Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 3/4 to October 4, 2019

Newfoundland Labrador

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

Contents

Prepared by:
Brenda Congram
Environmental Scientist
Department of Municipal Affairs & Environment
Water Resources Management Division
brendacongram@gov.nl.ca

Newfoundland Labrador

Real-Time Water Quality Deployment Report

Lower Churchill River Network

September 3/4 to October 4, 2019

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 Metchin River and Churchill River above Grizzle Rapids on September 3rd. Instruments at Churchill River below Muskrat Falls and Churchill River at English Point were deployed on September 4th.
- Instruments at Churchill River above Grizzle Rapids, Churchill River below Muskrat Falls and Churchill River at English Point were all removed on October 4th. Churchill River above Grizzle Rapids had a deployment period of 31 days, while the other two stations were deployed for 30 days.
- The instrument at Churchill River below Metchin River was not removed from the water until October 29th; however, for the purposes of this report, data from this station will be reported as if it had been. A 31 day deployment period will be used for reporting purposes, based on the removal date for the other three stations.
- 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 3/4 to October 4, 2019 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations September 3/4 to October 4, 2019

Churchill River Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River	September 3, 2019	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	October 4, 2019	Removal	N/A	N/A	N/A	N/A	N/A
Above Grizzle Rapids	September 3, 2019	Deployment	Good	Good	Excellent	Excellent	Excellent
	October 4, 2019	Removal	Good	Good	Excellent	Good	Excellent
Below Muskrat Falls	September 4, 2019	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	October 4, 2019	Removal	Good	Excellent	Excellent	Excellent	Excellent
At English Point	September 4, 2019	Deployment	Good	Good	Excellent	Excellent	Excellent
	October 4, 2019	Removal	Good	Good	Excellent	Good	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**
    - At deployment, all parameters ranked as ‘excellent’.
    - Comparison rankings are not available for removal since this instrument wasn’t physically removed from the water until October 29th.
- **Churchill River above Grizzle Rapids**
    - At deployment, all parameters ranked as ‘excellent’ or ‘good’.
    - At removal, all parameters again ranked as ‘excellent’ or ‘good’.
- **Churchill River below Muskrat Falls**
    - At deployment, all parameters ranked as ‘excellent’ or ‘good’.
    - At removal, all parameters again ranked as ‘excellent’ or ‘good’.

- **Churchill River at English Point**
    - At deployment, all parameters ranked as either 'excellent' or 'good'.
    - At removal, conductivity was 'excellent', while temperature, pH, and dissolved oxygen were 'good' and turbidity was 'fair'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from September 3/4 to October 4, 2019 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.

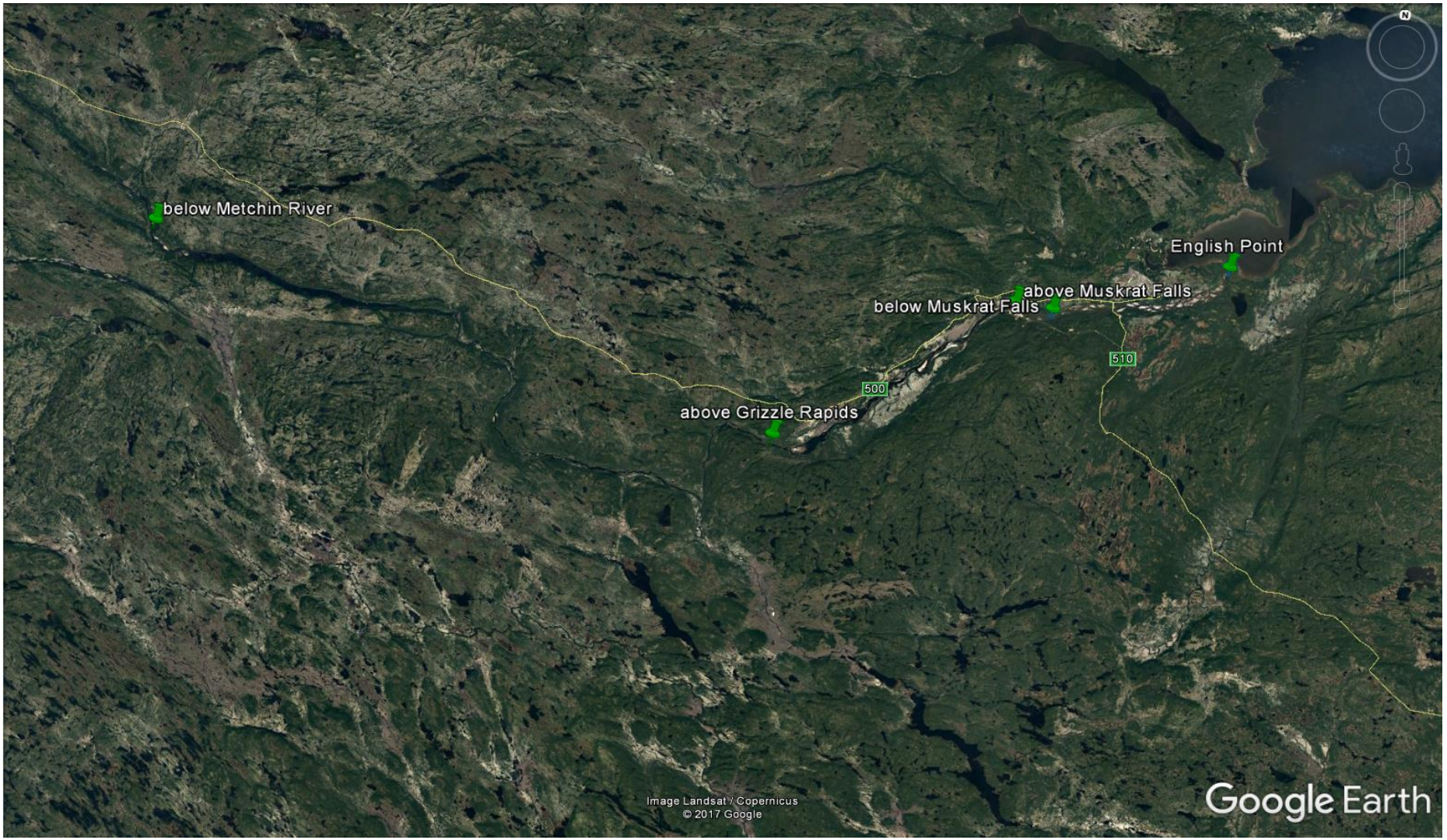


Figure 1: Lower Churchill Network of Real-Time Water Quality Stations

Churchill River below Metchin River

Water Temperature

- Over the deployment period, water temperature ranged from 7.40°C to 13.30°C, with a median value of 9.50°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 were also decreasing over the same period through September. 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.

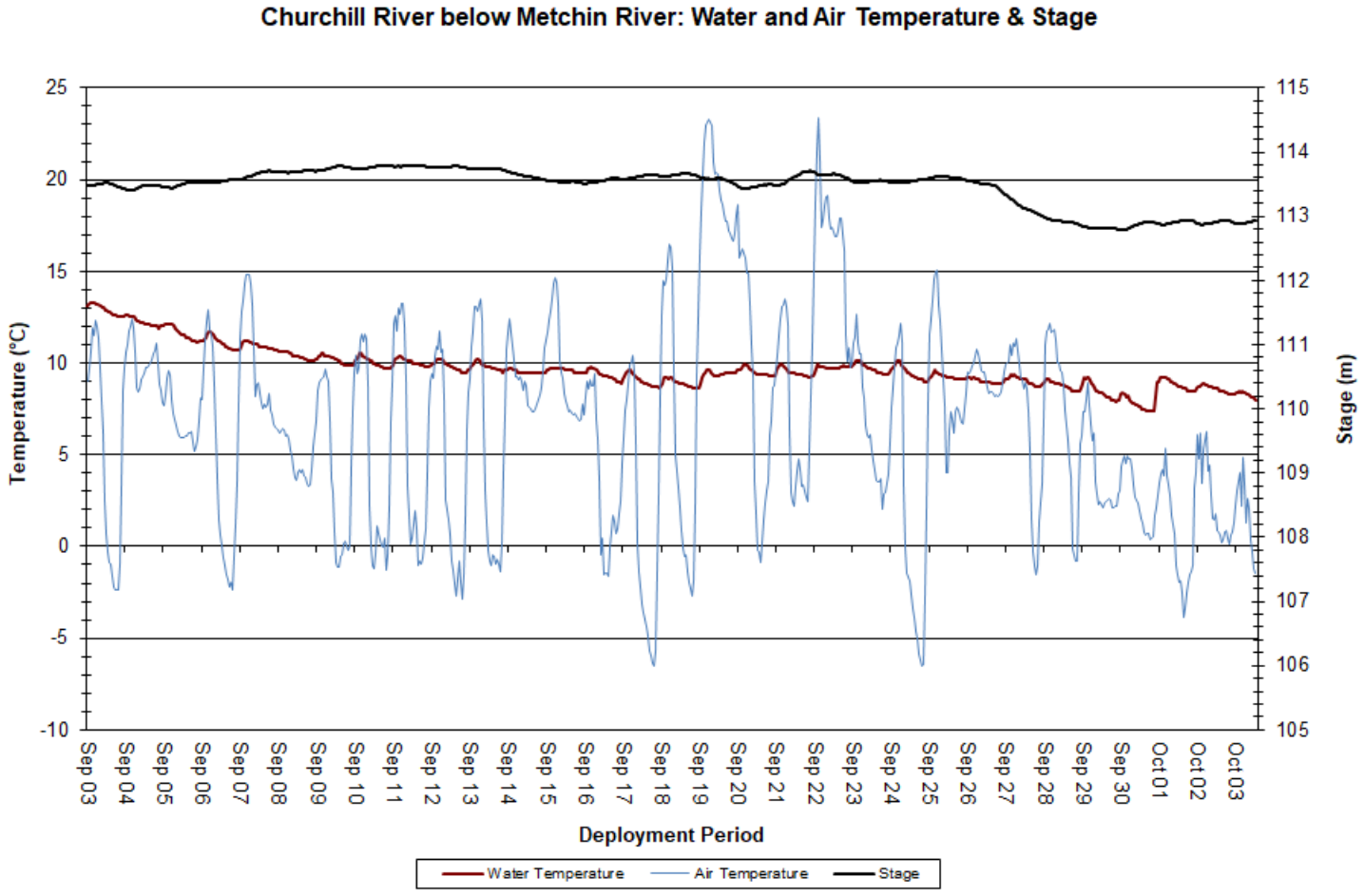


Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River

pH

- Over the deployment period, pH values ranged from 6.98 to 7.21 pH units, with a median value of 7.04 (Figure 3).
- pH values were stable over the course of deployment and fell within the CCME's Guidelines for the Protection of Aquatic Life for the duration 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.

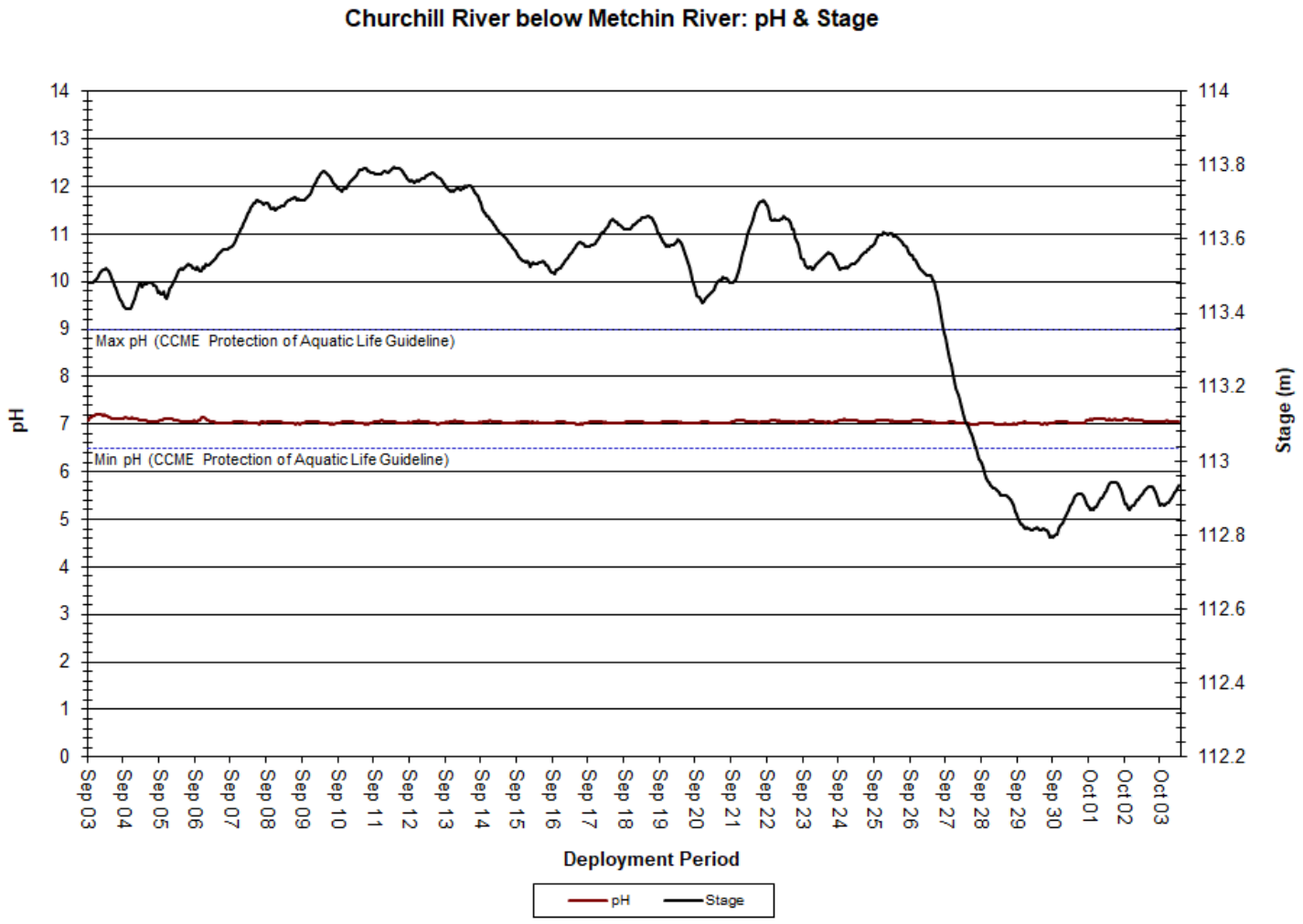


Figure 3: pH & Stage at Churchill River below Metchin River

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 17.9µS/cm to 19.8µS/cm, with a median value of 19.1µS/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. This relationship is evident in the graph below (Figure 4).
- 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.

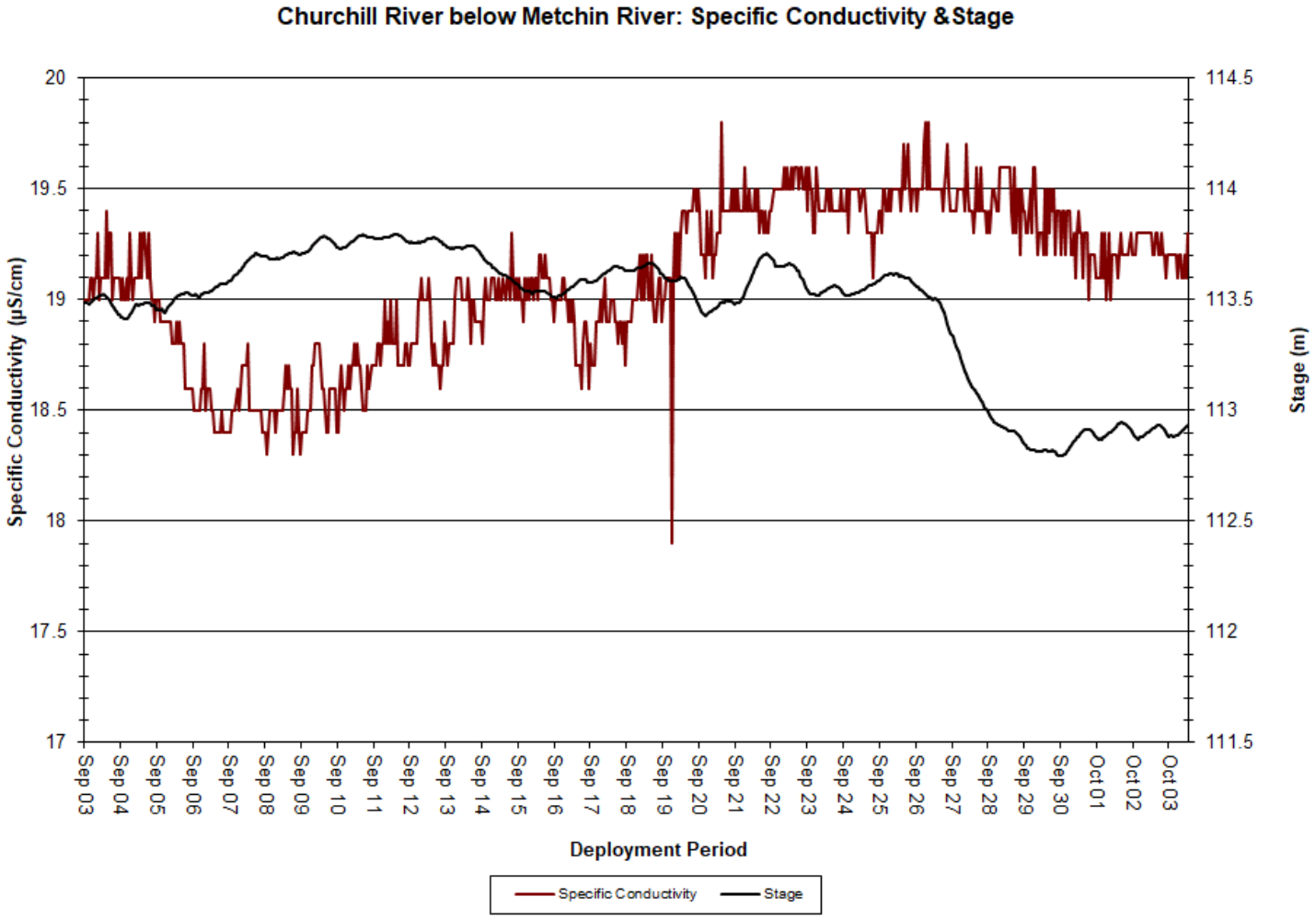


Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 9.53mg/L to 12.27mg/L, with a median value of 10.34mg/L. Saturation of dissolved oxygen ranged from 91.3% to 112.7%, with a median value of 93.7% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually increased, as water temperatures gradually decreased. 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 above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment.

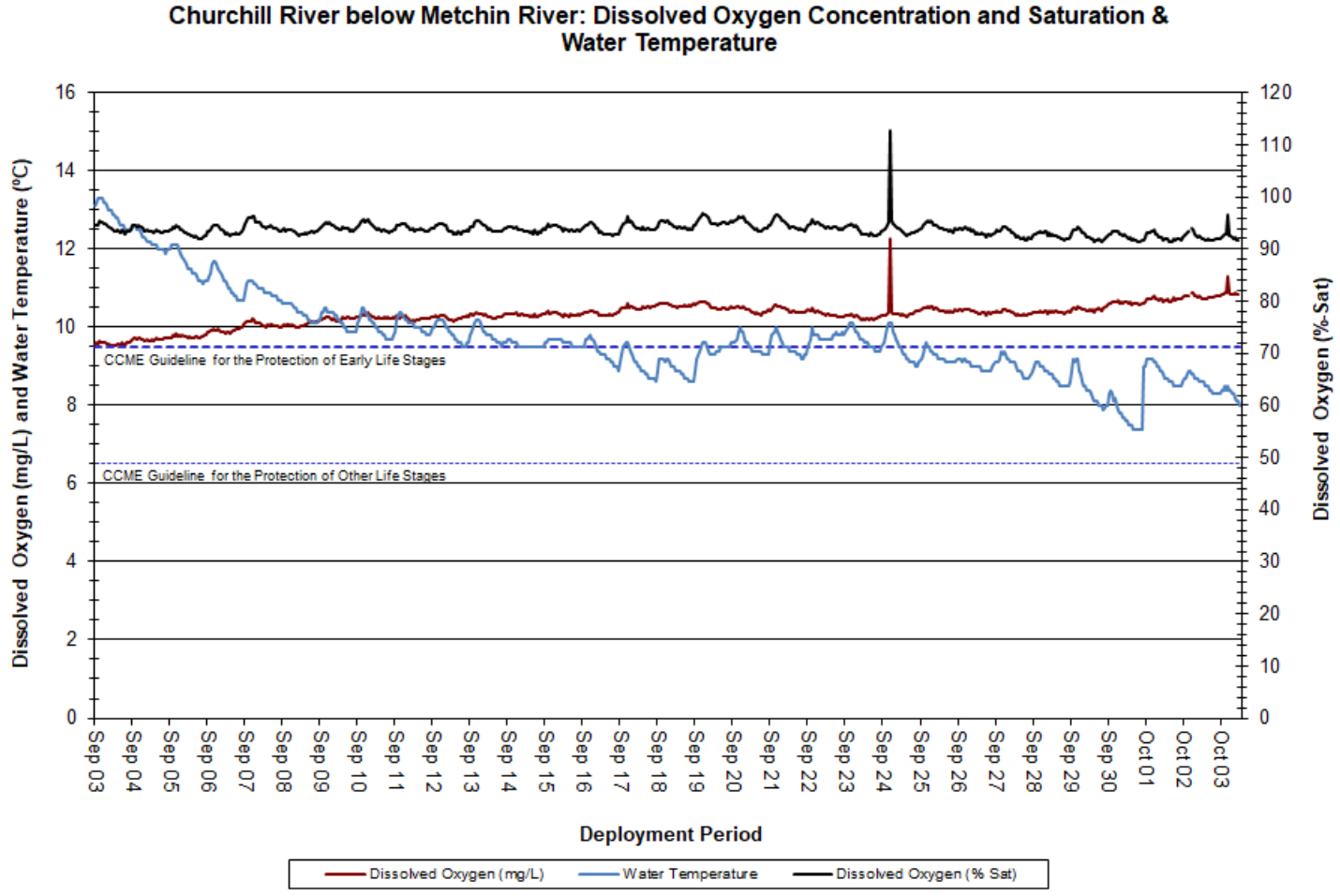


Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 6.8NTU, 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.
- Some of the turbidity spikes observed throughout the deployment period correlate with precipitation events (Figure 6); however, other 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.

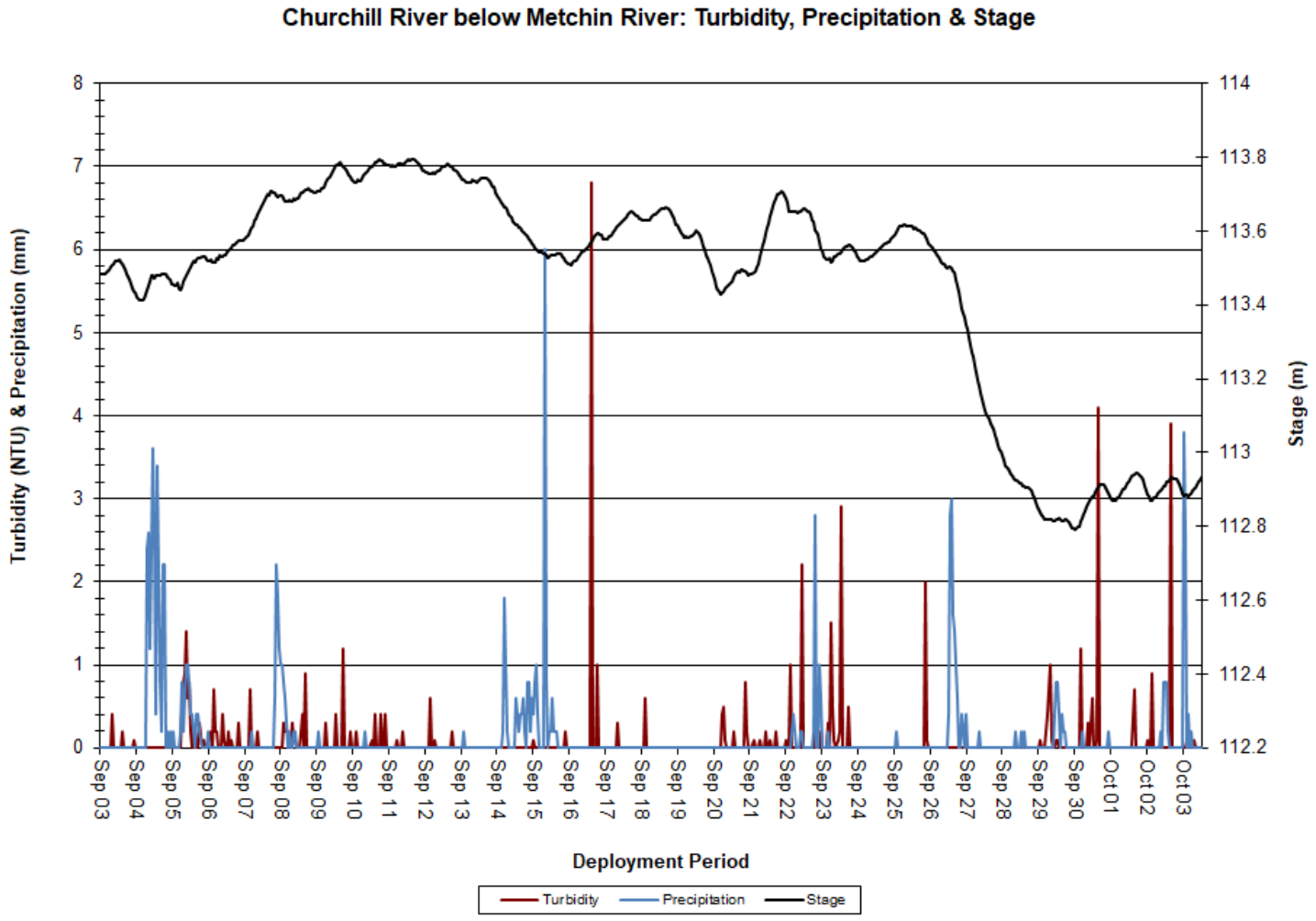


Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River

Stage and Flow

- Over the deployment period, stage levels ranged from 112.79m to 113.79m, with a median value of 113.55m. Flow ranged from 1166.93m^3/s to 1467.55m^3/s, with a median value of 1402.02m^3/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage and flow were slightly variable across the deployment period and followed a similar trend. Precipitation amounts across the same period correlate with increases in both stage and flow (Figure 8).
- 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.

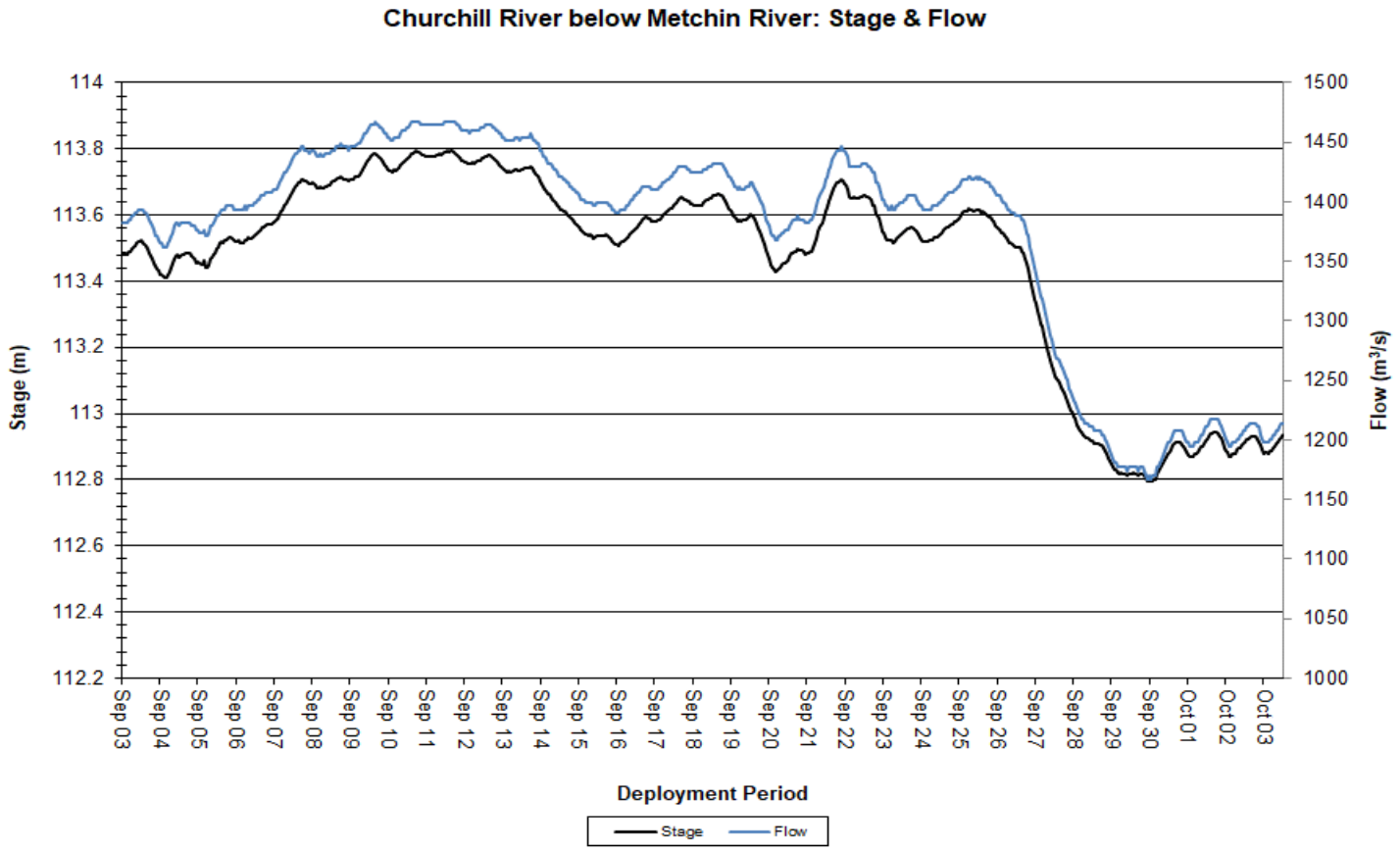


Figure 7: Stage & Flow at Churchill River below Metchin River

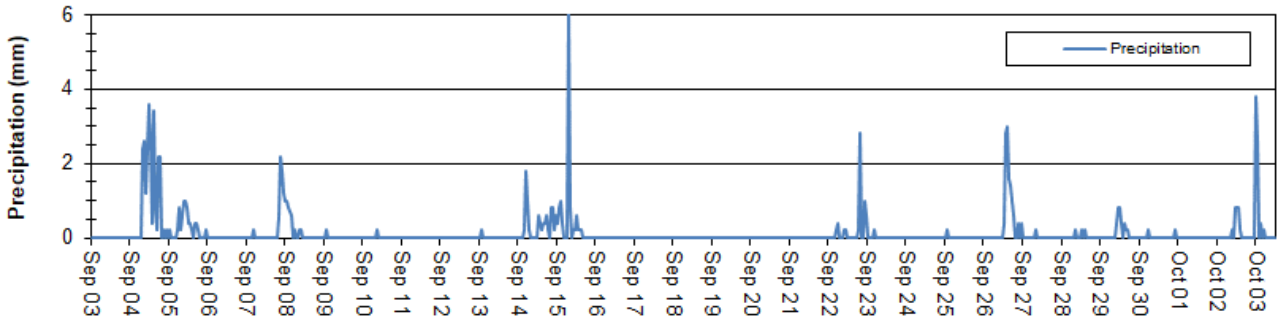


Figure 8: Precipitation at Churchill River below Metchin River

Churchill River above Grizzle Rapids

Water Temperature

- Over the deployment period, water temperature ranged from 9.00°C to 15.80°C, with a median value of 11.80°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 September. 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.

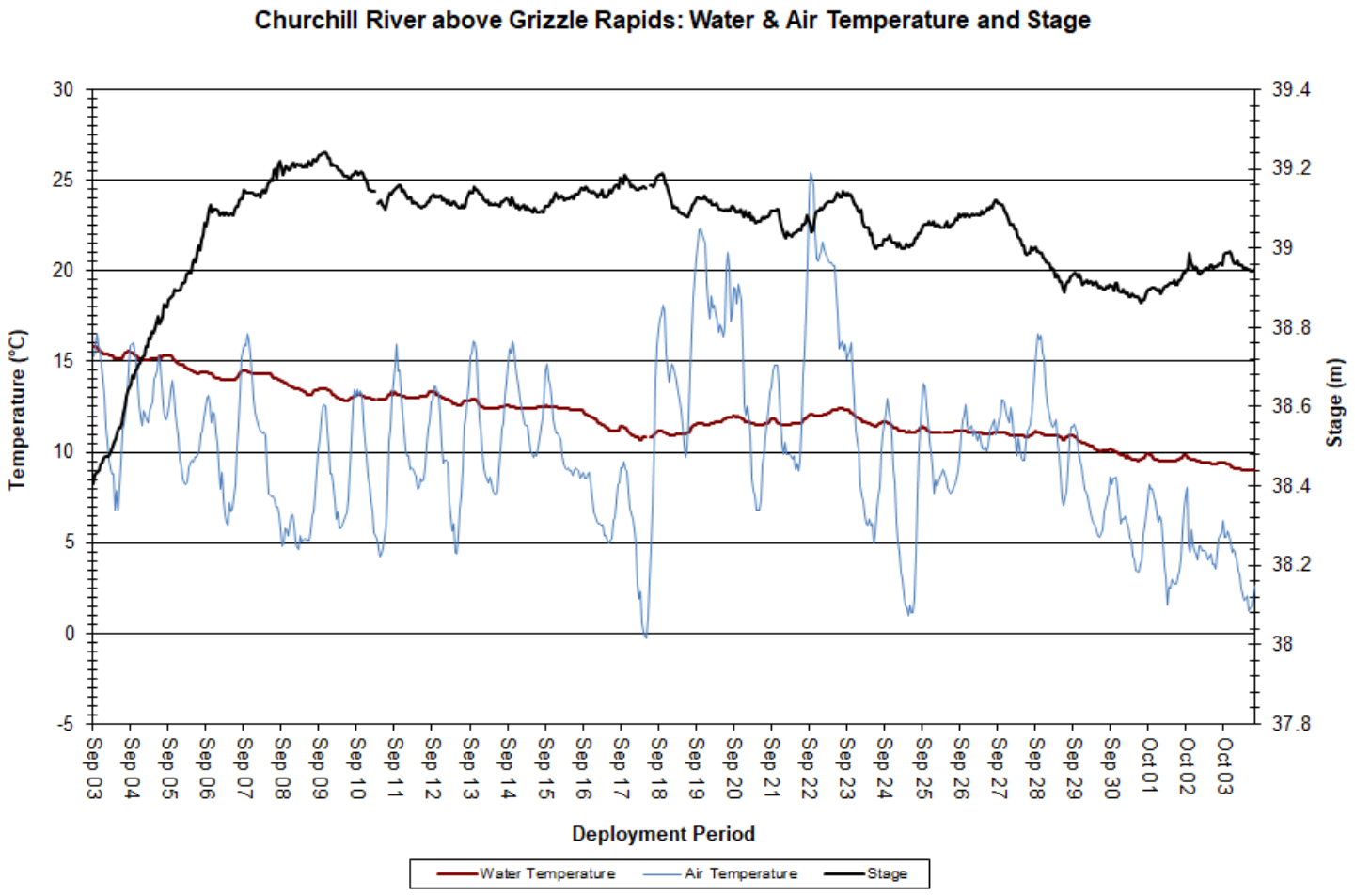


Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids

pH

- Over the deployment period, pH values ranged from 6.86 pH units to 7.17 pH units, with a median value of 7.00 (Figure 10).
- pH values were quite stable and fell within the CCME's Guidelines for the Protection of Aquatic Life for the duration 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 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.

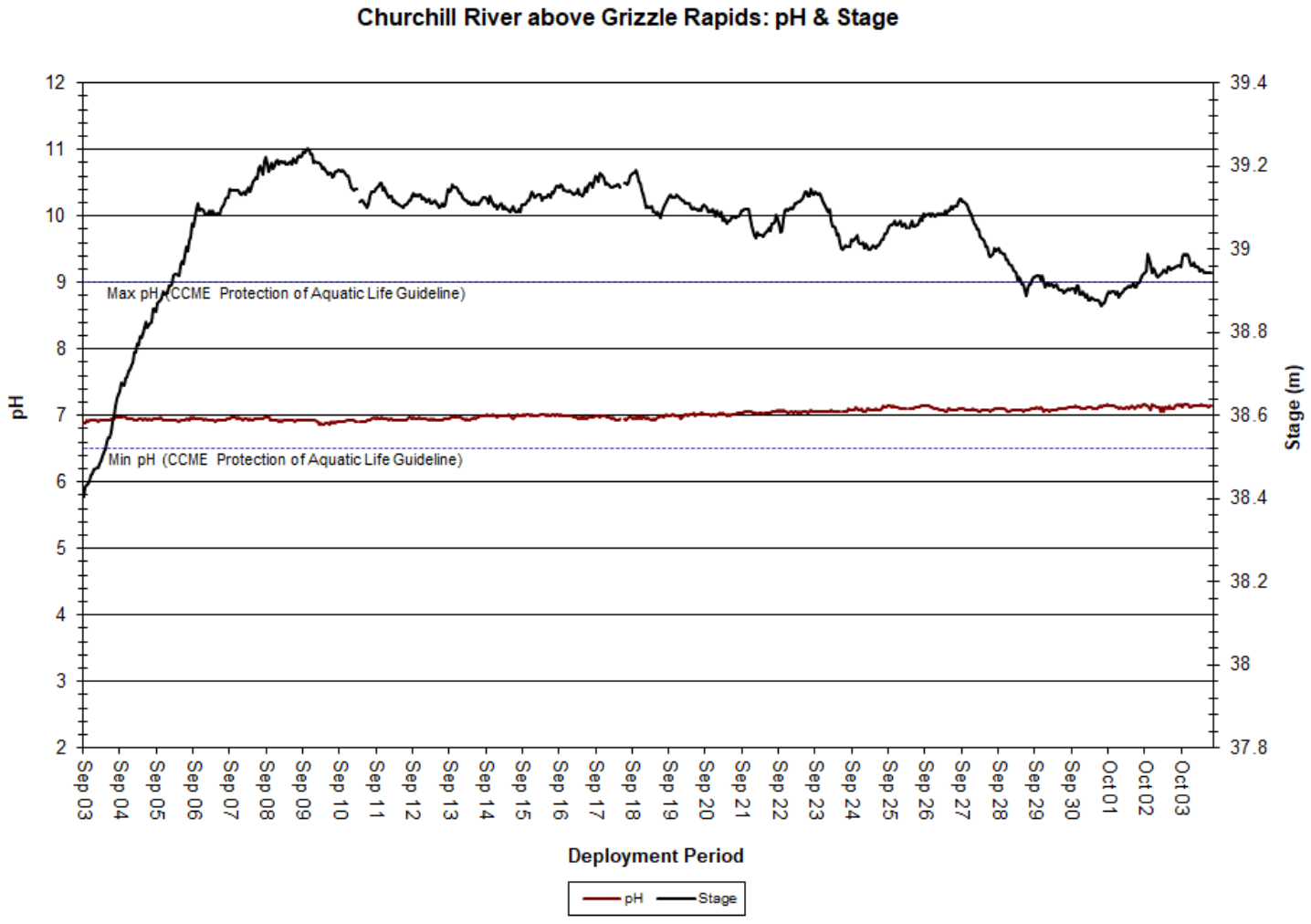


Figure 10: pH & Stage at Churchill River above Grizzle Rapids

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 15.1µS/cm to 17.1µS/cm, with a median of 15.8µS/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. This relationship is evident in the graph below (Figure 11).
- 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.

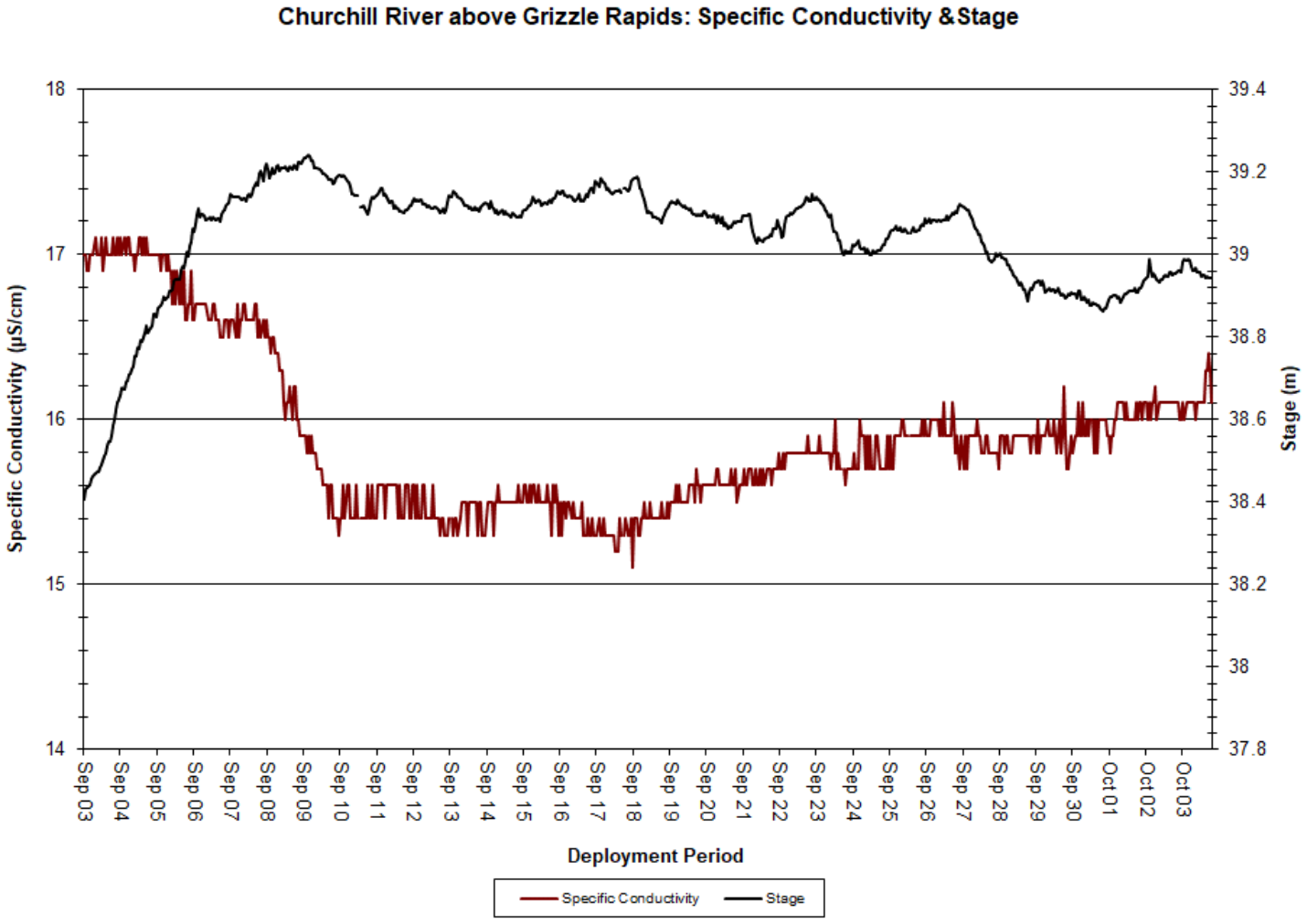


Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 9.37mg/L to 10.70mg/L, with a median value of 10.11mg/L. Saturation of dissolved oxygen ranged from 91.5% saturation to 95.9% saturation, with a median value of 93.5% (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 gradually decreased through September. 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 below the CCME's Guideline for the Protection of Early Life Stages for the very beginning of deployment, after which dissolved oxygen levels rose above the CCME's Guideline for the Protection of Early Life Stages for the remainder of deployment. This is to be expected given the cooler water temperatures observed through September. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment.

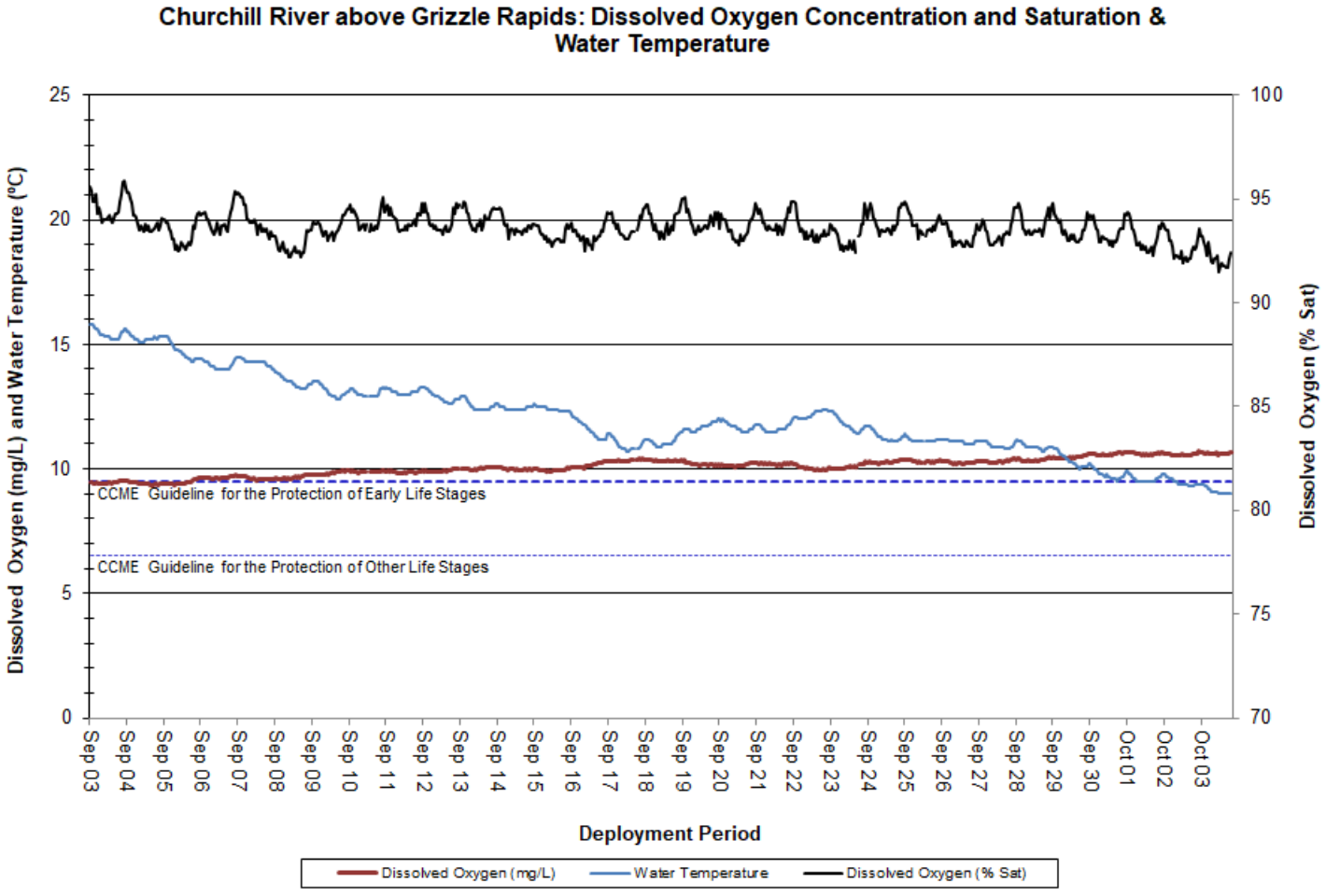


Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 0.6NTU, 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.
- Turbidity spikes observed over the deployment period did not correlate well with precipitation events (Figure 13). Furthermore, the scarcity of turbidity spikes at this station indicates that there may have been a sensor failure. While turbidity levels are not generally high at this station, we would expect to see more variability in turbidity levels than what was observed over this deployment 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.

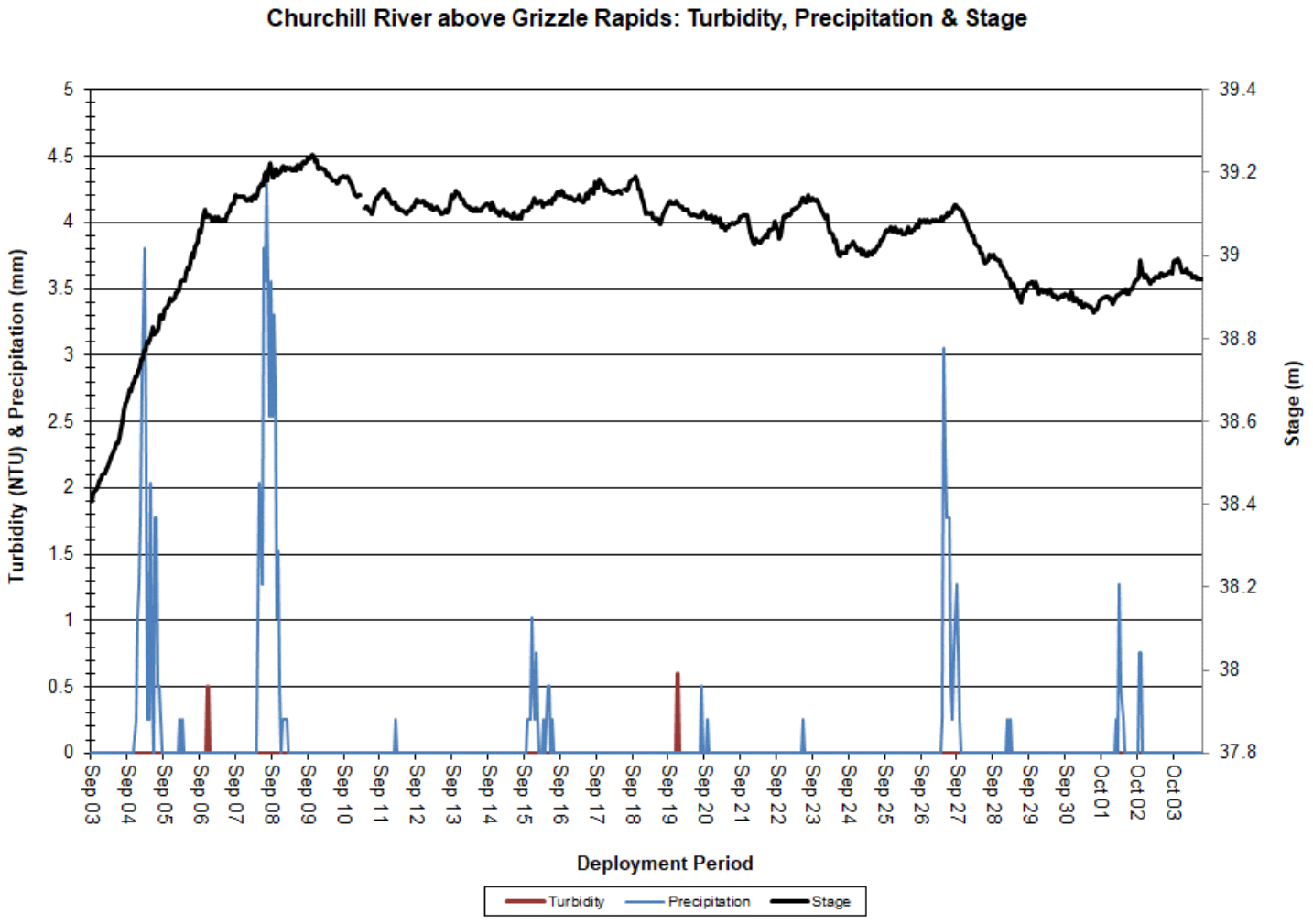


Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids

Stage & Flow

- Over the deployment period, stage ranged from 38.41m to 39.24m, with a median value of 39.09m (Figure 14). Flow ranged from 4015.68m^3/s to 4944.75m^3/s, with a median value of 4388.00m^3/s (Figure 14). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage was variable across the course of deployment. Flow started off following the same trend as stage; however, flow data is not available after September 5th as this station was modified to be water-level only going forwards. Precipitation across the same period is graphed below (Figure 15) to show that precipitation events often correlate with 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.

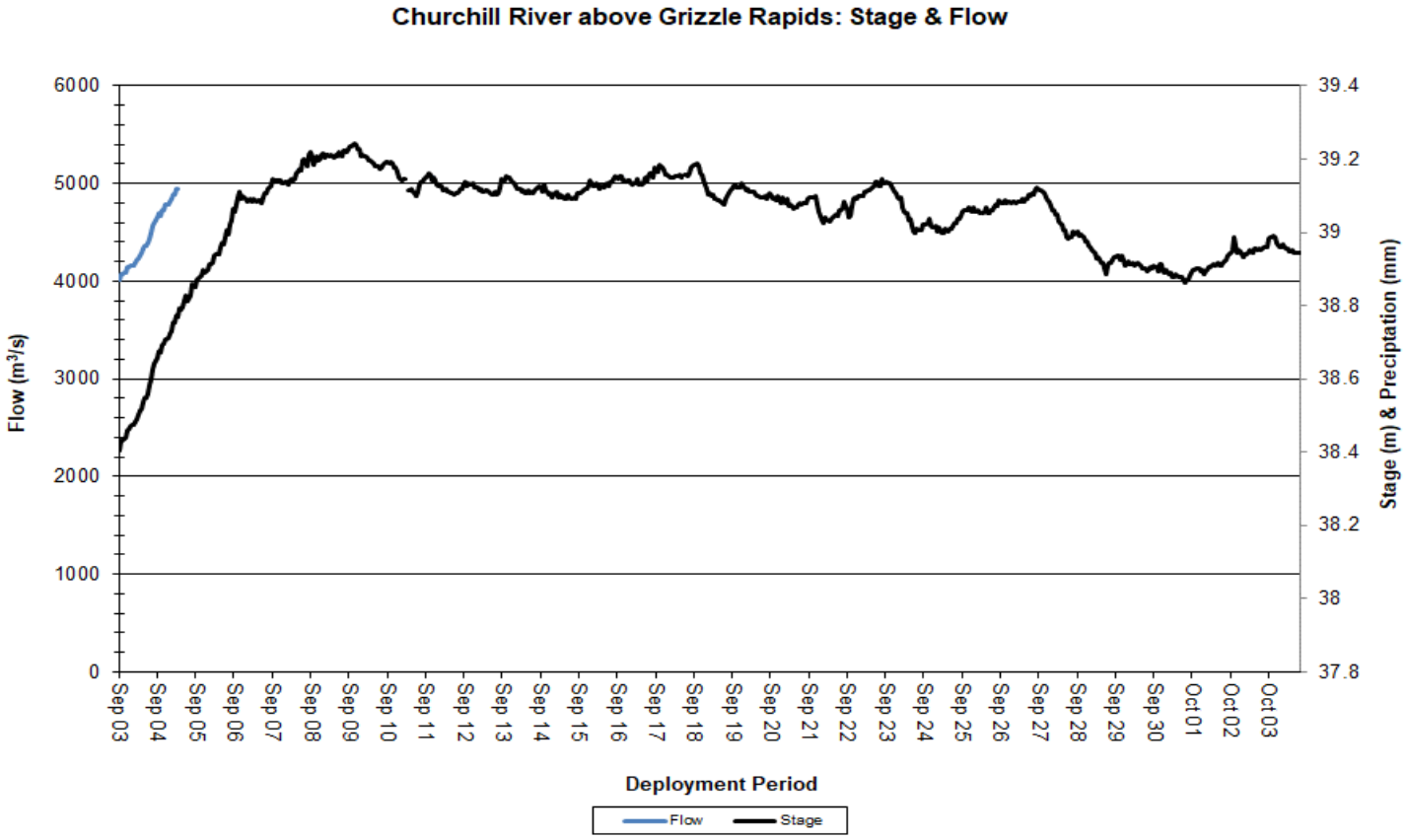


Figure 14: Stage & Flow at Churchill River above Grizzle Rapids

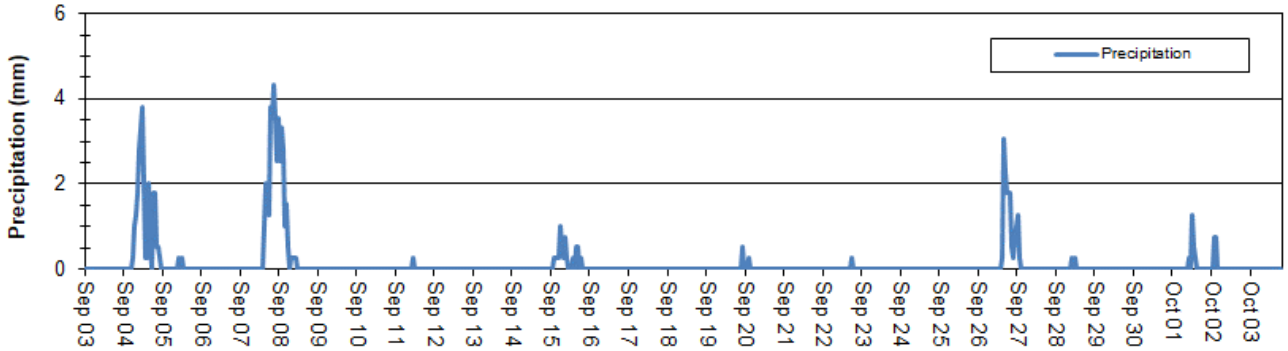


Figure 15: Precipitation at Churchill River above Grizzle Rapids

Churchill River below Muskrat Falls

Water Temperature

- Over the deployment period, water temperature ranged from 9.90°C to 16.60°C, with a median value of 12.80°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 September. 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.

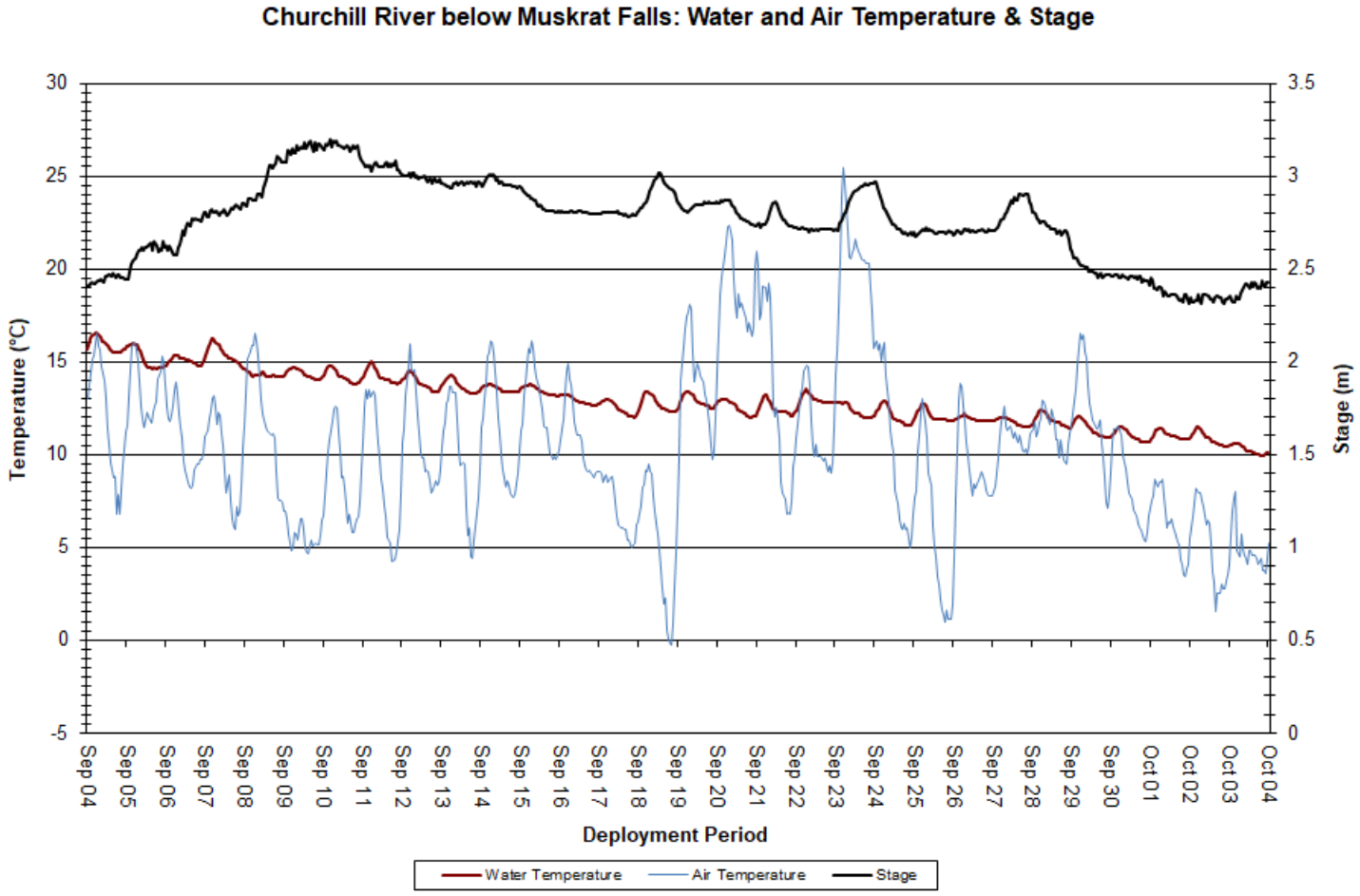


Figure 16: Water and Air Temperature & Stage at Churchill River below Muskrat Falls

pH

- Over the deployment period, pH ranged from 6.67 pH units to 6.88 pH units, with a median value of 6.77 (Figure 17).
- pH values were quite stable over the course of deployment, and remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment (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.

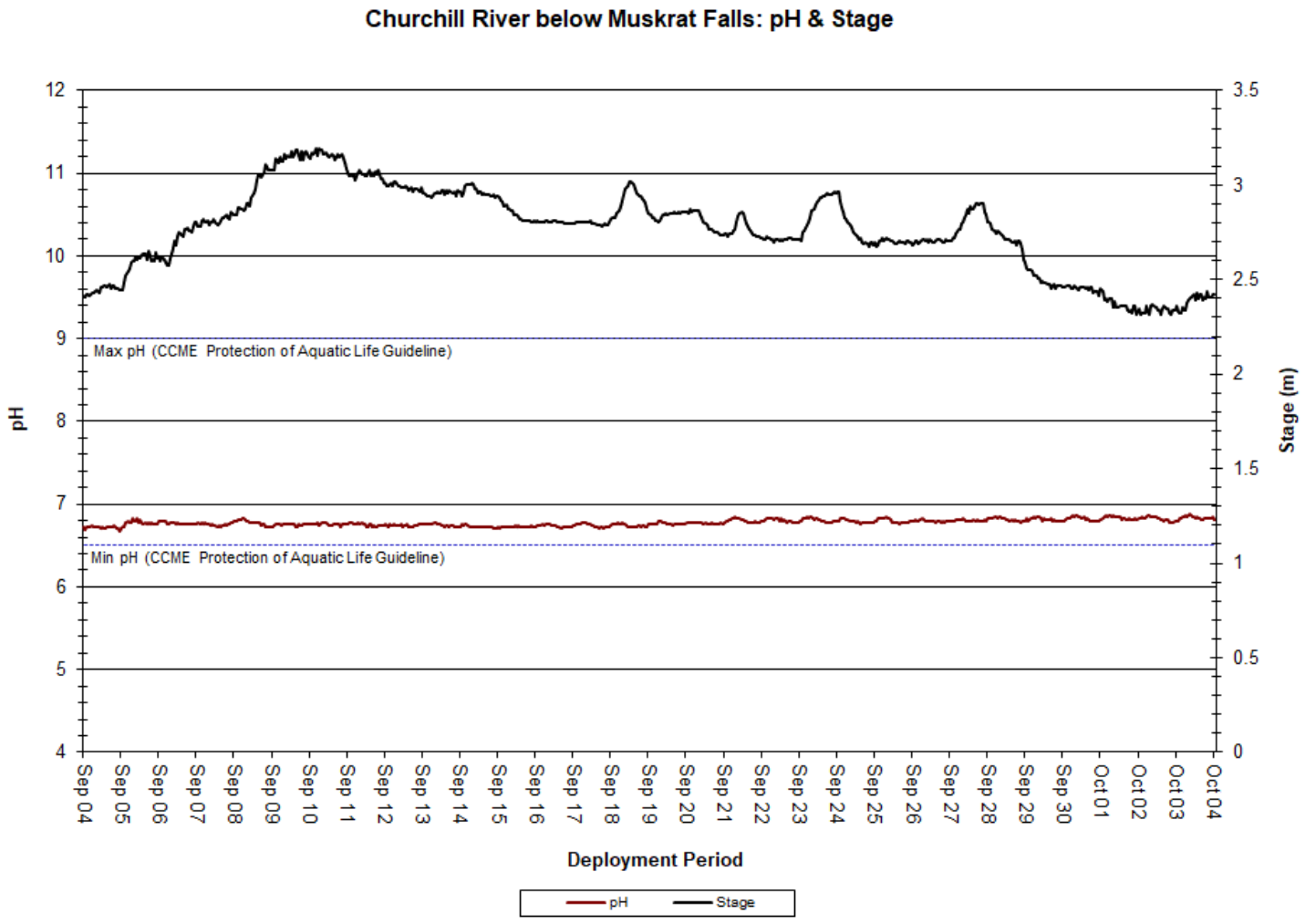


Figure 17: pH & Stage at Churchill River below Muskrat Falls

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 14.8µS/cm to 17.4µS/cm, with a median value of 16.1µS/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 somewhat 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.

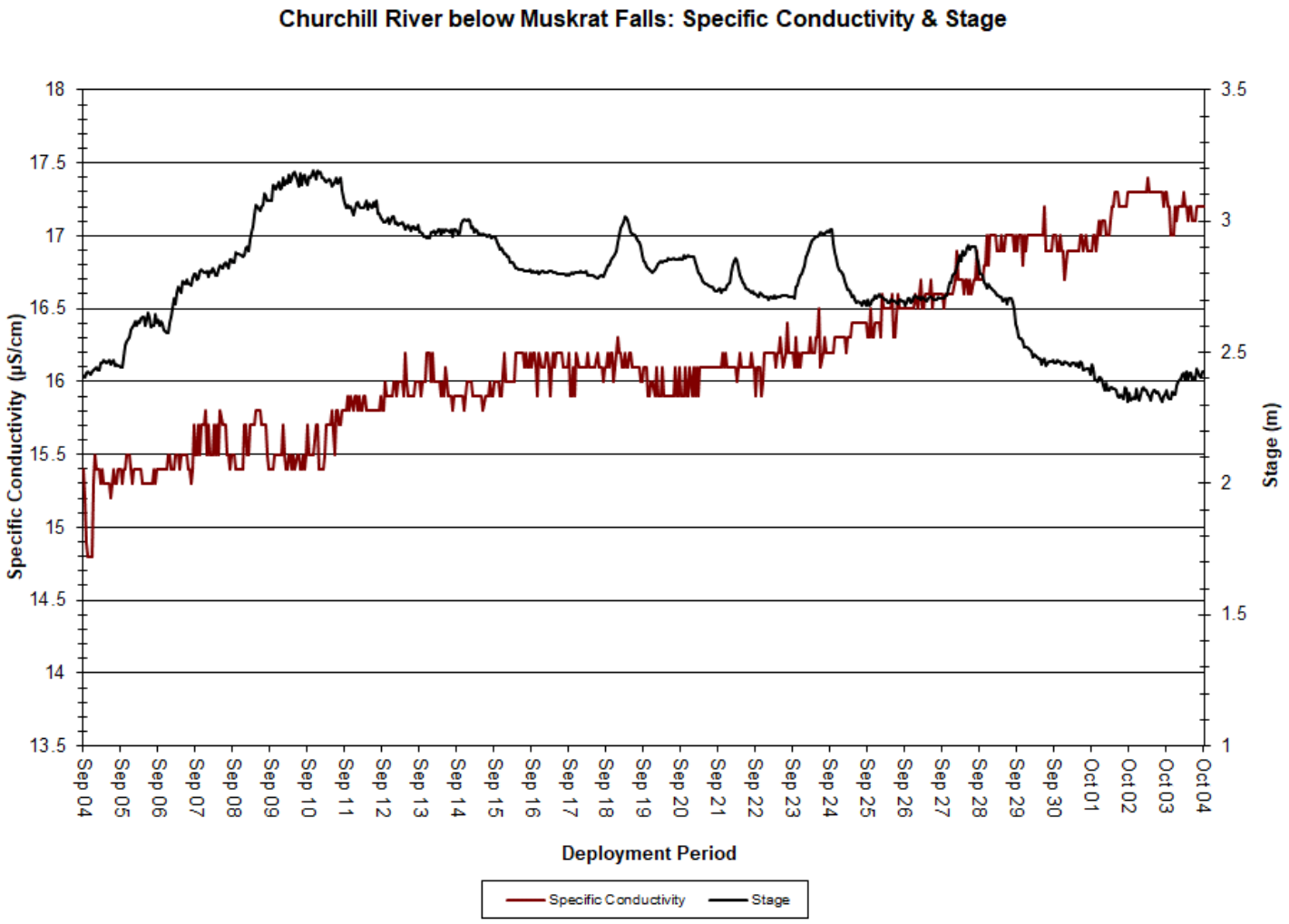


Figure 18: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 10.25mg/L to 12.78mg/L, with a median value of 12.30mg/L. Saturation of dissolved oxygen ranged from 101.9% to 125.0%, with a median value of 115.0% (Figure 19).
- Dissolved oxygen and water temperature exhibit an inverse relationship: as one parameter increases, the other decreases, and vice versa. Dissolved oxygen levels slowly increased over the course of deployment. This is to be expected since water temperatures were slowly decreasing over the same period. 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 Early and Other Life Stages for the duration of deployment.

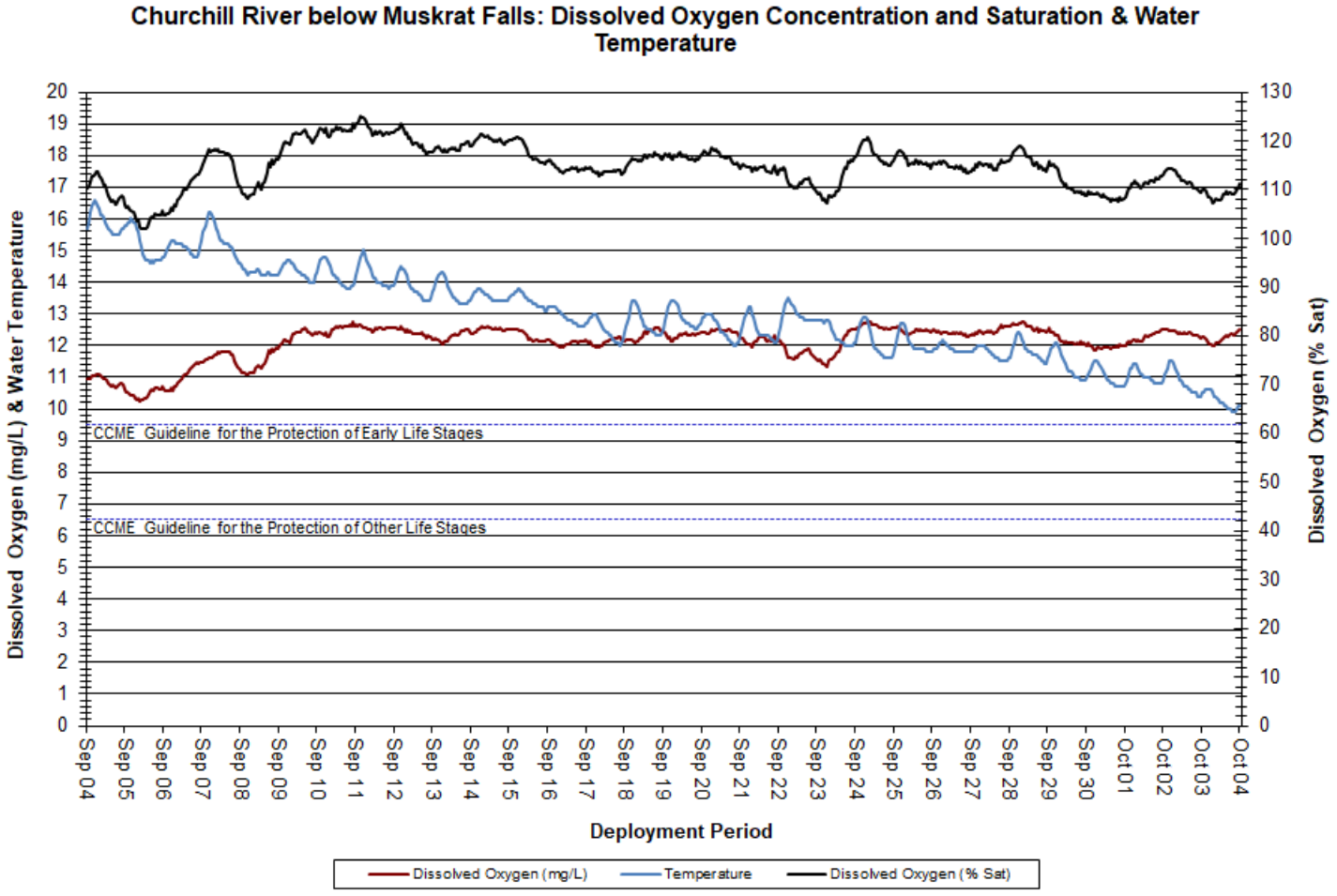


Figure 19: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Turbidity

- Over the deployment period, turbidity ranged from 2.7NTU to 30.5NTU, with a median value of 6.8NTU. A median value of 6.8NTU indicates a small amount of natural background turbidity in the waterbody. Precipitation data was obtained from the Muskrat Falls MET Station.
- Some of the larger turbidity spikes observed over the deployment period correlate closely with changes in stage and precipitation events (Figure 20). This station is located at a wide and deep section of the Churchill River with a sandy bottom, and therefore turbidity levels are less susceptible to precipitation events as compared to other areas.
- 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.

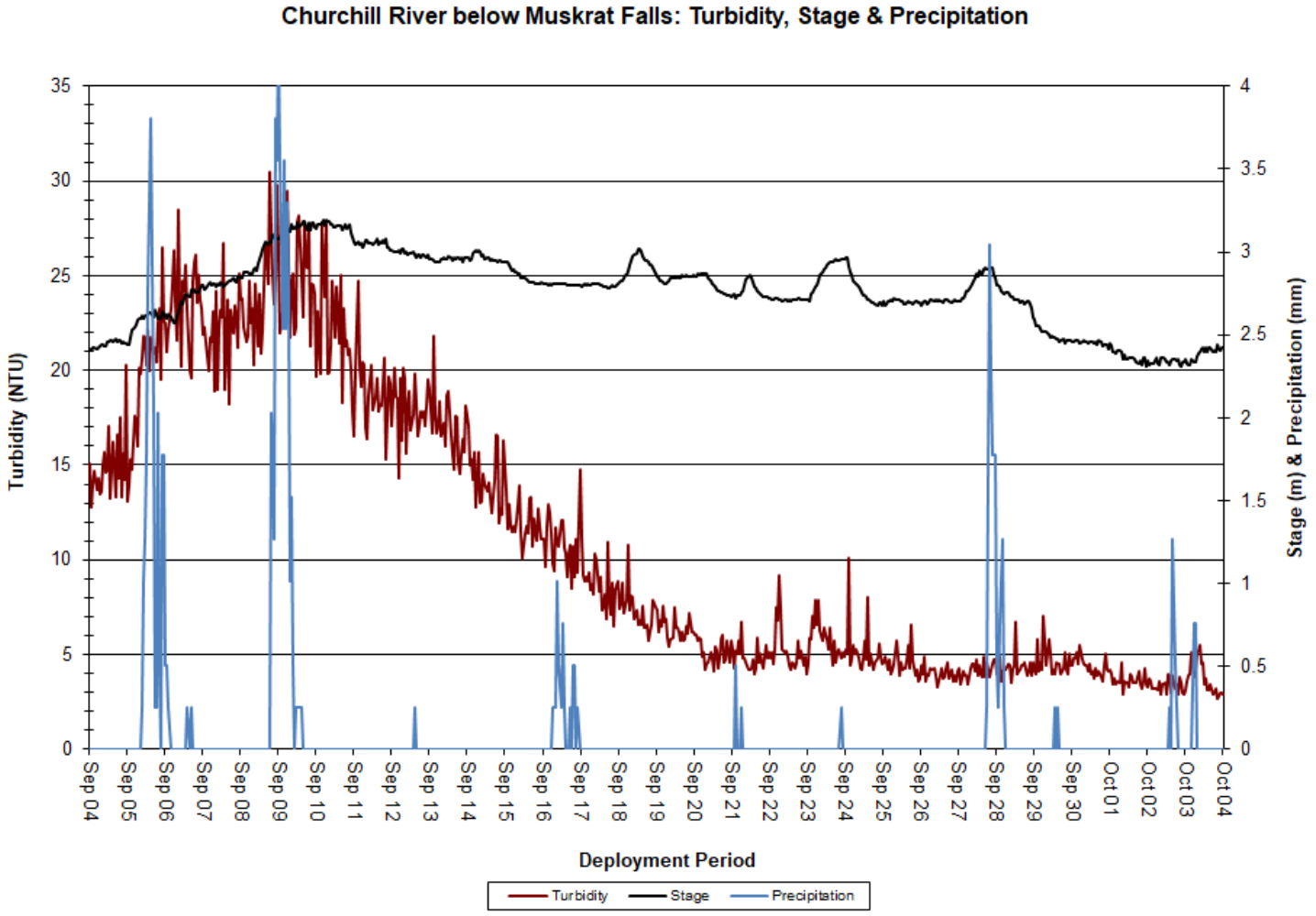


Figure 20: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls

Stage & Flow

- Over the deployment period, stage ranged from 2.31m to 3.19m, with a median value of 2.80m. Flow ranged from 1310.75m^3/s to 2217.08m^3/s, with a median value of 1792.93m^3/s (Figure 21). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage and flow were variable over the course of deployment and followed a very similar trend. Increases in stage and flow correlated with precipitation events on several occasions; however, other increases did not correlate with precipitation events. 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.

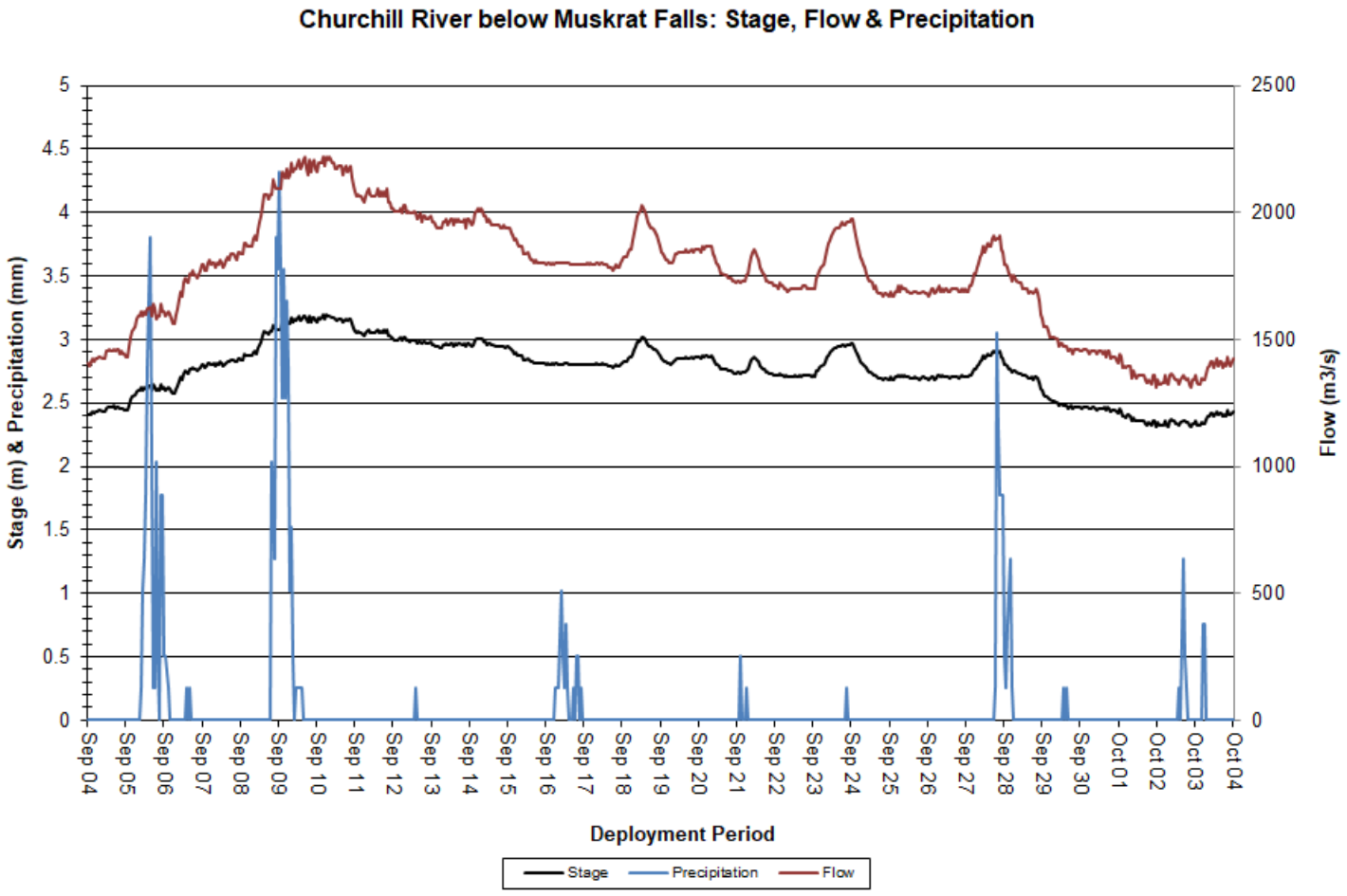


Figure 21: Stage & Precipitation at Churchill River below Muskrat Falls

Chlorophyll

- Over the deployment period, chlorophyll ranged from 1.77ug/L to 2.85ug/L, with a median value of 2.21ug/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.

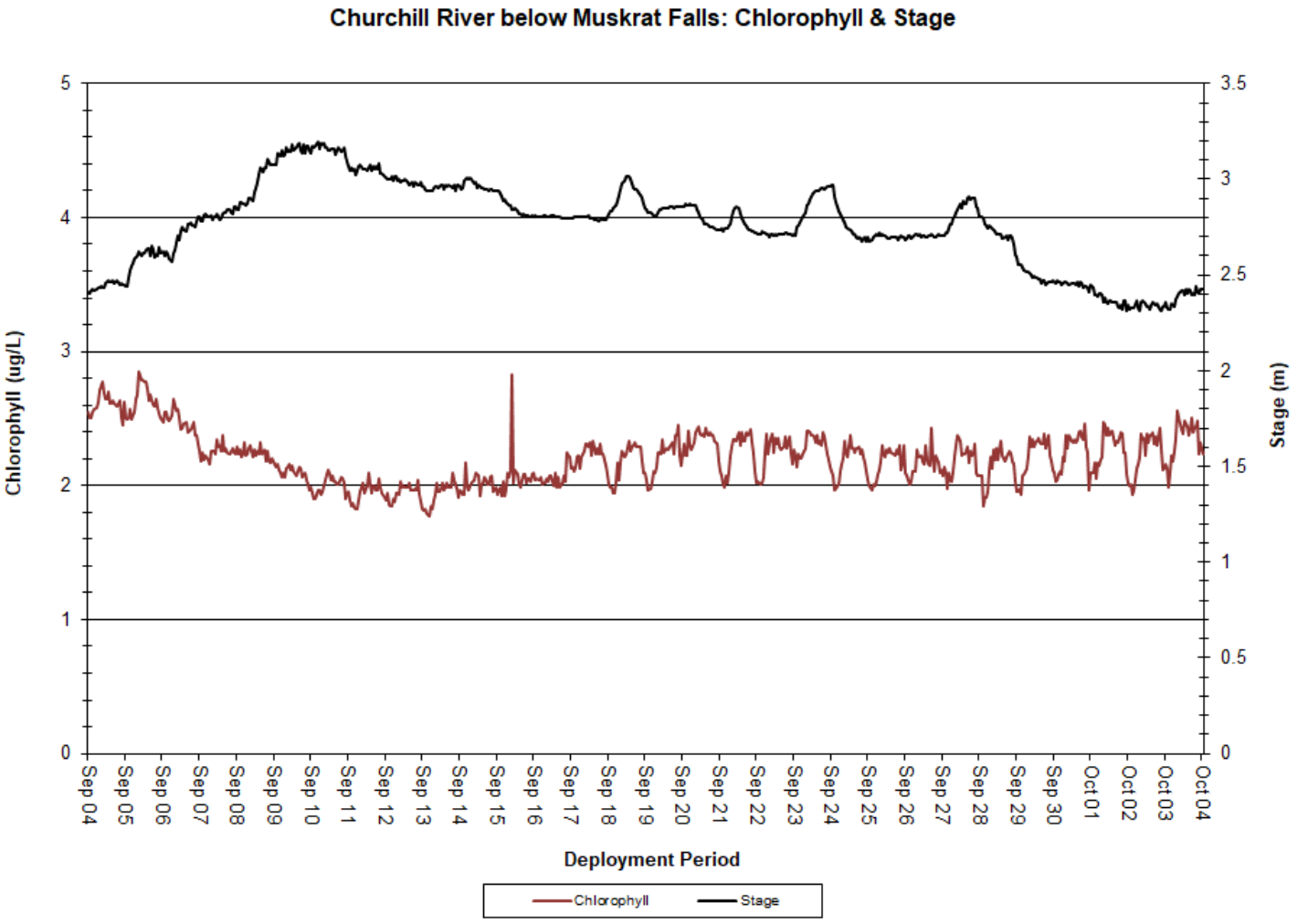


Figure 22: Chlorophyll & Stage at Churchill River below Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranged from 8.70°C to 15.70°C, with a median value of 12.00°C (Figure 23). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature decreased slowly 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.

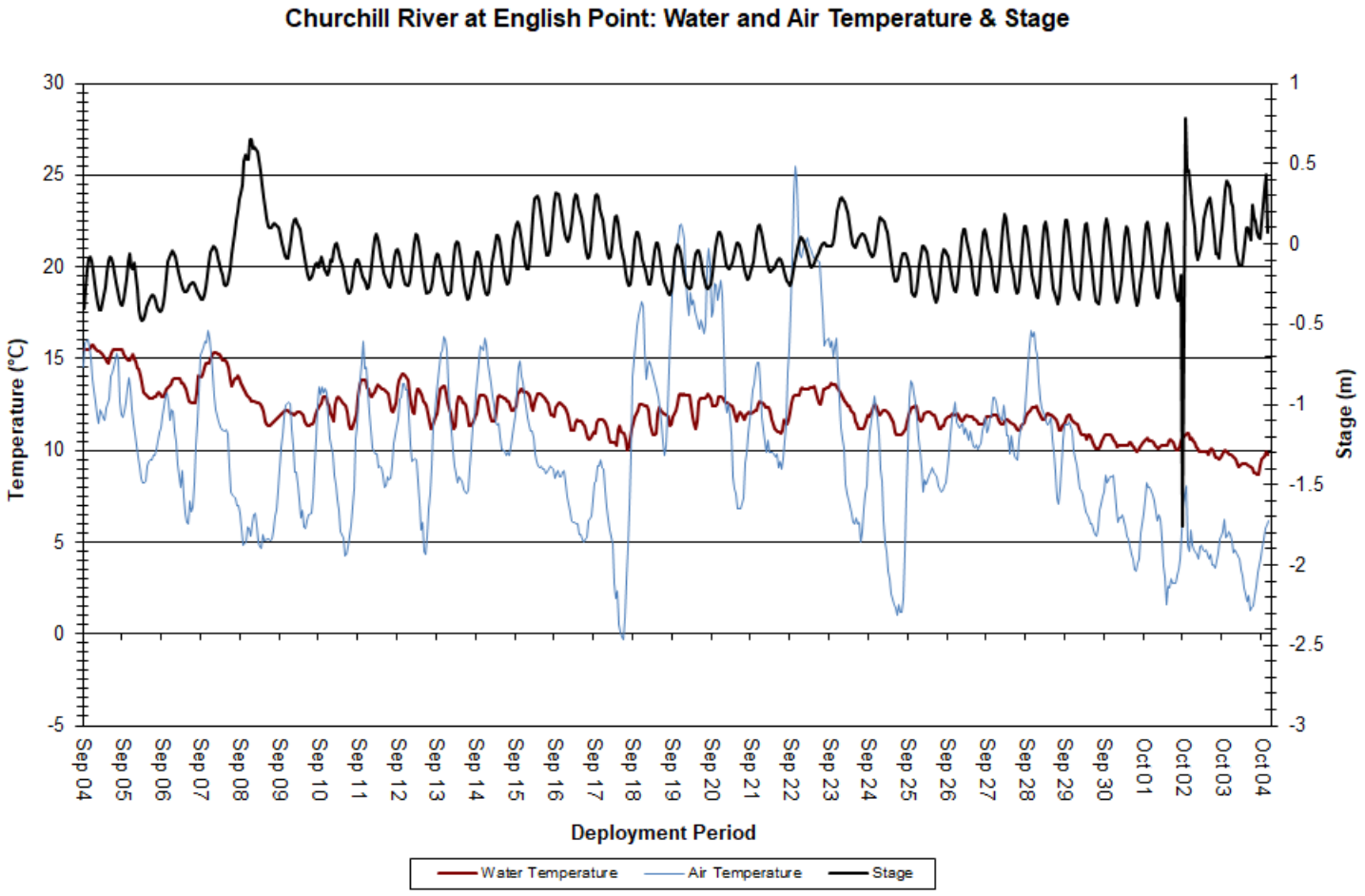


Figure 23: Water and Air Temperature & Stage at Churchill River at English Point

pH

- Over the deployment period, pH ranged from 5.70 pH units to 6.97 pH units, with a median value of 6.68 (Figure 24).
- pH values were variable across the deployment period. pH was within the CCME's Guidelines for the Protection of Aquatic Life for the beginning of deployment; however, from September 16th onwards, pH values fluctuated above and below the CCME's minimum 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.

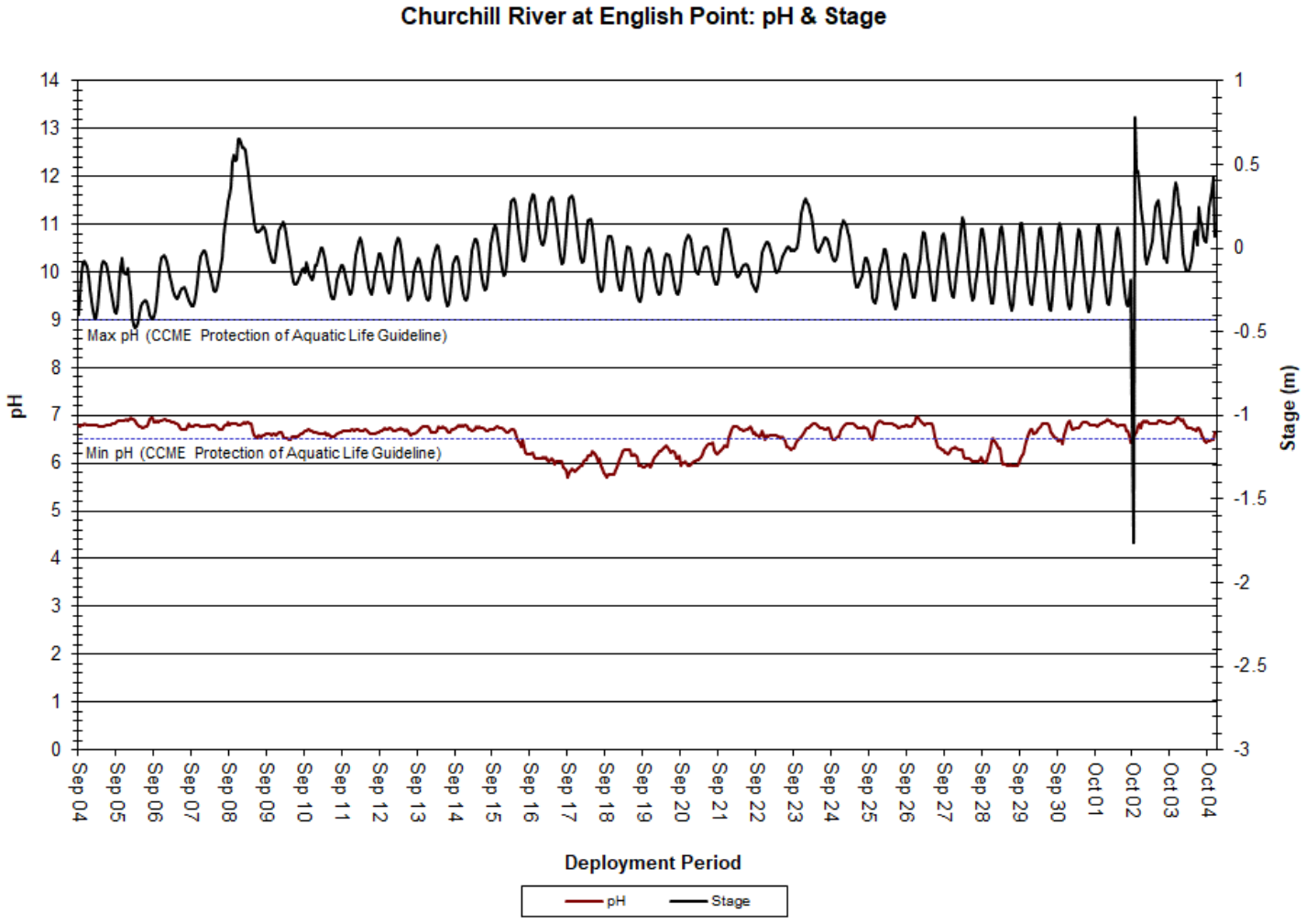


Figure 24: pH & Stage at Churchill River at English Point

Specific Conductivity

- Over the deployment period, specific conductivity ranged from 16.2µS/cm to 39.6µs/cm, with a median value of 25.6µS/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.

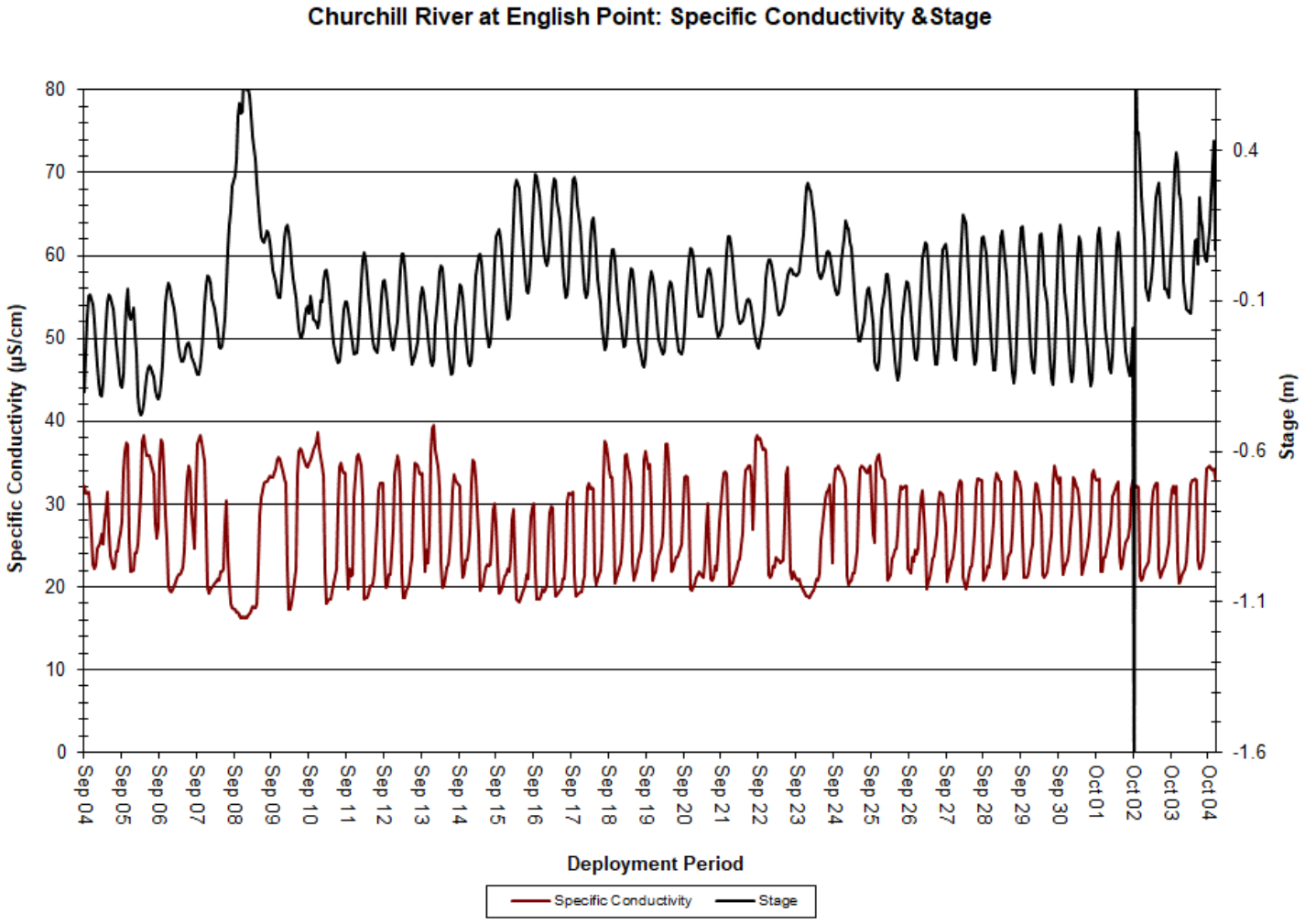


Figure 25: Specific Conductivity & Stage at Churchill River at English Point

Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 9.33mg/L to 11.66mg/L, with a median value of 10.58mg/L. Saturation of dissolved oxygen ranged from 85.2% to 110.9% saturation, with a median value of 98.8% (Figure 26).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures decreased over the deployment period, dissolved oxygen levels gradually 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 fell below the CCME's Guideline for the Protection of Early Life Stages on several brief occasions at the beginning of deployment; these instances correlated closely with warmer water temperatures. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Early Life Stages from September 10th onwards. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment (Figure 26).

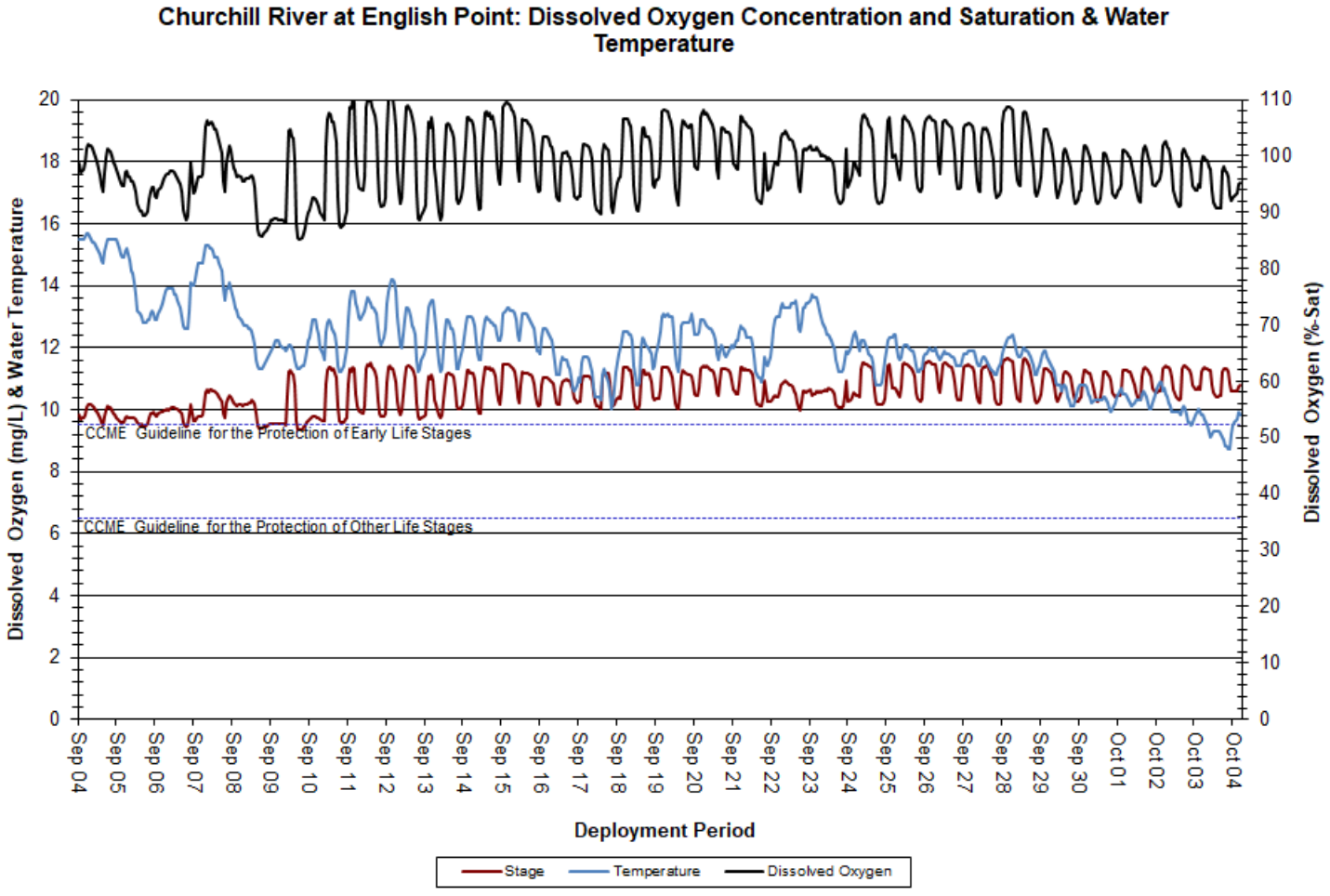


Figure 26: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Turbidity

- Over the deployment period, turbidity ranged from 0.0NTU to 187.4NTU, with a median value of 7.2NTU (Figure 27). A median value of 7.2NTU 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. High winds and tidal influences can also contribute to turbidity events at this station by disturbing sediment from the river bed (Figure 27). Wind speed data was obtained from the Churchill River at End of Mud Lake Road 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.

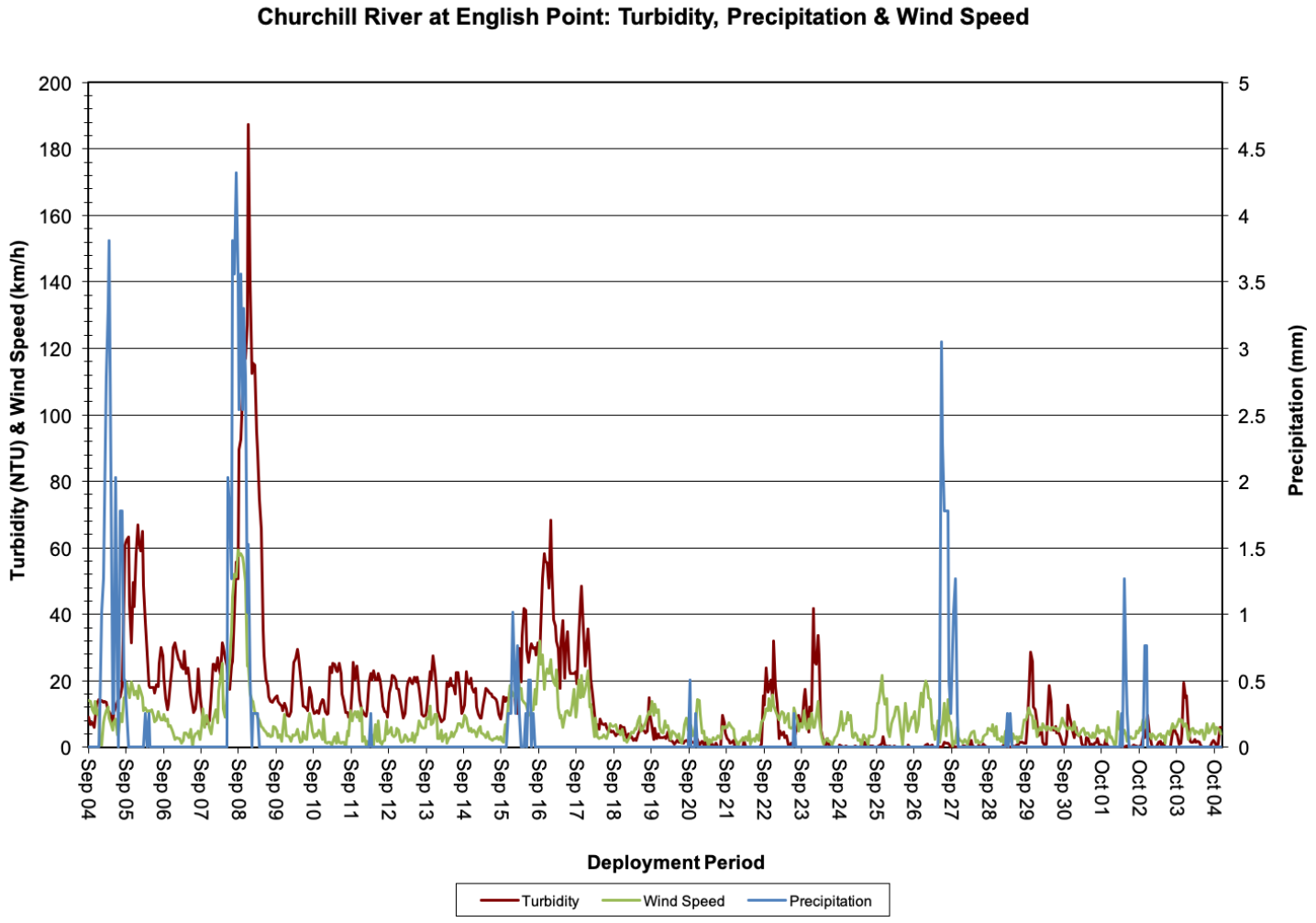


Figure 27: Turbidity, Precipitation & Wind Speed at Churchill River at English Point

Stage

- Over the deployment period, stage ranged from -1.76m to 0.78m, with a median value of -0.09m (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 (Figure 28).
- 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.

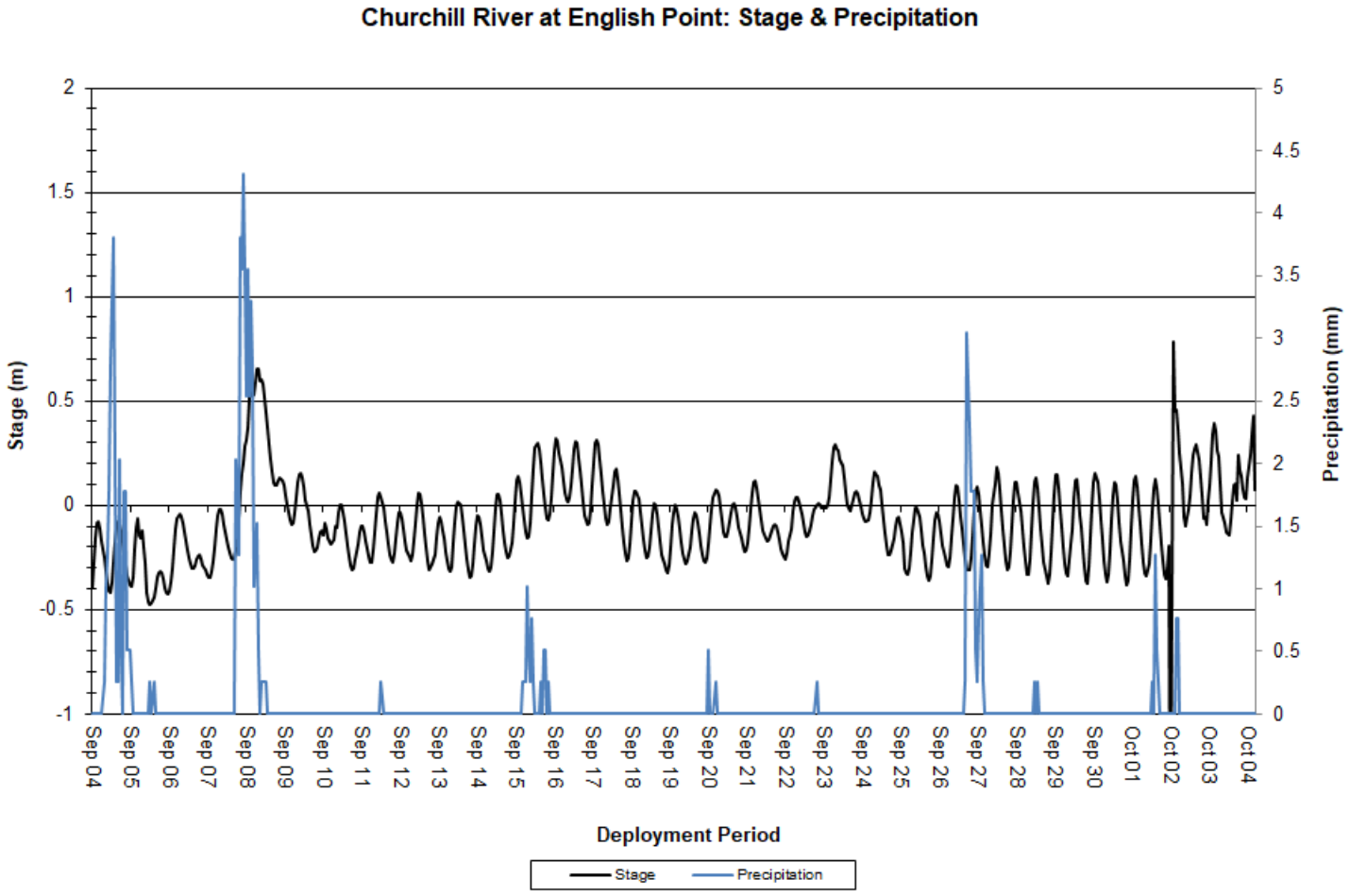


Figure 28: Stage & Precipitation at Churchill River at English Point

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from September 3/4 to October 4, 2019.
- 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 through September.
- pH was relatively stable at all stations over the course of deployment. pH was within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment at Churchill River below Metchin River, above Grizzle Rapids, and below Muskrat Falls, while pH hovered around the minimum Guideline at English Point.
- Specific conductivity generally increased 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 slowly increased over the course of deployment at all stations as water temperatures decreased through September. Dissolved oxygen levels are generally higher in water at cooler temperatures. Dissolved oxygen levels remained above the CCME's Guideline for the Protection of Early Life Stages for the duration of deployment at Churchill River below Metchin River and below Muskrat Falls. Dissolved oxygen levels at the other two stations started deployment below the CCME's Guideline for the Protection of Early Life Stages, but quickly rose and remained above the Guideline as deployment progressed. Dissolved oxygen levels were above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment at all stations.
- Turbidity events occurred at all stations and were generally related to precipitation, high winds or tidal events. In all cases, turbidity values returned to background levels following each observed event.

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

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: 1916856

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453757	WS-S-0000 CR Above GR	2019-6324-00-SI-SP	2019-09-03	Alkalinity as CaCO3	mg/L	5	10
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	40
				Conductivity	uS/cm	5	28
				Dissolved Organic Carbon	mg/L	0.5	4.7
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	10
				N-NH3 (Ammonia)	mg/L	0.01	0.02
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.56
				Sulphate	mg/L	1	2
				Total Dissolved Solids (COND - CALC)	mg/L	1	18
				Total Kjeldahl Nitrogen	mg/L	0.1	<0.1
				Total Organic Carbon	mg/L	0.5	4.7
				Turbidity	NTU	0.1	1.4
				Aluminum	mg/L	0.01	0.04

Sample comment:

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: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1916856**

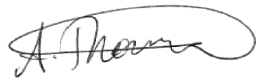
Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453757	WS-S-0000 CR Above GR	2019-6324-00-SI-SP	2019-09-03	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	4
				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	0.14
				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	0.011

Sample comment:

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: 

Addrine Thomas

REPORT OF ANALYSIS

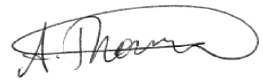
Lab Report Number: **1916856**

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453757	WS-S-0000	2019-6324-00-SI-SP	2019-09-03	Uranium	mg/L	0.001	<0.001
	CR Above GR			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.003
Sample comment:				Total Suspended Solids	mg/L	2	<2

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: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1916856

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453758	WS-S-0000	2019-6325-00-SI-SP	2019-09-04	Alkalinity as CaCO3	mg/L	5	10
	CR Below MF			Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	3
Sample comment:				Colour	TCU	2	57
				Conductivity	uS/cm	5	26
				Dissolved Organic Carbon	mg/L	0.5	5.7
Report comment:				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.01	0.03
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.54
				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	5.9
				Turbidity	NTU	0.1	21.6
				Aluminum	mg/L	0.01	0.29

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: **1916856**

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453758	WS-S-0000	2019-6325-00-SI-SP	2019-09-04	Antimony	mg/L	0.0005	<0.0005
	CR Below MF			Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	0.01
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	0.37
				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	0.012

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

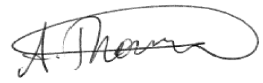
Lab Report Number: **1916856**

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453758	WS-S-0000	2019-6325-00-SI-SP	2019-09-04	Uranium	mg/L	0.001	<0.001
	CR Below MF			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.015
Sample comment:				Total Suspended Solids	mg/L	2	18

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: 

Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: 1916856

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453760	WS-S-0000 CR @ EP	2019-6327-00-SI-SP	2019-09-04	Alkalinity as CaCO3	mg/L	5	7
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	6
				Colour	TCU	2	69
				Conductivity	uS/cm	5	31
				Dissolved Organic Carbon	mg/L	0.5	6.3
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	9
				N-NH3 (Ammonia)	mg/L	0.01	0.03
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.07
				Sulphate	mg/L	1	1
				Total Dissolved Solids (COND - CALC)	mg/L	1	20
				Total Kjeldahl Nitrogen	mg/L	0.1	<0.1
				Total Organic Carbon	mg/L	0.5	6.5
				Turbidity	NTU	0.1	13.9
				Aluminum	mg/L	0.01	0.22

Sample comment:

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: Addrine Thomas

REPORT OF ANALYSIS

Lab Report Number: **1916856**

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453760	WS-S-0000 CR @ EP	2019-6327-00-SI-SP	2019-09-04	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	0.003
				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	3
				Strontium	mg/L	0.001	0.014

Sample comment:

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

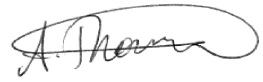
Lab Report Number: **1916856**

Cient:	Department of Environment	**COC Number:**	848802
Attention:	Ms. Leona Hyde	**Date Reported:**	2019-09-23
Client Project:		**Date Submitted:**	2019-09-16
Purchase Order:	2180014303	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1453760	WS-S-0000	2019-6327-00-SI-SP	2019-09-04	Uranium	mg/L	0.001	<0.001
	CR @ EP			Zinc	mg/L	0.01	<0.01
				Phosphorus	mg/L	0.002	0.012
Sample comment:				Total Suspended Solids	mg/L	2	8

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: 

Addrine Thomas