# Real-Time Water Quality Deployment Report

## Lower Churchill River Network

**May 26/28/June 14 to**
**July 7/8/27, 2021**

Newfoundland Labrador

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

## Contents



*Prepared by:*
Brenda Congram
Environmental Scientist
Department of Environment and Climate Change
Water Resources Management Division
brendacongram@gov.nl.ca

**Real-Time Water Quality Deployment Report**

**Lower Churchill River Network**

**May 26/28/June 14 to July 7/8/27, 2021**

## Real Time Water Quality Monitoring

- Staff with the Department of Environment and Climate Change monitor real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at four stations on the Lower Churchill River: Churchill River below Metchin River, Churchill River above Grizzle Rapids, Churchill River below Muskrat Falls and Churchill River at English Point.
- A real-time water quality monitoring instrument was deployed at Churchill River below Muskrat Falls on May 26th. Instruments were deployed at Churchill River above Grizzle Rapids and Churchill River at English Point on May 28th. An instrument was deployed at Churchill River below Metchin River on June 14th.
- The instrument at Churchill River above Grizzle Rapids was removed on July 7th for a deployment period of 38 days. The instruments at Churchill River below Muskrat Falls and Churchill River at English Point were removed on July 8th for deployment periods of 41 days and 39 days, respectively. The instrument at Churchill River below Metchin River was removed on July 27th for a deployment period of 43 days.
- The station at Churchill River 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. Even at raised water levels, the above Muskrat Falls station is situated quite far from the water, 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 May 26/28/June 14 to July 7/8/27, 2021 are summarized in Table 2.

**Table 2: Comparison rankings for Lower Churchill River stations May 26/28/June 14 to July 7/8/27, 2021**

| Churchill River Station | Date | Action | Comparison Ranking | | | | |
|---|---|---|---|---|---|---|---|
| | | | Temperature | pH | Conductivity | Dissolved Oxygen | Turbidity |
| Below Metchin River | June 14, 2021 | Deployment | Good | Excellent | Excellent | Good | Excellent |
| | July 27, 2021 | Removal | N/A | N/A | N/A | N/A | N/A |
| Above Grizzle Rapids | May 28, 2021 | Deployment | Excellent | Good | Excellent | Excellent | Excellent |
| | July 7, 2021 | Removal | Excellent | Good | Excellent | Excellent | Excellent |
| Below Muskrat Falls | May 26, 2021 | Deployment | Good | Good | Excellent | Marginal | Poor |
| | July 8, 2021 | Removal | Good | Excellent | Excellent | Excellent | Poor |
| At English Point | May 28, 2021 | Deployment | Excellent | Good | Excellent | Poor | Fair |
| | July 8, 2021 | Removal | Excellent | Excellent | Excellent | Good | Poor |
| 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 either ‘excellent’ or ‘good’.
  - QA/QC rankings could not be determined at removal because the instrument was out of water.
- **Churchill River above Grizzle Rapids**
  - At deployment, all parameters ranked as either ‘excellent’ or ‘good’.
  - At removal, all parameters ranked as either ‘excellent’ or ‘good'.
- **Churchill River below Muskrat Falls**
  - At deployment, conductivity was ‘excellent, temperature and pH were ‘good’, dissolved oxygen was ‘marginal’, while turbidity was ‘poor’.
  - At removal, all parameters again ranked as either ‘excellent’ or ‘good’, with the exception of turbidity. Given that turbidity ranked as ‘poor’ during deployment and removal, there may have been a calibration error that occurred with the field sonde. This is supported by a close comparison at deployment between the QA/QC sonde and the grab sample result.

- **Churchill River at English Point**
    - At deployment, temperature and conductivity were 'excellent', pH was 'good', turbidity was 'fair', while dissolved oxygen was 'poor'. This discrepancy is likely due to the QA/QC sonde not being placed in close enough proximity to the field sonde, or not being given sufficient time to acclimatize.
    - At removal, all parameters ranked as either 'excellent' or 'good', with the exception of turbidity. This discrepancy is being attributed to significant sediment build-up around the sensors on the field sonde.

## Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from May 26/28/June 14 to July 7/8/27, 2021 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.

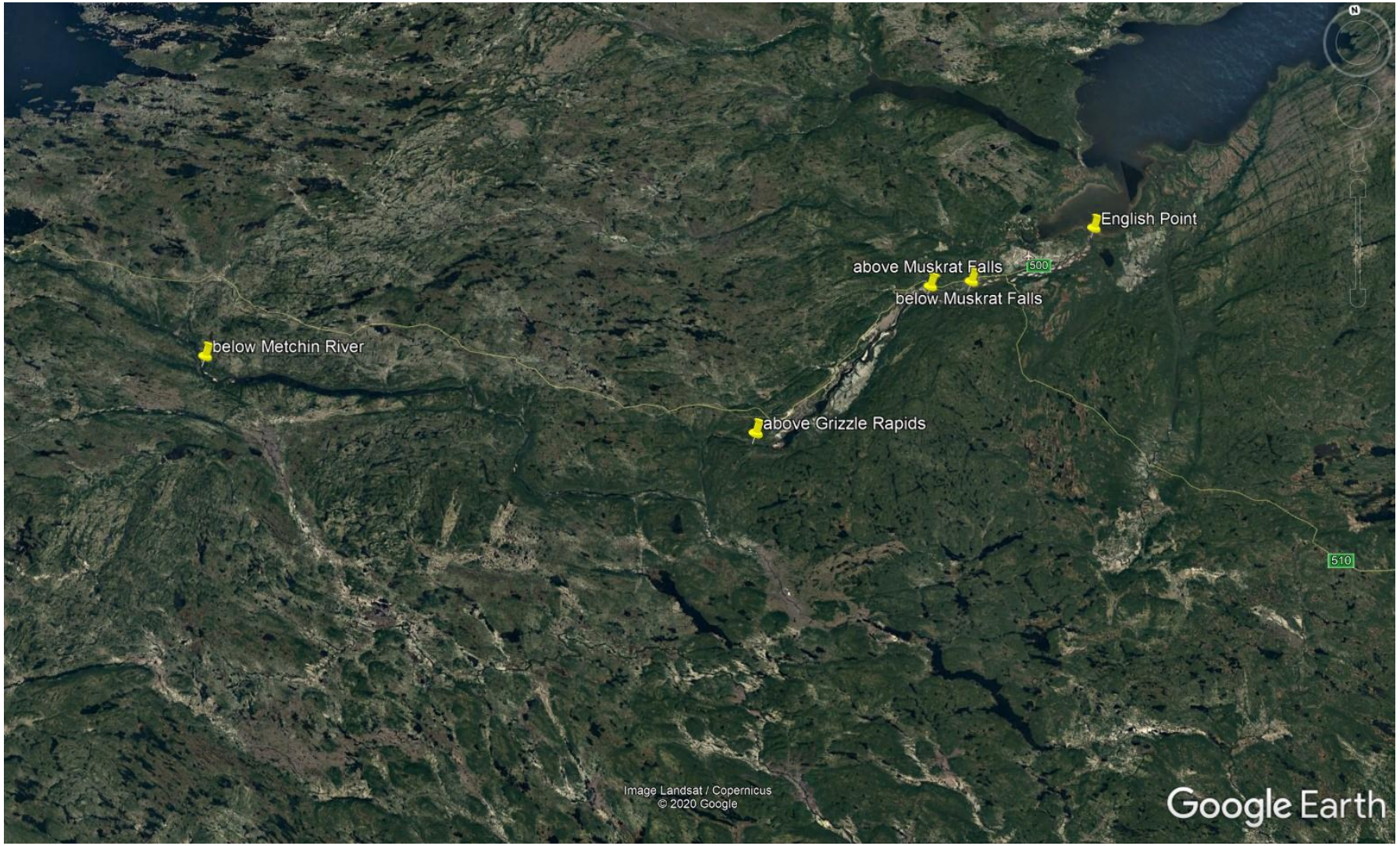


**Figure 1: Lower Churchill Network of Real-Time Water Quality Stations**

## Churchill River below Metchin River

### Water Temperature

- Over the deployment period, water temperature ranged from 8.4°C to 28.0°C, with a median value of 14.3°C (Figure 2). Air temperature data was obtained from the Metchin River near TLH Weather Station.
- Water temperature was gradually increasing over the course of deployment, which is to be expected as air temperatures were also increasing across the summer season. Water temperature data exhibits a diurnal pattern as expected, and closely correlates with ambient air temperatures. The higher temperatures and greater fluctuation in values observed from July 20th onwards are due to the instrument being out of water as stage decreased significantly.
- 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.

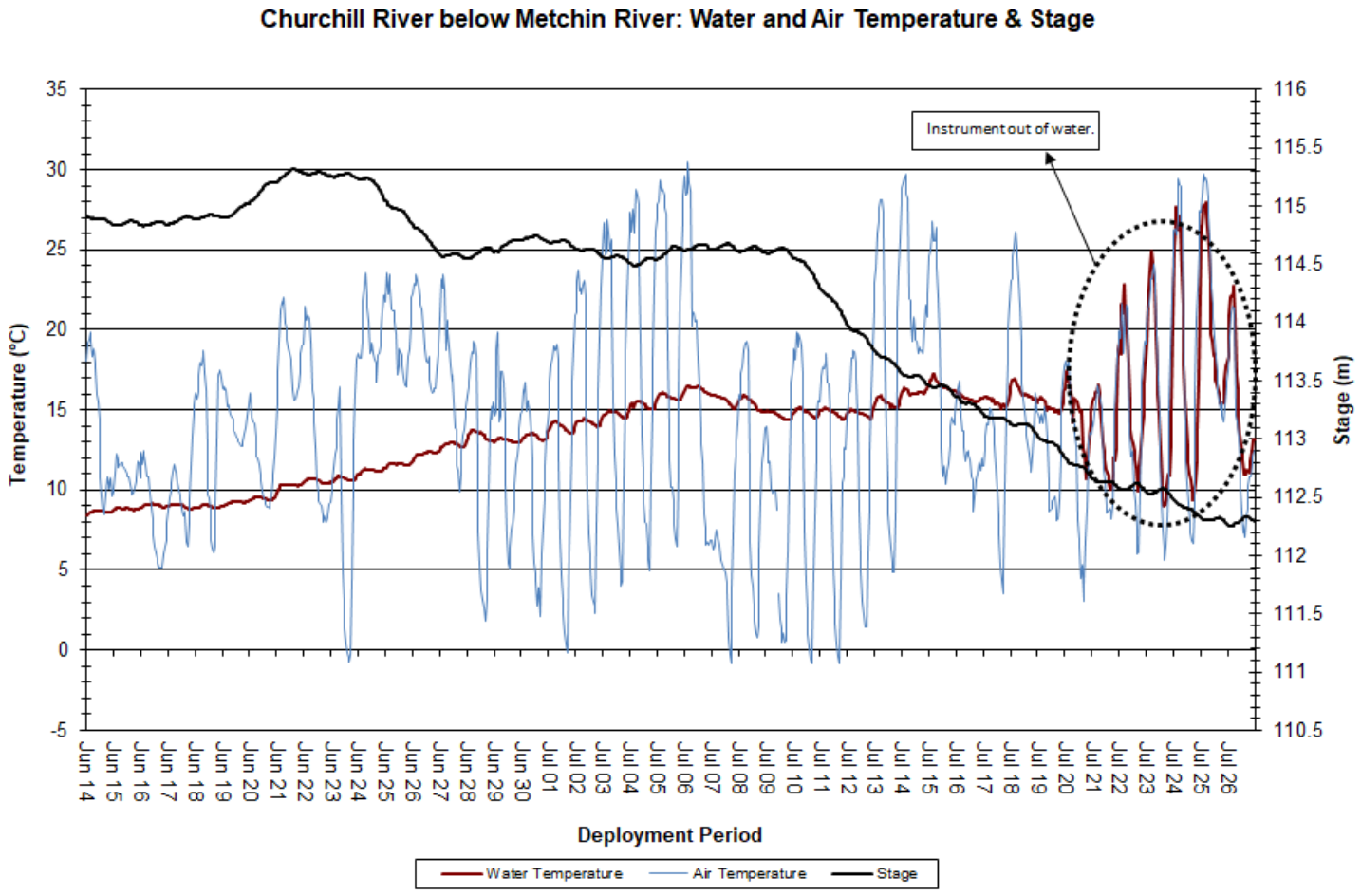


**Figure 2: Water and Air Temperature & Stage at Churchill River below Metchin River**

**pH**

- Over the deployment period, pH values ranged from 2.57 to 8.52 pH units, with a median value of 7.04 (Figure 3).
- pH values were stable over the course of deployment and remained within the CCME's Guidelines for the Protection of Aquatic Life for the duration of deployment. The fluctuations in pH observed from July 20th onwards are due to the instrument being out of water as stage decreased significantly.
- 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.

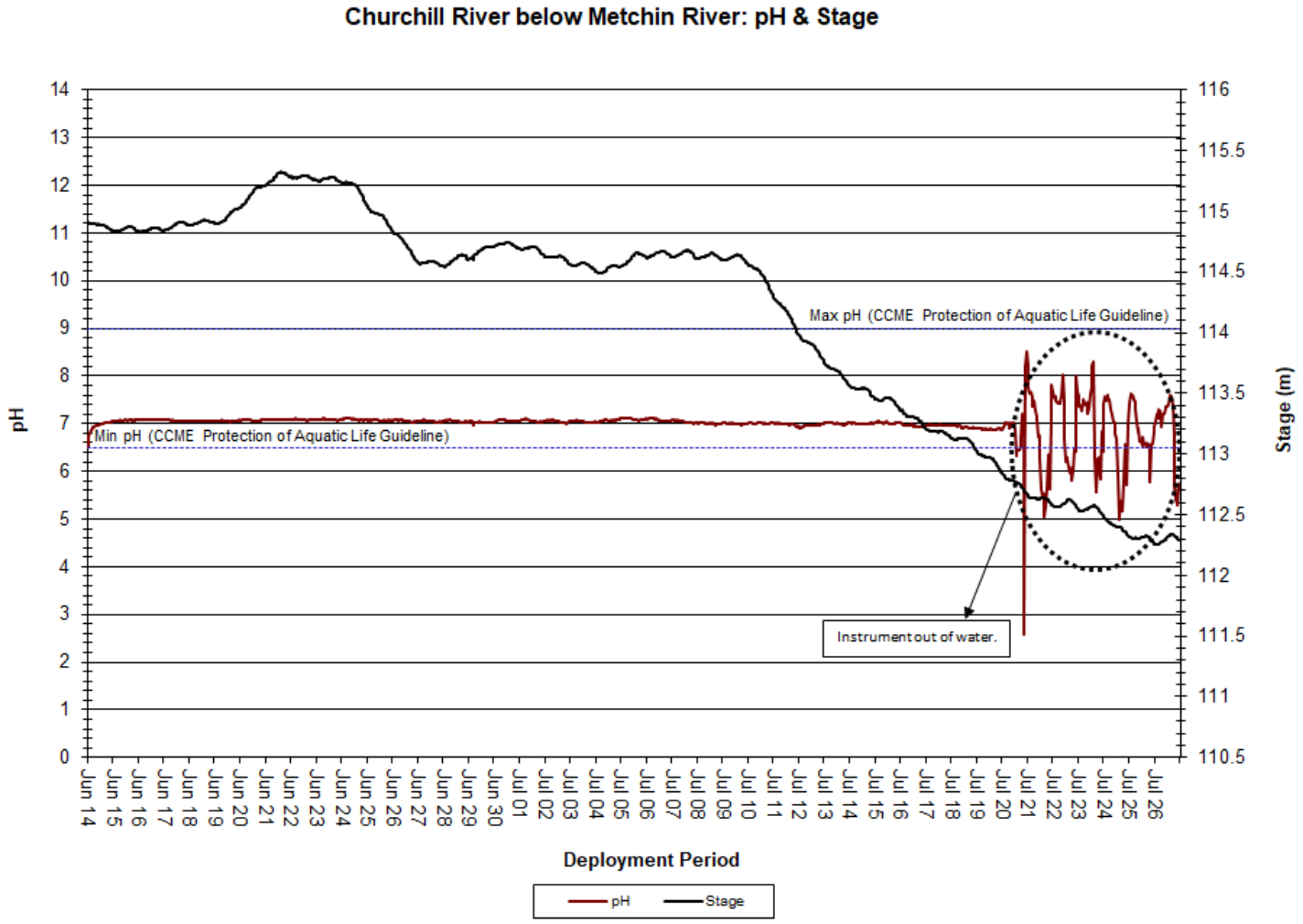


**Figure 3: pH & Stage at Churchill River below Metchin River**

**Specific Conductivity**

- Over the deployment period, specific conductivity ranged from 0µS/cm to 35.9µS/cm, with a median value of 20.7µS/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 somewhat evident in the graph below (Figure 4).
- The sharp fluctuations and zero readings observed from July 20th onwards are due to the instrument being out of water as stage decreased significantly.
- 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.

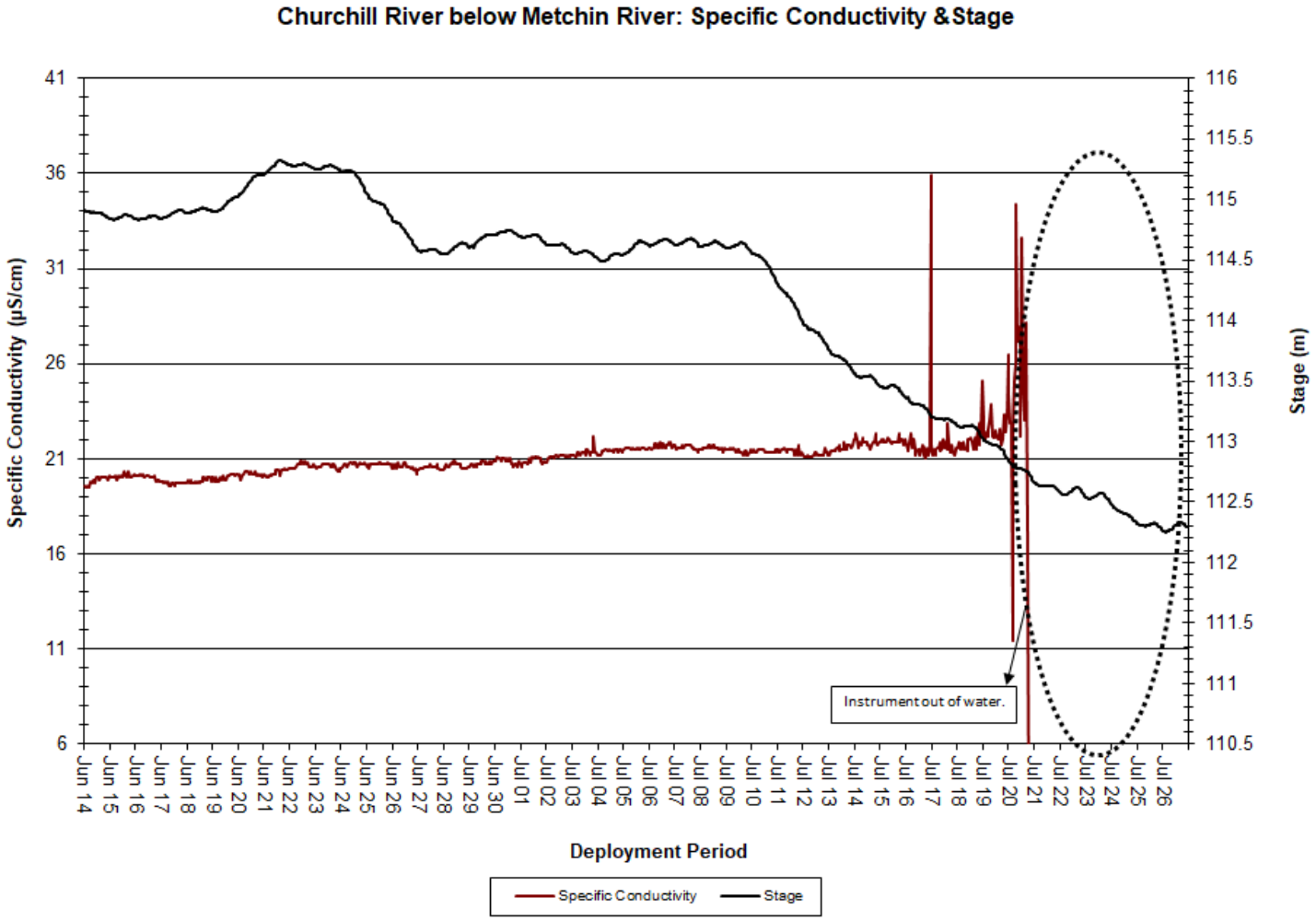


**Figure 4: Specific Conductivity & Stage at Churchill River below Metchin River**

## Dissolved Oxygen

- Over the deployment period, dissolved oxygen content ranged from 5.96mg/L to 12.00mg/L, with a median value of 10.26mg/L. Saturation of dissolved oxygen ranged from 53.6% to 103.9%, with a median value of 99.2% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels were steadily decreasing, as water temperatures were steadily increasing. 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. The greater fluctuations in dissolved oxygen concentrations observed from July 20th onwards are due to the instrument being out of water as stage decreased significantly.
- Dissolved oxygen levels remained above the CCME's Guideline for the Protection of Early Life Stages until mid-July, which corresponds closely to higher water temperatures. Dissolved oxygen levels remained above the CCME's Guideline for the Protection of Other Life Stages for the duration of deployment.

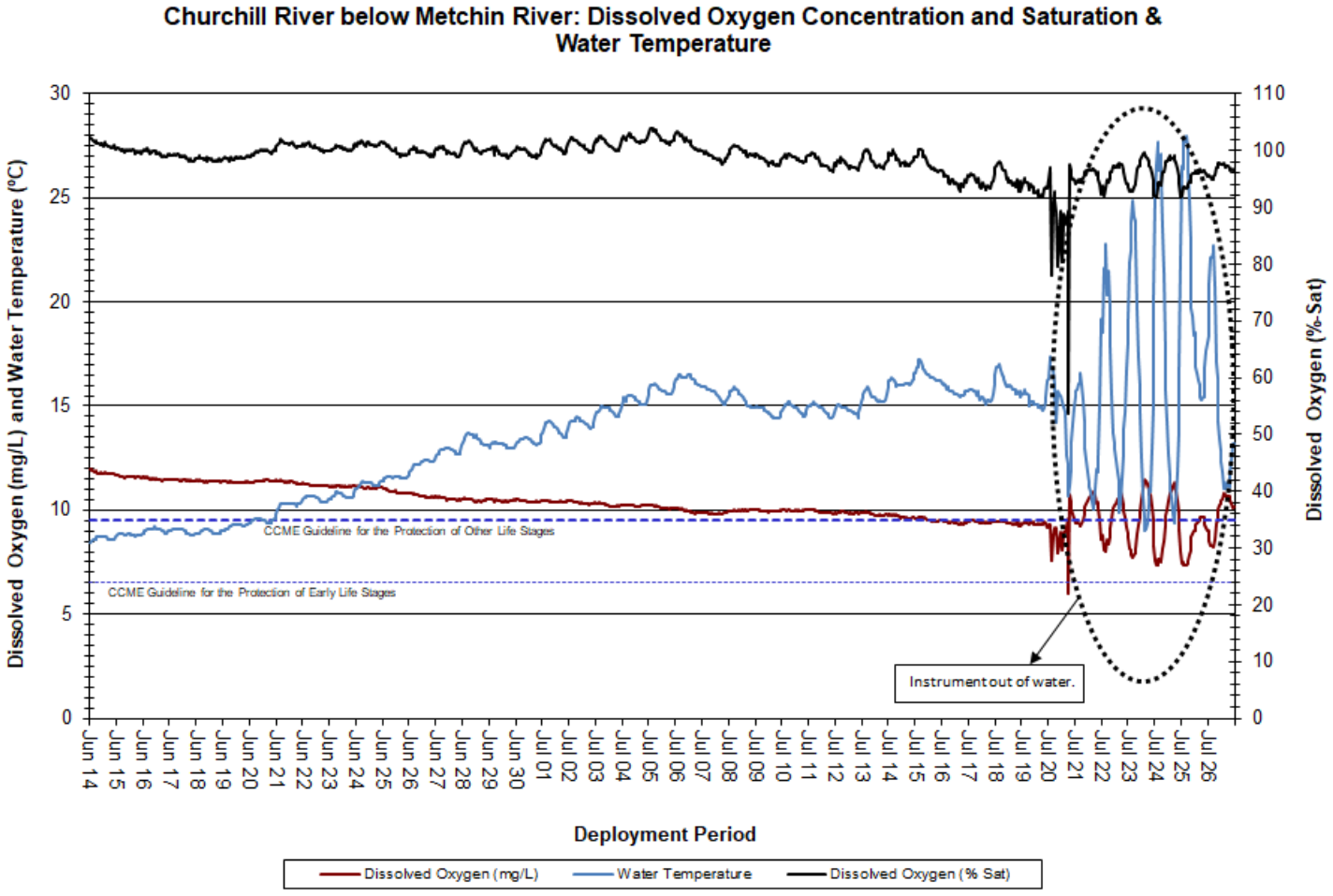


**Figure 5: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River**

**Turbidity**

- Over the deployment period, turbidity ranged from 0.0NTU to 625NTU, 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 observed throughout the deployment period correlate closely 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. The higher turbidity levels observed from July 20th onwards are due to the instrument being out of water as stage decreased significantly.
- 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.

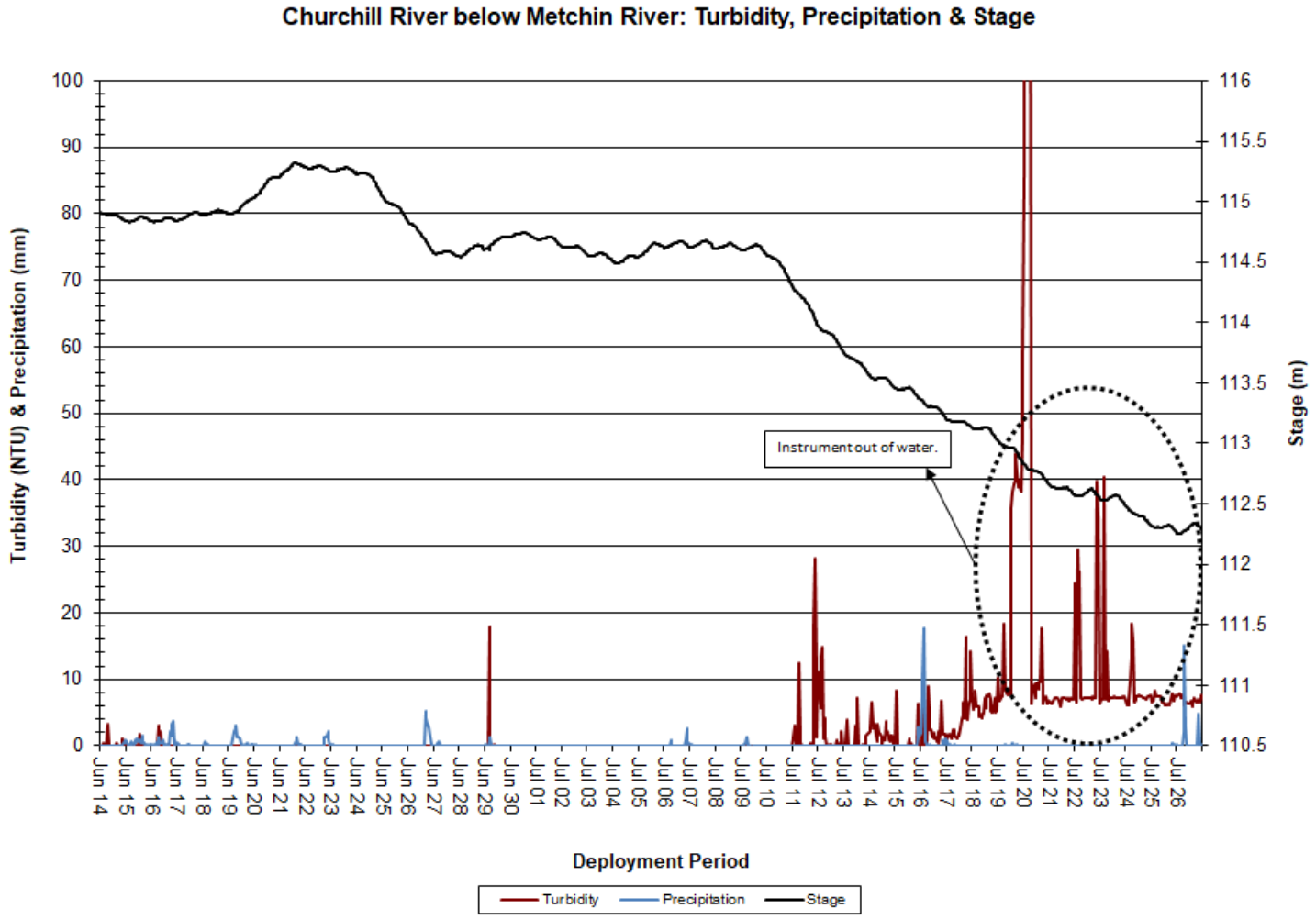


**Figure 6: Turbidity, Precipitation & Stage at Churchill River below Metchin River**

## Stage and Flow

- Over the deployment period, stage levels ranged from 112.251m to 115.323m, with a median value of 114.603m. Flow ranged from 900.818m$^3$/s to 1731.204m$^3$/s, with a median value of 1595.713m$^3$/s (Figure 7). Precipitation data was obtained from the Metchin River near TLH Weather Station.
- Stage and flow were relatively high and stable until July 11$^{th}$, after which they both decreased significantly. 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.

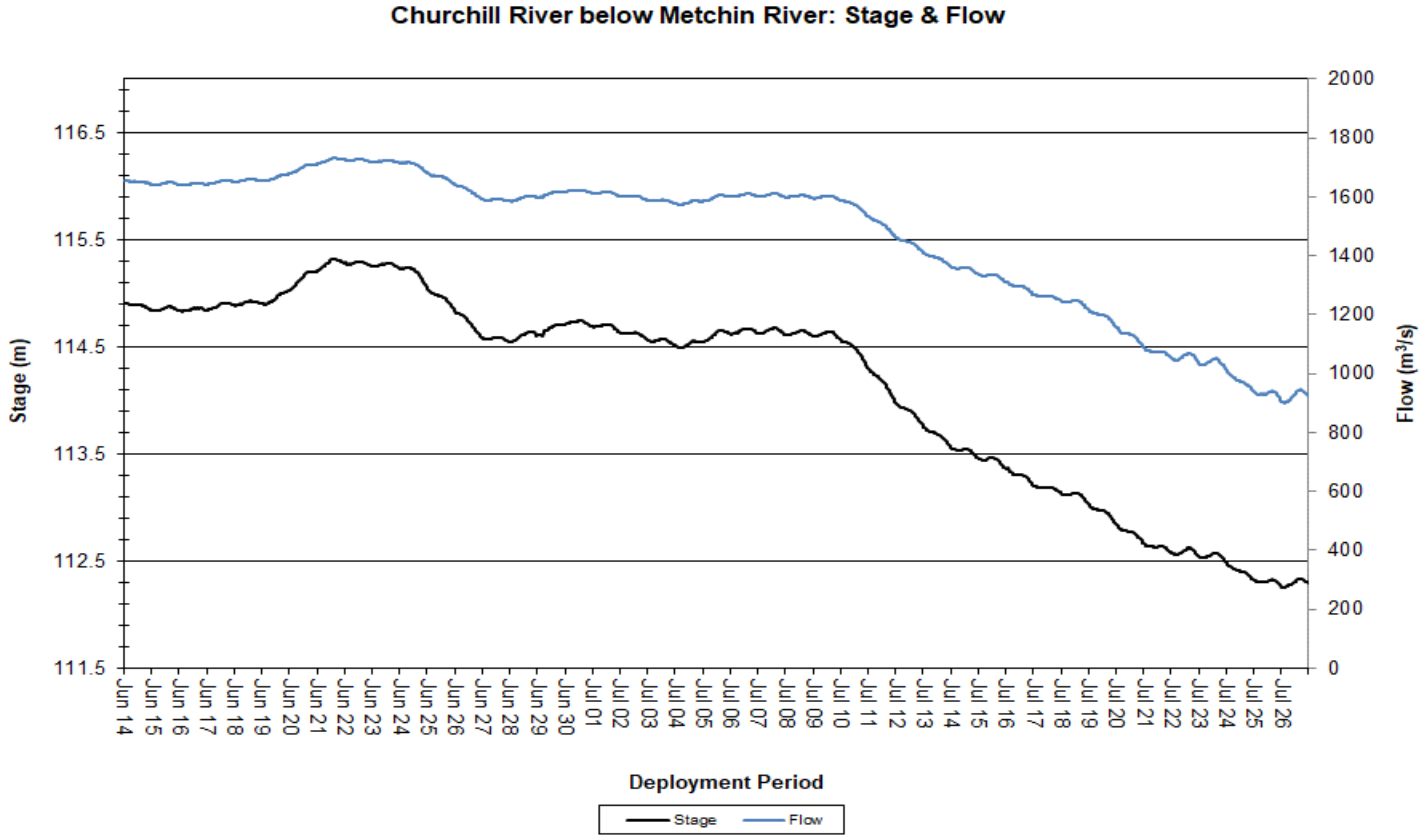


**Figure 7: Stage & Flow at Churchill River below Metchin River**

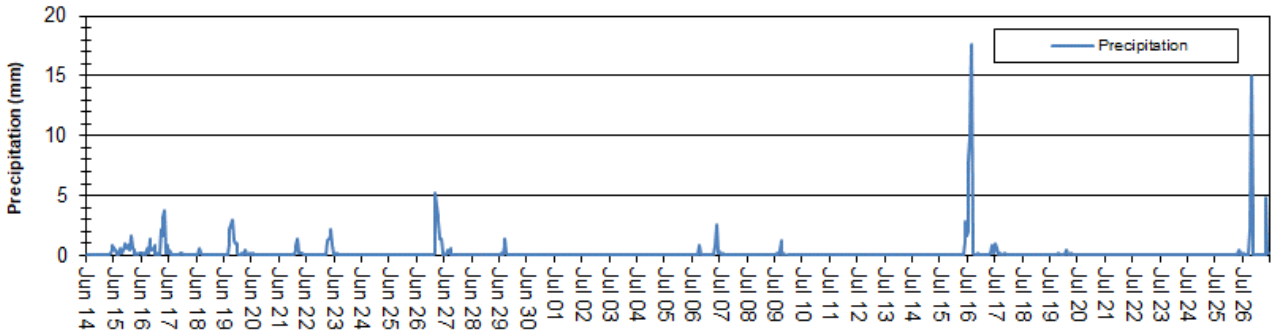


**Figure 8: Precipitation at Churchill River below Metchin River**

## Churchill River above Grizzle Rapids

### Water Temperature

- Over the deployment period, water temperature ranged from 3.6°C to 15.7°C, with a median value of 8.0°C (Figure 9). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature slowly increased across the deployment period. This trend is to be expected as air temperatures also increased through spring and summer. 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.

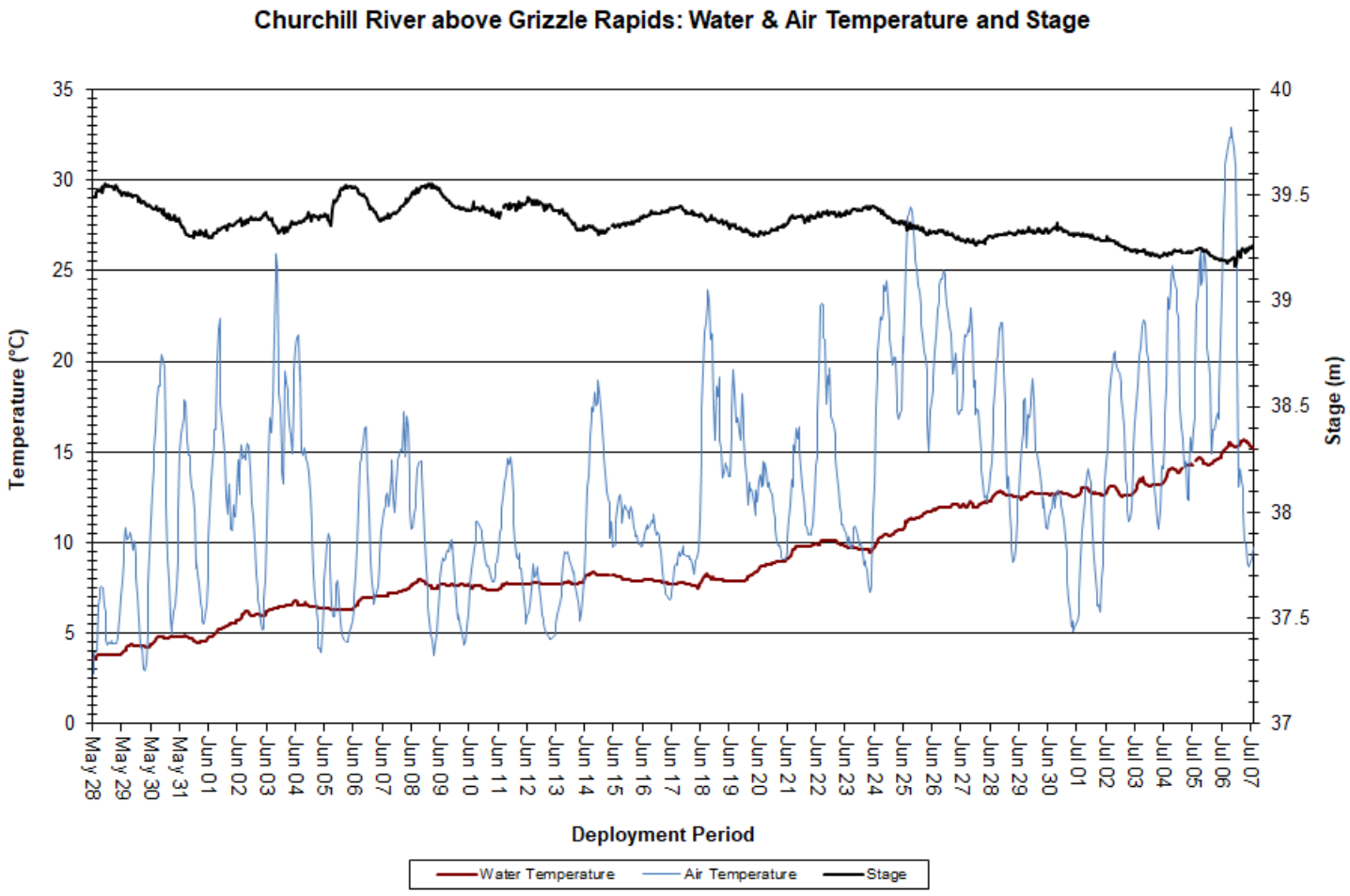


**Figure 9: Water and Air Temperature & Stage at Churchill River above Grizzle Rapids**

**pH**

- Over the deployment period, pH values ranged from 6.50 pH units to 6.80 pH units, with a median value of 6.66 (Figure 10).
- pH values were quite stable and remained 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.

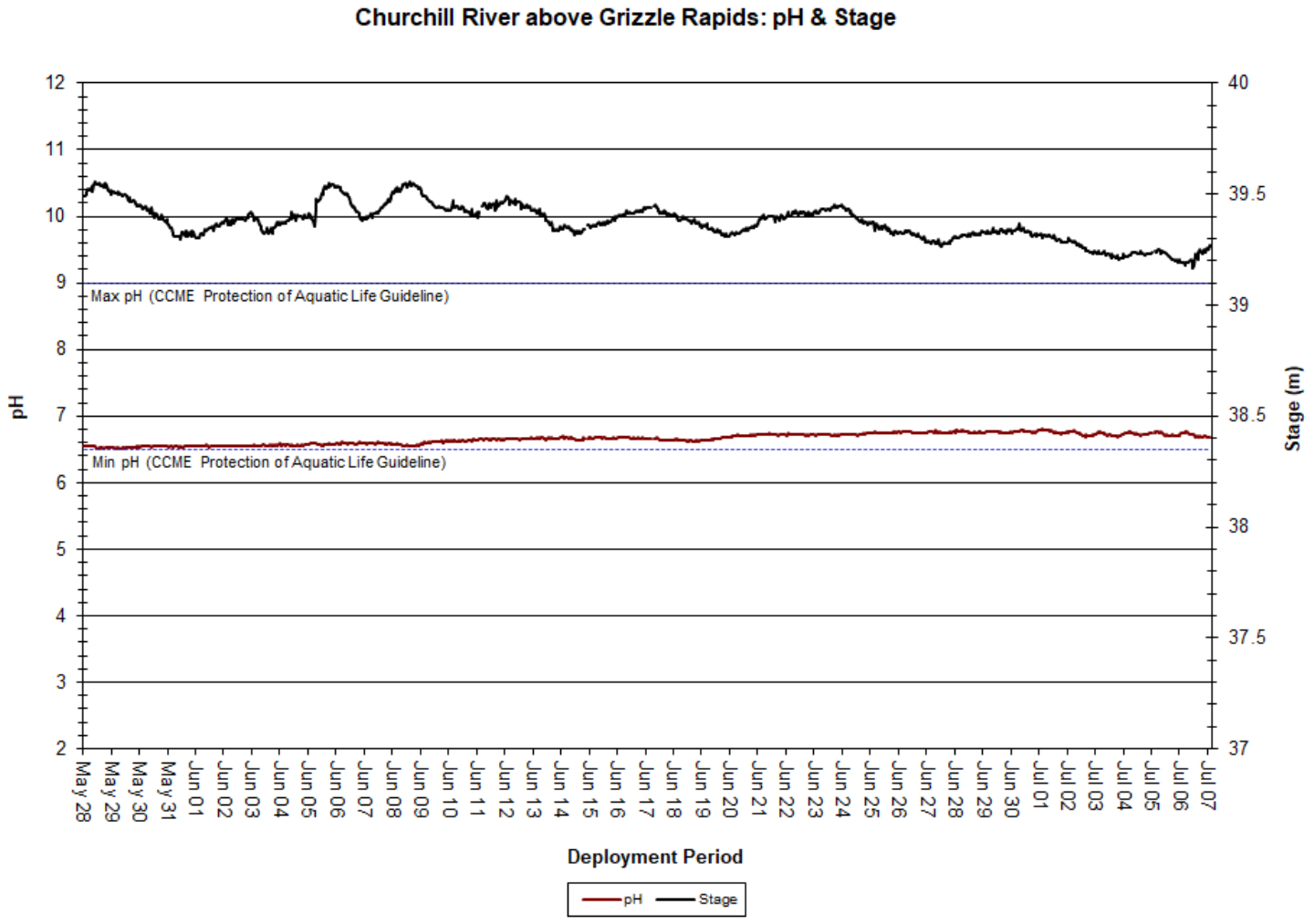


**Figure 10: pH & Stage at Churchill River above Grizzle Rapids**

### Specific Conductivity

- Over the deployment period, specific conductivity ranged from 14.0µS/cm to 19.6µS/cm, with a median of 15.7µS/cm (Figure 11).
- The relationship between conductivity and stage is generally inversed. When stage levels increase, specific conductivity levels generally decrease as the increased amount of water in the river system dilutes solids that are present. This relationship is only somewhat evident in the graph below, likely because this station is located at a deep and wide section of the Churchill River and other factors in the water column influence conductivity levels.
- 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.

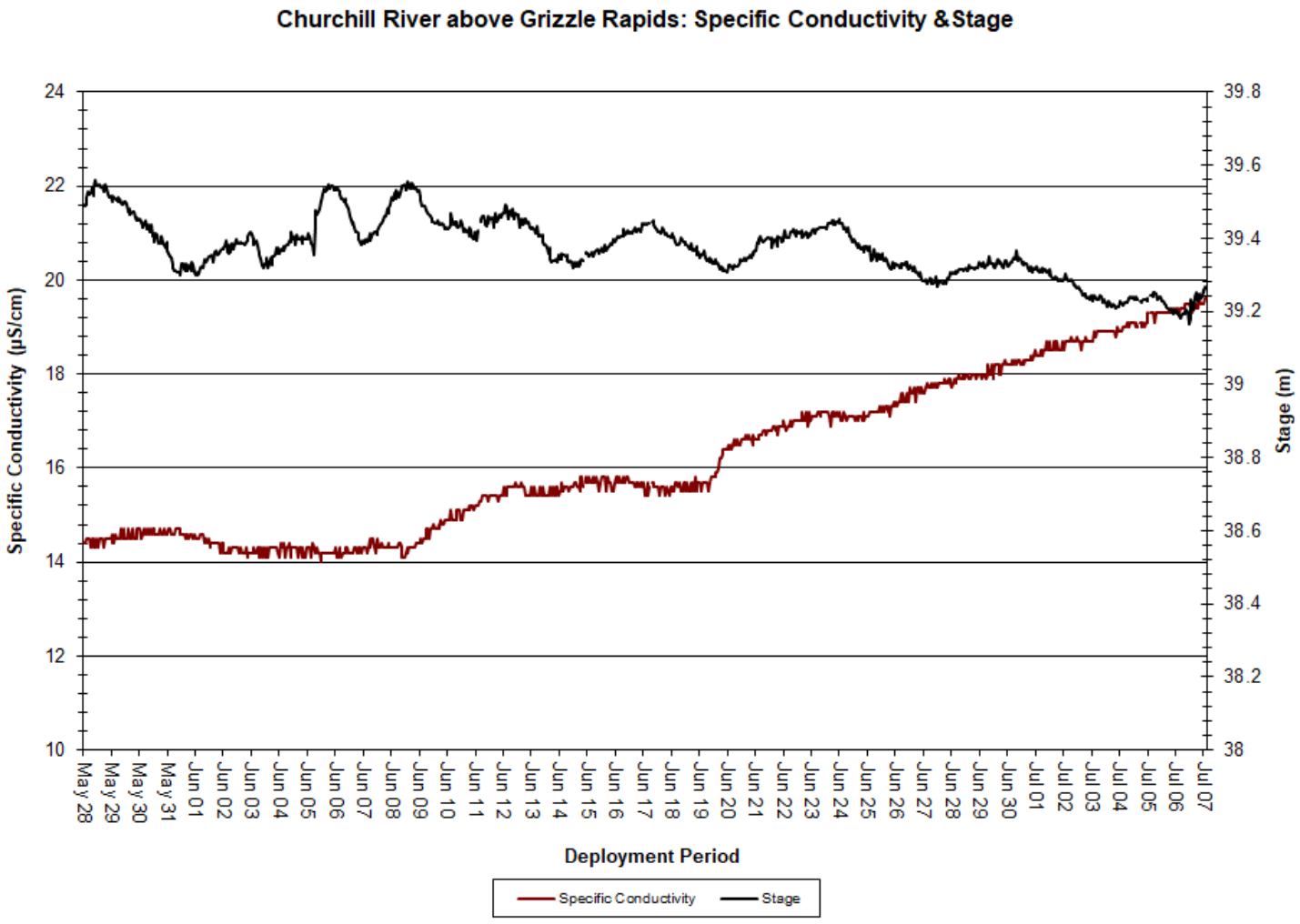


**Figure 11: Specific Conductivity & Stage at Churchill River above Grizzle Rapids**

**Dissolved Oxygen**

- Over the deployment period, dissolved oxygen content ranged from 9.57mg/L to 12.57mg/L, with a median value of 11.31mg/L. Saturation of dissolved oxygen ranged from 94.4% saturation to 99.1% saturation, with a median value of 96.5% (Figure 12).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period, dissolved oxygen levels gradually decreased as water temperatures increased through spring and summer. Dissolved oxygen also follows a diurnal pattern as water temperatures rise and fall under the influence of ambient air temperatures. Generally, dissolved oxygen levels are higher in a waterbody during cooler temperatures.
- Dissolved oxygen levels remained above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of deployment.

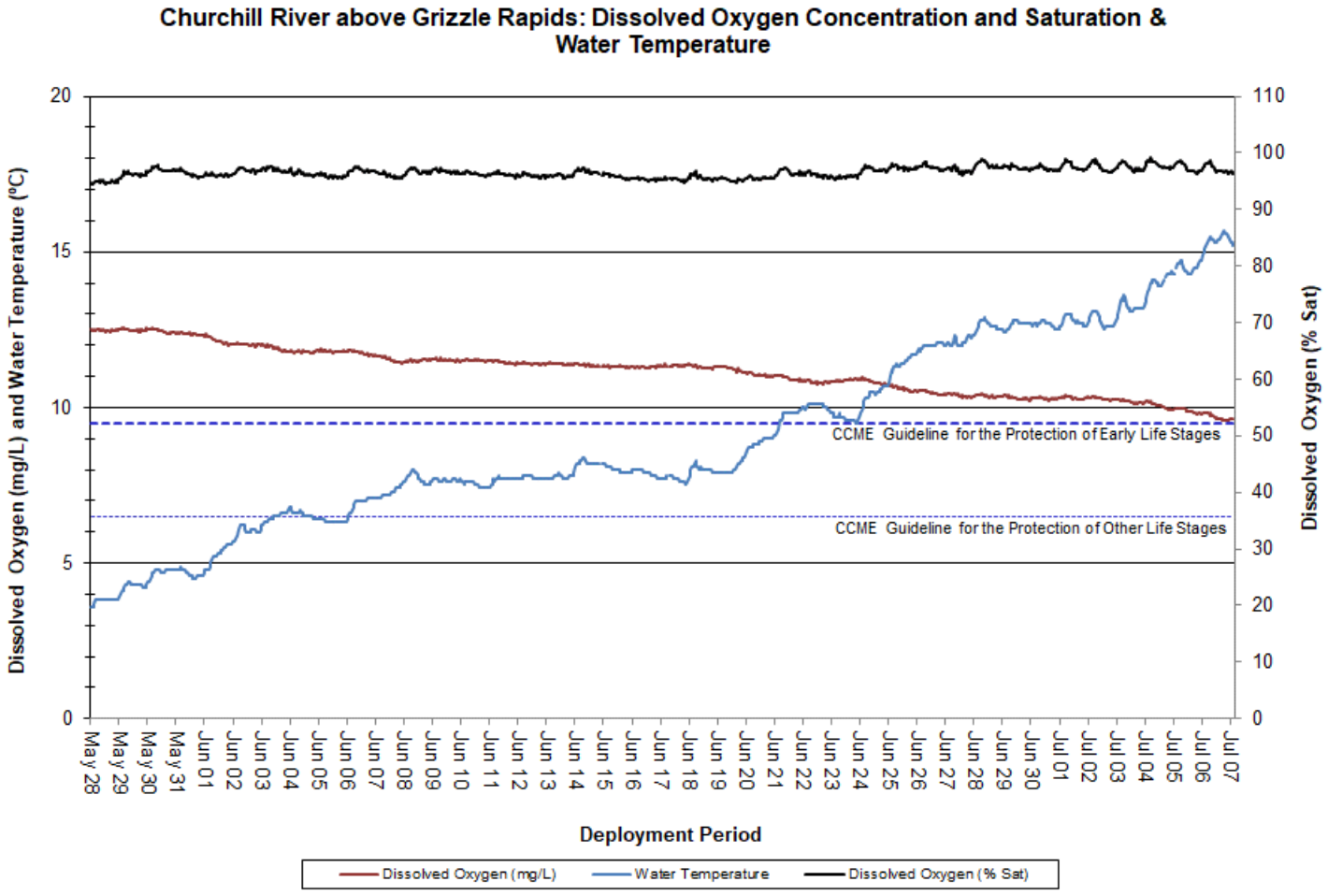


**Figure 12: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids**

**Turbidity**

- Over the deployment period, turbidity ranged from 0.0NTU to 9.7NTU, 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. Precipitation data was obtained from the Muskrat Falls MET Station.
- Turbidity spikes observed over the deployment period somewhat correlate with precipitation events (Figure 13). 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.

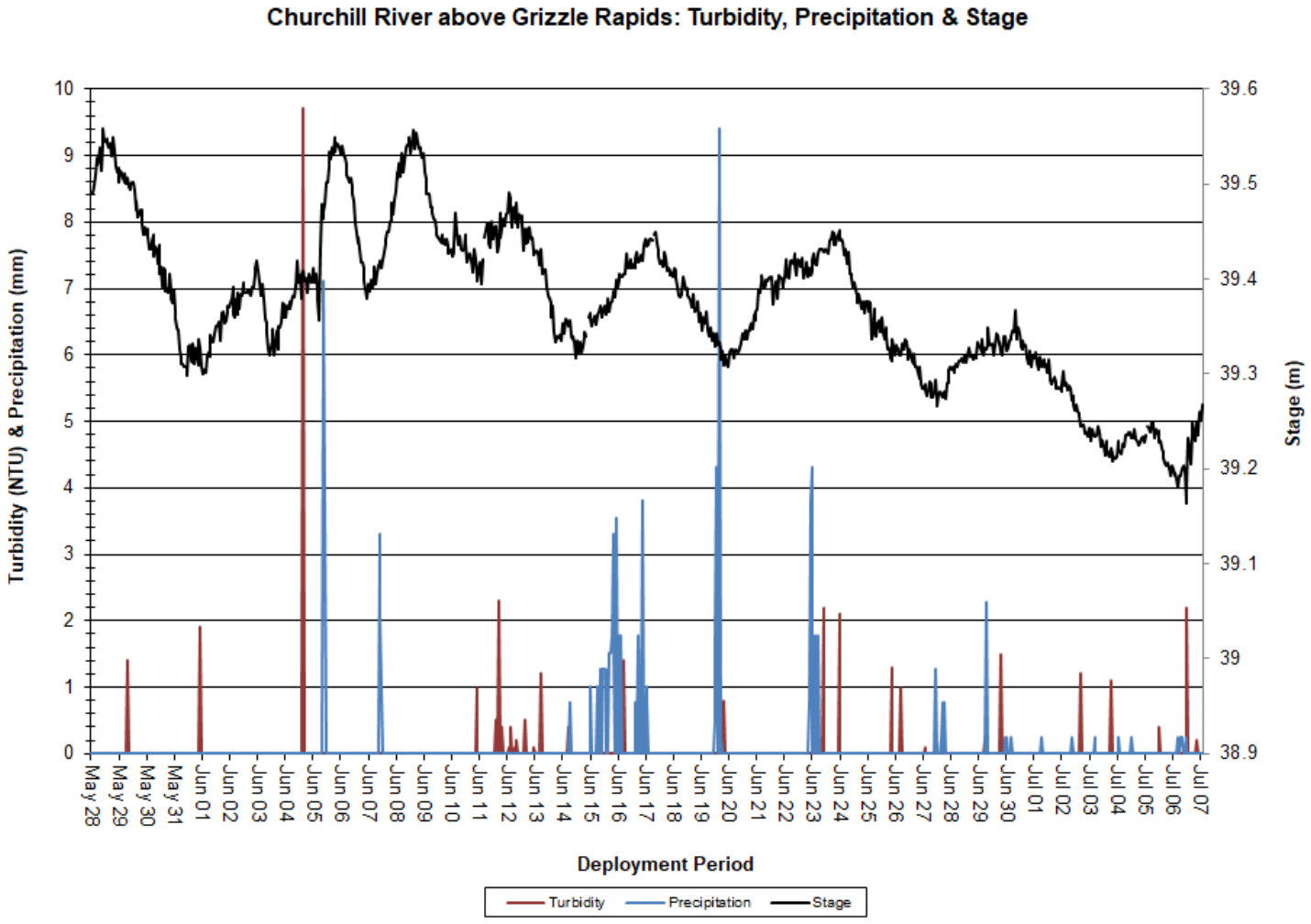


**Figure 13: Turbidity, Precipitation & Stage at Churchill River above Grizzle Rapids**

## Stage

- Over the deployment period, stage ranged from 39.164m to 39.558m, with a median value of 39.376m (Figure 14). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage was somewhat variable across the deployment period, with precipitation events closely correlating with increases in stage (Figure 14).
- 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.

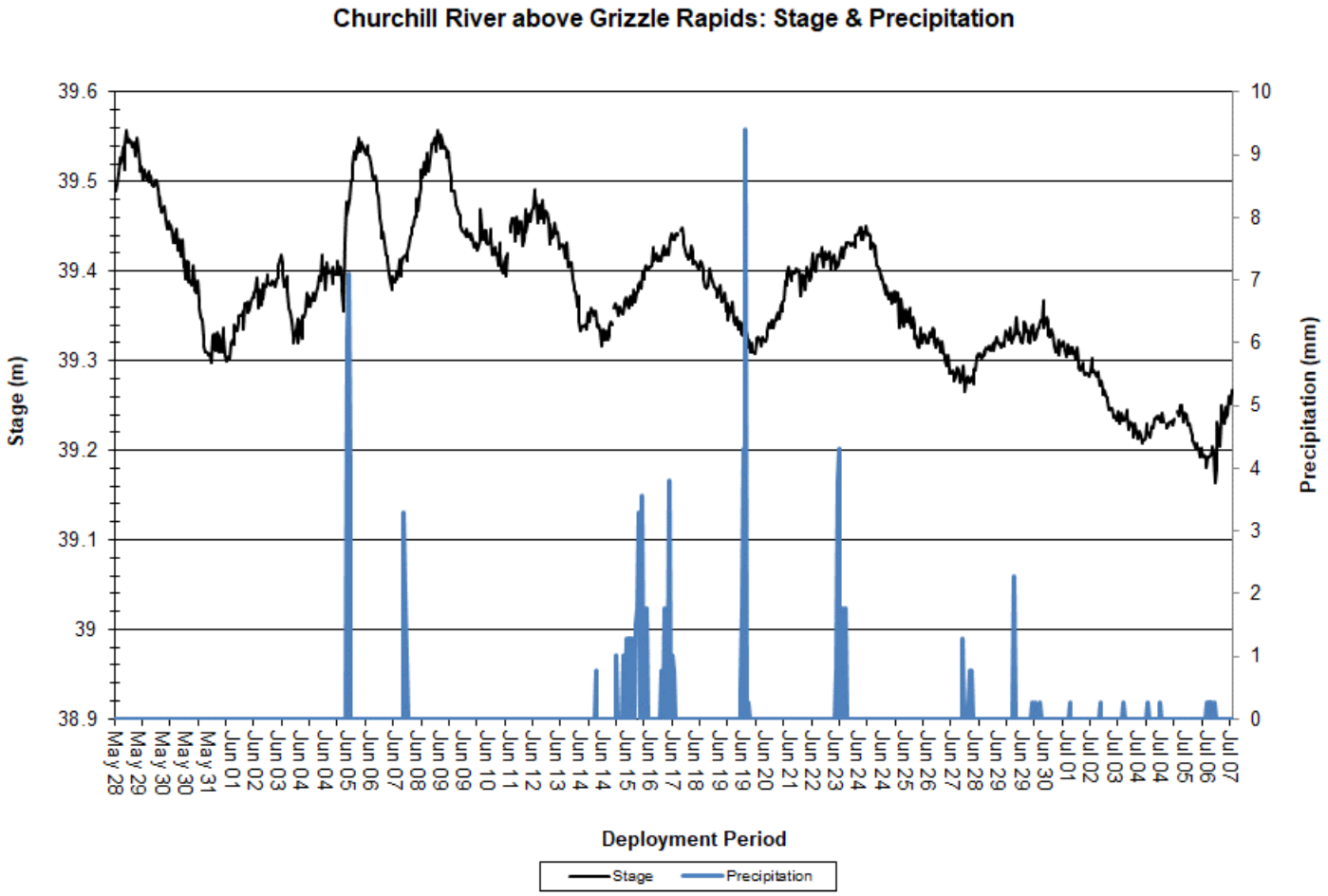


**Figure 14: Stage & Precipitation at Churchill River above Grizzle Rapids**

## Churchill River below Muskrat Falls

### Water Temperature

- Over the deployment period, water temperature ranged from 3.6°C to 15.2°C, with a median value of 7.9°C (Figure 15). Air temperature data was obtained from the Muskrat Falls MET Station.
- Water temperature slowly increased over the course of the deployment period. This is to be expected as ambient air temperatures also increased through June and July. 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.

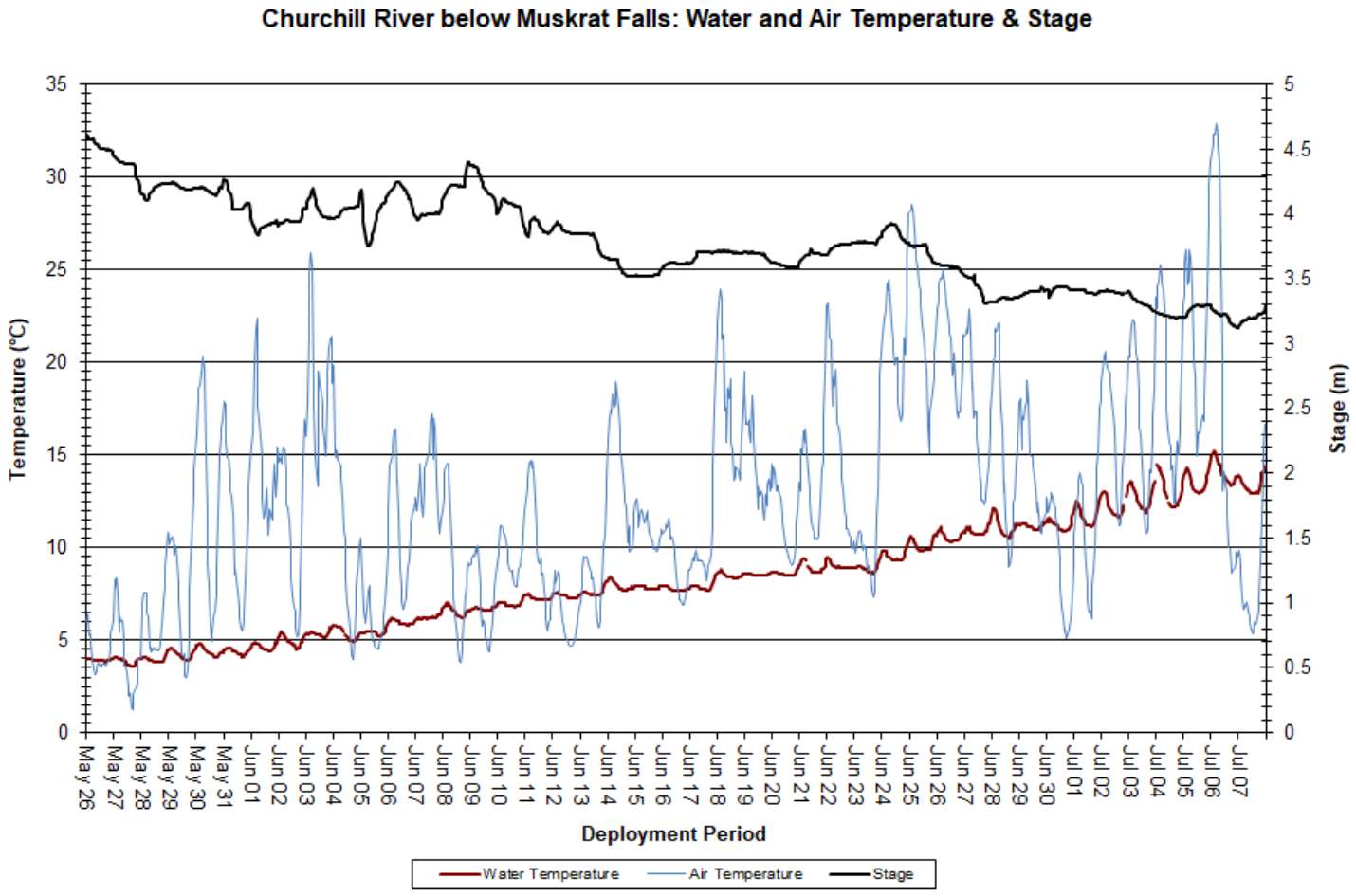


**Figure 15: Water and Air Temperature & Stage at Churchill River below Muskrat Falls**

**pH**

- Over the deployment period, pH ranged from 5.63 pH units to 6.66 pH units, with a median value of 6.34 (Figure 16).
- pH values were relatively stable over the course of deployment, but remained below the CCME's Guidelines for the Protection of Aquatic Life for the majority of deployment (Figure 16).
- 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.

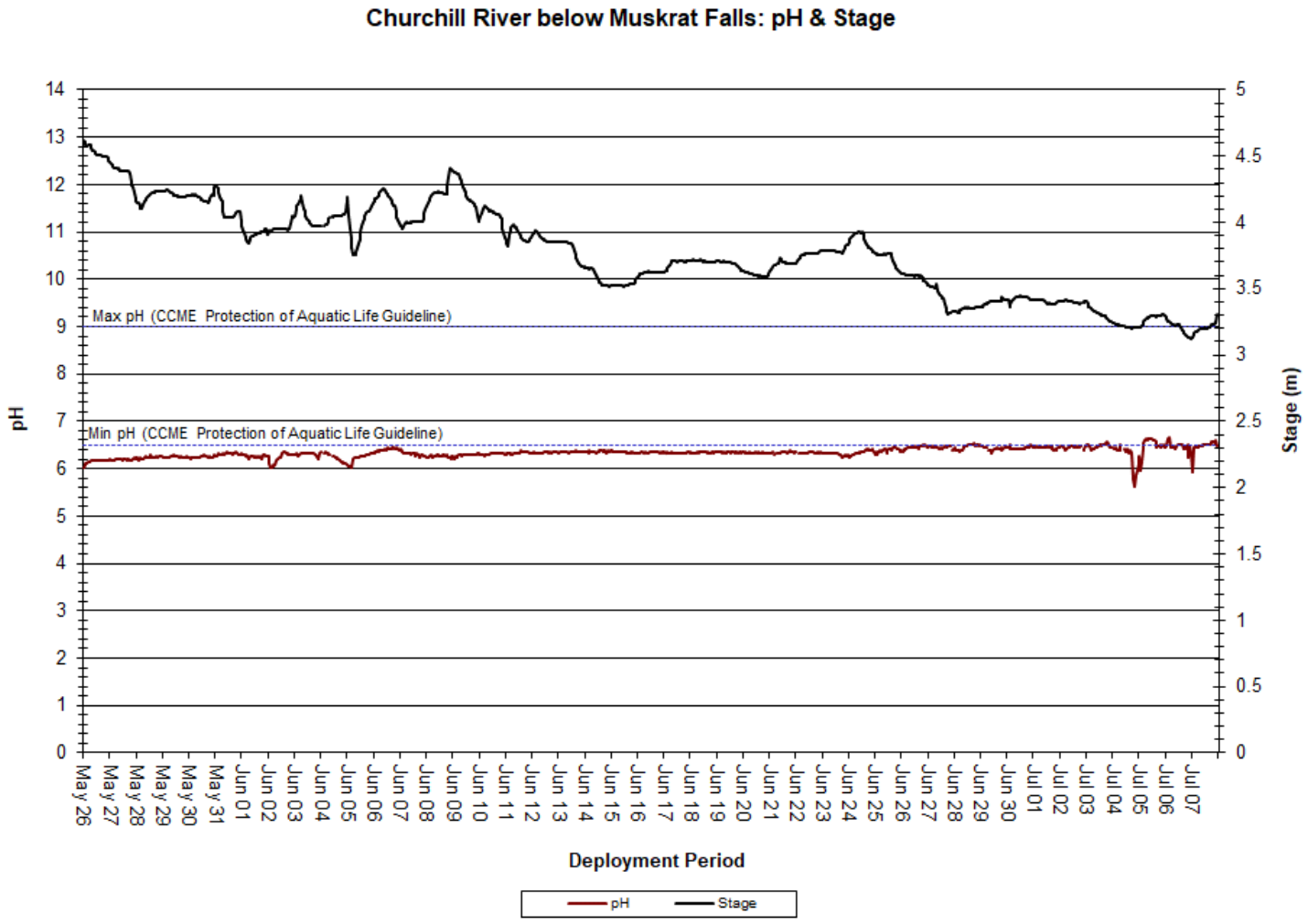


**Figure 16: pH & Stage at Churchill River below Muskrat Falls**

**Specific Conductivity**

- Over the deployment period, specific conductivity ranged from 0.3µS/cm to 18.8µS/cm, with a median value of 11.9µS/cm (Figure 17).
- 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 only somewhat evident in the graph below, likely because this station is located at a deep and wide section of the Churchill River and other factors in the water column influence conductivity levels (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.

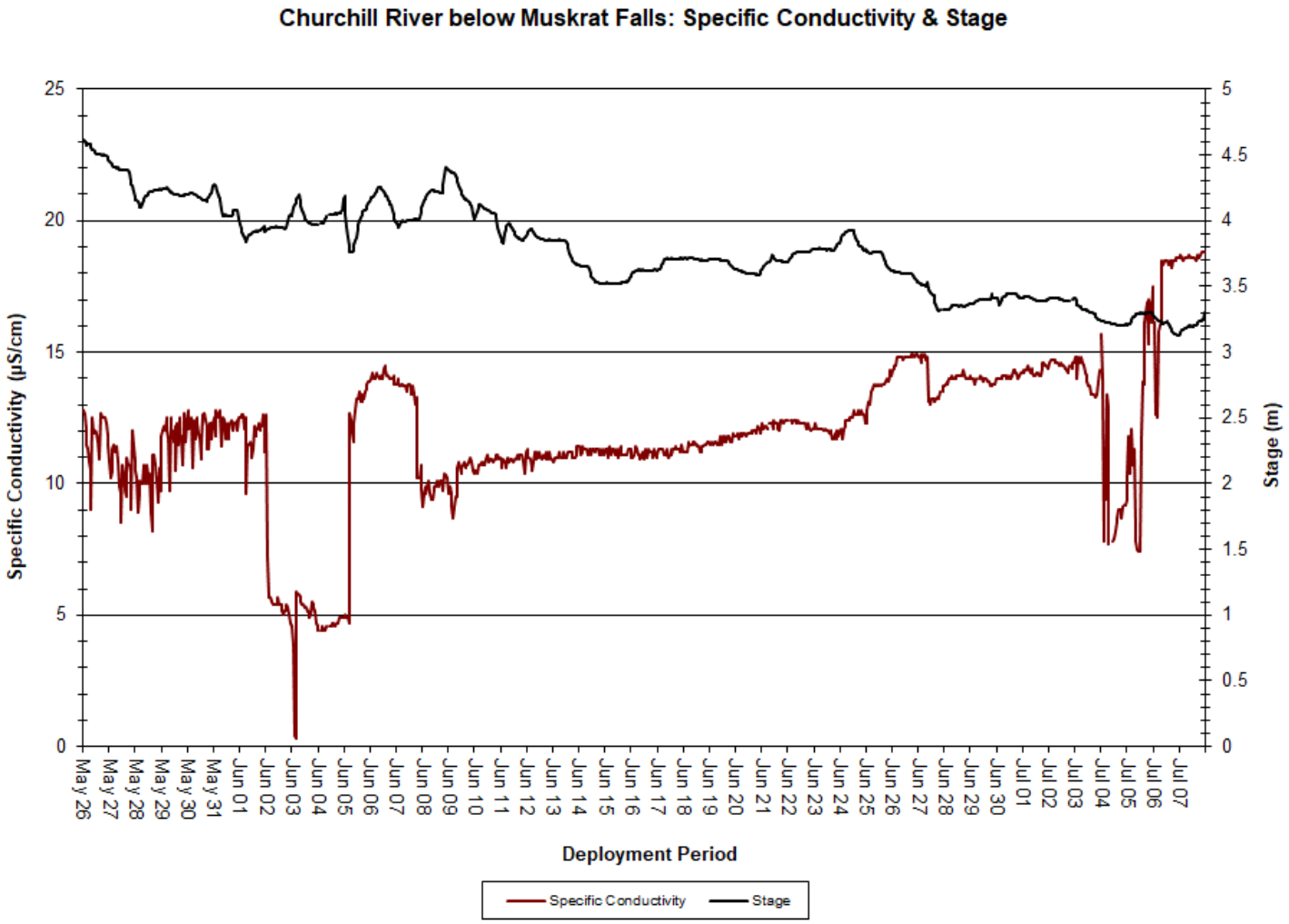


**Figure 17: Specific Conductivity & Stage at Churchill River below Muskrat Falls**

## Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 7.02mg/L to 16.09mg/L, with a median value of 13.84mg/L. Saturation of dissolved oxygen ranged from 65.7% to 125.3%, with a median value of 117.3% (Figure 18).
- Dissolved oxygen and water temperature exhibit an inverse relationship: as one parameter increases, the other decreases, and vice versa. Dissolved oxygen levels slowly decreased over the course of deployment. This is to be expected since water temperatures were slowly increasing 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 majority of deployment, with a brief temporary exception occurring on July 4th.

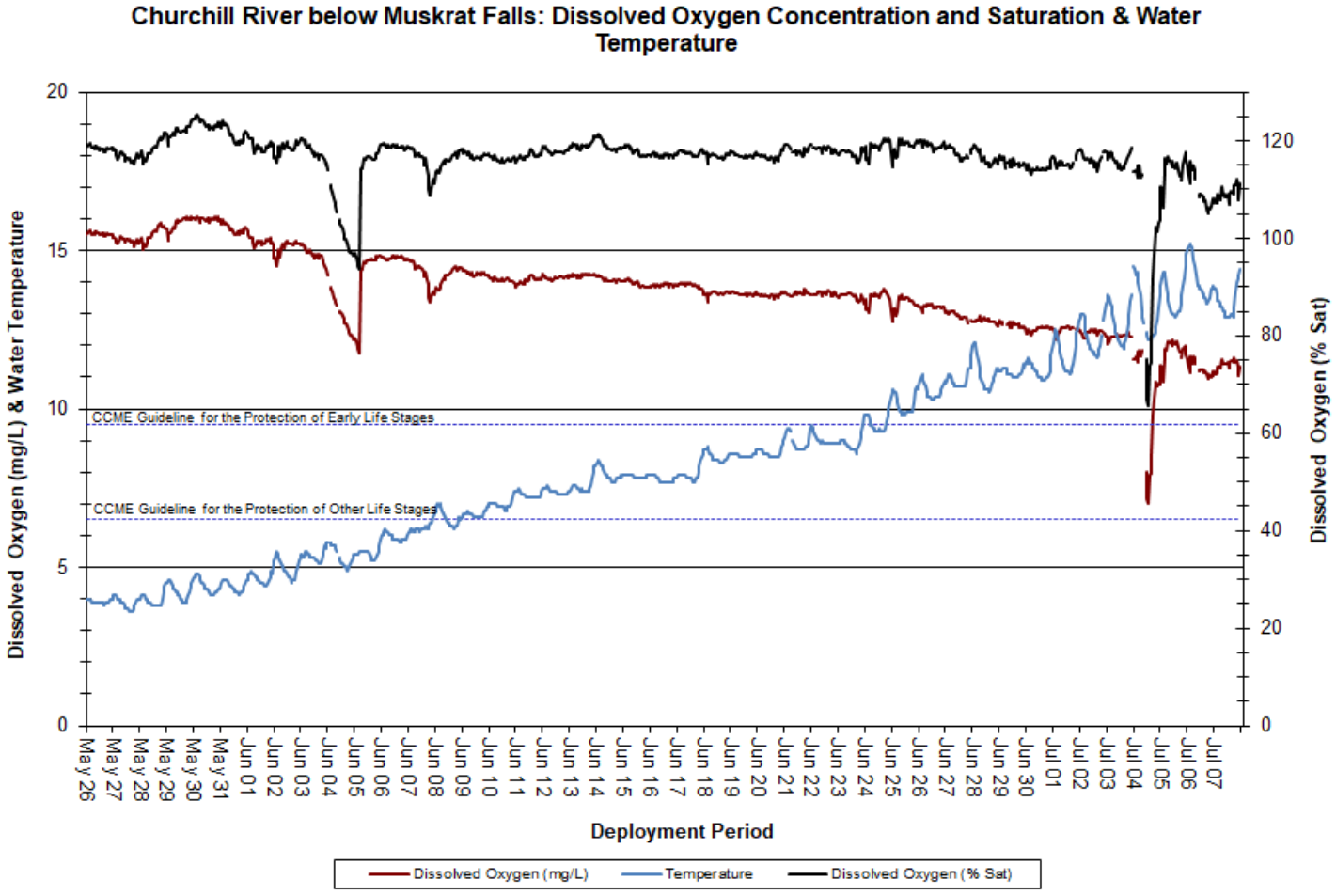


**Figure 18: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls**

**Turbidity**

- Over the deployment period, turbidity ranged from 80.5NTU to 3000NTU, with a median value of 250.2NTU. A median value of 250.2NTU indicates a large amount of natural background turbidity in the waterbody, which is not typical of this station. Precipitation data was obtained from the Muskrat Falls MET Station.
- There was very little correlation between turbidity events and precipitation events across the deployment period (Figure 19). Turbidity levels are often quite variable at this station, which is also not evidenced in the graph below. Given the poor comparison ratings observed between the field sonde and the QA/QC sonde at both deployment and removal, the higher-than-normal baseline turbidity levels are likely the result of a calibration error or an issue with the turbidity sensor.
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

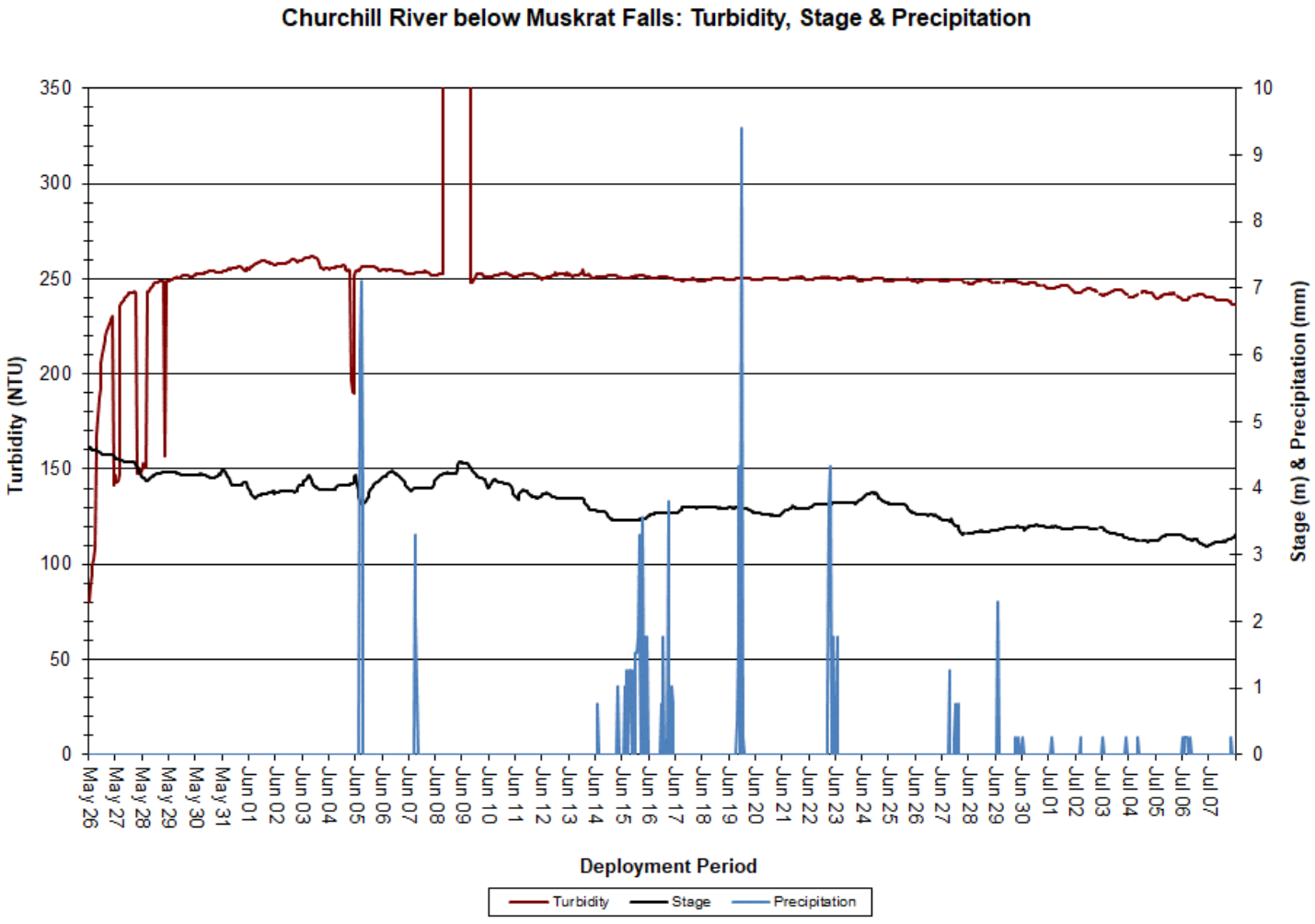


**Figure 19: Turbidity, Precipitation & Stage at Churchill River below Muskrat Falls**

### Stage & Flow

- Over the deployment period, stage ranged from 3.122m to 4.613m, with a median value of 3.761m. Flow ranged from 2168.051m$^3$/s to 4063.424m$^3$/s, with a median value of 2927.27m$^3$/s (Figure 20). Precipitation data was obtained from the Muskrat Falls MET Station.
- Stage and flow were variable and slightly decreasing over the course of deployment, and did not generally correlate closely with precipitation events. This is partly 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. Stage and flow at this station are also influenced by upstream activities at the Muskrat Falls hydroelectric project.
- 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.

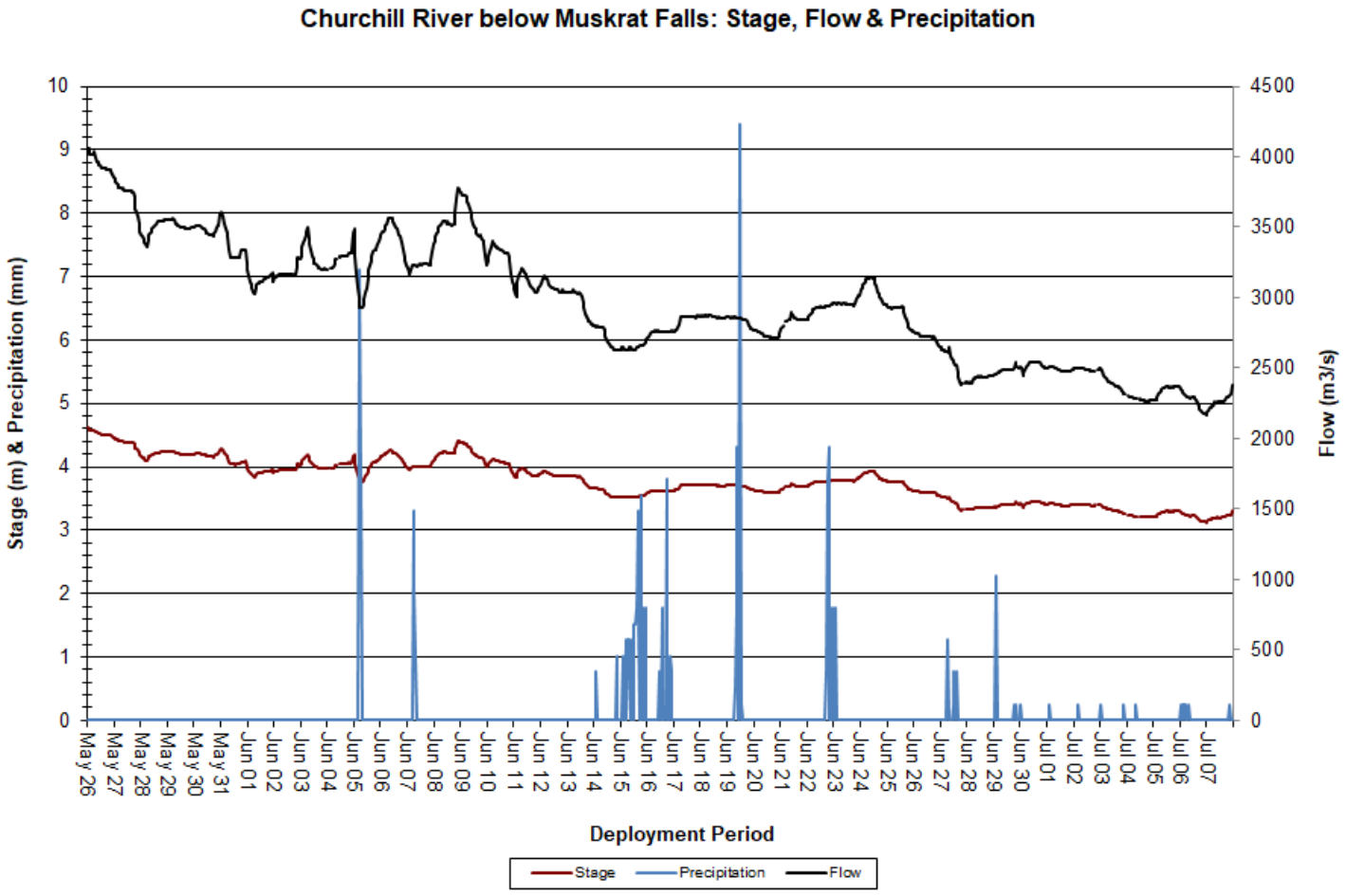


**Figure 20: Stage, Flow & Precipitation at Churchill River below Muskrat Falls**

## Chlorophyll

- Over the deployment period, chlorophyll ranged from 0.18ug/L to 6.79ug/L, with a median value of 1.79ug/L (Figure 21).
- 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.

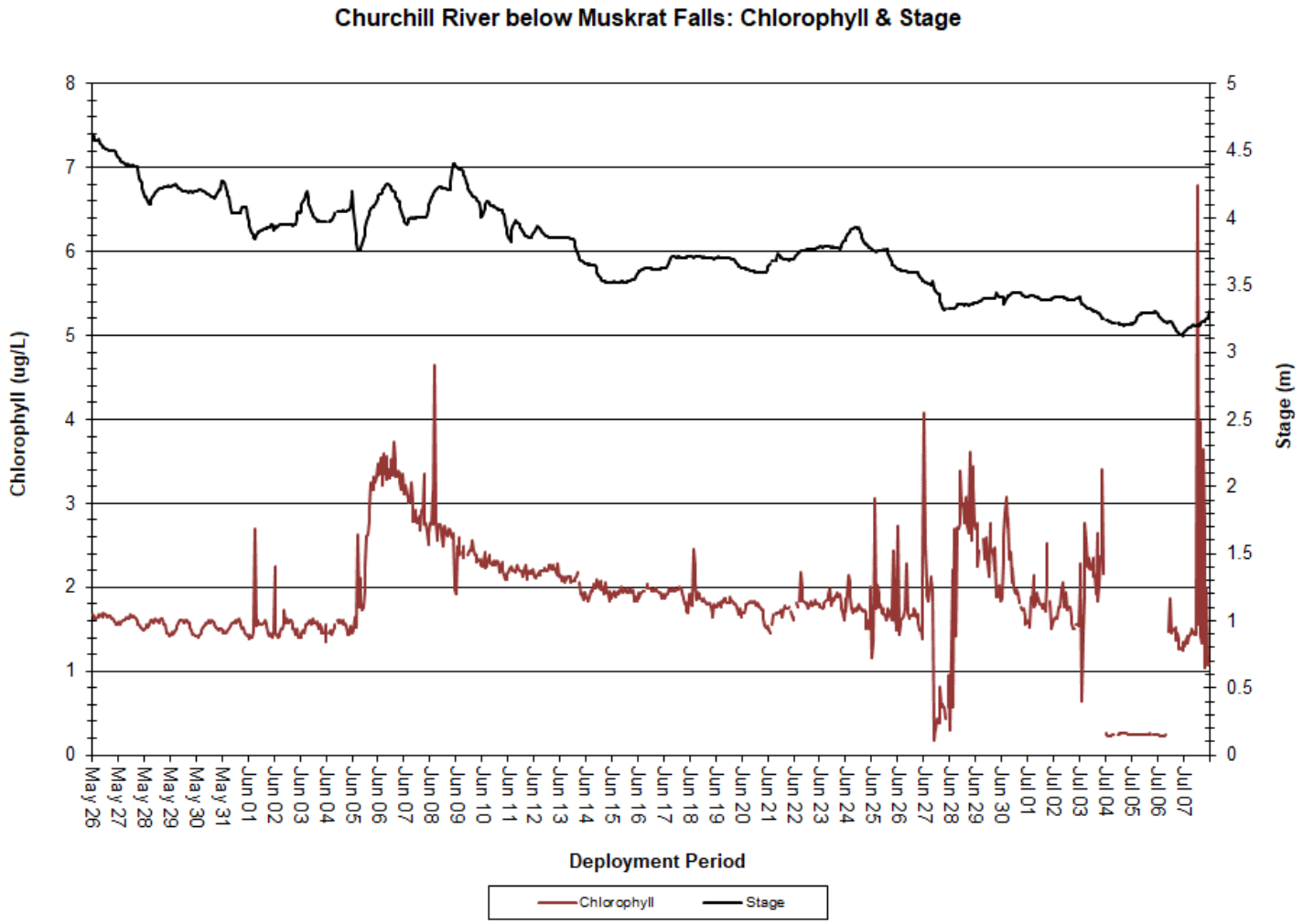


**Figure 21: Chlorophyll & Stage at Churchill River below Muskrat Falls**

## Churchill River at English Point

### Water Temperature

- Water temperature ranged from 4.2°C to 20.8°C, with a median value of 9.95°C (Figure 22). Air temperature data was obtained from the End of Mud Lake Road Weather Station.
- Water temperature increased steadily across the deployment period. 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.

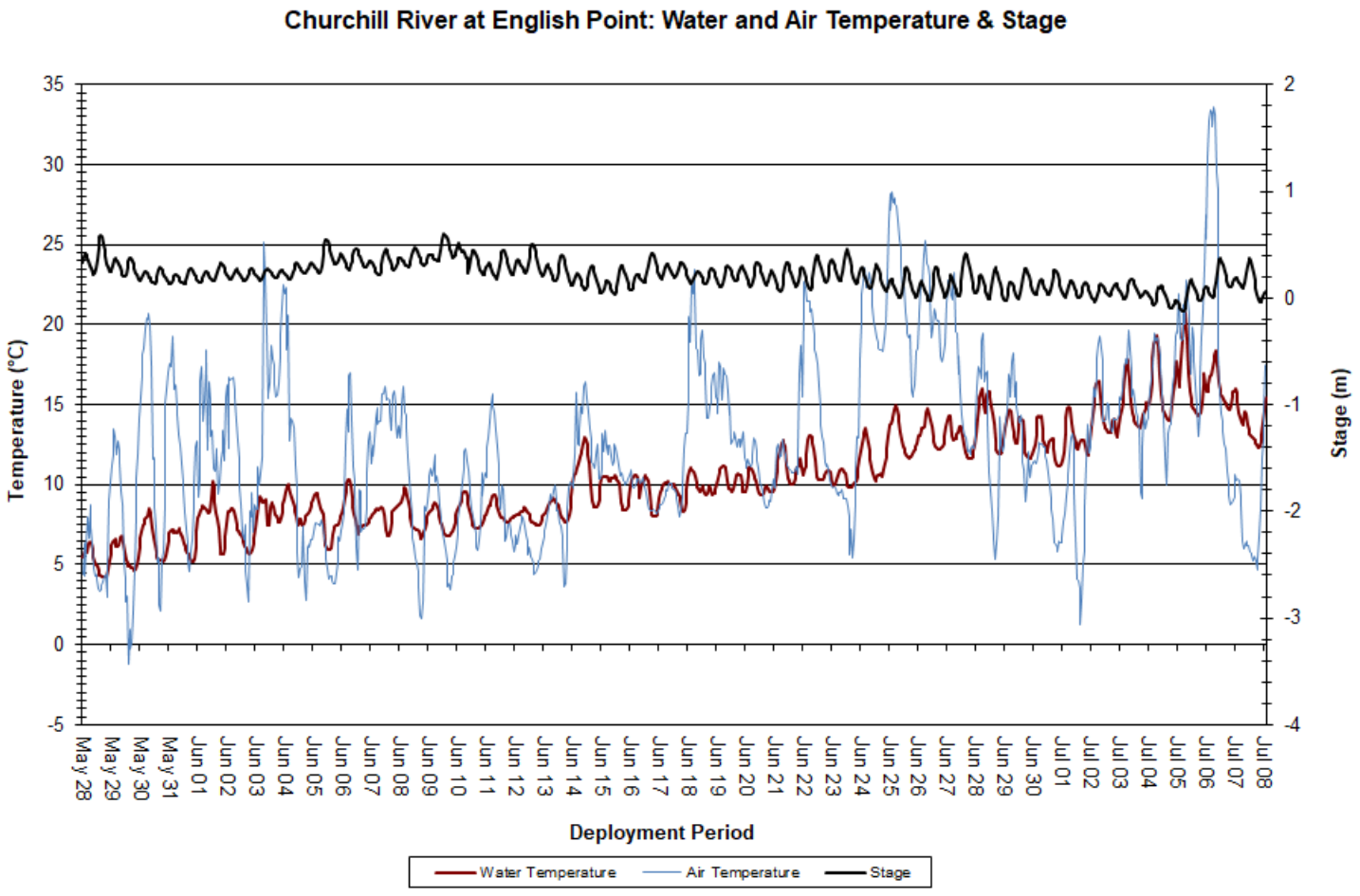


**Figure 22: Water and Air Temperature & Stage at Churchill River at English Point**

**pH**

- Over the deployment period, pH ranged from 5.85 pH units to 6.70 pH units, with a median value of 6.47 (Figure 23).
- pH values were relatively stable over the course of deployment. pH values hovered around the CCME's Minimum Guideline for the Protection of Aquatic Life until mid-June, after which it fell below the guideline for the remainder 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.

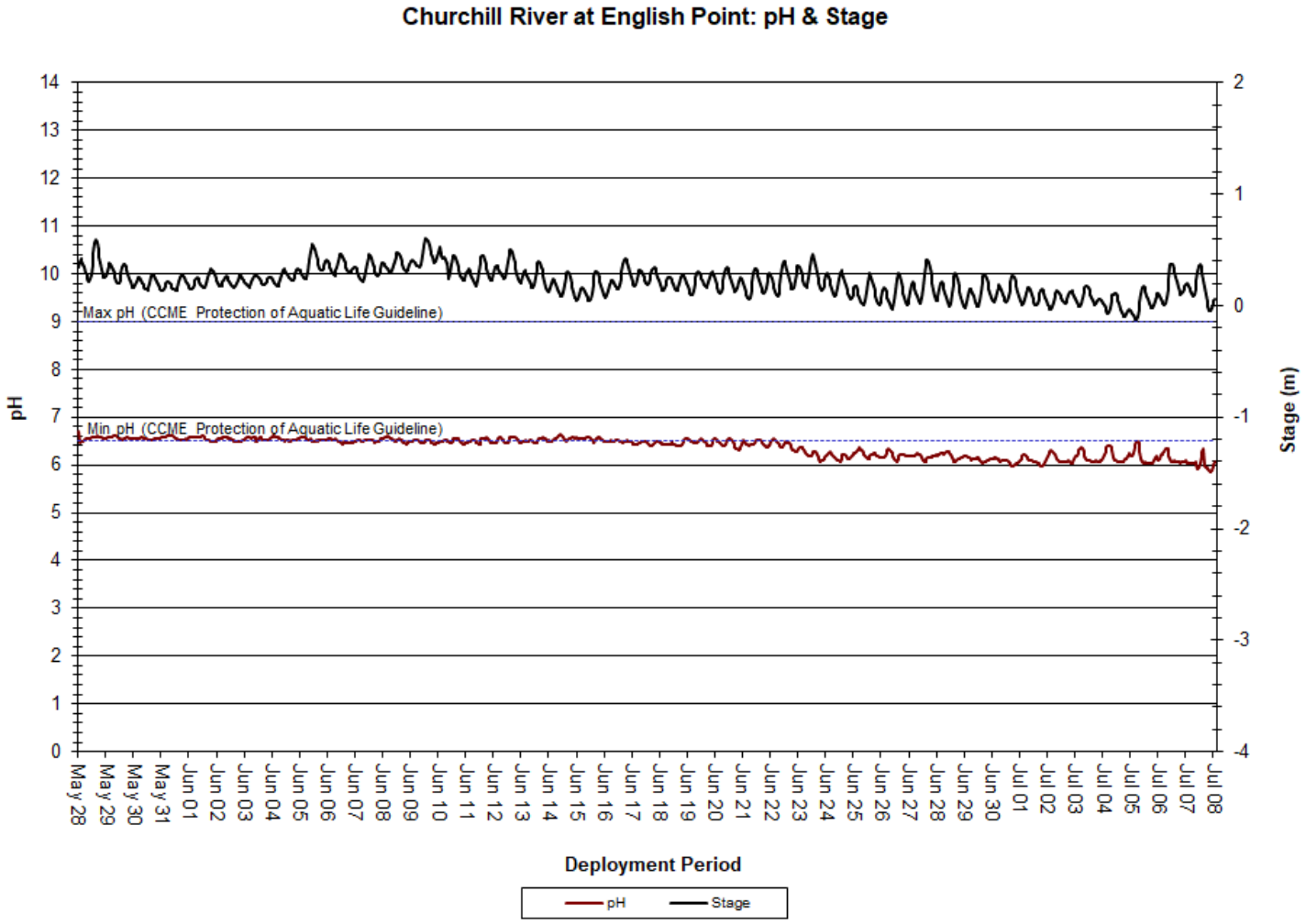


**Figure 23: pH & Stage at Churchill River at English Point**

**Specific Conductivity**

- Over the deployment period, specific conductivity ranged from 11.4µS/cm to 35.1µs/cm, with a median value of 23.9µS/cm (Figure 24).
- 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 24).
- Water Survey of Canada (Environment and Climate Change Canada) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

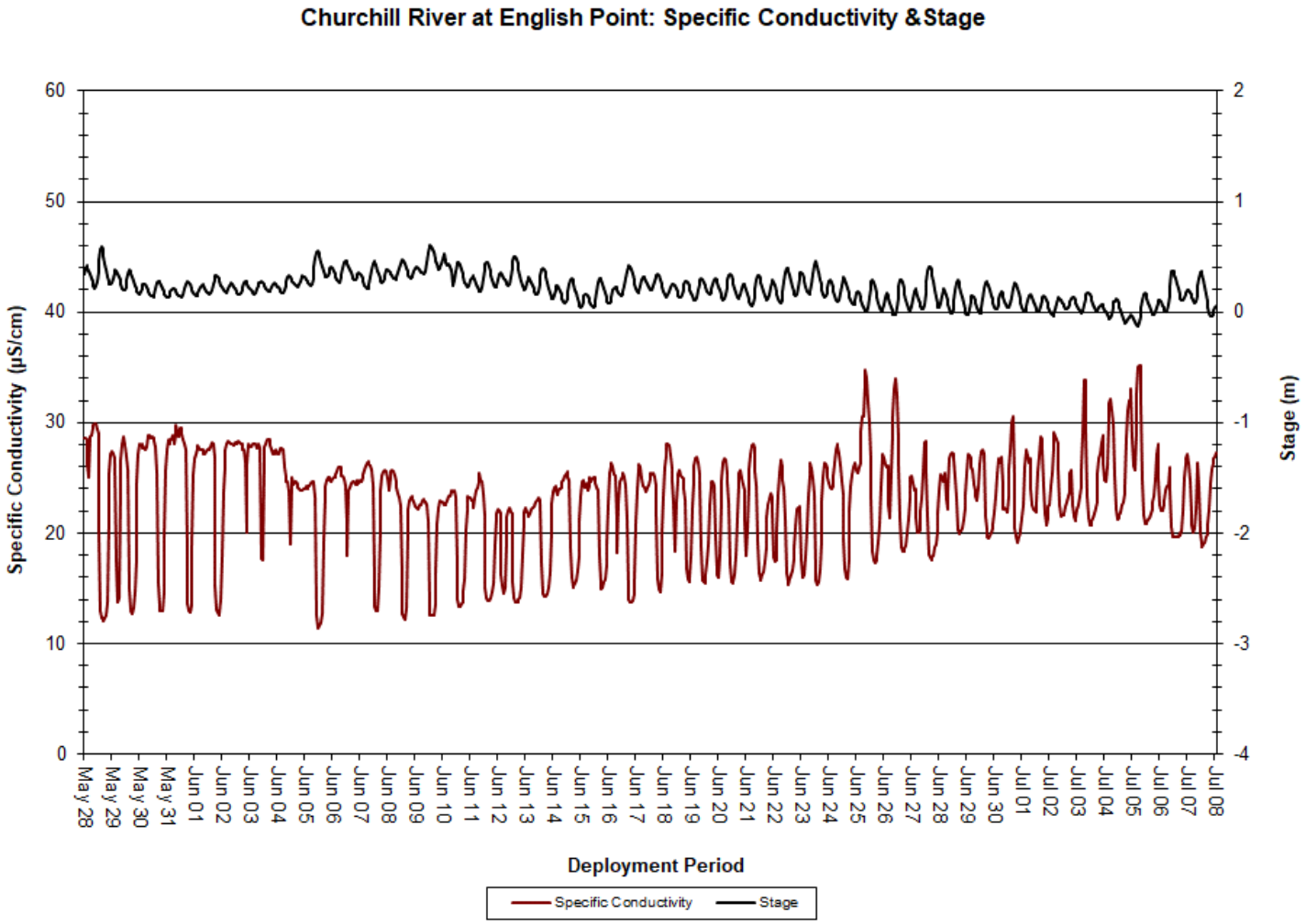


**Figure 24: Specific Conductivity & Stage at Churchill River at English Point**

### Dissolved Oxygen

- Over the deployment period, dissolved oxygen concentration ranged from 9.94mg/L to 15.00mg/L, with a median value of 11.88mg/L. Saturation of dissolved oxygen ranged from 95.9% to 122.6% saturation, with a median value of 105.5% (Figure 25).
- There is an evident relationship between water temperature and dissolved oxygen. As water temperatures increased over the deployment period, dissolved oxygen levels decreased. 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 Early and Other Life Stages for the duration of deployment (Figure 25).

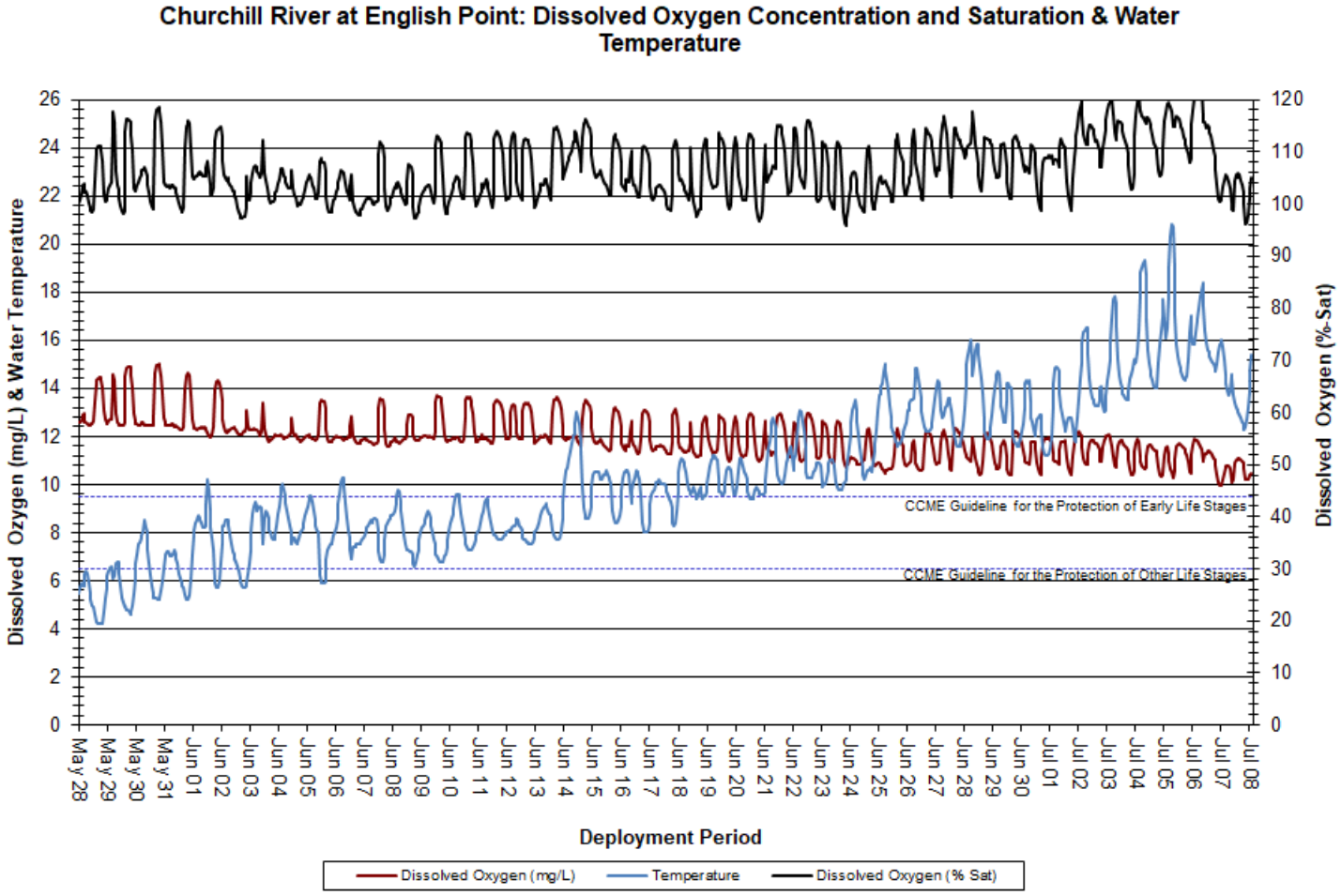


**Figure 25: Dissolved Oxygen & Water Temperature at Churchill River at English Point**

**Turbidity**

- Over the deployment period, turbidity ranged from 0.0NTU to 2264NTU, with a median value of 21.2NTU (Figure 26). A median value of 21.2NTU indicates a significant 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 End of Mud Lake Road Weather 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 26). Wind speed data was also obtained from the End of Mud Lake Road Weather Station.
- Sustained high turbidity levels observed from late-June onwards are being attributed to significant sediment build-up around the turbidity sensor, and likely do not accurately represent water quality events during that 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.

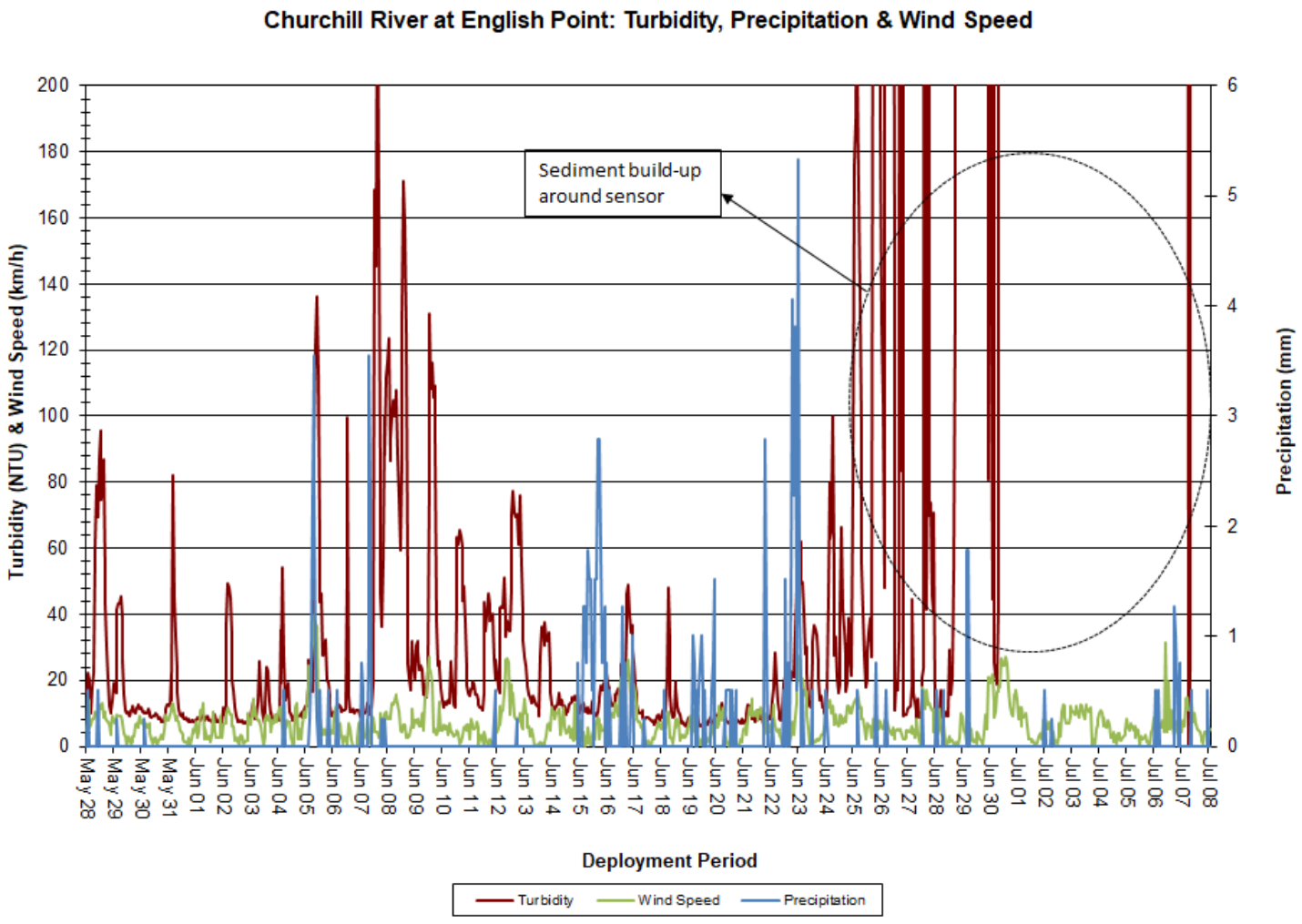

**Figure 26: Turbidity, Precipitation & Wind Speed at Churchill River at English Point**

## Stage

- Over the deployment period, stage ranged from -0.125m to 0.610m, with a median value of 0.212m (Figure 27). Precipitation data was obtained from the End of Mud Lake Road Weather 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.

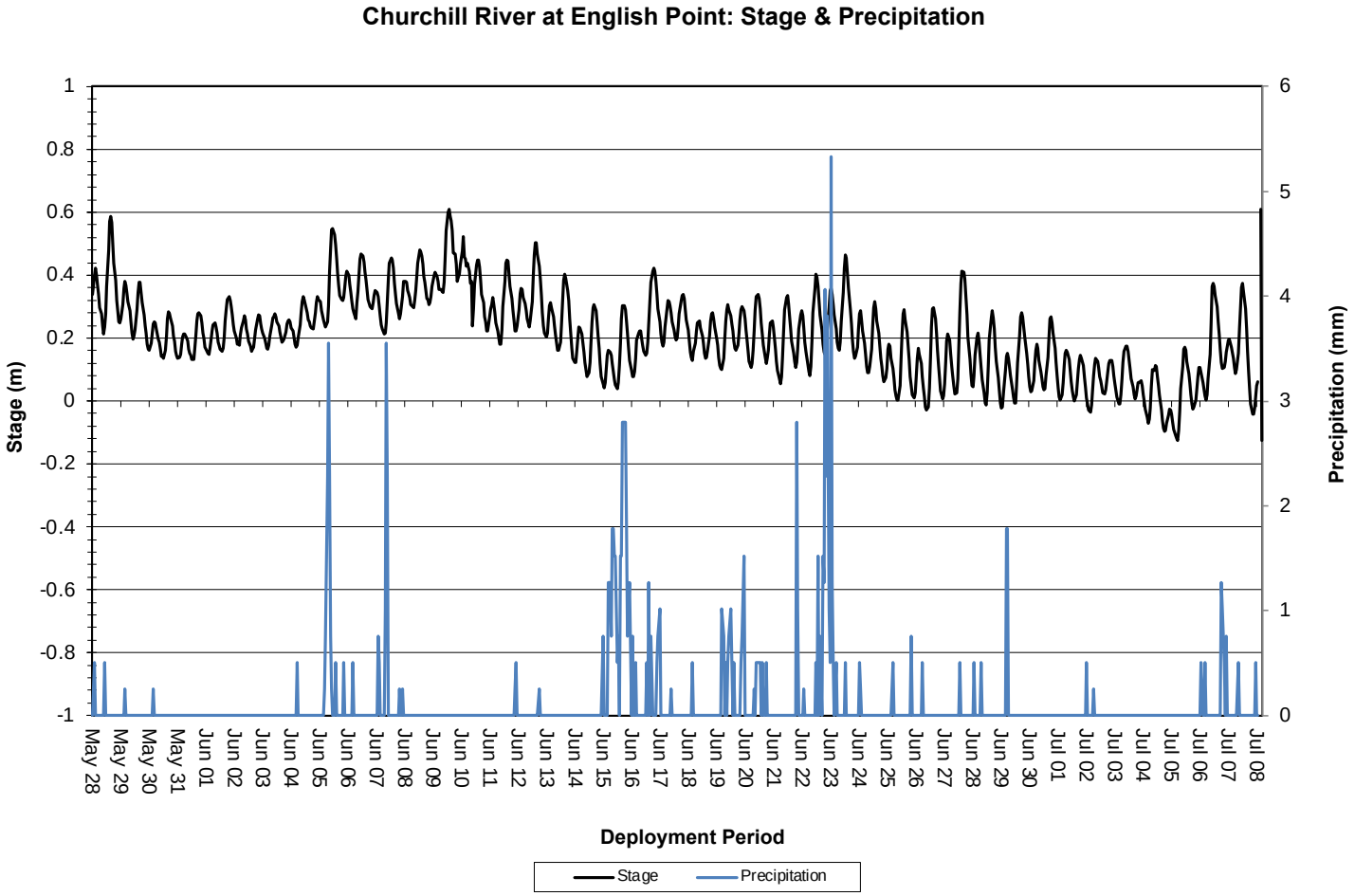


**Figure 27: Stage & Precipitation at Churchill River at English Point**

## Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from May 26/28/June 14 through July 7/8/27, 2021.
- Water temperature increased steadily at all stations over the course of deployment. This is to be expected based on ambient air temperature trends during the same period through July and August.
- 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 and above Grizzle Rapids. pH was below the CCME's Guidelines at Churchill River 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 decreased over the course of deployment at all stations as water temperatures increased through the summer. Dissolved oxygen levels are generally higher in water at cooler temperatures. Dissolved oxygen levels fell below the CCME's Guideline for the Protection of Early Life Stages at the very end of deployment at Churchill River below Metchin River, but remained above the Guideline at all other stations for the duration of deployment. 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, wind or tidal events. In most 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

BV Labs Job #: C1H1197
Report Date: 2021/06/30

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PWZ648 CR BELOW MR | | | | | | | | |
| Sampling Date 2021/06/14 12:45 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2021-6307-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Hardness (CaCO3) | - | 9.9 | 1.0 | mg/L | N/A | 2021/06/29 | | 7421568 |
| Nitrate (N) | - | 0.10 | 0.050 | mg/L | N/A | 2021/06/25 | | 7421572 |
| Total dissolved solids (calc., EC) | - | 12 | 1.0 | mg/L | N/A | 2021/06/28 | | 7422207 |
| **Inorganics** | | | | | | | | |
| Conductivity | - | 21 | 1.0 | uS/cm | N/A | 2021/06/28 | SHW | 7432549 |
| Chloride (Cl-) | - | ND | 1.0 | mg/L | N/A | 2021/06/28 | FD | 7431007 |
| Bromide (Br-) | - | ND | 1.0 | mg/L | N/A | 2021/06/28 | FD | 7431007 |
| Sulphate (SO4) | - | ND | 1.0 | mg/L | N/A | 2021/06/28 | FD | 7431007 |
| Total Alkalinity (Total as CaCO3) | - | 11 | 5.0 | mg/L | N/A | 2021/06/24 | MCN | 7424462 |
| Colour | - | 23 | 5.0 | TCU | N/A | 2021/06/25 | MCN | 7424483 |
| Dissolved Fluoride (F-) | - | ND | 0.10 | mg/L | N/A | 2021/06/28 | SHW | 7432553 |
| Total Kjeldahl Nitrogen (TKN) | - | 0.13 | 0.10 | mg/L | 2021/06/25 | 2021/06/25 | MJ1 | 7429564 |
| Nitrate + Nitrite (N) | - | 0.10 | 0.050 | mg/L | N/A | 2021/06/24 | MCN | 7424486 |
| Nitrite (N) | - | ND | 0.010 | mg/L | N/A | 2021/06/24 | MCN | 7424488 |
| Nitrogen (Ammonia Nitrogen) | - | ND | 0.050 | mg/L | N/A | 2021/06/25 | MCN | 7426809 |
| Dissolved Organic Carbon (C) | - | 3.6 | 0.50 | mg/L | N/A | 2021/06/26 | KMC | 7429002 |
| Total Organic Carbon (C) | - | 3.7 | 0.50 | mg/L | N/A | 2021/06/27 | KMC | 7429262 |
| pH | - | 7.29 | | pH | N/A | 2021/06/28 | SHW | 7432552 |
| Total Phosphorus | - | 0.008 | 0.004 | mg/L | 2021/06/25 | 2021/06/25 | SSV | 7429506 |
| Total Suspended Solids | - | 11 | 1.0 | mg/L | 2021/06/22 | 2021/06/24 | MKX | 7422381 |
| Turbidity | - | 1.2 | 0.10 | NTU | N/A | 2021/06/24 | SHW | 7426549 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | - | ND | 0.000013 | mg/L | 2021/06/28 | 2021/06/28 | NHU | 7429793 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | - | 0.065 | 0.0050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Antimony (Sb) | - | ND | 0.0010 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Arsenic (As) | - | ND | 0.0010 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Barium (Ba) | - | 0.0089 | 0.0010 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Boron (B) | - | ND | 0.050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Cadmium (Cd) | - | ND | 0.000010 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Calcium (Ca) | - | 2.6 | 0.10 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Chromium (Cr) | - | ND | 0.0010 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Copper (Cu) | - | ND | 0.00050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Iron (Fe) | - | 0.19 | 0.050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Lead (Pb) | - | ND | 0.00050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Magnesium (Mg) | - | 0.83 | 0.10 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Manganese (Mn) | - | 0.016 | 0.0020 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Nickel (Ni) | - | ND | 0.0020 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |



Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1H1197
Report Date: 2021/06/30

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PWZ648 CR BELOW MR<br>Sampling Date 2021/06/14 12:45<br>Matrix W<br>Sample # 2021-6307-00-SI-SP<br>Registration # WS-S-0000 | | | | | | | | |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Phosphorus (P) | - | ND | 0.10 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Selenium (Se) | - | ND | 0.00050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Sodium (Na) | - | 0.56 | 0.10 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Strontium (Sr) | - | 0.011 | 0.0020 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Uranium (U) | - | ND | 0.00010 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |
| Total Zinc (Zn) | - | ND | 0.0050 | mg/L | 2021/06/28 | 2021/06/28 | BAN | 7432496 |



Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1E6194
Report Date: 2021/06/08

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PRT917 CR ABOVE GR | | | | | | | | |
| Sampling Date 2021/05/26 13:30 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2021-6302-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Hardness (CaCO3) | - | 8.0 | 1.0 | mg/L | N/A | 2021/06/03 | | 7379506 |
| Nitrate (N) | - | ND | 0.050 | mg/L | N/A | 2021/06/04 | | 7379509 |
| Total dissolved solids (calc., EC) | - | 7.9 | 1.0 | mg/L | N/A | 2021/06/02 | | 7379569 |
| **Inorganics** | | | | | | | | |
| Conductivity | - | 14 | 1.0 | uS/cm | N/A | 2021/06/02 | SHW | 7383964 |
| Chloride (Cl-) | - | ND | 1.0 | mg/L | N/A | 2021/06/02 | FD | 7383350 |
| Bromide (Br-) | - | ND | 1.0 | mg/L | N/A | 2021/06/02 | FD | 7383350 |
| Sulphate (SO4) | - | ND | 1.0 | mg/L | N/A | 2021/06/02 | FD | 7383350 |
| Total Alkalinity (Total as CaCO3) | - | 9.3 | 5.0 | mg/L | N/A | 2021/06/03 | EMT | 7384316 |
| Colour | - | 38 | 5.0 | TCU | N/A | 2021/06/03 | EMT | 7384348 |
| Dissolved Fluoride (F-) | - | ND | 0.10 | mg/L | N/A | 2021/06/02 | SHW | 7383968 |
| Total Kjeldahl Nitrogen (TKN) | - | 0.12 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | RTY | 7385513 |
| Nitrate + Nitrite (N) | - | ND | 0.050 | mg/L | N/A | 2021/06/03 | EMT | 7384355 |
| Nitrite (N) | - | ND | 0.010 | mg/L | N/A | 2021/06/03 | EMT | 7384356 |
| Nitrogen (Ammonia Nitrogen) | - | ND | 0.050 | mg/L | N/A | 2021/06/02 | EMT | 7384020 |
| Dissolved Organic Carbon (C) | - | 4.6 | 0.50 | mg/L | N/A | 2021/06/01 | YLG | 7381617 |
| Total Organic Carbon (C) | - | 4.9 | 0.50 | mg/L | N/A | 2021/06/02 | YLG | 7381628 |
| pH | - | 6.80 | | pH | N/A | 2021/06/02 | SHW | 7383966 |
| Total Phosphorus | - | 0.007 | 0.004 | mg/L | 2021/06/04 | 2021/06/08 | SSV | 7389313 |
| Total Suspended Solids | - | 4.6 | 1.0 | mg/L | 2021/06/01 | 2021/06/02 | MKX | 7381460 |
| Turbidity | - | 1.3 | 0.10 | NTU | N/A | 2021/06/02 | SHW | 7384063 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | - | ND | 0.000013 | mg/L | 2021/06/02 | 2021/06/02 | NHU | 7381672 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | - | 0.14 | 0.0050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Antimony (Sb) | - | ND | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Arsenic (As) | - | ND | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Barium (Ba) | - | 0.0075 | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Boron (B) | - | ND | 0.050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Cadmium (Cd) | - | 0.000011 | 0.000010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Calcium (Ca) | - | 2.1 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Chromium (Cr) | - | ND | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Copper (Cu) | - | 0.00057 | 0.00050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Iron (Fe) | - | 0.25 | 0.050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Lead (Pb) | - | ND | 0.00050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Magnesium (Mg) | - | 0.70 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Manganese (Mn) | - | 0.016 | 0.0020 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Nickel (Ni) | - | ND | 0.0020 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |



Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1E6194
Report Date: 2021/06/08

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PRT917 CR ABOVE GR<br>Sampling Date 2021/05/26 13:30<br>Matrix W<br>Sample # 2021-6302-00-SI-SP<br>Registration # WS-S-0000 | | | | | | | | |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Phosphorus (P) | - | ND | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Selenium (Se) | - | ND | 0.00050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Sodium (Na) | - | 0.58 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Strontium (Sr) | - | 0.010 | 0.0020 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Uranium (U) | - | ND | 0.00010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Zinc (Zn) | - | ND | 0.0050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |


Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1E6194
Report Date: 2021/06/08

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PRT916 CR BELOW MF | | | | | | | | |
| Sampling Date 2021/05/26 13:30 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2021-6300-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Hardness (CaCO3) | - | 7.3 | 1.0 | mg/L | N/A | 2021/06/03 | | 7379506 |
| Nitrate (N) | - | ND | 0.050 | mg/L | N/A | 2021/06/04 | | 7379509 |
| Total dissolved solids (calc., EC) | - | 7.3 | 1.0 | mg/L | N/A | 2021/06/02 | | 7379569 |
| **Inorganics** | | | | | | | | |
| Conductivity | - | 13 | 1.0 | uS/cm | N/A | 2021/06/02 | SHW | 7383964 |
| Chloride (Cl-) | - | ND | 1.0 | mg/L | N/A | 2021/06/02 | FD | 7383350 |
| Bromide (Br-) | - | ND | 1.0 | mg/L | N/A | 2021/06/02 | FD | 7383350 |
| Sulphate (SO4) | - | ND | 1.0 | mg/L | N/A | 2021/06/02 | FD | 7383350 |
| Total Alkalinity (Total as CaCO3) | - | 8.5 | 5.0 | mg/L | N/A | 2021/06/03 | EMT | 7384316 |
| Colour | - | 45 | 5.0 | TCU | N/A | 2021/06/03 | EMT | 7384348 |
| Dissolved Fluoride (F-) | - | ND | 0.10 | mg/L | N/A | 2021/06/02 | SHW | 7383968 |
| Total Kjeldahl Nitrogen (TKN) | - | 0.14 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | RTY | 7385513 |
| Nitrate + Nitrite (N) | - | ND | 0.050 | mg/L | N/A | 2021/06/03 | EMT | 7384355 |
| Nitrite (N) | - | ND | 0.010 | mg/L | N/A | 2021/06/03 | EMT | 7384356 |
| Nitrogen (Ammonia Nitrogen) | - | ND | 0.050 | mg/L | N/A | 2021/06/02 | EMT | 7384020 |
| Dissolved Organic Carbon (C) | - | 5.0 | 0.50 | mg/L | N/A | 2021/06/01 | YLG | 7381617 |
| Total Organic Carbon (C) | - | 5.2 | 0.50 | mg/L | N/A | 2021/06/01 | YLG | 7381628 |
| pH | - | 6.75 | | pH | N/A | 2021/06/02 | SHW | 7383966 |
| Total Phosphorus | - | 0.014 | 0.004 | mg/L | 2021/06/04 | 2021/06/08 | SSV | 7389313 |
| Total Suspended Solids | - | 14 | 1.0 | mg/L | 2021/06/01 | 2021/06/02 | MKX | 7381460 |
| Turbidity | - | 9.8 | 0.10 | NTU | N/A | 2021/06/02 | SHW | 7384063 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | - | ND | 0.000013 | mg/L | 2021/06/02 | 2021/06/02 | NHU | 7381672 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | - | 0.34 | 0.0050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Antimony (Sb) | - | ND | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Arsenic (As) | - | ND | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Barium (Ba) | - | 0.0090 | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Boron (B) | - | ND | 0.050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Cadmium (Cd) | - | 0.000011 | 0.000010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Calcium (Ca) | - | 1.8 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Chromium (Cr) | - | ND | 0.0010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Copper (Cu) | - | 0.0030 | 0.00050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Iron (Fe) | - | 0.47 | 0.050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Lead (Pb) | - | ND | 0.00050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Magnesium (Mg) | - | 0.68 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Manganese (Mn) | - | 0.016 | 0.0020 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Nickel (Ni) | - | ND | 0.0020 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |



Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1E6194
Report Date: 2021/06/08

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PRT916 CR BELOW MF<br>Sampling Date 2021/05/26 13:30<br>Matrix W<br>Sample # 2021-6300-00-SI-SP<br>Registration # WS-S-0000 | | | | | | | | |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Phosphorus (P) | - | ND | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Selenium (Se) | - | ND | 0.00050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Sodium (Na) | - | 0.59 | 0.10 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Strontium (Sr) | - | 0.010 | 0.0020 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Uranium (U) | - | ND | 0.00010 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |
| Total Zinc (Zn) | - | ND | 0.0050 | mg/L | 2021/06/02 | 2021/06/03 | BAN | 7383946 |


Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1E7523
Report Date: 2021/06/10

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PSB380 CR @ EP | | | | | | | | |
| Sampling Date 2021/05/28 11:45 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2021-6301-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Hardness (CaCO3) | - | 11 | 1.0 | mg/L | N/A | 2021/06/07 | | 7381516 |
| Nitrate (N) | - | ND | 0.050 | mg/L | N/A | 2021/06/08 | | 7381519 |
| Total dissolved solids (calc., EC) | - | 17 | 1.0 | mg/L | N/A | 2021/06/08 | | 7381544 |
| **Inorganics** | | | | | | | | |
| Conductivity | - | 31 | 1.0 | uS/cm | N/A | 2021/06/08 | SHW | 7394542 |
| Chloride (Cl-) | - | 4.7 | 1.0 | mg/L | N/A | 2021/06/07 | FD | 7391443 |
| Bromide (Br-) | - | ND | 1.0 | mg/L | N/A | 2021/06/07 | FD | 7391443 |
| Sulphate (SO4) | - | ND | 1.0 | mg/L | N/A | 2021/06/07 | FD | 7391443 |
| Total Alkalinity (Total as CaCO3) | - | 9.3 | 5.0 | mg/L | N/A | 2021/06/07 | MCN | 7389181 |
| Colour | - | 79 | 25 | TCU | N/A | 2021/06/07 | MCN | 7389198 |
| Dissolved Fluoride (F-) | - | ND | 0.10 | mg/L | N/A | 2021/06/08 | SHW | 7394544 |
| Total Kjeldahl Nitrogen (TKN) | - | 0.12 | 0.10 | mg/L | 2021/06/04 | 2021/06/04 | RTY | 7389280 |
| Nitrate + Nitrite (N) | - | ND | 0.050 | mg/L | N/A | 2021/06/07 | MCN | 7389201 |
| Nitrite (N) | - | ND | 0.010 | mg/L | N/A | 2021/06/07 | MCN | 7389203 |
| Nitrogen (Ammonia Nitrogen) | - | ND | 0.050 | mg/L | N/A | 2021/06/07 | MCN | 7392401 |
| Dissolved Organic Carbon (C) | - | 6.9 | 0.50 | mg/L | N/A | 2021/06/03 | YLG | 7386511 |
| Total Organic Carbon (C) | - | 8.4(1) | 5.0 | mg/L | N/A | 2021/06/03 | YLG | 7386750 |
| pH | - | 6.88 | | pH | N/A | 2021/06/08 | SHW | 7394543 |
| Total Phosphorus | - | 0.043 | 0.004 | mg/L | 2021/06/07 | 2021/06/08 | SSV | 7393706 |
| Total Suspended Solids | - | 35 | 1.7 | mg/L | 2021/06/02 | 2021/06/03 | MKX | 7384016 |
| Turbidity | - | 44 | 0.10 | NTU | N/A | 2021/06/03 | SHW | 7386568 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | - | ND | 0.000013 | mg/L | 2021/06/03 | 2021/06/03 | NHU | 7386456 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | - | 1.2 | 0.0050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Antimony (Sb) | - | ND | 0.0010 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Arsenic (As) | - | ND | 0.0010 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Barium (Ba) | - | 0.019 | 0.0010 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Boron (B) | - | ND | 0.050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Cadmium (Cd) | - | ND | 0.000010 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Calcium (Ca) | - | 2.0 | 0.10 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Chromium (Cr) | - | 0.0025 | 0.0010 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Copper (Cu) | - | 0.0043 | 0.00050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Iron (Fe) | - | 1.7 | 0.050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Lead (Pb) | - | ND | 0.00050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Magnesium (Mg) | - | 1.4 | 0.10 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Manganese (Mn) | - | 0.048 | 0.0020 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |

(1) Elevated reporting limit due to turbidity.



Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com

BV Labs Job #: C1E7523
Report Date: 2021/06/10

NL Department of Environment, Climate Change and Municipalities
Your P.O. #: 220028978-2

| Sample Details/Parameters | A | Result | RDL | UNITS | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| PSB380 CR @ EP<br>Sampling Date 2021/05/28 11:45<br>Matrix W<br>Sample # 2021-6301-00-SI-SP<br>Registration # WS-S-0000 | | | | | | | | |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Nickel (Ni) | - | 0.0026 | 0.0020 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Phosphorus (P) | - | ND | 0.10 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Selenium (Se) | - | ND | 0.00050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Sodium (Na) | - | 3.8 | 0.10 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Strontium (Sr) | - | 0.017 | 0.0020 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Uranium (U) | - | ND | 0.00010 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |
| Total Zinc (Zn) | - | ND | 0.0050 | mg/L | 2021/06/04 | 2021/06/05 | BAN | 7388977 |



Bureau Veritas Laboratories 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.bvlabs.com