Real-Time Water Quality 2018 Annual Report

Churchill River Network

May 29 to November 15, 2018

Newfoundland Labrador

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

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Acknowledgements

The Real-Time Water Quality (RTWQ) monitoring network on the Churchill River is successful in tracking emerging water quality issues, as well as creating a database of baseline water quality data due to the hard work and diligence of certain individuals. The management and staff of Nalcor work in cooperation with the management and staff of the Department of Municipal Affairs and Environment (MAE) as well as Environment and Climate Change Canada (ECCC) to ensure the protection of ambient water resources in the Churchill River.

Employees with the Water Resources Management Division of the Department of MAE were integral in ensuring the smooth operation of such a technologically advanced network. WRMD staff was responsible for deployment and removal of instruments including cleaning, calibration, and maintenance, as well as preparation of monthly deployment reports for the 2018 season.

Water Survey of Canada staff with ECCC played an essential role in the data logging/communication aspect of the network. These individuals visited the site regularly to ensure the data logging equipment was operating properly and transmitting data efficiently. Finally, they played the lead role in dealing with hydrological quantity and flow issues.

Managers from each agency are fully committed to improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in decision-making processes. Throughout the summer and fall months of 2018, there was continued communication in the form of small meetings and email correspondence between MAE and Nalcor. This network is continually successful due to the participation and collaboration of all three agencies.

Abbreviations

ECCC	Environment and Climate Change Canada
MAE	NL Department of Municipal Affairs and Environment
CRbelowMR	Station at Churchill River below Metchin River
CRaboveGR	Station at Churchill River above Grizzle Rapids
CRbelowMF	Station at Churchill River below Muskrat Falls
CRatEngPt	Station at Churchill River at English Point
DO	Dissolved Oxygen
NL	Newfoundland and Labrador
QA/QC	Quality Assurance and Quality Control
RTWQ	Real-Time Water Quality
WRMD	Water Resources Management Division
%Sat	Percent Saturation

History

- The RTWQ monitoring network on the Lower Churchill River was successfully established by MAE and ECCC in cooperation with Nalcor Energy in September 2008.
- The objective of the network is to identify and track emerging water quality or quantity management issues and ensure protection of ambient water resources along the Lower Churchill River. The information being collected will serve as a baseline from which changes throughout the several phases of the Lower Churchill Hydroelectric Generation Project can be monitored.
- The original network, established in 2008, consisted of 4 water quality/quantity monitoring stations along the Lower Churchill River from just below the confluence with Metchin River to just below Muskrat Falls. In addition, there were two water quantity monitoring stations on the Churchill River below the Tailrace and above Grizzle Rapids, which strictly recorded stage level continuously. There were also hydrometric stations on select tributaries to the Churchill River (ie. East Metchin River, Pinus River, Minipi River (Figure 1)).
- In 2011, MAE in cooperation with ECCC established another water quality/quantity monitoring station at the mouth of the Churchill River (Churchill River at English Point). This station is included in this annual report for comparison purposes (Figure 1). A water quantity station was also established at Lake Melville east of Little River in 2011.
- During the 2014 deployment year, one water quality/quantity monitoring station (Churchill River below Metchin River) and three water quantity monitoring stations (Churchill River above Churchill Falls Tailrace, East Metchin River below Highway Bridge and Minipi River below Minipi Lake) were discontinued as per changes to the Memorandum of Agreement between MAE and Nalcor. An additional water quantity monitoring station (Churchill River at Mid Pool) was added to the agreement in 2014.
- During the 2017 deployment year, several stations were reactivated or added to the Churchill River network. Stations at Churchill River below Metchin River and Churchill River above Churchill Falls Tailrace were reactivated. New stations at Churchill River below Churchill Falls Tailrace, Churchill River at Happy Valley, and Mud Lake at Mud Lake were installed. With the exception of Churchill River below Metchin River, these reactivated and new stations collect water quantity data only.
- Continuous monitoring at four water quality/quantity monitoring stations in the Lower Churchill River Network recommenced in spring 2018. This annual deployment report illustrates, discusses and summarizes water quality related events from May 29 to November 15, 2018. Due to challenging site conditions, only two RTWQ stations (Churchill River below Muskrat Falls and Churchill River at English Point) were monitored for the entire season. Instruments were generally deployed for 30-50 day intervals referred to as deployment periods.
- Issues were encountered at a few of the stations during the deployment season. Due to the presence of an ice wall at above Grizzle Rapids and below Metchin River, these stations were not deployed until later in the season. The stations at above Muskrat Falls and Mid Pool were not deployed during the 2018 season due to inaccessibility and safety concerns.
- During the 2018 deployment year, new stations were installed throughout the Churchill River network at Churchill River below Traverspine River, Churchill River at end of Mud Lake Road, and Rabbit Island at Outlet of Churchill River. These new stations collect water quantity data only.
- Construction at the Muskrat Falls Hydroelectric Generation site began in 2013. In 2018, construction continued on the worksite; the North and South dams were completed, and significant progress was made on the powerhouse. Construction is scheduled to continue through 2019.

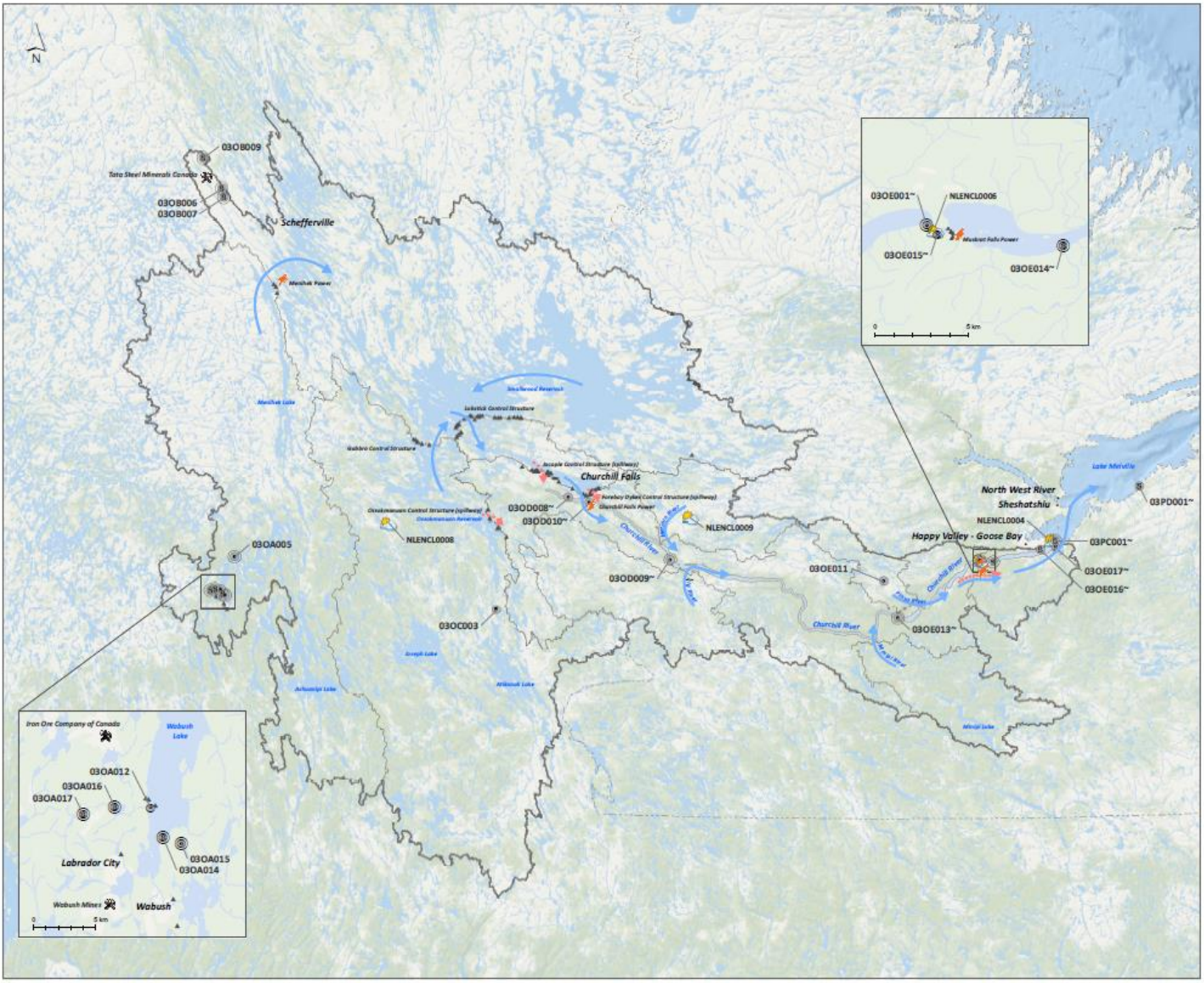

Figure 1: Churchill River Station Network Map

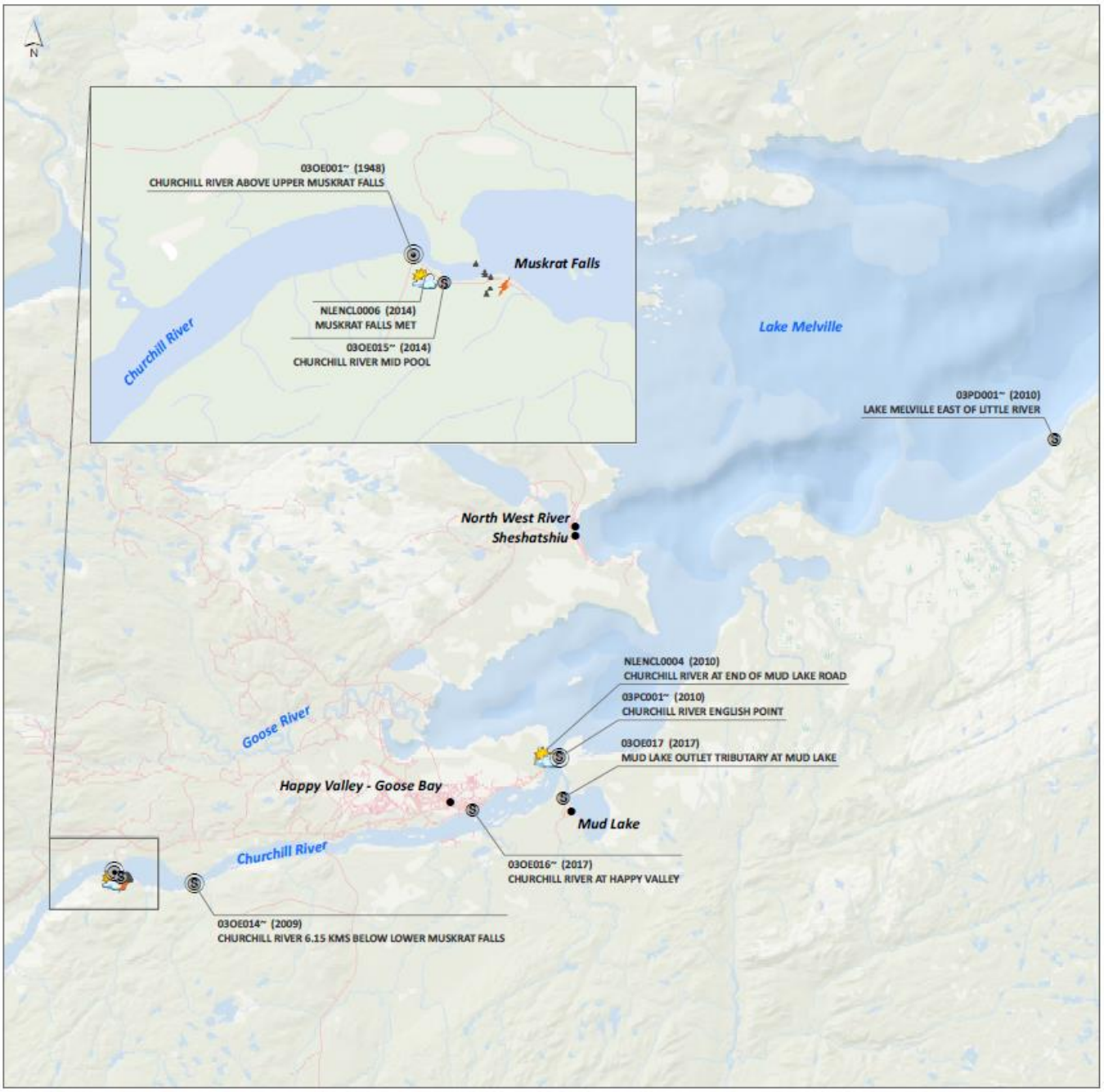

Figure 2: Lower Churchill River Network Station Map

Maintenance and Calibration

- Regular maintenance and calibration of the instruments is required to ensure data accuracy. This procedure is the responsibility of MAE staff and is performed generally every 30-50 days.
- Maintenance includes a thorough cleaning of the instrument and replacement of any small sensor parts that are damaged or unsuitable for reuse. Once the instrument is cleaned, MAE staff carefully calibrate each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity.
- Installation and removal dates for each station during the 2018 deployment season are summarized in Table 1.

Table 1: Installation and removal dates for 2018 deployment season

Station	Initial Installation	Removal	Deployment Periods (days)
Churchill River below Metchin River	August 17	November 15	90
Churchill River above Grizzle Rapids	July 13	November 15	35, 56, 34
Churchill River below Muskrat Falls	May 29	October 31	42, 50, 27, 35
Churchill River at English Point	May 29	October 31	42, 50, 27, 35

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. The procedure is based on the approach used by the United States Geological Survey (USGS).
  - ► 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 2).

Table 2: 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 > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

- 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.
- Comparison rankings for the Lower Churchill River stations during the 2018 deployment season are summarized in Table 3.
- For additional information and explanations of rankings, please refer to the monthly deployment reports.

Table 3: Comparison rankings for Lower Churchill River stations, 2018 deployment season

Station	Date	Action	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Churchill River below Metchin River		Deployment	Instrument not deployed				
		Removal					
		Deployment	Instrument not deployed				
		Removal					
	August 17	Deployment	Excellent	Good	Excellent	Excellent	Fair
		Removal	Instrument not removed				
		Deployment					
	November 15	Removal	Good	Excellent	Good	Excellent	Poor
Churchill River above Grizzle Rapids		Deployment	Instrument not deployed				
		Removal					
	July 13	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	August 17	Removal	Excellent	Excellent	Excellent	Excellent	Fair
	August 17	Deployment	Good	Good	Excellent	Excellent	Marginal
	October 12	Removal	Good	Good	Excellent	Good	Good
	October 12	Deployment	Excellent	Excellent	Excellent	Good	Fair
	November 15	Removal	Good	Marginal	Good	Excellent	Fair
Churchill River below Muskrat Falls	May 29	Deployment	Fair	Excellent	Excellent	Good	Good
	July 10	Removal	Good	Good	Excellent	Good	Good
	July 10	Deployment	Excellent	Good	Excellent	Good	Excellent
	August 29	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
	August 29	Deployment	Excellent	Excellent	Excellent	Good	Excellent
	September 26	Removal	Excellent	Excellent	Excellent	Excellent	Good
	September 26	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	October 31	Removal	Excellent	Poor	Excellent	Excellent	Poor
Churchill River at English Point	May 29	Deployment	Good	Excellent	Fair	Excellent	Fair
	July 10	Removal	Excellent	Good	Excellent	Excellent	Poor
	July 10	Deployment	Excellent	Good	Excellent	Excellent	Good
	August 29	Removal	Good	Good	Good	Excellent	Poor
	August 29	Deployment	Good	Good	Excellent	Good	Poor
	September 26	Removal	Excellent	Excellent	Excellent	Good	Fair
	September 26	Deployment	Good	Fair	Excellent	Excellent	Poor
	October 31	Removal	Good	Fair	Good	Fair	Fair

Data Interpretation and Review

- The following graphs and discussions illustrate significant water quality-related trends from May 29 to November 15 throughout the Churchill River network. In this summary of all 2018 deployment periods, general patterns will be discussed. For more detailed analysis and discussion of specific events, please refer to the monthly deployment reports.
- With the exception of water quantity data (stage and flow), all data used in the preparation of the graphs and subsequent discussion below adhere to stringent QA/QC protocol.
- Water Survey of Canada (ECCC) is responsible for QA/QC of water quantity data (stage and flow). Corrected data can be obtained upon request.
- For a general comparison, 2016 and 2017 data have been included (where available) to show trends in water quality on the Churchill River over the past 3 years.
- Summary statistics are calculated using the entire data set. This means that the number of values used to calculate the median, minimum, and maximum vary from year to year, and from station to station, depending on the length of the deployment season.

Churchill River below Metchin River

Temperature

- Over the 2018 deployment season, water temperature ranged from -0.3°C to 17.1°C, with a median value of 6.3°C (Figure 3).
- Since this station was not deployed until mid-August, the observed decreasing temperature trend is expected as summer transitioned to fall.
- Comparison data from 2016 is not available for this station.

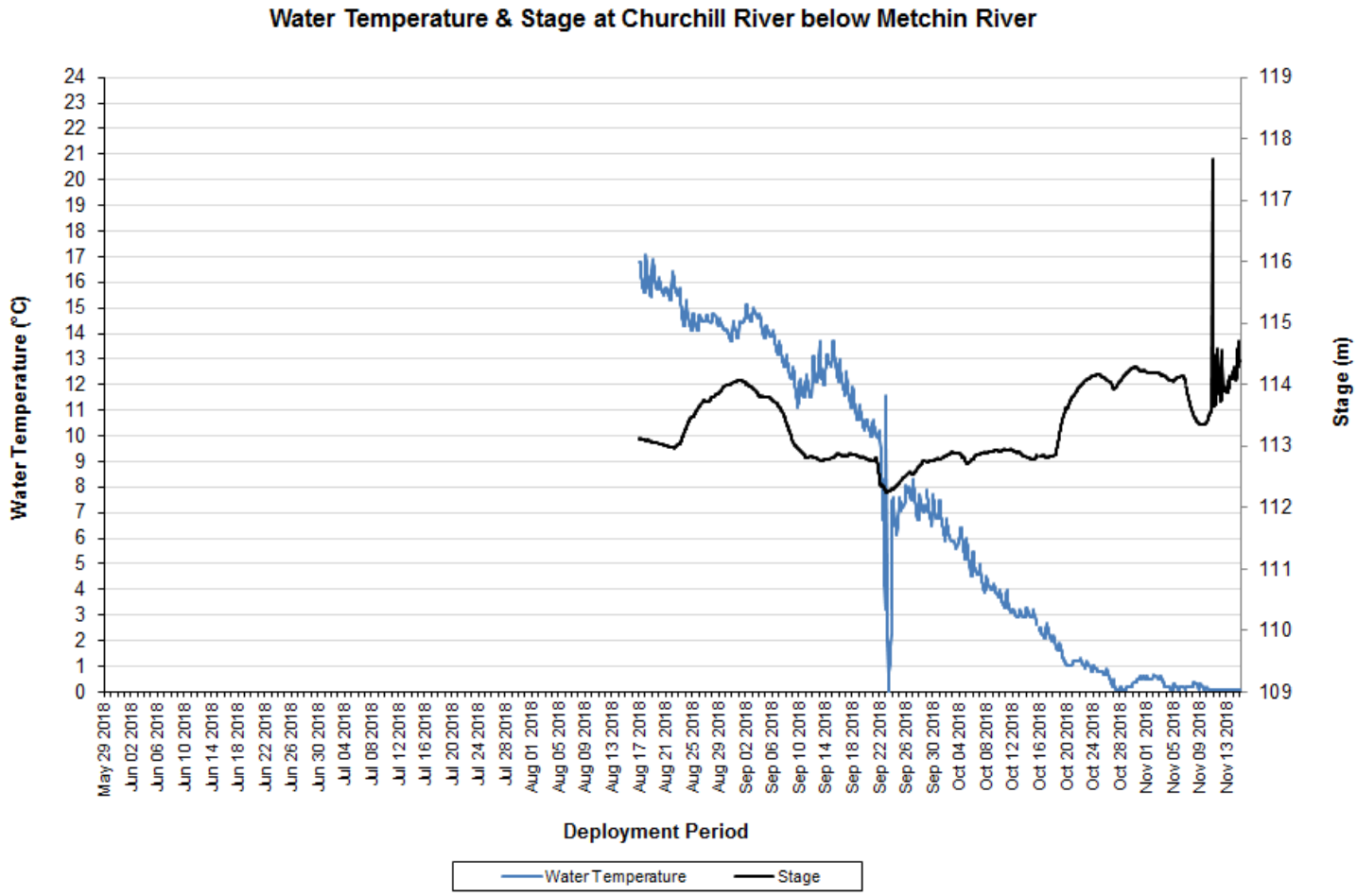

Figure 3: Water Temperature & Stage at Churchill River below Metchin River

Temperature (°C)	2018	2017	2016
Min	-0.3	2.9	-
Max	17.1	8.9	-
Median	6.3	5.4	-

- Water temperature values showed a typical seasonal trend and closely correlated with ambient air temperatures. Water and air temperatures both decreased from mid-August through the fall months (Figure 4). Air temperature data was obtained from the Muskrat Falls MET Station.

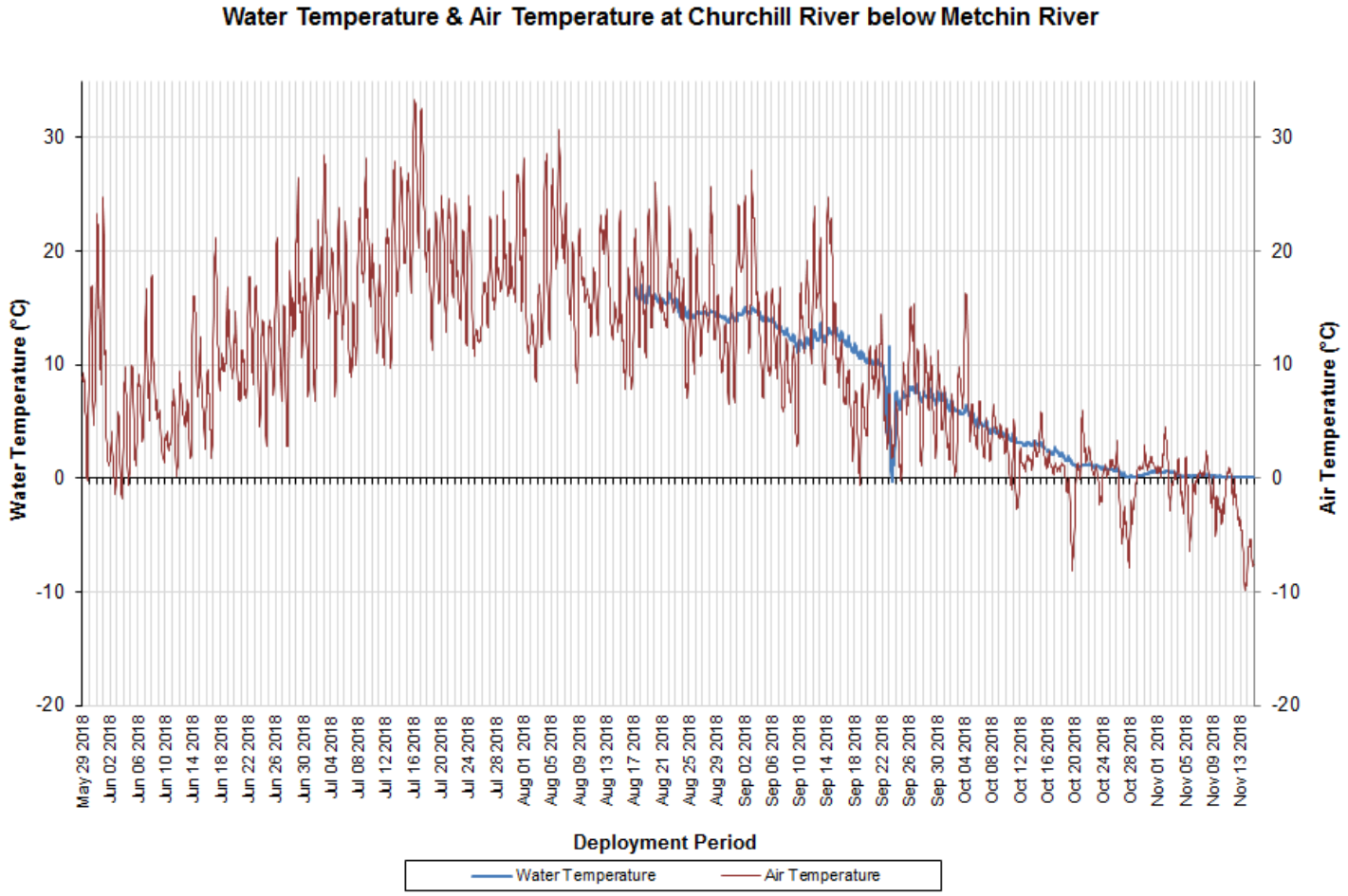

Figure 4: Water Temperature & Air Temperature at Churchill River below Metchin River

pH

- Over the 2018 deployment season, pH ranged from 6.43 to 6.74 pH units, with a median value of 6.60 pH units (Figure 5) which was similar to the 2017 median of 6.57.
- pH values were fairly consistent over the deployment season, with clear diurnal fluctuation.
- pH values remained within the CCME's Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units) for the majority of the deployment season. The occasions when pH fell below the CCME's Minimum Guideline correlated closely with significant increases in stage.
- Comparison data for 2016 is not available for this station.

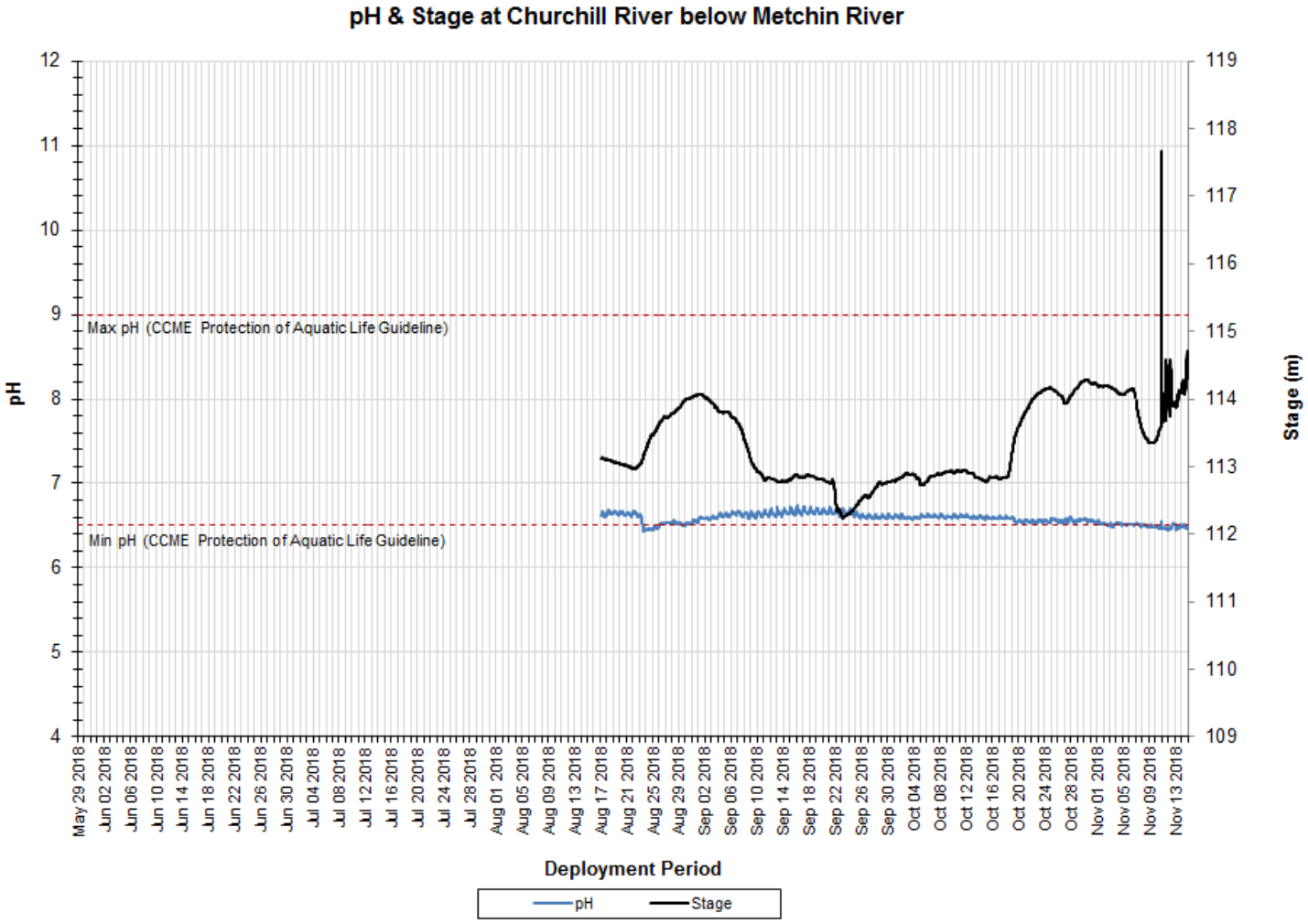

Figure 5: pH & Stage at Churchill River below Metchin River

pH (units)	2018	2017	2016
Min	6.43	6.58	-
Max	6.74	6.95	-
Median	6.60	6.75	-

Specific Conductivity

- Over the 2018 deployment season, specific conductivity ranged from 10.6µS/cm to 22.8µS/cm, with a median value of 20.3µS/cm (Figure 6) which was very similar to the 2017 median of 19.9.
- Specific conductivity was fairly consistent at this station for the duration of deployment, with only slight fluctuations.
- Increases and decreases in specific conductivity are generally related to fluctuations in stage. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, when stage increases due to precipitation events, specific conductivity usually decreases due to the dilution of dissolved solids.
- Comparison data for 2016 is not available for this station.

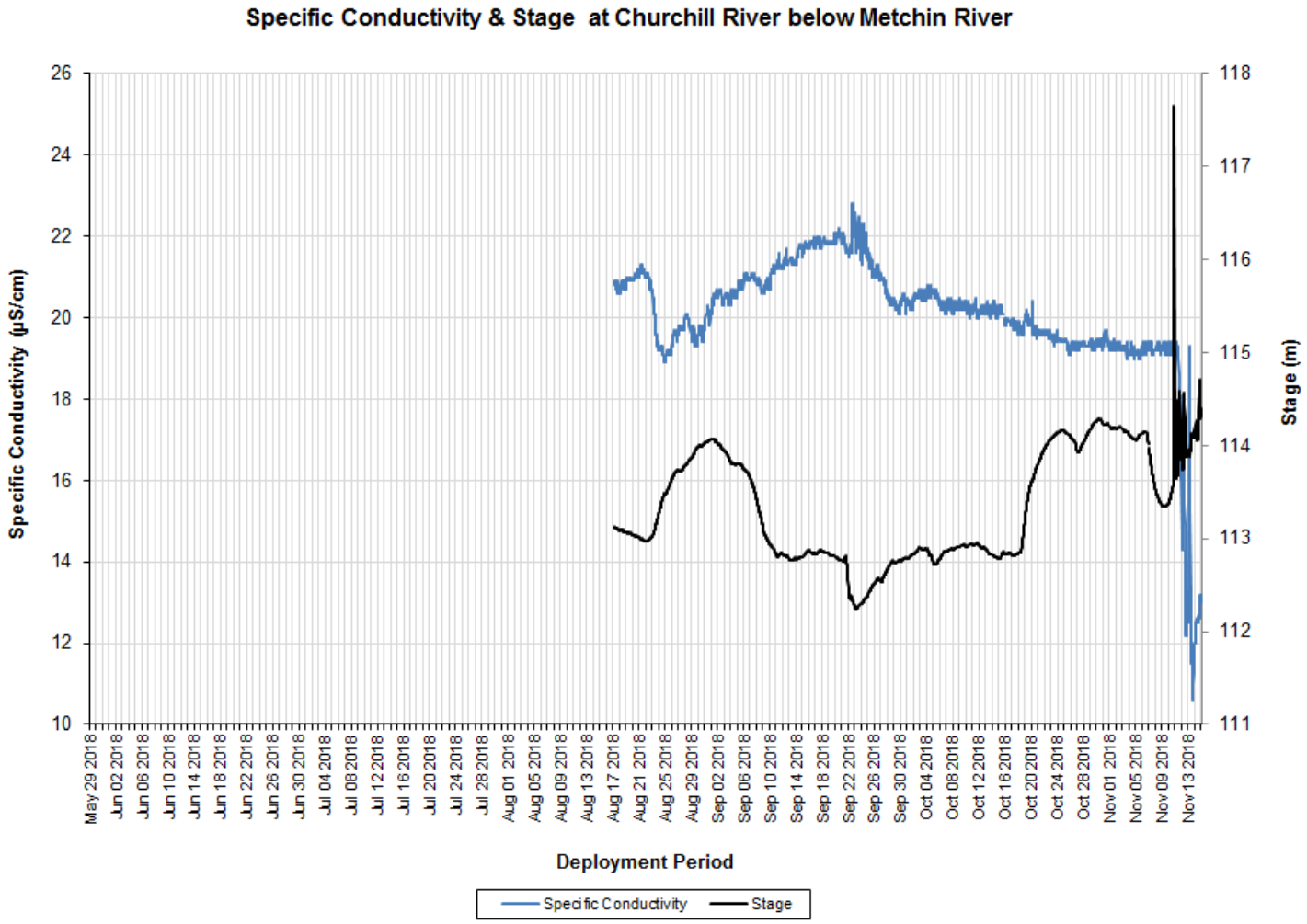

Figure 6: Specific Conductivity & Stage at Churchill River below Metchin River

Specific Conductivity (µS/cm)	2018	2017	2016
Min	10.6	18.7	-
Max	22.8	21.5	-
Median	20.3	19.9	-

Dissolved Oxygen

- Over the 2018 deployment season, dissolved oxygen ranged from 9.18mg/L to 14.43mg/L, with a median value of 11.56mg/L (Figure 7) which was very similar to the 2017 median of 11.87. Percent saturation ranged from 91.1% to 98.0%, with a median value of 94.5% (Figure 7).
- Dissolved oxygen content fluctuates regularly on a daily basis. Percent saturation is generally consistent throughout the deployment season. As water temperatures decreased into the fall, dissolved oxygen content steadily increased.
- Dissolved oxygen values were above the CCME's Guidelines for the Protection of Early and Other Life Stages (6.5mg/L and 9.5mg/L respectively) for the majority of deployment. The occasion where dissolved oxygen values fell below the CCME's Guideline for the Protection of Early Life Stages closely correlated with a period of higher water temperature. This is to be expected as dissolved oxygen levels are generally lower in warmer water bodies.
- Comparison data for 2016 is not available for this station.

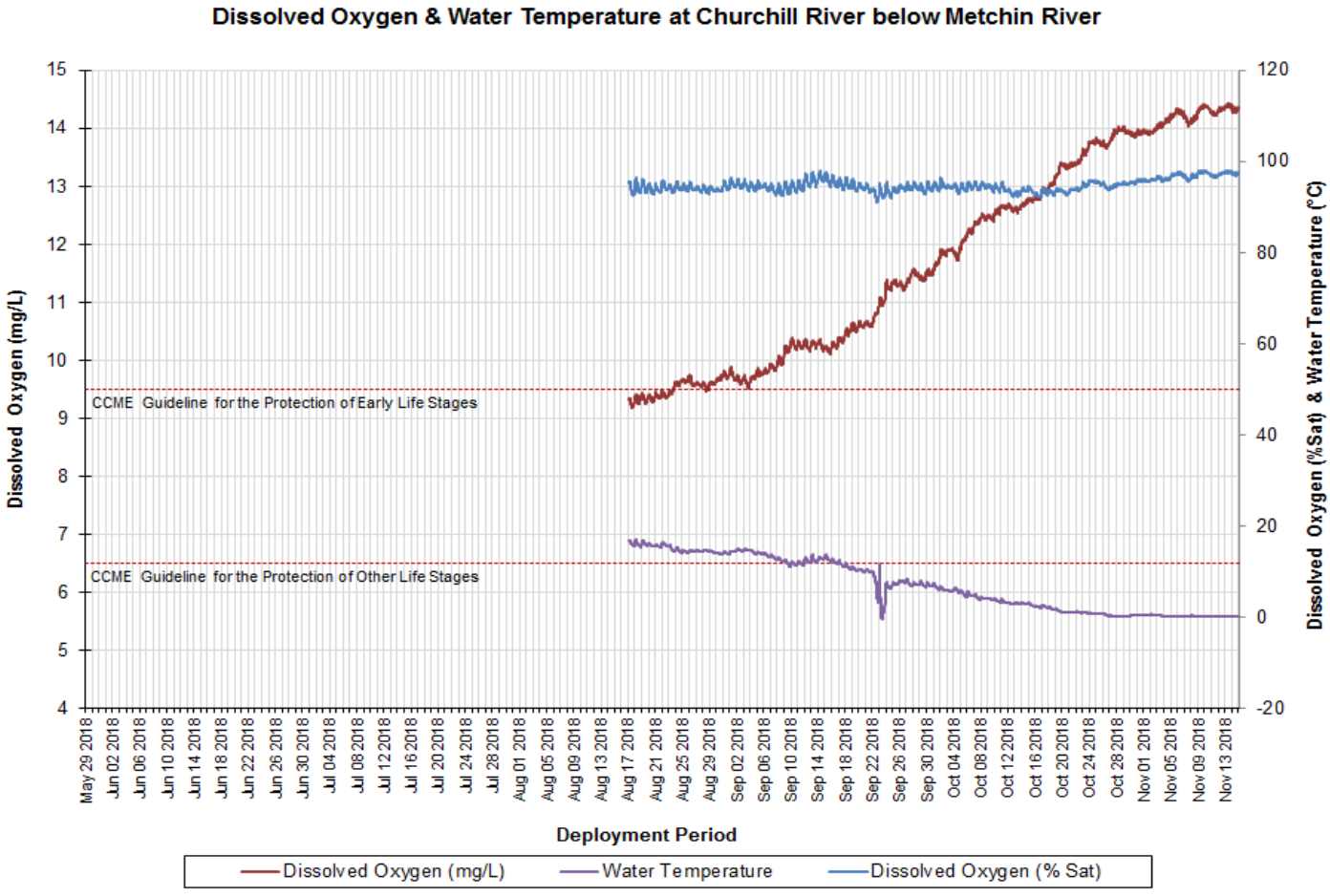

Figure 7: Dissolved Oxygen & Water Temperature at Churchill River below Metchin River

Dissolved Oxygen (mg/L)	2018	2017	2016		Dissolved Oxygen (%Sat)	2018	2017	2016
Min	9.18	10.67	-		**Min**	91.1	90.8	-
Max	14.43	12.48	-		**Max**	98.0	95.5	-
Median	11.56	11.87	-		**Median**	94.5	92.4	-

Turbidity & Precipitation

- Over the 2018 deployment season, turbidity ranged from 0 NTU to 17.5 NTU, with a median value of 0 NTU (Figure 8). A median value of 0 NTU indicates that there is very little natural background turbidity at this station.
- Turbidity is graphed below against stage and precipitation. Precipitation events often correlate closely with temporary increases in both stage and turbidity levels, which can be observed in the graph below. It is important to note, however, that this station is located on a very wide and deep section of the Churchill River and so turbidity is less influenced by precipitation events when compared to other stations. Precipitation data was obtained from the Muskrat Falls MET Station.
- Comparison data for 2016 is not available for this station.

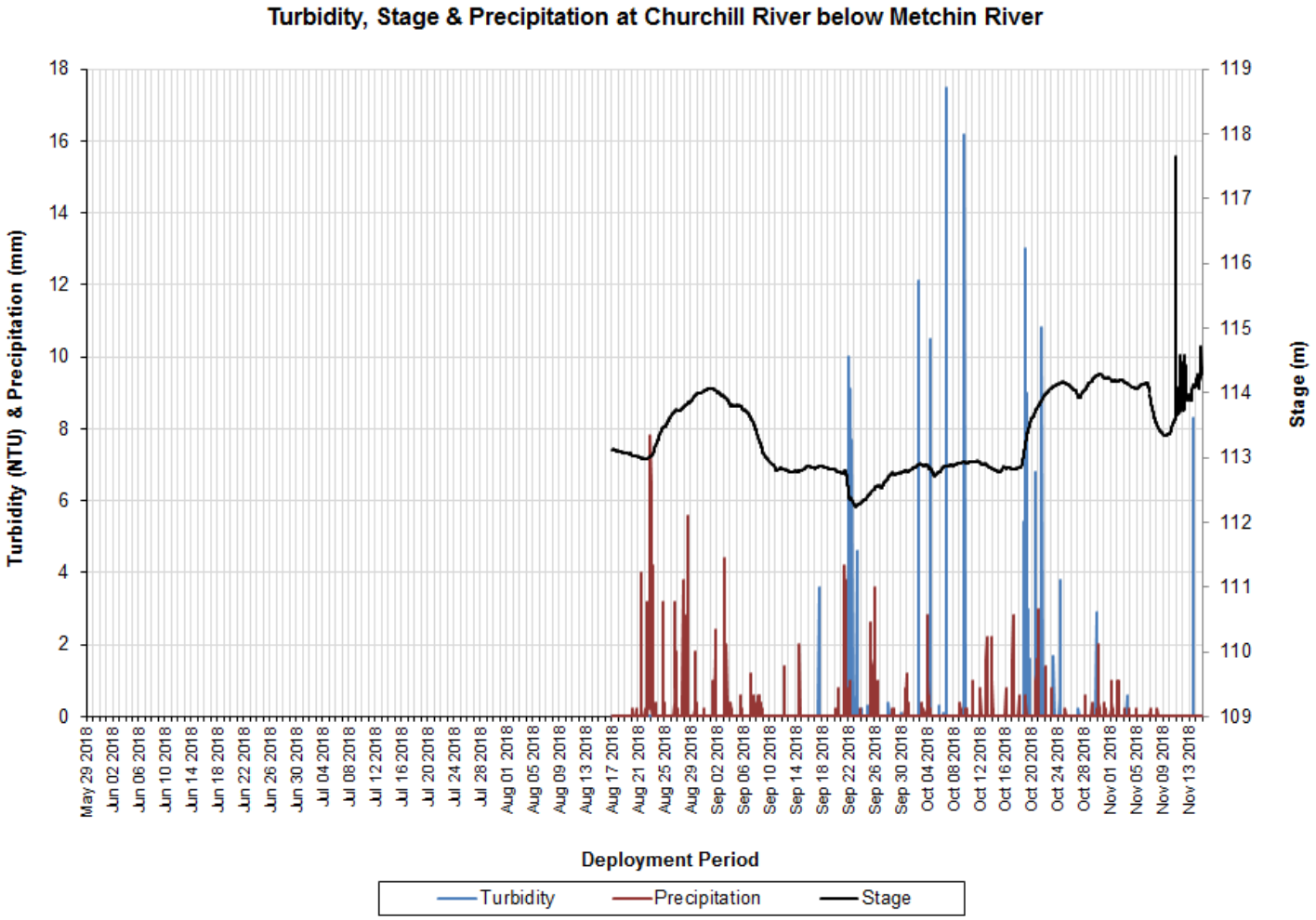

Figure 8: Turbidity, Stage & Precipitation at Churchill River below Metchin River

Turbidity (NTU)	2018	2017	2016
Min	0	0	-
Max	17.5	59.2	-
Median	0	0	-

Stage & Flow

- Over the 2018 deployment season, stage ranged from 112.242m to 117.662m, with a median value of 113.099m (Figure 9). Stage remained relatively stable throughout the deployment season. Flow ranged from 926.532m^3/s to 1695.073m^3/s, with a median value of 1268.779m^3/s.
- Comparison data for 2016 is not available for this station for stage. Comparison data for 2017 and 2016 is not available for this station for flow.
- Water Survey of Canada (ECCC) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

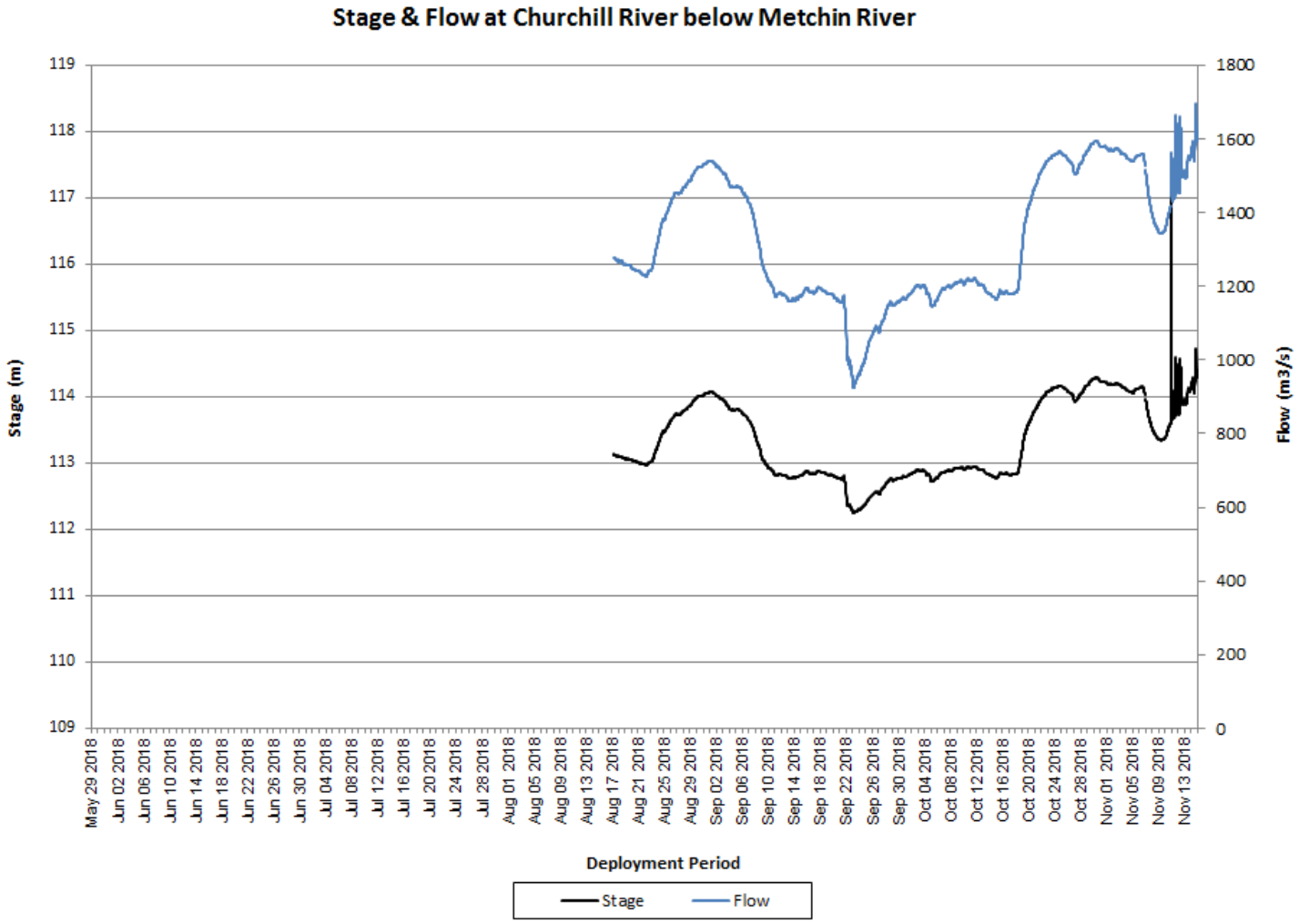

Figure 9: Stage & Flow at Churchill River below Metchin River

Stage (m)	2018	2017	2016		Flow (m^3/s)	2018	2017	2016
Min	112.242	112.121	-		**Min**	926.532	-	-
Max	117.662	113.228	-		**Max**	1695.073	-	-
Median	113.099	112.623	-		**Median**	1268.779	-	-

Churchill River above Grizzle Rapids

Temperature

- Over the 2018 deployment season, water temperature ranged from -0.2°C to 19.6°C, with a median value of 12.8°C (Figure 10).
- Water temperatures peaked during the first half of August, after which they steadily declined through late summer and fall.
- Comparison data for 2016 is not available for this station.

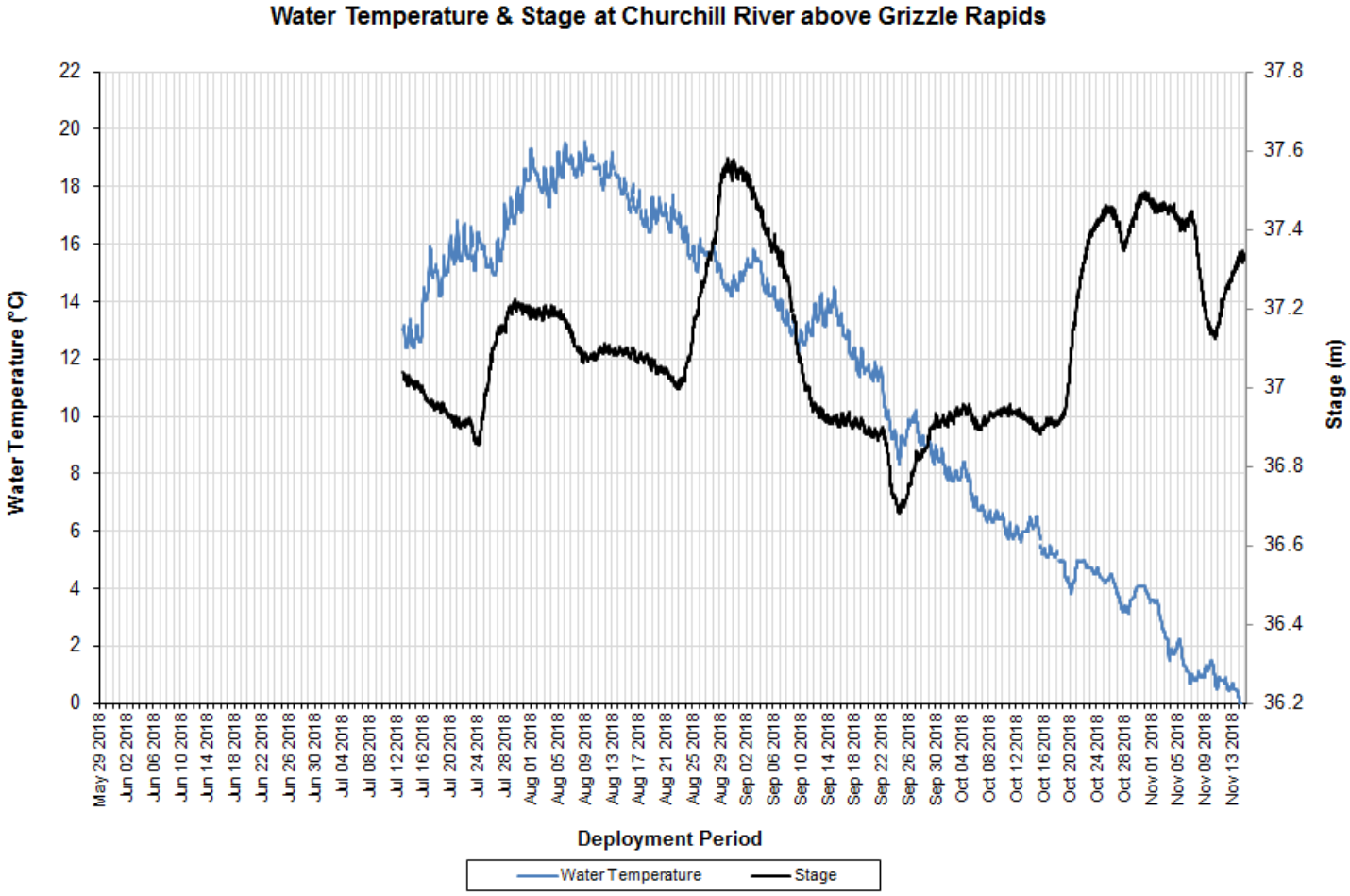

Figure 10: Water Temperature & Stage at Churchill River above Grizzle Rapids

Temperature (°C)	2018	2017	2016
Min	-0.2	5.58	-
Max	19.6	17.57	-
Median	12.8	13.98	-

- Water and air temperatures both showed typical seasonal trends (Figure 11), where temperatures steadily increased until mid-August, after which they gradually declined again through late summer and fall. Air temperature data was obtained from the Muskrat Falls MET Station.

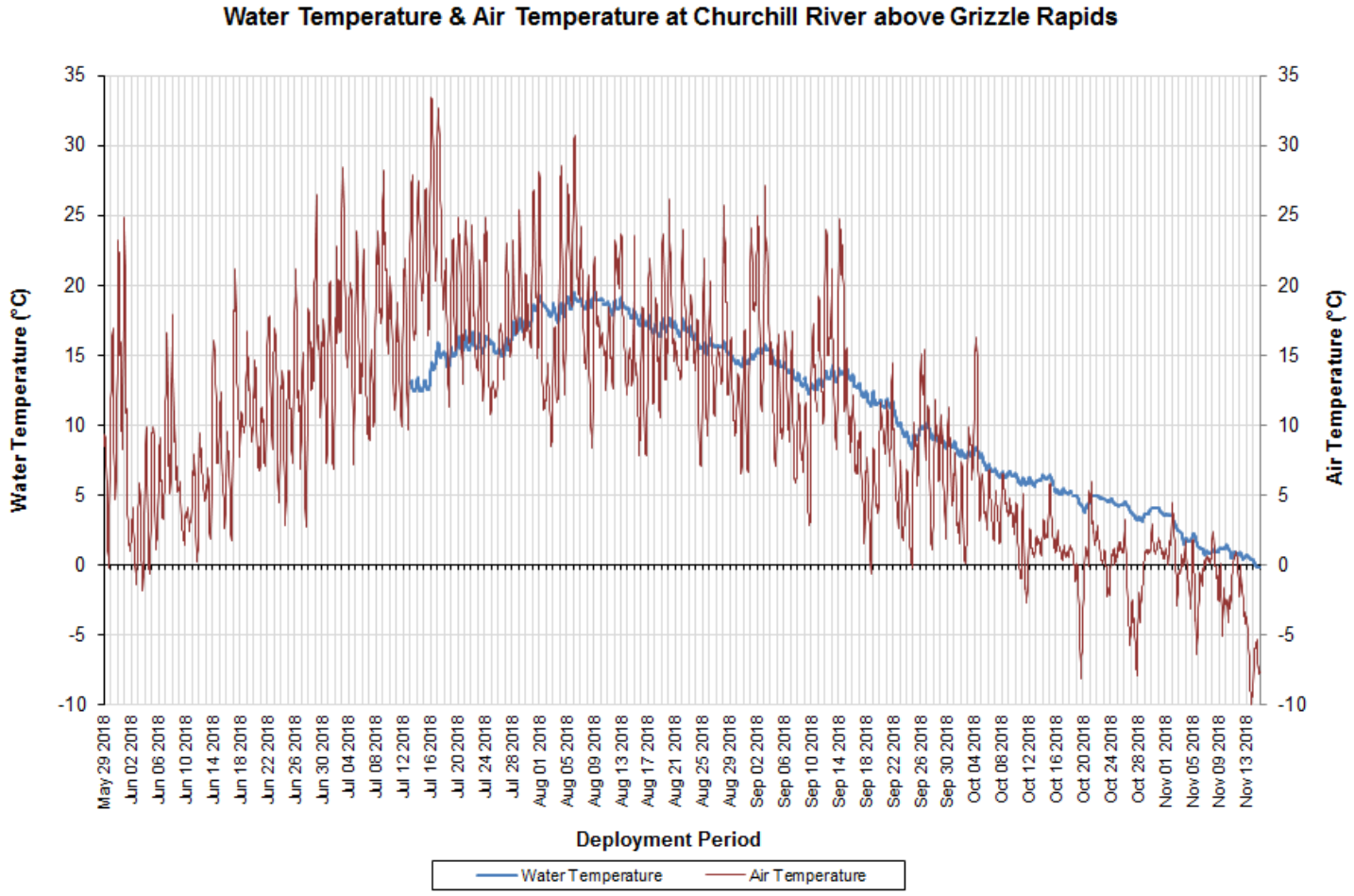

Figure 11: Water Temperature & Air Temperature at Churchill River above Grizzle Rapids

pH

- Over the 2018 deployment season, pH ranged from 6.47 to 7.00 pH units, with a median value of 6.78 pH units (Figure 12).
- pH values were relatively consistent across the deployment season, and remained within the CCME's Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). A single exception occurred near the end of October, which correlated closely with a significant increase in stage.
- Comparison data for 2016 is not available for this station.

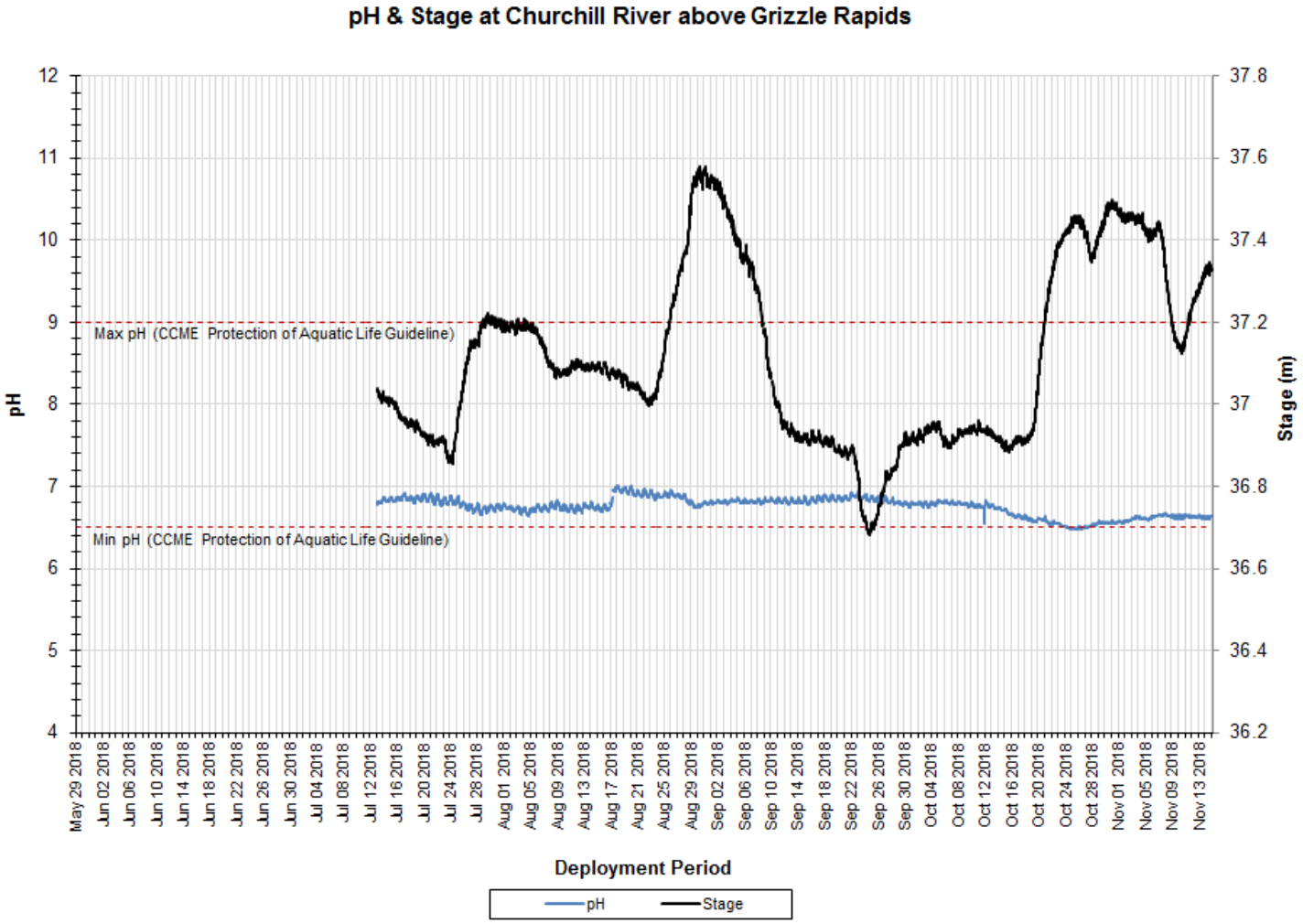

Figure 12: pH & Stage at Churchill River above Grizzle Rapids

pH (units)	2018	2017	2016
Min	6.47	6.45	-
Max	7.00	7.16	-
Median	6.78	6.91	-

Specific Conductivity

- Over the 2018 deployment season, specific conductivity ranged from 15.6µS/cm to 20.3µS/cm, with a median value of 17.9µS/cm (Figure 13) which was very similar to the 2017 median of 17.
- Specific conductivity was relatively consistent across the deployment season, with increases and decreases in specific conductivity generally correlating with fluctuations in stage. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, when stage increases, specific conductivity decreases due to the dilution of dissolved solids in the water column.
- Comparison data for 2016 is not available for this station.

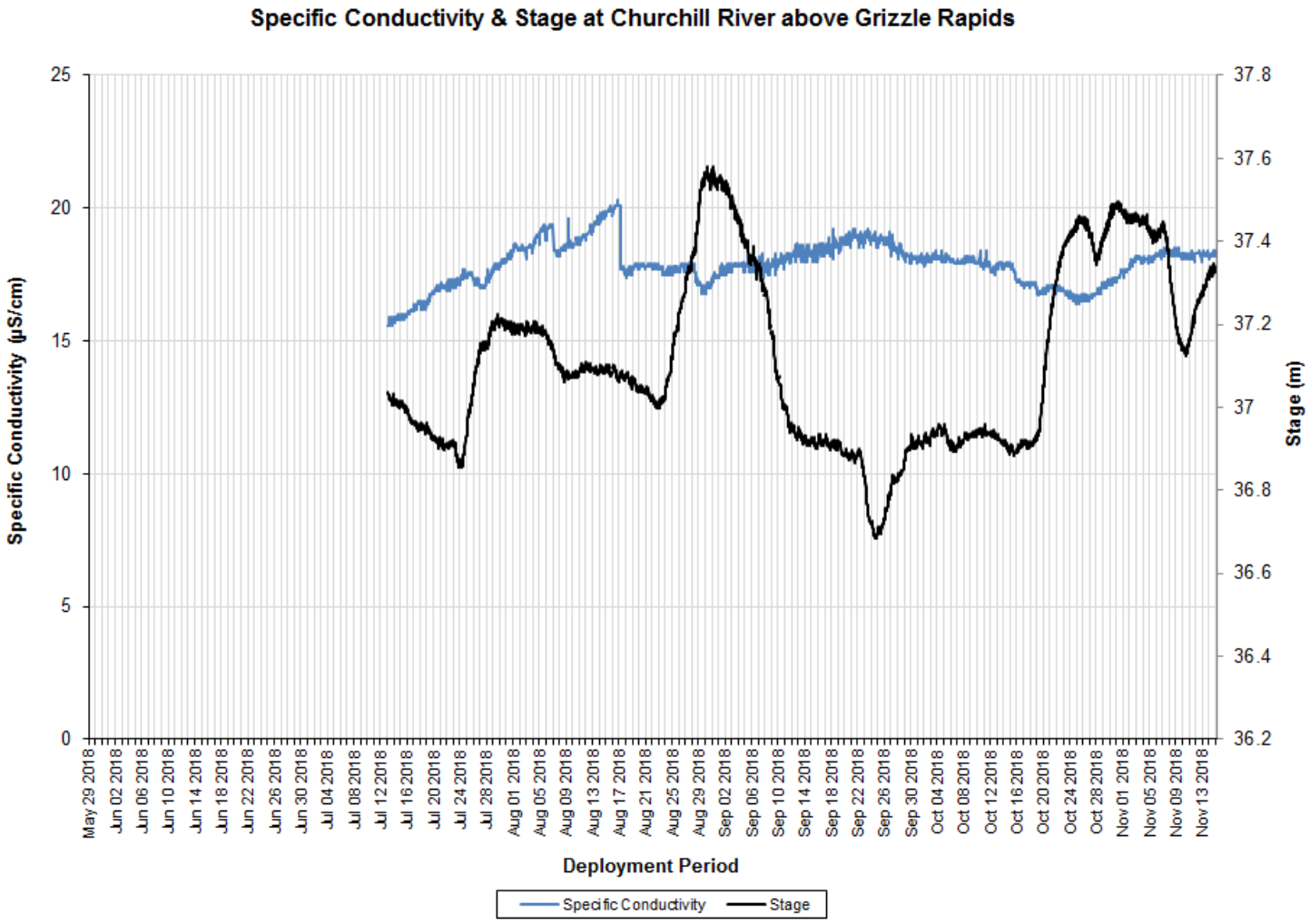

Figure 13: Specific Conductivity & Stage at Churchill River above Grizzle Rapids

Specific Conductivity (µS/cm)	2018	2017	2016
Min	15.6	15	-
Max	20.3	19	-
Median	17.9	17	-

Dissolved Oxygen

- Over the 2018 deployment season, dissolved oxygen ranged from 8.82mg/L to 14.06mg/L, with a median value of 10.34mg/L. Percent saturation ranged from 92.4% to 101.7%, with a median value of 96.0% (Figure 14).
- Dissolved oxygen content displayed a typical seasonal trend, where levels were lowest during the summer months and then increased through the fall (September-October). Warmer temperatures decrease the amount of oxygen present in the water, and vice versa. Percent saturation remained fairly consistent across the deployment season.
- Dissolved oxygen values remained above the CCME's Guideline for the Protection of Early and Other Life Stages (6.5mg/L and 9.5mg/L respectively), with the exception of a period from late July to mid-August when water temperatures were at their warmest.
- Comparison data for 2016 is not available for this station.

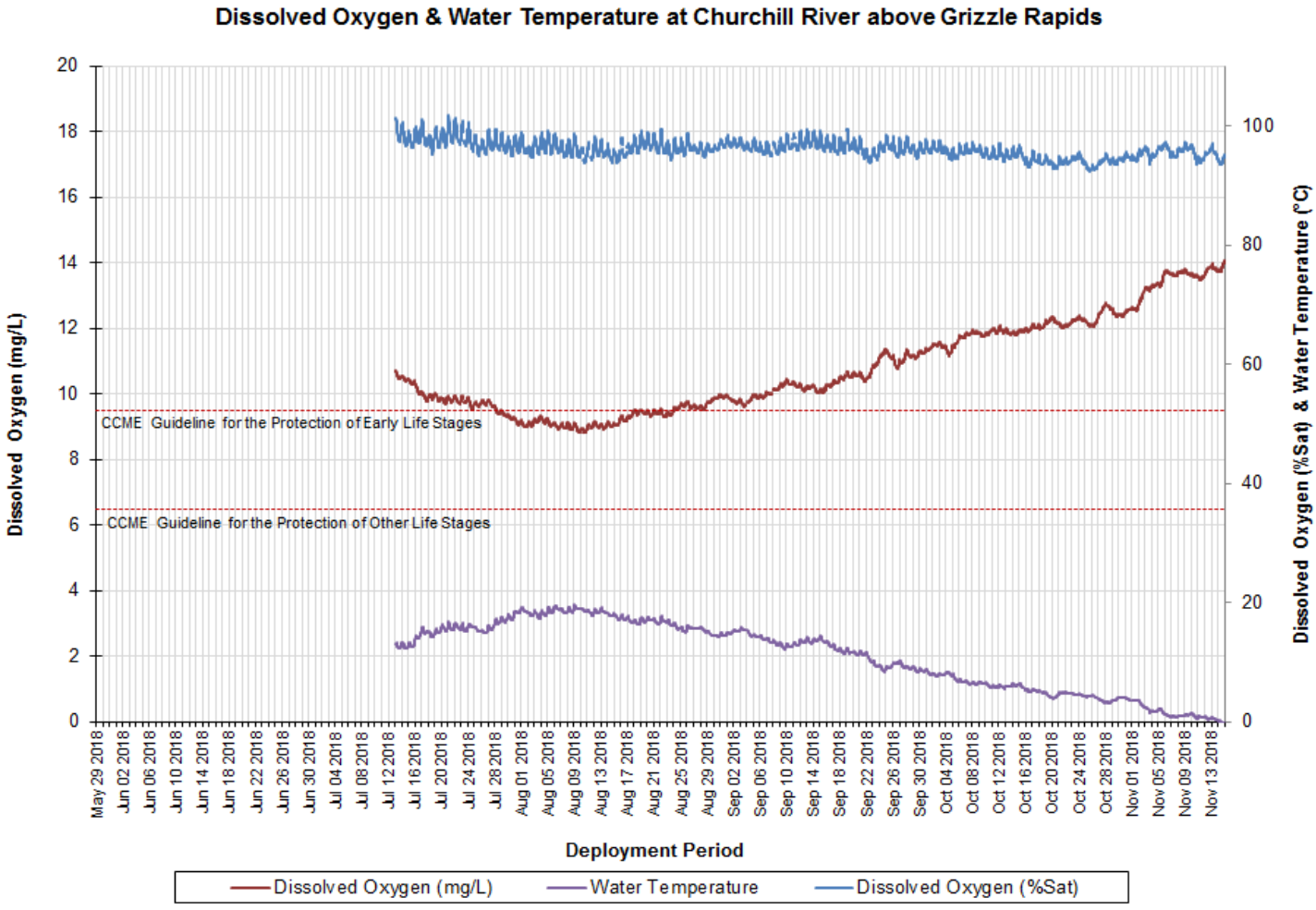

Figure 14: Dissolved Oxygen & Water Temperature at Churchill River above Grizzle Rapids

Dissolved Oxygen (mg/L)	2018	2017	2016		Dissolved Oxygen (% Sat)	2018	2017	2016
Min	8.82	9.27	-		**Min**	92.4	91.9	-
Max	14.06	11.81	-		**Max**	101.7	101.2	-
Median	10.34	9.94	-		**Median**	96.0	95.5	-

Turbidity & Precipitation

- Over the 2018 deployment season, turbidity ranged from 0 NTU to 36.7 NTU, with a median value of 0 NTU (Figure 15). A median value of 0 NTU indicates that there is very little natural background turbidity at this station.
- Turbidity spikes generally correlate with increases in stage, which often correlate with precipitation events. Turbidity levels returned to background levels following each observed increase.
- Comparison data for 2016 is not available for this station.

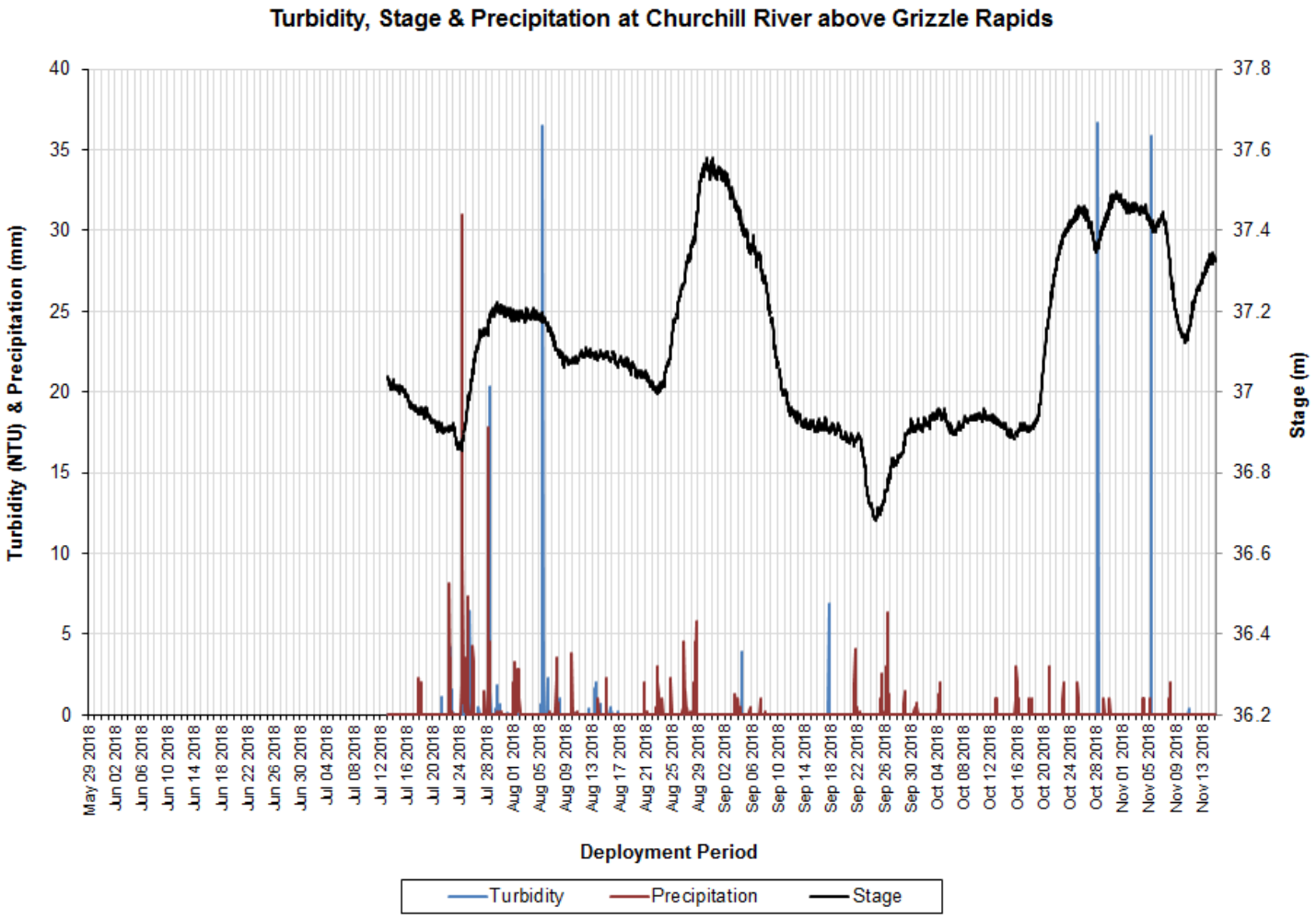

Figure 15: Turbidity, Stage & Precipitation at Churchill River above Grizzle Rapids

Turbidity (NTU)	2018	2017	2016
Min	0	0	-
Max	36.7	19.3	-
Median	0	0	-

Stage & Flow

- Over the 2018 deployment seasons, stage ranged from 36.683m to 37.58m, with a median value of 37.079m. Flow ranged from 1082.175m^3/s to 2314.122m^3/s, with a median value of 1557.811m^3/s (Figure 16).
- Comparison data for 2016 is not available for this station for stage. Comparison data for 2017 and 2016 is not available for this station for flow.
- Water Survey of Canada (ECCC) is responsible for QA/QC of water quantity data (stage and flow). Corrected data can be obtained upon request.

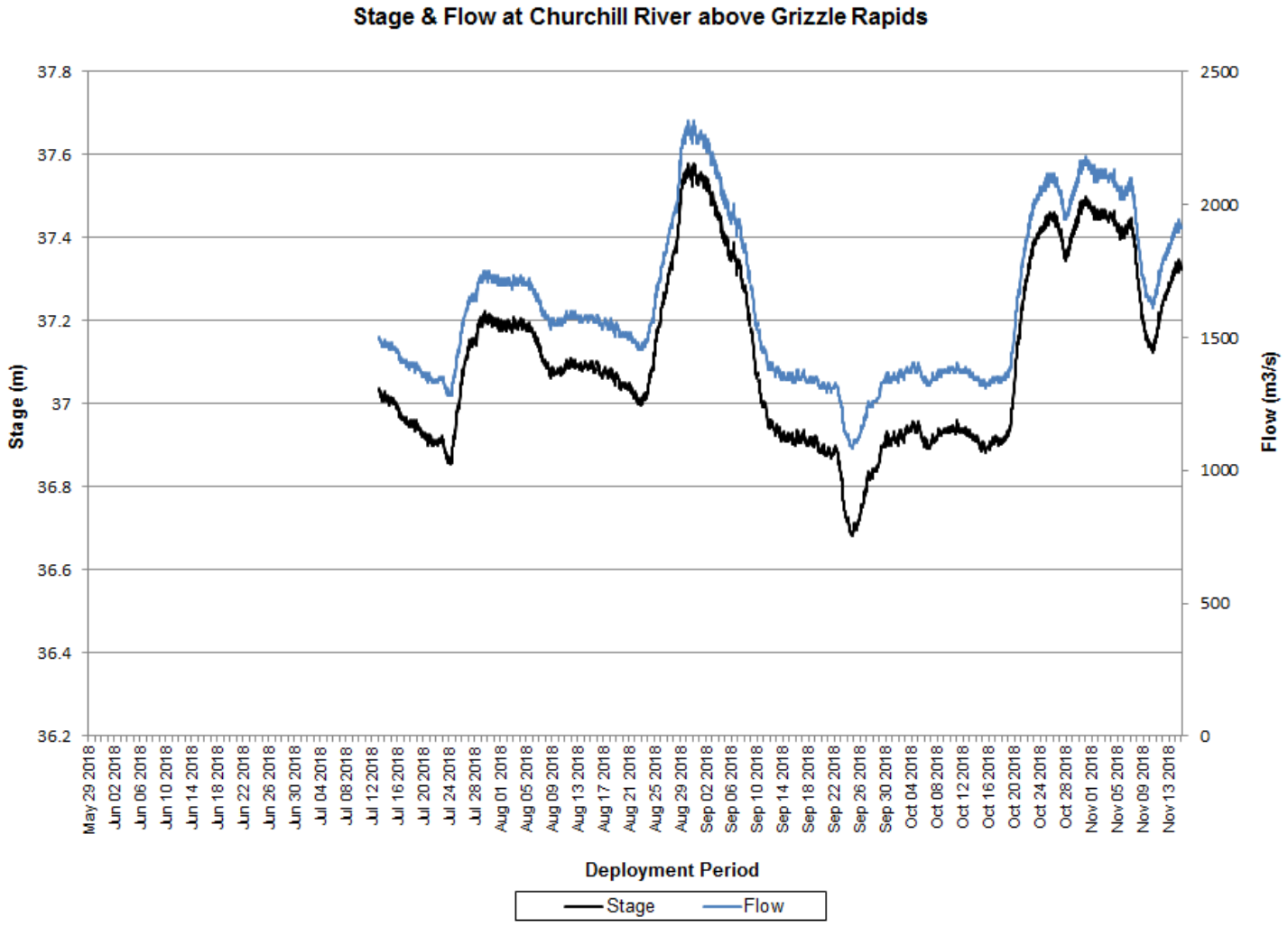

Figure 16: Stage & Flow at Churchill River above Grizzle Rapids

Stage (m)	2018	2017	2016		Flow (m^3/s)	2018	2017	2016
Min	36.683	36.661	-		**Min**	1082.175	-	-
Max	37.58	37.355	-		**Max**	2314.122	-	-
Median	37.079	36.866	-		**Median**	1557.811	-	-

Churchill River below Muskrat Falls

Temperature

- Over the 2018 deployment season, water temperature ranged from 1.2°C to 20.2°C, with a median value of 11.3°C (Figure 17) which was slightly less than the median values from 2017 and 2016.
- Water temperatures followed typical season trends; temperatures increased steadily from May through to mid-August, after which they steadily declined again through September and October.

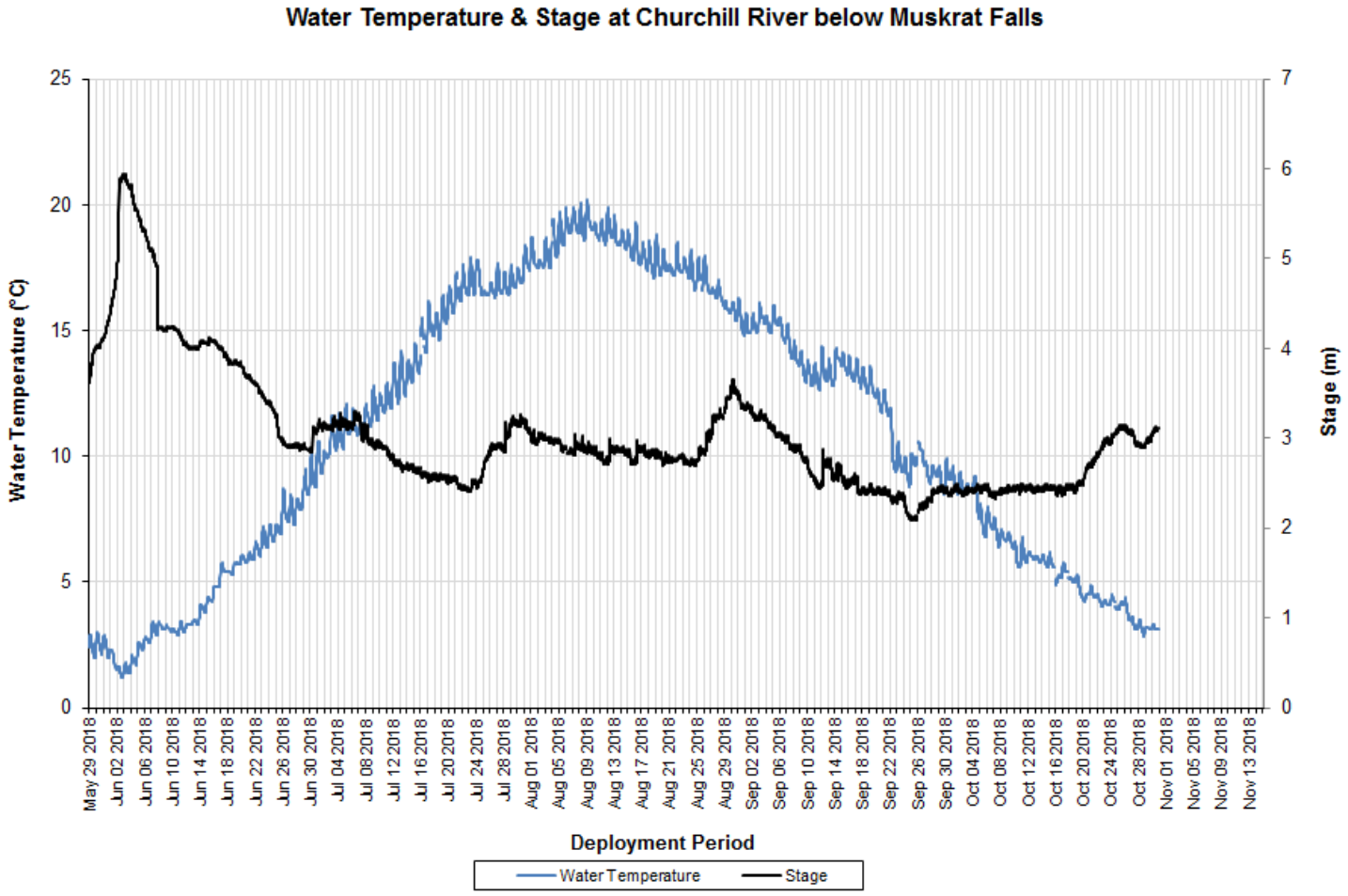

Figure 17: Water Temperature & Stage at Churchill River below Muskrat Falls

Temperature (°C)	2018	2017	2016
Min	1.2	3.2	2.9
Max	20.2	18.2	19.9
Median	11.3	13.0	13.1

- Water temperature values correlated closely with air temperatures; both increased through the summer months and then gradually decreased again into the fall season. Air temperature data was obtained from the Muskrat Falls MET Station.

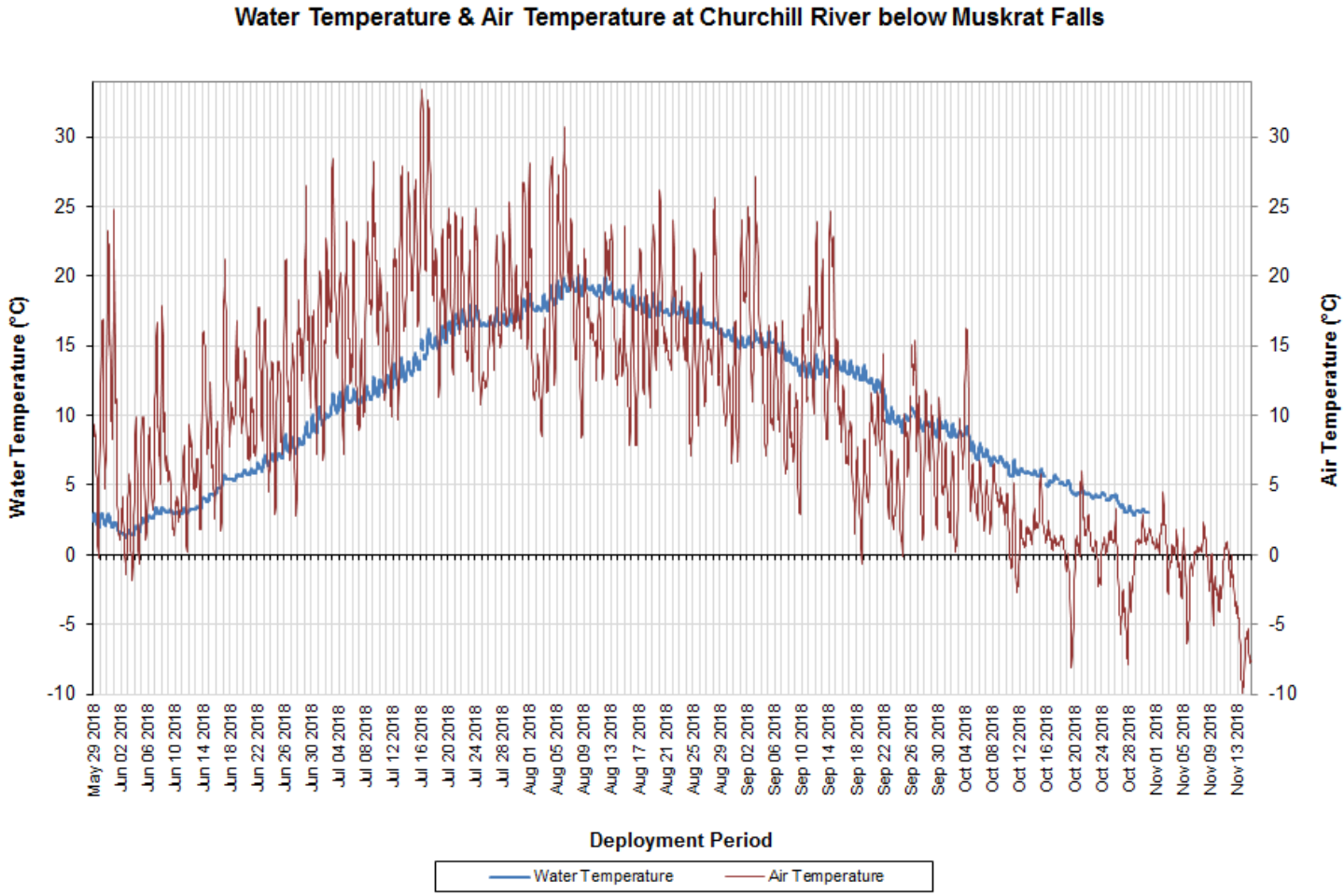

Figure 18: Water Temperature & Air Temperature at Churchill River below Muskrat Falls

pH

- Over the 2018 deployment season, pH ranged from 5.51 to 7.81 pH units, with a median value of 6.17 pH units (Figure 19) which was slightly less than the 2017 and 2016 median values.
- There were several notable drops in pH, which generally corresponded to increases in stage. pH data for the majority of October was removed from the data set due to a sensor failure.
- pH values were below the CCME's Guidelines for the Protection of Aquatic Life for the first three months of the deployment season (>6.5 and <9.0 pH units). pH values were within the CCME's Guidelines for the month of September.

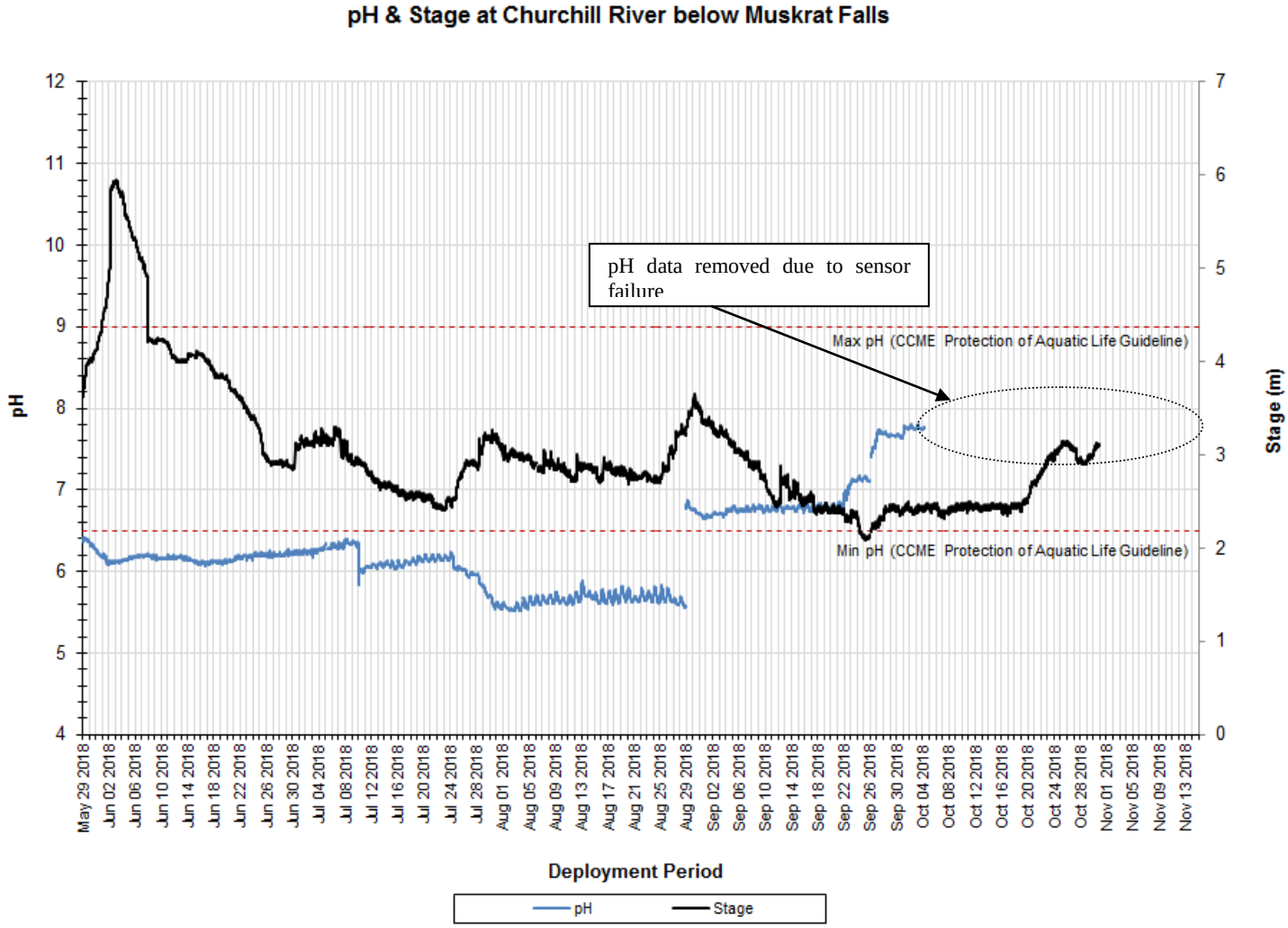

Figure 19: pH & Stage at Churchill River below Muskrat Falls

pH (units)	2018	2017	2016
Min	5.51	6.01	5.08
Max	7.81	7.19	7.26
Median	6.17	6.67	6.54

Specific Conductivity

- Over the 2018 deployment season, specific conductivity ranged from 8.8µS/cm to 19.7µS/cm, with a median value of 17.4µS/cm (Figure 20), which was comparable to the 2017 and 2016 medians.
- Specific conductivity gradually increased throughout the spring and summer months. Generally, specific conductivity does not vary greatly in the Lower Churchill River, which is evidenced in the graph below.
- Increases and decreases in specific conductivity are generally related to fluctuations in stage. As stage decreases, specific conductivity usually increases as the concentration of dissolved solids increases. Inversely, when stage increases, specific conductivity decreases due to the dilution of dissolved solids in the water column.

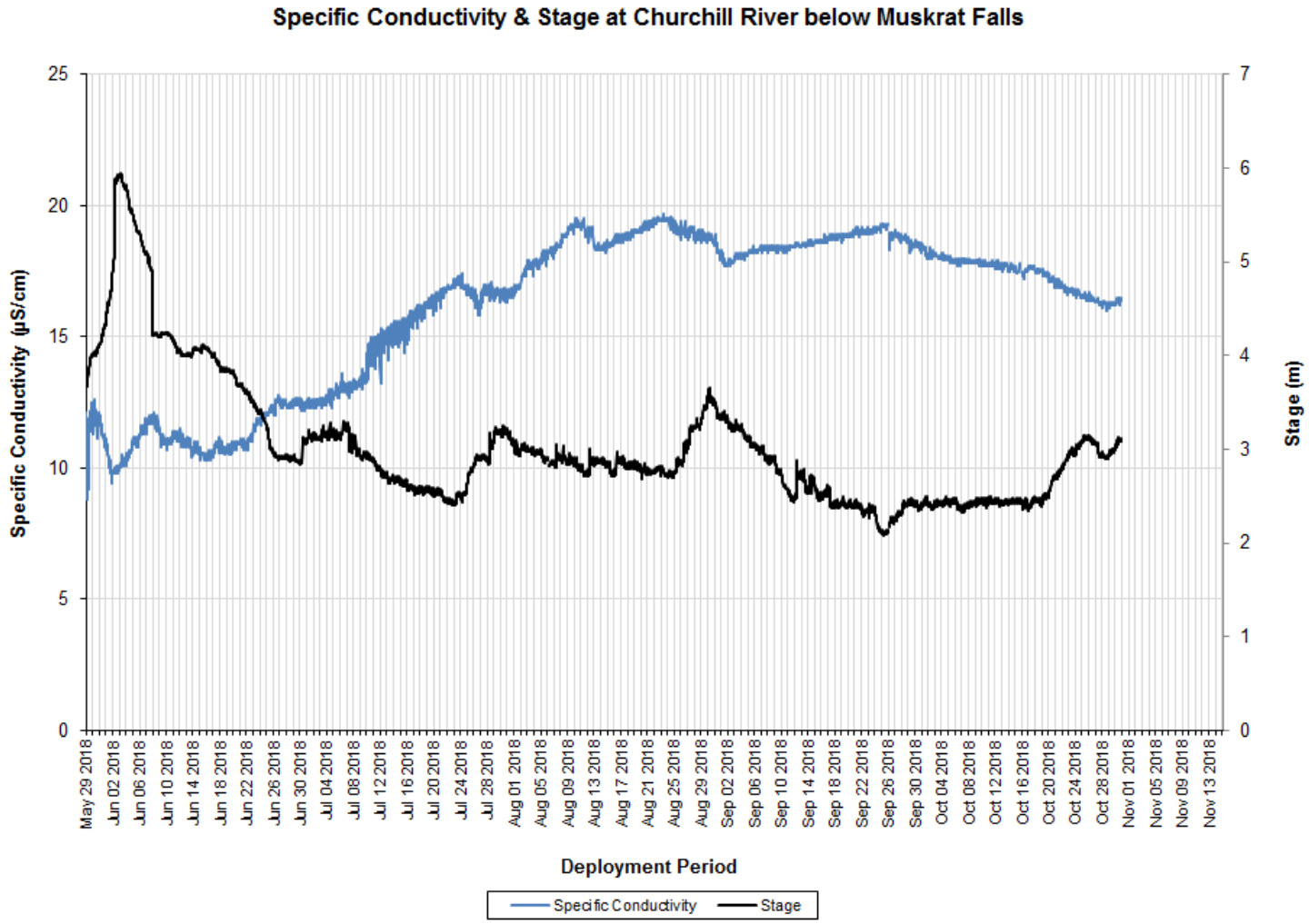

Figure 20: Specific Conductivity & Stage at Churchill River below Muskrat Falls

Specific Conductivity (µS/cm)	2018	2017	2016
Min	8.8	11.0	14
Max	19.7	20.0	20.7
Median	17.4	18.1	17.3

Dissolved Oxygen

- Over the 2018 deployment season, dissolved oxygen ranged from 9.74mg/L to 17.58mg/L, with a median value of 12.23mg/L, which was slightly higher than the 2017 and 2016 medians (Figure 21). Percent saturation ranged from 99.0% to 128.1%, with a median value of 113.5%, which was higher than the 2017 median but very similar to 2016 (Figure 21).
- Dissolved oxygen displayed a typical seasonal trend throughout 2018, with the lowest values observed throughout August. Warmer temperatures decrease the amount of oxygen present in water, and vice versa. Percent saturation remained fairly consistent throughout the deployment season.
- Dissolved oxygen levels remained above the CCME's Guidelines for the Protection of Early and Other Life Stages for the duration of the 2018 deployment season (Figure 21).

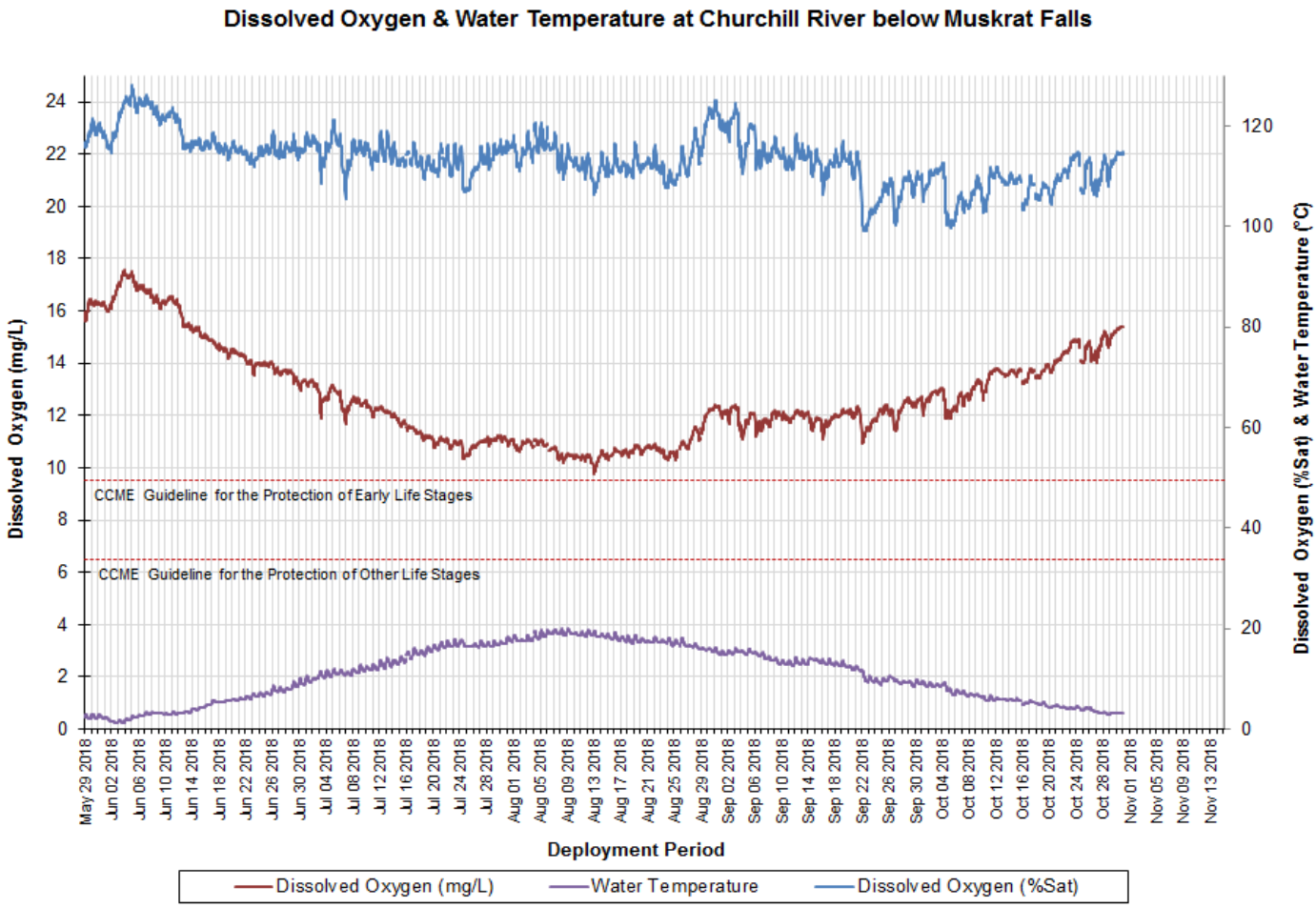

Figure 21: Dissolved Oxygen & Water Temperature at Churchill River below Muskrat Falls

Dissolved Oxygen (mg/L)	2018	2017	2016		Dissolved Oxygen (% Sat)	2018	2017	2016
Min	9.74	9.54	9.78		**Min**	99.0	96.3	101.2
Max	17.58	14.82	14.99		**Max**	128.1	114.2	123.3
Median	12.23	11.40	11.85		**Median**	113.5	106.4	112.3

Turbidity & Precipitation

- Over the 2018 deployment season, turbidity ranged from 0 NTU to 185.2 NTU, with a median value of 0.3 NTU. (Figure 22). A median value of 0.3 NTU indicates that there is a small amount of natural background turbidity at this station.
- Turbidity events throughout the 2018 deployment season generally correlated with increases in stage, which were further linked to precipitation events.

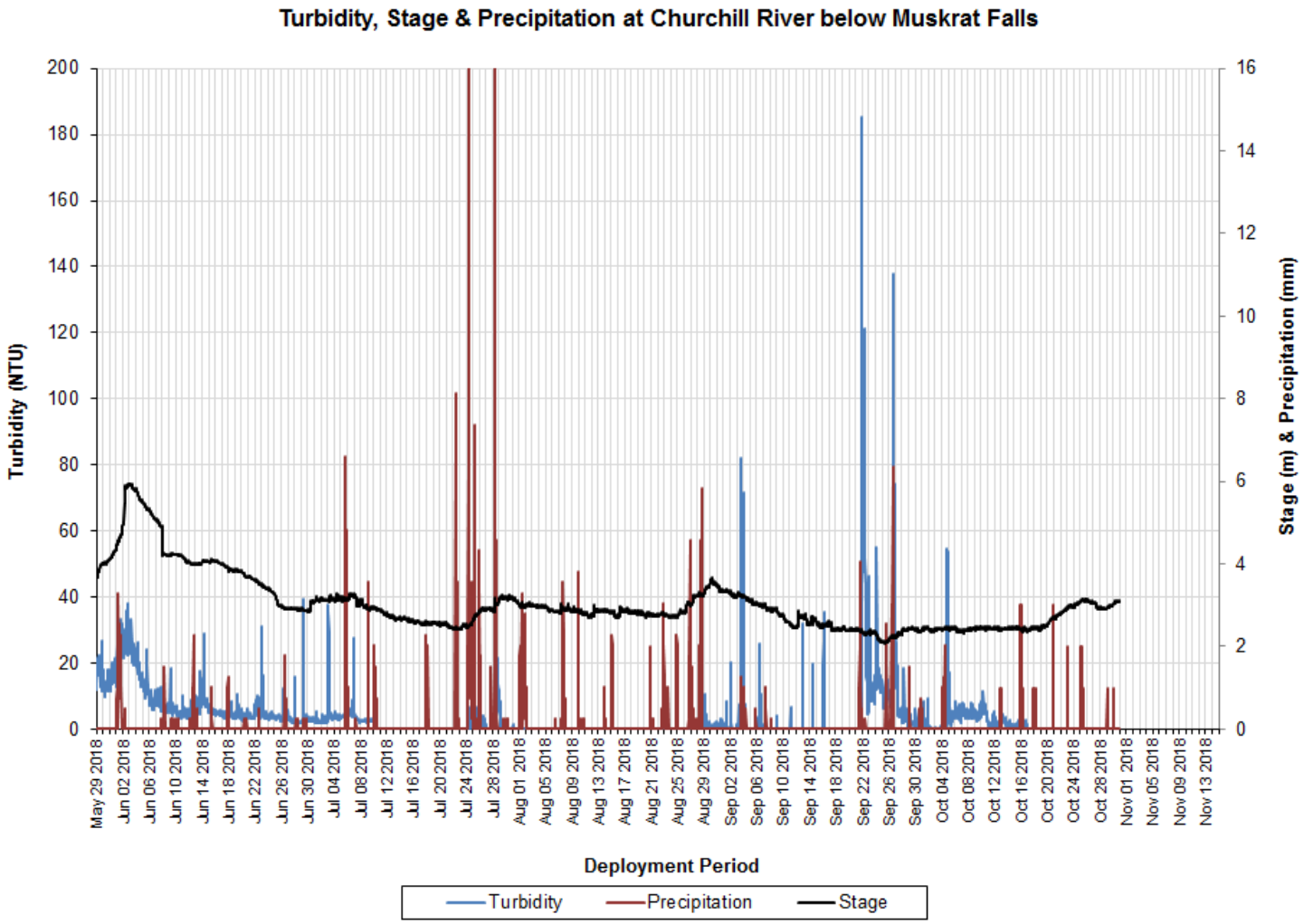

Figure 22: Turbidity, Stage & Precipitation at Churchill River below Muskrat Falls

Turbidity (NTU)	2018	2017	2016
Min	0	0	0
Max	185.2	105.5	241.7
Median	0.3	1.5	4.3

Stage

- Over the 2018 deployment season, stage ranged from 2.081m to 5.944m, with a median value of 2.886m (Figure 23), which was comparable to the previous two seasons.
- Stage increases were generally associated with precipitation events throughout the 2018 season (Figure 23).
- Water Survey of Canada (ECCC) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

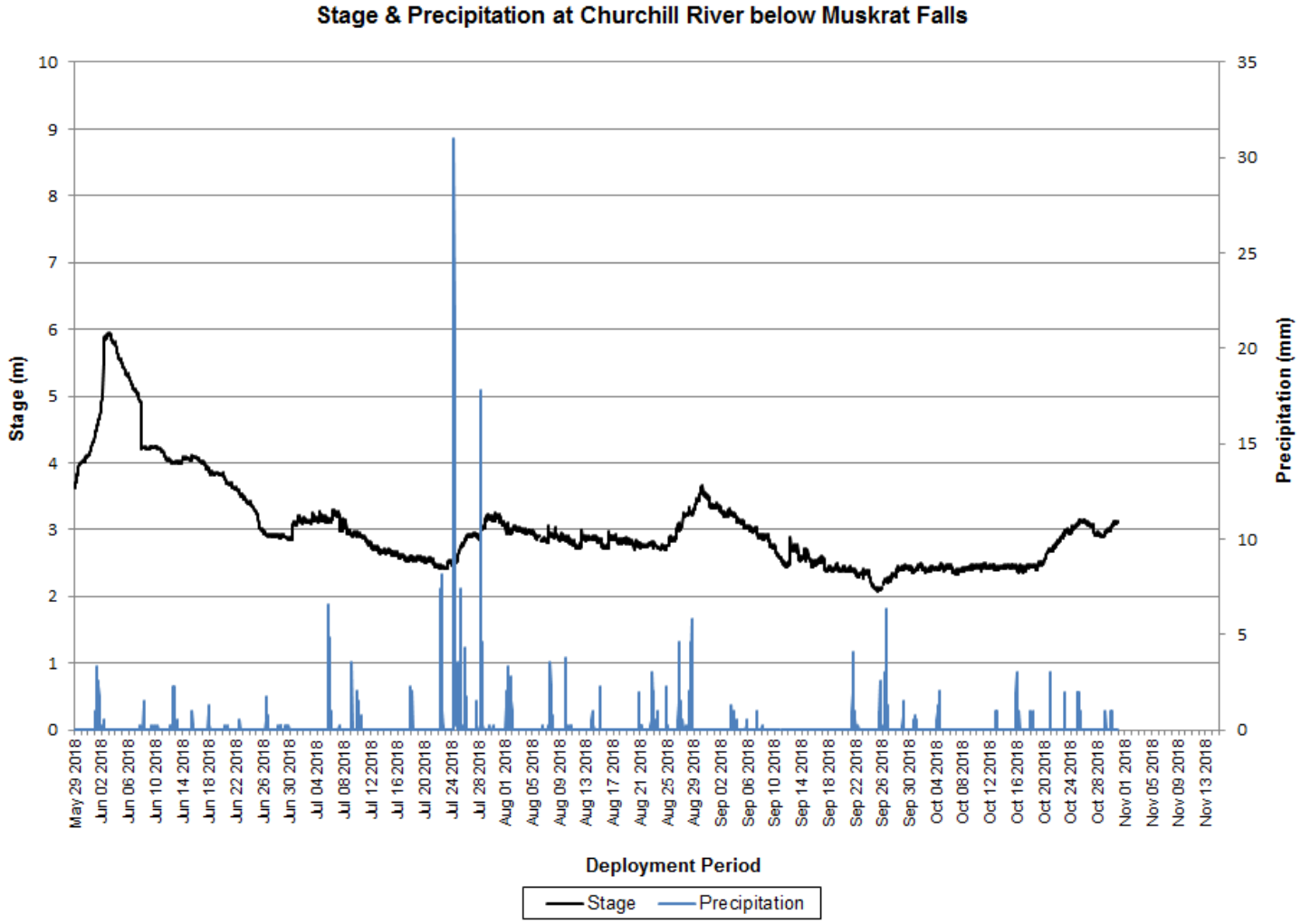

Figure 23: Stage & Precipitation at Churchill River below Muskrat Falls

Stage (m)	2018	2017	2016
Min	2.081	2.096	2.291
Max	5.944	3.446	4.331
Median	2.886	2.517	2.762

Churchill River at English Point

Temperature

- Over the 2018 deployment season, water temperature ranged from 1.2°C to 21.8°C, with a median value of 11.9°C (Figure 24), which was comparable to the previous two seasons.
- Daily fluctuations at this station are far greater compared to the other stations in the Churchill River network due to tidal influences from the Atlantic Ocean and Lake Melville.

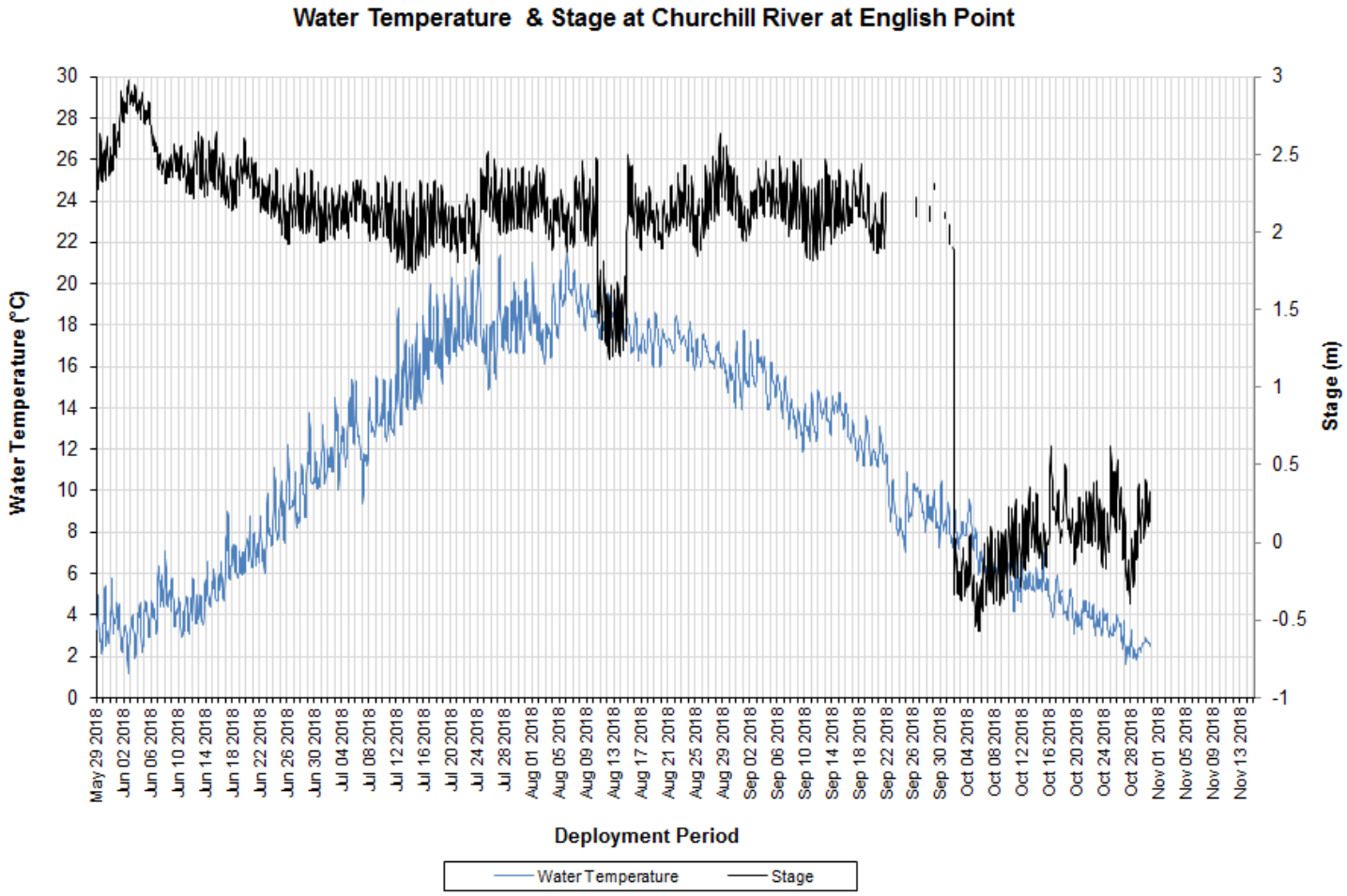

Figure 24: Water Temperature & Stage at Churchill River at English Point

Temperature (°C)	2018	2017	2016
Min	1.2	4.2	1.60
Max	21.8	20.6	21.70
Median	11.9	13.8	12.10

- Temperatures followed a typical seasonal trend (Figure 25), where both water and air temperatures increased throughout the spring and early summer with water temperatures peaking in early August. Water and air temperatures decreased steadily from mid-August onwards. Air temperature data was obtained from the Muskrat Falls MET Station.

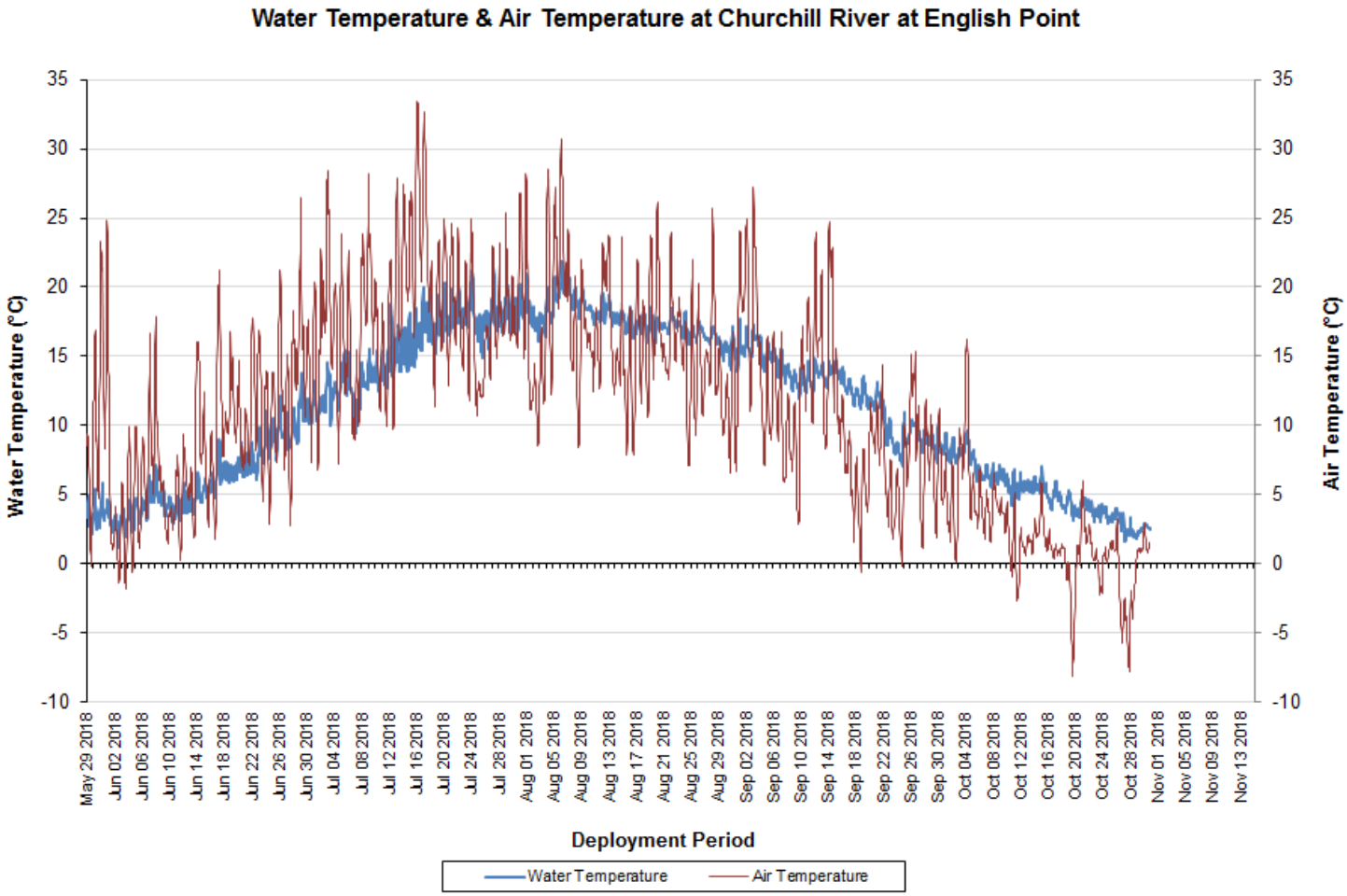

Figure 25: Water Temperature & Air Temperature at Churchill River at English Point

pH

- Over the 2018 deployment season, pH ranged from 5.67 to 7.33 pH units, with a median value of 6.48 pH units (Figure 26), which was slightly lower than the previous two seasons.
- pH values were within the CCME's Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units) for roughly half of the deployment season (Figure 26).

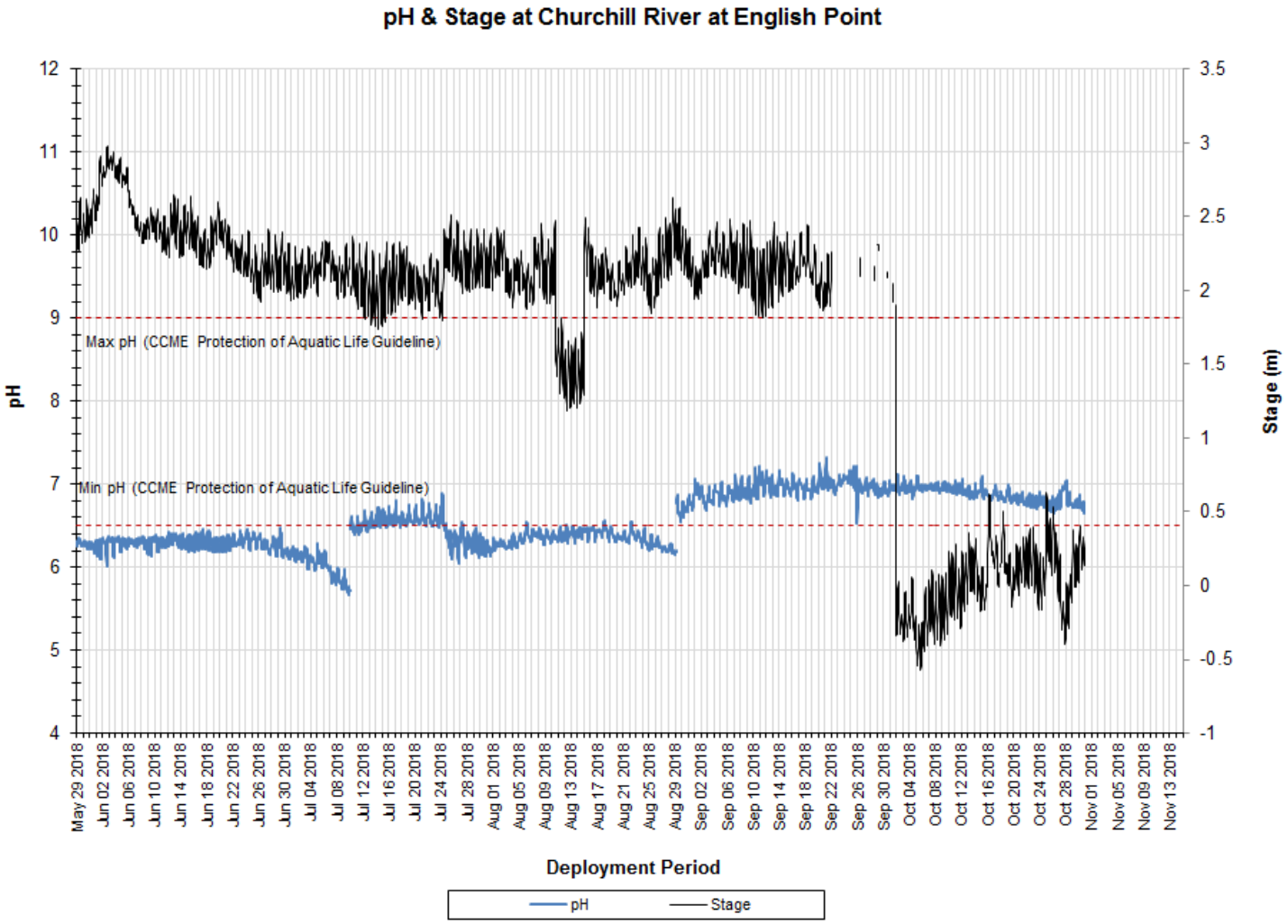

Figure 26: pH & Stage at Churchill River at English Point

pH (units)	2018	2017	2016
Min	5.67	6.14	6.20
Max	7.33	7.34	7.32
Median	6.48	6.79	6.69

Specific Conductivity

- Over the 2018 deployment season, specific conductivity ranged from 9.4µS/cm to 58.0µS/cm, with a median value of 28.2µS/cm, which was very similar to the previous two seasons (Figure 27).
- Specific conductivity is highly variable at this station, fluctuating significantly every day due to tidal influences from the Atlantic Ocean. As the tide comes in, specific conductivity increases as dissolved solids and salinity increase. Similarly, when the tide goes out, specific conductivity decreases as dissolved solids and salinity decrease. This increase and decrease in specific conductivity and stage occurs twice daily.

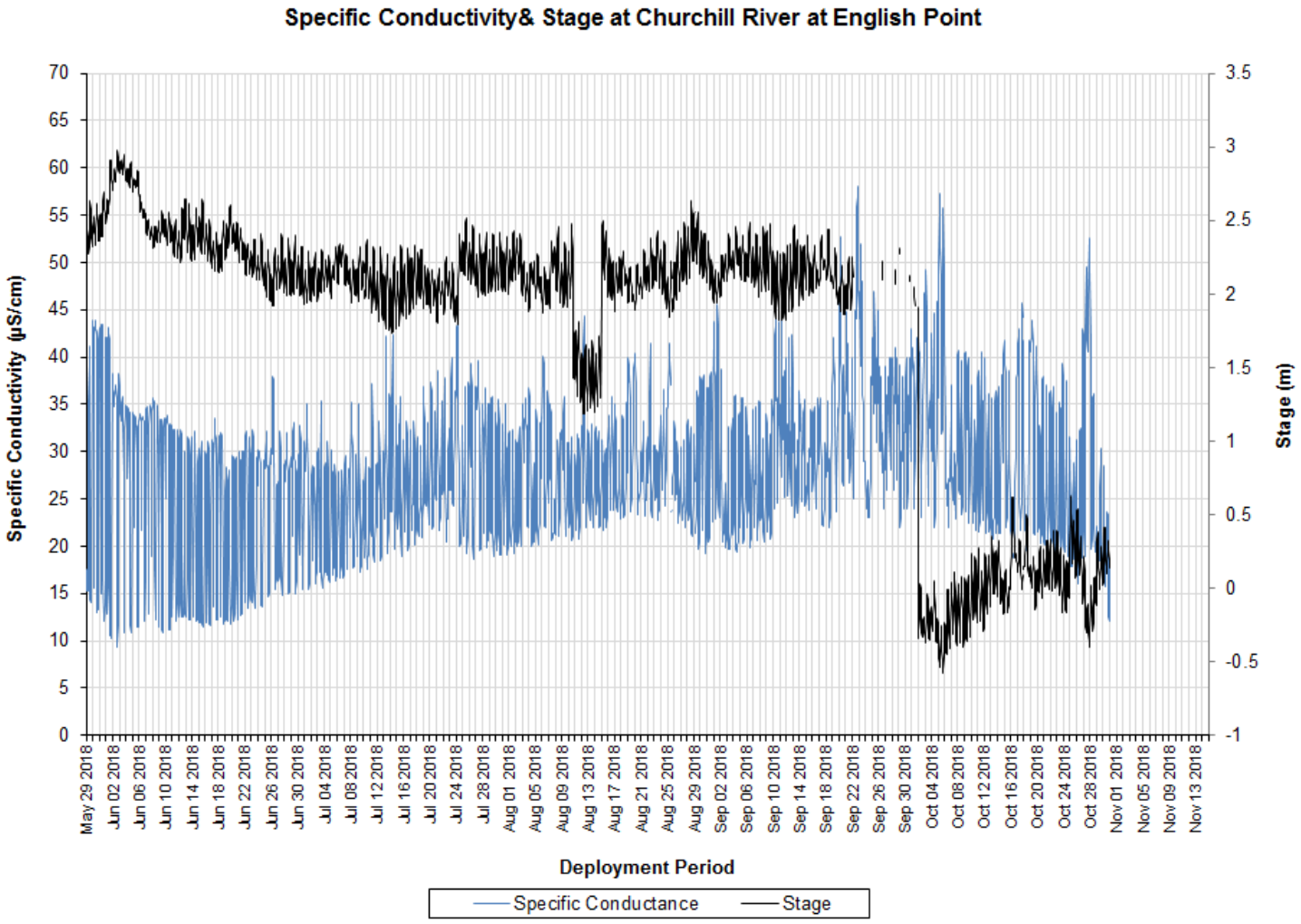

Figure 27: Specific Conductivity & Stage at Churchill River at English Point

Specific Conductivity (µS/cm)	2018	2017	2016
Min	9.4	16.1	12.2
Max	58.0	60.9	72.0
Median	28.2	29.6	30.1

Dissolved Oxygen

- Over the 2018 deployment season, dissolved oxygen ranged from 8.39mg/L to 15.48mg/L, with a median value of 11.04mg/L (Figure 28), which was comparable to previous seasons. Percent saturation ranged from 80.0% to 115.8%, with a median value of 99.8% (Figure 28), which was also comparable to previous seasons.
- Dissolved oxygen content displayed typical daily and seasonal fluctuations. Percent saturation was generally consistent throughout the deployment season.
- Dissolved oxygen values were above the CCME's Guidelines for the Protection of Other & Early Life Stages (6.5mg/L and 9.5mg/L respectively) for most of the deployment season. An obvious exception was from mid-July to mid-August when water temperatures were highest, which is to be expected since dissolved oxygen levels are generally lower in warmer water bodies.

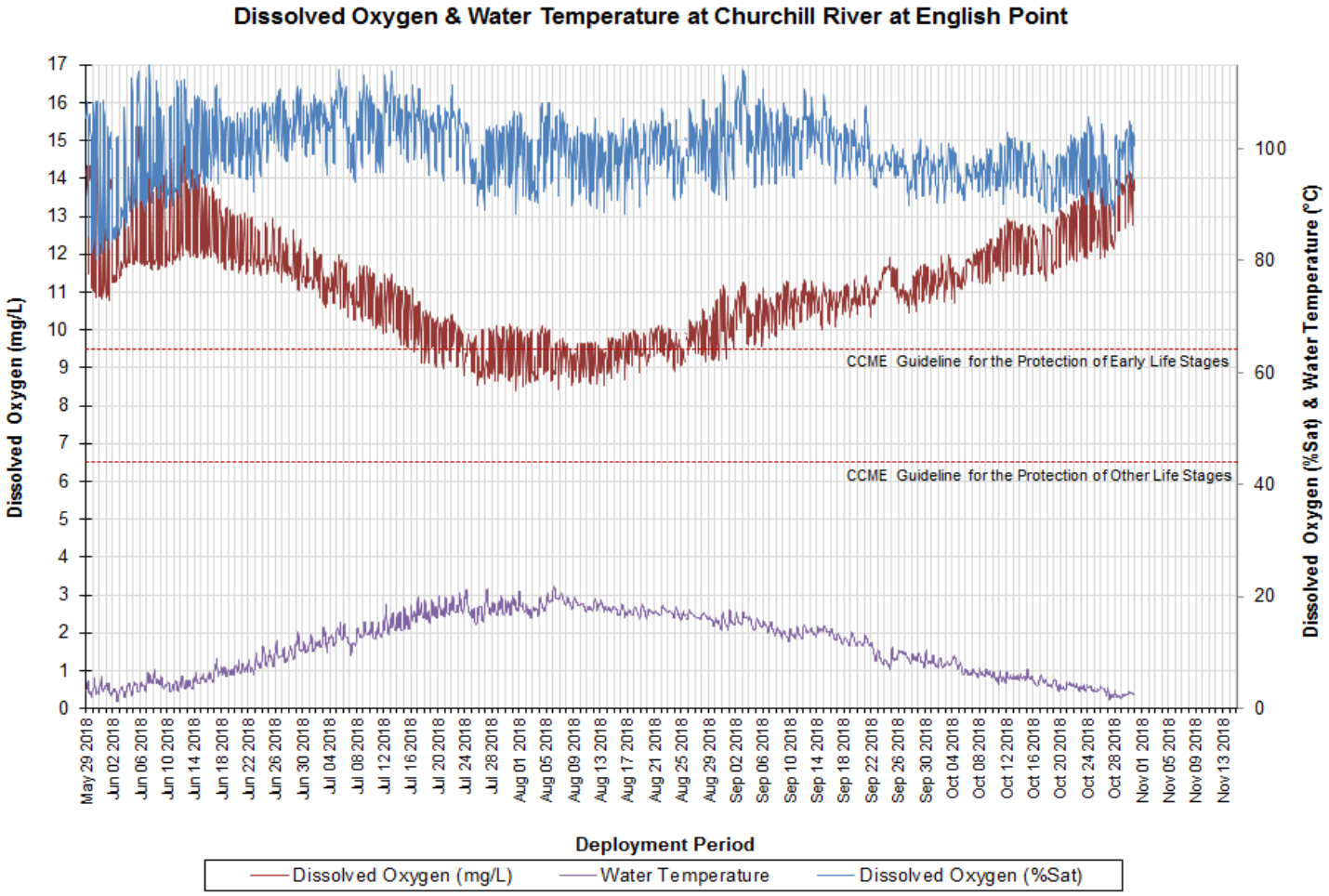

Figure 28: Dissolved Oxygen & Water Temperature at Churchill River at English Point

Dissolved Oxygen (mg/L)	2018	2017	2016		Dissolved Oxygen (% Sat)	2018	2017	2016
Min	8.39	8.7	9.04		**Min**	80.0	86.9	86.3
Max	15.48	13.31	14.14		**Max**	115.8	112.1	115.2
Median	11.04	10.35	10.94		**Median**	99.8	98.5	100.7

Turbidity & Precipitation

- Over the 2018 deployment season, turbidity ranged from 0 NTU to 601.0 NTU, with a median value of 5.0 NTU (Figure 29). A median value of 5.0 NTU indicates that there is significant natural background turbidity at this station, and is the exact same median value as the 2017 season.
- Turbidity increases were often associated with precipitation events; however, tidal influences at this station also contribute to increased turbidity levels given the sandy nature of the river bed. Precipitation data was obtained from the Muskrat Falls MET Station.

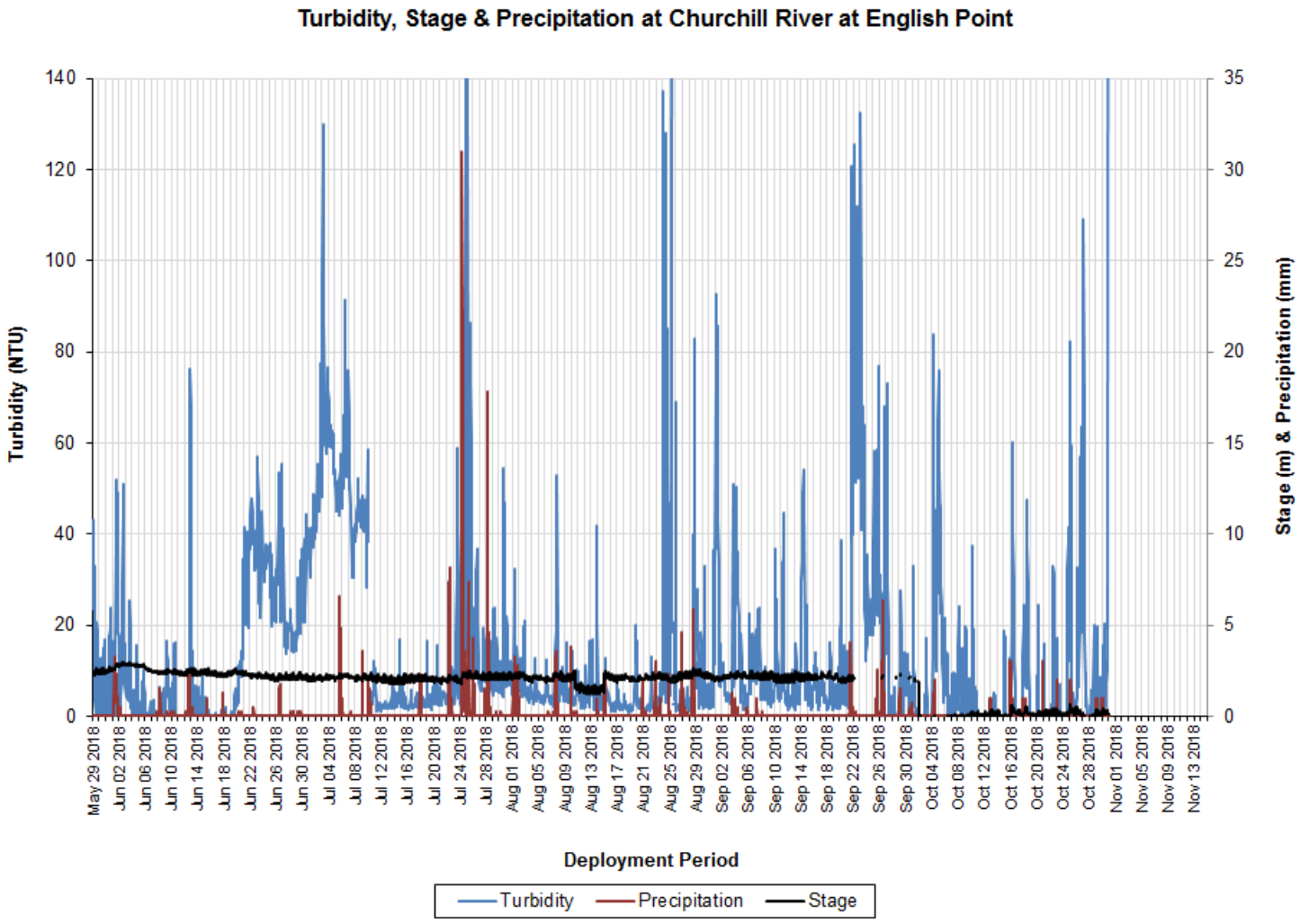

Figure 29: Turbidity, Stage & Precipitation at Churchill River at English Point

Turbidity (NTU)	2018	2017	2016
Min	0.0	0.0	0.0
Max	601.0	117.9	322.9
Median	5.0	5.0	10.5

Stage

- Over the 2018 deployment season, stage ranged from -0.575m to 2.982m, with a median value of 2.115m (Figure 30), which is comparable to the previous two seasons.
- While stage is relatively consistent over the course of the deployment season, stage values at this station do fluctuate considerably on a daily basis due to tidal influences from the Atlantic Ocean.
- Water Survey of Canada (ECCC) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

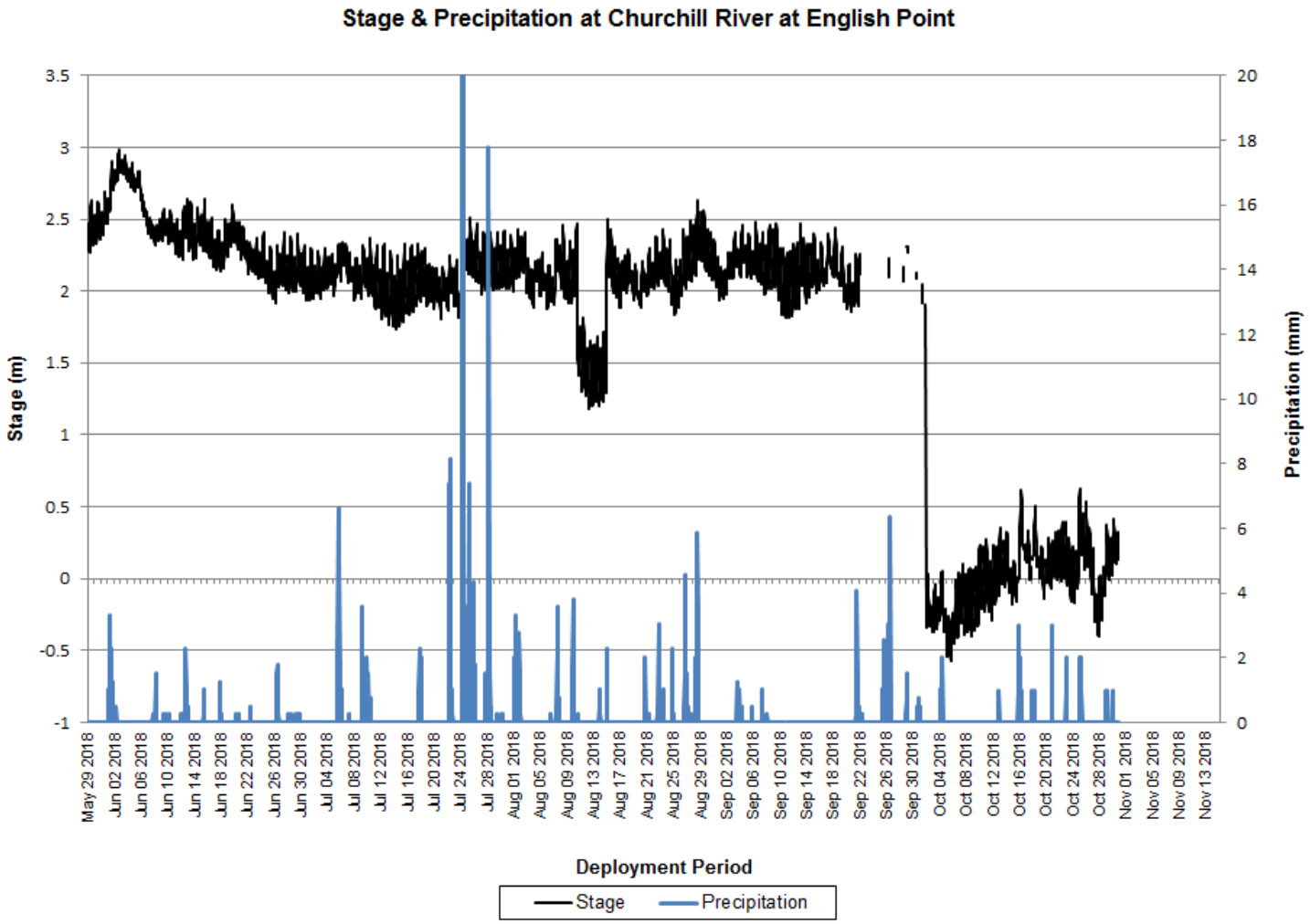

Figure 30: Stage & Precipitation at Churchill River at English Point

Stage (m)	2018	2017	2016
Min	-0.575	1.728	1.70
Max	2.982	2.701	3.06
Median	2.115	2.113	2.16

Station Comparison

Temperature

- Water temperatures at each of the four stations on the Churchill River displayed a similar trend throughout the 2018 deployment season (Figure 31). Overall, increases and decreases occurred at all stations around the same time, though to different extents.
- Water temperature was generally warmest at English Point, while this station also had the greatest diurnal fluctuations. Into the summer months, the coolest water temperatures were recorded above Grizzle Rapids, while the warmest were recorded at English Point. Median water temperature values typically show a decrease in temperature as you move downstream through the river, from below Metchin River to English Point; however, since instruments were deployed at different times during the 2018 season, this trend is not observed.

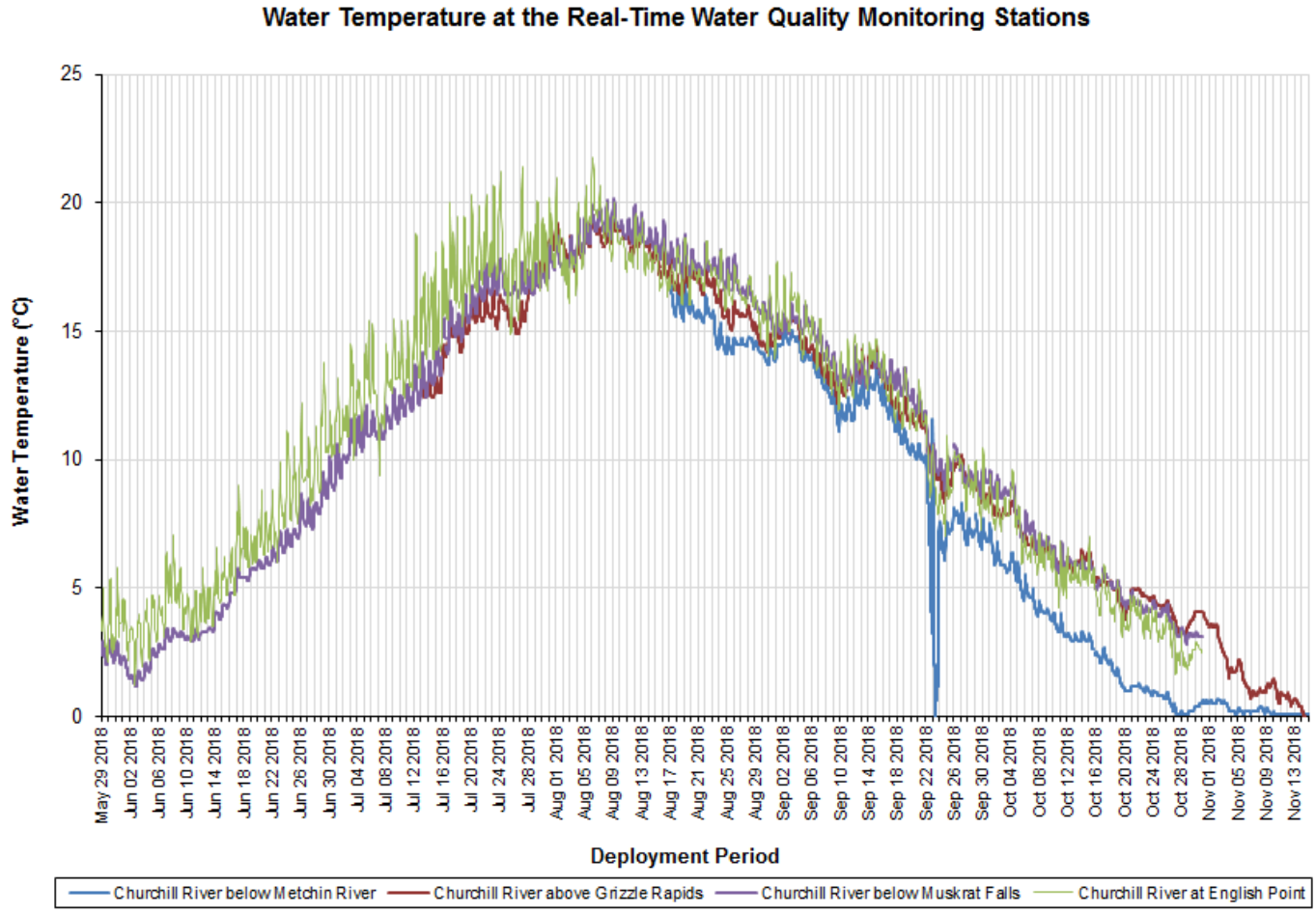

Figure 31: Water Temperature at all Stations on the Churchill River in 2018

Temperature (°C)	CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt
Min	-0.3	-0.2	1.2	1.2
Max	17.1	19.6	20.2	21.8
Median	6.3	12.8	11.3	11.9

- Water temperatures at each of the four stations on the Churchill River displayed clear seasonal trends in response to changes in ambient air temperatures throughout the deployment season (Figure 32).

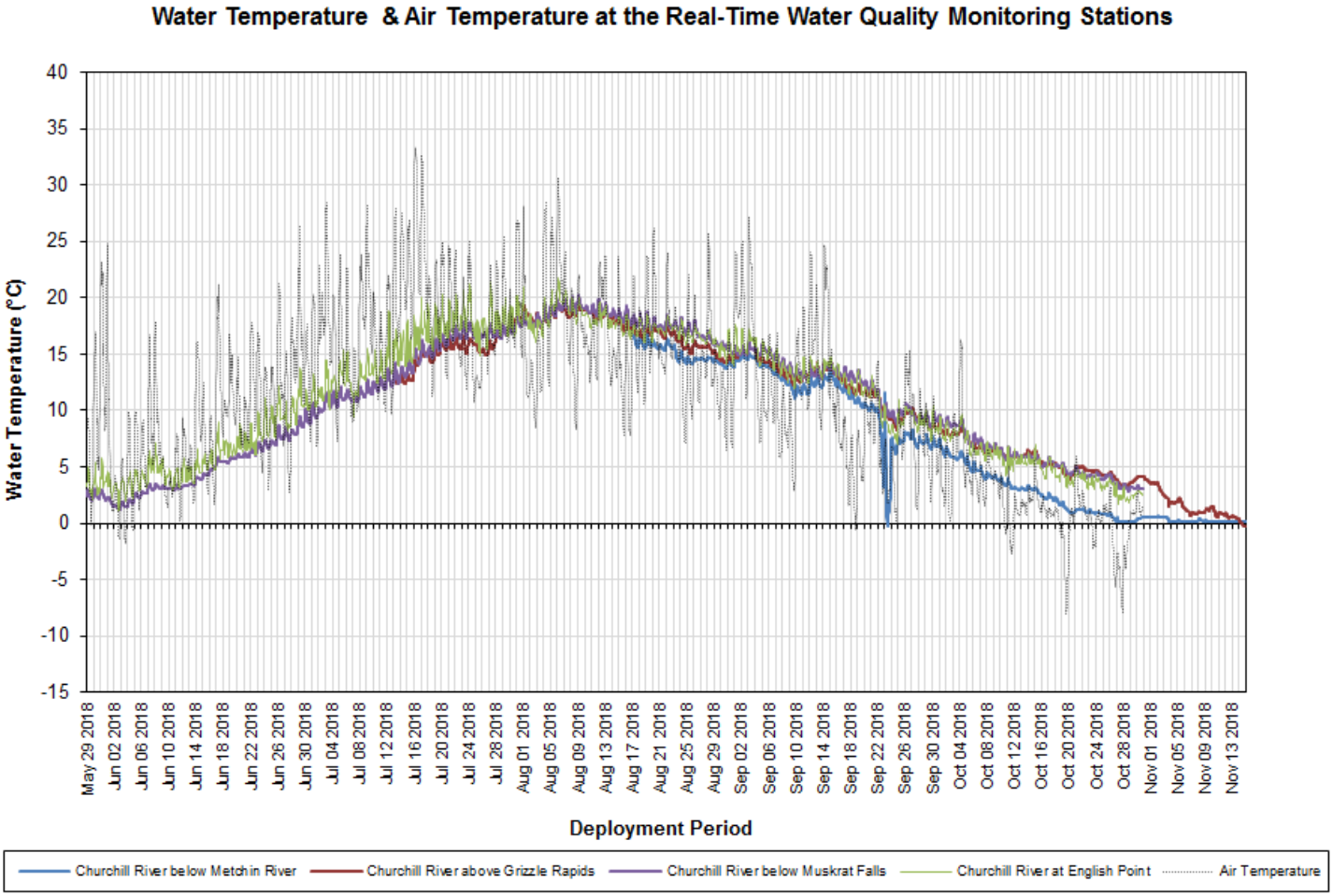

Figure 32: Water Temperature & Air Temperature at all Stations on the Churchill River in 2018

pH

- pH values at each of the four stations on the Churchill River displayed similar trends throughout the 2018 deployment season (Figure 33). An obvious exception is at the station below Muskrat Falls, which displayed a much lower pH at certain times during the season as compared to the other three stations.
- Median values for below Metchin River, above Grizzle Rapids and at English Point were very similar, while the median value for below Muskrat Falls was slightly lower.
- pH values at English Point showed the greatest daily variation throughout the deployment season due to the position of this station at the mouth of the Churchill River and tidal influences from the Atlantic Ocean.

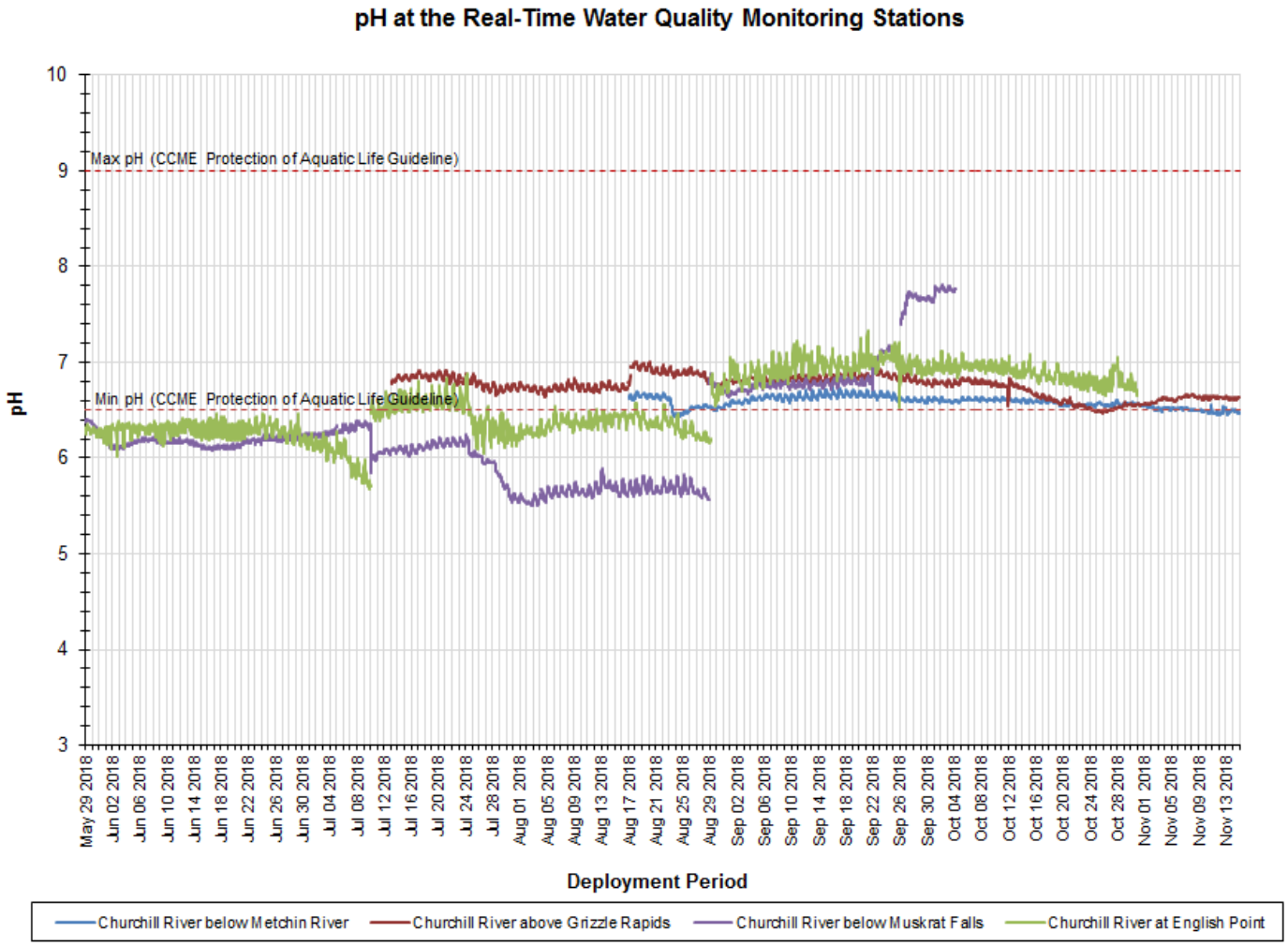

Figure 33: pH at all Stations on the Churchill River in 2018

pH	CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt
Min	6.43	6.47	5.51	5.67
Max	6.74	7.00	7.81	7.33
Median	6.60	6.78	6.17	6.48

Specific Conductivity

- Specific conductivity values at each of the four stations on the Churchill River displayed similar trends throughout the 2018 deployment season, with the exception of the station at English Point (Figure 34).
- Specific conductivity is generally very stable on the Churchill River (above English Point), fluctuating very little over the course of a deployment period. In contrast, specific conductivity at English Point is highly variable, fluctuating significantly twice daily due to the tidal influences of the Atlantic Ocean.

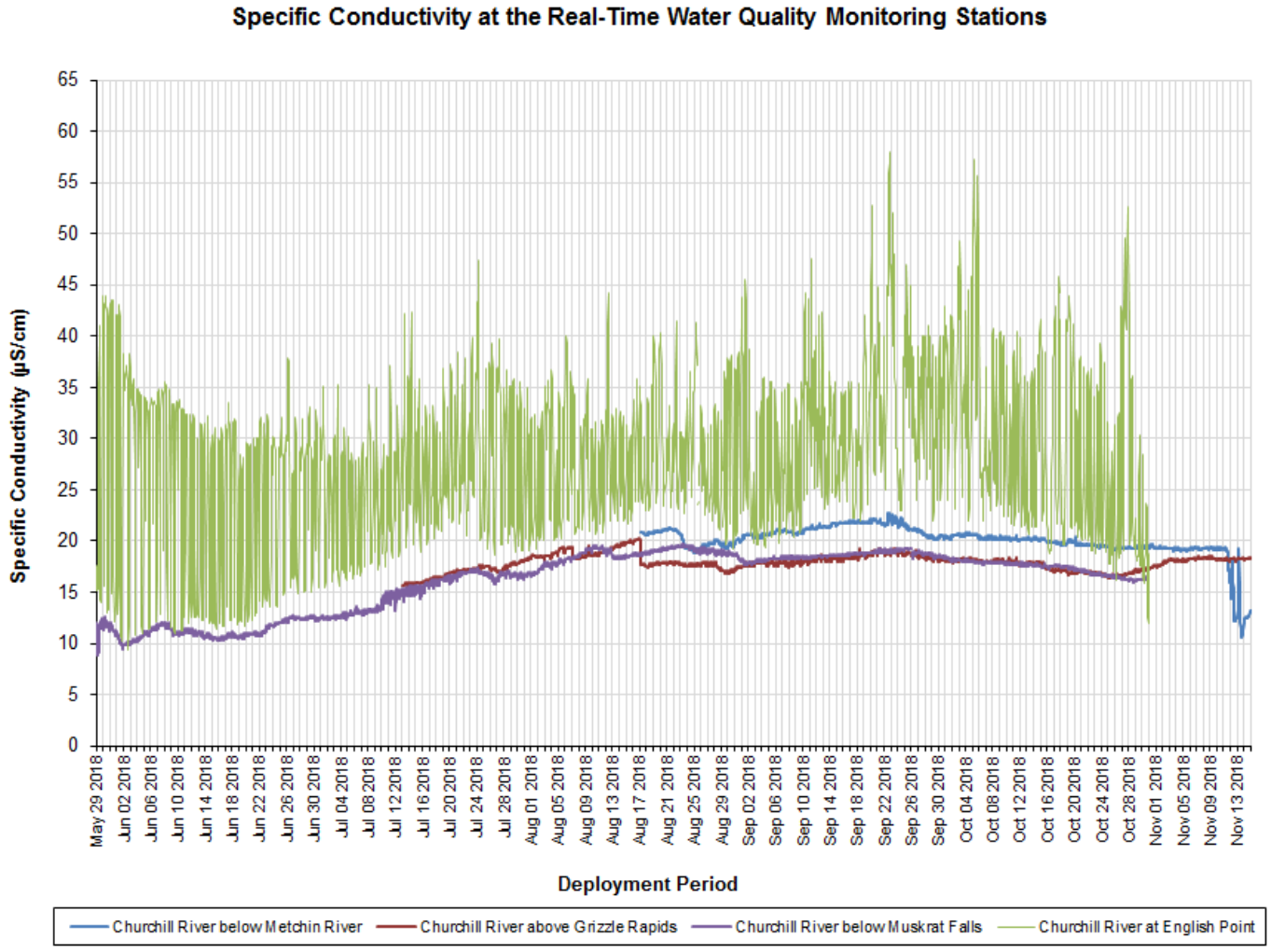

Figure 34: Specific Conductivity at all Stations on the Churchill River in 2018

Specific Conductivity (µS/cm)	CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt
Min	10.6	15.6	8.8	9.4
Max	22.8	20.3	19.7	58.0
Median	20.3	17.9	17.4	28.2

Dissolved Oxygen

- Dissolved oxygen content and percent saturation values at each of the four stations on the Churchill River were similar throughout the 2018 deployment season (Figure 35a and 35b).
- Dissolved oxygen (mg/L) displayed a very clear inverse relationship with water temperature, and followed a distinct seasonal trend whereby values decreased through spring and early summer, then increased through late summer into fall (Figure 35a). In contrast, dissolved oxygen (% Sat) remained relatively stable across the deployment season at all stations (Figure 35b).
- Generally, dissolved oxygen content is highest at the station below Muskrat Falls compared to all other stations due to its downstream proximity to Muskrat Falls. Dissolved oxygen content at below Muskrat Falls remained above the CCME's Guideline for the Protection of Early Life Stages (9.5mg/L) for the duration of the 2018 deployment season, whereas values at above Grizzle Rapids and at English Point dipped below the CCME's Guidelines during the warmer summer months. Due to being deployed in August, dissolved oxygen content at below Metchin River started below the CCME's Guidelines, but quickly increased to above the guidelines for the remainder of the season.

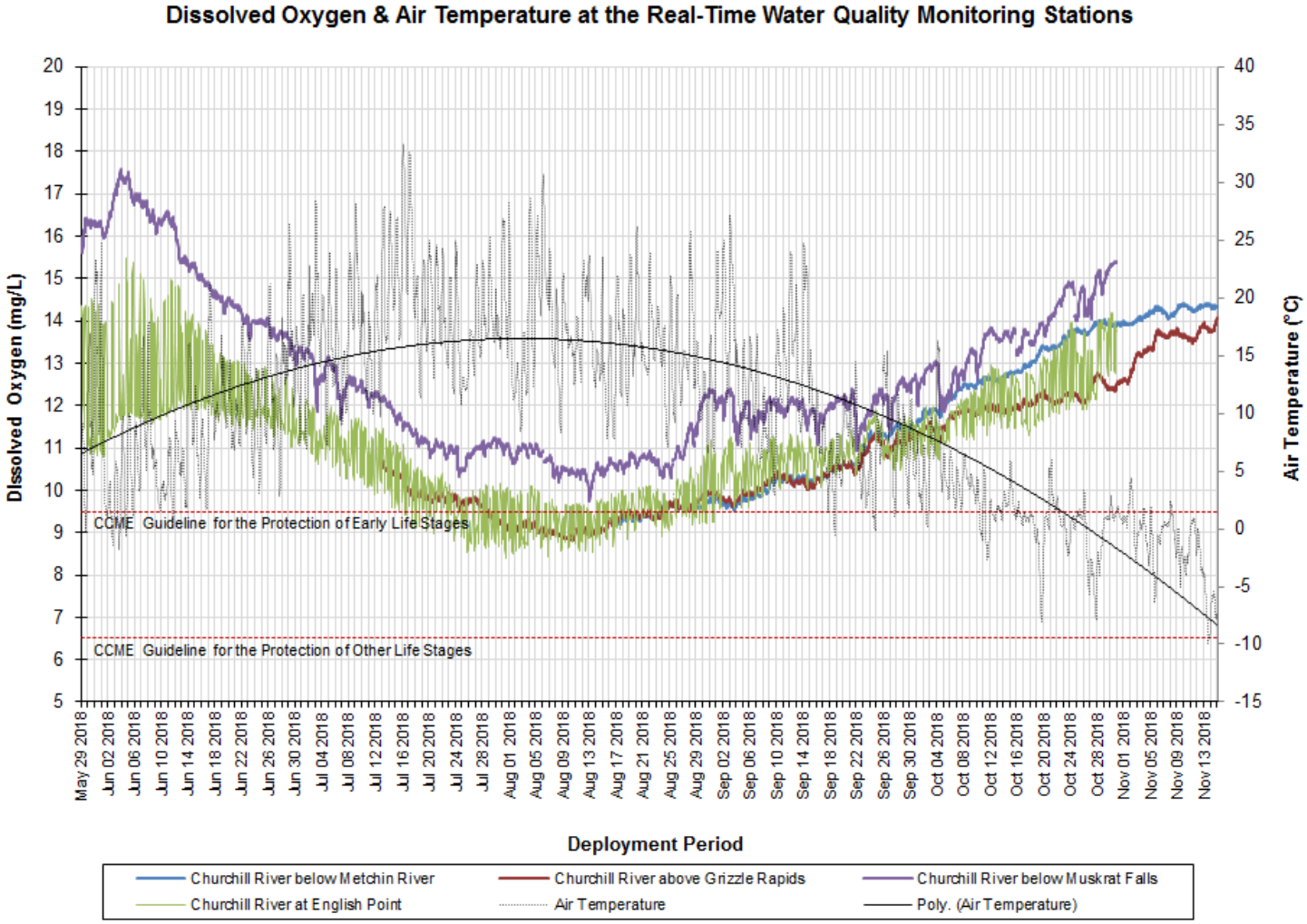

Figure 35a: Dissolved Oxygen (mg/L) at all Stations on the Churchill River in 2018

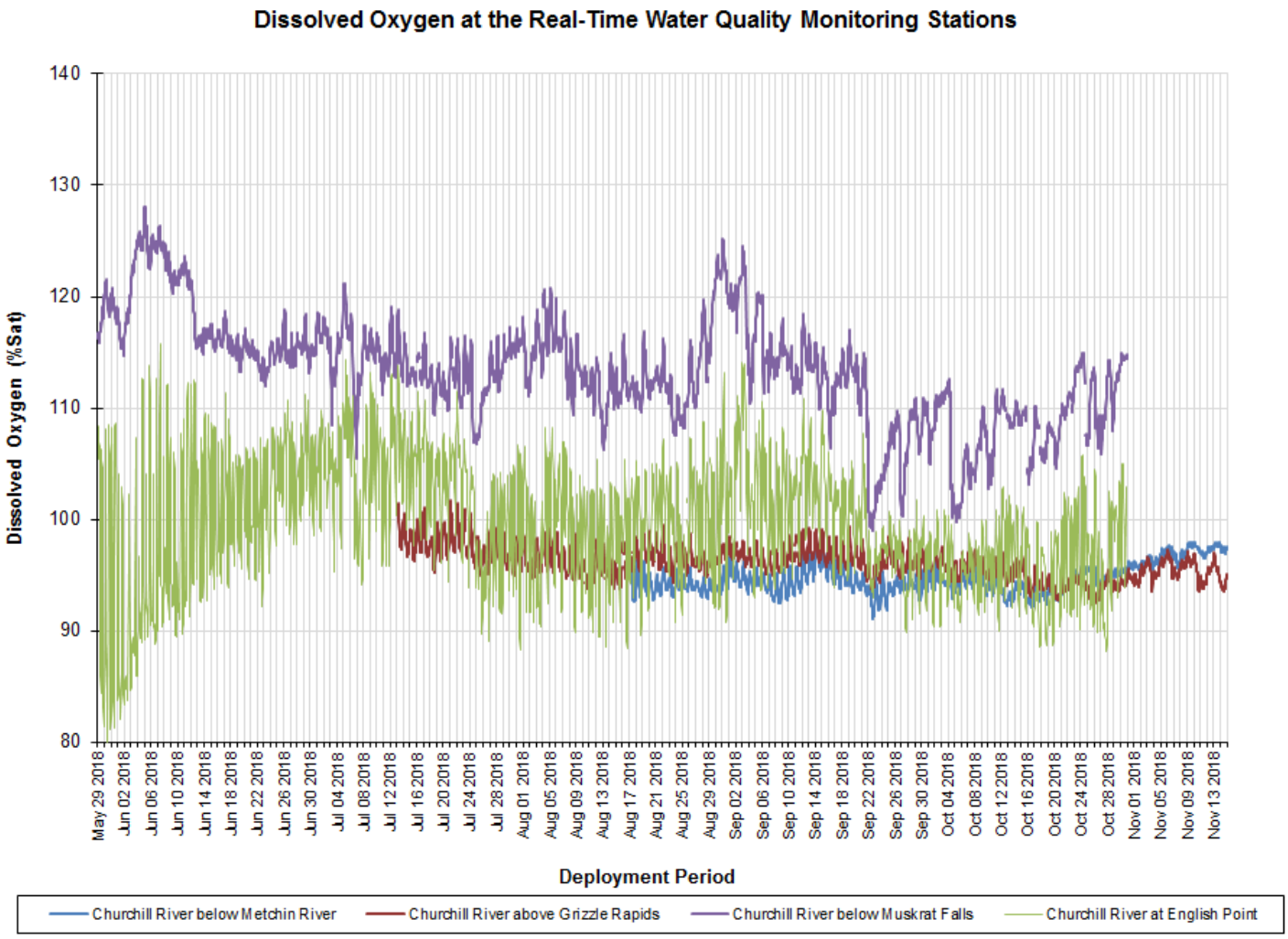

Figure 35b: Dissolved Oxygen (%Sat) at all Stations on the Churchill River in 2018

	Dissolved Oxygen (mg/L)					Dissolved Oxygen (% Sat)			
	CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt		CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt
Min	9.18	8.82	9.74	8.39		91.1	92.4	99.0	80.0
Max	14.43	14.06	17.58	15.48		98	101.7	128.1	115.8
Median	11.56	10.34	12.23	11.04		94.5	96.0	113.5	99.8

Turbidity

- Turbidity values at each of the four stations on the Churchill River were somewhat similar during the 2018 deployment season (Figure 36), with median values ranging from 0 NTU to 5 NTU.
- Turbidity values showed the most variation at below Muskrat Falls and at English Point, where values ranged from 0 NTU to 185.2 NTU and from 0 NTU to 601.0 NTU, respectively. English Point showed a higher range of turbidity values and more frequent increases throughout 2018, likely due to tidal influences at this location as sediment is stirred up by wave action.

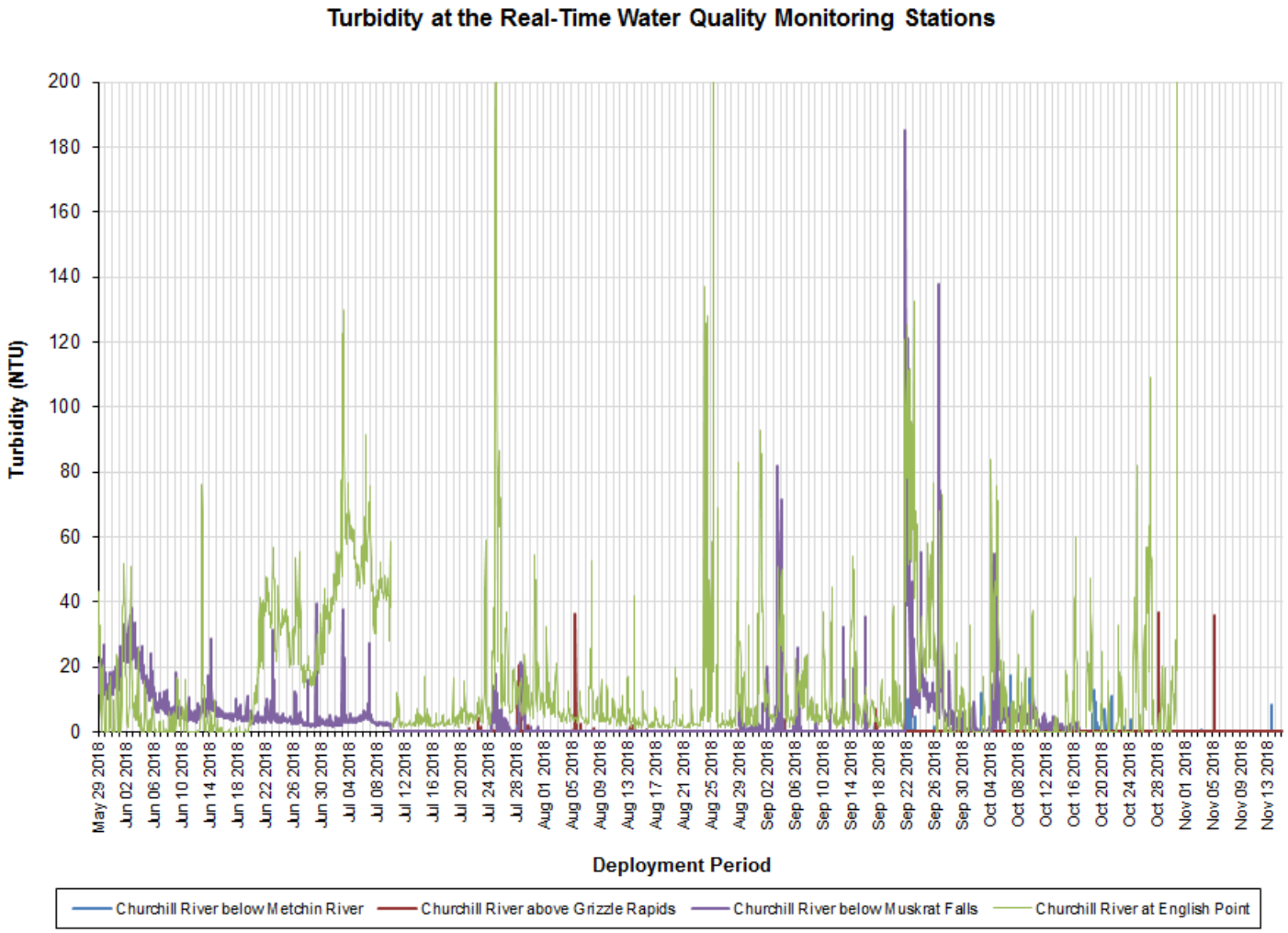

Figure 36: Turbidity at all Stations on the Churchill River in 2018

Turbidity (NTU)	CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt
Min	0.0	0.0	0.0	0.0
Max	17.5	36.7	185.2	601.0
Median	0.0	0.0	0.3	5.0

Stage

- Stage values on the Churchill River varied significantly from one station to the next during the 2018 deployment season (Figure 37), with the exception of at the below Muskrat Falls and at English Point stations.
- Stage was generally quite stable at each station across the deployment season. The greatest variability in stage was observed at English Point, where values are greatly affected by tidal influences from the Atlantic Ocean.
- Stage generally decreases as you move downstream through the Churchill River network, with the highest values being observed below Metchin River and the lowest values being observed at English Point.
- Water Survey of Canada (ECCC) is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

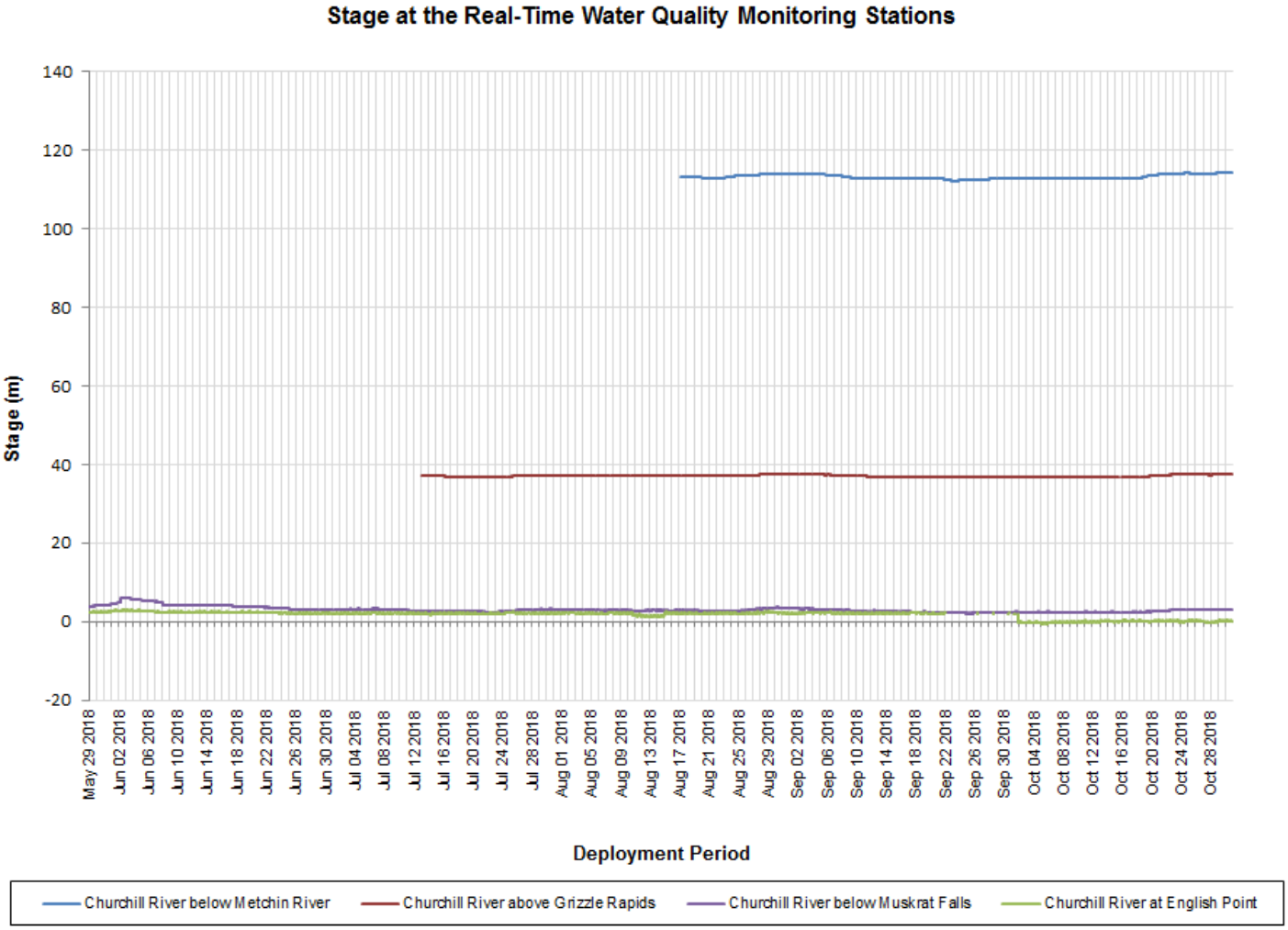

Figure 37: Stage at all Stations on the Churchill River in 2018

Stage (m)	CRbelowMR	CRaboveGR	CRbelowMF	CRatEngPt
Min	112.242	36.683	2.081	-0.575
Max	117.662	37.58	5.944	2.982
Median	113.0985	37.079	2.886	2.115

Conclusions

- Water quality monitoring instruments were successfully deployed on the Churchill River for different lengths of time during the spring, summer, and fall of 2018. The station below Metchin River was not deployed until August and the station above Grizzle Rapids was not deployed until July. The station above Muskrat Falls was not deployed at all in 2018 due to safety concerns that hindered access to that site.
- In most cases, weather related events can explain fluctuations in water levels. The deployed stations continue to perform well at capturing water quality baseline data along different reaches of the river. The English Point station provides a last measurement of water quality in the Lower Churchill River before entering Lake Melville. This station is affected by tidal influences from the Atlantic Ocean.
- Regular visits on a 30-50 day deployment schedule were mostly adhered to for the 2018 deployment season. This has provided good quality data with limited drift. The effects of bio fouling rarely impact the instruments due to the cold pristine nature of the river and regular monthly maintenance.
- Instruments performed well for much of the deployment season with only limited disruptions to data collection.
- Data collected in 2018 was comparable with datasets from previous years; however, the reactivation of the station below Metchin River in 2017 prevented some comparisons at that station. Generally speaking, water quality parameters do not tend to vary significantly from year to year.
- Water temperatures followed a typical seasonal trend at all stations in the network, whereby temperatures increased through the spring and early summer, then decreased through late summer into fall.
- The majority of recorded pH values were within the CCME's Guidelines for the Protection of Aquatic Life, with the exception of several extended periods of time at the stations below Muskrat Falls and at English Point.
- During the warmer summer months, dissolved oxygen at two stations (above Grizzle Rapids and at English Point) fell below the CCME's Guideline for the Protection of Early Life Stages (9.5mg/L). Dissolved oxygen values at all stations remained above the CCME's Guideline for the Protection of Other Life Stages (6.5mg/L) for the duration of deployment.
- Specific conductivity is generally stable on the Churchill River (above English Point), experiencing only minor fluctuations during deployment. In contrast, specific conductivity at English Point is highly variable, experiencing significant daily fluctuations due to tidal influences from the Atlantic Ocean. As the tide comes in, specific conductivity increases as dissolved solids and salinity increase; the opposite is true as the tide goes out.
- Turbidity was variable along the Churchill River in 2018, with median values ranging from 0NTU to 5.0NTU. The stations below Muskrat Falls and at English Point showed frequent turbidity events as expected.

Path Forward

In order for this agreement to be successful, it is essential to continually evaluate and move forward. The 2018 deployment season was successful in providing water quality data for the Churchill River. The following is a list of planned activities to be carried out in the upcoming year. This list also includes some multi-year activities planned in previous years that are still in progress.

- MAE staff will deploy RTWQ instruments in spring 2019 when ice conditions allow and perform regular site visits throughout the 2019 deployment season for calibration and maintenance of the instruments.
- ECCC staff will perform regular site visits to ensure water quantity instrumentation is correctly calibrated and providing accurate measurements.
- Nalcor will continue to be informed of data trends and any significant water quality events in the form of a monthly deployment report when the deployment season begins. Nalcor will also receive an annual report summarizing the events of the deployment season.
- Nalcor will continue to receive batch datasets of all RTWQ data. Raw data will be provided if requested.
- Open communication lines will continue to be maintained between MAE, ECCC and Nalcor employees involved with the agreement in order to respond to emerging issues on a proactive basis.
- MAE will continuously update the TSS-Turbidity model for the stations above and below Muskrat Falls as new grab sample data becomes available. The model will then be tested and validated in consultation with Nalcor or their consultants as necessary.
- Research into the use of remote sensing (using satellite imagery) to predict/map water quality parameters (i.e. turbidity and TSS) will continue in 2019. Satellite imagery will be acquired by MAE to further this area of research.
- The Lake Melville station remains a water quantity station. RTWQ monitoring was stopped in 2012 following continued damage to the deployed instrument.
- MAE purchased a NexSens CB-450 data buoy that was deployed in Lake Melville in August 2015. The buoy was deployed during the 2018 season; however, due to issues with the battery data was not transmitted and very little data was obtained. The buoy will be deployed again in 2019 with hopes of obtaining more complete data as Lake Melville is very important to assessing the water quality of the Lower Churchill River ecosystem.

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