Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 26/October 12 to October 31/November 15, 2018

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.
- Real-time water quality monitoring instruments were deployed at Churchill River below Muskrat Falls and Churchill River at English Point on September 26th. The instrument at Churchill River above Grizzle Rapids was deployed on October 12th. The instruments at Churchill River below Muskrat Falls and Churchill River at English Point were removed on October 31st for a deployment period of 35 days. The instrument at Churchill River above Grizzle Rapids was removed on November 15th for a deployment period of 34 days.
- The instrument at Churchill River below Metchin River was deployed from August 17th until November 15th; however, for the purposes of this report, data from this station will be reported as if it had been deployed on October 12th. A 34 day deployment period will be used for reporting purposes, based on the installation and removal dates for Churchill River above Grizzle Rapids.
- 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 26/October 12 to October 31/November 15, 2018 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations September 26/October 12 to October 31/November 15, 2018

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	October 12, 2018	Deployment	N/A	N/A	N/A	N/A	N/A
	November 15, 2018	Removal	Good	Excellent	Good	Excellent	Poor
Above Grizzle Rapids	October 12, 2018	Deployment	Excellent	Excellent	Excellent	Good	Fair
	November 15, 2018	Removal	Good	Marginal	Good	Excellent	Fair
Below Muskrat Falls	September 26, 2018	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	October 31, 2018	Removal	Excellent	Poor	Excellent	Excellent	Poor
At English Point	September 26, 2018	Deployment	Good	Fair	Excellent	Excellent	Poor
	October 31, 2018	Removal	Good	Fair	Good	Fair	Fair
Above Muskrat Falls	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A

- **Churchill River below Metchin River**
  - Comparison rankings are not available for deployment since this instrument was physically deployed on August 17th.
  - At removal, pH and dissolved oxygen were 'excellent', temperature and conductivity were 'good', which turbidity was 'poor'. This discrepancy may have been caused by the QA/QC instrument not being placed in close enough proximity to the field sonde.

- **Churchill River above Grizzle Rapids**
  - At deployment, temperature, pH and conductivity were 'excellent', dissolved oxygen was 'good', while turbidity was 'fair'.
  - At removal, dissolved oxygen was 'excellent', temperature and conductivity were 'good', pH was 'marginal', and turbidity was 'fair'.

- **Churchill River below Muskrat Falls**
    - At deployment, all parameters were 'excellent'.
    - At removal, temperature, conductivity and dissolved oxygen were 'excellent', while pH and turbidity were 'poor'. Discrepancies observed for both pH and turbidity are likely due to sensor failures on the field sonde. As such, all affected data has been removed from the data set.

- **Churchill River at English Point**
    - At deployment, conductivity and dissolved oxygen were 'excellent', temperature was 'good', pH was 'fair', while turbidity was 'poor'. This discrepancy was likely caused by the QA/QC instrument not being placed in close enough proximity to the field sonde. This conclusion is supported by a 'good' QA/QC ranking between the field sonde and grab sample.
    - At removal, temperature and conductivity were 'good', while pH, dissolved oxygen and turbidity were 'fair'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from September 26/October 12 to October 31/November 15, 2018 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 stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

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

Churchill River below Metchin River

Water Temperature

- Over the deployment period, water temperature ranged from 0.10°C to 3.30°C, with a median value of 0.50°C (Figure 2). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature slowly decreased over the course of deployment. This is to be expected as air temperatures also decreased through the fall season. Water temperature data exhibits a diurnal pattern as expected, and closely correlates with ambient air temperatures.
- 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.

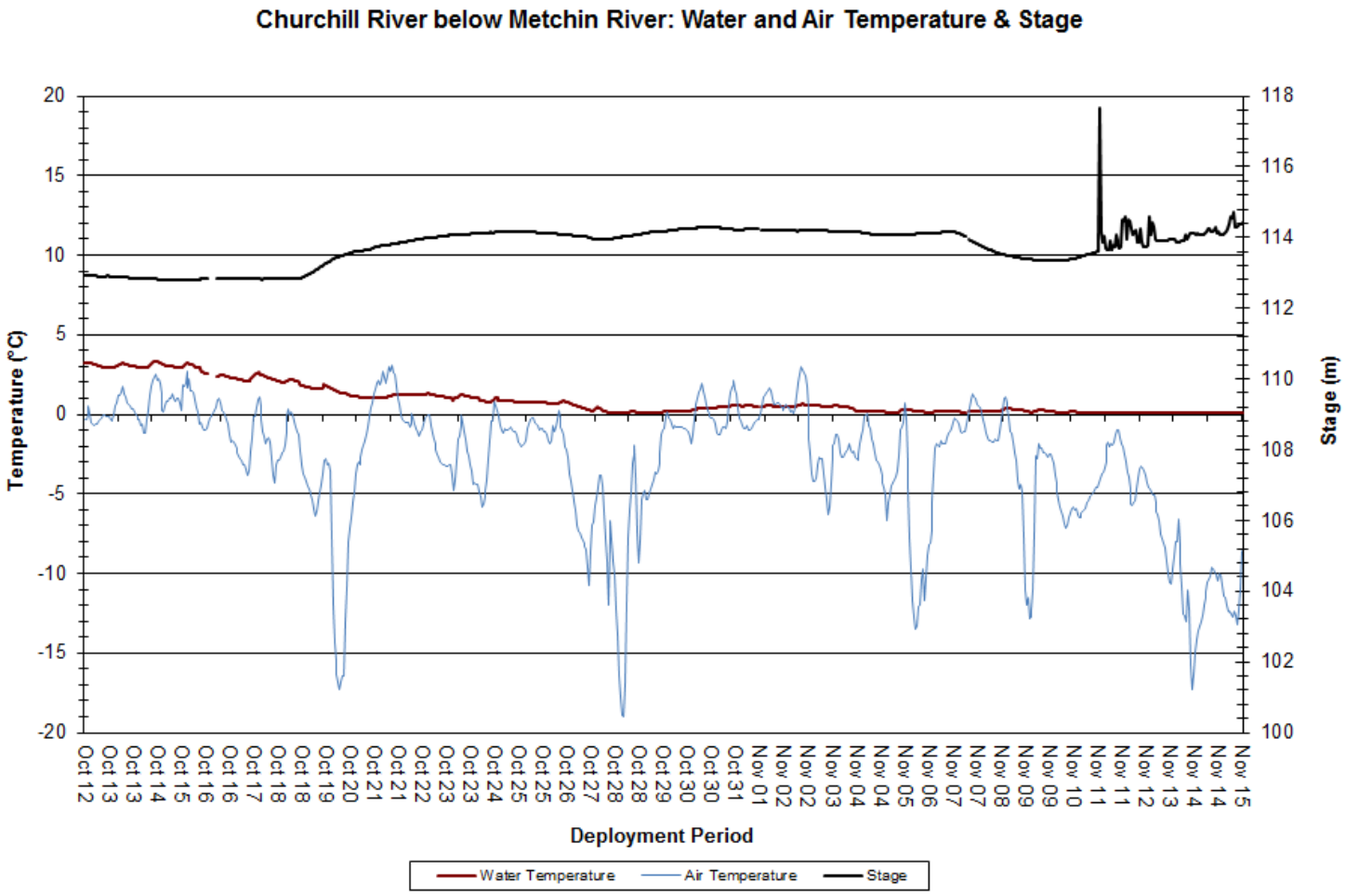

Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River

pH

- Over the deployment period, pH values ranged from 6.45 to 6.63 pH units, with a median value of 6.55 (Figure 3).
- pH values were very stable over the course of deployment and fell just within the CCME's Guidelines for the Protection of Aquatic Life for the majority of deployment.
- 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.

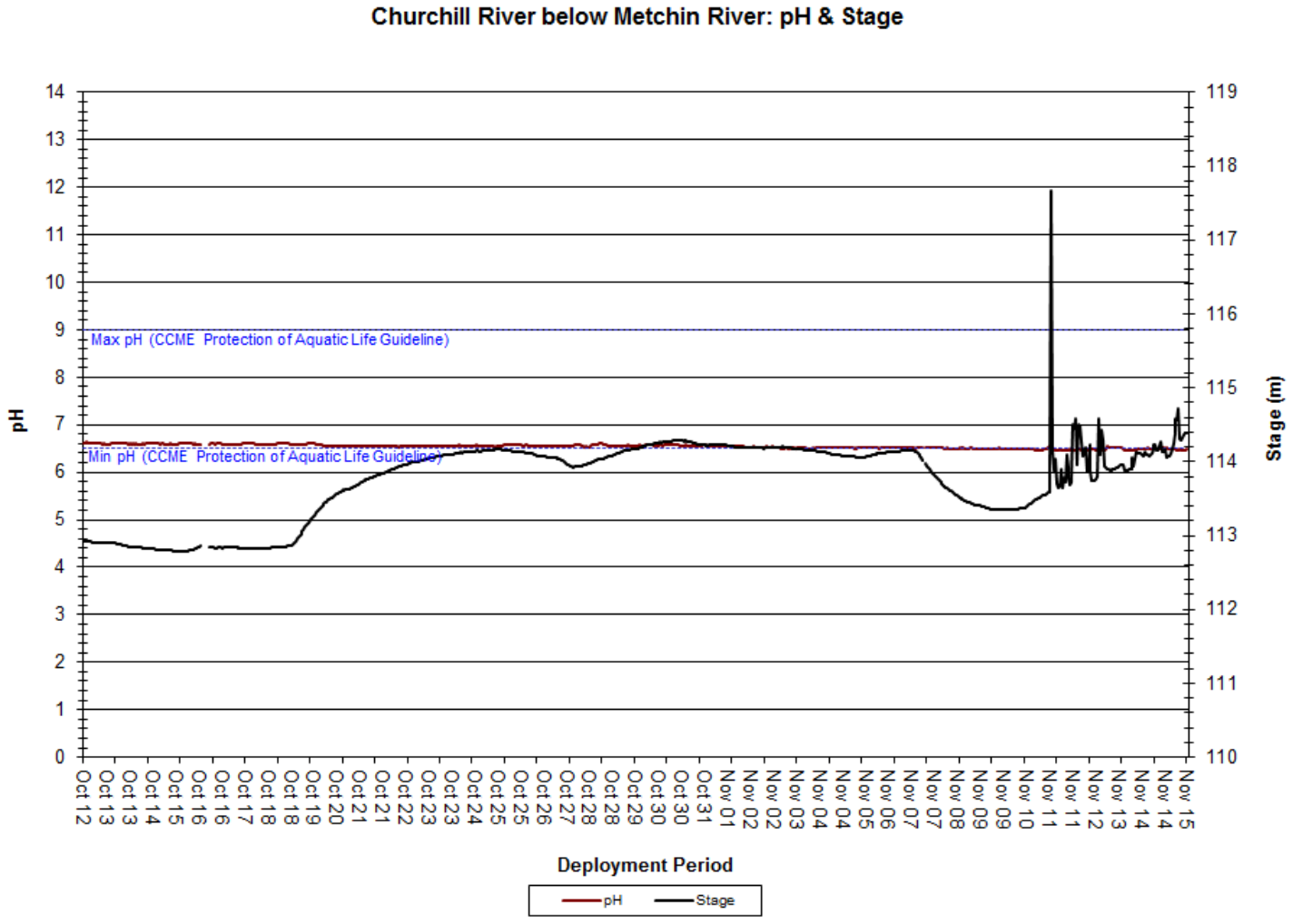

Figure 3: pH & Stage at Churchill River below Metchin River

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 10.6µS/cm to 20.4µS/cm, with a median value of 19.4µS/cm (Figure 4).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity 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.

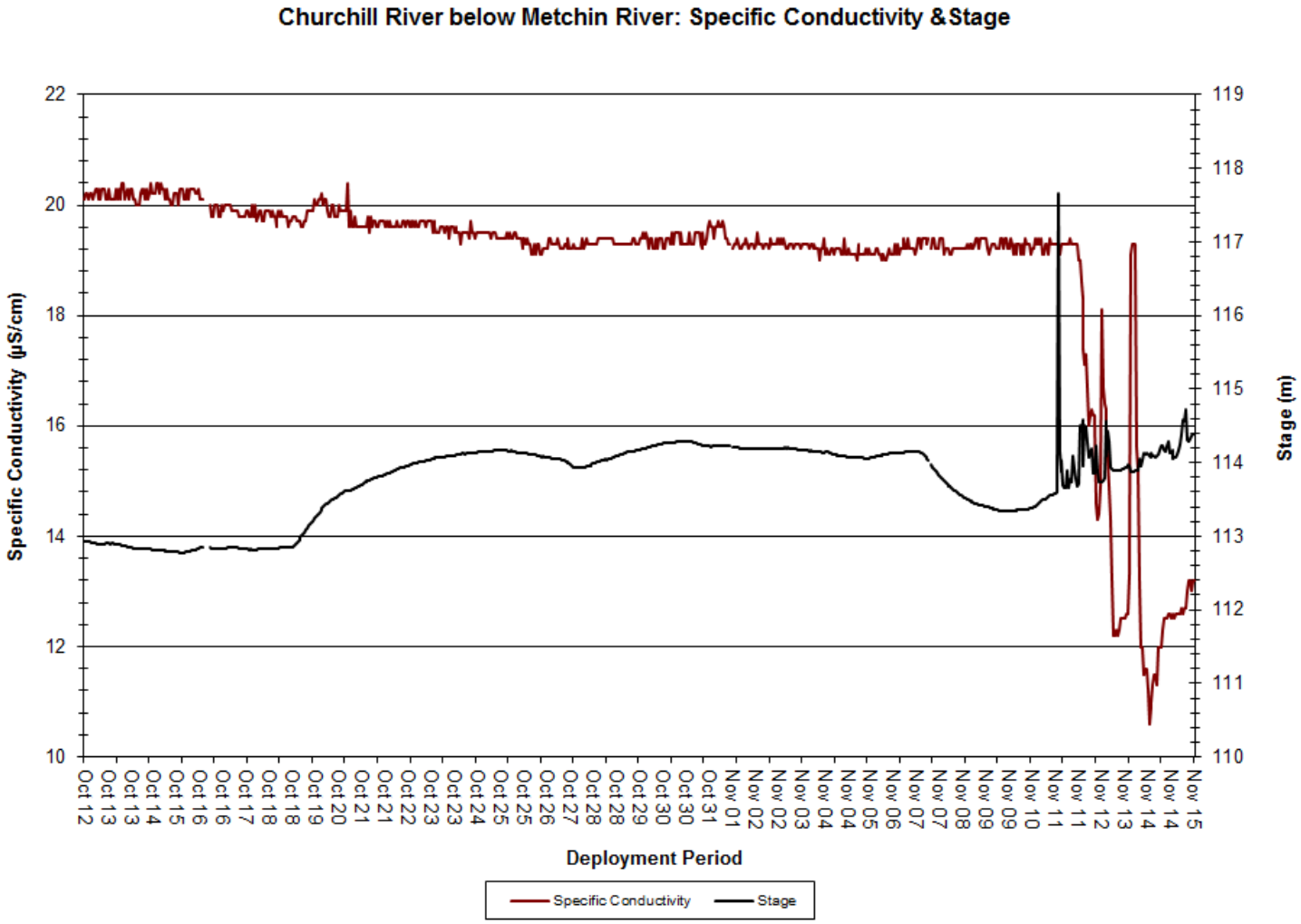

Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 12.53mg/L to 14.43mg/L, with a median value of 13.91mg/L. Saturation of dissolved oxygen ranged from 92.1% to 98.0%, with a median value of 95.4% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually increased as temperatures decreased 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 were well above the CCME's Guideline for the Protection of Early Life Stages for the duration of deployment.

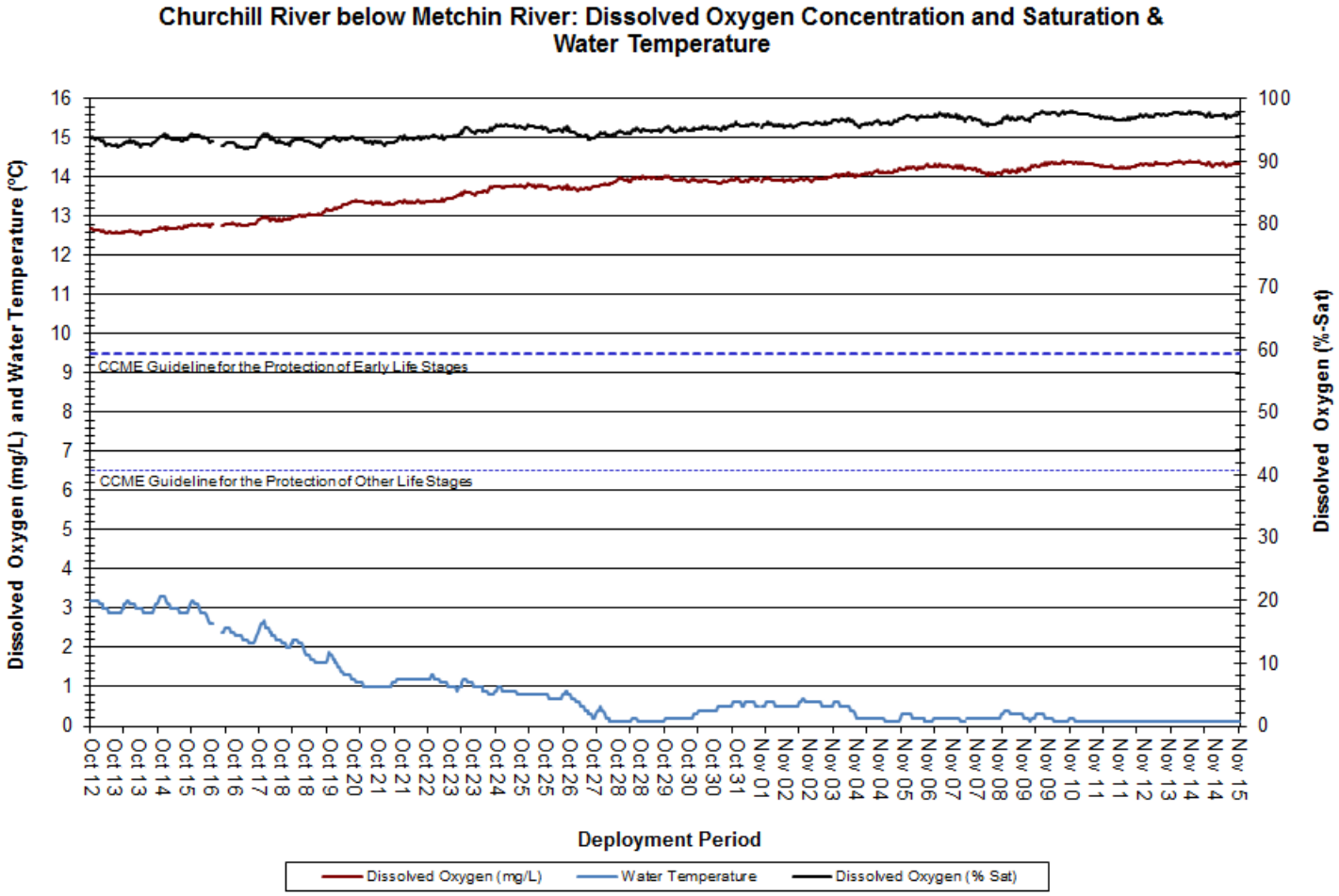

Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 13.0NTU, 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. Precipitation data was obtained from the Metchin River near TLH Weather Station.
- 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.
- 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.

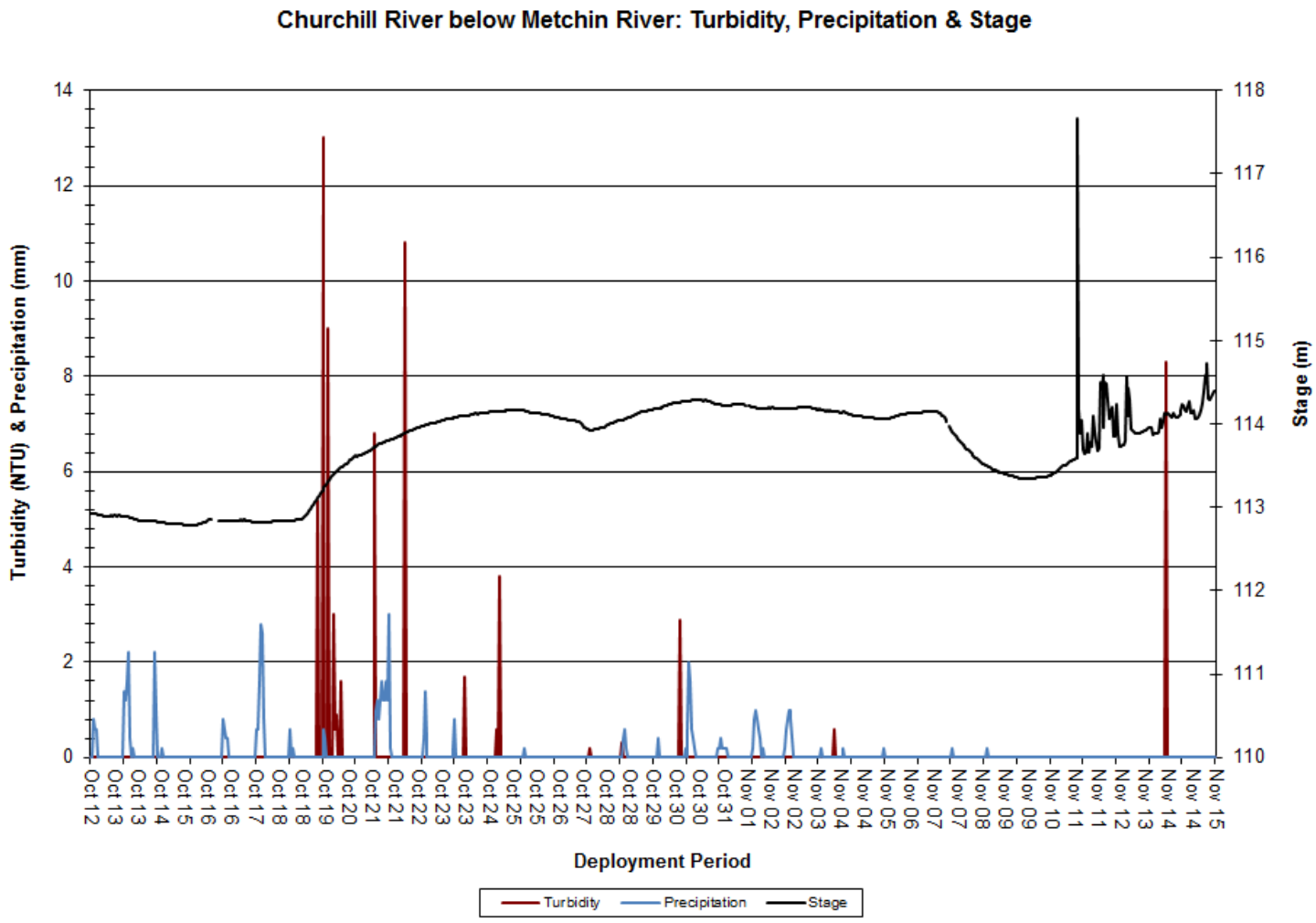

Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River

Stage and Flow

- Over the deployment period, stage levels ranged from 112.78m to 117.66m, with a median value of 114.01m. Flow ranged from 1163.48m^3/s to 1665.37m^3/s, with a median value of 1522.30m^3/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage was slightly variable across the deployment period, with flow following a very similar trend. Precipitation amounts across the same period are graphed below (Figure 8) to show that precipitation events often correlate with increases in both stage and flow.
- 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.

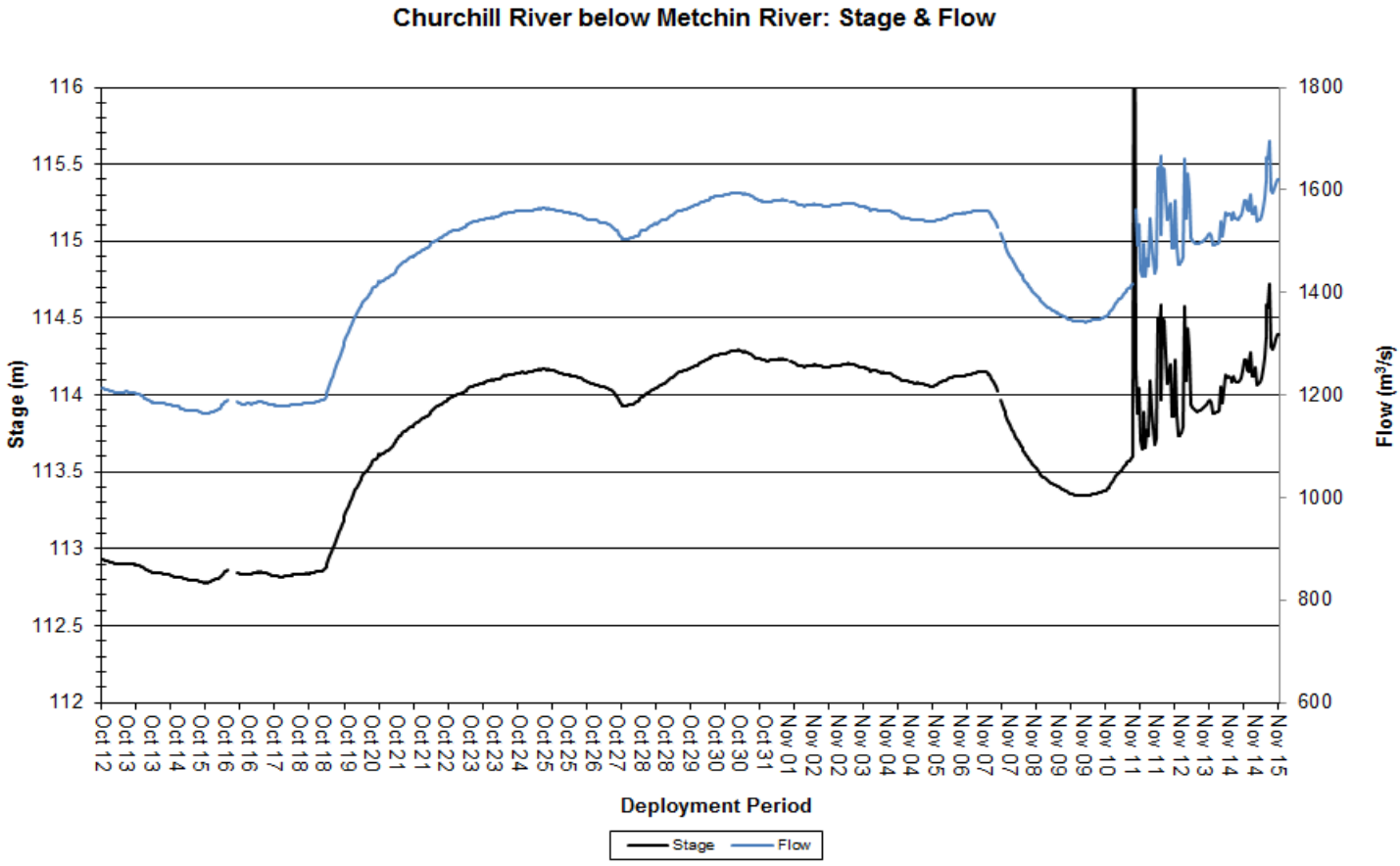

Figure 7: Stage & Flow at Churchill River below Metchin River

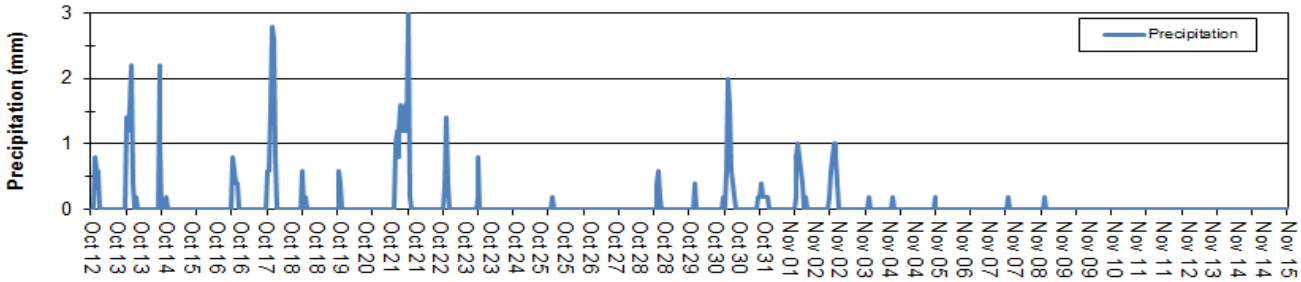

Figure 8: Precipitation at Churchill River below Metchin River

Churchill River above Grizzle Rapids

Water Temperature

- Over the deployment period, water temperature ranged from -0.20°C to 6.50°C, with a median value of 3.80°C (Figure 9). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature slowly decreased across the deployment period. This trend is to be expected as air temperatures also decreased through the fall season. Water temperature data exhibits a diurnal pattern, and closely correlates with ambient air temperatures.
- 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.

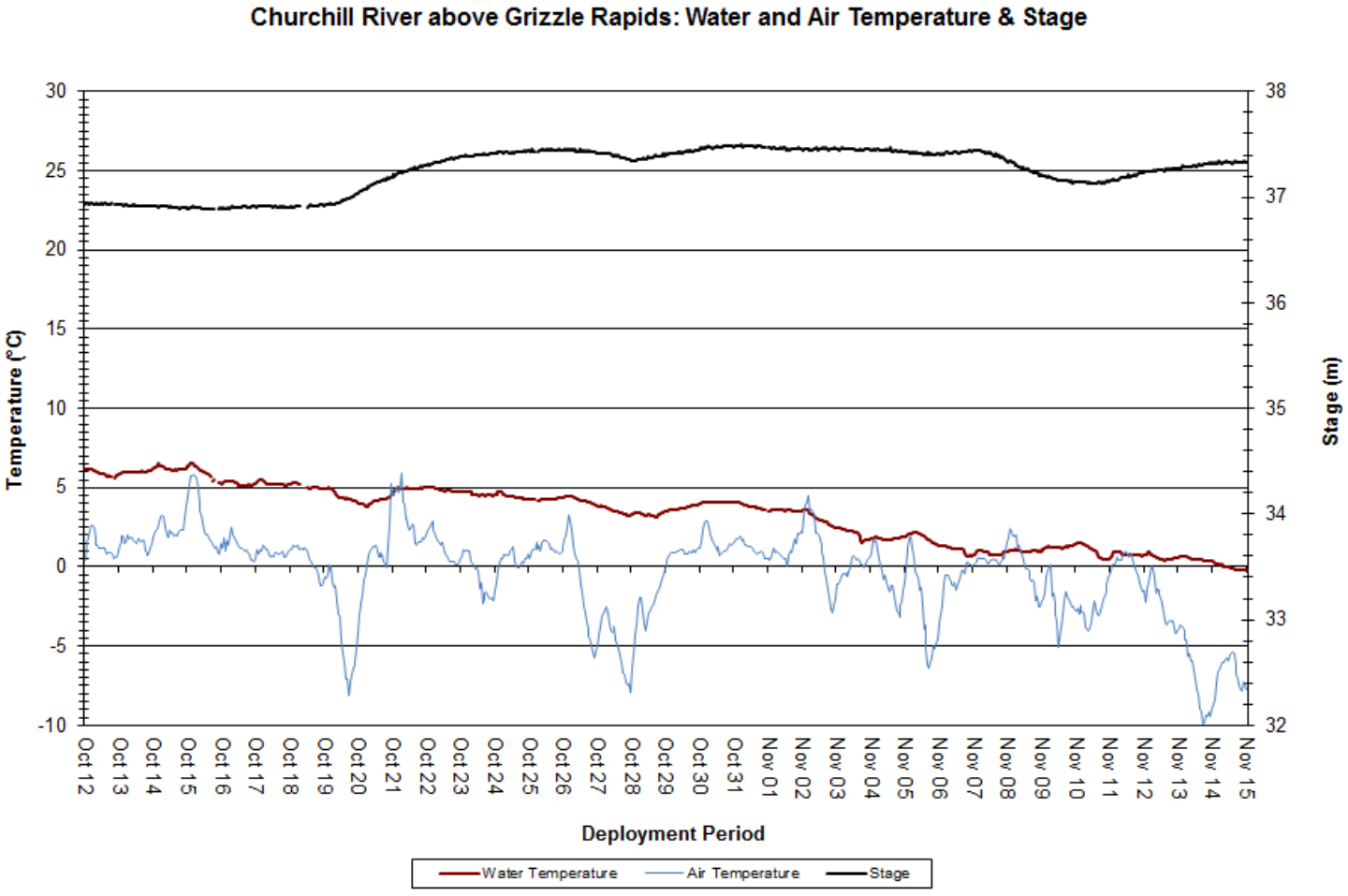

Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids

pH

- Over the deployment period, pH values ranged from 6.47 pH units to 6.83 pH units, with a median value of 6.61 (Figure 10).
- pH values were relatively stable and fell within the CCME's Guidelines for the Protection of Aquatic Life for the majority of deployment. An exception occurred from October 25th through October 28th, which corresponded closely with a significant increase in stage.
- 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 10).
- 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.

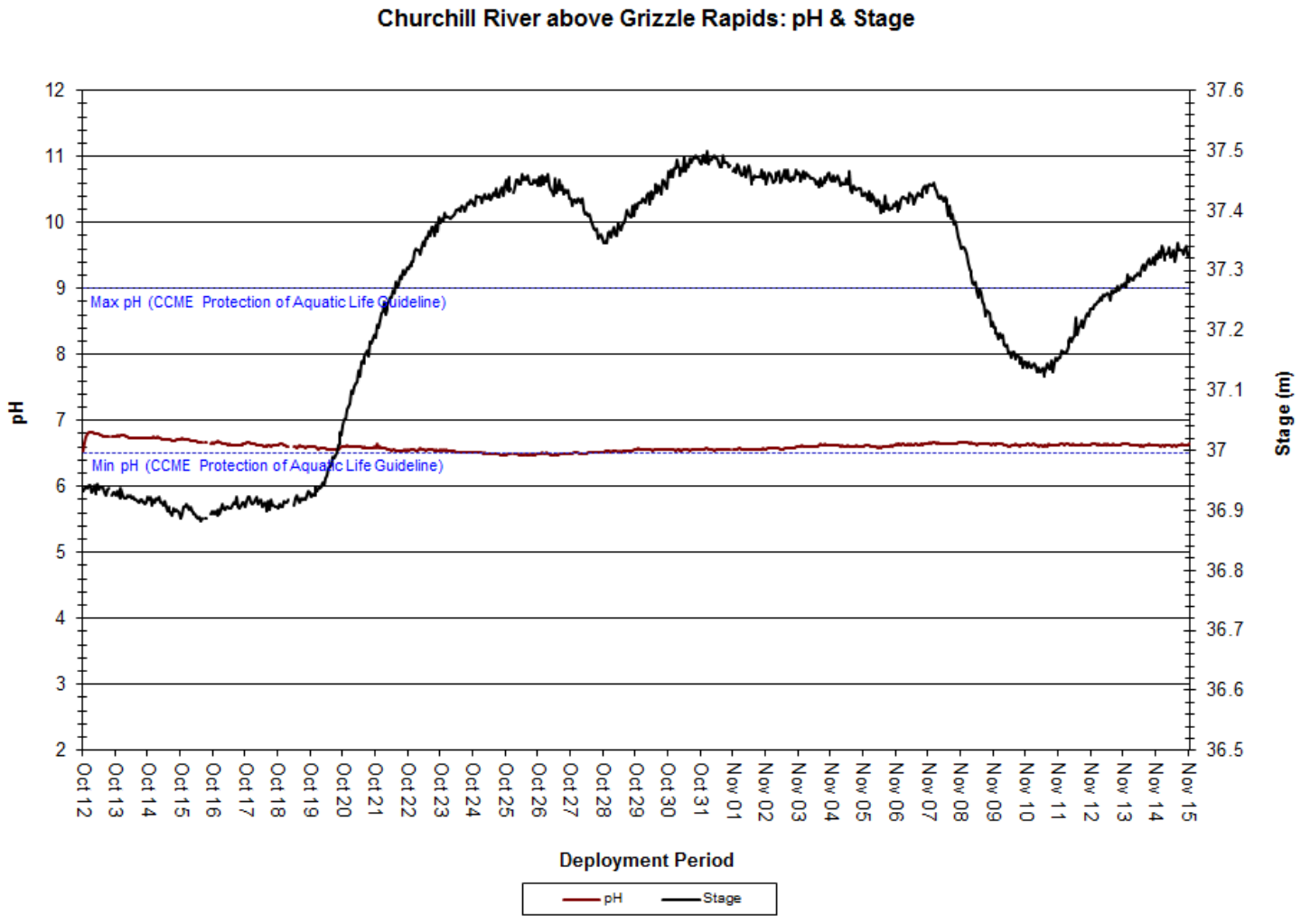

Figure 10: pH & Stage at Churchill River above Grizzle Rapids

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 16.4µS/cm to 18.5µS/cm, with a median of 17.6µS/cm (Figure 11).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity 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.

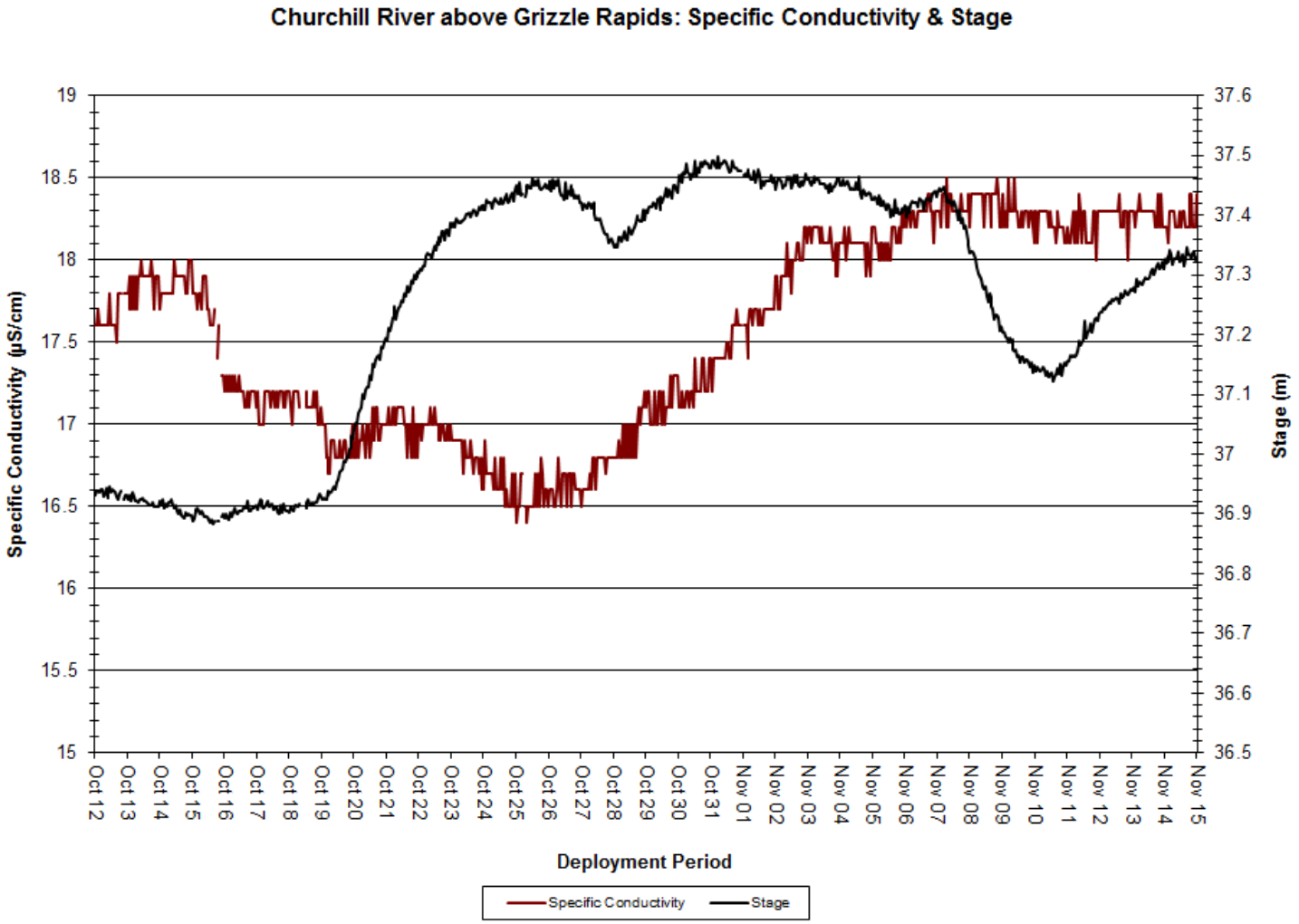

Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 11.81mg/L to 14.06mg/L, with a median value of 12.49mg/L. Saturation of dissolved oxygen ranged from 92.4% saturation to 97.3% saturation, with a median value of 94.7% (Figure 12).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually increased as water temperatures decreased 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 were well above the CCME's Guideline for the Protection of Early Life Stages for the duration of deployment. This is to be expected given the lower water temperatures observed through October and November.

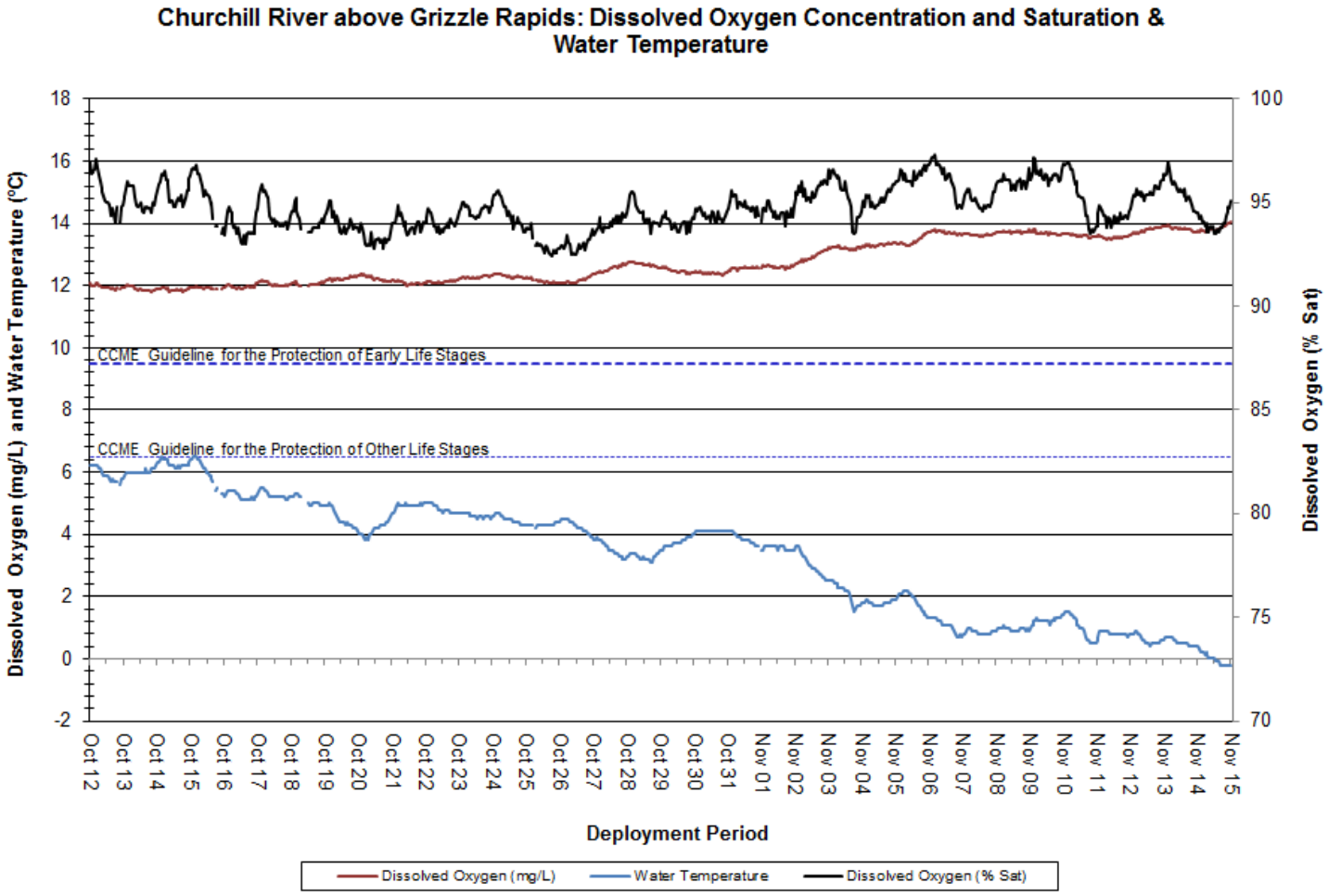

Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 36.7 NTU, with a median value of 0.0NTU (Figure 13). A median value of 0.0NTU indicates a very low level of natural background turbidity in the waterbody; however, the very small range of turbidity values observed may indicate an error with the sensor.
- Only two turbidity spikes were observed over the deployment period, which is very unusual for this station. Generally, turbidity spikes correlate with increases in stage, which further correlate with precipitation events; however, this relationship is not easily observed in the graph below (Figure 13).
- 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.

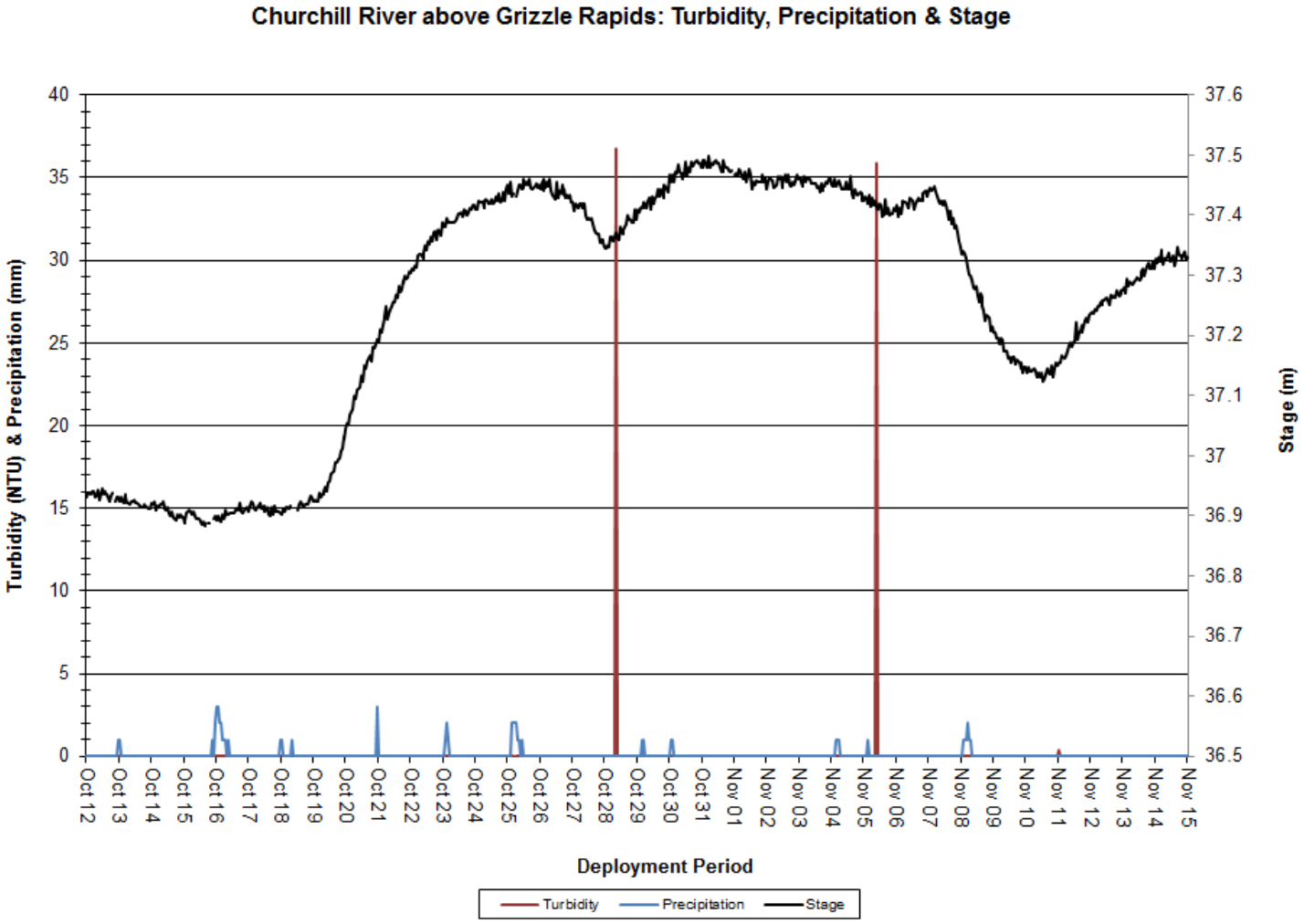

Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids

Stage & Flow

- Over the deployment period, stage ranged from 36.88m to 37.50m, with a median value of 37.34m (Figure 14). Flow ranged from 1306.36m^3/s to 2180.31m^3/s, with a median value of 1927.58m^3/s (Figure 14). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage and flow were variable across the course of deployment but followed a very similar trend. Precipitation across the same period is graphed below (Figure 15) to show that precipitation events often correlate with increases in both stage and flow.
- 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.

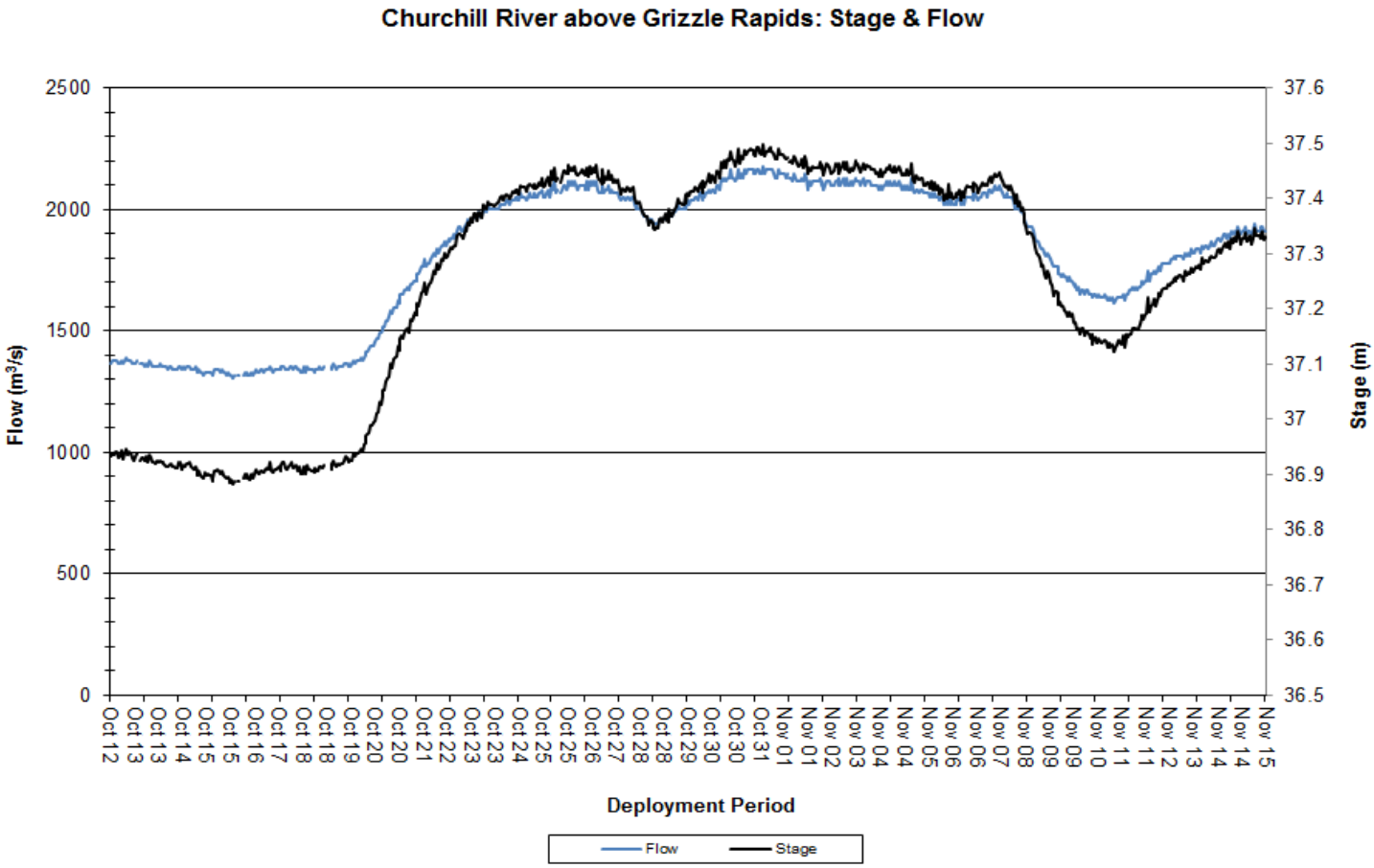

Figure 14: Stage & Flow at Churchill River above Grizzle Rapids

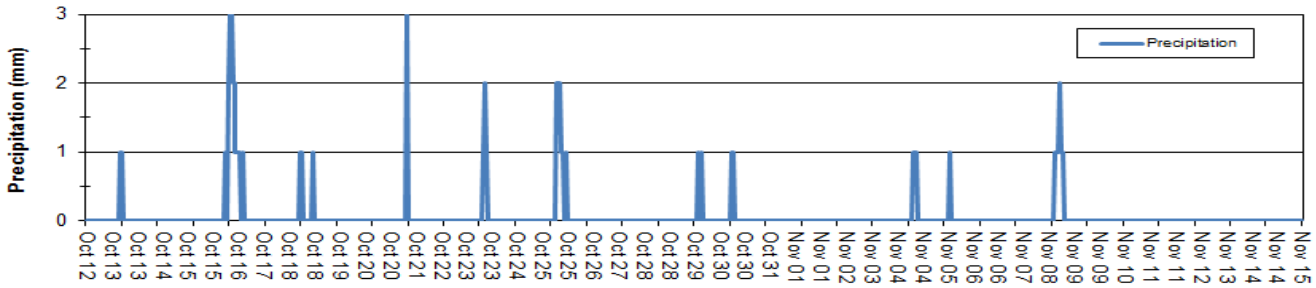

Figure 15: Precipitation at Churchill River above Grizzle Rapids

Churchill River below Muskrat Falls

Water Temperature

- Over the deployment period, water temperature ranged from 2.80°C to 10.20°C, with a median value of 5.90°C (Figure 16). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature slowly decreased over the course of the deployment period. This is to be expected as ambient air temperatures also decreased through the fall season. Water temperatures closely correlate with ambient air temperatures.
- 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.

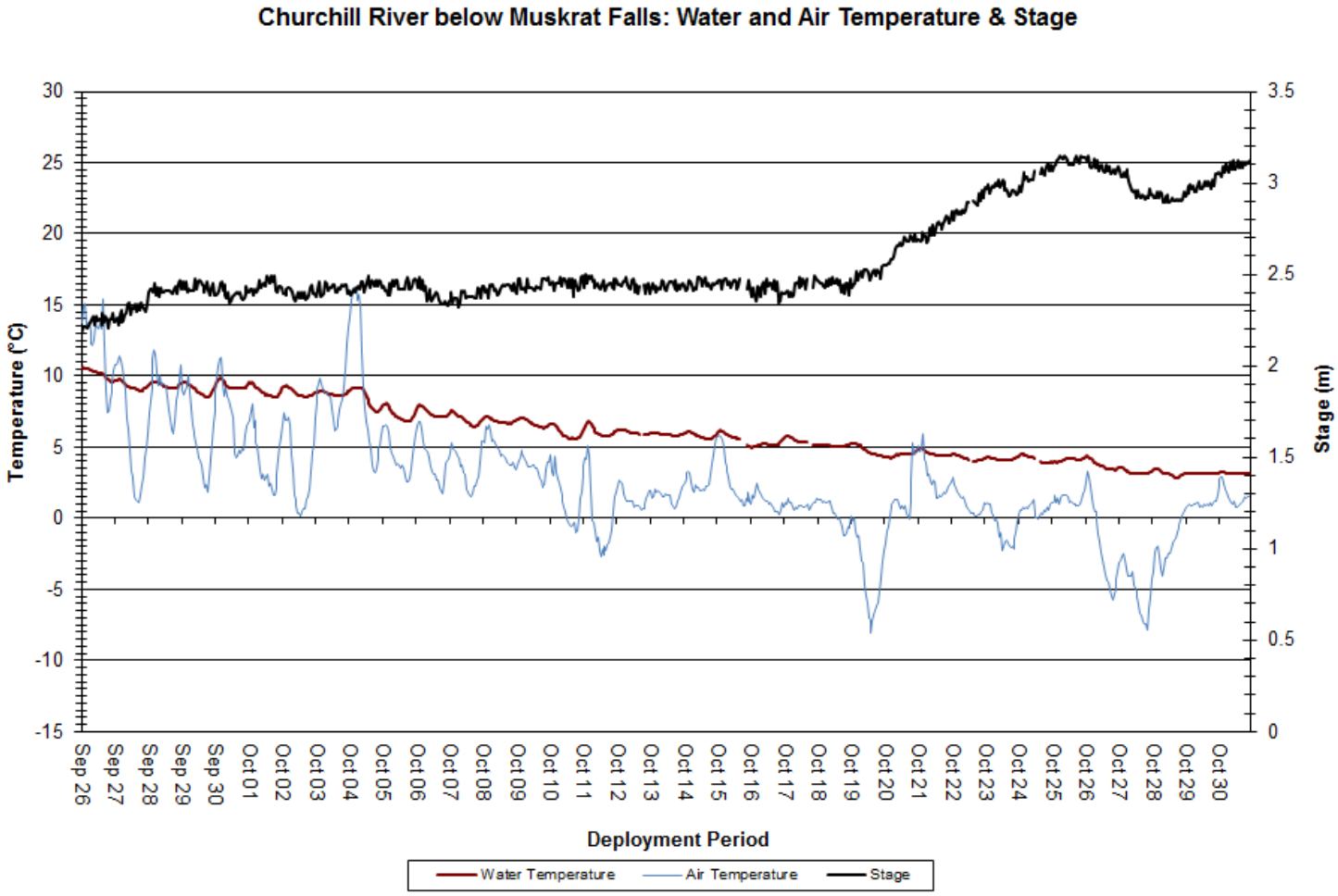

Figure 16: Water and Air Temperature & Stage at Churchill River below Muskrat Falls

pH

- Over the deployment period, pH ranged from 7.51 pH units to 7.81 pH units, with a median value of 7.70 (Figure 17).
- pH values were stable at the start of deployment; however, pH levels then increased quickly and remained very high for the remainder of deployment. This was very likely the result of a sensor failure on the field sonde, as there were no corresponding changes in stage that could explain prolonged higher-than-usual levels. As such, the affected data has been removed from the data set.
- 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.

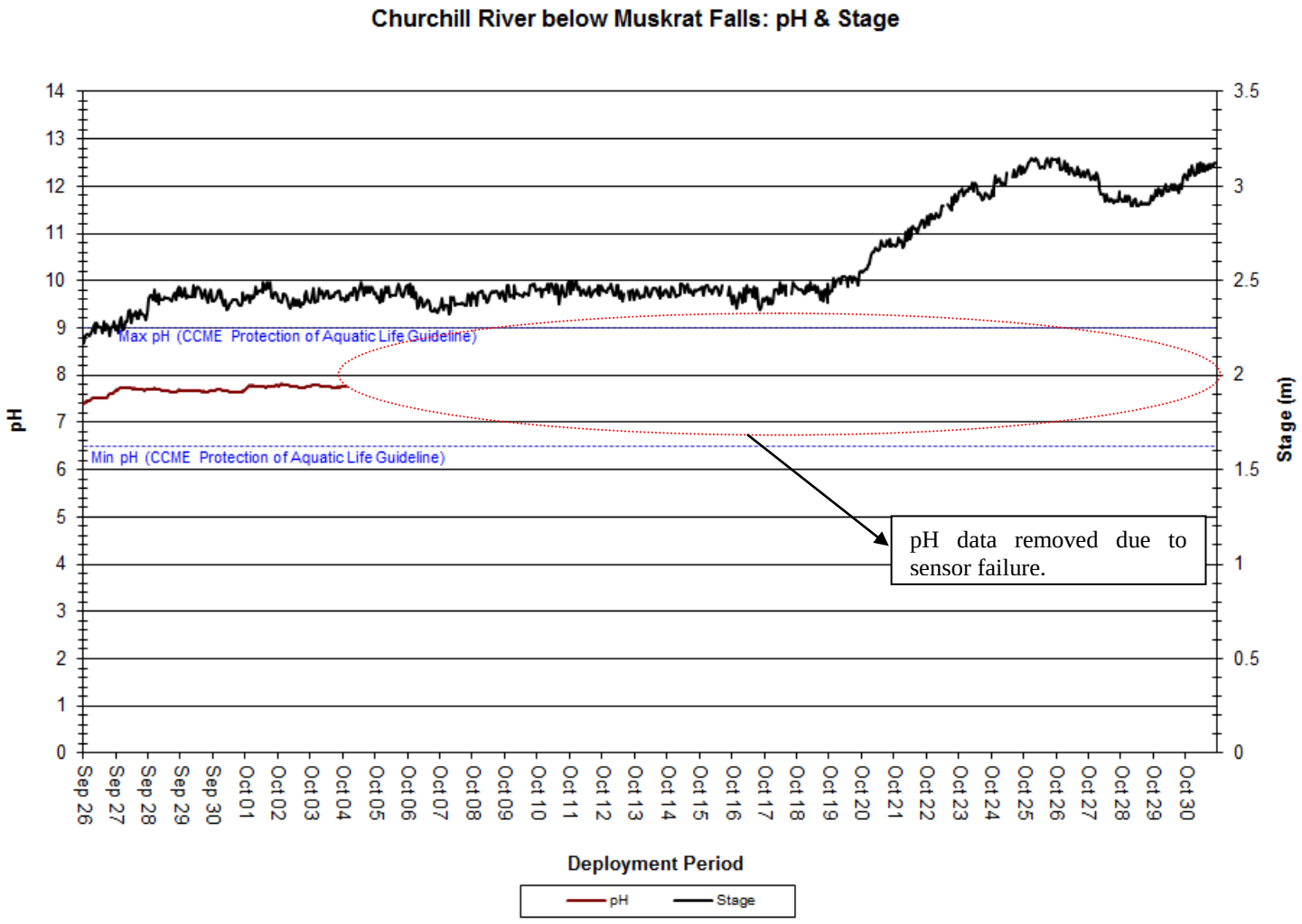

Figure 17: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 16.0µS/cm to 19.1µS/cm, with a median value of 17.7µS/cm (Figure 18).
- The relationship between conductivity and stage is generally inversed. When stage decreases, specific conductivity increases as the decreased amount of water in the river system concentrates solids that are present, and vice versa. This relationship is apparent in the graph below.
- 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.

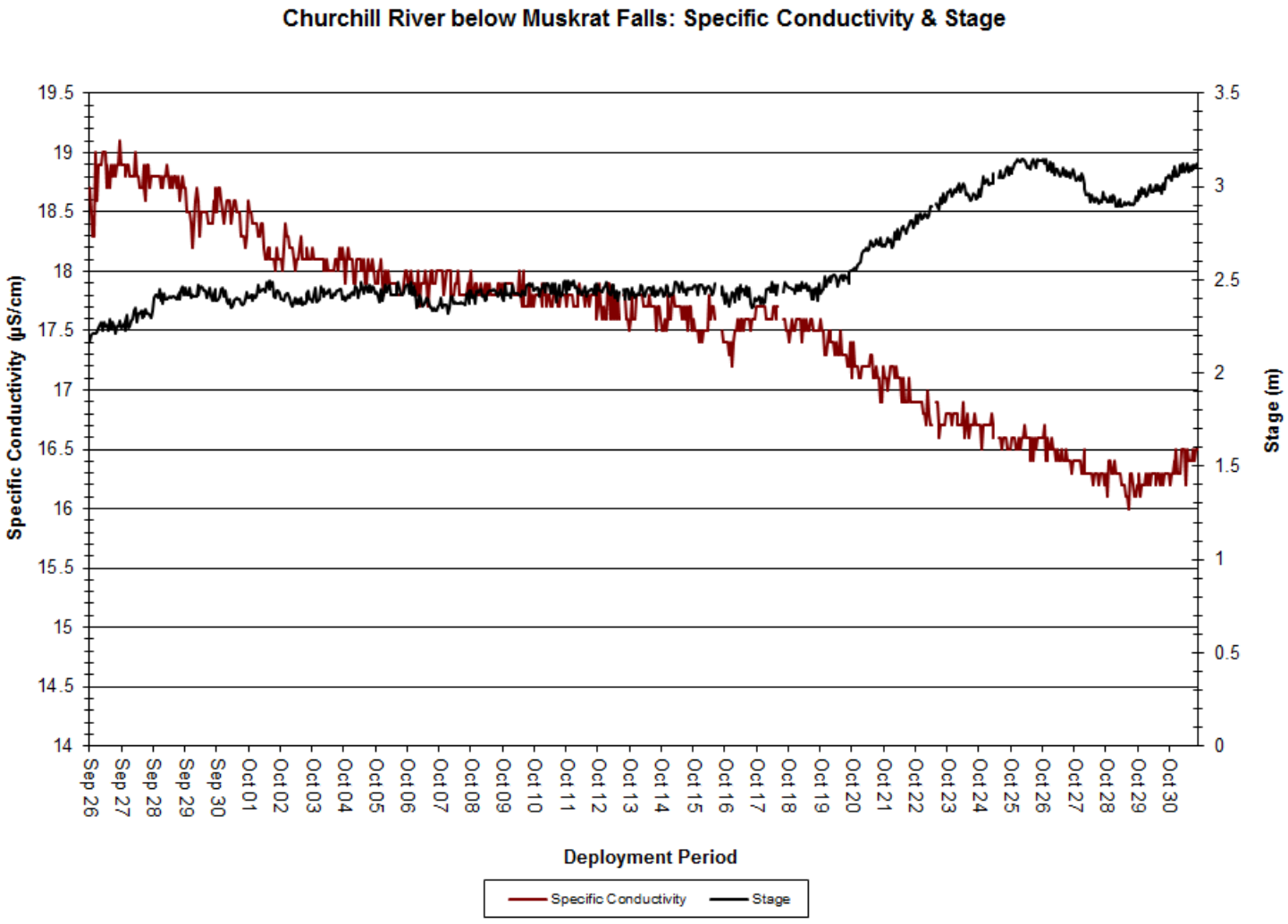

Figure 18: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 11.40mg/L to 15.41mg/L, with a median value of 13.56mg/L. Saturation of dissolved oxygen ranged from 99.8% to 114.9%, with a median value of 108.8% (Figure 19).
- Dissolved oxygen and water temperature exhibit an inverse relationship: as one parameter increases, the other decreases, and vice versa. Dissolved oxygen levels steadily increased over the course of deployment. This is to be expected since water temperatures steadily decreased through October. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures.
- Dissolved oxygen levels remained above the CCME's Guidelines for the Protection of Other and Early Life Stages for the duration of deployment.

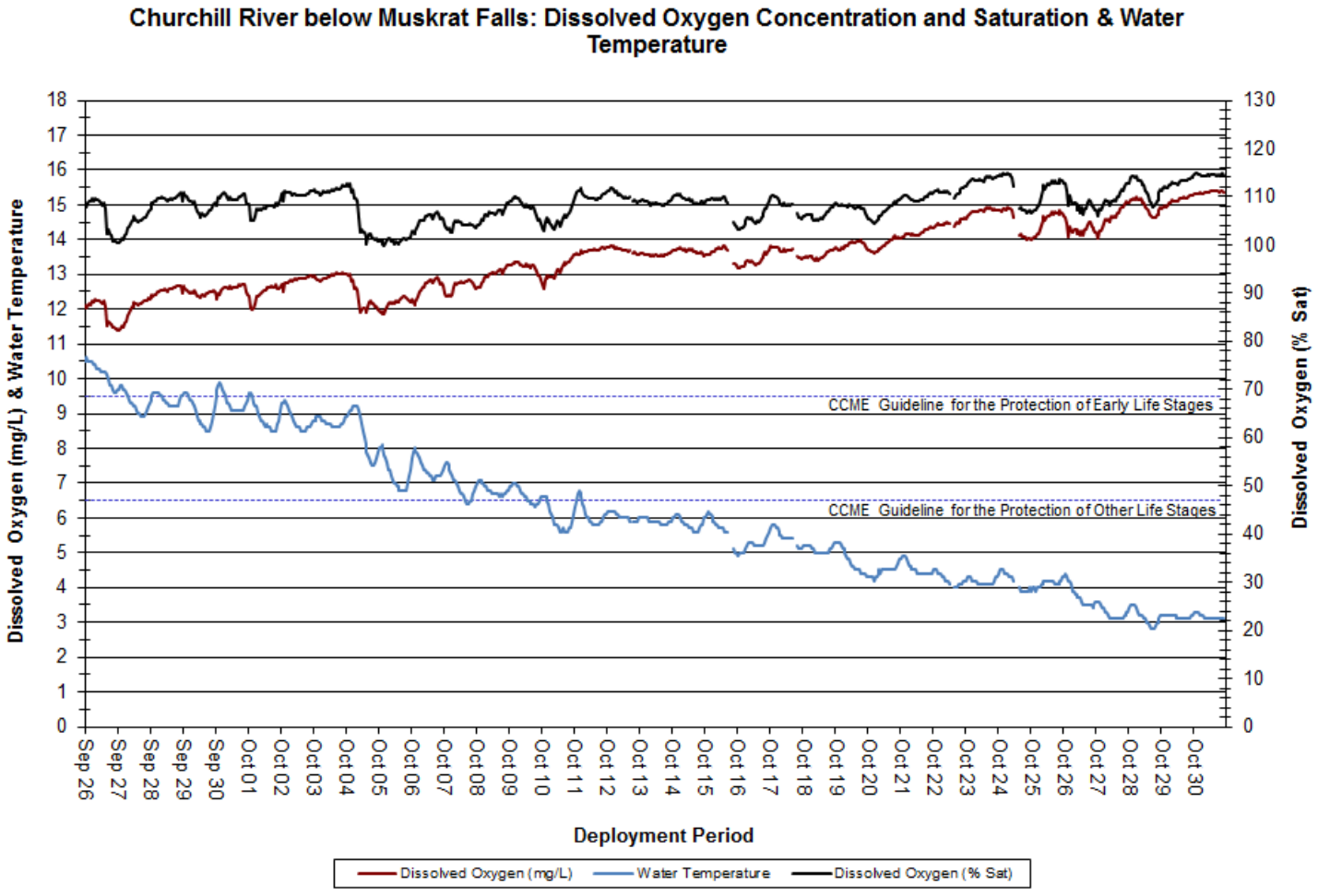

Figure 19: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 137.7NTU, with a median value of 2.4NTU. A median value of 2.4NTU indicates a low level of natural background turbidity in the waterbody. Precipitation data was obtained from the Muskrat Falls MET Station.
- Larger turbidity spikes observed over the deployment period correlated closely with precipitation events (Figure 20).
- Turbidity data from October 17th onwards was removed from the data set. Turbidity levels rose and never returned to baseline levels, which is indicative of a sensor failure.
- 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.

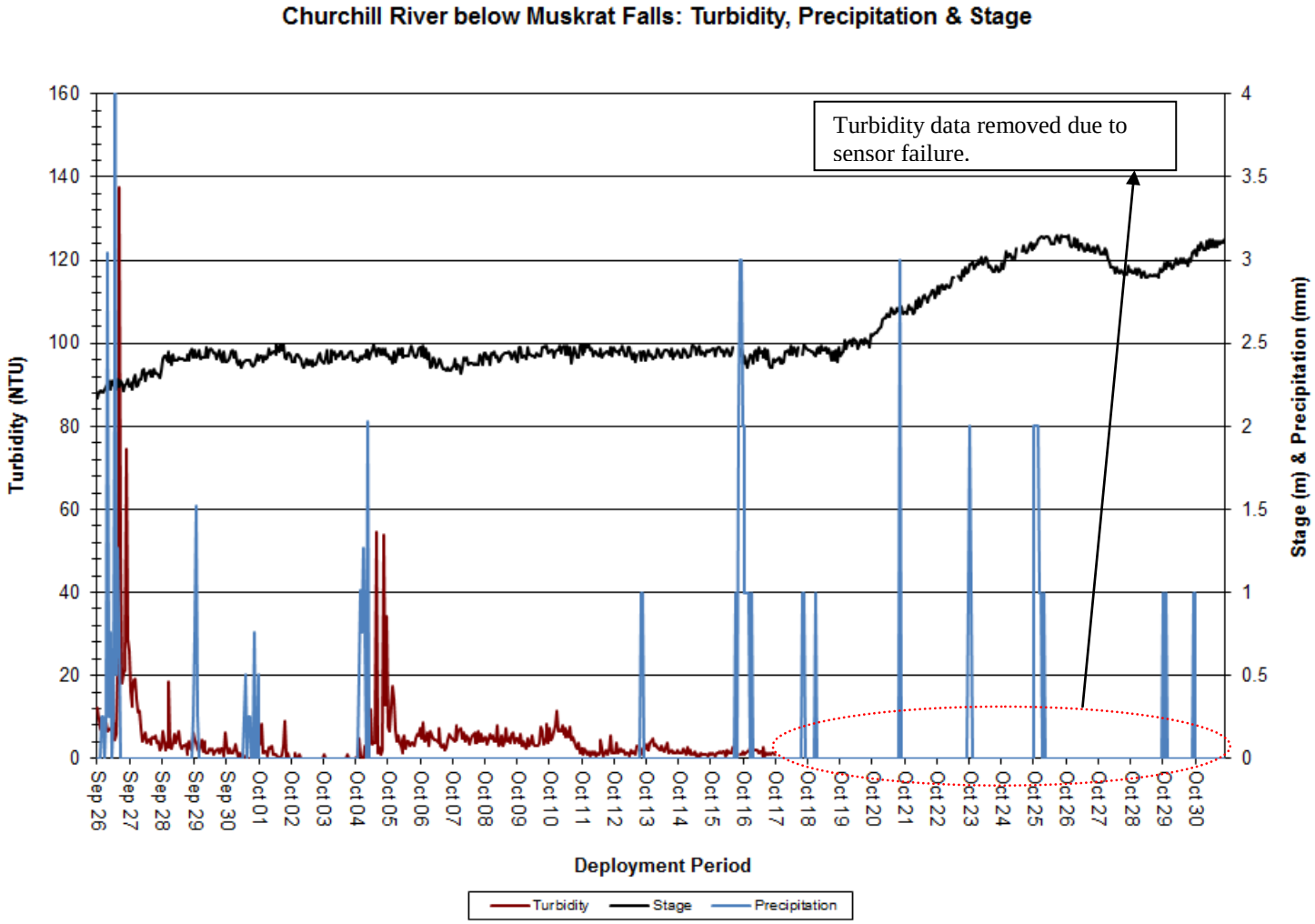

Figure 20: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls

Stage

- Over the deployment period, stage ranged from 2.21m to 3.15m, with a median value of 2.45m (Figure 21). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage was steady for the first part of deployment and then started to increase around October 21st. While stage often correlates closely with precipitation, this relationship is not particularly evident in the graph below. This is likely related to the fact that this station is located on a very wide section of the Churchill River and therefore not as easily influenced by smaller 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.

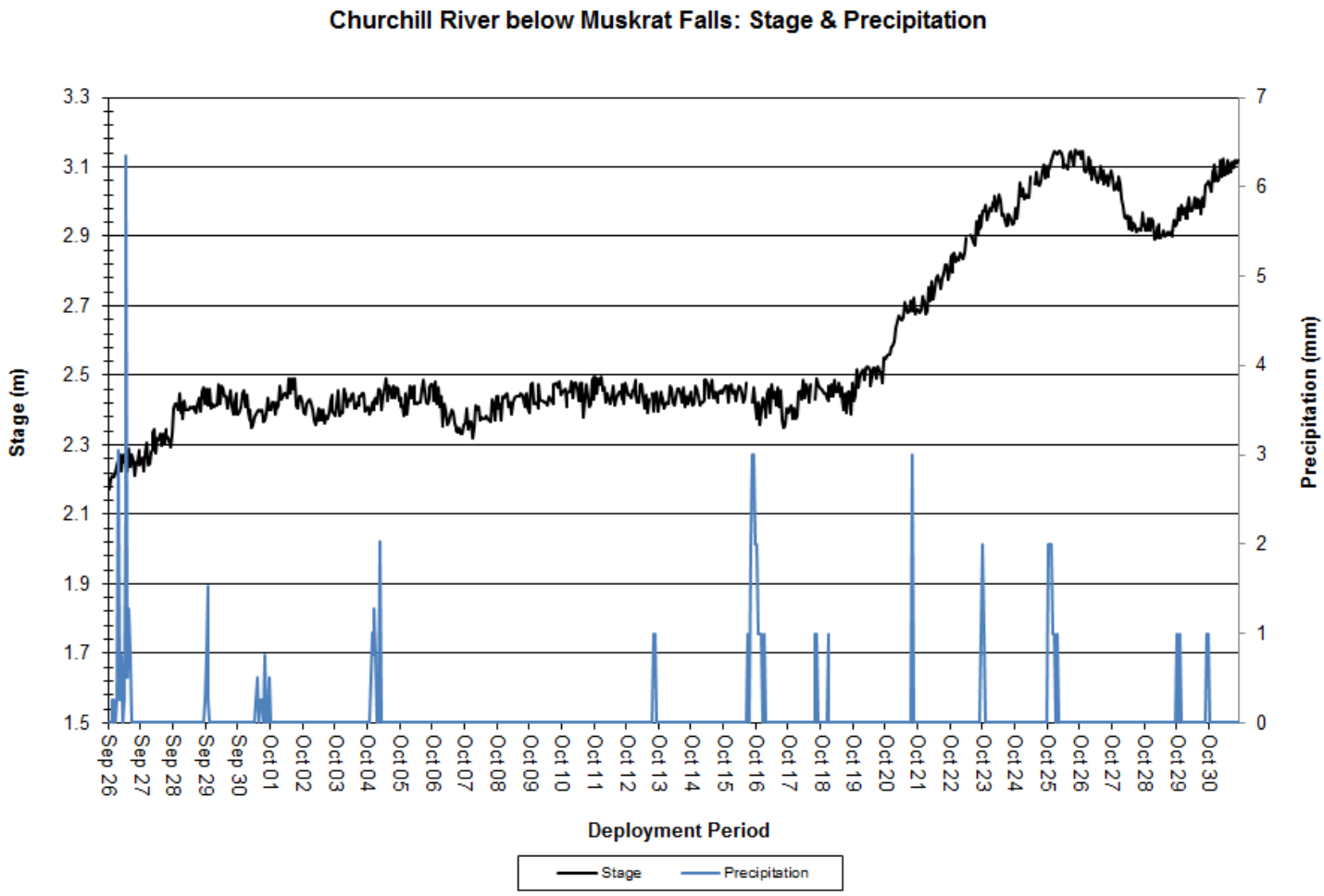

Figure 21: Stage & Precipitation at Churchill River below Muskrat Falls

Chlorophyll

- Over the deployment period, chlorophyll ranged from 1.76ug/L to 3.64ug/L, with a median value of 2.44ug/L (Figure 22).
- 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.

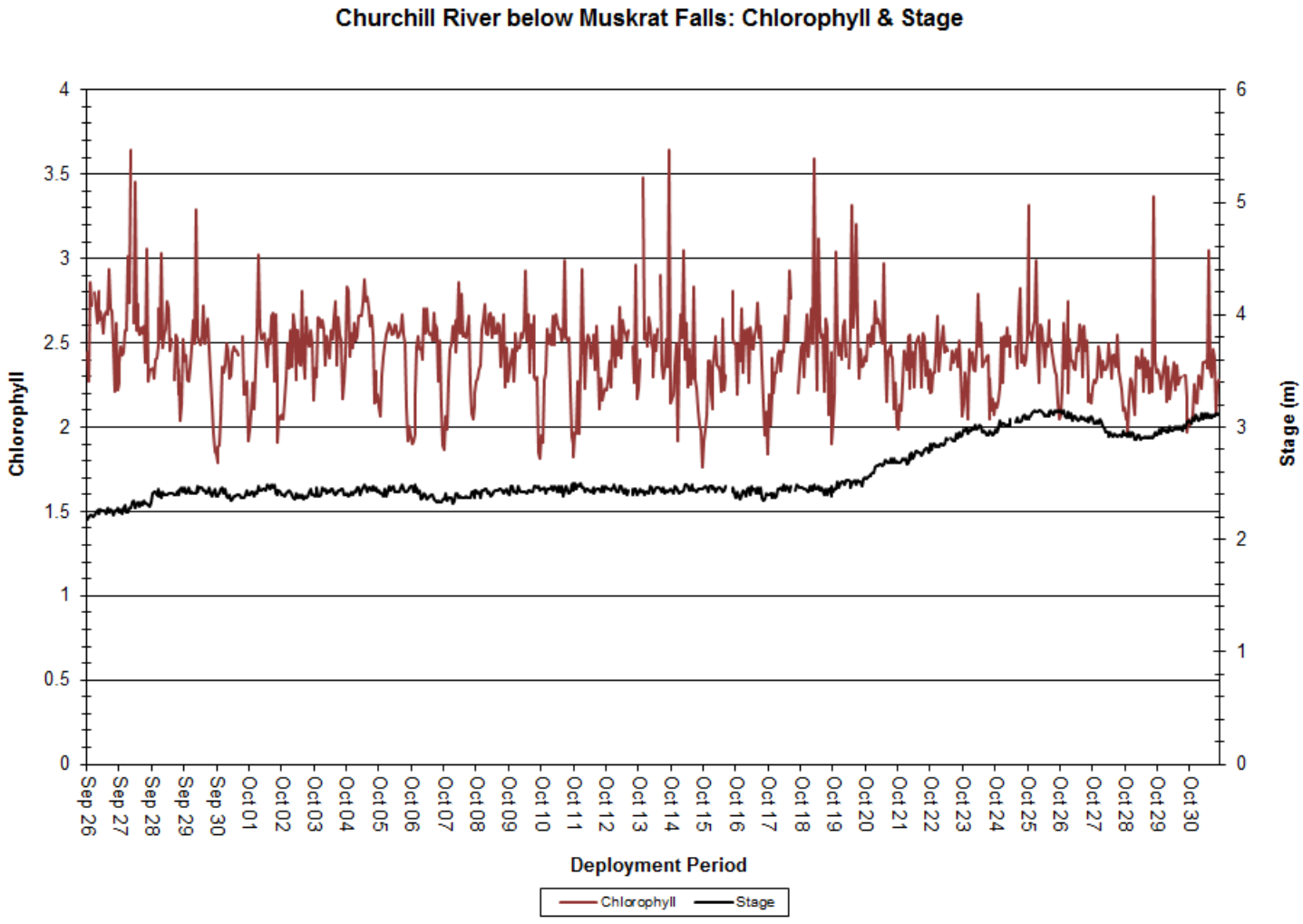

Figure 22: Chlorophyll & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranged from 1.60°C to 10.48°C, with a median value of 5.40°C (Figure 23). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature decreased steadily over the course of deployment. Water temperatures closely correlated with ambient air temperatures, which followed a similar trend across the same period.
- 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.

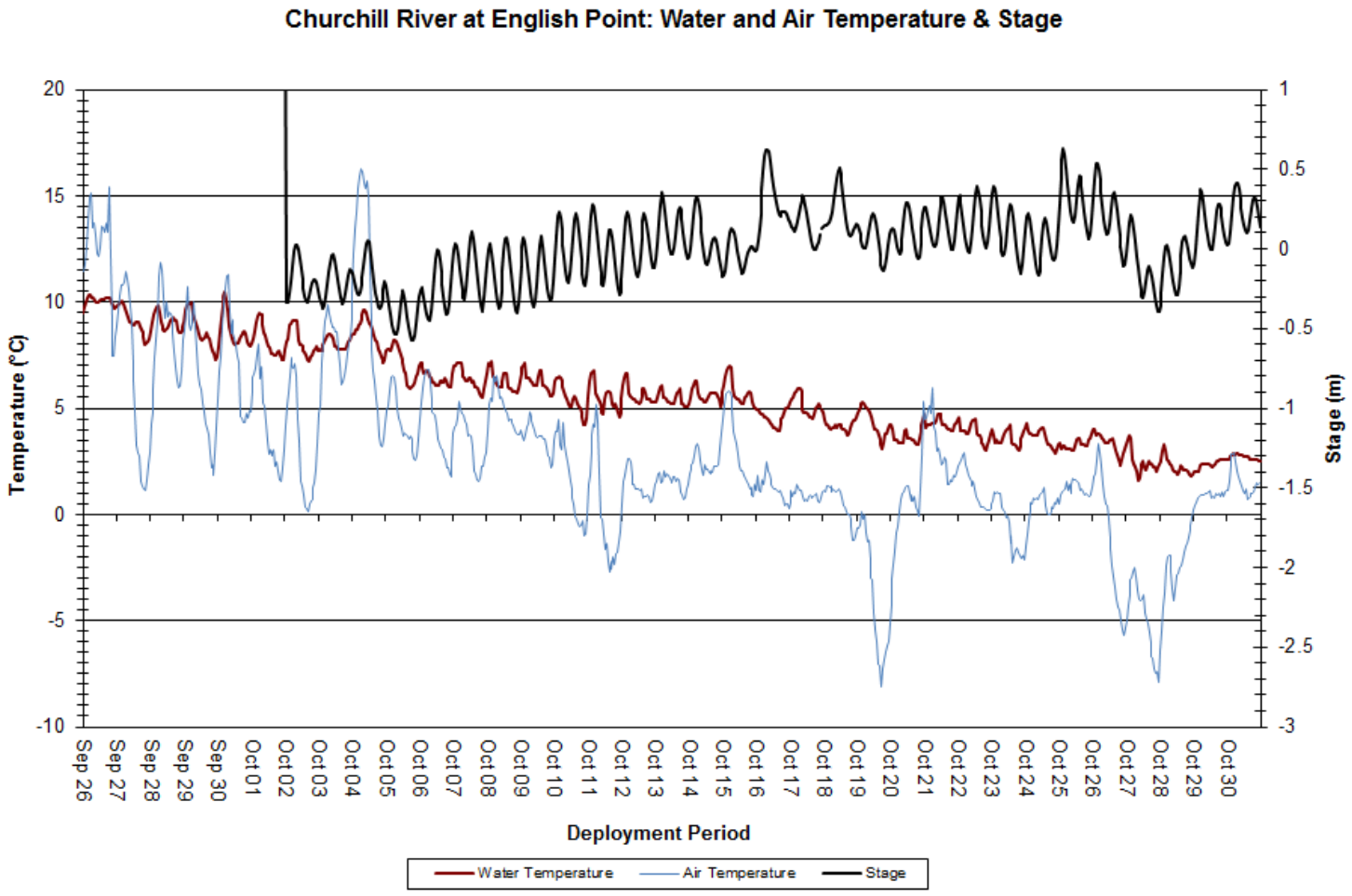

Figure 23: Water and Air Temperature & Stage at Churchill River at English Point

pH

- Over the deployment period, pH ranged from 6.52 pH units to 7.11 pH units, with a median value of 6.90 (Figure 24).
- pH values were relatively stable and remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration 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.

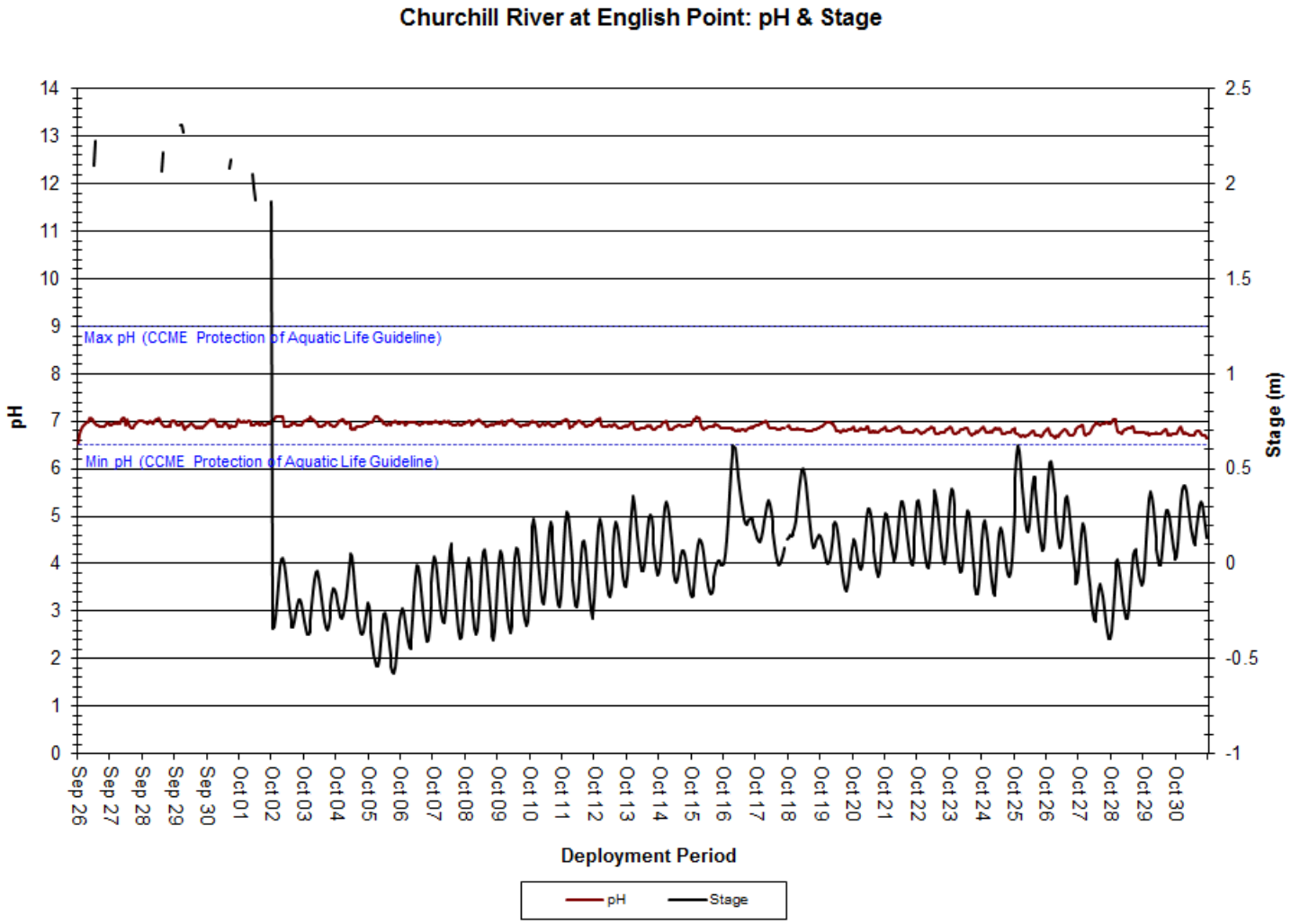

Figure 24: pH & Stage at Churchill River at English Point

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 12.0µS/cm to 57.3µs/cm, with a median value of 29.6µS/cm (Figure 25).
- 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 25).
- 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.

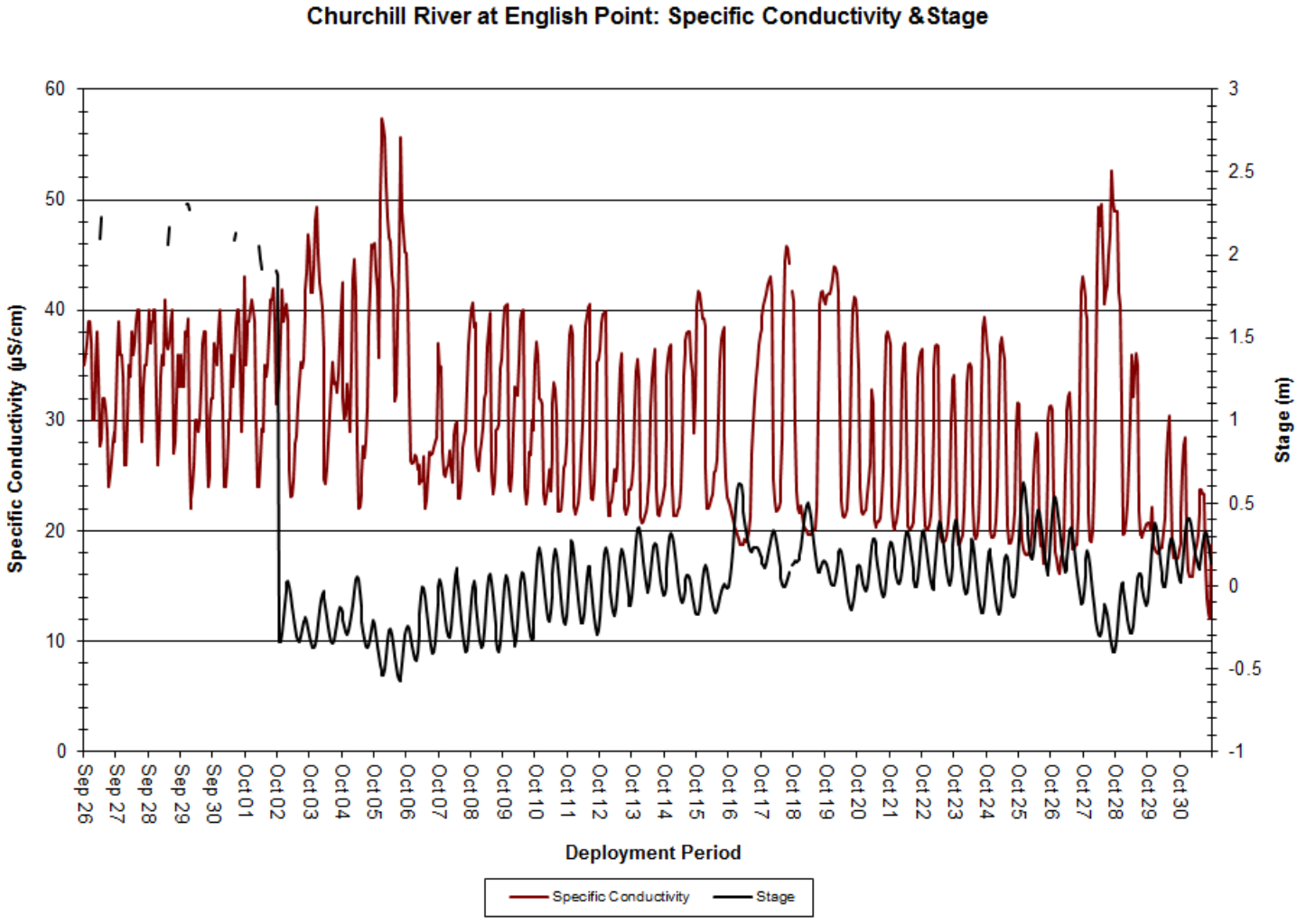

Figure 25: Specific Conductivity & Stage at Churchill River at English Point

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 10.46mg/L to 14.20mg/L, with a median value of 11.98mg/L. Saturation of dissolved oxygen ranged from 88.1% to 105.8% saturation, with a median value of 96.4% (Figure 26).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decreased over the deployment period, dissolved oxygen levels steadily 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's Guidelines for the Protection of Other and Early Life Stages for the duration of deployment (Figure 26).

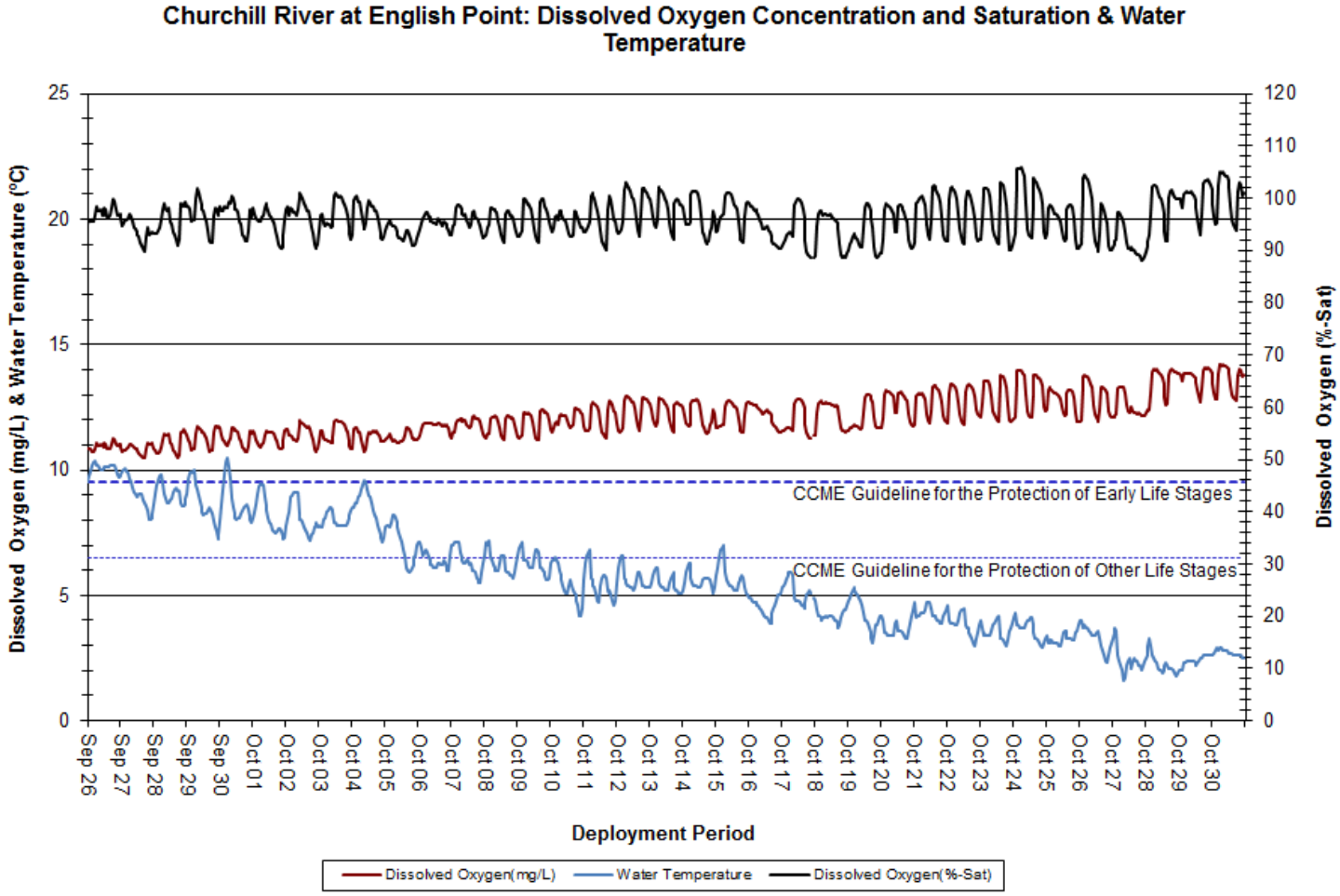

Figure 26: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 455.0NTU, with a median value of 0.8NTU (Figure 27). A median value of 0.8NTU indicates a low level of background turbidity; this is to be expected considering the sandy river bed and tidal influences present at this station.
- Precipitation data was obtained from the Muskrat Falls MET Station.
- Turbidity events generally correlate with precipitation events, as these can increase the presence of suspended material in water (Figure 27). High winds can also contribute to turbidity events at this station by disturbing sediment from the river bed.

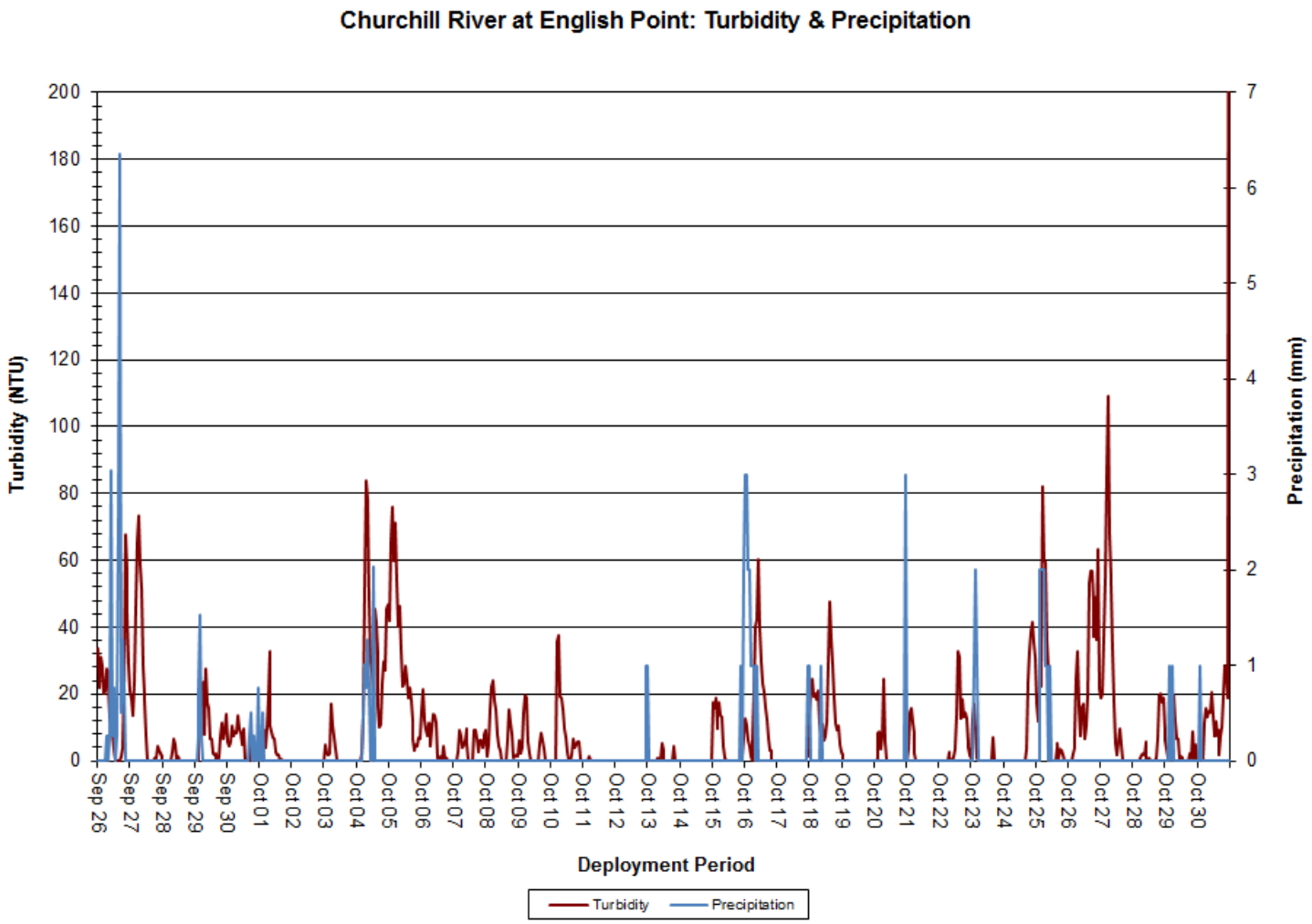

Figure 27: Turbidity & Precipitation at Churchill River at English Point

Stage

- Over the deployment period, stage ranged from -0.58m to 2.31m, with a median value of 0.02m (Figure 28). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. This pattern is consistent over the deployment period. Increases in stage often correlate with 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.

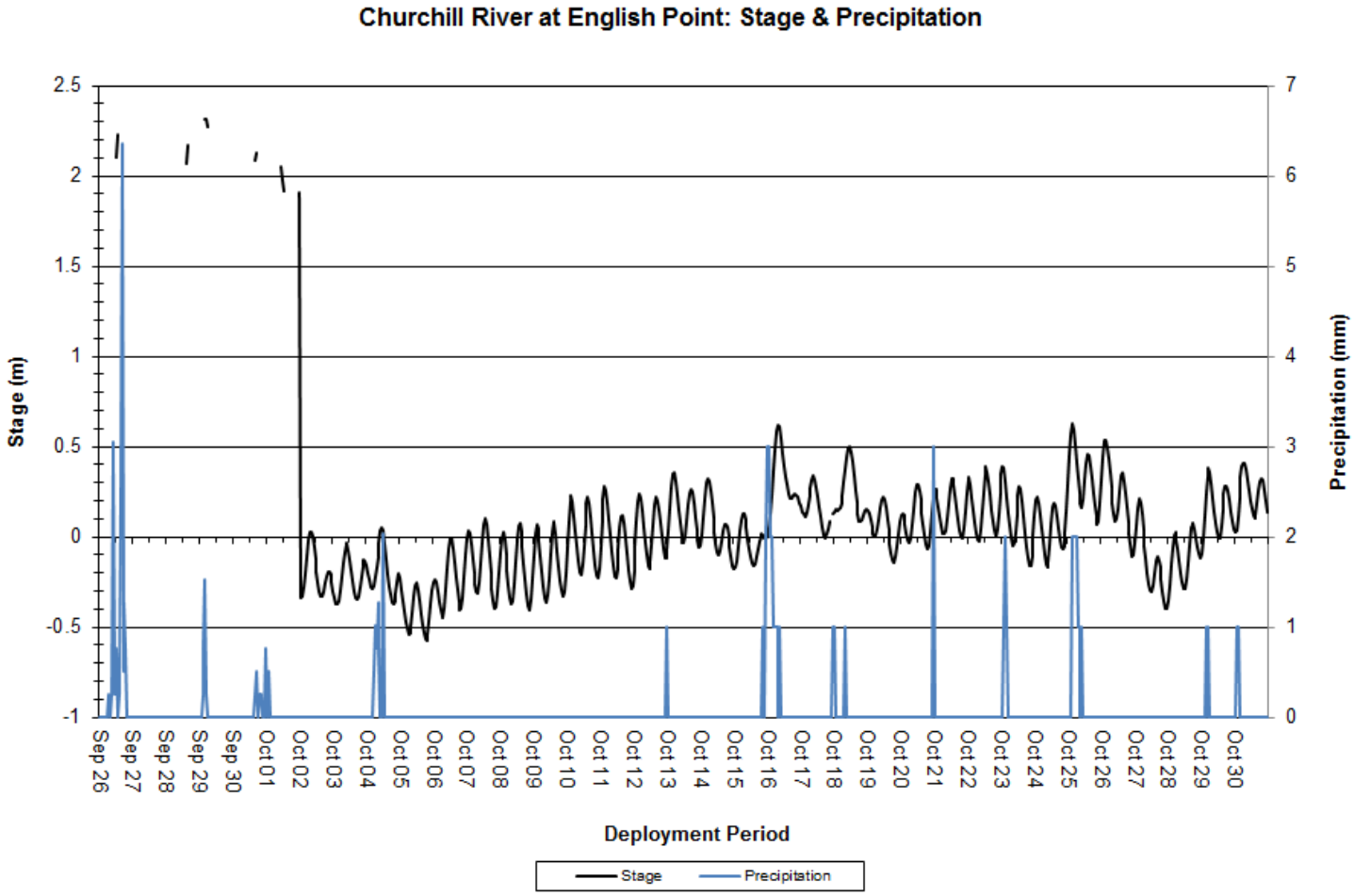

Figure 28: Stage & Precipitation at Churchill River at English Point

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from September 26/October 12 through October 31/November 15, 2018.
- Water temperature decreased slowly at all stations over the course of deployment. This is to be expected based on ambient air temperature trends during the same period.
- pH was relatively stable at all stations over the course of deployment. pH fell within the CCME's Guidelines for the Protection of Aquatic Life for the majority of deployment at all stations. pH data at Churchill River below Muskrat Falls from October 4th onwards was removed from the data set due to a sensor failure.
- Specific conductivity fluctuated over the course of deployment at all stations. 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, which is comparable to other deployments at this location.
- Dissolved oxygen levels steadily increased over the course of deployment at all stations as water temperatures decreased through the fall season. Dissolved oxygen levels are generally higher in water at cooler temperatures. Dissolved oxygen concentrations remained above the CCME's Guideline for the Protection of Early Life Stages for the duration of deployment at all stations.
- Turbidity events occurred at all stations and often correlated with precipitation events. Turbidity values generally returned to background levels following each observed event; however, this was not the case at Churchill River below Muskrat Falls and so turbidity data was removed from the data set from October 17th onwards.

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].

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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

Water Parameter Description

Water Parameter Description

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

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

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

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

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

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

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

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

APPENDIX B

Grab Sample Results

REPORT OF ANALYSIS

Lab Report Number: **1818791**

Cient:	Department of Environment	**COC Number:**	836607
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-24
Client Project:		**Date Submitted:**	2018-10-15
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1393303	WS-S-0000 CR above Grizzle Rapids	2018-6329-00-SI-SP	2018-10-12

Sample comment:

Report comment:

This is an amendment and supersedes all previous copies of this report dated 2018-10-24. The sample ID for 1393303 has been corrected.

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	11
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	<1
Colour	TCU	2	25
Conductivity	uS/cm	5	26
Dissolved Organic Carbon	mg/L	0.5	4.5
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.02	0.02
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.50
Sulphate	mg/L	1	1
Total Dissolved Solids (COND - CALC)	mg/L	1	17
Total Kjeldahl Nitrogen	mg/L	0.1	0.1
Total Organic Carbon	mg/L	0.5	4.5
Turbidity	NTU	0.1	0.8
Aluminum	mg/L	0.01	0.06

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1818791**

Cient:	Department of Environment	**COC Number:**	836607
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-24
Client Project:		**Date Submitted:**	2018-10-15
Purchase Order:	2180014302	**Sample Matrix:**	Water

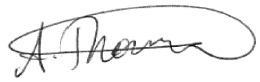
LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1393303	WS-S-0000	2018-6329-00-SI-SP	2018-10-12	Antimony	mg/L	0.0005	<0.0005
	CR above Grizzle Rapids			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	0.11
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.012

Sample comment:

Report comment:

This is an amendment and supersedes all previous copies of this report dated 2018-10-24. The sample ID for 1393303 has been corrected.

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1818791**

Cient:	Department of Environment	**COC Number:**	836607
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-24
Client Project:		**Date Submitted:**	2018-10-15
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1393303	WS-S-0000	2018-6329-00-SI-SP	2018-10-12	Uranium	mg/L	0.001	<0.001
	CR above Grizzle Rapids			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.006

Sample comment:

Report comment:

This is an amendment and supersedes all previous copies of this report dated 2018-10-24. The sample ID for 1393303 has been corrected.

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
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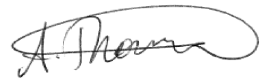
APPROVAL: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1817676**

Cient:	Department of Environment	**COC Number:**	836120
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-05
Client Project:		**Date Submitted:**	2018-09-28
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1390325	WS-S-0000 CR Below MF	2018-6330-00-SI-SP	2018-09-26

Sample comment:

Holding time for turbidity analysis was exceeded for entire report.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	9
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	<1
Colour	TCU	2	35
Conductivity	uS/cm	5	31
Dissolved Organic Carbon	mg/L	0.5	3.9
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	5
N-NH3 (Ammonia)	mg/L	0.02	0.11
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.08
Sulphate	mg/L	1	3
Total Dissolved Solids (COND - CALC)	mg/L	1	20
Total Kjeldahl Nitrogen	mg/L	0.1	0.2
Total Organic Carbon	mg/L	0.5	3.9
Turbidity	NTU	0.1	11.3
Aluminum	mg/L	0.01	0.31

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1817676**

Cient:	Department of Environment	**COC Number:**	836120
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-05
Client Project:		**Date Submitted:**	2018-09-28
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1390325	WS-S-0000 CR Below MF	2018-6330-00-SI-SP	2018-09-26	Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001
				Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	0.36
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.013

Sample comment:

Holding time for turbidity analysis was exceeded for entire report.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1817676**

Cient:	Department of Environment	**COC Number:**	836120
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-05
Client Project:		**Date Submitted:**	2018-09-28
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1390325	WS-S-0000	2018-6330-00-SI-SP	2018-09-26	Uranium	mg/L	0.001	<0.001
	CR Below MF			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.013
				Total Suspended Solids	mg/L	2	8

Sample comment:

Holding time for turbidity analysis was exceeded for entire report.

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1817676

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-05
Client Project:		**Date Submitted:**	2018-09-28
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1390326	WS-S-0000	2018-6332-00-SI-SP	2018-09-26	Alkalinity as CaCO3	mg/L	5	12
	CR @ English Point			Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	4
Sample comment:				Colour	TCU	2	48
				Conductivity	uS/cm	5	45
				Dissolved Organic Carbon	mg/L	0.5	4.4
Report comment:				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	9
				N-NH3 (Ammonia)	mg/L	0.02	0.10
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.35
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	29
				Total Kjeldahl Nitrogen	mg/L	0.1	0.3
				Total Organic Carbon	mg/L	0.5	4.6
				Turbidity	NTU	0.1	25.5
				Aluminum	mg/L	0.01	0.53

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1817676

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-05
Client Project:		**Date Submitted:**	2018-09-28
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1390326	WS-S-0000	2018-6332-00-SI-SP	2018-09-26	Antimony	mg/L	0.0005	<0.0005
	CR @ English Point			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	0.02
Sample comment:				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
Report comment:				Chromium	mg/L	0.001	0.001
				Copper	mg/L	0.001	0.002
				Iron	mg/L	0.03	0.80
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	1
				Manganese	mg/L	0.01	0.03
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	3
				Strontium	mg/L	0.001	0.019

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1817676

Cient:	Department of Environment	**COC Number:**	
Attention:	Ms. Tara Clinton	**Date Reported:**	2018-10-05
Client Project:		**Date Submitted:**	2018-09-28
Purchase Order:	2180014302	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1390326	WS-S-0000	2018-6332-00-SI-SP	2018-09-26	Uranium	mg/L	0.001	<0.001
	CR @ English Point			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.050
Sample comment:				Total Suspended Solids	mg/L	2	44

Report comment:

Eurofins (Ottawa) is accredited for specific parameters by CALA. The scope can be viewed at http://www.cala.ca/scopes/2602.pdf.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: A. Thomas

Addrine Thomas