Real-Time Water Quality Deployment Report

Lower Churchill River Network

August 2 to
September 1, 2011

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division

Contents

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General

- Department of Environment and Conservation staff monitors the real-time web pages regularly.
- This deployment report discusses water quality related events occurring at the four stations on the Lower Churchill River: below Metchin River, below Grizzle Rapids and above and below Muskrat Falls.
- On August 2, 2011, real-time water quality monitoring instruments were deployed at the four Lower Churchill River Stations for a period of 29 days. Instruments were removed on September 1.

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.
  - ► At deployment and removal, a QA/QC Instrument is temporarily deployed along side 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: Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (oC)	<=+/-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 dependant, 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 August 2 to September 1, 2011 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations, August 2– September 1, 2011

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Metchin River (45701)	Aug 2, 2011	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	Sep 1, 2011	Removal	Excellent	Good	Excellent	Excellent	Fair
Below Grizzle Rapids (45709)	Aug 2, 2011	Deployment	Good	Fair	Excellent	Excellent	Excellent
	Sep 1, 2011	Removal	Good	Good	Excellent	Excellent	Good
Above Muskrat Falls (47590)	Aug 2, 2011	Deployment	Excellent	Good	Excellent	Good	Excellent
	Sep 1, 2011	Removal	Excellent	Excellent	Excellent	Good	Fair
Below Muskrat Falls (45700)	Aug 2, 2011	Deployment	Good	Excellent	Excellent	n/a	n/a
	Aug 3, 2011	Removal	Good	Excellent	Excellent	n/a	n/a
Below Muskrat Falls (45708)	Aug 3, 2011	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	Sep 1, 2011	Removal	Good	Excellent	Good	Good	Poor

- At the station below Metchin River, all parameters ranked 'good' or 'excellent' at deployment. Temperature, pH, conductivity and dissolved oxygen all ranked 'good' or 'excellent' at removal while turbidity ranked 'fair'. The field instrument read a value of 0.0NTU and the QA/QC instrument read a value of 6.8NTU. Turbidity values are typically 0NTU at this station and the QA/QC instrument was reading high throughout the day at other sampling stations. A calibration error with the QA/QC instrument is likely the cause of the discrepancy between the two instruments.
- At the station below Grizzle Rapids, temperature, conductivity, dissolved oxygen and turbidity all ranked 'good' or 'excellent' at deployment while pH ranked 'fair'. The field instrument read a value of 6.47 and the QA/QC instrument read a value of 7.08. This is likely due to insufficient time for the field instrument to stabilize in the water body. At the time of the first transmission after deployment (approximately 1 hour after deployment) the pH value on the field instrument had increased to 7.05, which would yield a ranking of 'excellent' when compared to the QA/QC instrument. At removal, all parameters ranked 'good' or 'excellent'.
- At the station above Muskrat Falls, all parameters ranked 'good' or 'excellent' at deployment. Temperature, pH, conductivity, and dissolved oxygen all ranked either 'good' or 'excellent' at removal while turbidity ranked 'fair'. The field instrument read a value of 8.1NTU and the QA/QC instrument read a value of 16.0NTU. The average turbidity reading at this station throughout the deployment period was 7.0NTU indicating that the field instrument was most likely correct at this time. This discrepancy is likely caused by a calibration error with the QA/QC instrument which resulted in higher than expected values for turbidity throughout the day at numerous sampling stations.

- At the station below Muskrat Falls, temperature, pH and conductivity all ranked either 'good' or 'excellent' at deployment on August 2. There was an error with the DO and turbidity sensors as they were not functioning properly and therefore have no ranking comparisons. ENVC staff returned to the station the next day with a replacement instrument and removed the instrument with the sensor issue. At removal on August 3, temperature, pH and conductivity all ranked either 'good' or 'excellent'. DO and turbidity were not ranked due to sensor failure.
- On August 3, a new instrument was deployed at the station below Muskrat Falls. All parameters ranked either 'good' or 'excellent' at deployment. Temperature, pH, conductivity and dissolved oxygen all ranked either 'good' or 'excellent' at removal on September 1. Turbidity was ranked 'poor'. The field instrument read a value of 5.1NTU while the QA/QC instrument read a value of 18.1NTU. The average turbidity reading at this station throughout the deployment period was 6.1NTU indicating that the field instrument was most likely correct at this time. This discrepancy is likely caused by a calibration error with the QA/QC instrument which resulted in higher than expected values for turbidity throughout the day at numerous sampling stations.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from August 2 to September 1 in the Lower Churchill River Network.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Churchill River below Metchin River

- Water temperature ranged from 14.20°C to 19.00°C during this deployment period (Figure 1).
- Water temperature is stable throughout the deployment period and begins to decrease slightly in late August. This trend is expected due to the warm summer temperatures and the increasing cooler air temperatures as fall begins (Figure 2). Water temperature fluctuates diurnally.

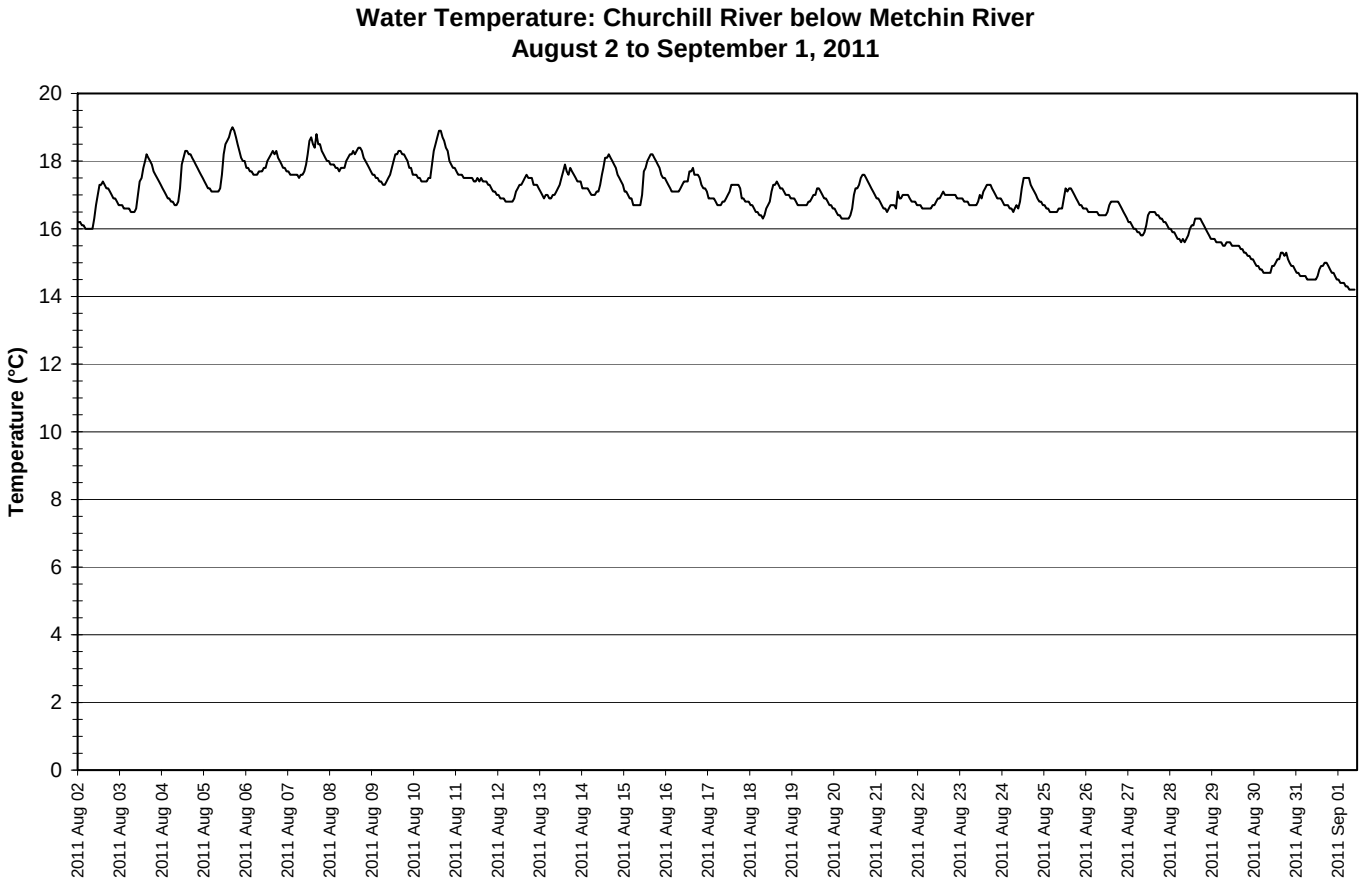

Figure 1: Water temperature at Churchill River below Metchin River

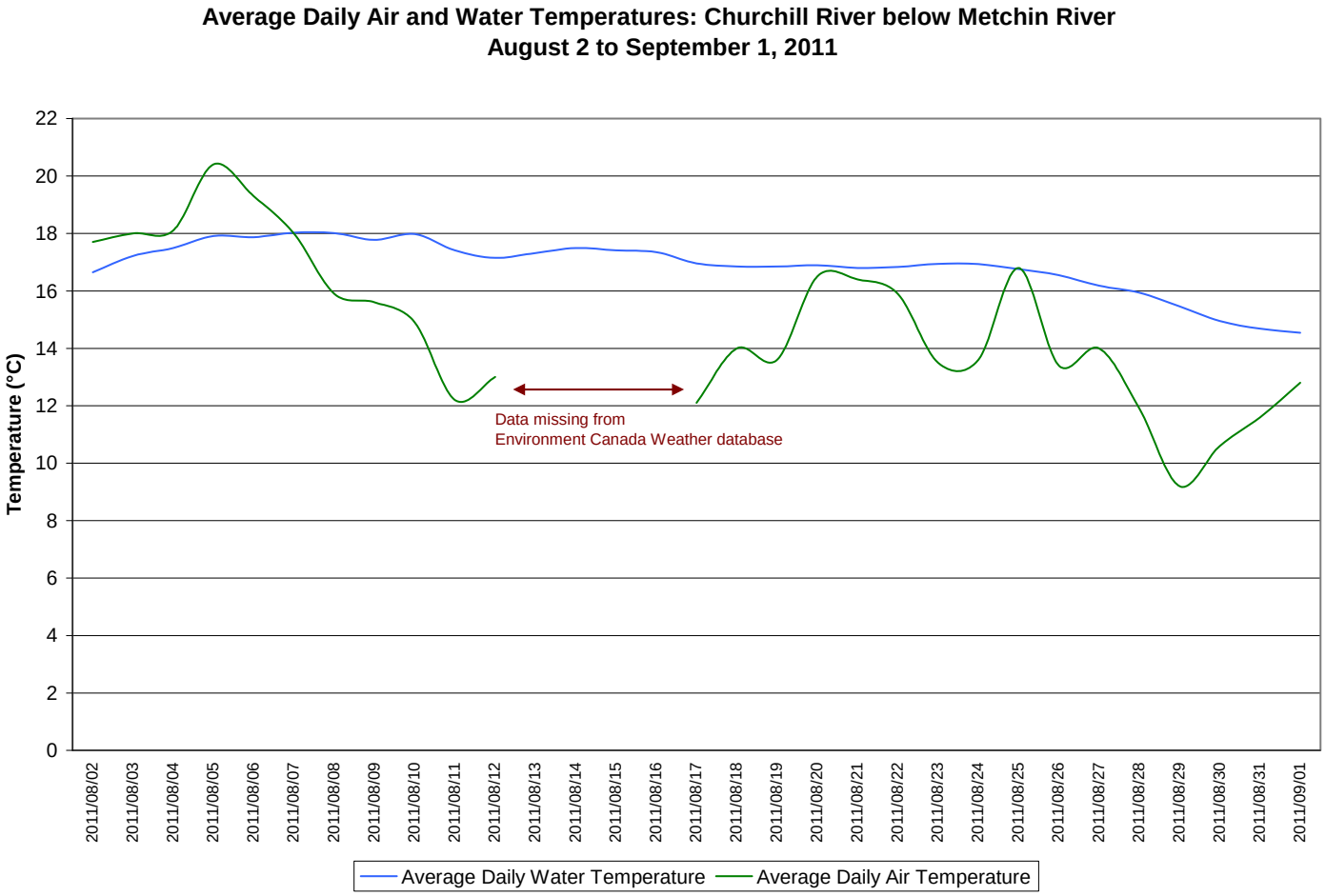

Figure 2: Average daily air and water temperatures at Churchill River below Metchin River (weather data recorded at Churchill Falls)

- pH ranges between 6.42 and 7.10 pH units and generally remains stable throughout the deployment period (Figure 3).
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units).

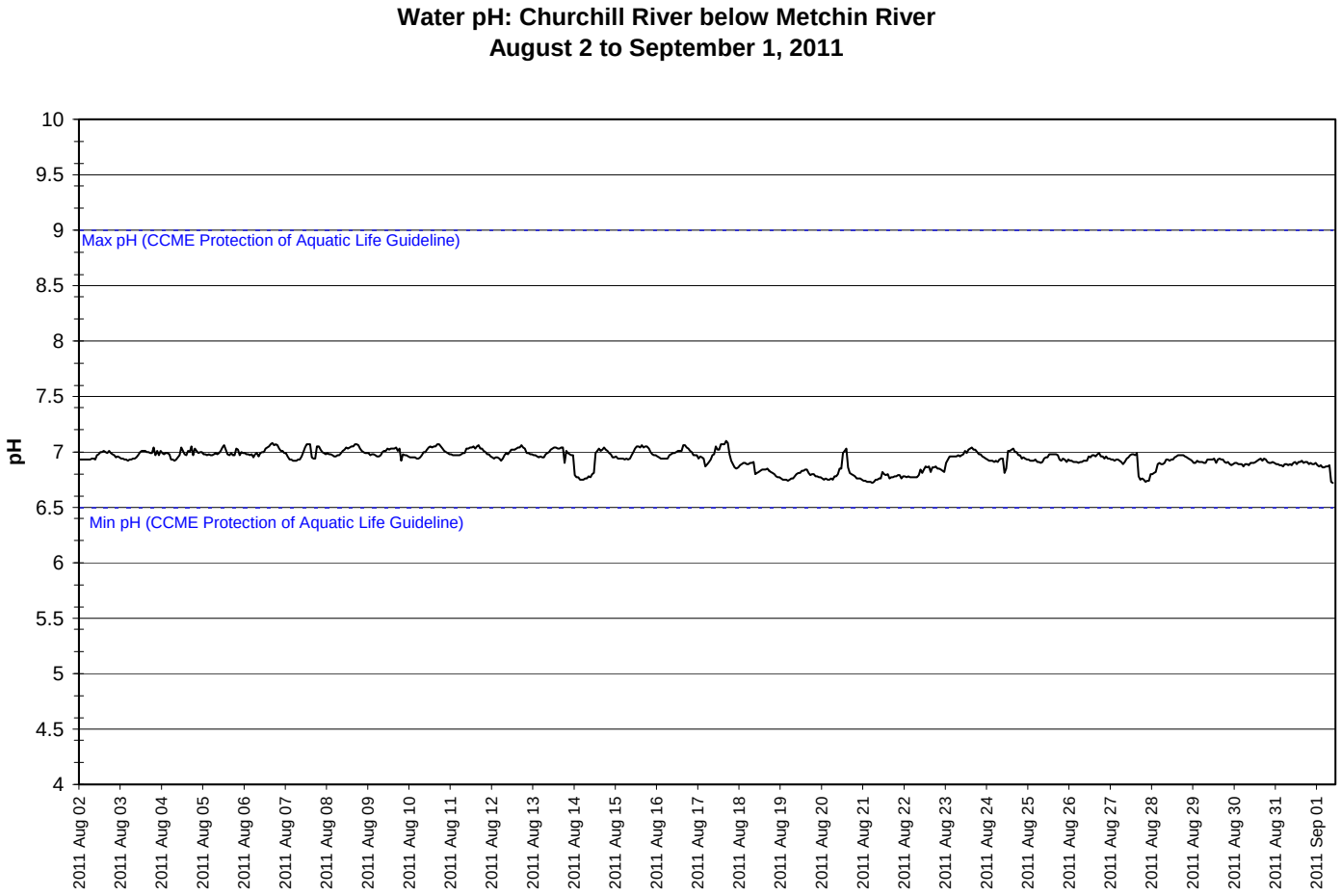

Figure 3: pH at Churchill River below Metchin River

- Specific conductivity typically ranges from 19.8 to 22.9µS/cm during the deployment period, averaging 21.7µS/cm (Figure 4). There is one instance where specific conductivity increases to 26.1uS/cm however this increase only lasts for one hour and is not considered a water quality event.
- Specific conductance is increasing slightly during the first half of the deployment period and then decreases slightly during the latter half. Stage is included in Figure 4 to illustrate the inverse relationship between conductivity and water level. Stage is decreasing during the first half of the deployment period before it begins to increase in the final 10 days of the deployment period. As stage decreases, specific conductivity generally increases due to the increased concentration of dissolved solids in the water column. Precipitation input can decrease the specific conductivity of the water body by diluting the concentration of dissolved solids present.

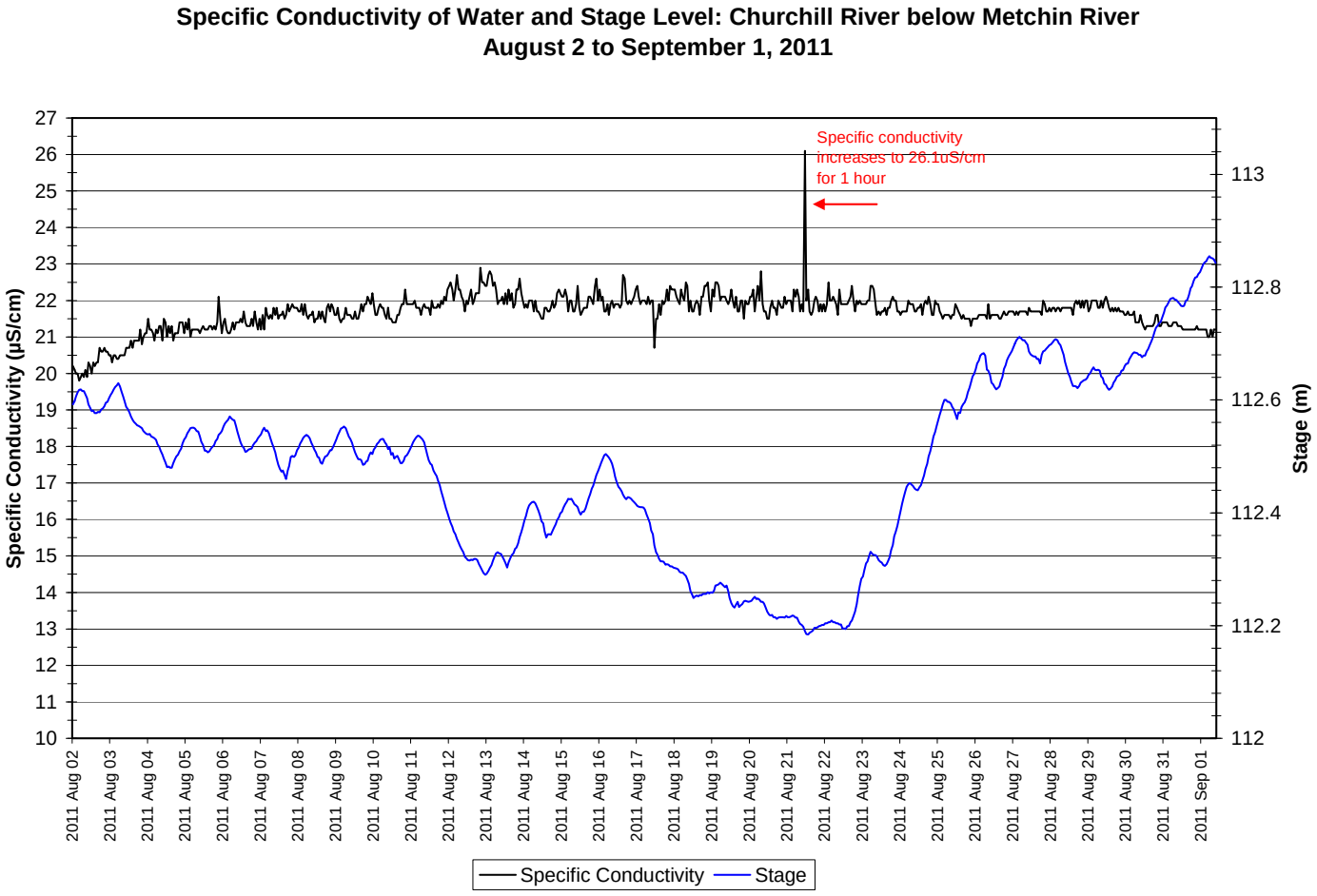

Figure 4: Specific conductivity and stage level at Churchill River below Metchin River

- The saturation of dissolved oxygen ranged from 91.9 to 99.4% and a range of 8.91 to 9.61mg/l was found in the concentration of dissolved oxygen with a median value of 9.12 mg/l (Figure 5).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. For the majority of the deployment period, dissolved oxygen values are just below the minimum CCME Guideline for the Protection of Aquatic Life at Early Life Stages. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen content is generally stable throughout the deployment period. This trend is expected given the consistent warm air and water temperatures (Figure 2). The low dissolved oxygen levels are directly related to the warm air and water temperatures experienced during this time of the year which decrease the amount of oxygen available in the water column.

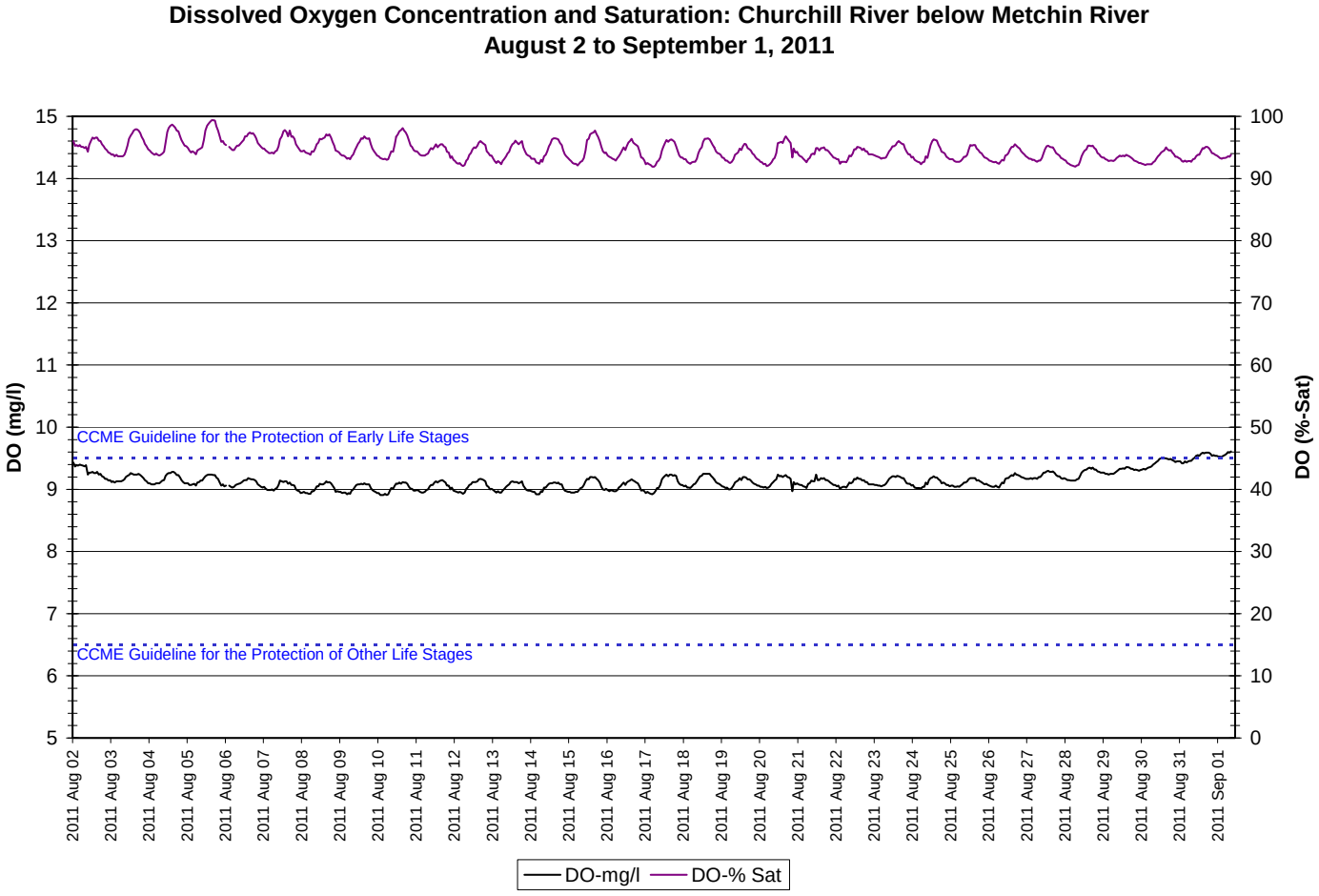

Figure 5: Dissolved oxygen and percent saturation at Churchill River below Metchin River

- Turbidity generally remains at 0NTU for the majority of the deployment period (Figure 6). A median value of 0 NTU indicates there is generally no natural background turbidity value at this station.
- There are several instances where turbidity increases (to as high at 28.8NTU) for very short periods of time (1-3 hours). These are not considered water quality events as they are isolated and infrequent events. In a couple of instances, turbidity values do remain elevated for up to 9 hours however, the magnitude of these events is small (<20NTU).

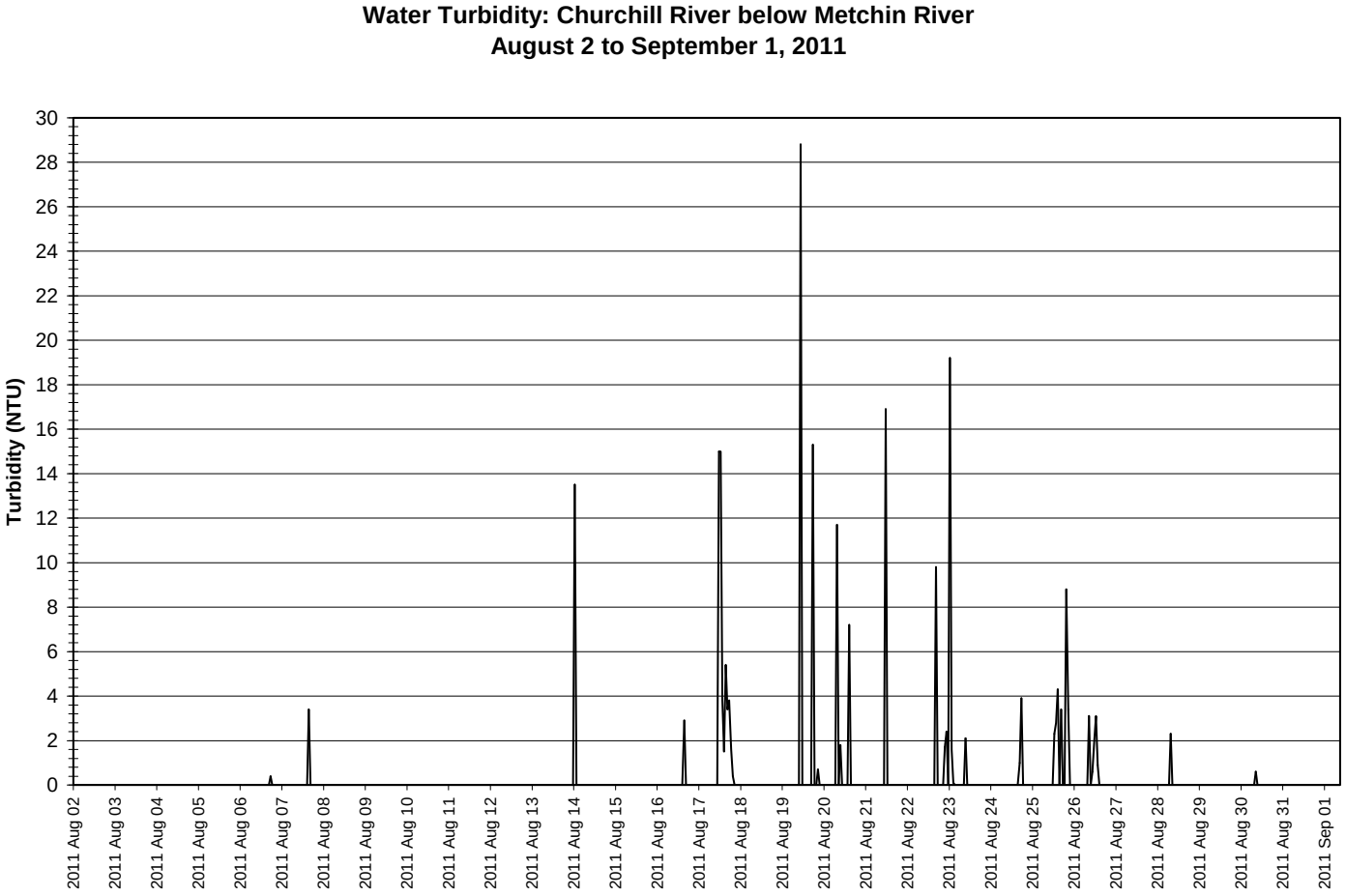

Figure 6: Turbidity at Churchill River below Metchin River

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 7). Stage is generally decreasing during the first half of the deployment period before increase during the last ten days.

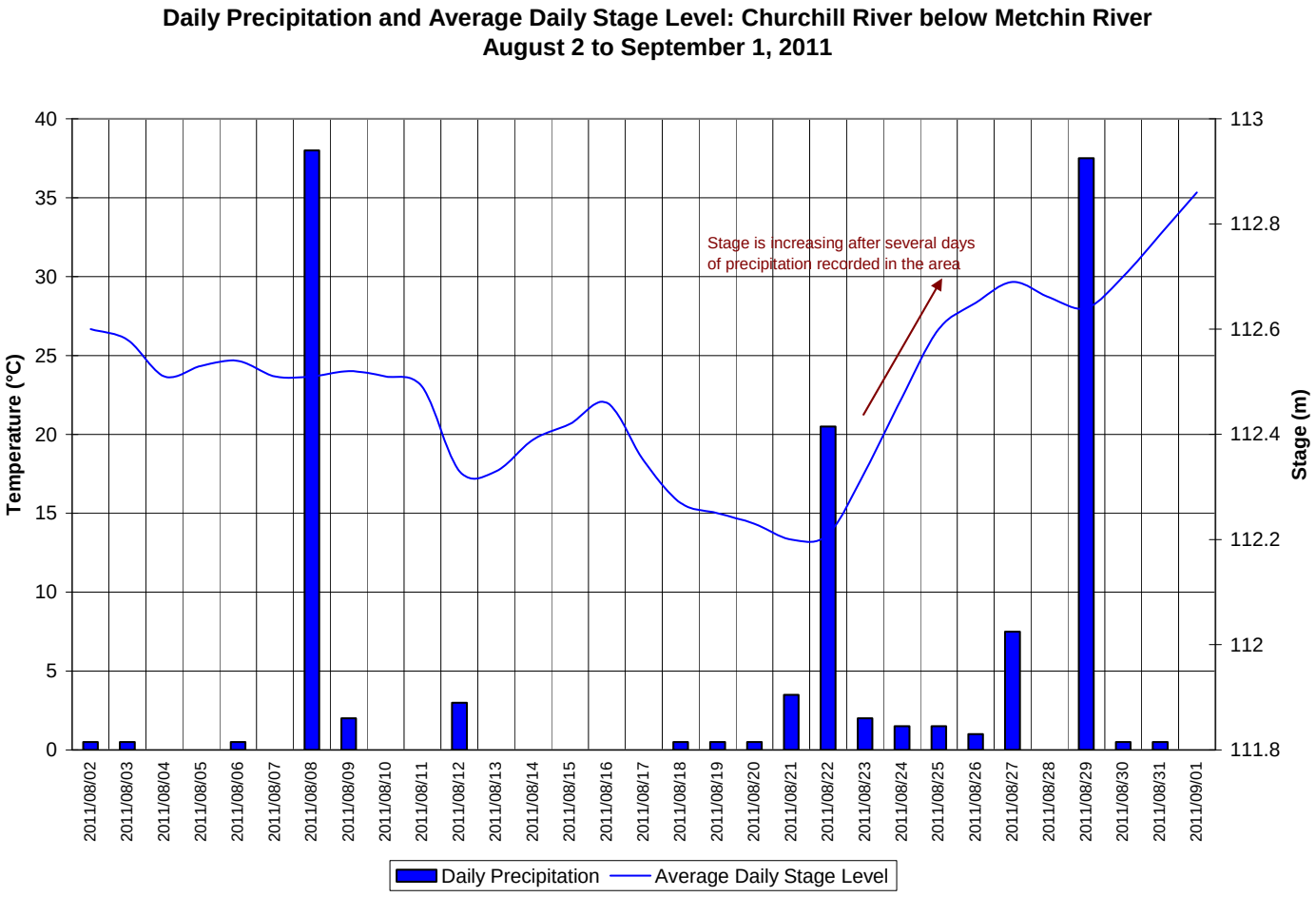

Figure 7: Daily precipitation and average daily stage level at Churchill River below Metchin River (weather data recorded at Churchill Falls)

Churchill River below Grizzle Rapids

- Water temperature ranged from 15.20 to 19.90^{o}C during this deployment period (Figure 8).
- Water temperature is stable throughout the deployment period. This trend is expected due to the consistent ambient air temperatures in the summer season (Figure 9). Water temperature fluctuates diurnally.

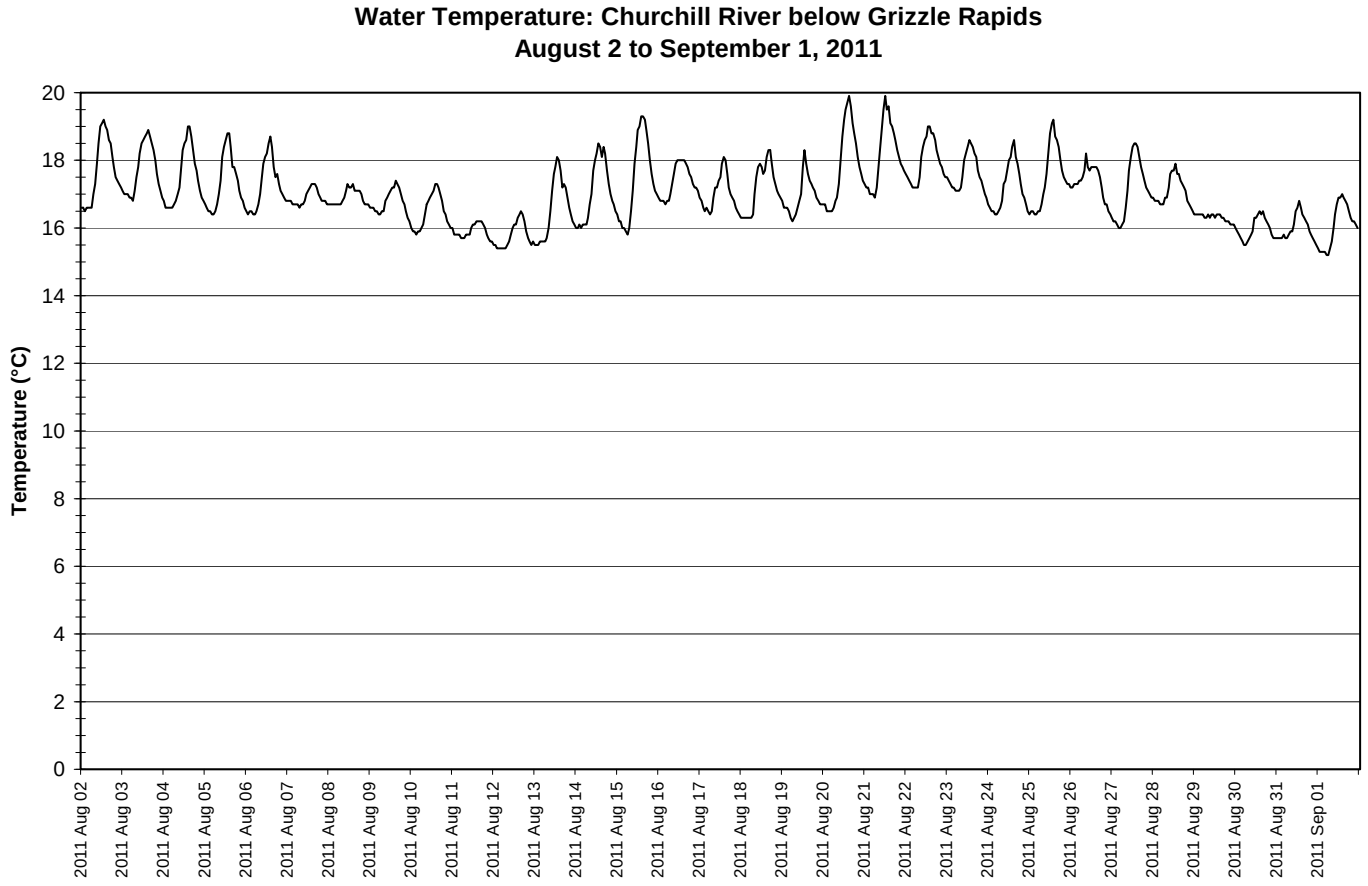

Figure 8: Water temperature at Churchill River below Grizzle Rapids

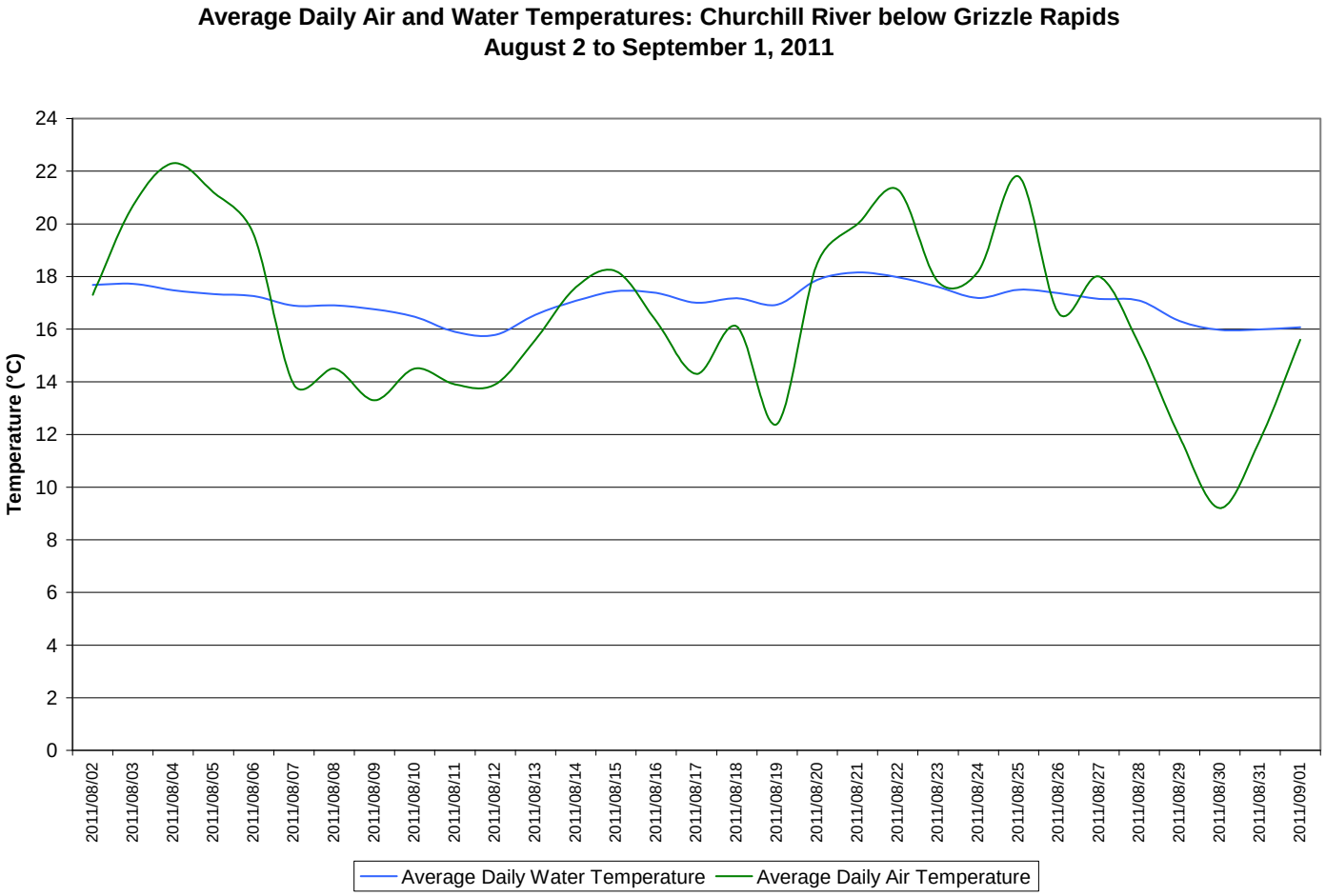

Figure 9: Average daily air and water temperatures at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

- pH ranges between 7.00 and 7.42 pH units and remains very consistent throughout the deployment period (Figure 10). pH fluctuates diurnally.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units).

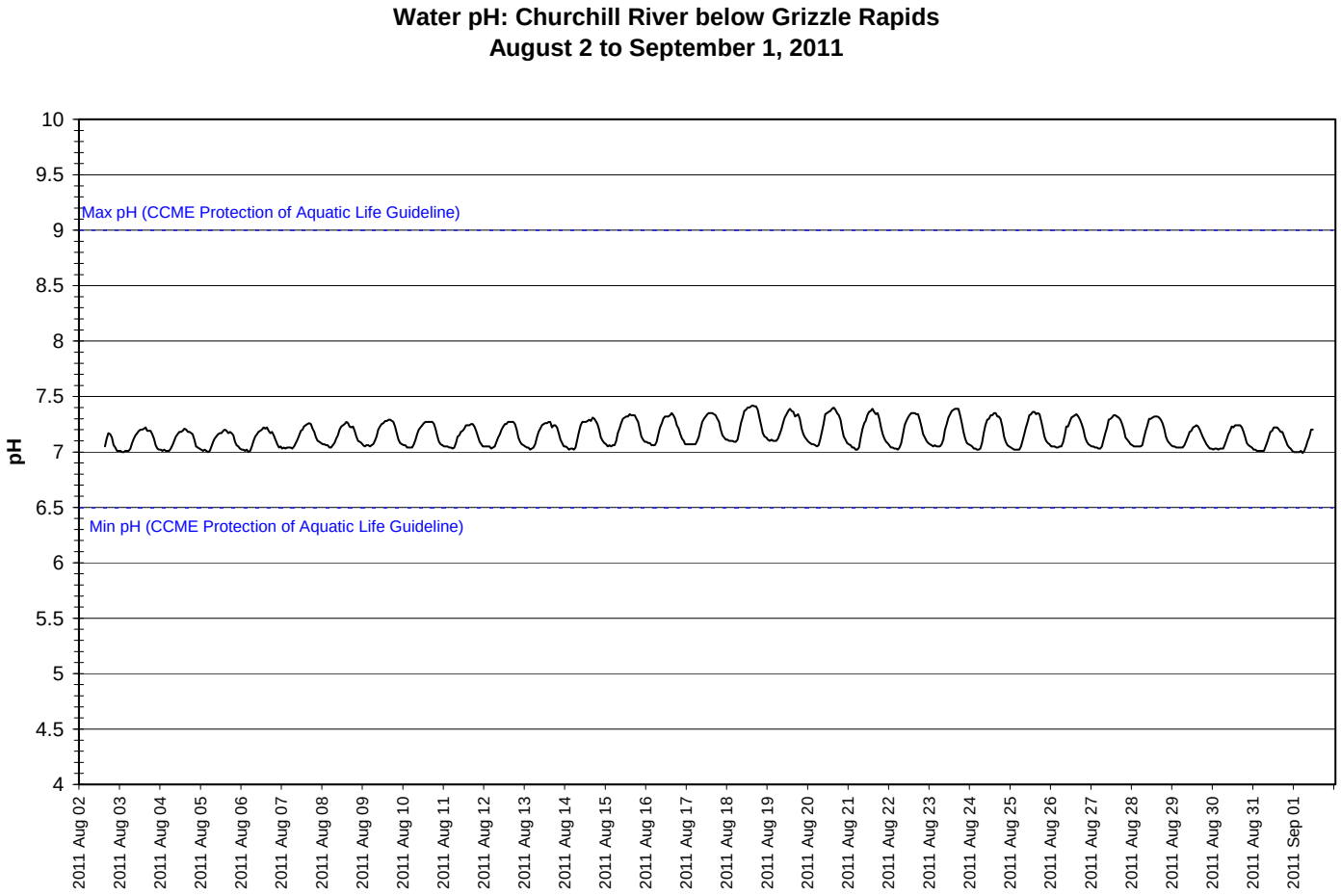

Figure 10: pH at Churchill River below Grizzle Rapids

- Specific conductivity ranges from 18.2 to 21.2µS/cm during the deployment period, averaging 19.9µS/cm (Figure 11). Specific conductance is increasing throughout the deployment period.
- Stage is included in Figure 11 to illustrate the inverse relationship between conductivity and water level. Stage is generally decreasing throughout the first half of the deployment period before increasing during the last 10 days. As stage increases, specific conductivity generally decreases. The reduction in water level increases the concentration of dissolved solids in the water column consequently increasing the specific conductivity. Precipitation input can decrease the specific conductivity of the water body by diluting the concentration of dissolved solids present.

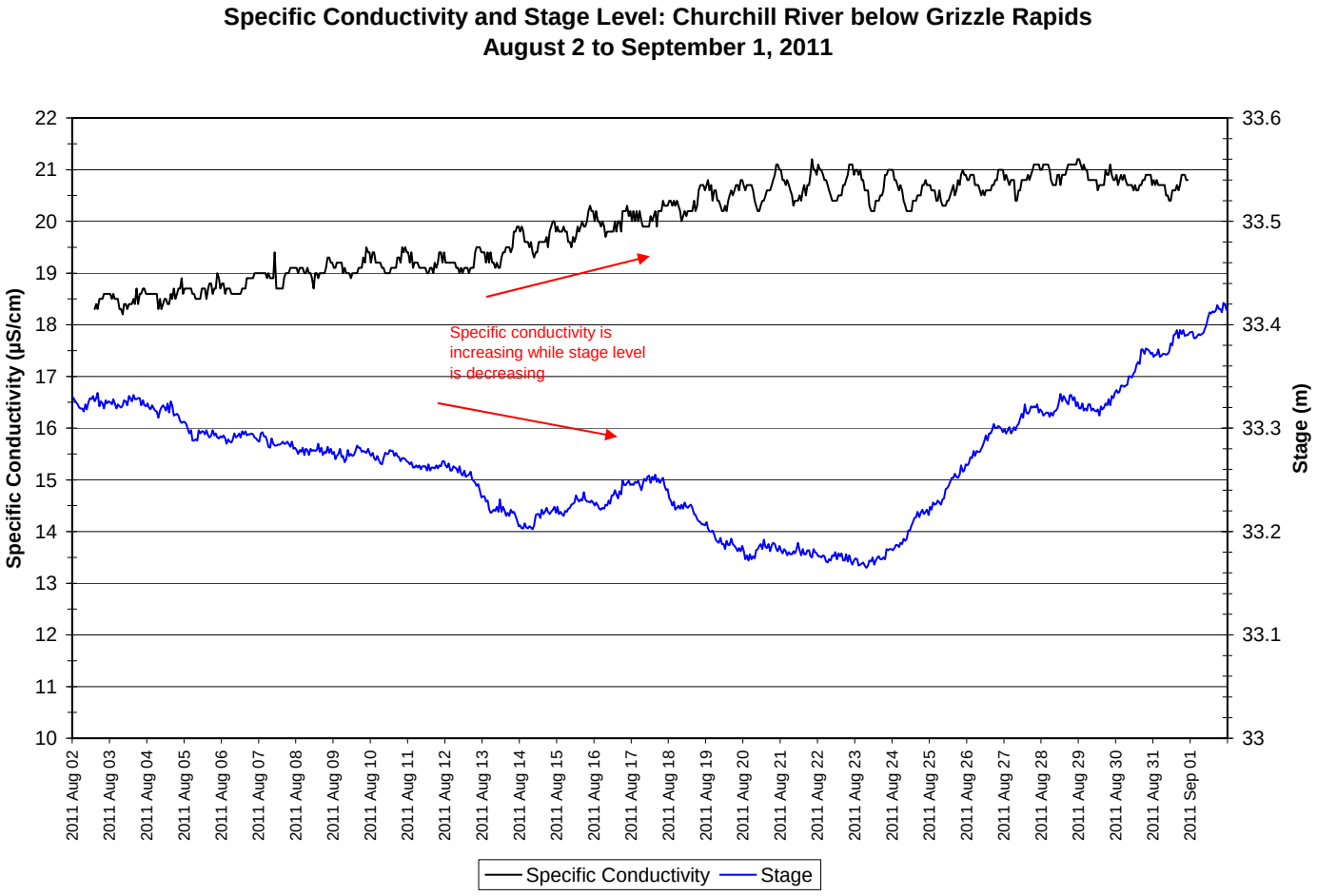

Figure 11: Specific conductivity and stage level at Churchill River below Grizzle Rapids

- The saturation of dissolved oxygen ranged from 91.5 to 104.7% and a range of 8.90 to 9.83mg/l was found in the concentration of dissolved oxygen with a median value of 9.39mg/l (Figure 12).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. Values recorded during the peak daytime hours were just above the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l. During the evening and early morning hours, dissolved oxygen fell below the guideline. The guidelines are indicated in blue on Figure 12.
- Dissolved oxygen content is generally stable throughout the deployment period. The low dissolved oxygen levels are directly related to the warm air and water temperatures experienced during this time of the year which decrease the amount of oxygen available in the water column. Dissolved oxygen values fluctuate at consistent diurnal intervals throughout the deployment period.

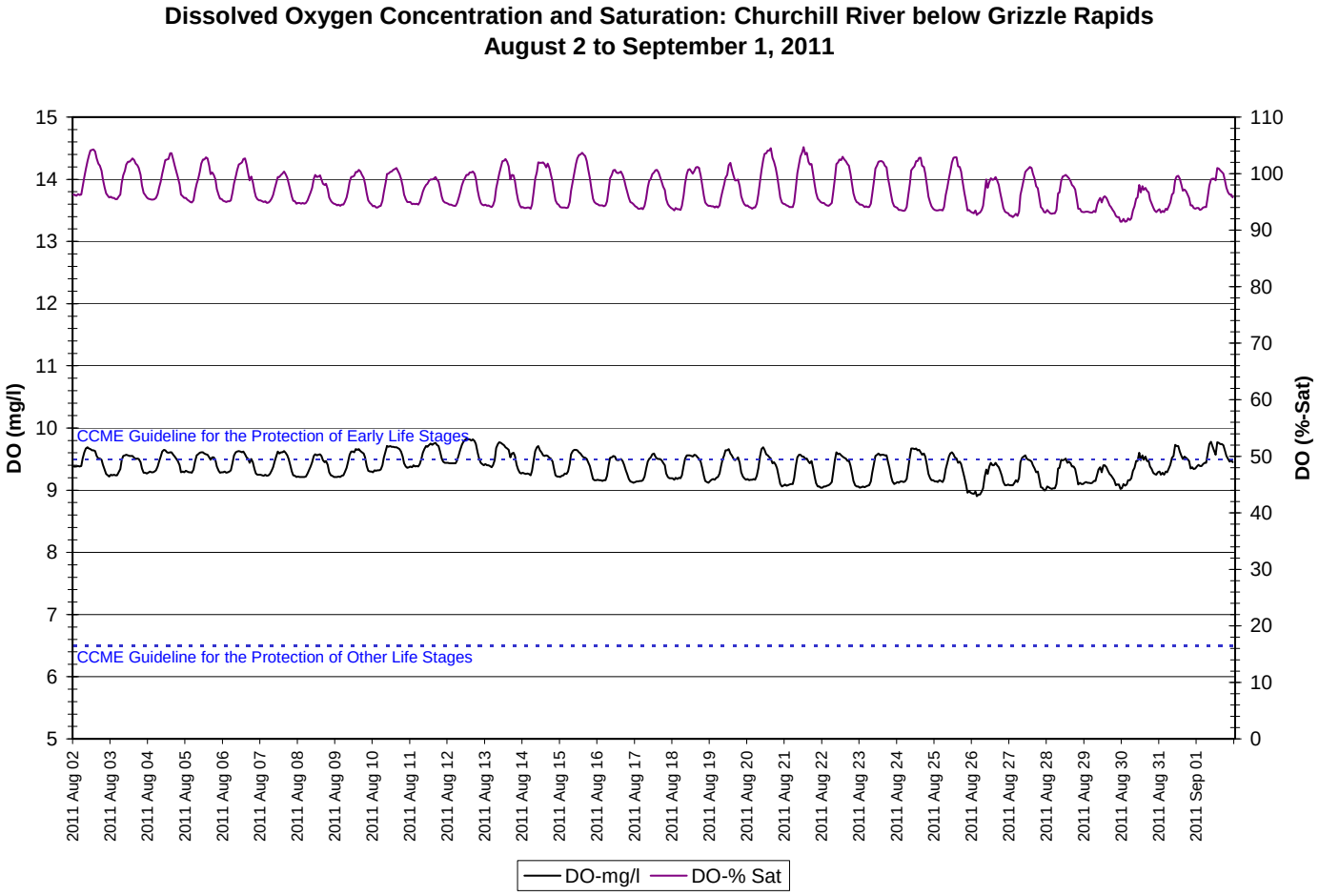

Figure 12: Dissolved oxygen and percent saturation at Churchill River below Grizzle Rapids

- Turbidity values are typically 0NTU at this station (Figure 13). A median value of 0 NTU indicates there is generally no natural background turbidity value at this station.
- Turbidity increases up to 15.4NTU were recorded during this deployment period however these events were short lived (1-2 hours) and of low magnitude and therefore are not considered water quality events.

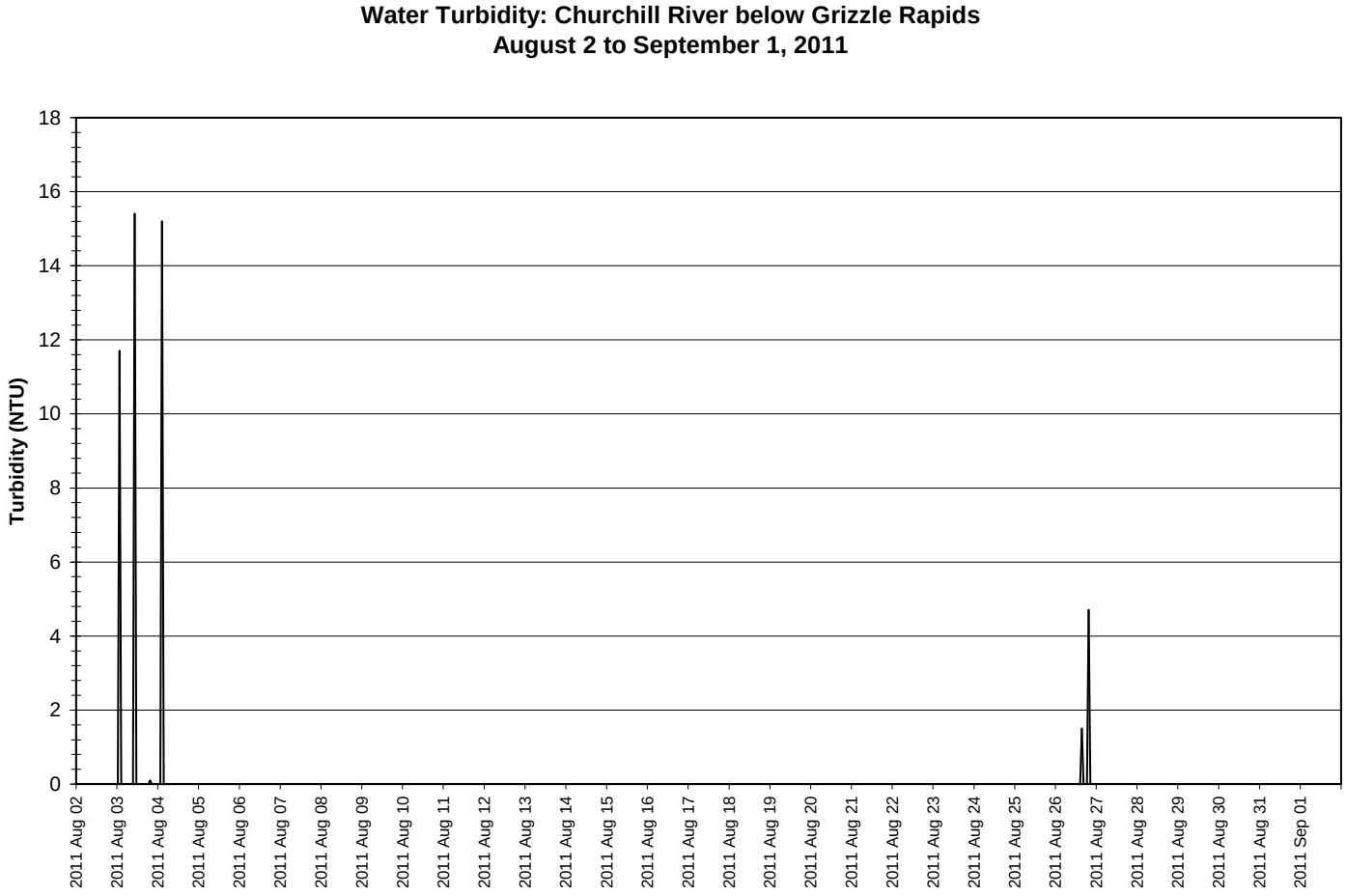

Figure 13: Turbidity at Churchill River below Grizzle Rapids

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 14). Stage is generally decreasing throughout the beginning of the deployment period before increasing during the last 10 days. Precipitation records vary throughout the deployment period.

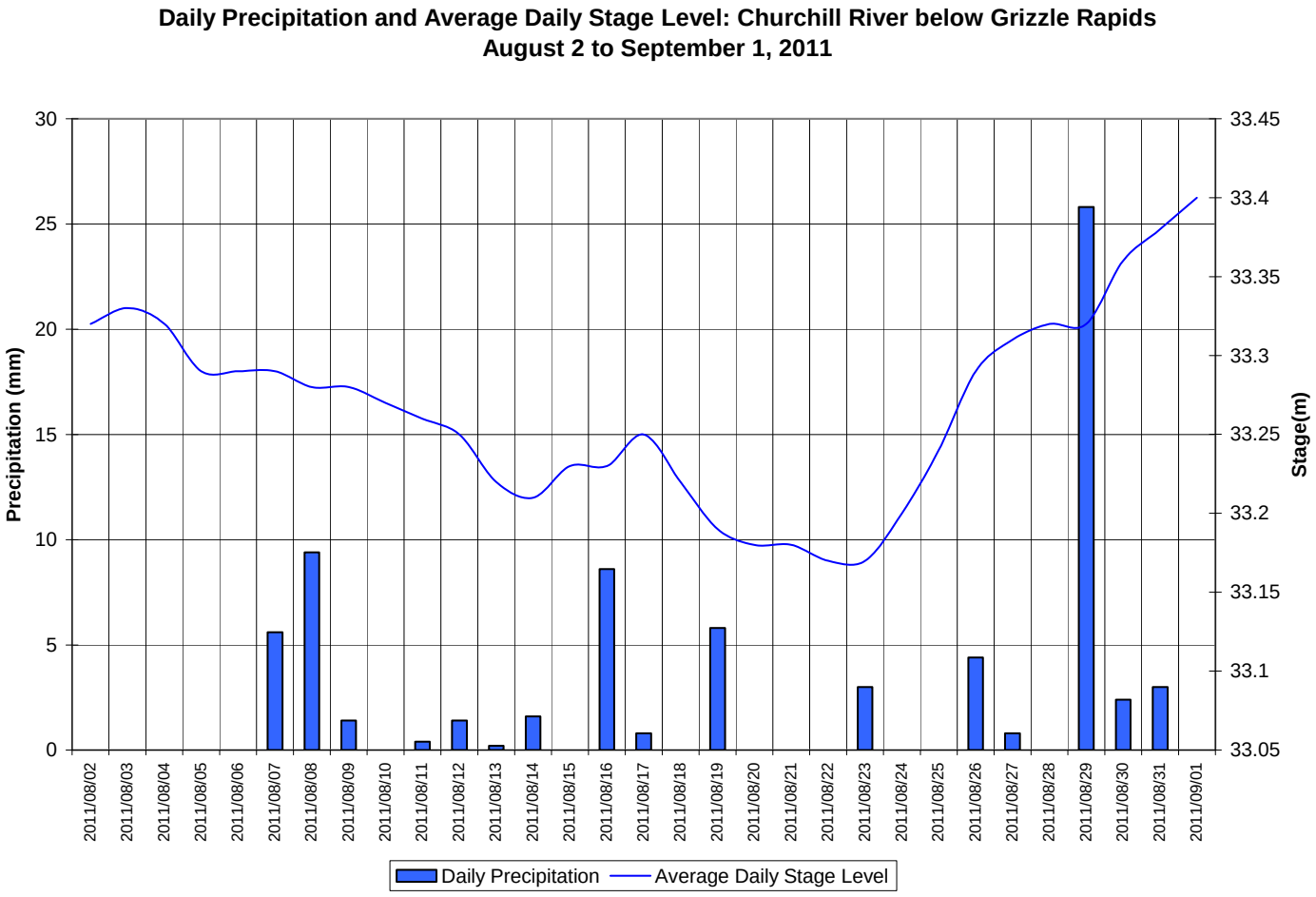

Figure 14: Daily precipitation and average daily stage level at Churchill River below Grizzle Rapids (weather data recorded at Goose Bay)

Churchill River above Muskrat Falls

- Water temperature ranges from 15.44 to 19.32^{o}C during this deployment period (Figure 15).
- Water temperature is generally stable throughout the deployment period. This trend is expected given the consistent warm ambient air temperatures in the summer months (Figure 16). Water temperature fluctuates diurnally.

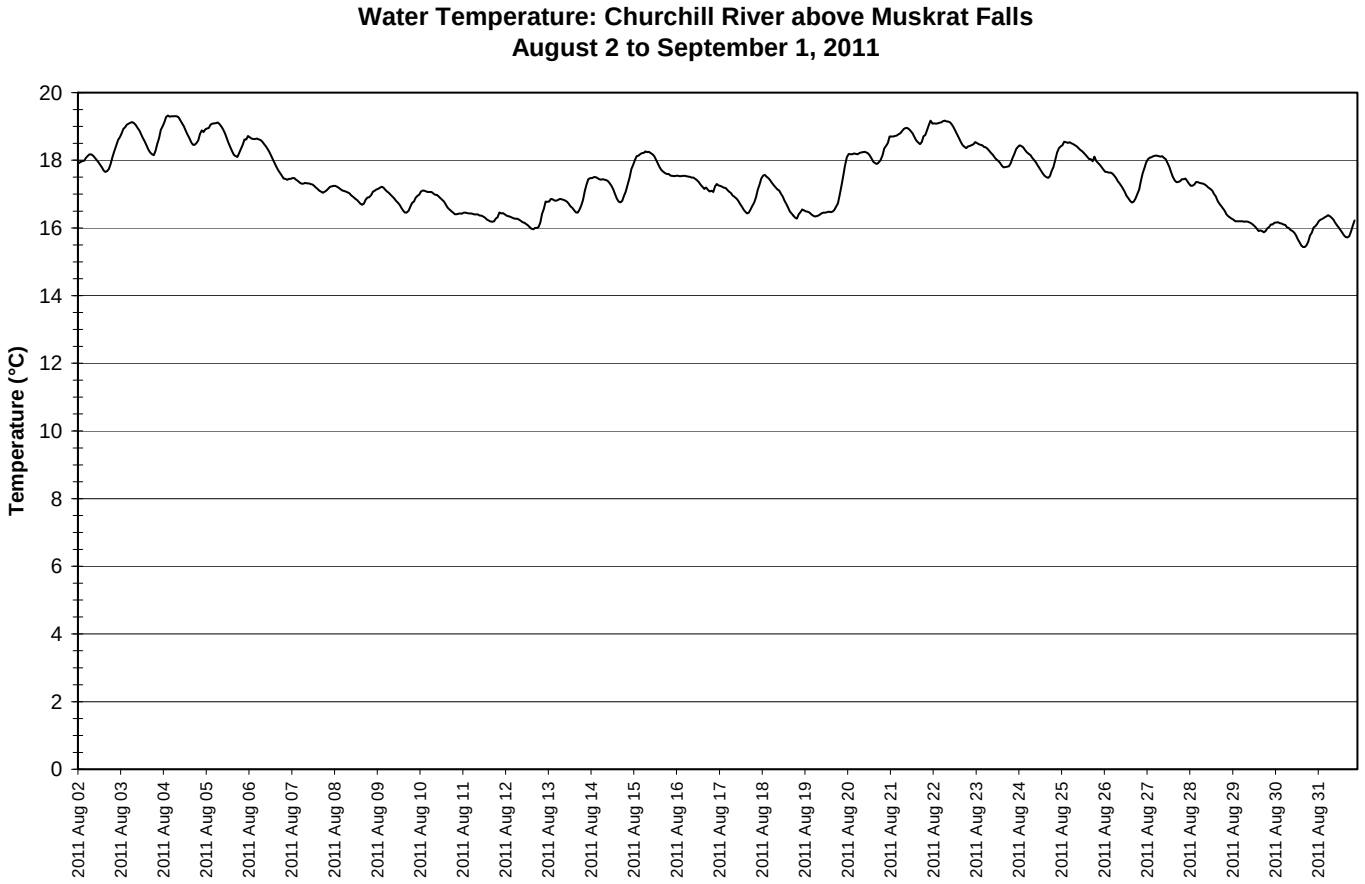

Figure 15: Water temperature at Churchill River above Muskrat Falls

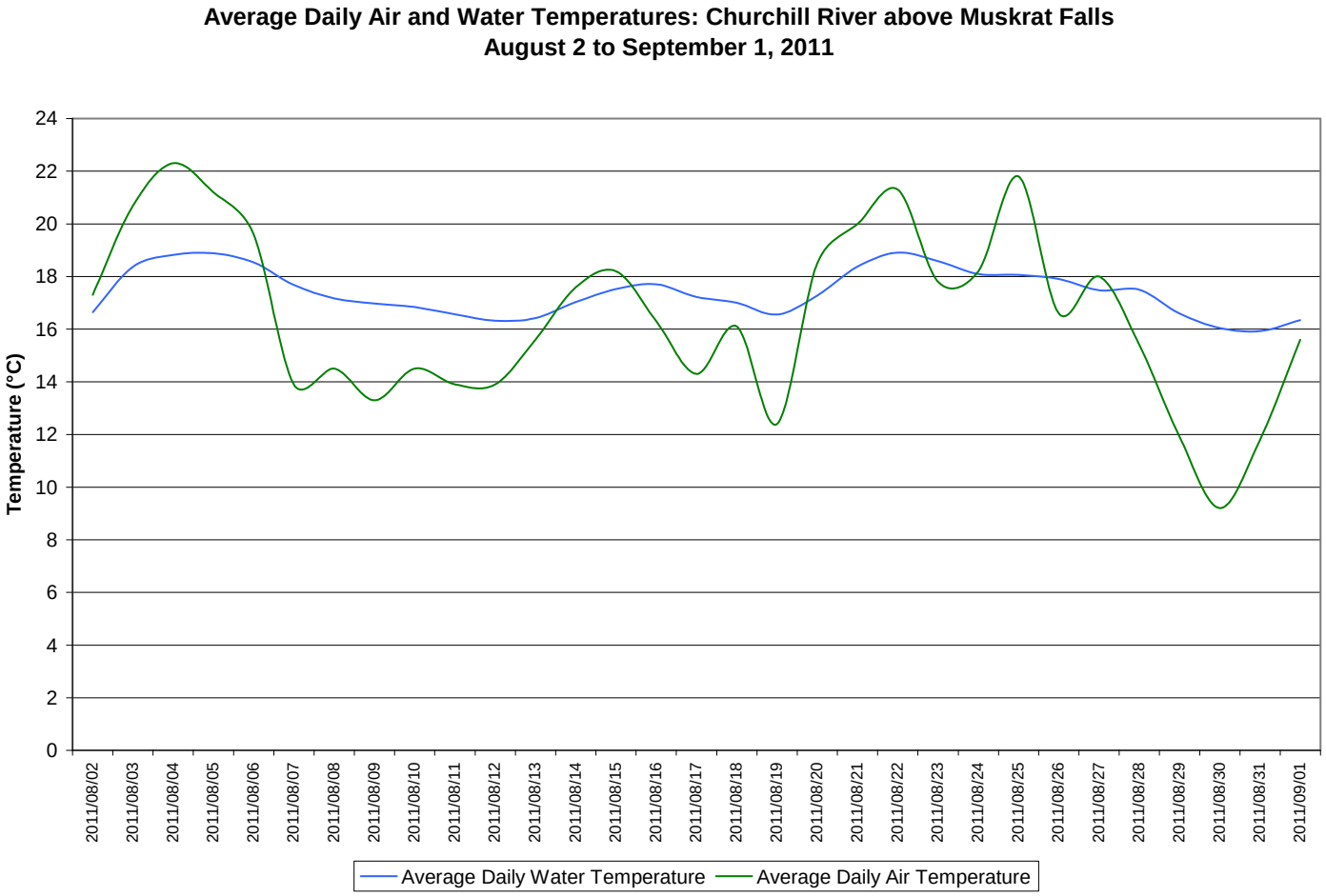

Figure 16: Average daily air and water temperatures at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

- pH ranges between 6.92 and 7.18pH units (Figure 17). pH values are generally stable throughout the deployment period. pH fluctuates slightly on a diurnal interval.
- All values are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 17).

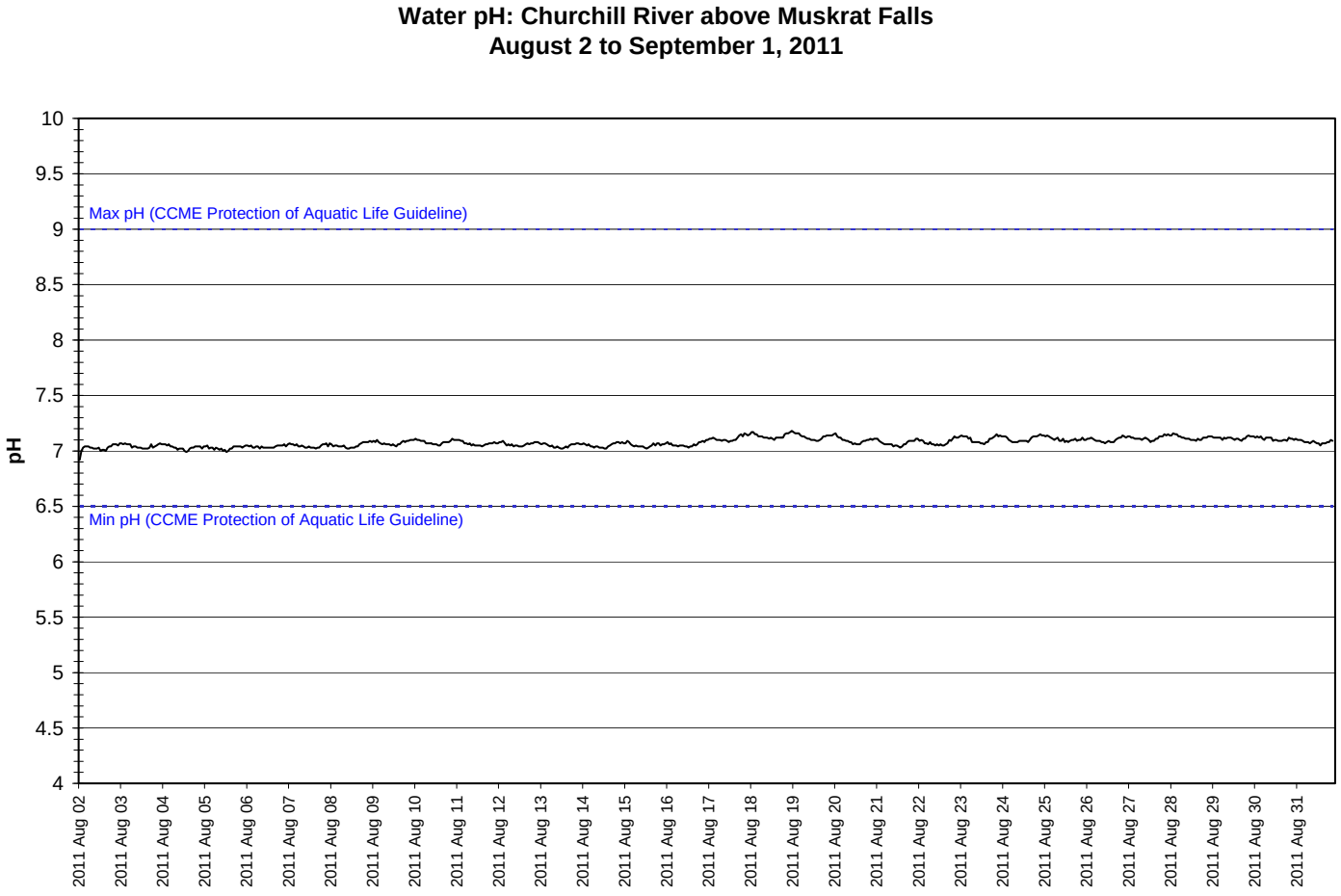

Figure 17: pH at Churchill River above Muskrat Falls

- Specific conductivity generally ranges between 18.8 and 22.5µS/cm and is increasing slightly throughout the deployment period (Figure 18).
- There are two instances where specific conductivity increases to above average values, up to 31.3µS/cm. These instances are short lived (2-3 hours) and are identified on Figure 18. The cause of these increases is unknown.
- Stage is included in Figure 18 to illustrate the inverse relationship between conductivity and water level. Stage is generally decreasing throughout the deployment period before increasing during the last 10 days. As stage decreases, specific conductivity generally increases (indicated on Figure 18). Reduction in water level increases the concentration of dissolved solids in the water column hence increasing the specific conductivity. Precipitation input can decrease the specific conductivity of the water body by diluting the concentration of dissolved solids present.

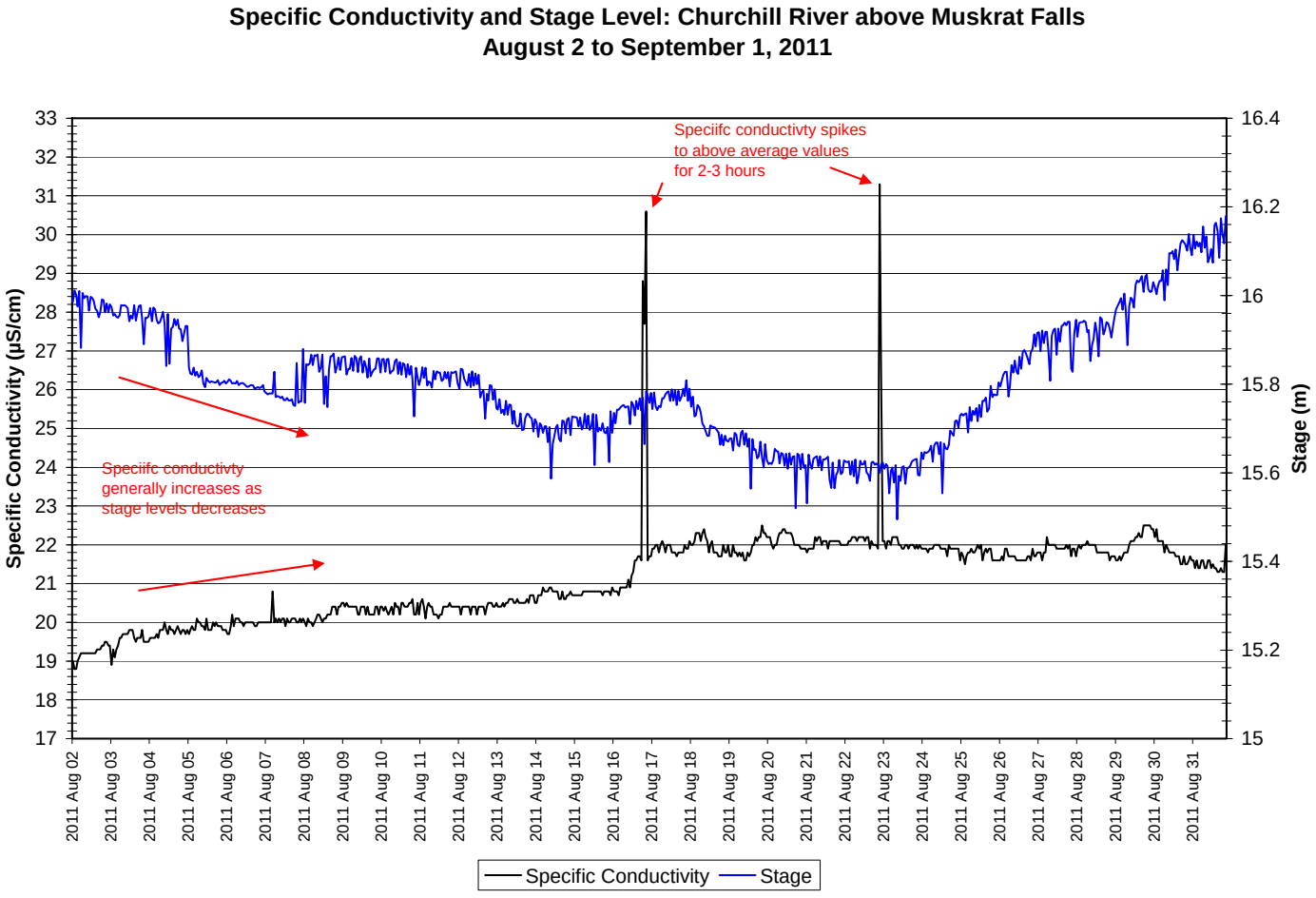

Figure 18: Specific conductivity and stage level at Churchill River above Muskrat Falls

- The saturation of dissolved oxygen ranged from 94.4 to 101.2% and a range of 9.06 to 9.66mg/l was found in the concentration of dissolved oxygen with a median value of 9.33mg/l (Figure 19).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. Most values were just below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l. The guidelines are indicated in blue on Figure 19.
- Dissolved oxygen content is generally stable throughout the deployment period. The low dissolved oxygen levels are directly related to the warm air and water temperatures experienced during this time of the year (Figure 16) which decrease the amount of oxygen available in the water column. Dissolved oxygen values fluctuate at consistent diurnal intervals throughout the deployment period.

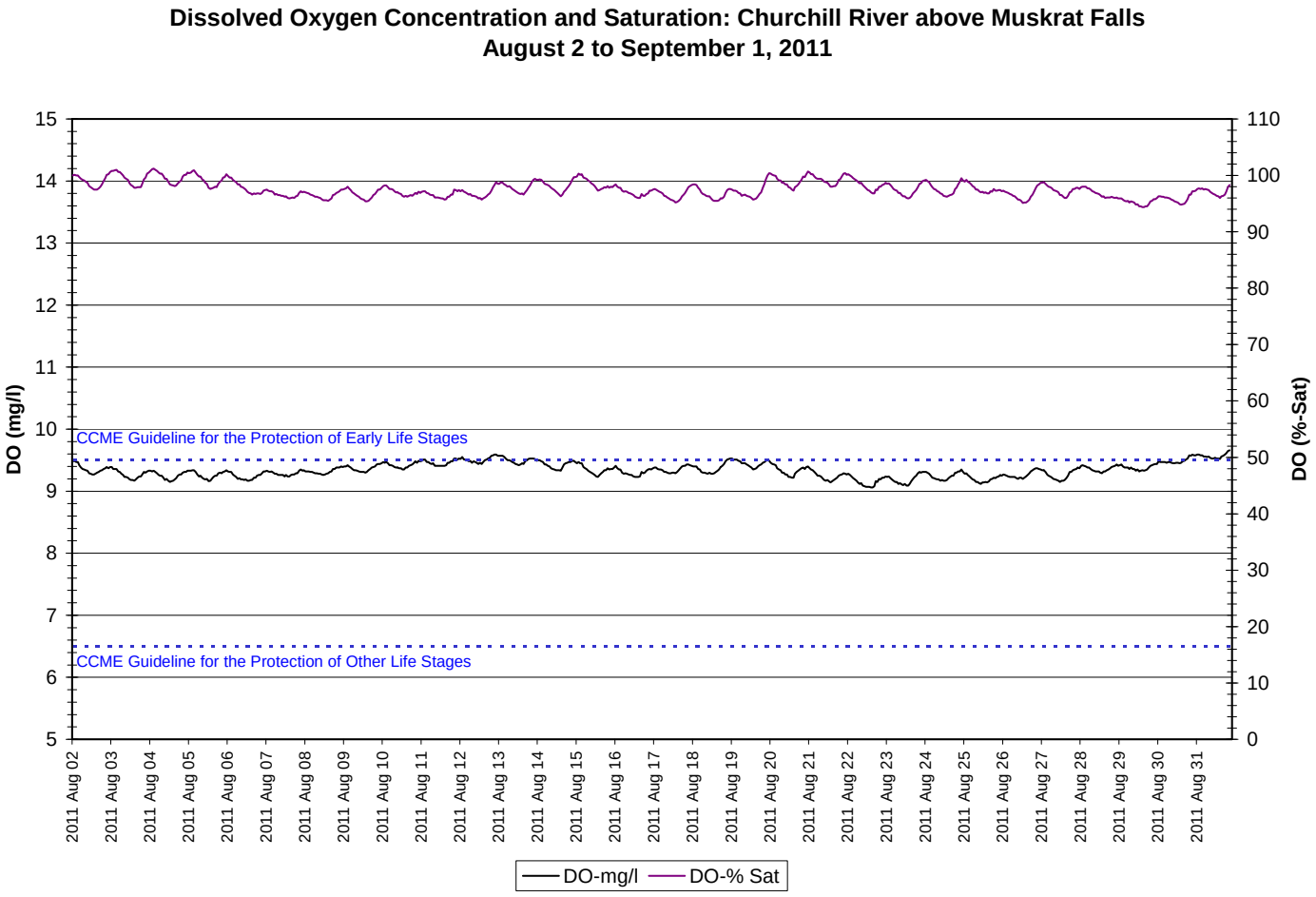

Figure 19: Dissolved oxygen and percent saturation at Churchill River above Muskrat Falls

- A range of 5.0 to 32.0 was recorded for turbidity for this deployment period (Figure 20). A median value of 7.0 NTU indicates there is a consistent natural background turbidity value at this station.
- Between August 14 and 21, there are several spikes in turbidity however there is no corresponding weather event. Stage is rising slightly at this time. A rainfall event recorded between August 26 and 31 (and stage level increase) corresponds with a turbidity increase during the same time period.

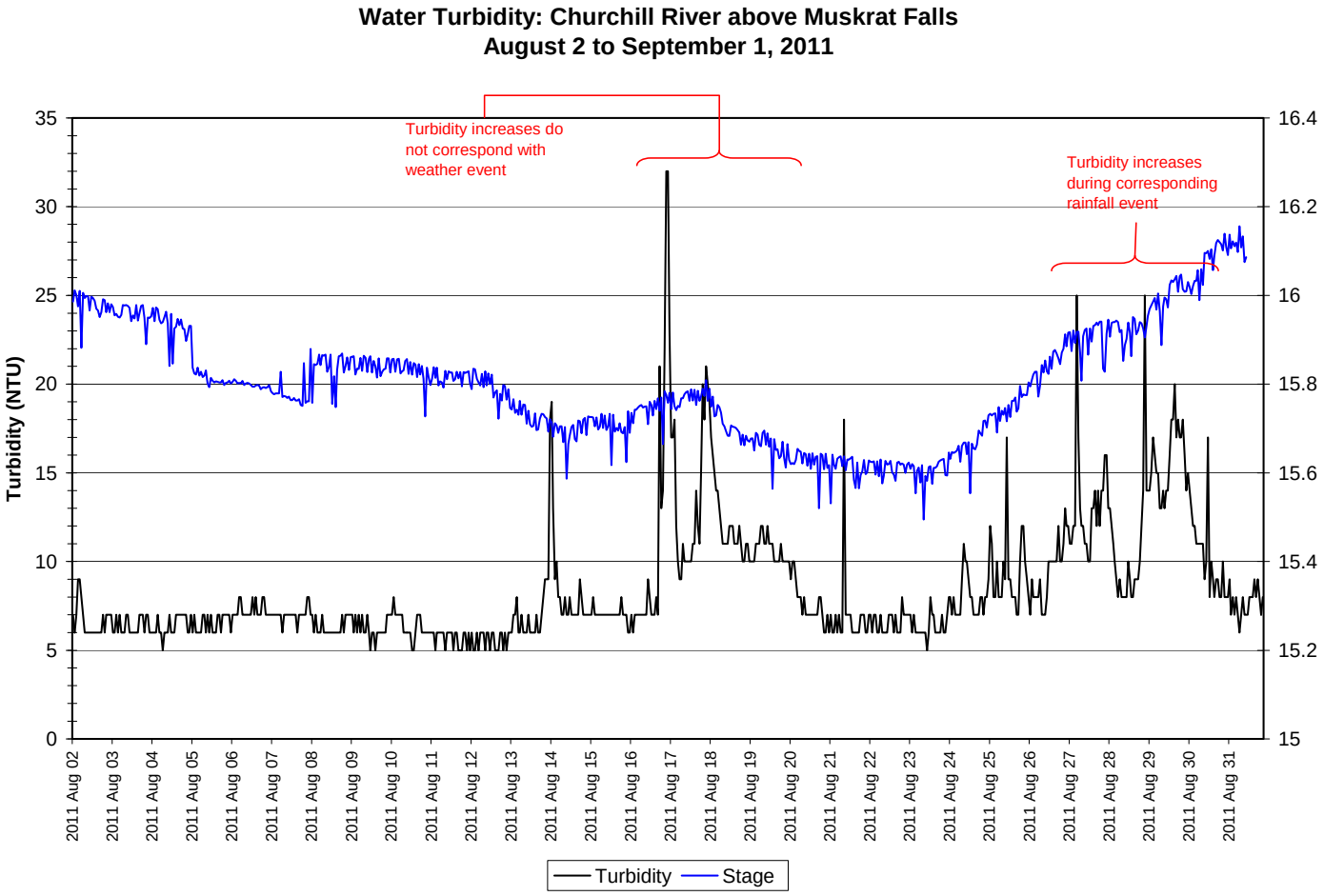

Figure 20: Turbidity and stage level at Churchill River above Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 21). Stage is generally decreasing throughout the first part of the deployment period before increasing during the last 10 days. Precipitation records vary throughout the deployment period.

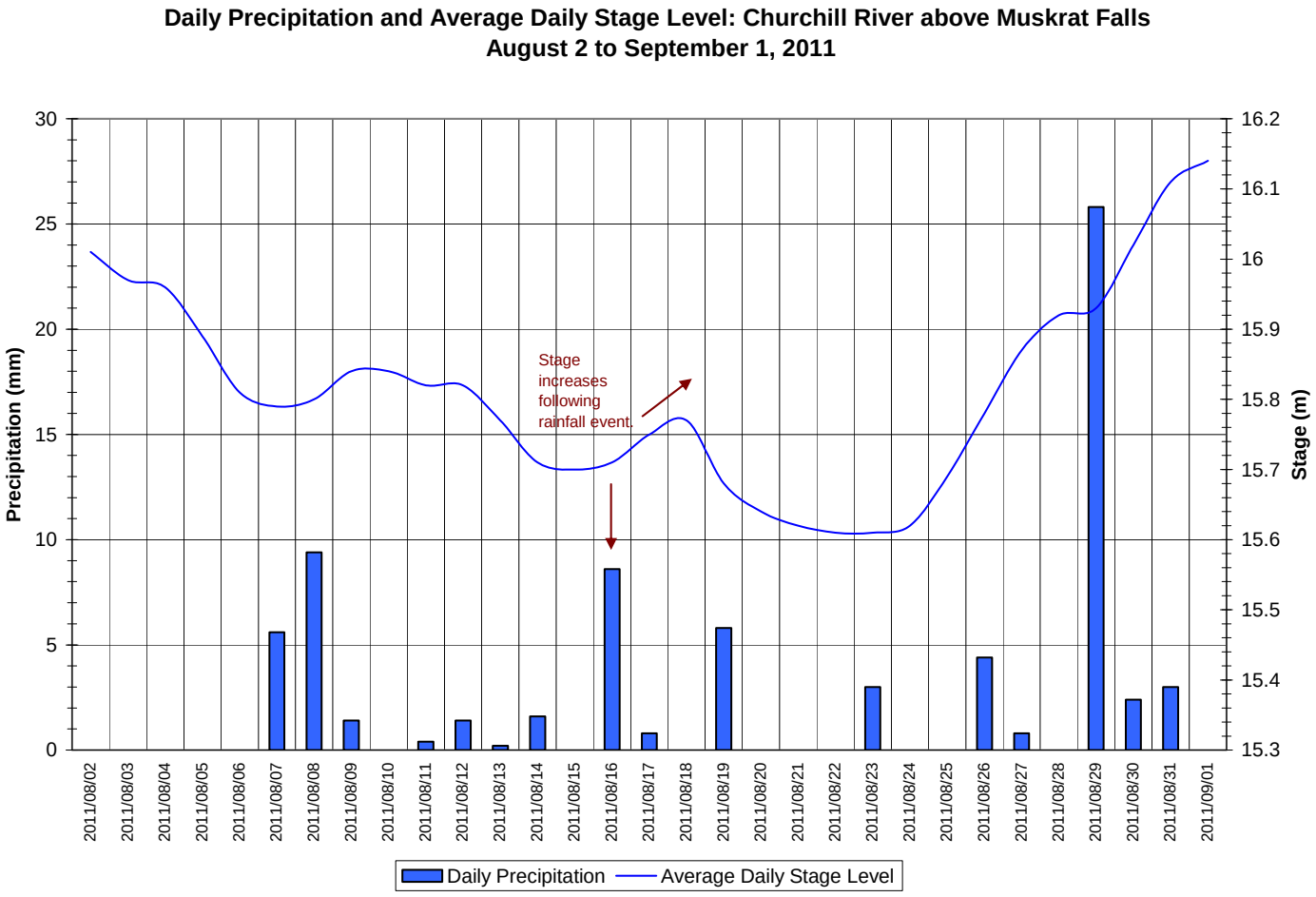

Figure 21: Daily precipitation and average daily stage level at Churchill River above Muskrat Falls (weather data recorded at Goose Bay)

Churchill River below Muskrat Falls

- The instrument deployed on August 2 experienced a dissolved oxygen sensor failure. The instrument was removed the following day, August 3, and replaced with a new instrument. Data collected for temperature, pH, and turbidity during August 2-3 is included in the discussion below. Dissolved oxygen, percent saturation and specific conductivity values have been removed from the data set during this time as the instrument was reporting inaccurate values.
- Water temperature ranges from 15.90 to 19.20^{o}C during this deployment period (Figure 22).
- Water temperature is generally stable throughout the deployment period. This trend is expected given consistent warm ambient air temperatures in the summer season (Figure 23). Water temperature fluctuates diurnally.

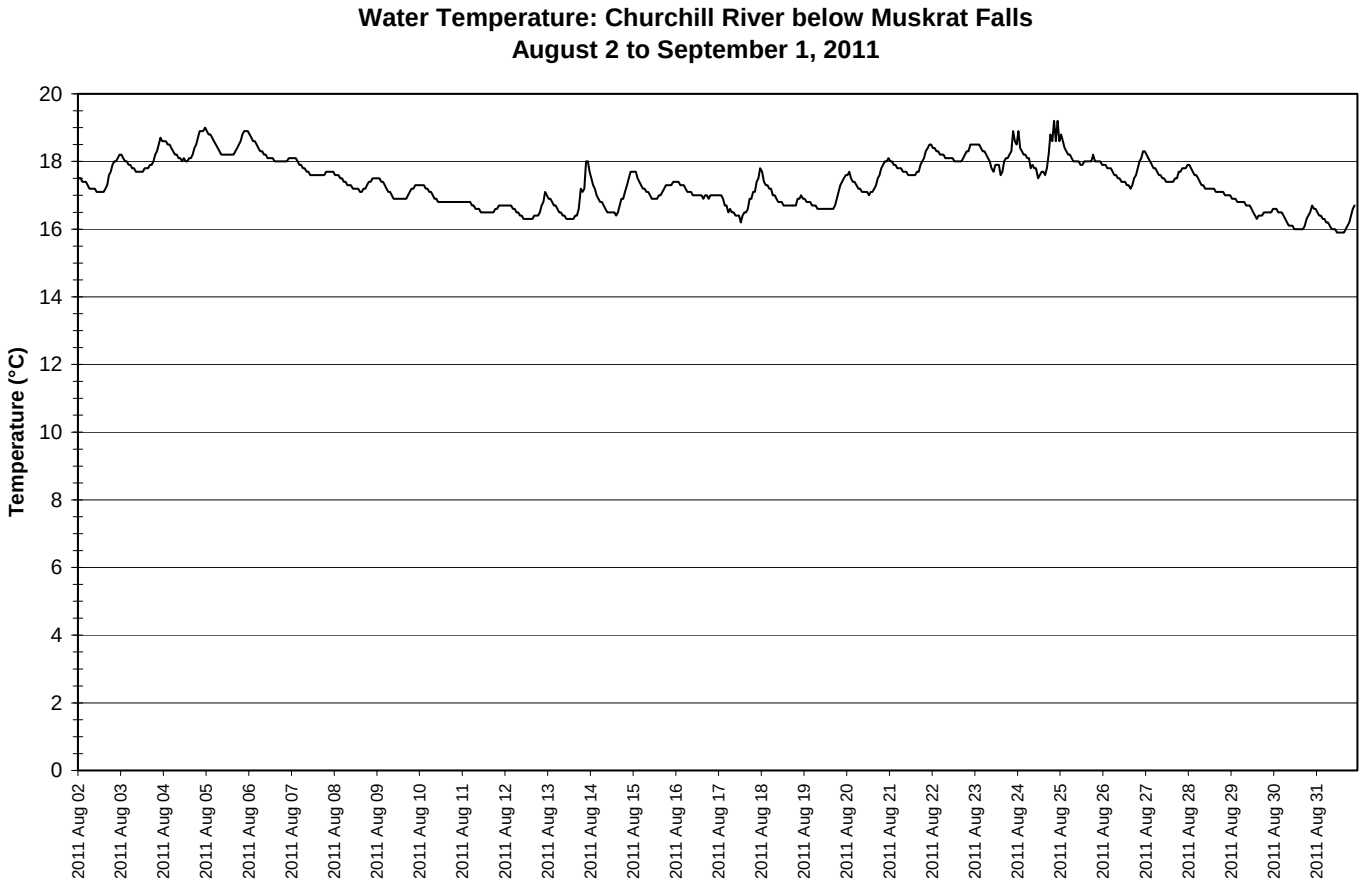

Figure 22: Water temperature at Churchill River below Muskrat Falls

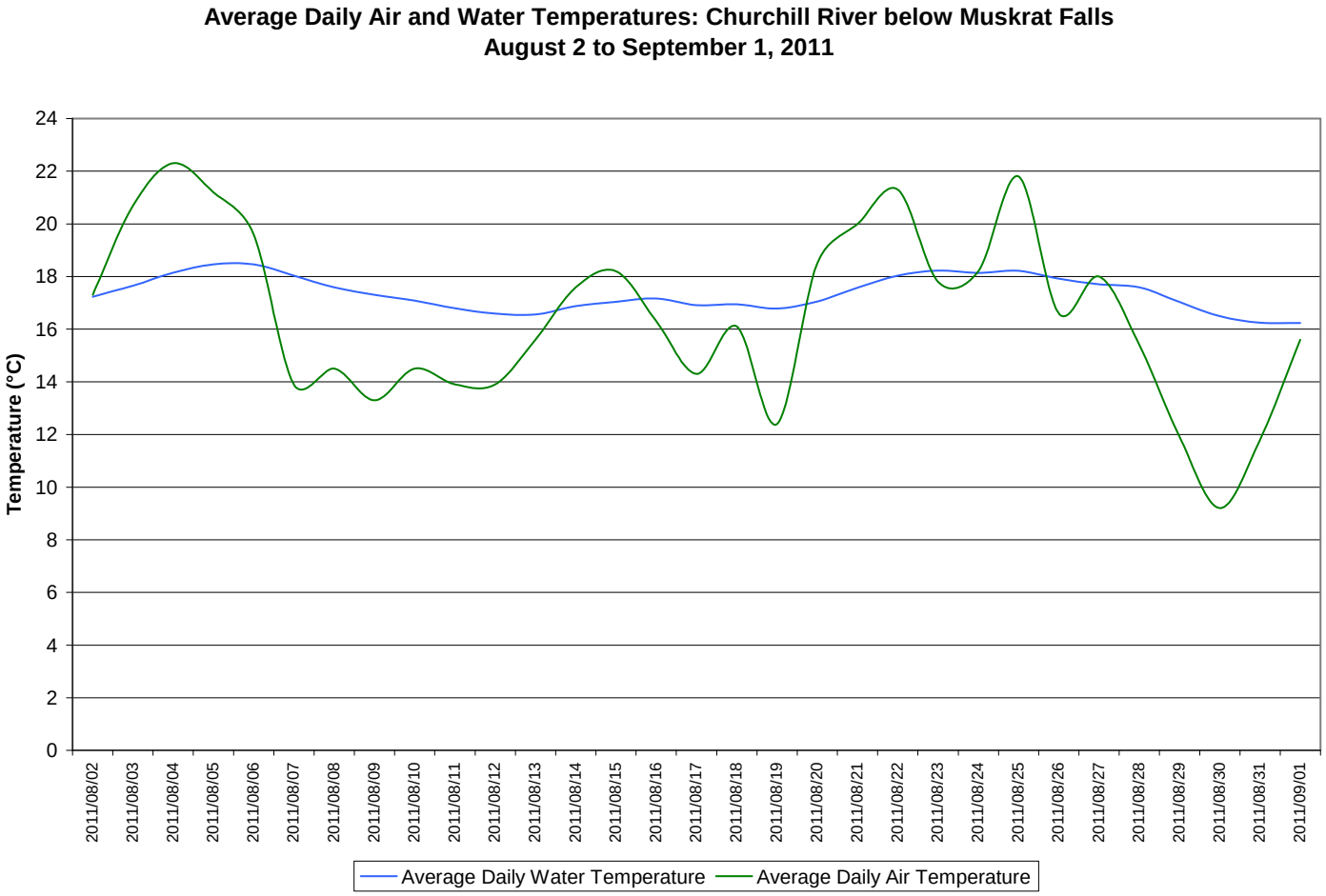

Figure 23: Average daily air and water temperatures at Churchill River below Muskrat Falls

(weather data recorded at Goose Bay)

- pH ranges between 6.85 and 7.30 pH units (Figure 24). pH values generally remain stable throughout the deployment period.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 24).
- There is a decrease in pH on August 18 lasting for 2 hours (indicated by red arrows on Figure 24). It is unknown what caused this change in pH as there is no corresponding weather event and the event is not noticeable at any of the stations further upstream. There is a slight decrease in pH on August 26. This decrease corresponds with a rainfall event recorded at the Goose Bay Airport weather station.

Water pH: Churchill River below Muskrat Falls
August 2 to September 1, 2011

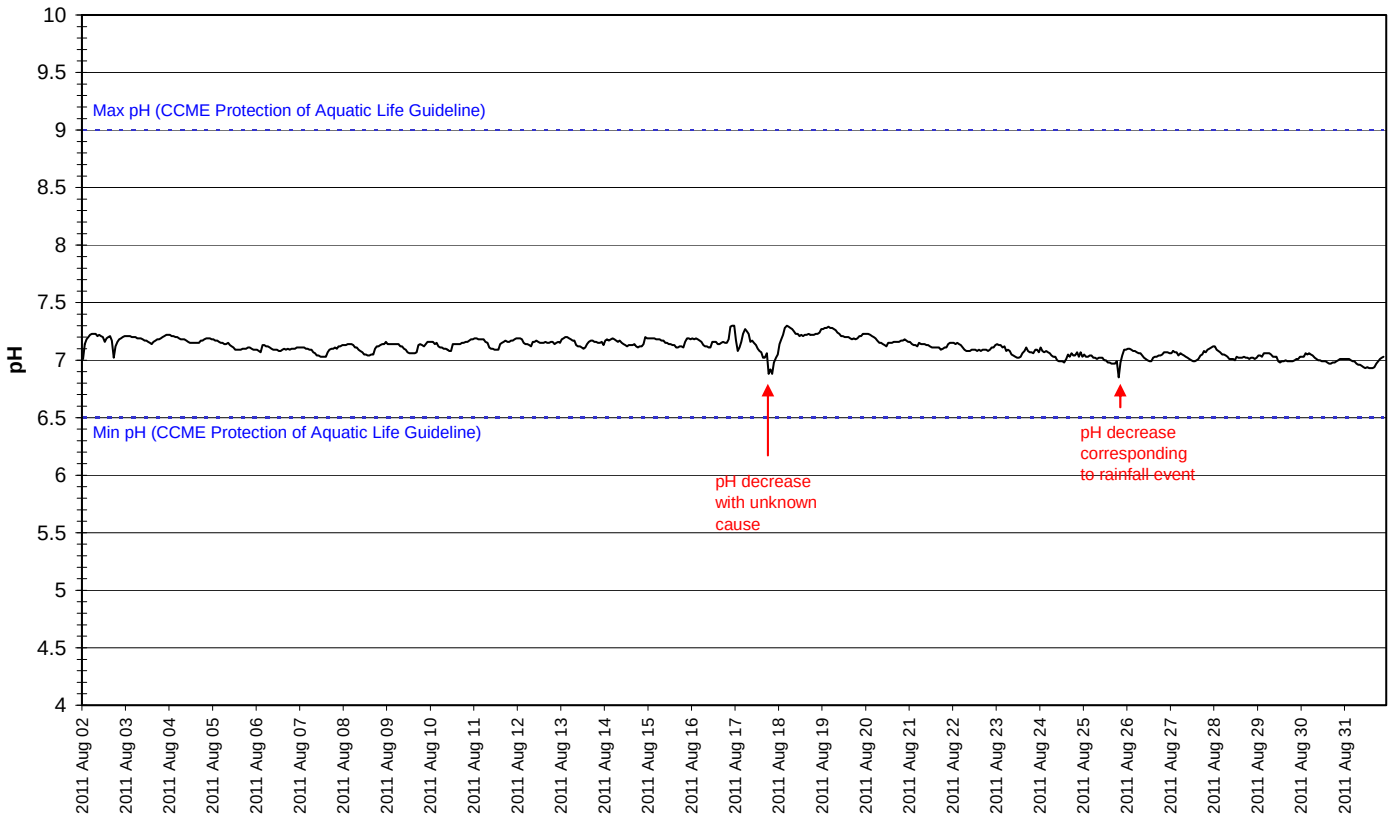

Figure 24: pH at Churchill River below Muskrat Falls

- Specific conductivity generally ranged from 12.6 to 18.0µS/cm during the deployment period (Figure 25).
- Specific conductance fluctuates throughout the deployment period at somewhat irregular intervals particularly during the first half of the deployment period. After August 18, specific conductivity fluctuates at lower magnitudes and generally remains stable for the reminder of the deployment period.
- Stage is included in Figure 25 to illustrate the inverse relationship between conductivity and water level. Stage is decreasing during the first part of the deployment period and increases during the last ten days. As stage decreases, specific conductivity typically increases. Reduction in water level increases the concentration of dissolved solids in the water column hence increasing the specific conductivity. Precipitation input can decrease the specific conductivity of the water body by diluting the concentration of dissolved solids present.

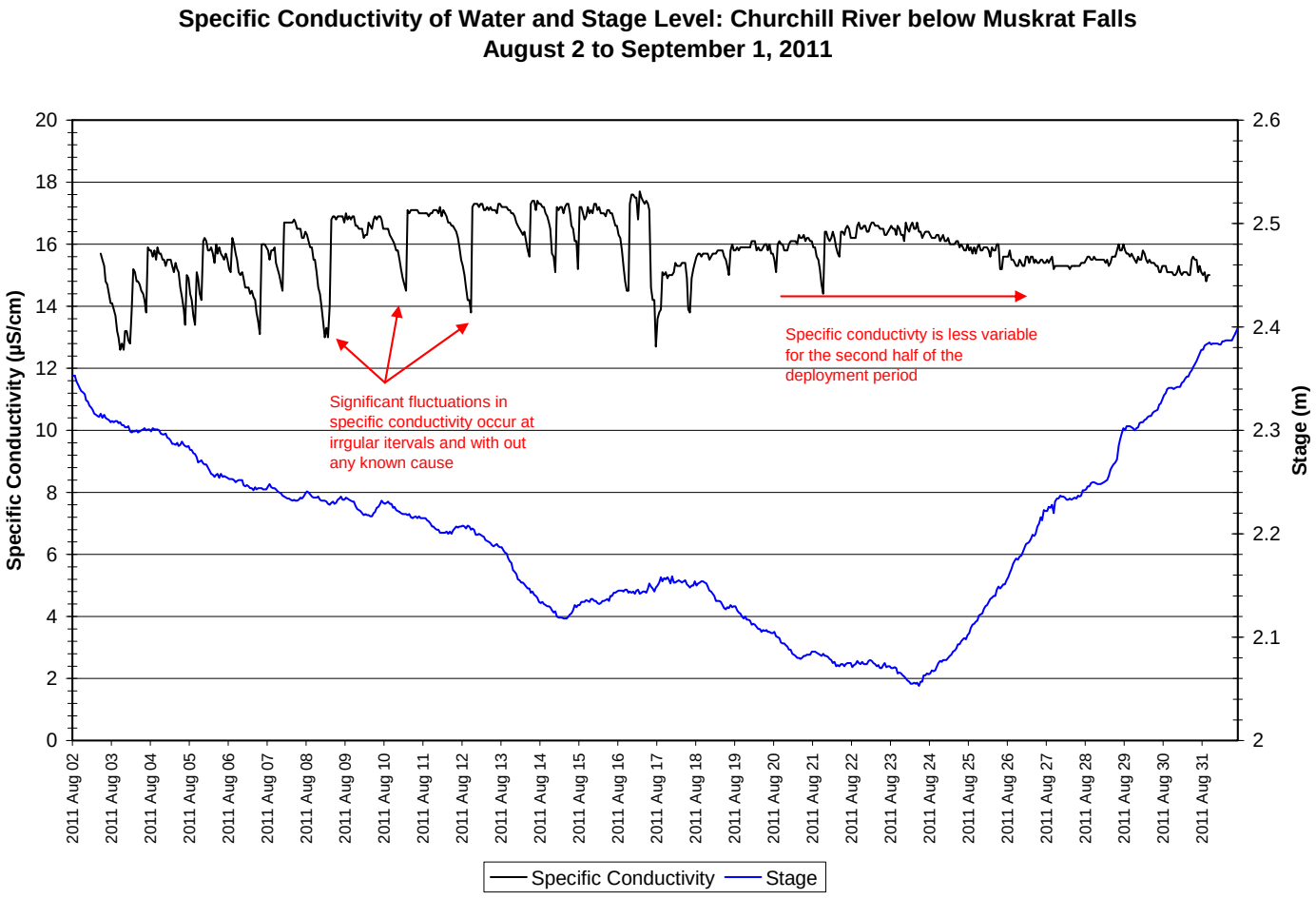

Figure 25: Specific conductivity and stage level at Churchill River below Muskrat Falls

- The saturation of dissolved oxygen generally ranged from 101.5 to 114.0% and a range of 9.71 to 10.79mg/l was found in the concentration of dissolved oxygen with a median value of 10.42mg/l (Figure 26).
- All values were above both the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l and the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l. The guidelines are indicated in blue on Figure 26.
- There are a few instances of decreased dissolved oxygen and percent saturation on August 18 and then again from August 24 to 28. Both instances correspond with periods of decreased pH, the former which caused by an unknown source and the latter which corresponds with a rainfall event.
- Dissolved oxygen content is generally stable throughout the deployment period. This trend is expected given the consistent air and water temperatures during the deployment period (Figure 23). Dissolved oxygen is typically higher at this station compared to the other stations further upstream due to the addition of oxygen to the water at Muskrat Falls.

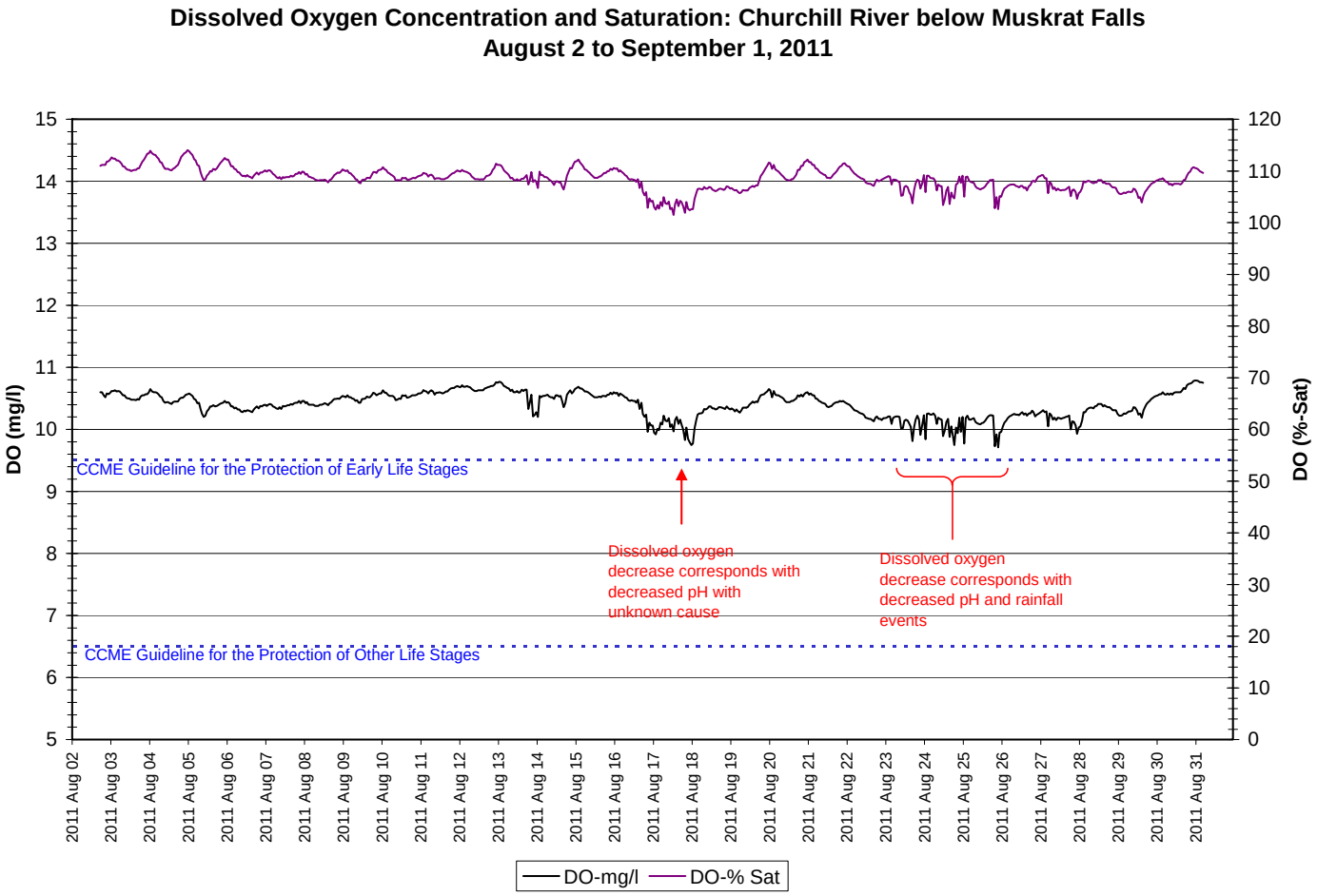

Figure 26: Dissolved oxygen and percent saturation at Churchill River below Muskrat Falls

- A range of 0.9 to 208.4NTU was recorded for turbidity for this deployment period (Figure 27). A median value of 4.3 NTU indicates there is a consistent natural background turbidity value at this station.
- An increase in turbidity on August 17-18 corresponds with increase pH and dissolved oxygen and follows a rainfall event recorded on August 16.
- Turbidity values fluctuate (5 – 100NTU) in the last ten days of the deployment period while stage levels are rising (indicated by red arrows on Figure 27).

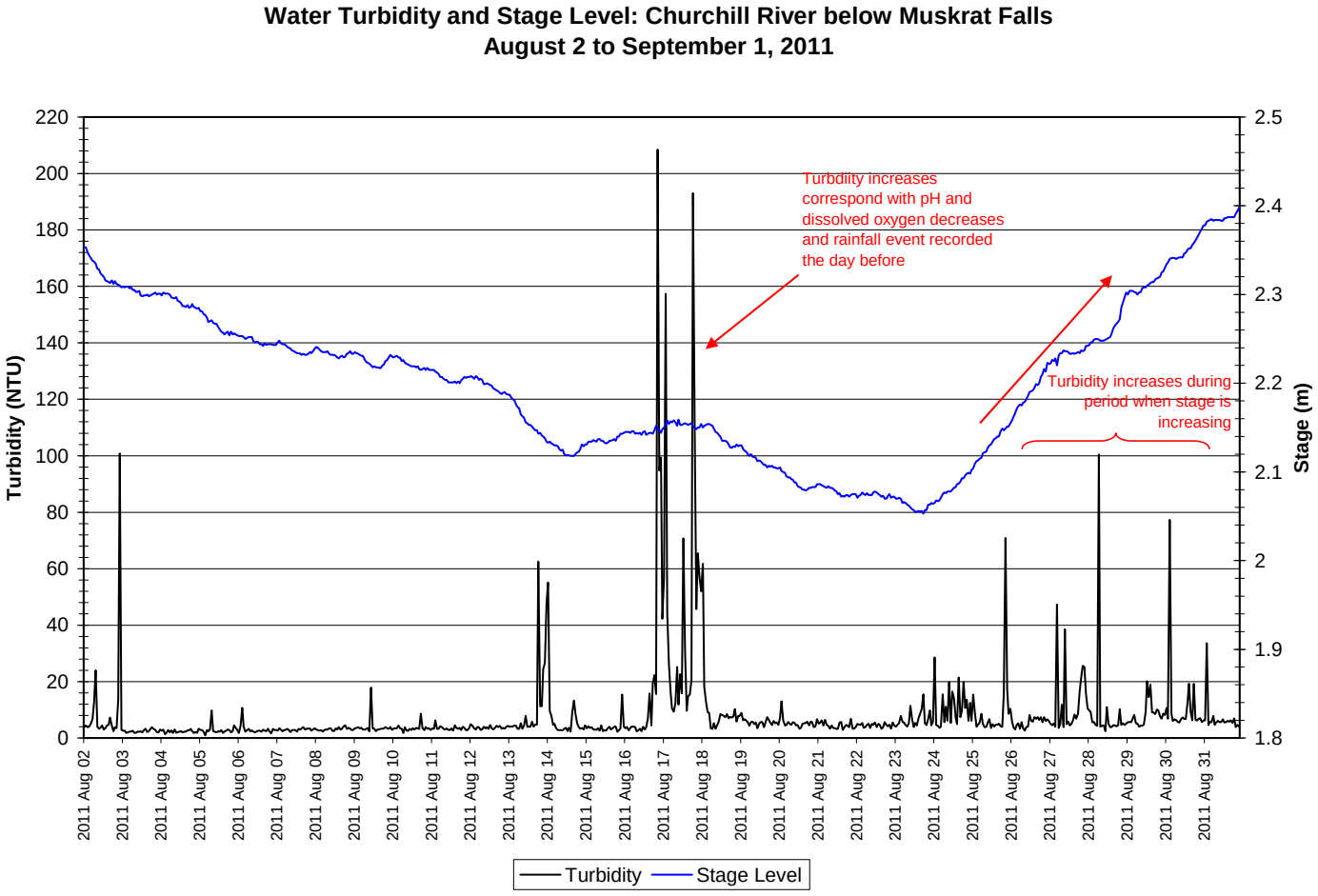

Figure 27: Turbidity and stage level at Churchill River below Muskrat Falls

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 28). Stage is generally decreasing throughout the deployment period before increasing during the final 10 days. Precipitation varies through out the deployment period.

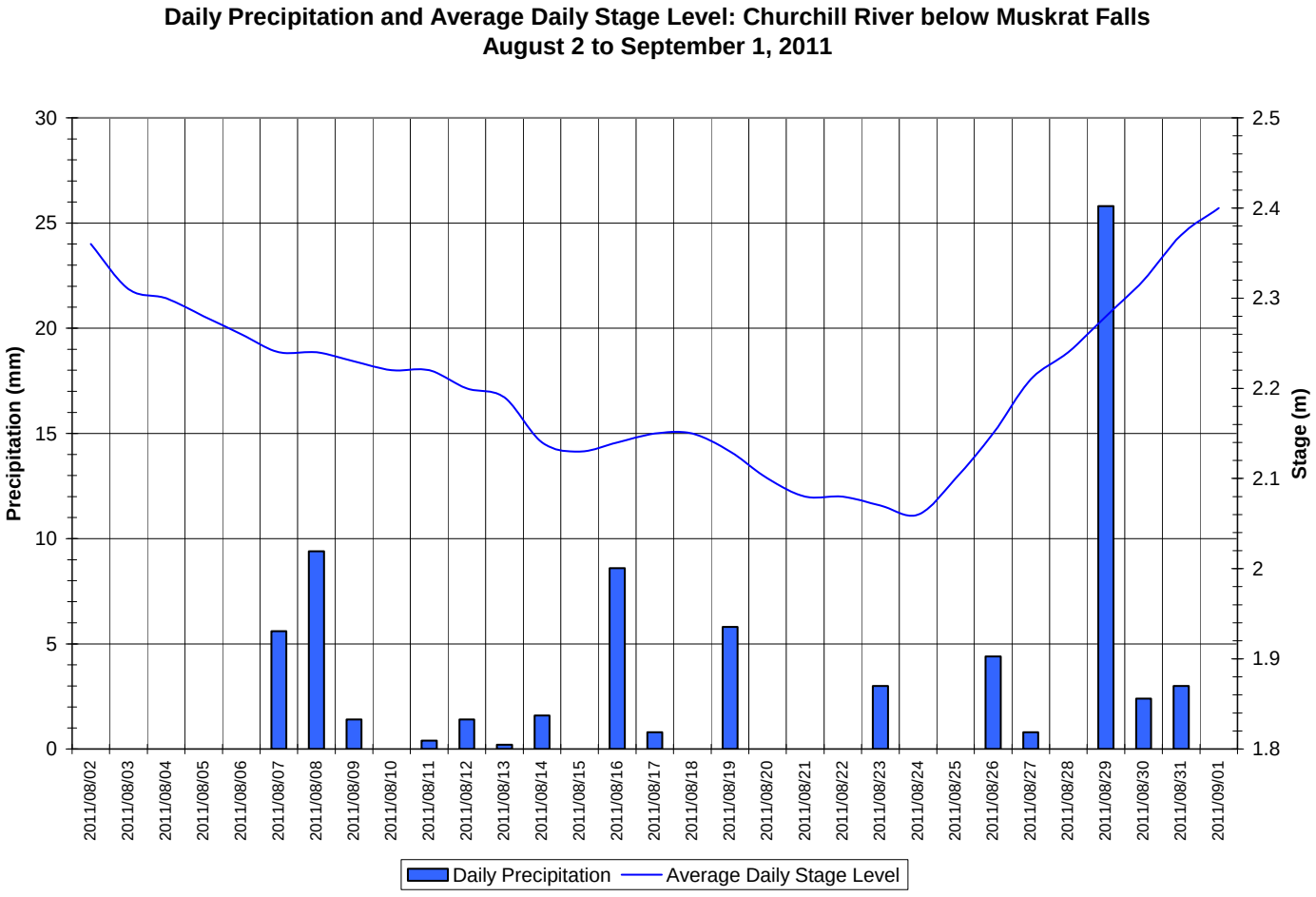

Figure 28: Daily precipitation and average daily stage level at Churchill River below Muskrat Falls (weather data recorded at Goose Bay)

Conclusions

- Instruments at four water quality monitoring stations on the Lower Churchill River were deployed from August 2 to September 1, 2011.
- No significant water quality events were captured during this time. In most cases, weather related events or increase/decreases in water level could be used to explain the fluctuations.
- Stage levels generally decreased for the first part of the deployment period and then consistently increased during the last ten days across the four stations.
- Water temperature was generally stable at all stations throughout the deployment period due to the consistent warm ambient air temperatures in the region during the summer season. Water temperature typically ranged between 15°C and 19°C and fluctuated up to 2°C between day and night.
- pH values were all within the recommended CCME Guidelines for the Protection of Aquatic Life. There was a short-lived decrease in pH lasting only a few hours which was only noticeable at the station below Muskrat Falls.
- Specific conductance fluctuated inversely to the changing stage level. In most cases, as specific conductivity increased, stage decreased and vice versa. There were a few instances where specific conductivity increased sharply above the average conditions however these increases are generally short-lived. Specific conductivity averages between 18µS/cm and 22µS/cm at the three stations upstream of Muskrat Falls while the fourth station below Muskrat Falls averages slightly less between 12µS/cm and 18µS/cm.
- Dissolved oxygen content was generally stable throughout the deployment period at all four stations as water temperatures were consistent and warm. All values were above the CCME Guideline for the Protection of Aquatic Life for other life stages. Dissolved oxygen content at station below Metchin River, below Grizzle Rapids and above Muskrat Falls all saw the dissolved oxygen content just slightly below the CCME Guideline for the Protection of Aquatic Life for Early Life stage throughout the deployment period when the water temperatures were at the seasonal high. The station below Muskrat Falls consistently has high dissolved oxygen content due to the location of the Muskrat Falls, 6km upstream.
- Turbidity events were infrequent and of low magnitude at stations below Metchin River and below Grizzle Rapids which is typical for these stations. At the station above and below Muskrat Falls, there is a natural background turbidity value. These stations are also more susceptible to turbidity increases during rainfall and weather events. Recovery periods for turbidity events range depending on the size of the disturbance and vary from 1 to 8 days.

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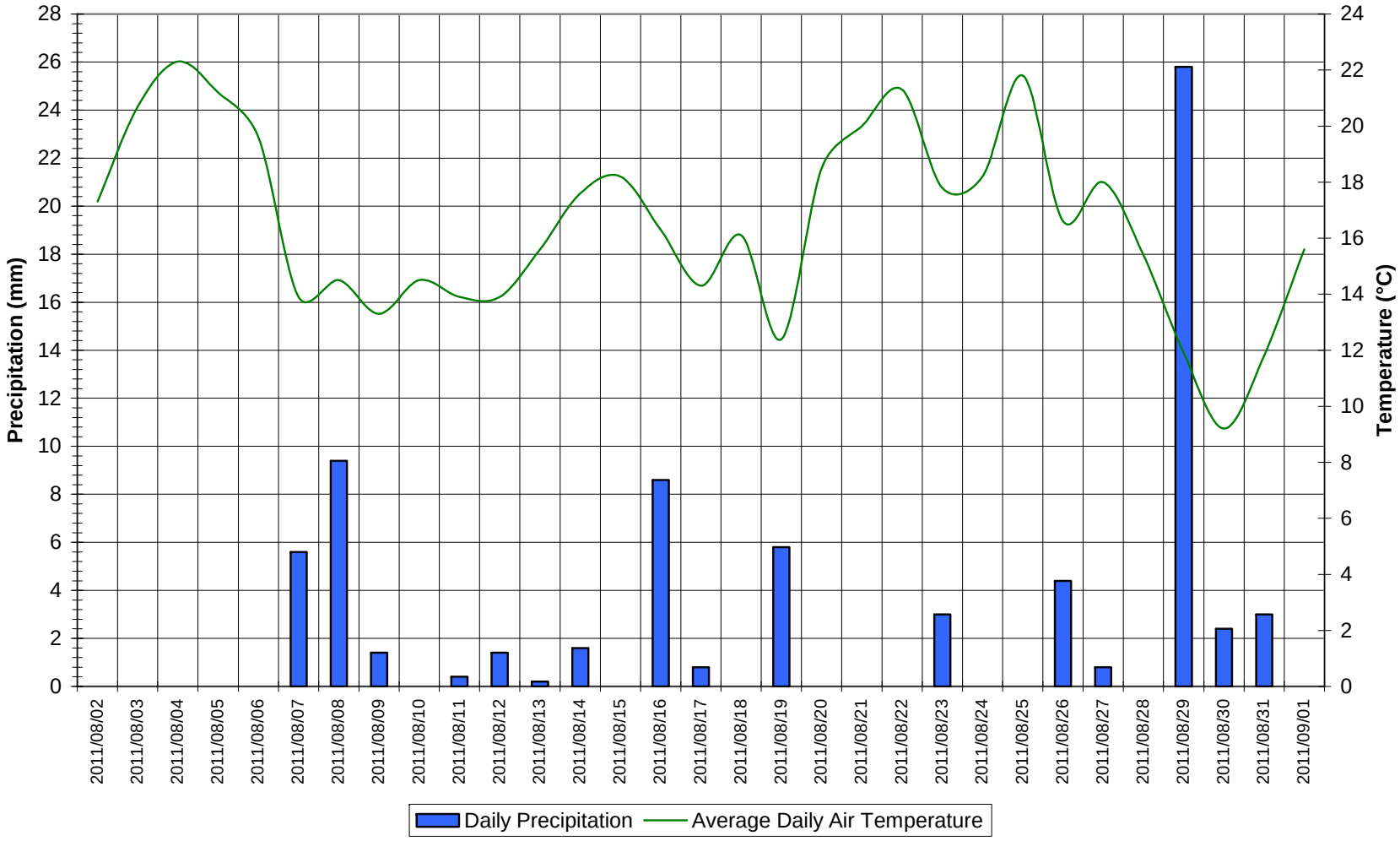
Appendix 1

Average Daily Air Temperature and Daily Precipitation: Happy Valley Goose Bay, NL
August 2 to September 1, 2011



Average Daily Air Temperature and Daily Precipitation: Churchill Falls, NL
August 2 to September 1, 2011