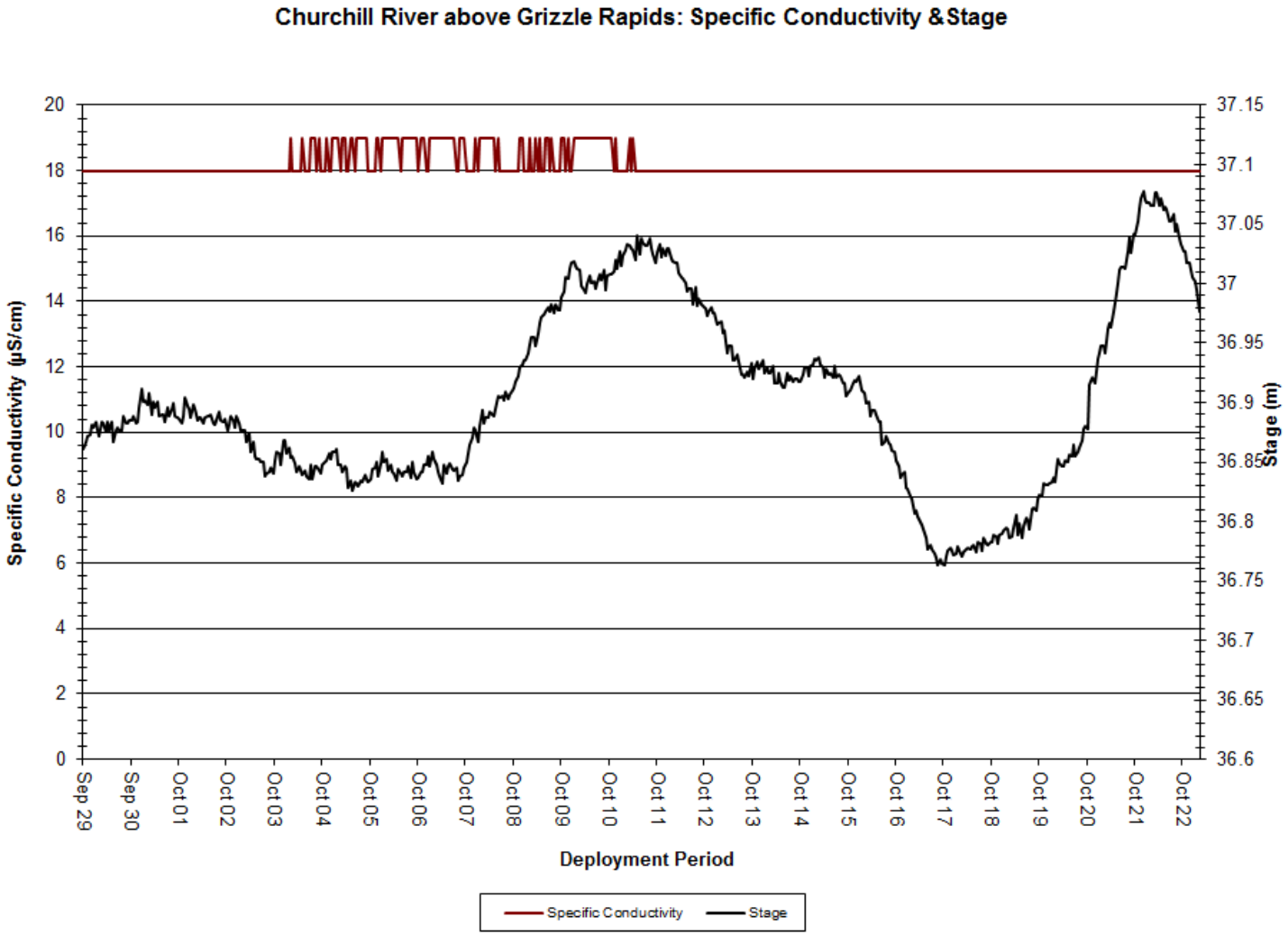

Figure 10: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Dissolved Oxygen

- Dissolved oxygen concentration ranged from 10.54mg/L to 11.81mg/L, with a median value of 10.98mg/L. The saturation of dissolved oxygen ranged from 91.9% to 97.0%, with a median value of 93.6% (Figure 11).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels are slowly increasing as temperatures decrease into the fall season. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages and the CCME Guidelines for the Protection of Early Stages for the duration of deployment.

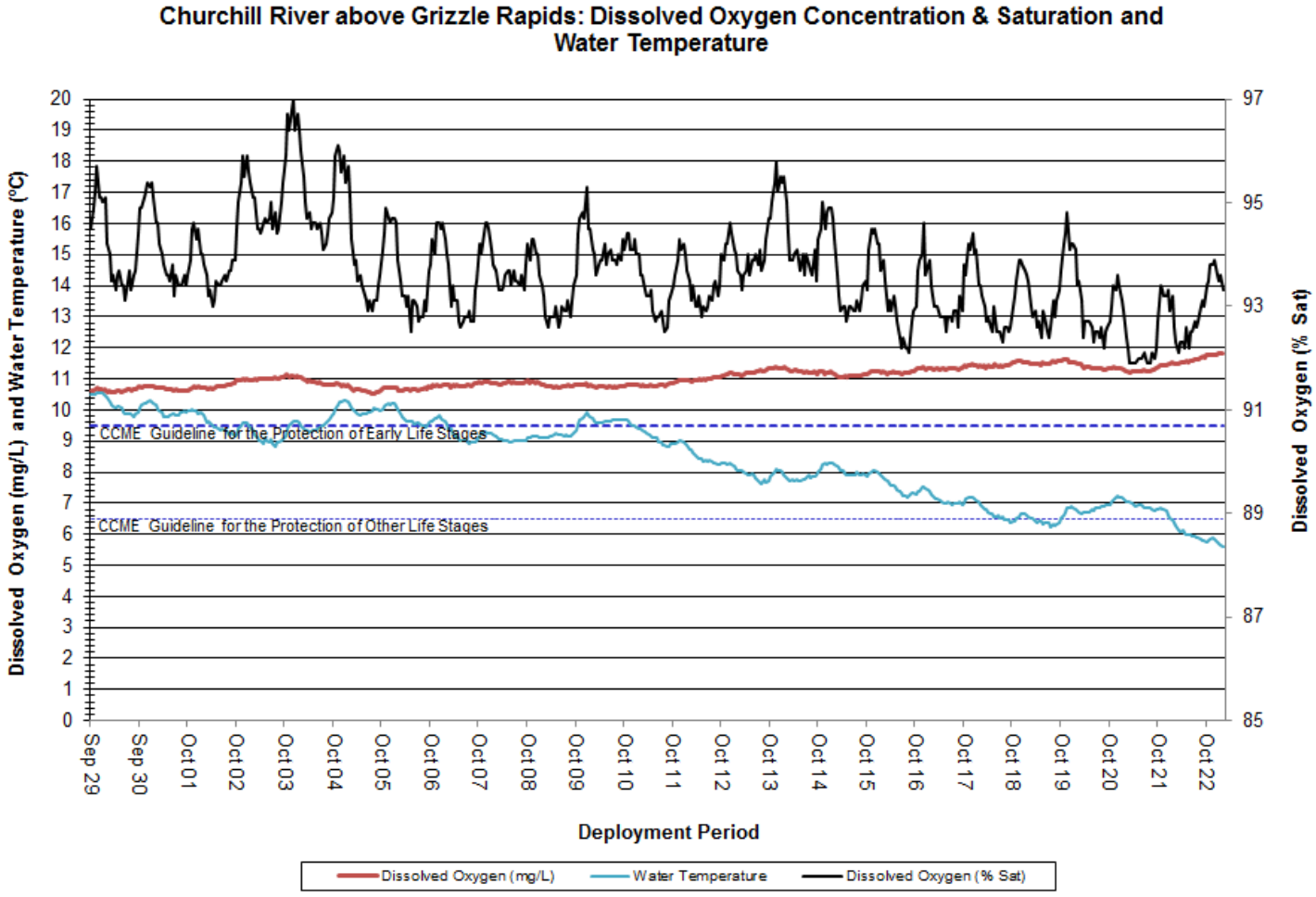

Figure 11: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Turbidity

- Turbidity remained constant at 0.0NTU for the duration of deployment. Given the natural aquatic conditions at this station, this likely indicates a sensor failure and so turbidity data has been removed from the dataset.

Stage

- Stage ranged from 36.76m to 37.08m, with a median value of 36.89m (Figure 12).
- Stage remained relatively consistent over the course of deployment, with precipitation events often correlating 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.

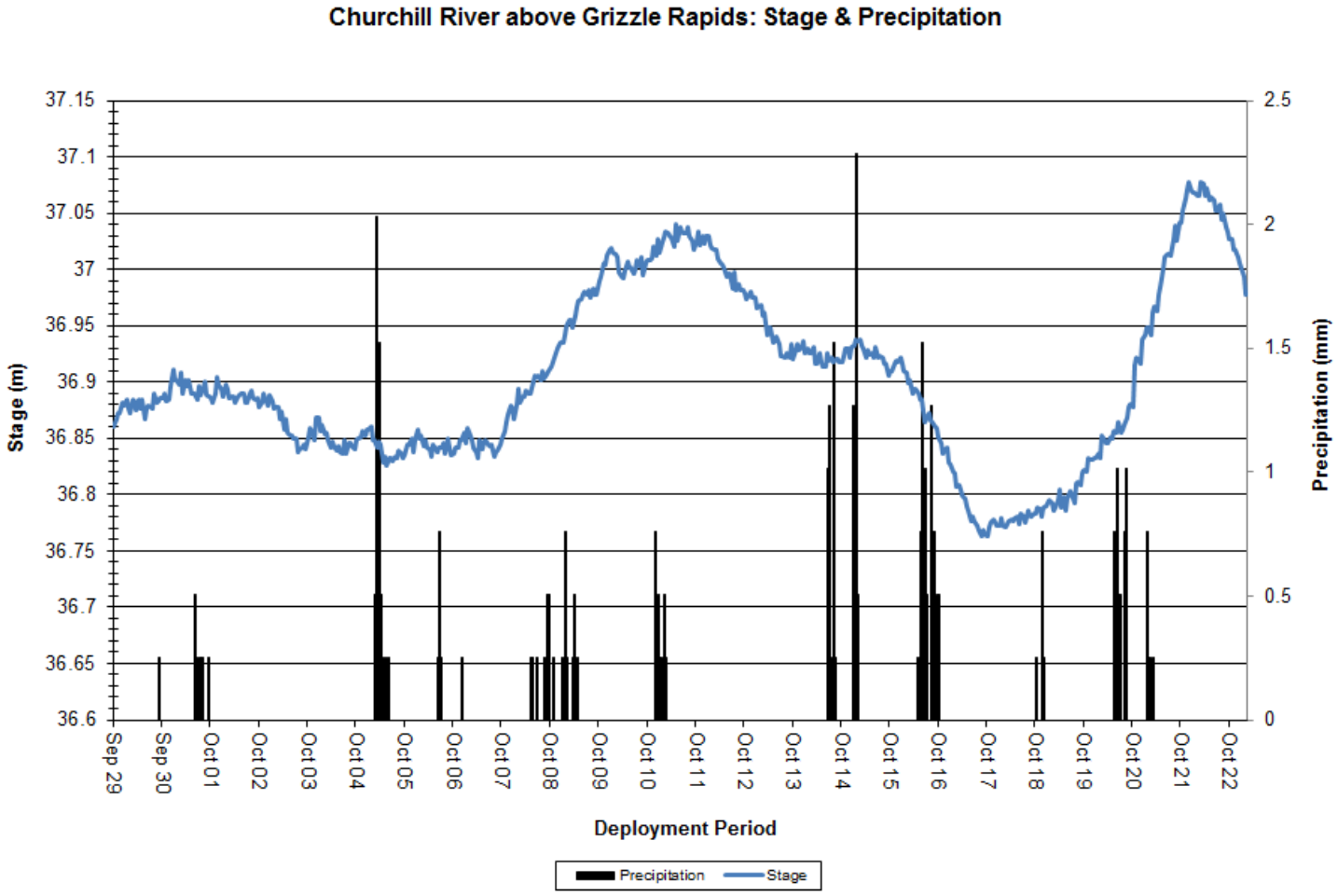

Figure 12: Stage & Precipitation (Muskrat Falls Weather Station) at Churchill River above Grizzle Rapids

Churchill River below Muskrat Falls

Water Temperature

- Water temperature ranged from 5.00°C to 11.90°C, with a median value of 7.80°C (Figure 13).
- Water temperature gradually decreases over the course of deployment, a trend that is expected as air temperatures fall after the summer months. Water temperatures closely correlate with ambient air temperatures (Muskrat Falls Weather 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.

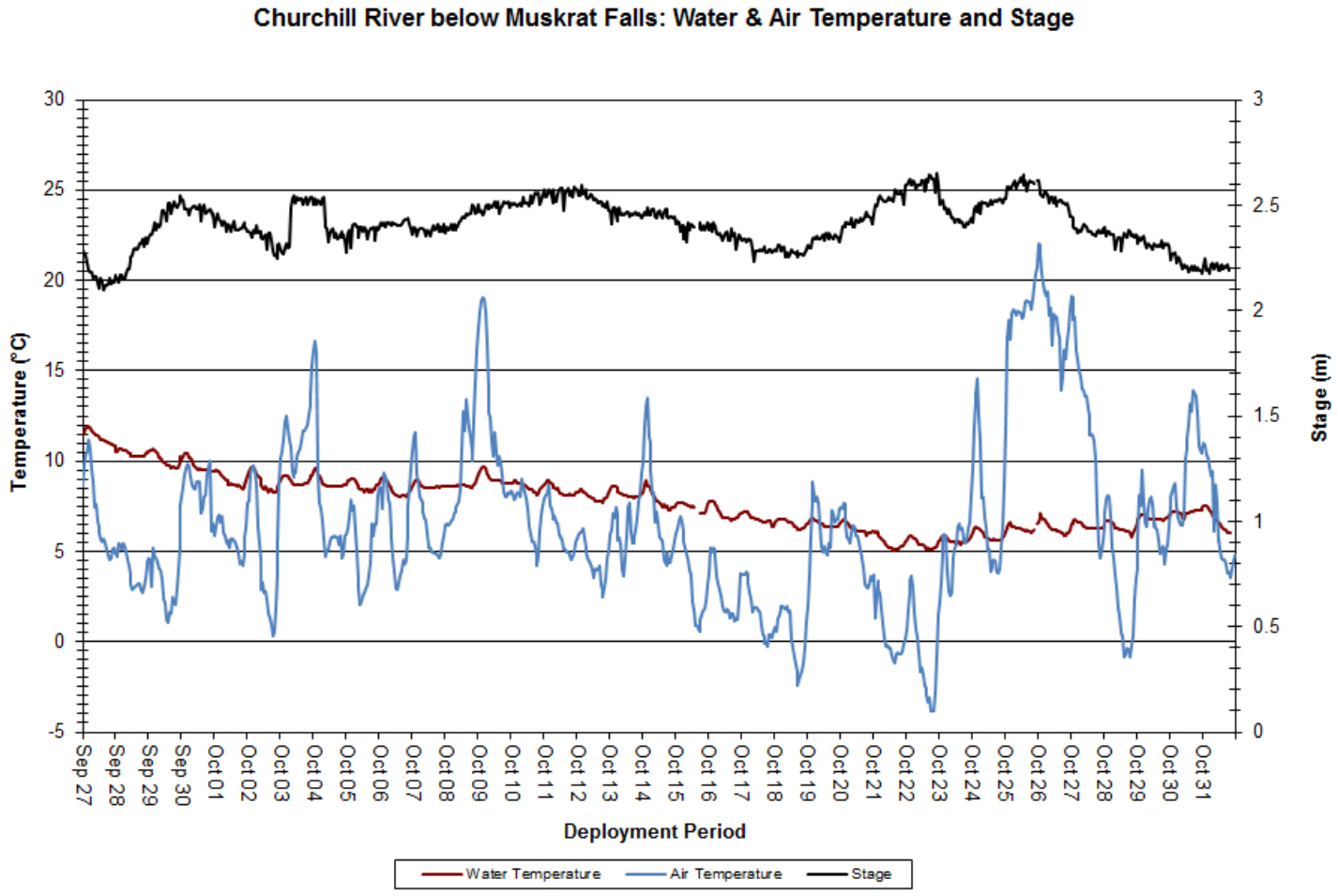

Figure 13: Water & Air Temperature (Muskrat Falls Weather Station) and Stage at Churchill River below Muskrat Falls

pH

- pH ranged from 6.22 to 6.59 pH units, with a median value of 6.46 (Figure 14).
- pH values remained below the CCME Guidelines for Protection of Aquatic Life for the majority of deployment.
- 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.

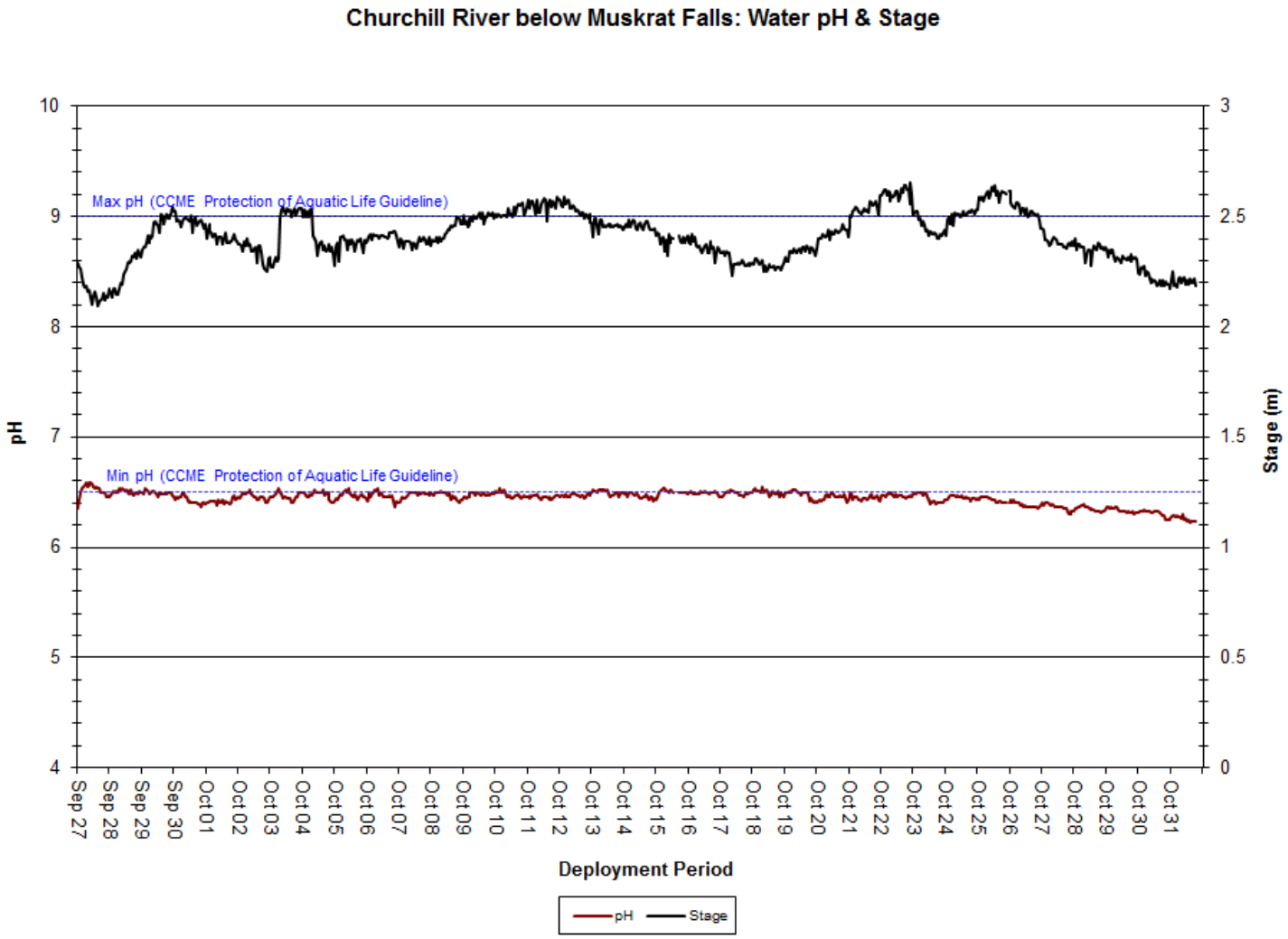

Figure 14: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Specific conductivity ranged from 17.8µS/cm to 19.1µs/cm, with a median value of 18.3µS/cm (Figure 15).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductance levels decrease as the increased amount of water in the river system dilutes 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.

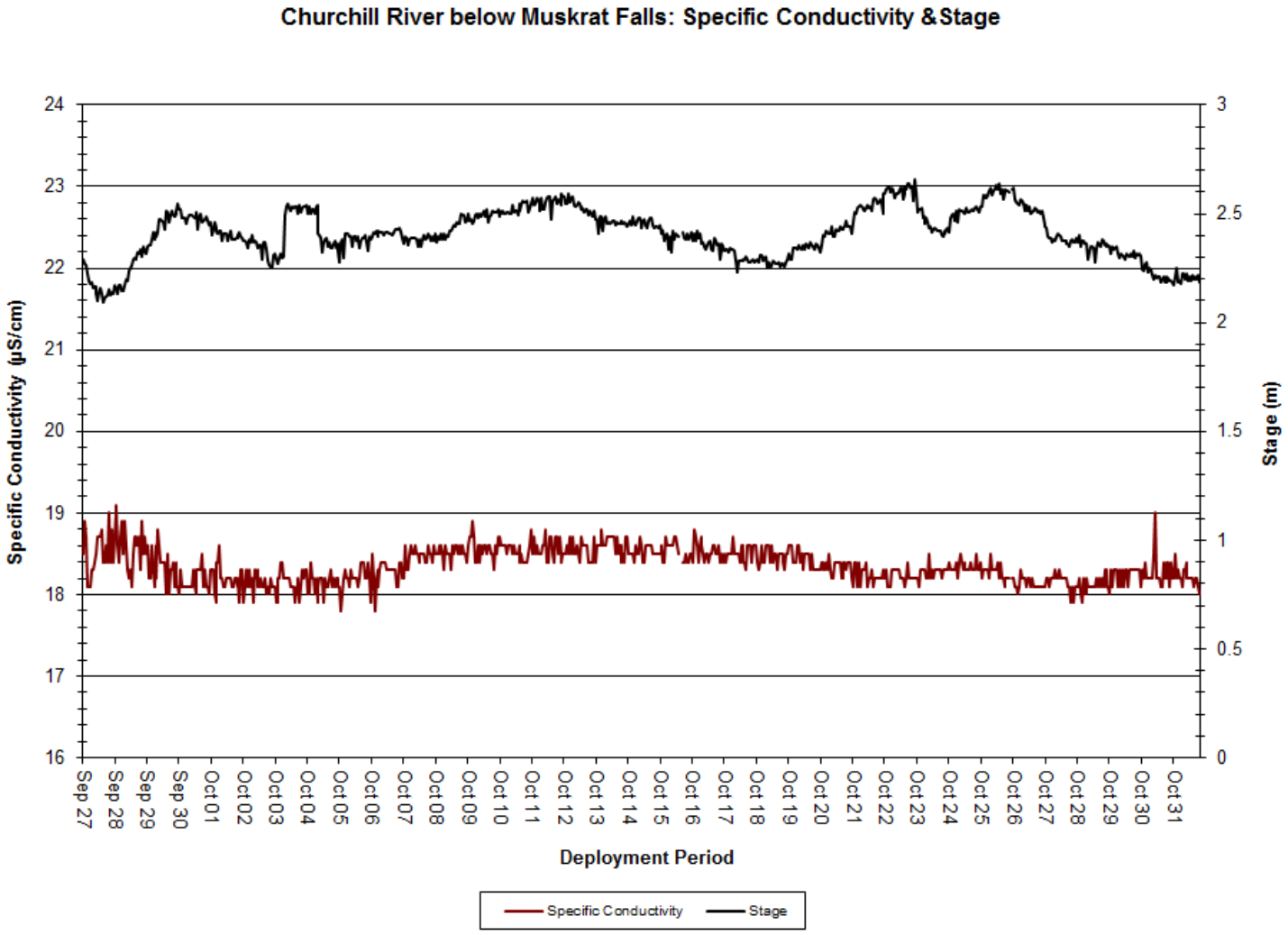

Figure 15: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen concentration ranged from 11.55mg/L to 14.15mg/L, with a median value of 12.76mg/L. The saturation of dissolved oxygen ranged from 99.1% to 112.9% saturation, with a median value of 107.5% (Figure 16).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decrease over the deployment period, dissolved oxygen levels slowly increase. Dissolved oxygen levels also follow a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early and Other Life Stages for the duration of deployment (Figure 16). This is to be expected considering decreasing water temperatures.

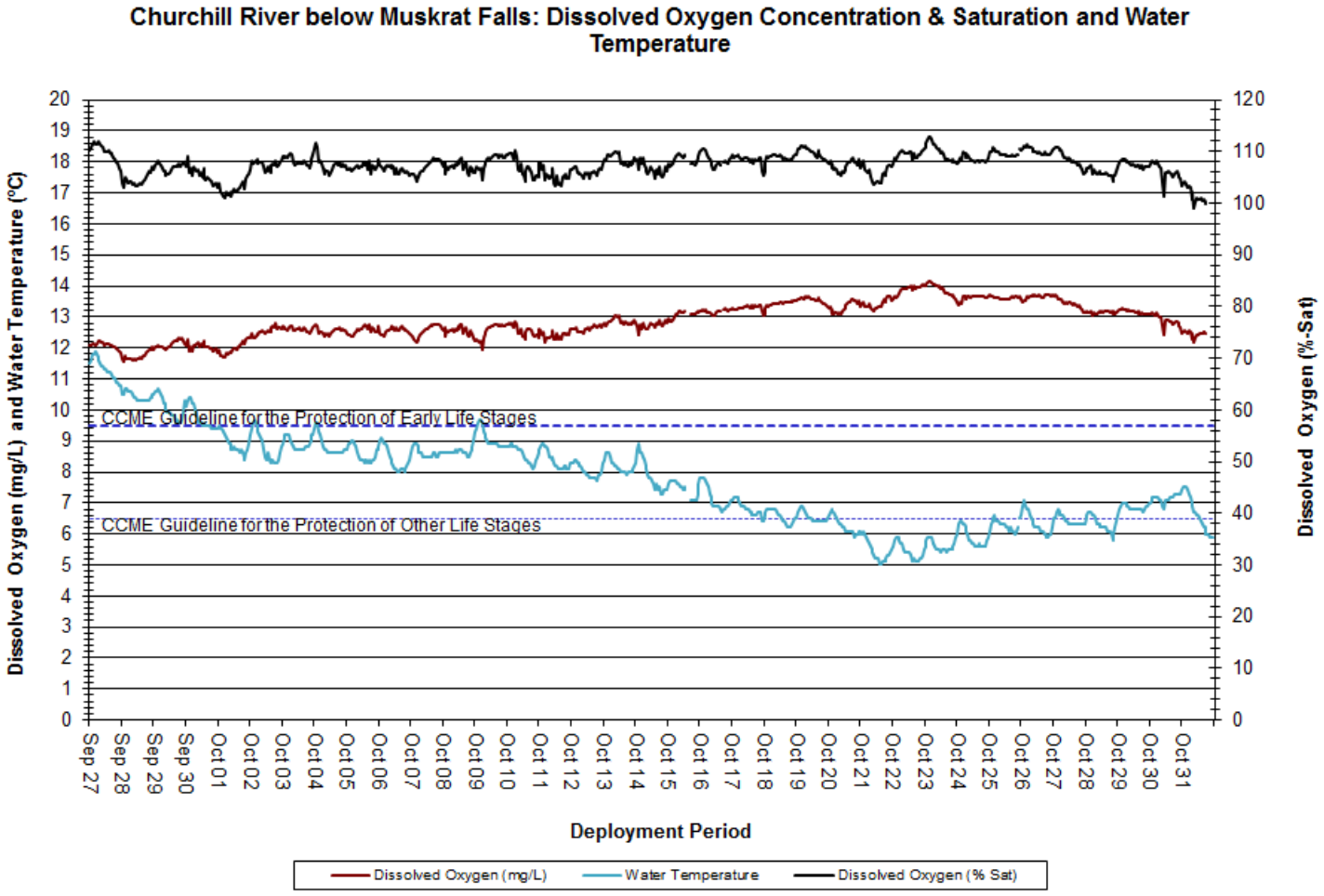

Figure 16: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Turbidity ranged from 0.7NTU to 35.7NTU, with a median value of 2.5NTU (Figure 17). A median of 2.5NTU indicates that there is a very small level of background turbidity at this station.
- Turbidity events often correlate with increases in stage and precipitation events. Precipitation can increase the presence of suspended material in water (Figure 17).
- 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.

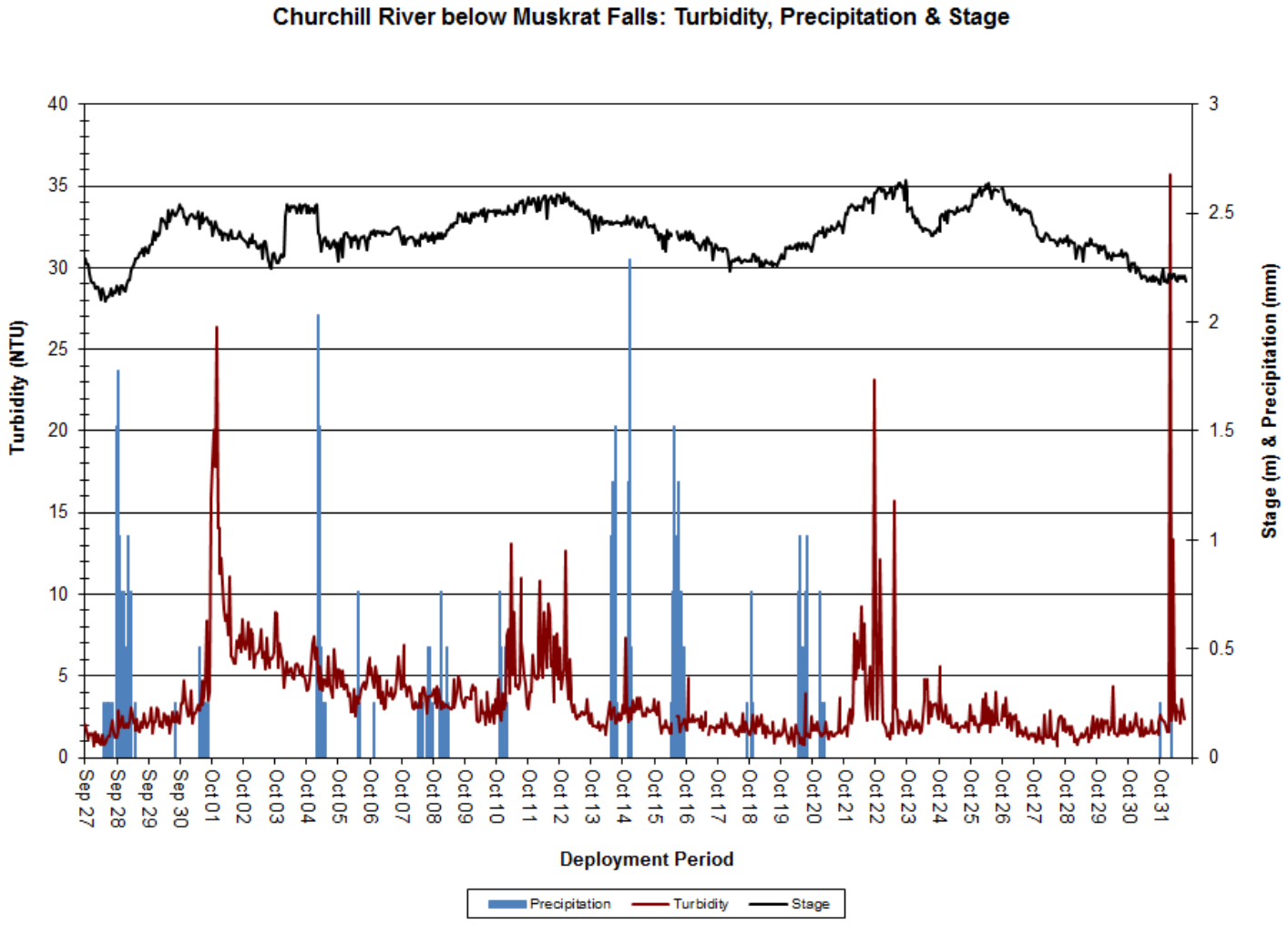

Figure 17: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls

Stage

- Stage ranged from 2.10m to 2.66m, with a median value of 2.41m (Figure 18).
- 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.

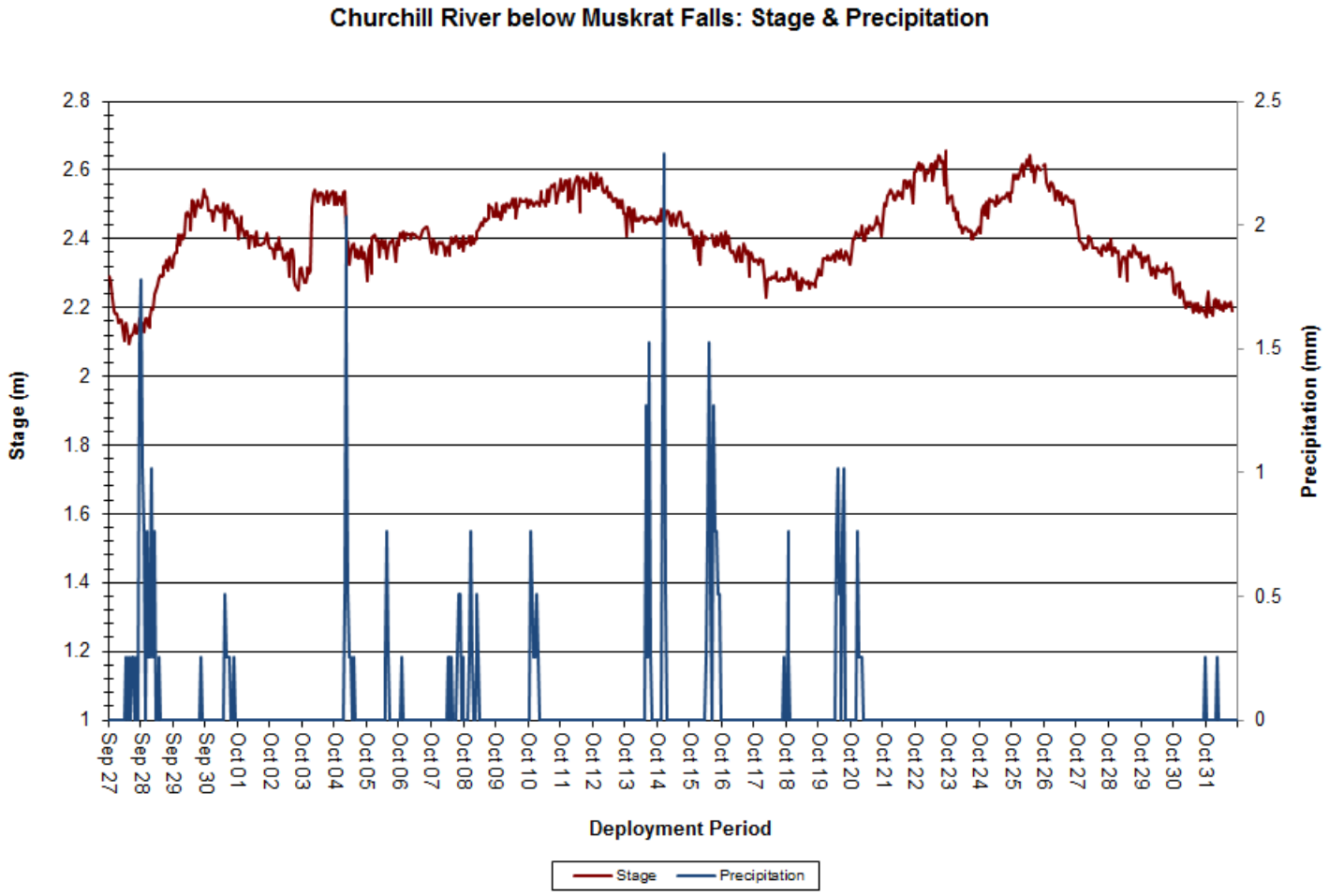

Figure 18: Stage & Precipitation (Muskrat Falls Weather Station) at Churchill River below Muskrat Falls

Chlorophyll

- Chlorophyll ranged from 2.01ug/L to 4.46ug/L, with a median value of 2.67ug/L (Figure 19).
- 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.
- 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.

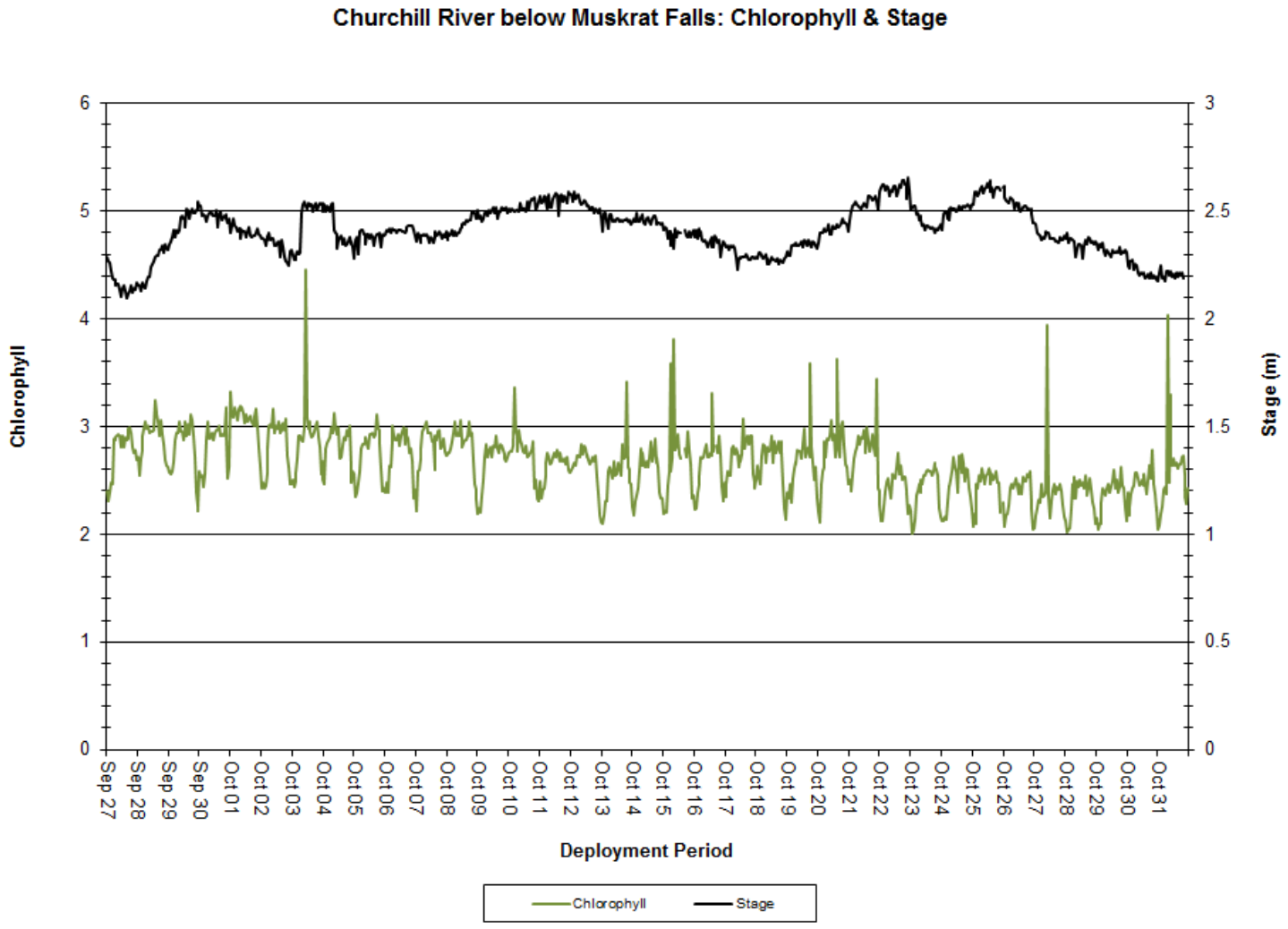

Figure 19: Chlorophyll & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranged from 4.20°C to 12.40°C, with a median value of 7.90°C (Figure 20).
- Water temperature gradually decreases over the course of deployment, a trend that is expected as air temperatures decrease through the fall season. Water temperatures closely correlate with ambient air temperatures (Mud Lake Weather Station). There was a notable increase in water temperature from October 22nd through October 27th, which correlates with higher-than-expected ambient air temperatures in the region.
- 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.

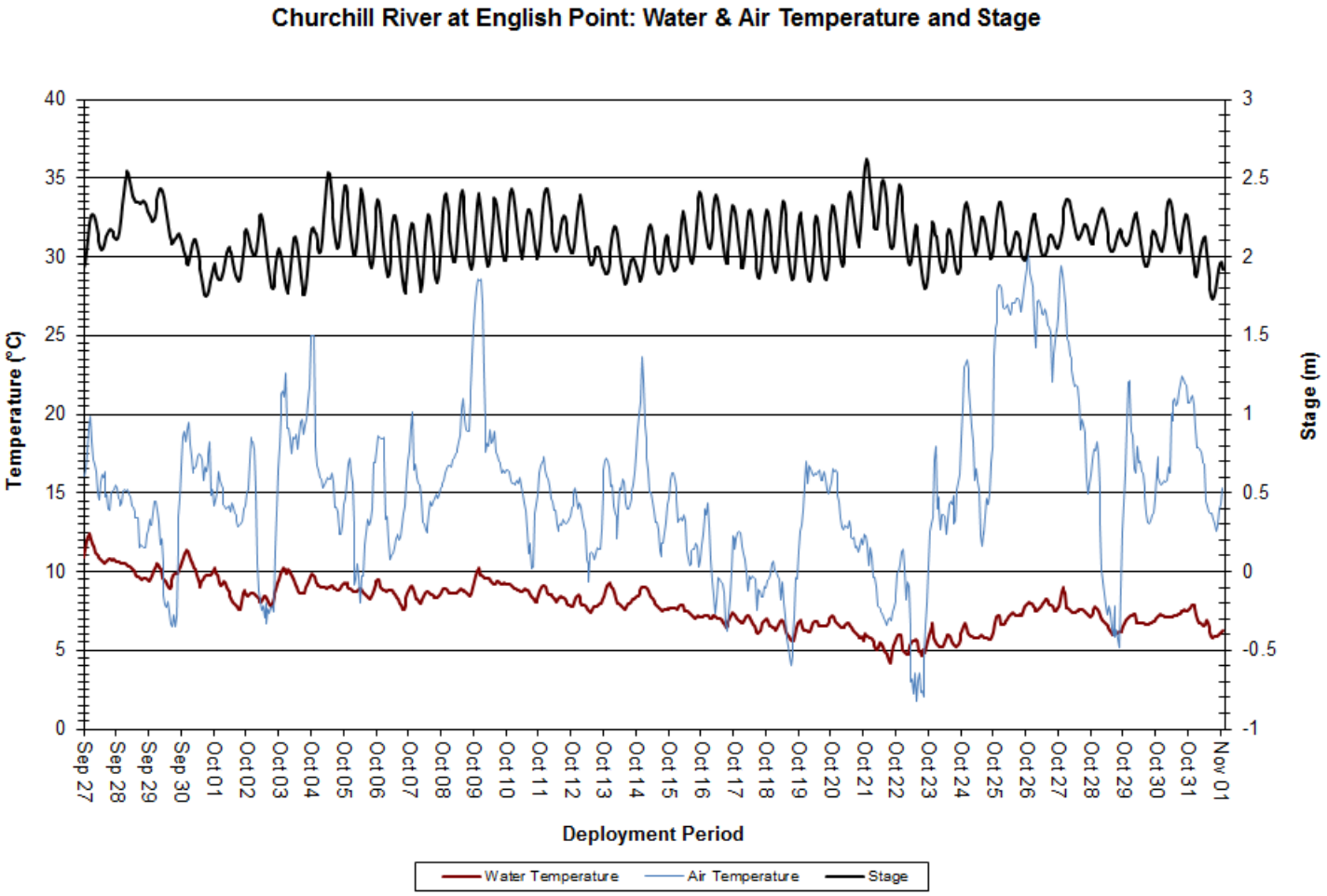

Figure 20: Water & Air Temperature (Mud Lake Weather Station) and Stage at Churchill River at English Point

pH

- pH ranged from 6.14 to 7.09 pH units, with a median value of 6.80 (Figure 21).
- pH values slowly decreased over the course of deployment. pH values remained within the CCME Guidelines for Protection of Aquatic Life until October 23rd, after which they alternated above and below the minimum CCME Guideline.
- 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.

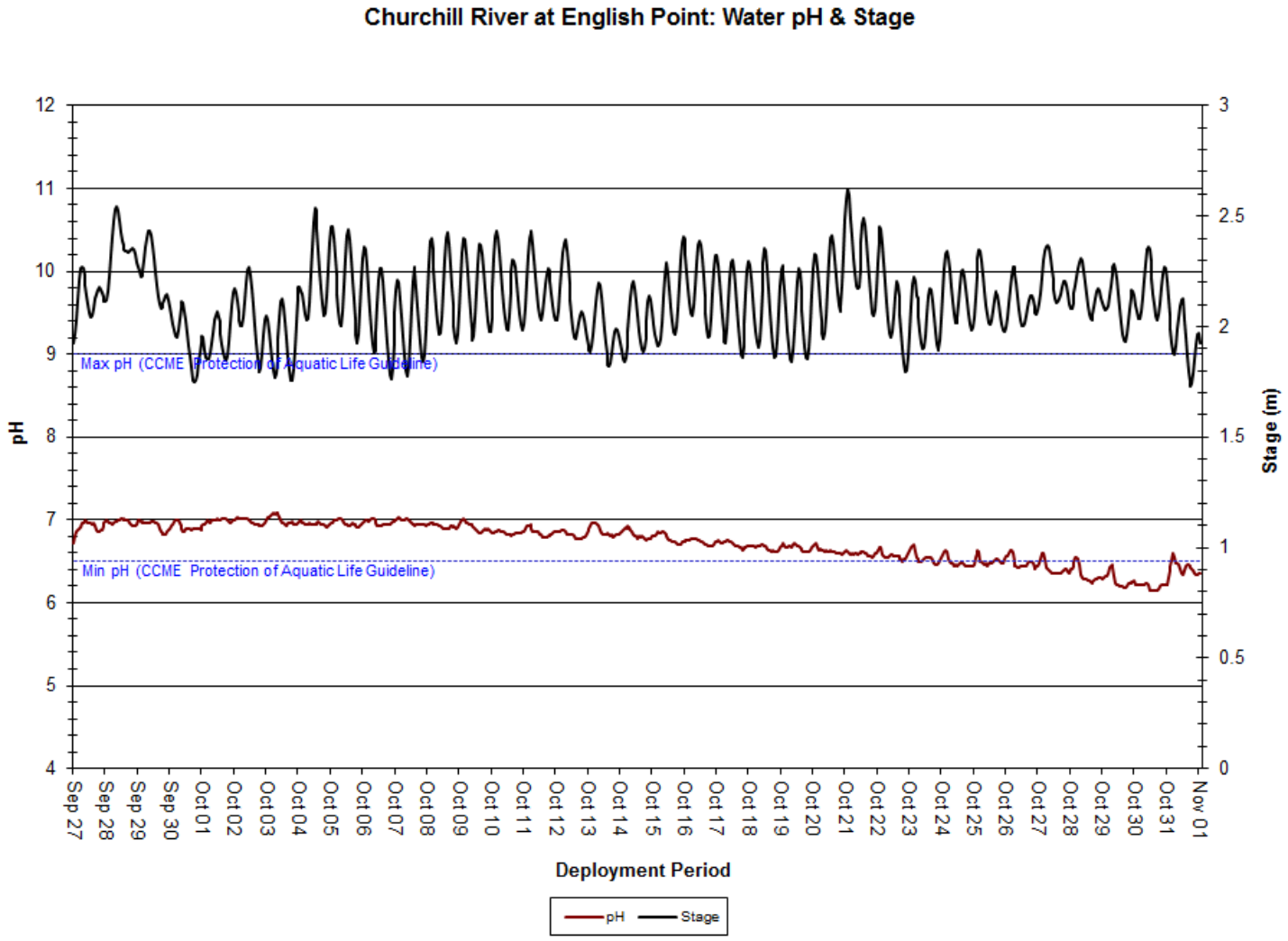

Figure 21: pH & Stage at Churchill River at English Point

Specific Conductivity

- Specific conductivity ranged from 20.1µS/cm to 57.9µs/cm, with a median value of 30.3µS/cm (Figure 22).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean on Lake Melville. As the tide comes in, specific conductivity increases as 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 22).
- 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.

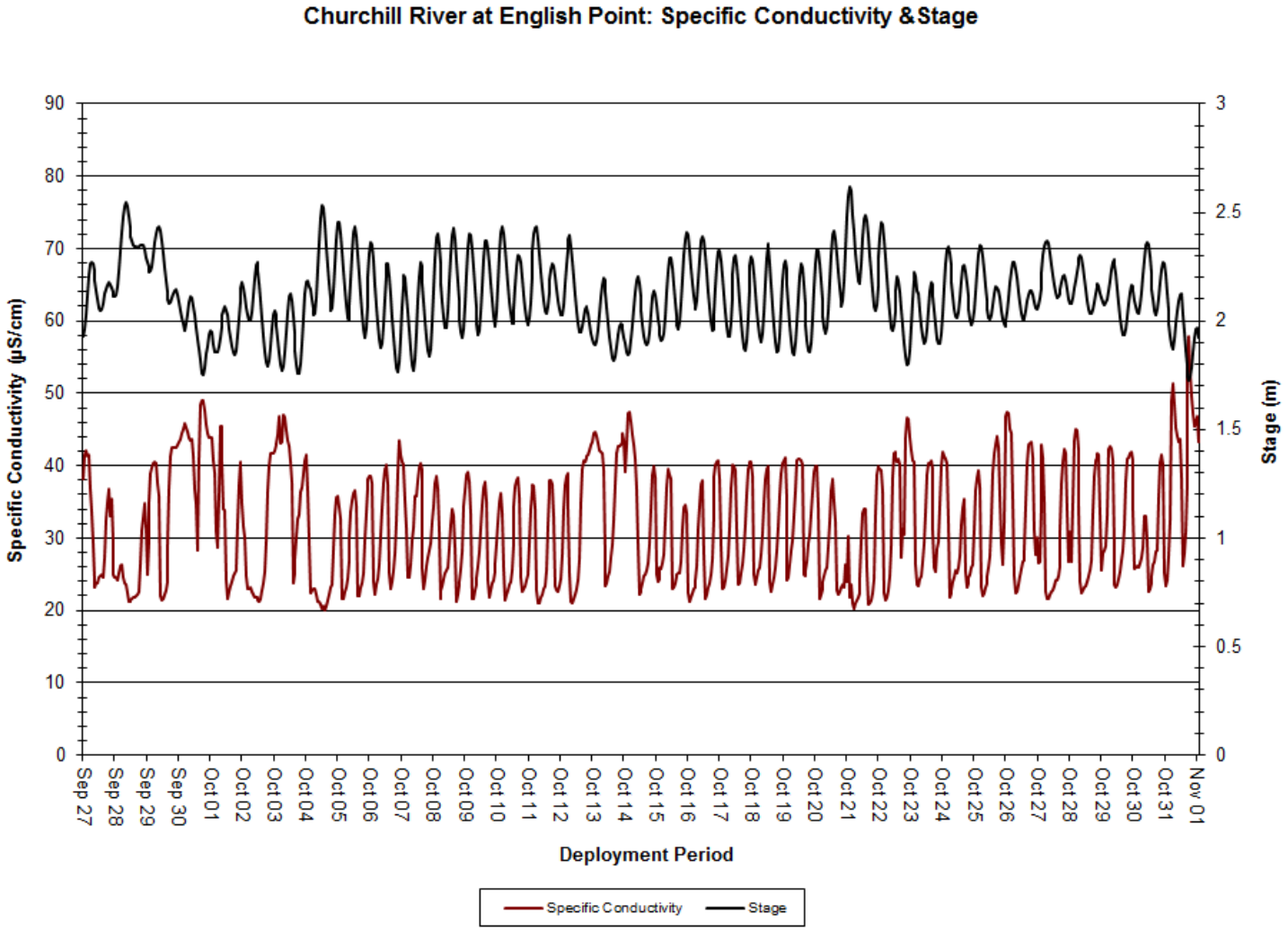

Figure 22: Specific Conductivity & Stage at Churchill River at English Point

Dissolved Oxygen

- Dissolved oxygen concentration ranged from 9.98mg/L to 13.31mg/L, with a median value of 11.71mg/L. The saturation of dissolved oxygen ranged from 87.8% to 106.9% saturation, with a median value of 98.1% (Figure 23).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decreased over the deployment period, dissolved oxygen levels slowly increased. Dissolved oxygen levels also follow a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels remained above the CCME Guidelines for the Protection of Early and Other Life Stages for the duration of deployment (Figure 23). This is to be expected considering decreasing water temperatures.

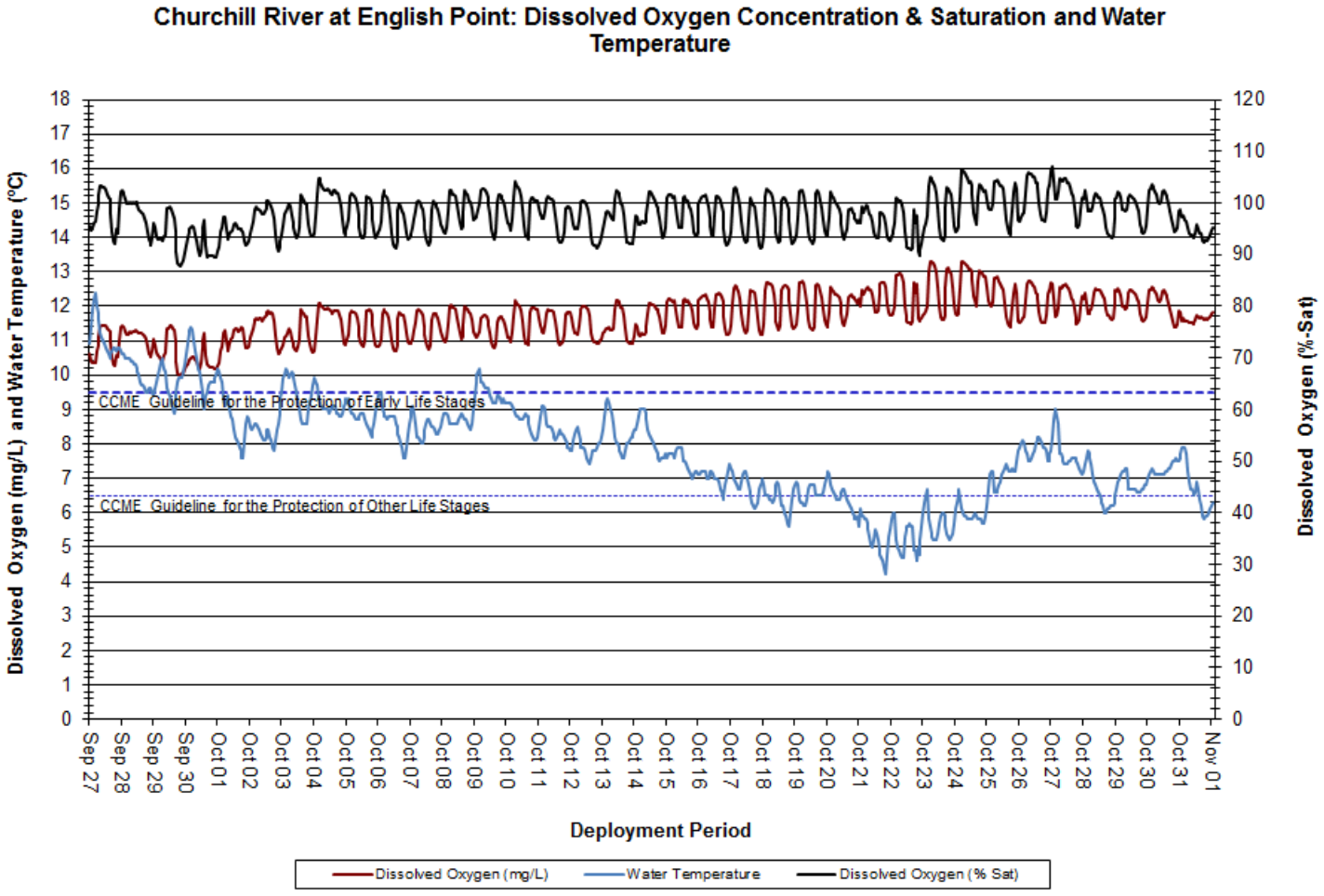

Figure 23: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Turbidity

- Turbidity ranged from 0.0NTU to 91.6NTU, with a median value of 0.0NTU (Figure 24). A median value of 0.0NTU indicates that there is very little background turbidity at this station.
- Turbidity events often correlate with increases in stage and precipitation events. Precipitation can increase the presence of suspended material in water (Figure 24).
- 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.

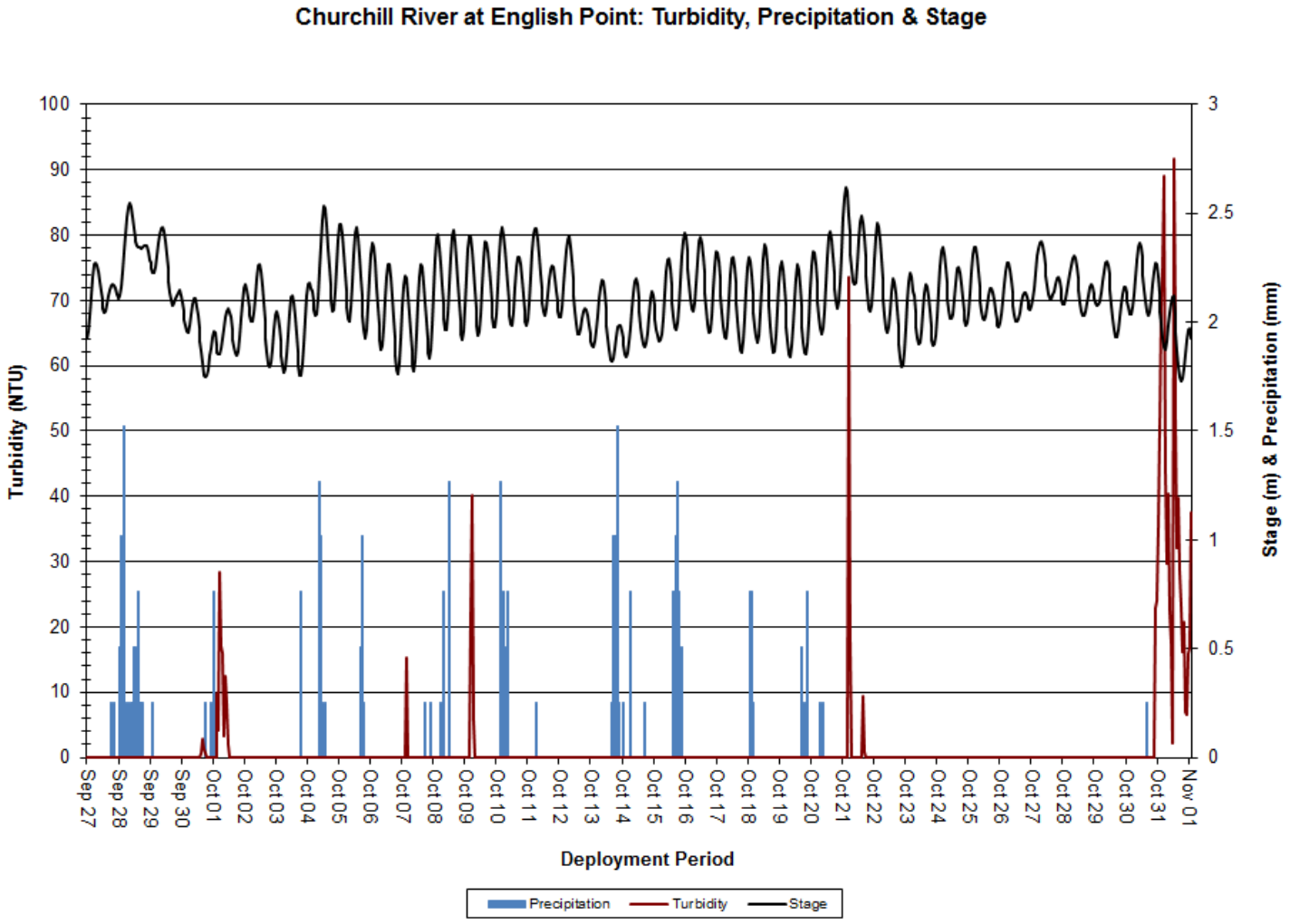

Figure 24: Turbidity, Precipitation & Stage at Churchill River at English Point

Stage

- Stage ranged from 1.73m to 2.62m, with a median value of 2.11m (Figure 25).
- Stage fluctuates at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, stage increases causing tide-related turbidity events, and vice versa as the tide goes out. This pattern is generally consistent throughout the deployment period (Figure 25). Tidal action may also suspend material in the water column, causing spikes in turbidity unrelated to precipitation events.
- 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.

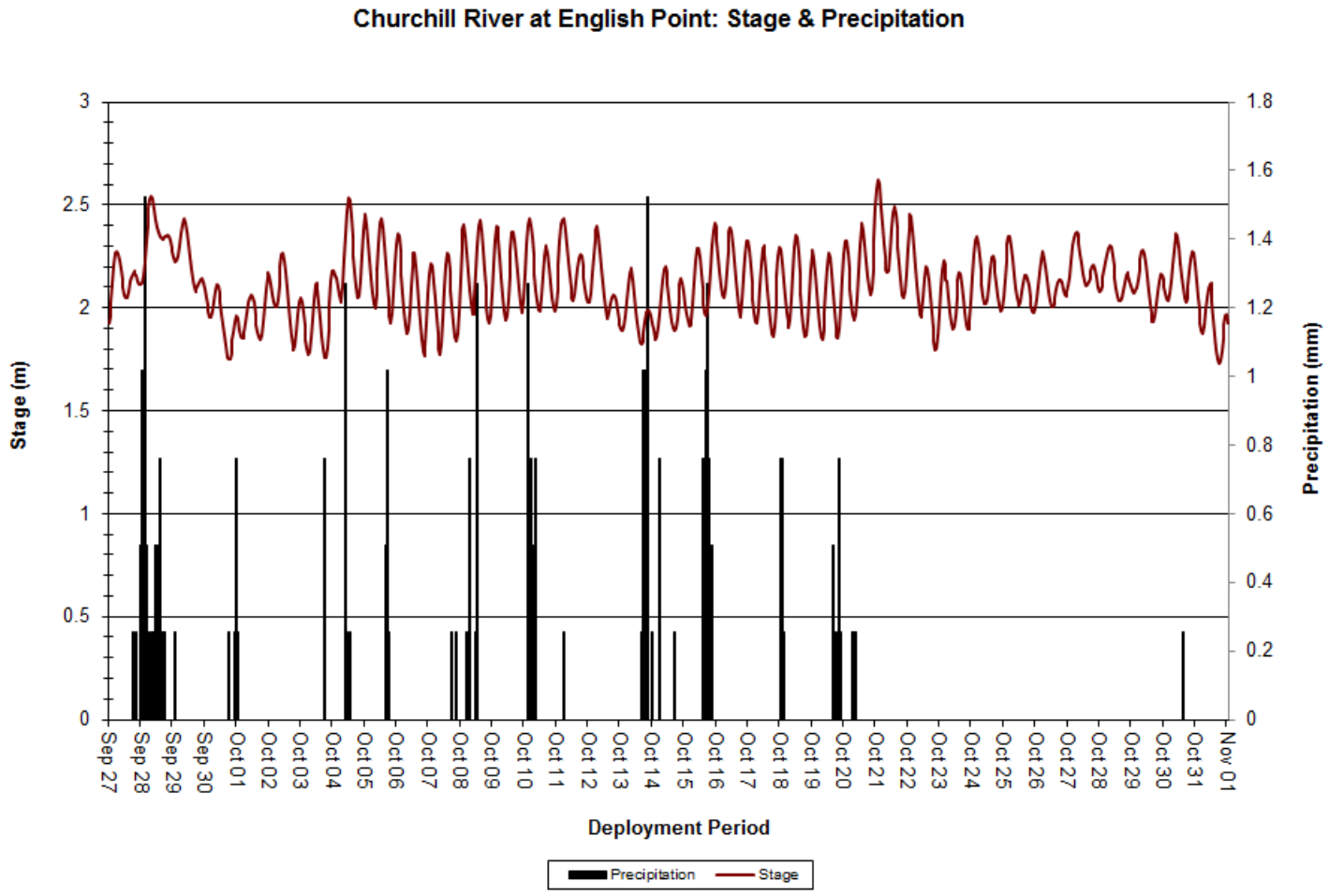

Figure 25: Stage & Precipitation (Mud Lake Weather Station) at Churchill River at English Point

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from September 27/29 to November 1/2, 2017 for periods of 33-35 days. Due to an unforeseen power issue, data from the Churchill River above Grizzle Rapids station is only available up to and including October 22nd, 2017.
- Water temperature was decreasing at all stations throughout the deployment period due to decreasing ambient air temperatures in the region. Water temperature ranged from 2.90°C at Churchill River below Metchin River to 12.40°C at Churchill River at English Point.
- pH was generally neutral and stable at stations along the Lower Churchill River, ranging from 6.14 to 7.09 at all stations. pH values were within the recommended CCME Guidelines for the Protection of Aquatic Life for the majority of deployment at three stations. pH values at Churchill River below Muskrat Falls were below the minimum guideline for most of this deployment period.
- Specific conductivity was relatively stable at the below Metchin River, above Grizzle Rapids and below Muskrat Falls stations, ranging from 17.8 to 21.5µS/cm. Since English Point is influenced by tides in Lake Melville, specific conductivity values at the Churchill River at English Point station had a much wider range between 20.1µS/cm and 57.9µS/cm. This is comparable to other deployments at this location.
- Dissolved oxygen was generally increasing throughout the deployment period at all stations as water temperatures decreased into the fall season. Dissolved oxygen levels are generally higher in a waterbody at cooler temperatures. Dissolved oxygen values ranged from 9.98mg/L to 14.15mg/L, and remained above the CCME Guideline for the Protection of Early Life Stages for the duration of deployment at all stations.
- Turbidity events occurred at three stations, and were related to both precipitation events and tidal influences. At all stations, median turbidity values ranged from 0.0NTU to 2.5NTU, which indicate low background turbidity levels. Turbidity at all stations ranged from 0.0 to 91.6NTU.

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. Available at: http://st-ts.ccme.ca/en/index.html?chems=154,162&chapters=1 [Accessed December 12, 2017].

Fondriest Environmental Inc. (2016a). Fundamentals of Environmental Measurements [Online]. Available at: http://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/#cond15 [Accessed December 12, 2017].

Fondriest Environmental Inc. (2016b). Fundamentals of Environmental Measurements [Online]. Available at: http://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature/#watertemp1 [Accessed December 12, 2017].

Swenson, H.A., and Baldwin, H.L. (1965). A Primer on Water Quality, U.S. Geological Survey. Available at: https://pubs.usgs.gov/gip/7000057/report.pdf [Accessed December 12, 2017].

United States Geological Survey. (2017). Water properties: Dissolved oxygen [Online]. Available at: https://water.usgs.gov/edu/dissolvedoxygen.html [Accessed December 12, 2017].

APPENDIX A

Station Comparisons

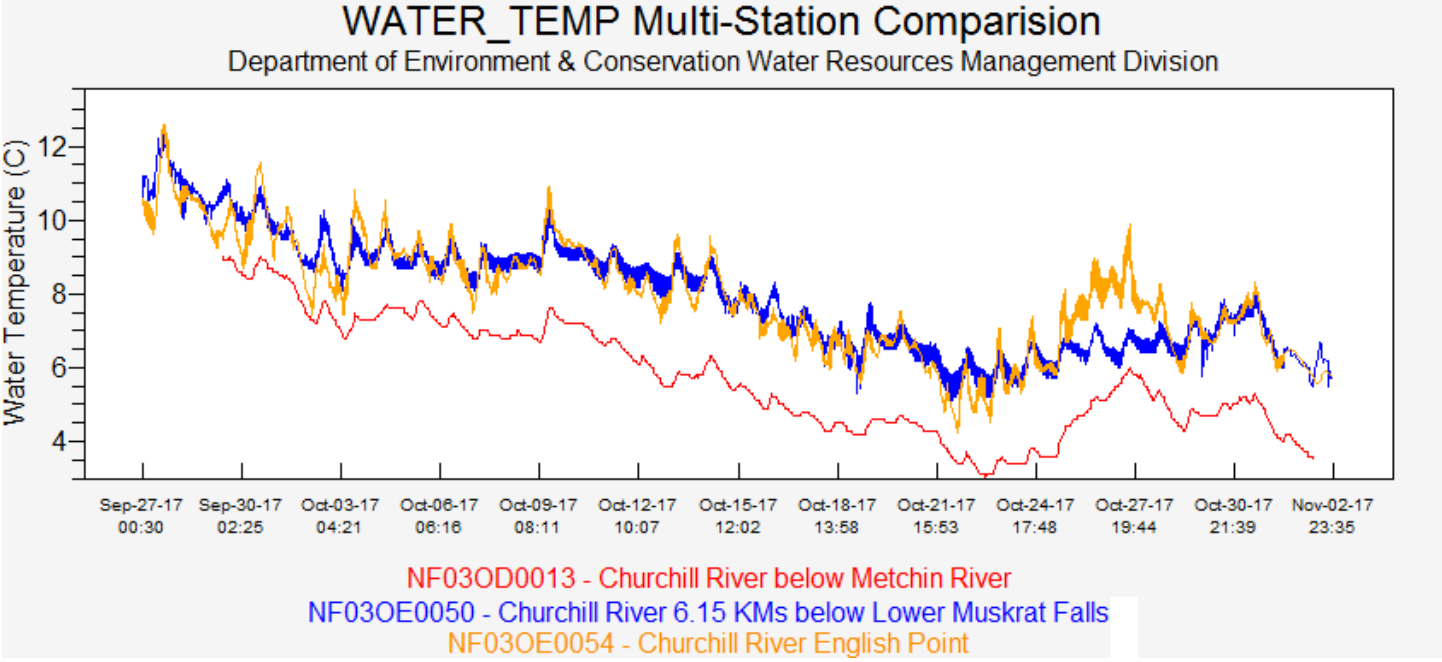

Figure A1: Comparison of Water Temperature at the Real-Time Stations on Churchill River

(Note: Grizzle Rapids station not included due to transmission issues)

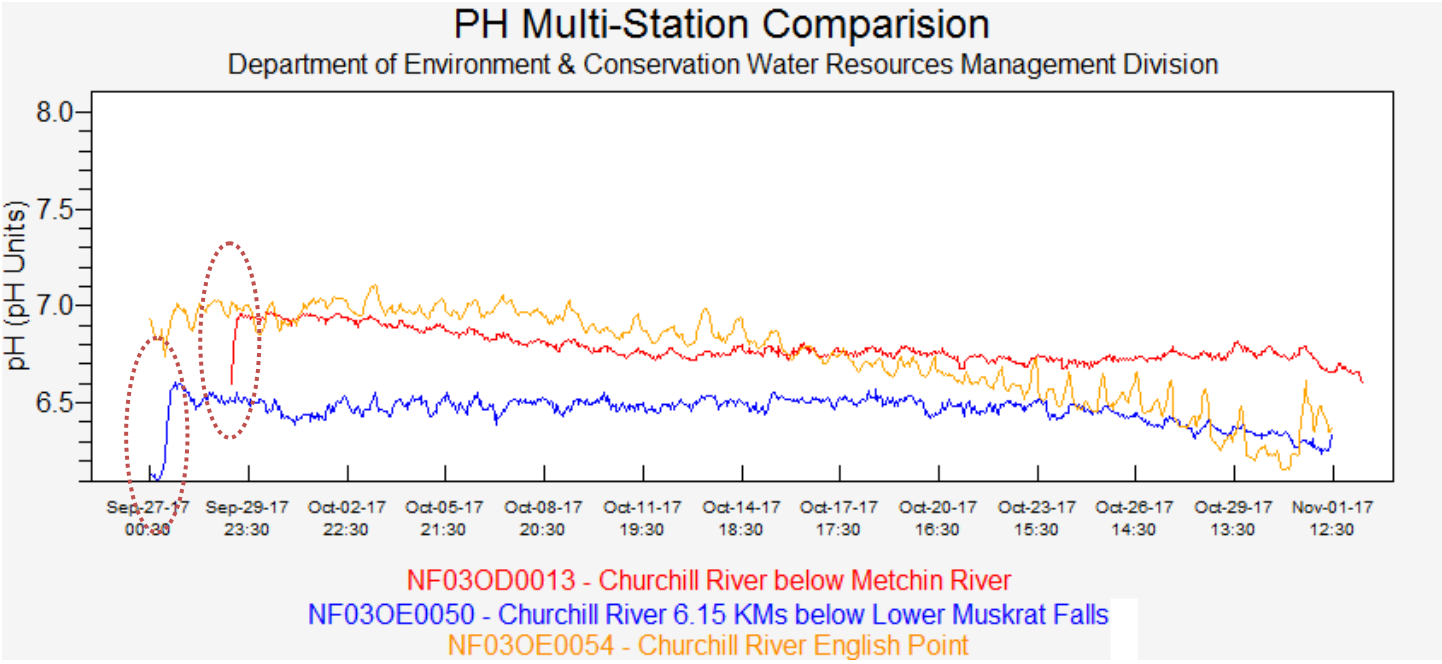

Figure A2: Comparison of pH at the Real-Time Stations on Churchill River. Circled data represents stabilization and acclimatization period for instrument sensor.

(Note: Grizzle Rapids station not included due to transmission issues)

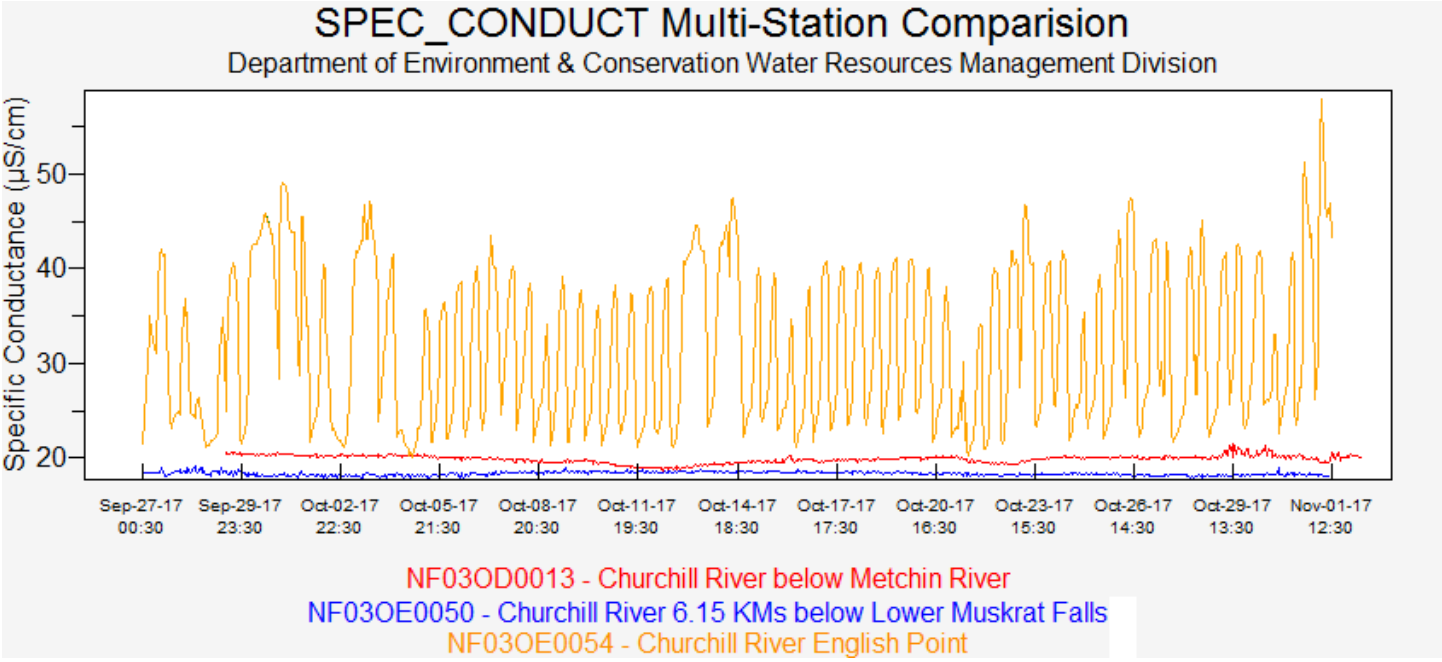

Figure A3: Comparison of Specific Conductivity at the Real-Time Stations on Churchill River

(Note: Grizzle Rapids station not included due to transmission issues)

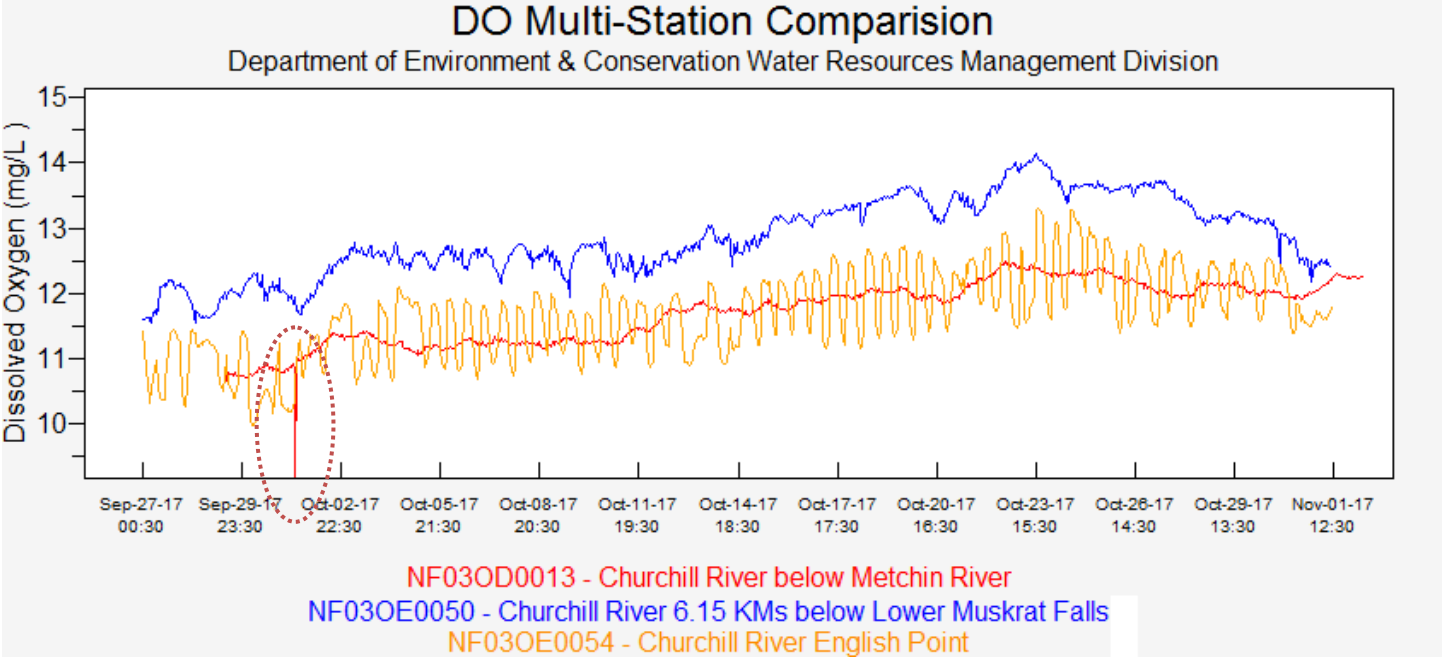

Figure A4: Comparison of Dissolved Oxygen at the Real-Time Stations on Churchill River. Circled data point removed for QA/QC purposes.

(Note: Grizzle Rapids station not included due to transmission issues)

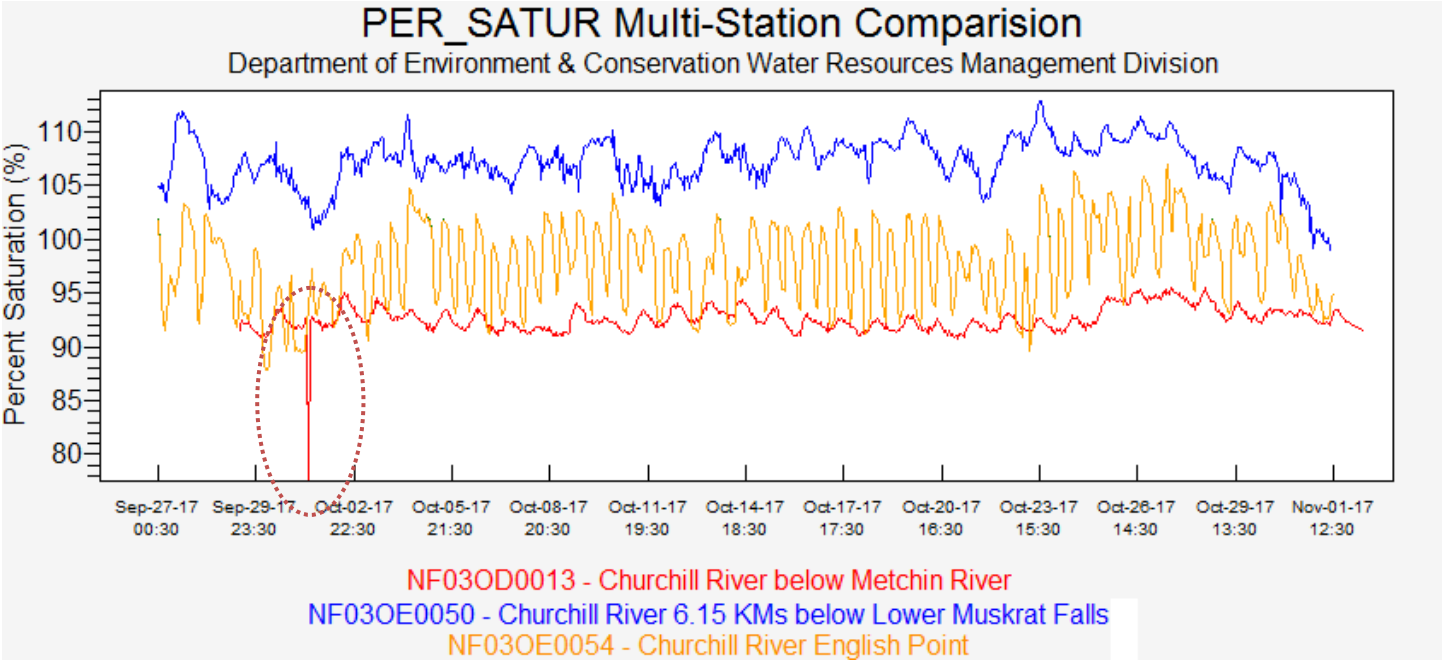

Figure A5: Comparison of Dissolved Oxygen (% Sat) at the Real-Time Stations on Churchill River. Circled data point removed for QA/QC purposes.

(Note: Grizzle Rapids station not included due to transmission issues)

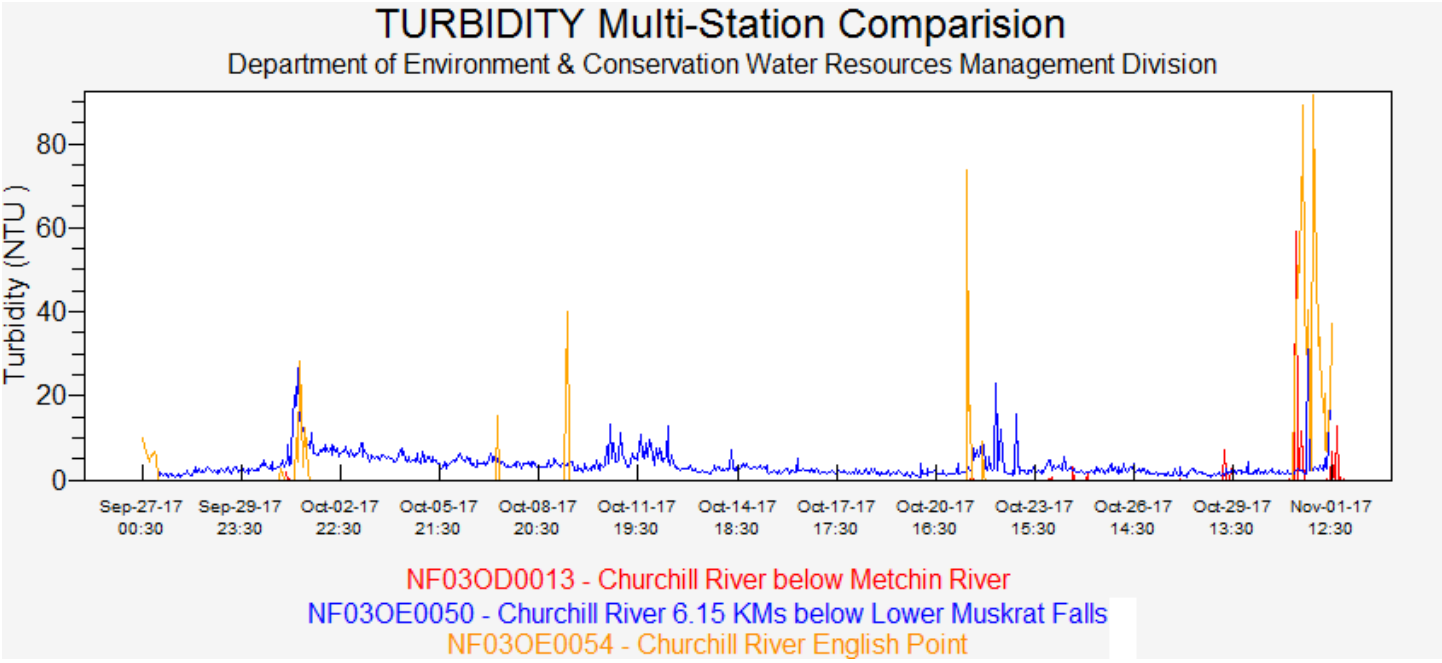

Figure A6: Comparison of Turbidity at the Real-Time Stations on Churchill River

(Note: Grizzle Rapids station not included due to transmission issues)

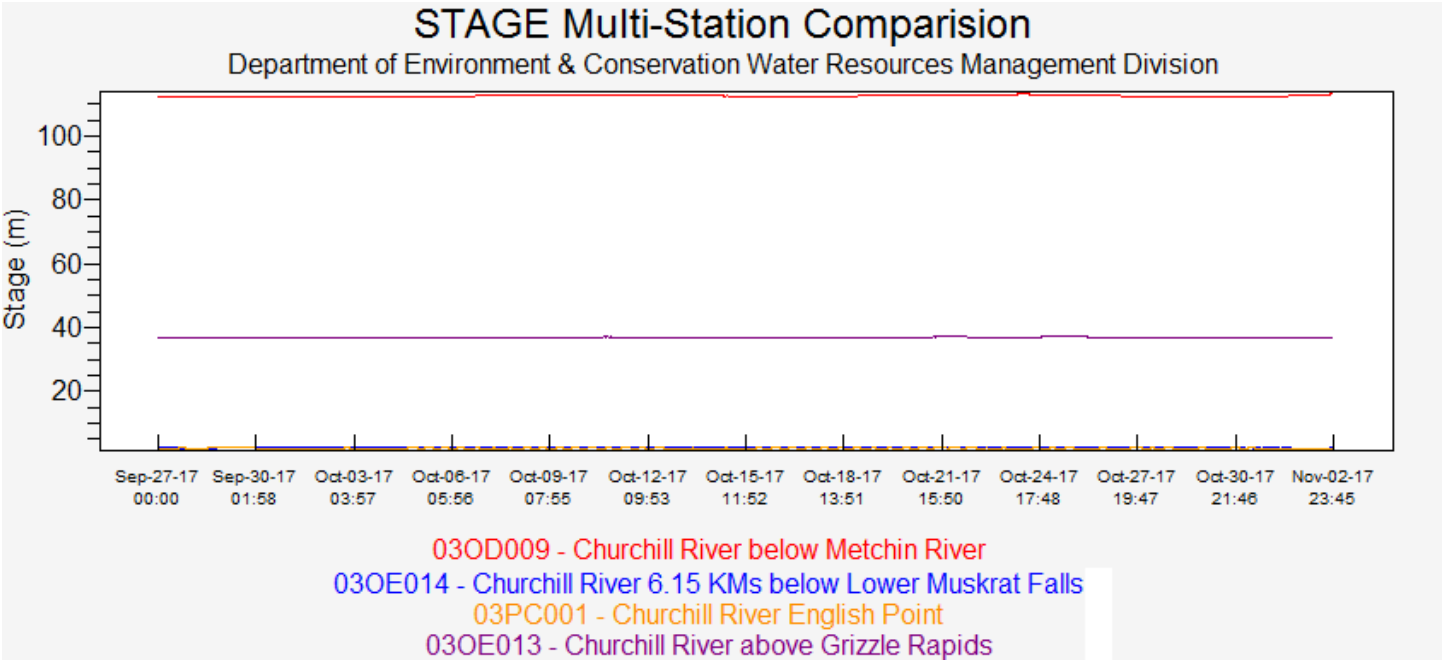

Figure A7: Comparison of Stage at the Real-Time Stations on Churchill River

APPENDIX B

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 C

Grab Sample Results

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Maxxam Job #: B7L6751
Report Date: 2017/10/13

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
FFZ807 CR below HR								
Sampling Date 2017/09/29 11:20								
Matrix W								
Sample # 2017-6333-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	14	1.0	mg/L	N/A	2017/10/12	2017/10/12		5193727
Hardness (CaCO3)	9.5	1.0	mg/L	N/A	2017/10/06	2017/10/06		5193720
Nitrate (N)	<0.050	0.050	mg/L	N/A	2017/10/12	2017/10/12		5193723
Inorganics								
Conductivity	21	1.0	uS/cm	N/A	2017/10/06	2017/10/06	SSI	5200160
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2017/10/06	2017/10/06	FD	5200522
Total Alkalinity (Total as CaCO3)	11	5.0	mg/L	N/A	2017/10/11	2017/10/11	MCN	5203855
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2017/10/12	2017/10/12	MCN	5203857
Colour	18	5.0	TCU	N/A	2017/10/12	2017/10/12	MCN	5203875
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2017/10/06	2017/10/06	SSI	5200162
Total Kjeldahl Nitrogen (TKN)	0.12	0.10	mg/L	+/- <RDL	2017/10/07	2017/10/10	RTY	5202477
Nitrite (N)	<0.010	0.010	mg/L	N/A	2017/10/12	2017/10/12	MCN	5203888
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2017/10/11	2017/10/11	MCN	5205716
Dissolved Organic Carbon (C)	3.7	0.50	mg/L	N/A	2017/10/13	2017/10/13	SMT	5210366
Total Organic Carbon (C)	3.9	0.50	mg/L	N/A	2017/10/13	2017/10/13	SMT	5210235
pH	7.26	N/A	pH	N/A	2017/10/06	2017/10/06	SSI	5200159
Total Phosphorus	<0.004	0.004	mg/L	N/A	2017/10/07	2017/10/10	ASP	5202515
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2017/10/11	2017/10/11	MCN	5203863
Turbidity	0.64	0.10	NTU	N/A	2017/10/10	2017/10/10	SSI	5203509
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2017/10/06	2017/10/10	ARS	5200870
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.038	0.0050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Barium (Ba)	0.0075	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Boron (B)	<0.050	0.050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Calcium (Ca)	2.4	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Iron (Fe)	0.12	0.050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Magnesium (Mg)	0.83	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Manganese (Mn)	0.016	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Potassium (K)	0.26	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518

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 #: B7L6751
Report Date: 2017/10/13

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
FFZ807 CR below HR								
Sampling Date 2017/09/29 11:20								
Matrix W								
Sample # 2017-6333-00-SI-SP								
Registration # WS-S-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Sodium (Na)	0.53	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Strontium (Sr)	0.011	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518

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Maxxam Job #: B7L6755
Report Date: 2017/10/11

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
FFZ819 CR below HR Sampling Date 2017/09/29 11:20 Matrix W Sample # 2017-6333-00-SI-SP Registration # WS-S-0000 **RESULTS OF ANALYSES OF WATER** **Inorganics**								
Total Suspended Solids	1.6	1.0	mg/L	N/A	2017/10/05	2017/10/10	AM6	5198507

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

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Maxxam Job #: B7L6751
Report Date: 2017/10/13

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
FFZ808 CR above GR								
Sampling Date 2017/09/29 10:40								
Matrix W								
Sample # 2017-6334-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	12	1.0	mg/L	N/A	2017/10/12	2017/10/12		5193727
Hardness (CaCO3)	8.4	1.0	mg/L	N/A	2017/10/06	2017/10/06		5193720
Nitrate (N)	<0.050	0.050	mg/L	N/A	2017/10/12	2017/10/12		5193723
Inorganics								
Conductivity	19	1.0	uS/cm	N/A	2017/10/06	2017/10/06	SSI	5200160
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2017/10/06	2017/10/06	FD	5200528
Total Alkalinity (Total as CaCO3)	8.9	5.0	mg/L	N/A	2017/10/11	2017/10/11	MCN	5203855
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2017/10/12	2017/10/12	MCN	5203857
Colour	29	5.0	TCU	N/A	2017/10/12	2017/10/12	MCN	5203875
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2017/10/06	2017/10/06	SSI	5200162
Total Kjeldahl Nitrogen (TKN)	0.12	0.10	mg/L	+/- <RDL	2017/10/07	2017/10/10	RTY	5202477
Nitrite (N)	<0.010	0.010	mg/L	N/A	2017/10/12	2017/10/12	MCN	5203888
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2017/10/11	2017/10/11	MCN	5205716
Dissolved Organic Carbon (C)	4.6	0.50	mg/L	N/A	2017/10/13	2017/10/13	SMT	5210366
Total Organic Carbon (C)	4.8	0.50	mg/L	N/A	2017/10/13	2017/10/13	SMT	5210235
pH	7.06	N/A	pH	N/A	2017/10/06	2017/10/06	SSI	5200159
Total Phosphorus	<0.004	0.004	mg/L	N/A	2017/10/07	2017/10/10	ASP	5202515
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2017/10/11	2017/10/11	MCN	5203863
Turbidity	0.62	0.10	NTU	N/A	2017/10/10	2017/10/10	SSI	5203505
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2017/10/06	2017/10/10	ARS	5200870
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.058	0.0050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Barium (Ba)	0.0070	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Boron (B)	<0.050	0.050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Calcium (Ca)	2.2	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Iron (Fe)	0.14	0.050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Magnesium (Mg)	0.72	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Manganese (Mn)	0.0083	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Potassium (K)	0.27	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518

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Maxxam Job #: B7L6751
Report Date: 2017/10/13

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
FFZ808 CR above GR								
Sampling Date 2017/09/29 10:40								
Matrix W								
Sample # 2017-6334-00-SI-SP								
Registration # WS-S-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Sodium (Na)	0.55	0.10	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Strontium (Sr)	0.012	0.0020	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2017/10/05	2017/10/06	BAN	5198518

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Maxxam Job #: B7L6755
Report Date: 2017/10/11

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
FFZ820 CR above GR								
Sampling Date 2017/09/29 10:40								
Matrix W								
Sample # 2017-6334-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	1.8	1.0	mg/L	N/A	2017/10/05	2017/10/10	AM6	5198507

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Maxxam Job #: B7L3428
Report Date: 2017/10/12

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
FFI962 Lower Muskrat								
Sampling Date 2017/09/27 12:15								
Matrix W								
Sample # 2017-6329-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	13	1.0	mg/L	N/A	2017/10/11	2017/10/11		5187384
Hardness (CaCO3)	8.7	1.0	mg/L	N/A	2017/10/05	2017/10/05		5187378
Nitrate (N)	<0.050	0.050	mg/L	N/A	2017/10/11	2017/10/11		5187381
Inorganics								
Conductivity	19	1.0	uS/cm	N/A	2017/10/04	2017/10/04	SSI	5195795
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2017/10/03	2017/10/03	FD	5193796
Total Alkalinity (Total as CaCO3)	10	5.0	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200389
Dissolved Chloride (Cl)	<1.0	1.0	mg/L	N/A	2017/10/11	2017/10/11	KBT	5200395
Colour	33	5.0	TCU	N/A	2017/10/11	2017/10/11	KBT	5200413
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2017/10/04	2017/10/04	SSI	5195797
Total Kjeldahl Nitrogen (TKN)	0.13	0.10	mg/L	+/- <RDL	2017/10/03	2017/10/04	RTY	5194099
Nitrite (N)	<0.010	0.010	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200420
Nitrogen (Ammonia Nitrogen)	0.080	0.050	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200842
Dissolved Organic Carbon (C)	4.4	0.50	mg/L	N/A	2017/10/12	2017/10/12	SMT	5205650
Total Organic Carbon (C)	5.0	0.50	mg/L	N/A	2017/10/12	2017/10/12	SMT	5205661
pH	7.06	N/A	pH	N/A	2017/10/04	2017/10/04	SSI	5195794
Total Phosphorus	0.006	0.004	mg/L	+/- 0.004	2017/10/03	2017/10/03	ASP	5193756
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200405
Turbidity	1.0	0.10	NTU	N/A	2017/10/04	2017/10/04	SSI	5200217
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2017/10/04	2017/10/05	ARS	5195971
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.15	0.0050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Barium (Ba)	0.0084	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Boron (B)	<0.050	0.050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Calcium (Ca)	2.2	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Iron (Fe)	0.23	0.050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Magnesium (Mg)	0.76	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Manganese (Mn)	0.0082	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Potassium (K)	0.27	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840

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Maxxam Job #: B7L3428
Report Date: 2017/10/12

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
FFI962 Lower Muskrat								
Sampling Date 2017/09/27 12:15								
Matrix W								
Sample # 2017-6329-00-SI-SP								
Registration # WS-S-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Sodium (Na)	0.68	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Strontium (Sr)	0.012	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5195840

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Maxxam Job #: B7L3411
Report Date: 2017/10/06

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
FFI840 Lower Muskrat								
Sampling Date 2017/09/27 12:15								
Matrix W								
Sample # 2017-6329-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	3.0	1.0	mg/L	N/A	2017/10/04	2017/10/05	AM6	5195820

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Maxxam Job #: B7L3428
Report Date: 2017/10/12

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
FFI964 CR @ EP								
Sampling Date 2017/09/27 10:30								
Matrix W								
Sample # 2017-6331-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Calculated Parameters								
Calculated TDS	22	1.0	mg/L	N/A	2017/10/11	2017/10/11		5187384
Hardness (CaCO3)	9.6	1.0	mg/L	N/A	2017/10/05	2017/10/05		5187378
Nitrate (N)	<0.050	0.050	mg/L	N/A	2017/10/11	2017/10/11		5187381
Inorganics								
Conductivity	34	1.0	uS/cm	N/A	2017/10/04	2017/10/04	SSI	5195795
Bromide (Br-)	<1.0	1.0	mg/L	N/A	2017/10/03	2017/10/03	FD	5193796
Total Alkalinity (Total as CaCO3)	10	5.0	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200422
Dissolved Chloride (Cl)	4.6	1.0	mg/L	N/A	2017/10/11	2017/10/11	KBT	5200425
Colour	48	5.0	TCU	N/A	2017/10/11	2017/10/11	KBT	5200432
Dissolved Fluoride (F-)	<0.10	0.10	mg/L	N/A	2017/10/04	2017/10/04	SSI	5195797
Total Kjeldahl Nitrogen (TKN)	0.13	0.10	mg/L	+/- <RDL	2017/10/03	2017/10/04	RTY	5194099
Nitrite (N)	<0.010	0.010	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200437
Nitrogen (Ammonia Nitrogen)	<0.050	0.050	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200842
Dissolved Organic Carbon (C)	5.8	0.50	mg/L	N/A	2017/10/12	2017/10/12	SMT	5205650
Total Organic Carbon (C)	5.9	0.50	mg/L	N/A	2017/10/11	2017/10/11	SMT	5205591
pH	7.01	N/A	pH	N/A	2017/10/04	2017/10/04	SSI	5195794
Total Phosphorus	0.014	0.004	mg/L	+/- 0.005	2017/10/03	2017/10/03	ASP	5193756
Dissolved Sulphate (SO4)	<2.0	2.0	mg/L	N/A	2017/10/10	2017/10/10	KBT	5200430
Turbidity	4.4	0.10	NTU	N/A	2017/10/05	2017/10/05	SSI	5196728
MERCURY BY COLD VAPOUR AA (WATER)								
Metals								
Total Mercury (Hg)	<0.000013	0.000013	mg/L	N/A	2017/10/04	2017/10/05	ARS	5195971
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Aluminum (Al)	0.21	0.0050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Antimony (Sb)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Arsenic (As)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Barium (Ba)	0.0089	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Boron (B)	<0.050	0.050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Cadmium (Cd)	<0.000010	0.000010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Calcium (Ca)	2.2	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Chromium (Cr)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Copper (Cu)	<0.0020	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Iron (Fe)	0.43	0.050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Lead (Pb)	<0.00050	0.00050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Magnesium (Mg)	0.99	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Manganese (Mn)	0.018	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Nickel (Ni)	<0.0020	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Potassium (K)	0.43	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093

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Maxxam Job #: B7L3428
Report Date: 2017/10/12

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
FFI964 CR @ EP								
Sampling Date 2017/09/27 10:30								
Matrix W								
Sample # 2017-6331-00-SI-SP								
Registration # WS-S-0000								
ELEMENTS BY ICP/MS (WATER)								
Metals								
Total Selenium (Se)	<0.0010	0.0010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Sodium (Na)	3.1	0.10	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Strontium (Sr)	0.017	0.0020	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Uranium (U)	<0.00010	0.00010	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093
Total Zinc (Zn)	<0.0050	0.0050	mg/L	N/A	2017/10/04	2017/10/05	BAN	5196093

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Maxxam Job #: B7L3411
Report Date: 2017/10/06

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
FFI842 CR @ EP								
Sampling Date 2017/09/27 10:30								
Matrix W								
Sample # 2017-6331-00-SI-SP								
Registration # WS-S-0000								
RESULTS OF ANALYSES OF WATER								
Inorganics								
Total Suspended Solids	4.6	1.0	mg/L	N/A	2017/10/04	2017/10/05	AM6	5195820

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