Real-Time Water Quality

2010 Annual Deployment Report

Lower Churchill River Network

May 20 to November 3, 2010

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

Real-Time Water Quality Deployment Report

Lower Churchill River Network

May 20 to November 3, 2010

Table of Contents

Acknowledgements

The Real-Time Water Quality Monitoring (RTWQM) Network on the Lower 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 Environment and Conservation (ENVC) as well as Environment Canada (EC) to ensure the protection of ambient water resources in the Lower Churchill River.

Various individuals from ENVC have been integral in ensuring the smooth operation of such a technologically advanced network. In 2010, ENVC Environmental Scientist, Grace Gillis, was responsible for deployment and removal of instruments including cleaning/calibration and preparation of monthly deployment reports. Keith Abbott, Tara Clinton, Ryan Pugh, and Eric Watton are acknowledged for their efforts during deployment and removal procedures in 2010.

EC staff, under the Meteorological Service of Canada Water Survey Canada (Brent Ruth, Perry Pretty, Roger Ellsworth, Dwayne Akerman and Mike Ludwicki) play an essential role in the data logging/communication aspect of the network. These individuals visit the site regularly to ensure the data logging equipment is operating properly and transmitting the data efficiently. Finally, they play the lead role in dealing with hydrological quantity and flow issues.

The managers from each agency (Marion Organ – Nalcor; Robert Picco and Renee Paterson - ENVC; Howie Wills – EC) are fully committed to improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in the decision-making process. In June 2010, Renee Paterson participated in a monitoring workshop hosted by Nalcor and AMEC. In November 2010, a meeting between ENVC, EC and Nalcor was held to discuss the Memorandum of Agreement for real time monitoring and how the program can be improved to meet the needs of all parties involved. This network is continually successful due the participation and collaboration of all three agencies.

Introduction

- The real-time water quality monitoring network on the Lower Churchill was successfully established by ENVC and EC in cooperation with Nalcor Energy in fall 2008.
- The objective of the network is to identify and track any emerging water quality or quantity management issues and ensure protection of ambient water resources along the Lower Churchill River. The information currently 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 RTWQM network consists of 4 stations along the Churchill River from just below the confluence with Metchin River to just below Muskrat Falls. These stations measure water quality parameters such as water temperature, pH, specific conductivity, dissolved oxygen, and turbidity. Two additional parameters, total dissolved solids and percent saturation are calculated from measured parameters.
- These stations as well as 2 additional stations along the Lower Churchill record continuous stage level and flow rate data. These parameters are the responsibility of EC, however, if needed, ENVC staff reporting on water quality will have access to water quantity information to understand and explain water quality fluctuations.
- Continuous monitoring recommenced in spring 2010 when ice conditions permitted. This annual deployment report illustrates, discusses and summarizes water quality related events from May 20 to November 3, 2010. During this time, 6 visits were made to each of the 4 real time monitoring sites. Instruments were deployed for five, month long intervals referred to as deployment periods.
- ENVC staff monitors the real-time web pages regularly.

Maintenance and Calibration of Instrument

- It is recommended that regular maintenance and calibration take place on a monthly basis to ensure accurate data collection. This procedure is the responsibility of the ENVC staff and is performed preferably every 30 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, ENVC staff carefully calibrates each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity.
- An extended deployment period (>30 days) can result in Datasonde sensor drift which may result in skewed data. The Datasonde sensors will still work to capture any water quality event even though the exact data values collected may be inaccurate. Installation and removal dates for each station in the 2009 deployment season are summarized in Table 1.

Table 1: Installation and removal dates for 2010 deployment periods

Installation	Removal	Deployment Period
20-May	23-Jun	34
23-Jun	23-Jul	30
23-Jul	22-Aug	30
22-Aug	21-Sep	30
21-Sep	2/3-Nov	42/43

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QAQC), 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 Sonde is temporarily deployed along side the Field Sonde. 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 Sonde and QAQC Sonde at deployment, a qualitative statement is made on the data quality (Table 2).
  - ► At the end of a deployment period, readings are taken in the water body from the Field Sonde before and after a thorough cleaning in order to assess the degree of biofouling. During calibration in the laboratory, an assessment of calibration drift is made and the two error values are combined to give Total Error (T_e). If T_e exceeds a predetermined data correction criterion, a correction based on T_e is applied to the dataset using linear interpolation.

Table 2: 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 sonde 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 sonde the entire sonde 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 Churchill River stations deployed between May 20 and November 2/3, 2010 are summarized in Table 3.

Table 3: Comparison rankings for Churchill River stations, May 20 – November 2/3, 2010

Station	Date	Action	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Muskrat Falls	20-May-10	Deployment	Good	Good	Excellent	Poor	Good
	23-Jun-10	Removal	Good	Good	Good	Marginal	Good
	23-Jun-10	Deployment	Good	Good	Excellent	Excellent	Excellent
	23-Jul-10	Removal	Good	Good	Excellent	Good	Excellent
	23-Jul-10	Deployment	Excellent	Good	Excellent	Good	Excellent
	22-Aug-10	Removal	Good	Good	Excellent	Excellent	Excellent
	22-Aug-10	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	21-Sep-10	Removal	Good	Good	Excellent	Excellent	Poor
	21-Sep-10	Deployment	Good	Excellent	Excellent	Excellent	Poor
	3-Nov-10	Removal	Fair	Good	Excellent	Excellent	Fair
Above Muskrat Falls	20-May-10	Deployment	Good	Good	Excellent	Fair	Excellent
	23-Jun-10	Removal	Instrument exposed to air upon removal				
	23-Jun-10	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	23-Jul-10	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
	23-Jul-10	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	22-Aug-10	Removal	Good	Good	Excellent	Excellent	Excellent
	22-Aug-10	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	21-Sep-10	Removal	Excellent	Good	Excellent	Excellent	Poor
	21-Sep-10	Deployment	Good	Fair	Excellent	Excellent	Good
	2-Nov-10	Removal	Good	Fair	Excellent	Excellent	Excellent
Below Grizzle Rapids	20-May-10	No Deployment					
	23-Jun-10						
	23-Jun-10	Deployment	Excellent	Fair	Excellent	Excellent	Excellent
	23-Jul-10	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
	23-Jul-10	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	22-Aug-10	Removal	Excellent	Good	Excellent	Excellent	Excellent
	22-Aug-10	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	21-Sep-10	Removal	Excellent	Fair	Excellent	Excellent	Excellent
	21-Sep-10	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	2-Nov-10	Removal	Excellent	Fair	Excellent	Excellent	Excellent
Below Metchin River	20-May-10	Deployment	Excellent	Good	Excellent	Poor	Excellent
	23-Jun-10	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
	23-Jun-10	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	23-Jul-10	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
	23-Jul-10	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	22-Aug-10	Removal	Excellent	Good	Good	Excellent	Excellent
	22-Aug-10	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	21-Sep-10	Removal	Good	Fair	Excellent	Excellent	Excellent
	21-Sep-10	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	2-Nov-10	Removal	Good	Fair	Excellent	Excellent	n/a*

* The turbidity sensor on the instrument deployed at the station below Metchin River reported erratic, uncharacteristic data for the entire deployment period due to a large invertebrate living on the sensor. Data for this period is not valid and therefore not ranked.

Data Interpretation and Review

- The following graphs and discussion illustrate significant water quality-related events from May 20 to November 3 in the Lower Churchill River Network. In this summary of the deployment periods for 2010, general trends will be discussed. More detailed analysis and discussion of specific events can be found in the monthly deployment reports.
- For a general comparison, 2009 data has been included in the following graphs to show differences in trends in water quality on the Lower Churchill River over the past 2 years.
- 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 QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request. Where appropriate, corrected data for water quality parameters are indicated.

Churchill River below Muskrat Falls

- Water temperature ranged from 2.30 to 19.30°C during the 2010 deployment season (Figure 1a).
- On average, water temperatures are about 0.5°C warmer in 2010 than in 2009. Most noticeable is the warmer temperatures in fall 2010 when compared to the same season in the previous year.
- Water temperature values show a typical seasonal trend (Figure 1b). Water temperature is increasing for the first part of the deployment season during the spring and early summer. Water temperature peaks in late August at 19.3°C. Water temperature begins to decrease in the beginning of September.

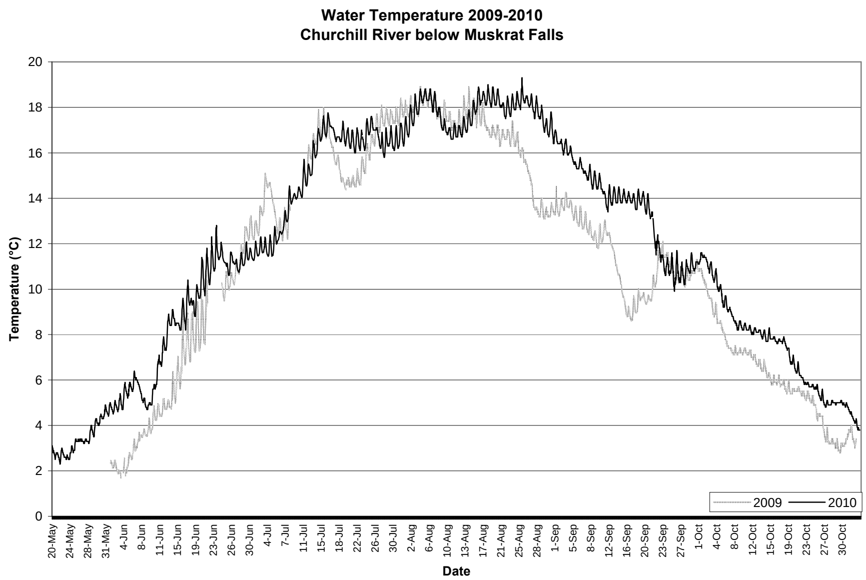


Figure 1a: Water temperature at Churchill River below Muskrat Falls

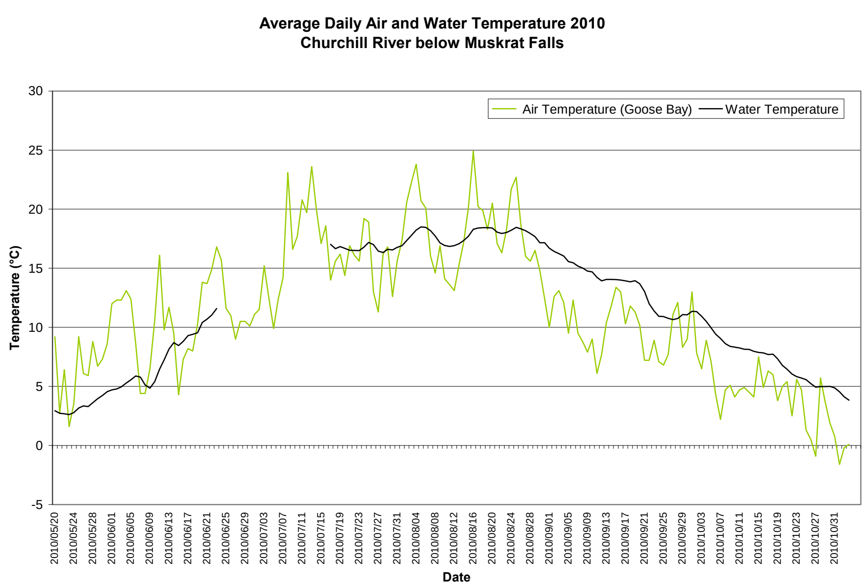


Figure 2b: Average daily air and water temperature at Churchill River below Muskrat Falls

- pH ranges between 6.51 and 7.63 pH units throughout the 2010 deployment season (Figure 2).
- All values during the deployment season are within the CCME Guidelines for the Protection of Aquatic Life. Guidelines are indicated in blue on Figure 2.
- pH values in 2010 are comparable to those values recorded in 2009.

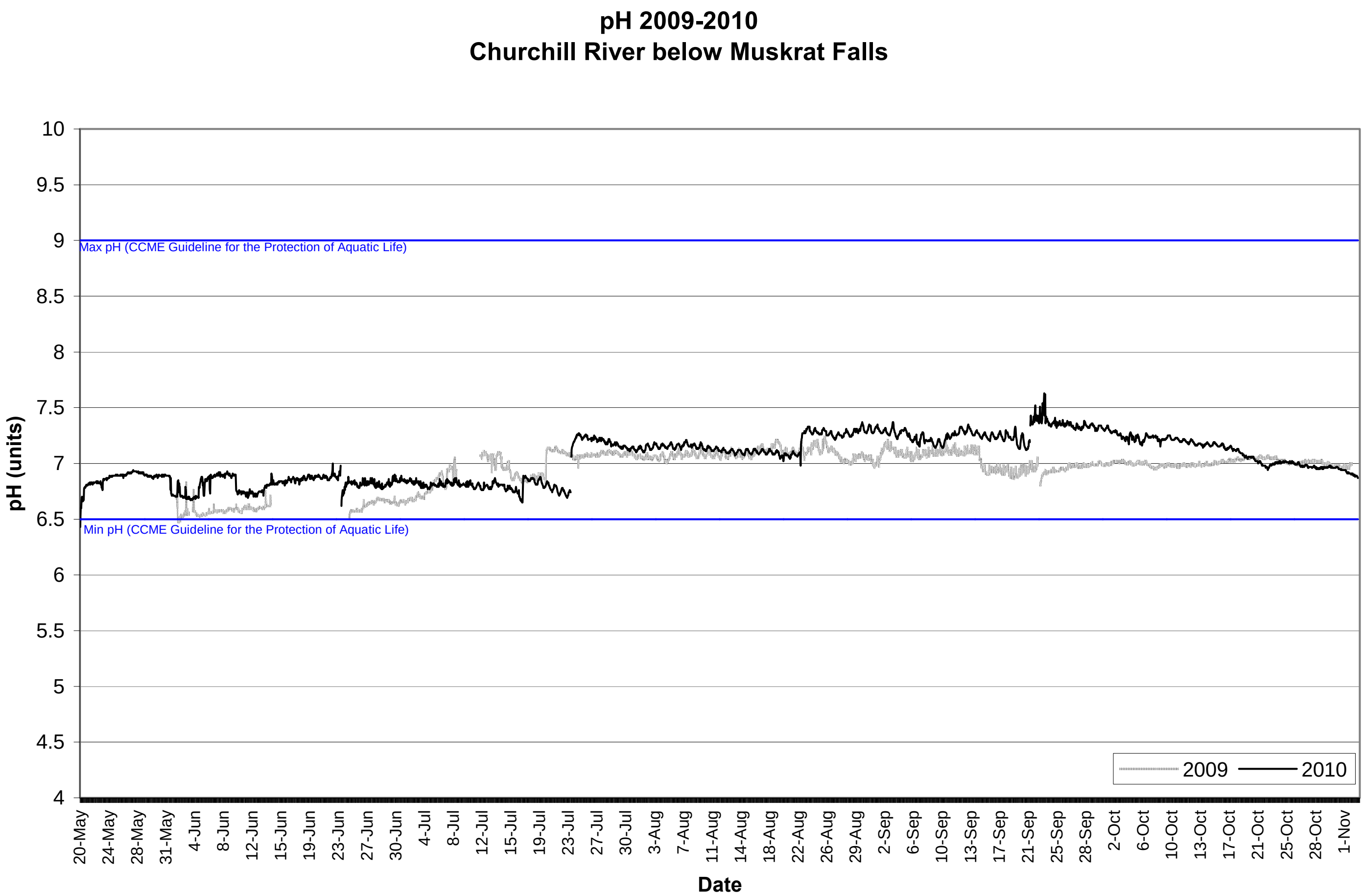


Figure 3: pH at Churchill River below Muskrat Falls

- Specific conductivity ranges from 9.9 to 23.0µS/cm during the 2010 deployment season (Figure 3).
- Specific conductivity generally rises throughout the spring and summer months, peaking on September 18. This rise corresponds with decreasing stage level as seasonal low stage levels are recorded in late September. This trend and correspondence is due to the dilution effect on total dissolved solids in the water column.
- When compared to data in 2009, specific conductance values peak much earlier in mid-summer; however stage levels for that year were at their lowest for the season, similar to the trend observed in 2010.

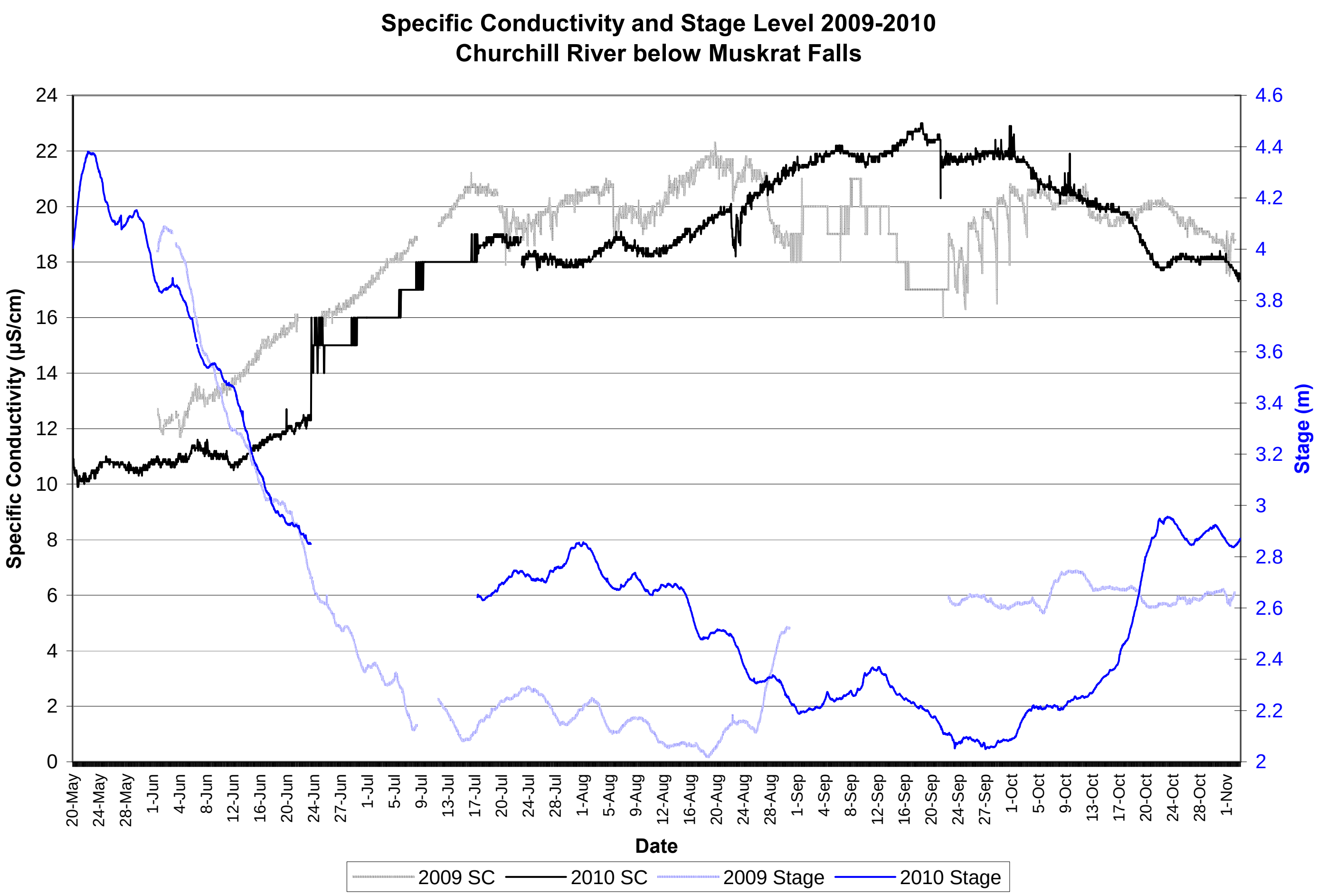


Figure 4: Specific conductivity and stage level at Churchill River below Muskrat Falls

- Dissolved oxygen content ranges between 9.85 and 15.34mg/L for the 2010 deployment season (Figure 4).
- 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 4
- Dissolved oxygen content shows a typical seasonal fluctuation, decreasing throughout the spring and early summer months during the time when water temperatures are increasing. Dissolved oxygen content reaches a seasonal low on August 27, 2010. When water temperatures begin to decrease in the late summer, dissolved oxygen content begins to rise again.
- When compared to data from 2009, there is a similar trend due to the inverse relationship between dissolved oxygen and water temperature. Water temperatures in the fall 2010 were warmer than in 2009, therefore dissolved oxygen content during this time is slightly lower than in 2009.

Dissolved Oxygen 2009-2010
Churchill River below Muskrat Falls

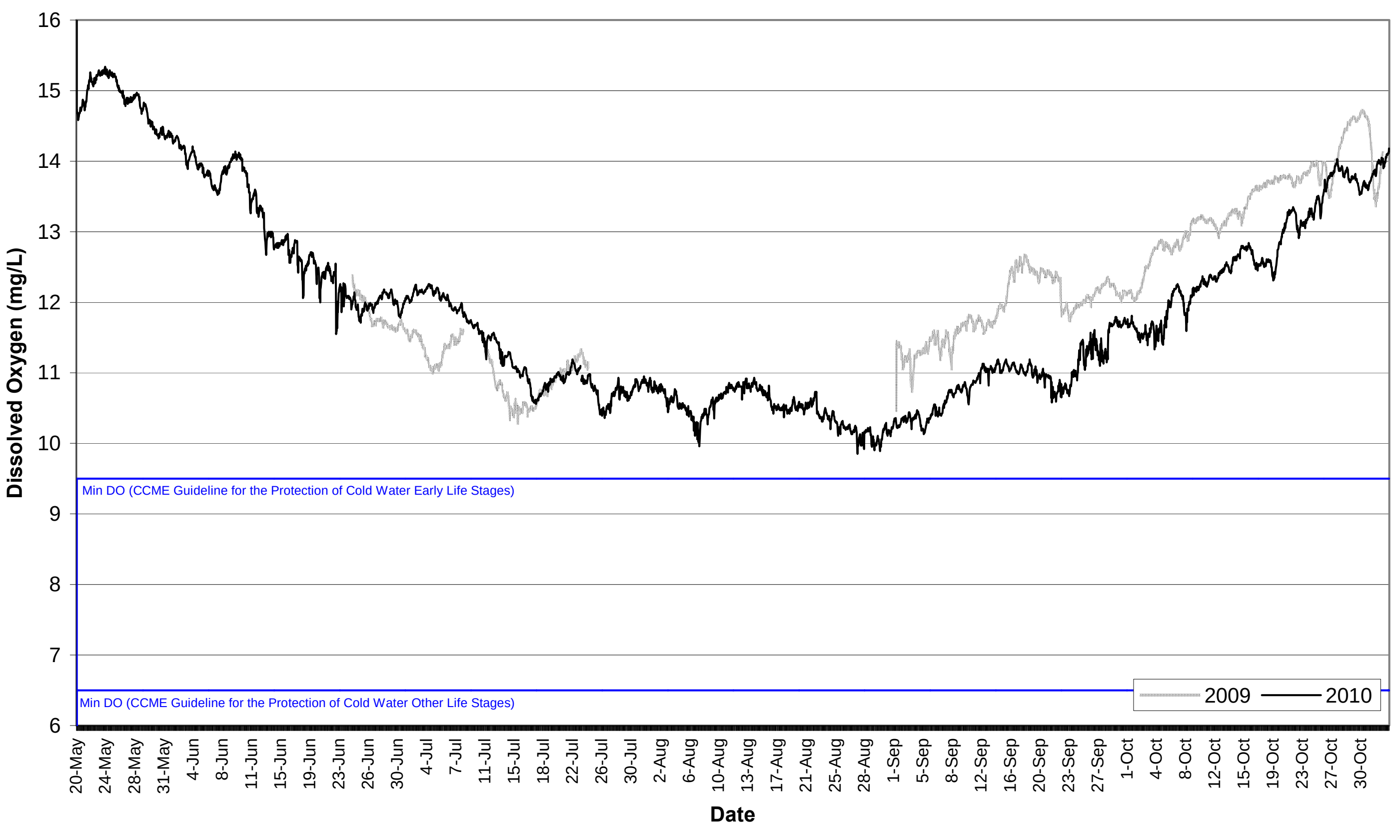


Figure 5: Dissolved oxygen at Churchill River below Muskrat Falls

- Turbidity values at this station ranged between 0.0 and 944.0NTU during the 2010 deployment season (Figure 5a & 5b). A median value of 5.2 NTU indicates there is a consistent natural background turbidity value at this station.
- Figure 5a shows turbidity data on a scale from 0 to 500NTU to illustrate the more significant events. Figure 5b displays the same data on a smaller scale, 0 to 100NTU, to clearly show the background turbidity values throughout the deployment season.
- There are several variations in turbidity values throughout the 2010 season, most of which are related to weather conditions and precipitation events.
- Data from 2009 shows a similar trend with the median value for the 2009 deployment season slightly higher at 9.6NTU.

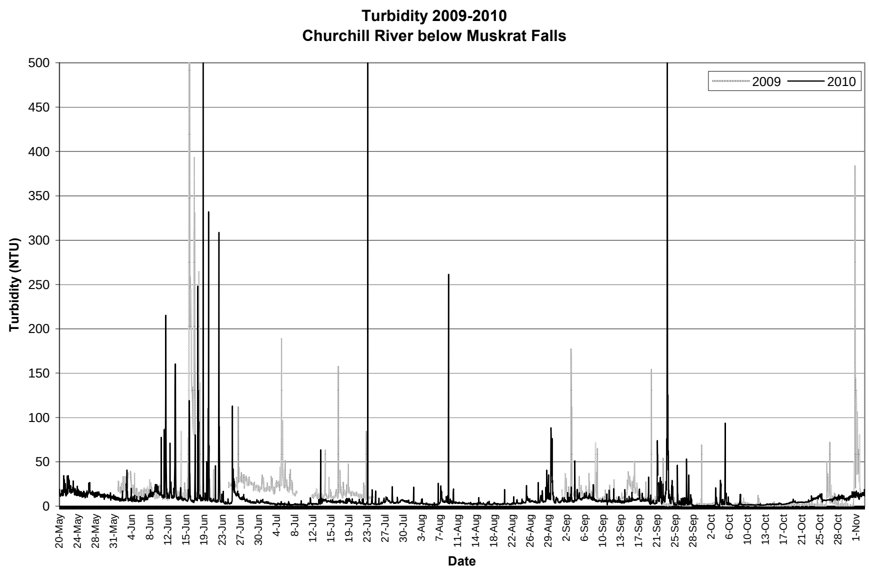


Figure 5a: Turbidity (0 to 500NTU) at Churchill River below Muskrat Falls

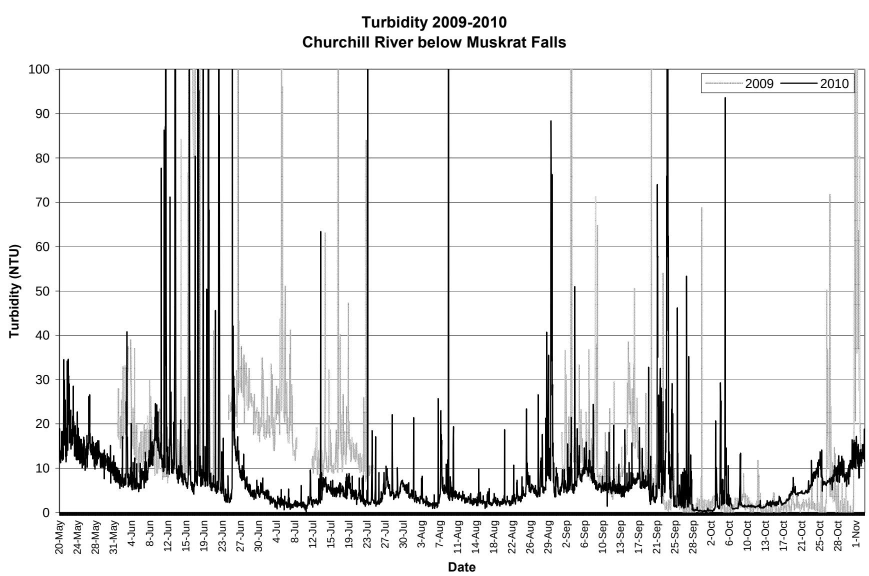


Figure 5b: Turbidity (0 to 100NTU) at Churchill River below Muskrat Falls

- Stage level is decreasing for much of the 2010 deployment season (Figure 6). Precipitation records vary throughout the season.
- Only precipitation data from Goose Bay is displayed on Figure 6. Precipitation data from upstream (Churchill Falls) is missing from the EC database (Appendix 1).

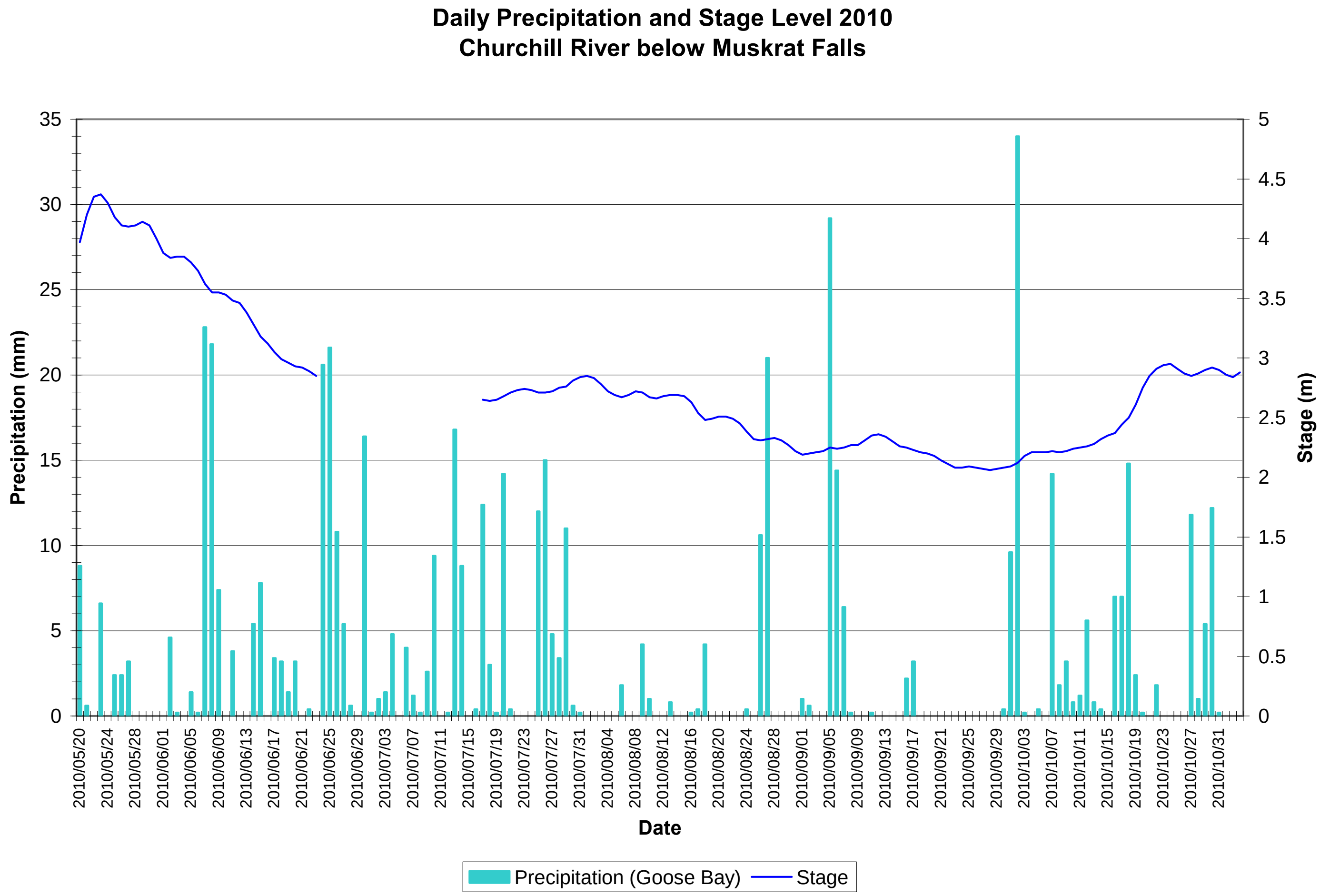


Figure 6: Average daily precipitation and stage level at Churchill River below Muskrat Falls

Churchill River above Muskrat Falls

- Water temperature ranges between 2.31 and 19.63°C during the 2010 deployment season (Figure 7a).
- On average, water temperatures are about 0.6°C warmer in 2010 than in 2009. Most noticeable is the warmer temperatures in fall 2010 when compared to the same season in the previous year.
- Water temperature values show a typical seasonal trend (Figure 7b). Water temperature is increasing for the first part of the deployment season during the spring and early summer while the ambient air temperature is also increasing. Water temperature peaks in early August at 19.63°C and begins to decrease in the beginning of September.

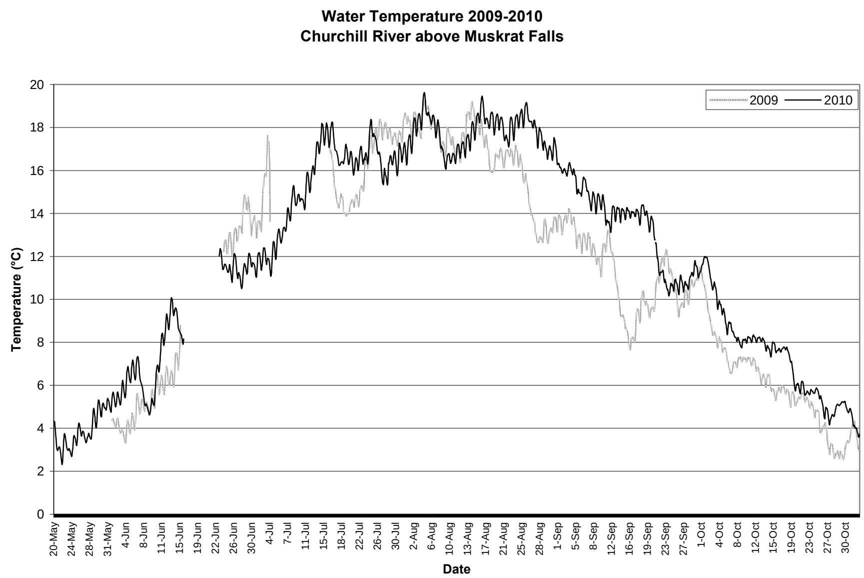


Figure 7a: Water temperature at Churchill River above Muskrat Falls

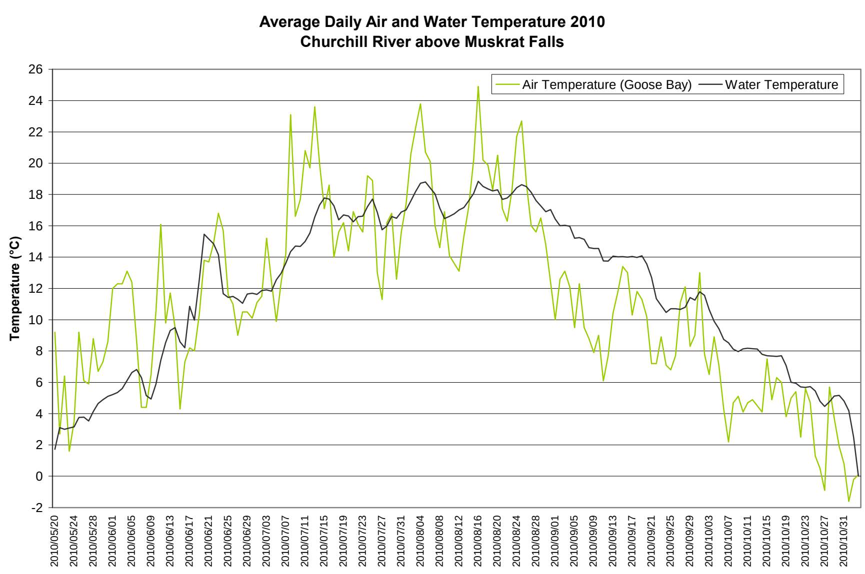


Figure 7b: Average daily air and water temperature at Churchill River above Muskrat Falls

- pH ranges between 6.08 and 7.43 pH units throughout the 2010 deployment season (Figure 8).
- For the majority of the deployment season (May 20 to October 21), all values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 8). After October 21, pH values decrease below the minimum guideline of 6.5 units.
- pH values in 2010 are comparable to those values recorded in 2009 for most of the deployment season. Only in the late fall, there is a noticeable difference between 2009 and 2010 data where pH values are decreasing from late September to early November. This supports speculation of sensor drift during the final deployment period in 2010 due to an extended deployment period (see monthly deployment report for September 21 to November 3, 2010 for additional information).

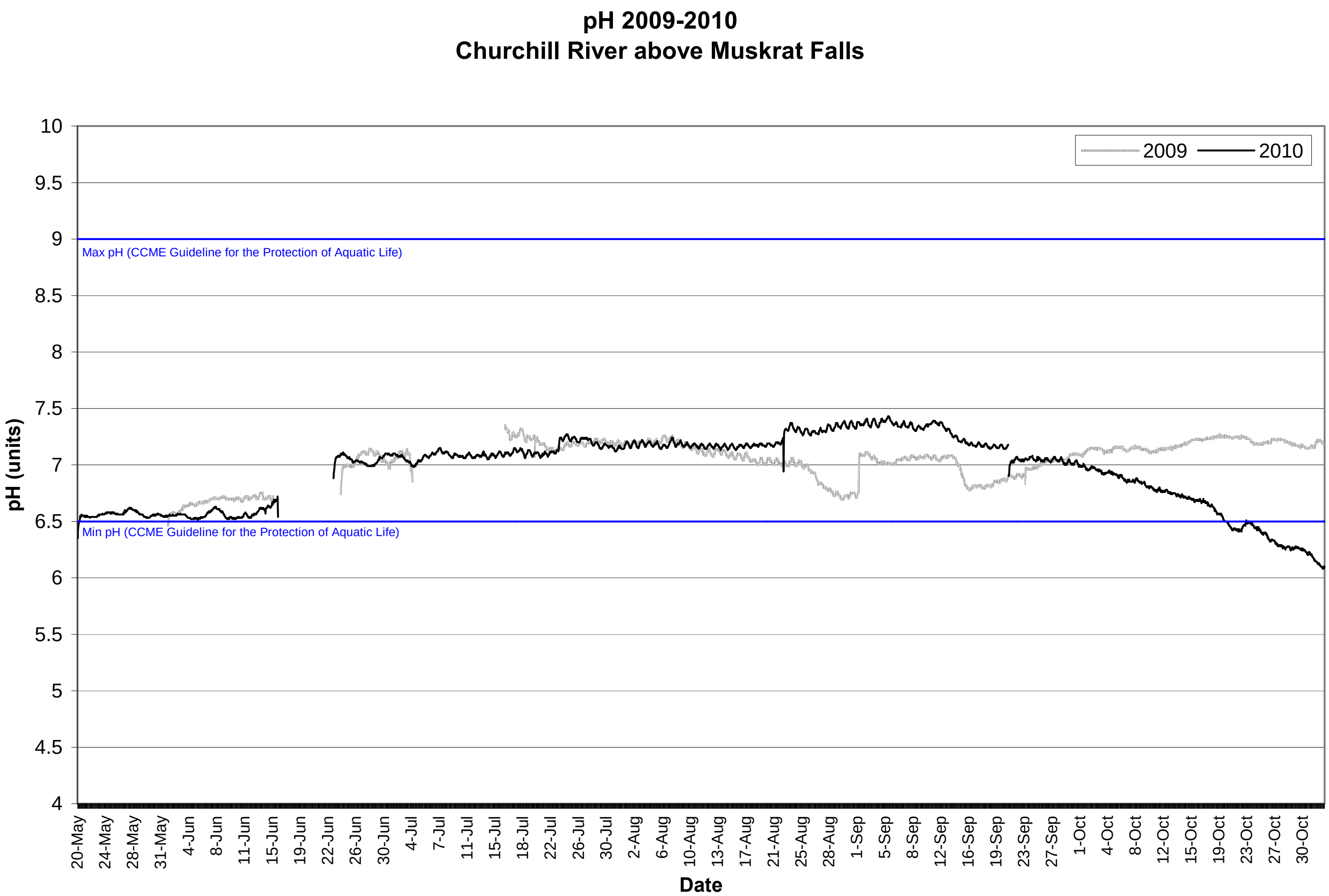


Figure 8: pH at Churchill River above Muskrat Falls

- Specific conductivity ranges from 11.6 to 24.0µS/cm during the 2010 deployment season (Figure 9).
- Stage is included in Figure 9 to illustrate the inverse relationship between conductivity and water level. Specific conductivity generally rises throughout the spring and summer months, peaking on October 2. This rise corresponds with low stage levels. Seasonal low stage levels are recorded in late September. This trend and correspondence is due to the dilution affect on total dissolved solids in the water column.
- When compared to data from 2009, specific conductance values peak much earlier in mid-summer; however stage levels for this year are at their lowest for the season, similar to the trend observed in 2010.

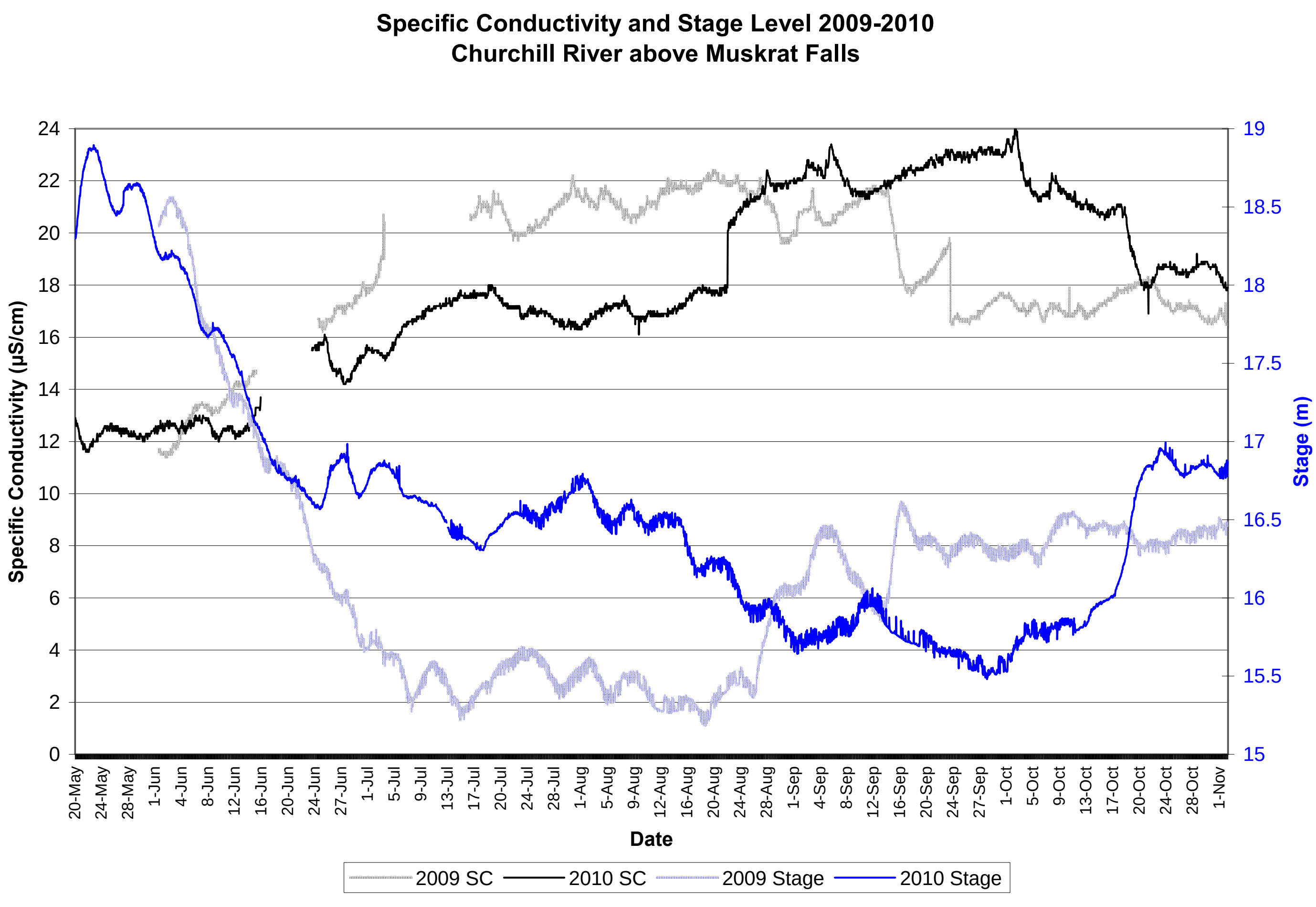


Figure 9: Specific conductivity and stage at Churchill River above Muskrat Falls

- Dissolved oxygen content ranges between 9.85 and 15.34mg/L for the 2010 deployment season (Figure 10).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. For most of the season, values were above the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l. From late July to early September, during the warmest part of the season, dissolved oxygen content was just below the guideline. The guidelines are indicated in blue on Figure 10.
- Dissolved oxygen content shows a typical seasonal fluctuation, decreasing throughout the spring and early summer months during the time when water temperatures are increasing. Dissolved oxygen content reaches a seasonal low on August 7, 2010. When water temperatures begin to decrease in the late summer, dissolved oxygen content begins to rise again.
- When compared to data from 2009, there is a similar trend due to the inverse relationship between dissolved oxygen and water temperature. Water temperatures in the fall 2010 were warmer than in 2009, therefore dissolved oxygen content during this time is slightly lower than in 2009.

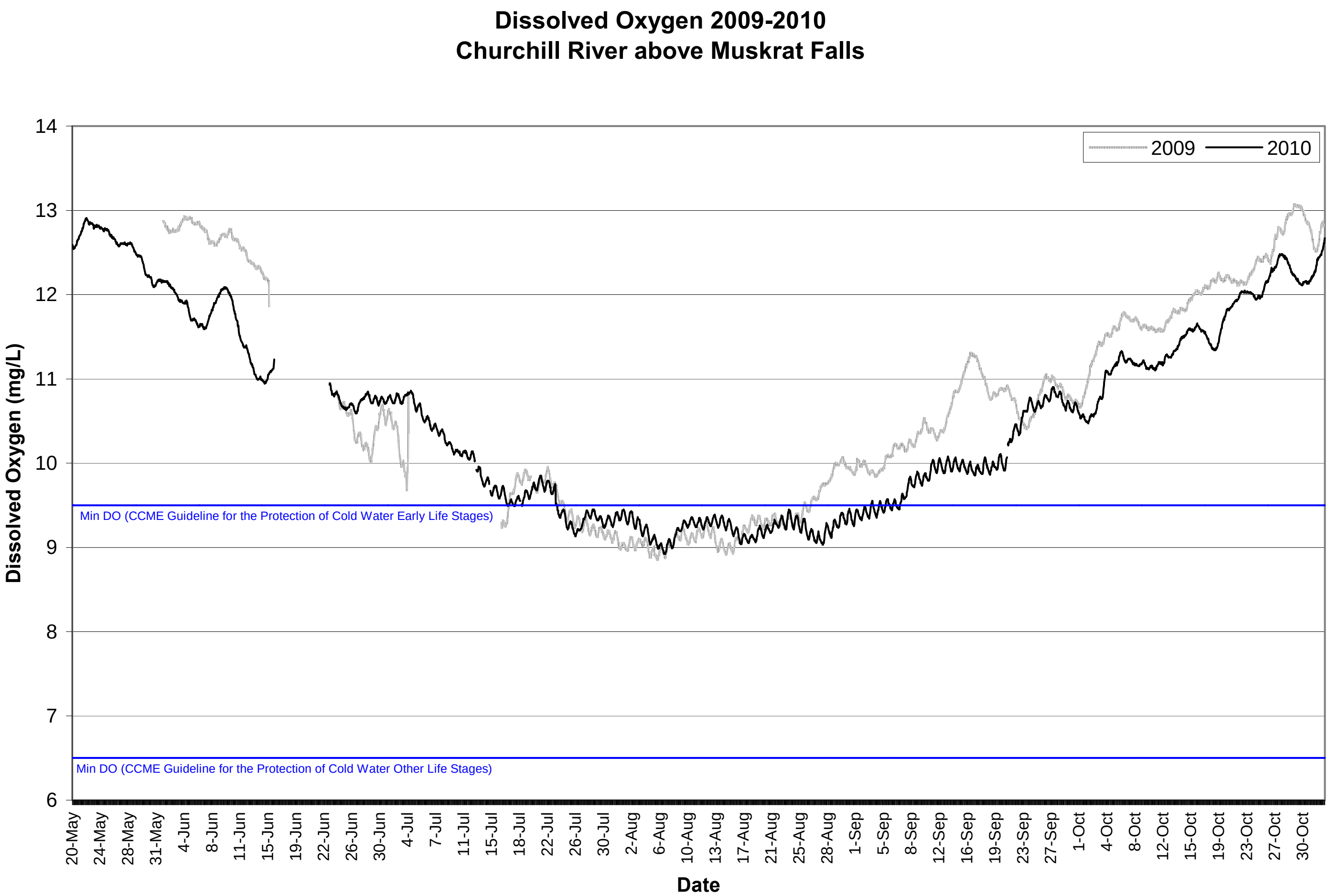


Figure 10: Dissolved oxygen at Churchill River above Muskrat Falls

- A range of 0.0 to 431.0 NTU was recorded for turbidity for the 2010 deployment season (Figure 11). A median value of 4.0 NTU indicates there is a minimal natural background turbidity value at this station.
- There are several variations in turbidity values throughout the 2010 season, most of which are related to weather conditions and precipitation events.
- Data from 2009 shows a similar trend with the median values for the 2009 season slightly higher at 11.0 NTU.

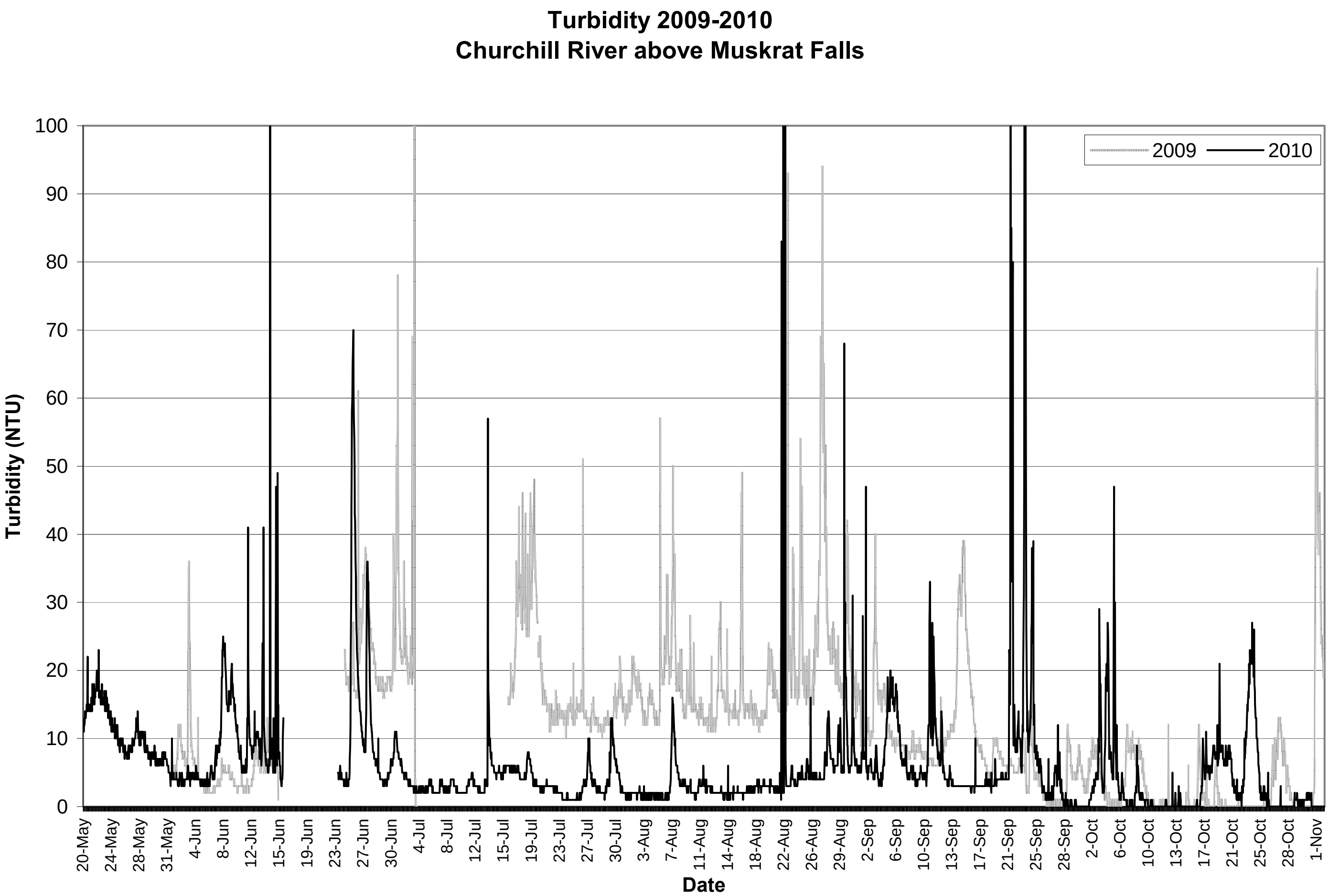


Figure 6: Turbidity at Churchill River above Muskrat Falls

- Stage level is decreasing for much of the 2010 deployment season (Figure 12). Precipitation records vary throughout the season.
- Only precipitation data from Goose Bay is displayed on Figure 12. Precipitation data from upstream (Churchill Falls) is missing from the EC database (Appendix 1).

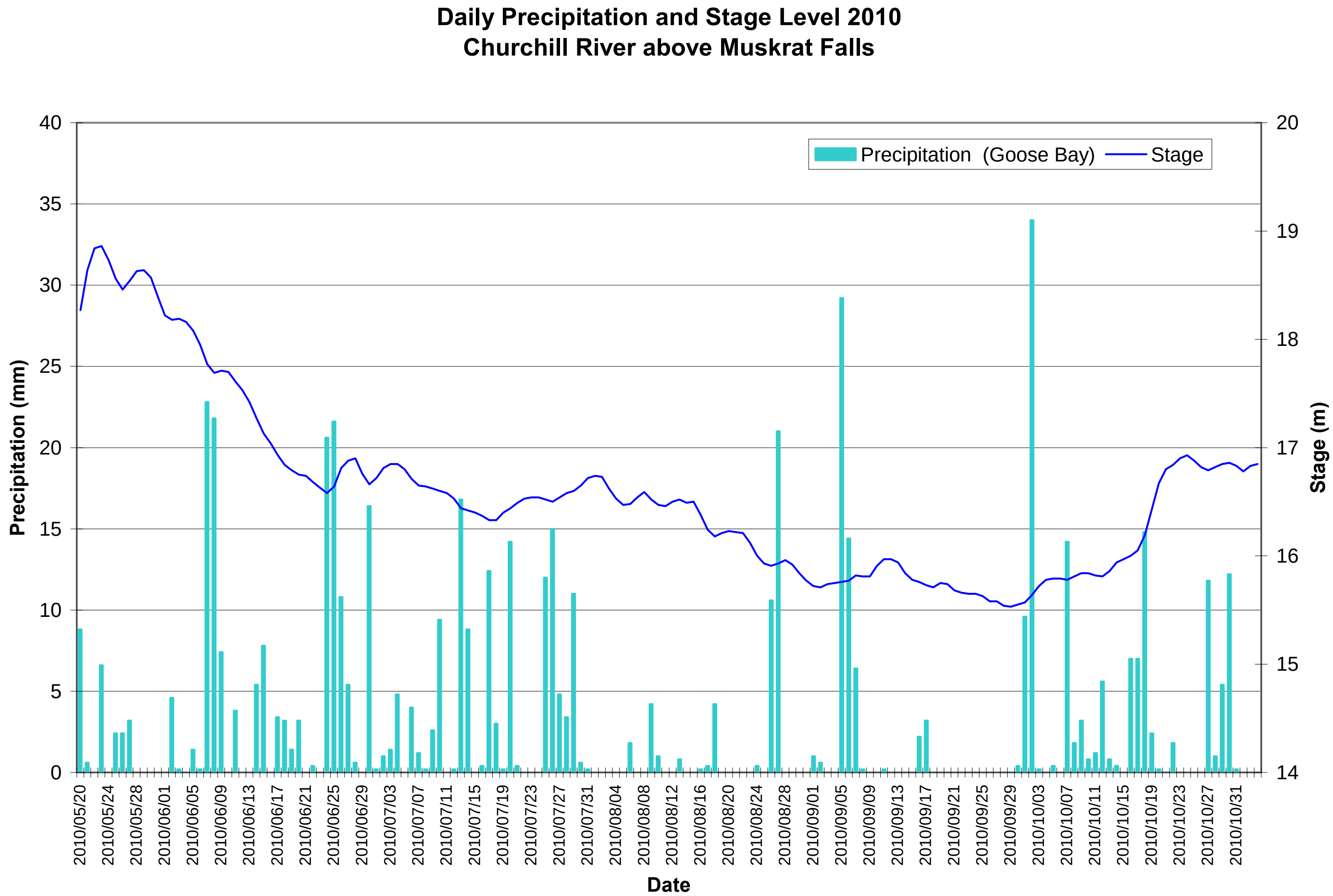


Figure 12: Average daily precipitation and stage level at Churchill River above Muskrat Falls

Churchill River below Grizzle Rapids

- Water temperature ranges from 4.2 to 19.6°C during the 2010 deployment season (Figure 13a).
- On average, water temperatures are about 0.9°C warmer in 2010 than in 2009. Most noticeable is the warmer temperatures in fall 2010 when compared to the same season in the previous year.
- Water temperature values show a typical seasonal trend (Figure 13b). Water temperature is increasing for the first part of the deployment season during the spring and early summer. Water temperature peaks in late August at 19.3°C. Water temperature begins to decrease in the beginning of September.

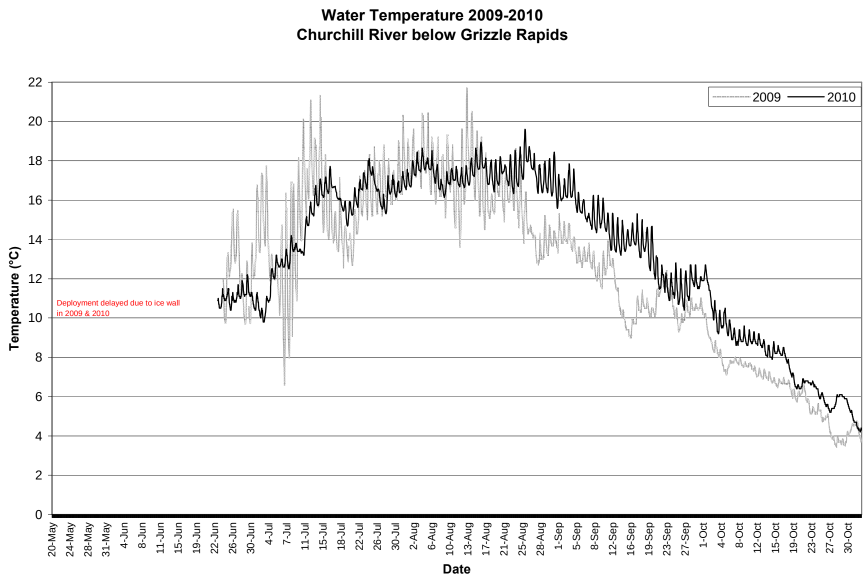


Figure 13a: Water temperature at Churchill River below Grizzle Rapids

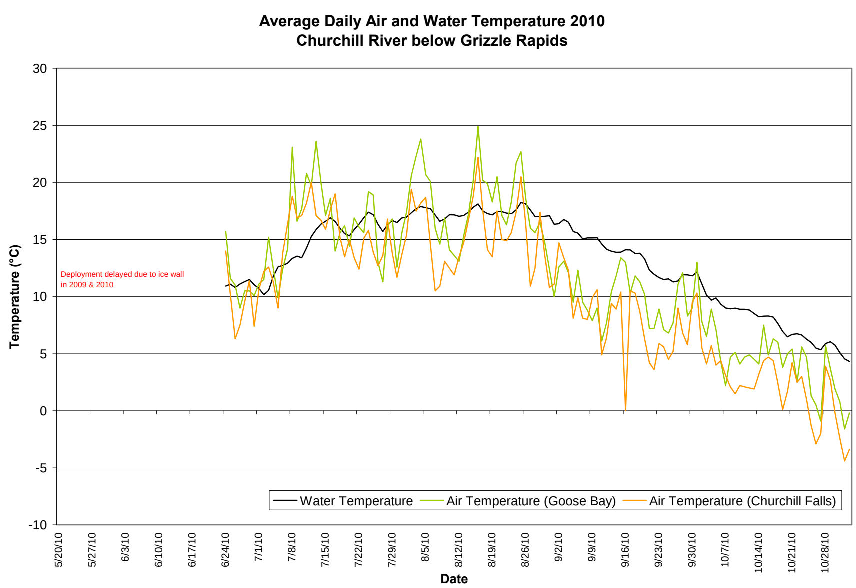


Figure 13b: Average daily air and water temperature at Churchill River below Grizzle Rapids

- pH ranges between 6.68 and 7.50 pH units throughout the 2010deployment season (Figure 14).
- All values during the 2010 deployment are within the recommended range as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 14).
- pH values in 2010 are comparable to those values recorded in 2009 for most of the deployment season. Values recorded in the first deployment period in 2009 (late June to July) are noticeably higher than values recorded in 2010 for this time period.

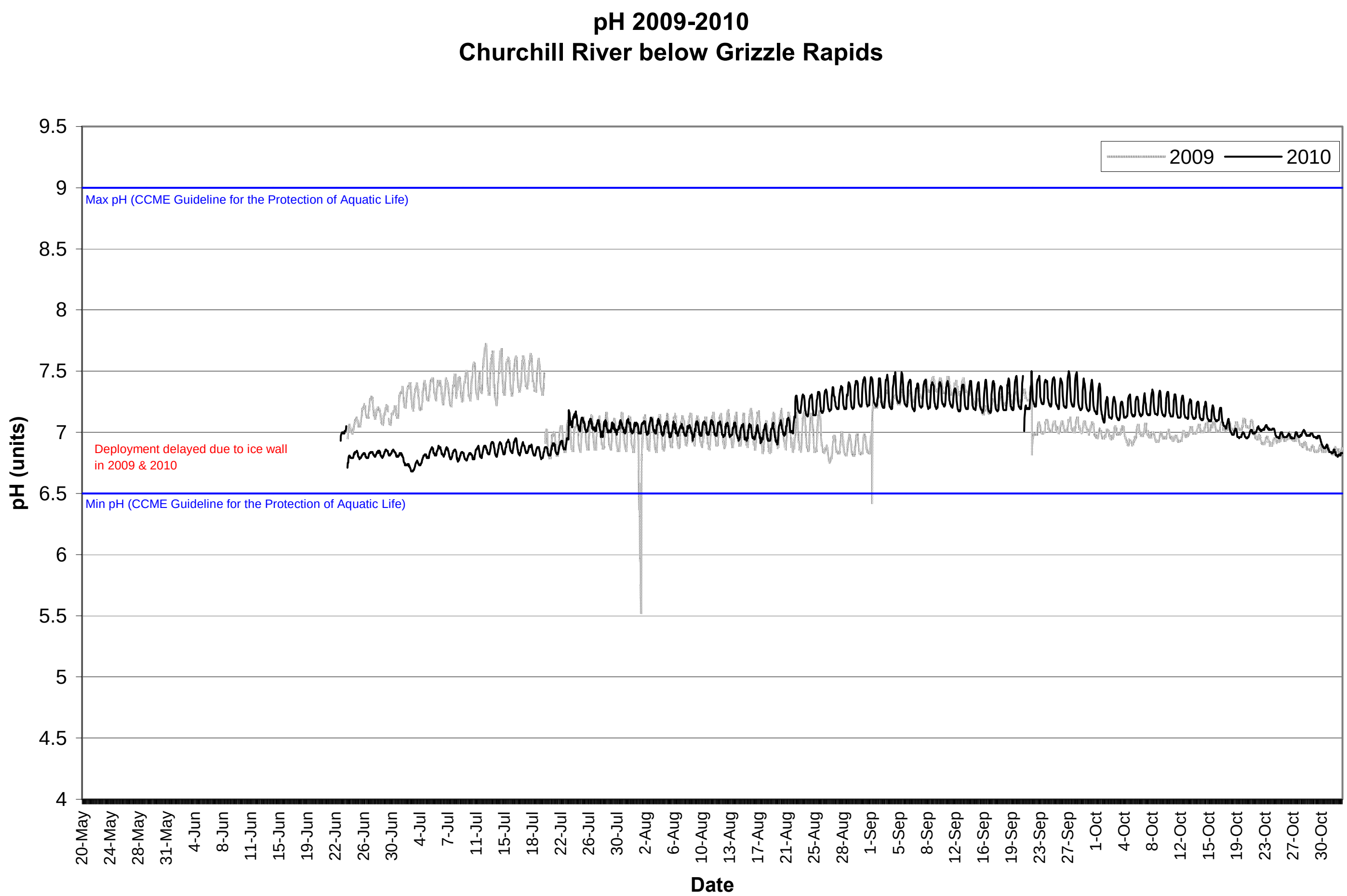


Figure 14: pH at Churchill River below Grizzle Rapids

- Specific conductivity ranges between 13.3 and 22.0µS/cm during the deployment season (Figure 15).
- Stage data is for the most part unavailable for this station during the 2010 season due to a transmission error that occurred during most of the summer. However, stage data from the hydrometric station above Grizzle Rapids is available. Given the close proximity (~1km upstream), this data will be used to explain trends in specific conductivity.
- Stage data is included in Figure 15 to illustrate the inverse relationship between conductivity and water level. Specific conductivity generally rises throughout the spring and summer months while the stage level is decreasing. Peak conductivity and seasonal low stage levels for the Lower Churchill are recorded in the late September. This trend and correspondence is due to the dilution affect on total dissolved solids in the water column.
- When compared to data from 2009, specific conductance values peak much earlier in mid-summer; however stage levels for this year are at their lowest for the season, similar to the trend observed in 2010.

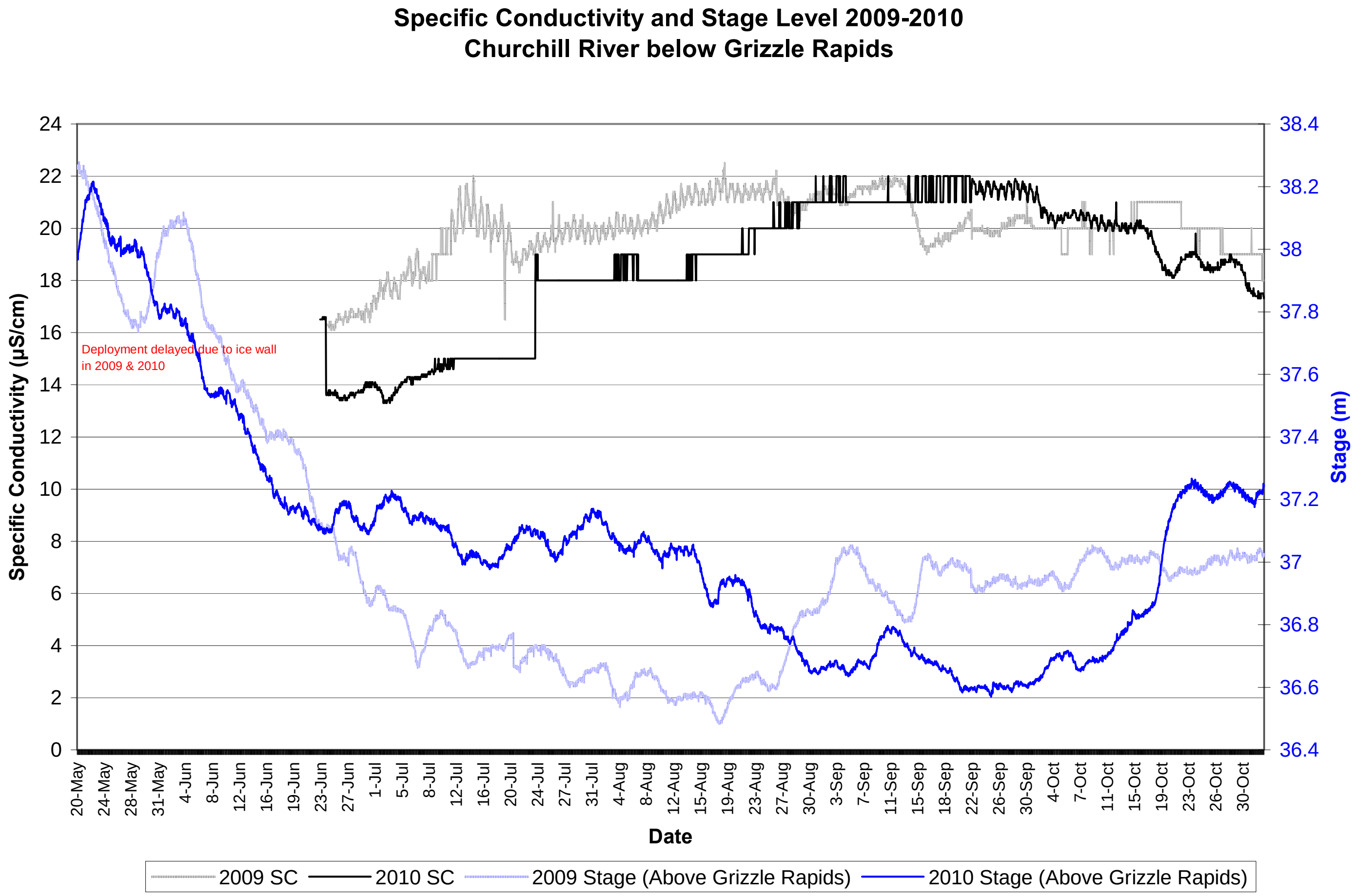


Figure 15: Specific conductivity and stage at Churchill River above and below Grizzle Rapids

- Dissolved oxygen content ranges between 8.89 and 12.15mg/L for the 2010 deployment season (Figure 16).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. For most of the season, values were above the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l. From late July to early September, during the warmest part of the season, dissolved oxygen content was just below the guideline. The guidelines are indicated in blue on Figure 16.
- Dissolved oxygen content shows a typical seasonal fluctuation, decreasing throughout the spring and early summer months during the time when water temperatures are increasing. Dissolved oxygen content reaches a seasonal low on August 26, 2010. When water temperatures begin to decrease in the late summer, dissolved oxygen content begins to rise again.
- When compared to data from 2009, there is a similar trend due to the inverse relationship between dissolved oxygen and water temperature. Water temperatures in the fall 2010 were warmer than in 2009, therefore dissolved oxygen content during this time is slightly lower than in 2009.

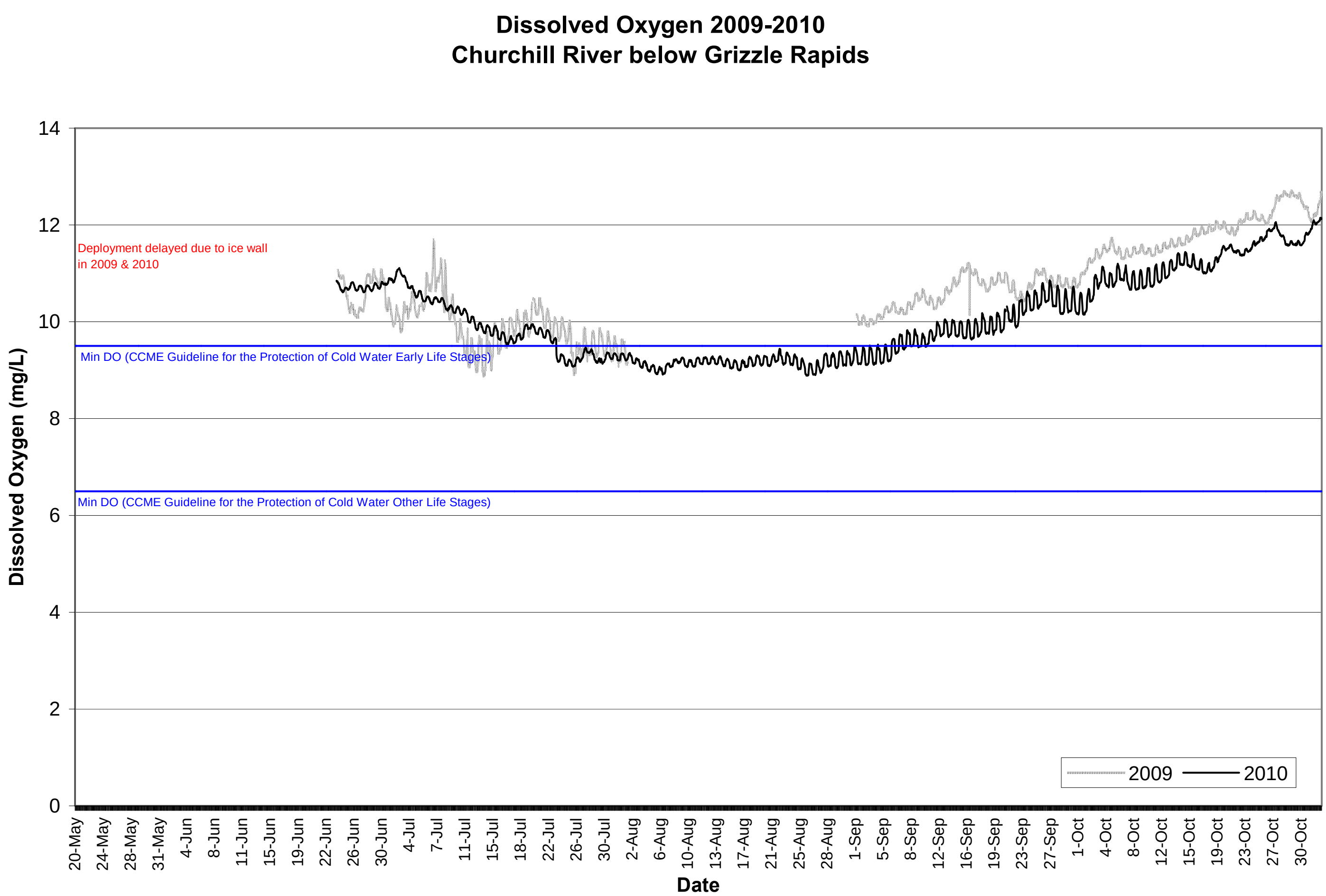


Figure 16: Dissolved oxygen at Churchill River below Grizzle Rapids

- Turbidity remains at or near 0.0NTU for the entire deployment season with the exception only a few short spikes reaching up to 38.4NTU (Figure 17). This site is naturally clear with very few turbidity events.

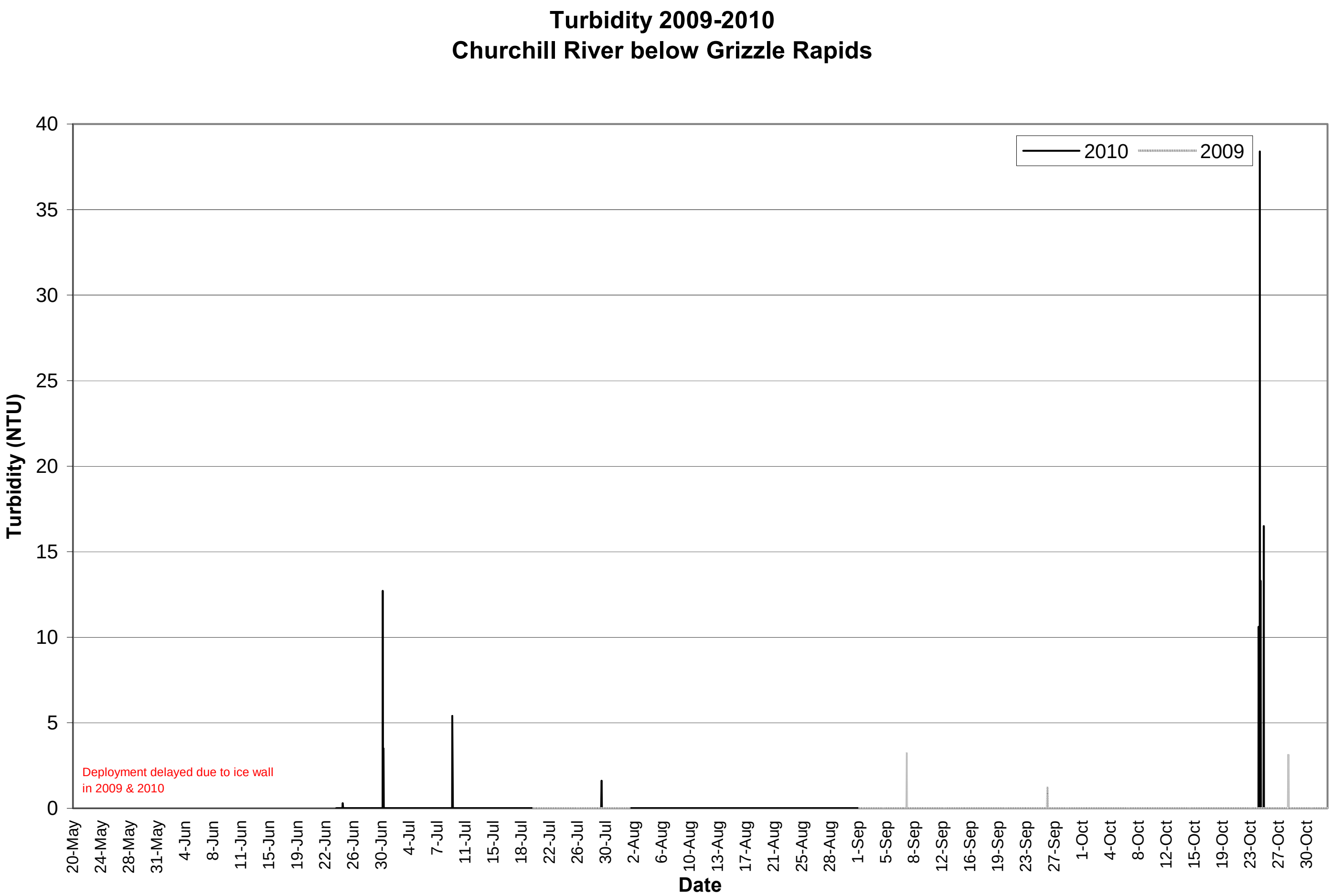


Figure 17: Turbidity at Churchill River below Grizzle Rapids

- Stage data is for the most part unavailable for the station below Grizzle Rapids, therefore data from the station above Grizzle Rapids (1km upstream) is used for the purpose of discussion.
- Stage level is decreasing for much of the 2010 deployment season (Figure 18). Precipitation records vary throughout the season.
- Only precipitation data from Goose Bay is displayed on Figure 18. Precipitation data from upstream (Churchill Falls) is missing from the EC database (Appendix 1).

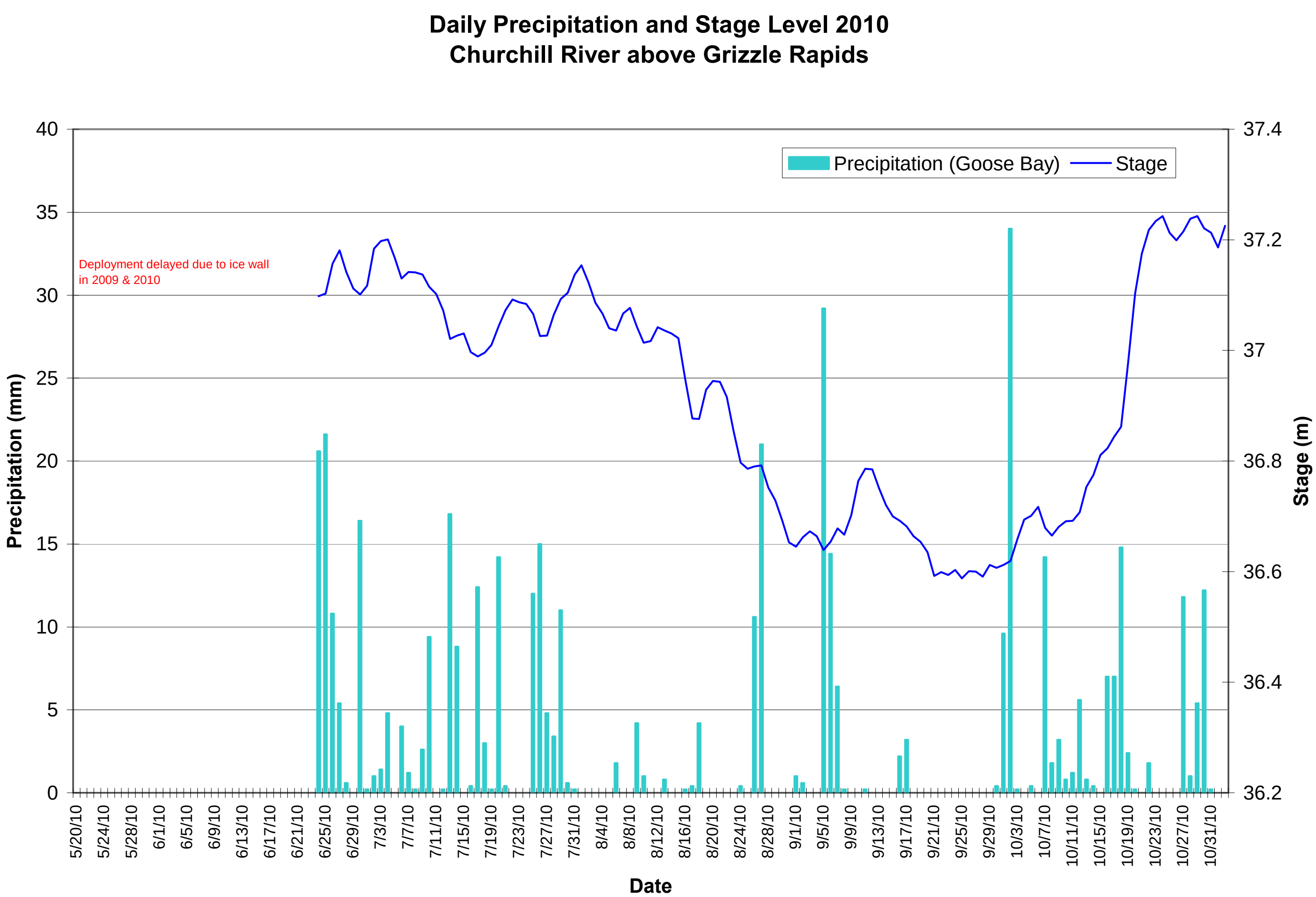


Figure 18: Average daily precipitation and stage level at Churchill River above Grizzle Rapids

Churchill River below Metchin River

- Water temperature ranges from 1.9 to 18.3°C during the 2010 deployment season (Figure 19a).
- On average, water temperatures are about 1.1°C warmer in 2010 than in 2009. Most noticeable is the warmer temperatures in both the spring and fall 2010 when compared to the same seasons in the previous year.
- Water temperature values show a typical seasonal trend (Figure 19b). Water temperature is increasing for the first part of the deployment season during the spring and early summer. Water temperature peaks in late August at 18.3°C. Water temperature begins to decrease in the beginning of September.

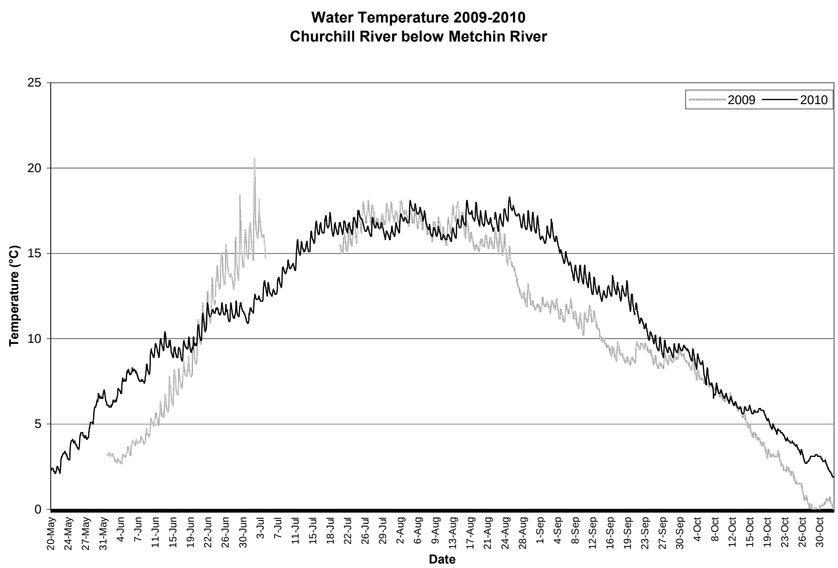


Figure 19a: Water temperature at Churchill River below Metchin River

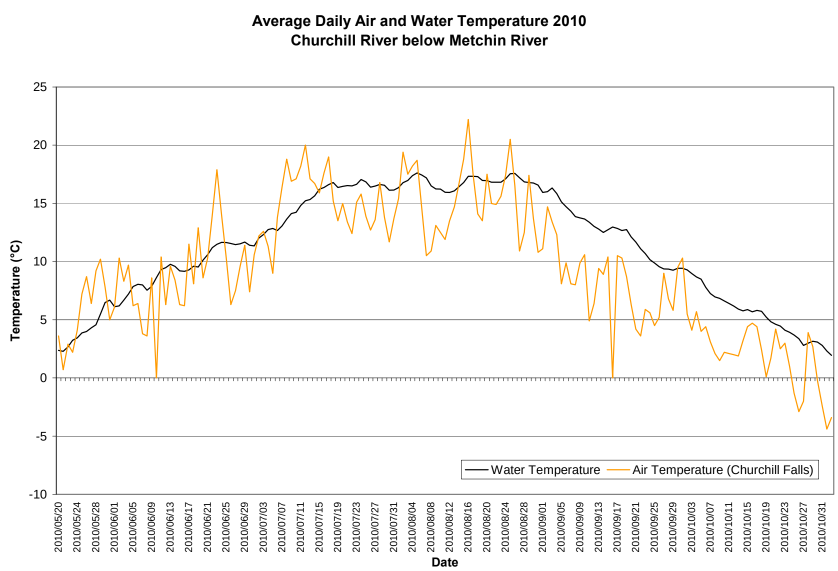


Figure 19b: Average daily air and water temperature at Churchill River below Metchin River

- pH ranges between 6.66 and 7.47 pH units throughout the 2010 deployment season (Figure 20).
- All values during the 2010 deployment are within the recommended range as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 20).
- pH values in 2010 are comparable to those values recorded in 2009.

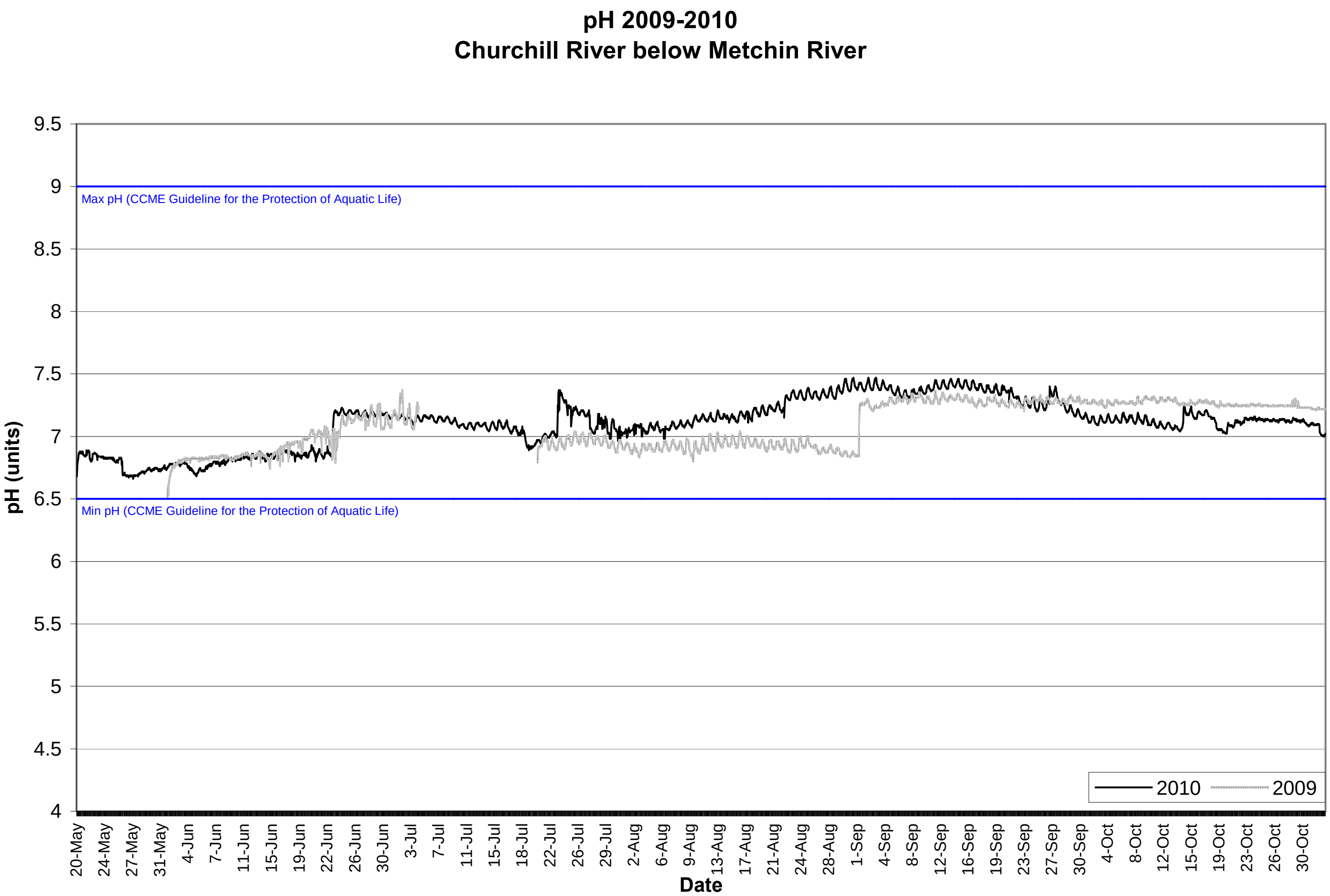


Figure 20: pH at Churchill River below Metchin River

- Specific conductivity generally ranges from 14.6 to 23.0µS/cm during the 2010 deployment season with a few recorded increases up to 35.5µS/cm (Figure 21).
- Stage is included in Figure 21 to illustrate the inverse relationship between conductivity and water level. Specific conductivity generally rises throughout the spring and summer months, peaking in September. These higher levels in conductivity correspond with low stage levels. Seasonal low stage levels are recorded in late September. This trend and correspondence is due to the dilution affect on total dissolved solids in the water column.
- When compared to data from 2009, specific conductance values peak much earlier in mid-summer; however stage levels for this year are at their lowest for the season, similar to the trend observed in 2010.

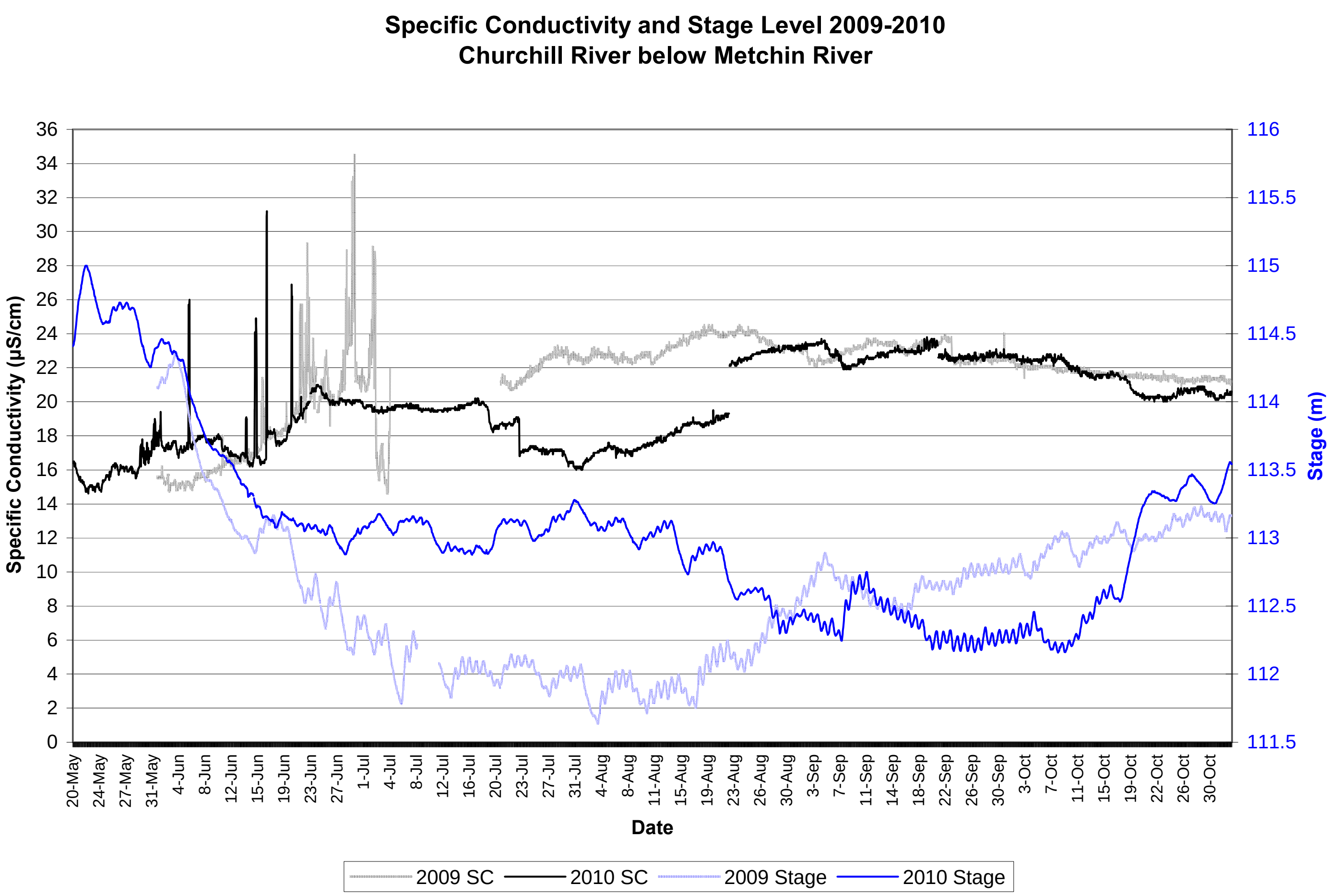


Figure 21: Specific conductivity and stage level at Churchill River below Metchin River

- Dissolved oxygen content ranges between 8.89 and 12.15mg/L for the 2010 deployment season (Figure 22).
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l. For most of the season, values were above the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l. From mid July to early September, during the warmest part of the season, dissolved oxygen content was just below the guideline. The guidelines are indicated in blue on Figure 22.
- Dissolved oxygen content shows a typical seasonal fluctuation, decreasing throughout the spring and early summer months during the time when water temperatures are increasing. Dissolved oxygen content reaches a seasonal low on August 26, 2010. When water temperatures begin to decrease in the late summer, dissolved oxygen content begins to rise again.
- When compared to data from 2009, there is a similar trend due to the inverse relationship between dissolved oxygen and water temperature. Water temperatures in the spring 2010 were warmer than in 2009; therefore the dissolved oxygen content is slightly lower than values during the same period in the previous year. Similarly, water temperatures in the fall 2010 were warmer than in 2009, therefore dissolved oxygen content during this time is slightly lower than in 2009.

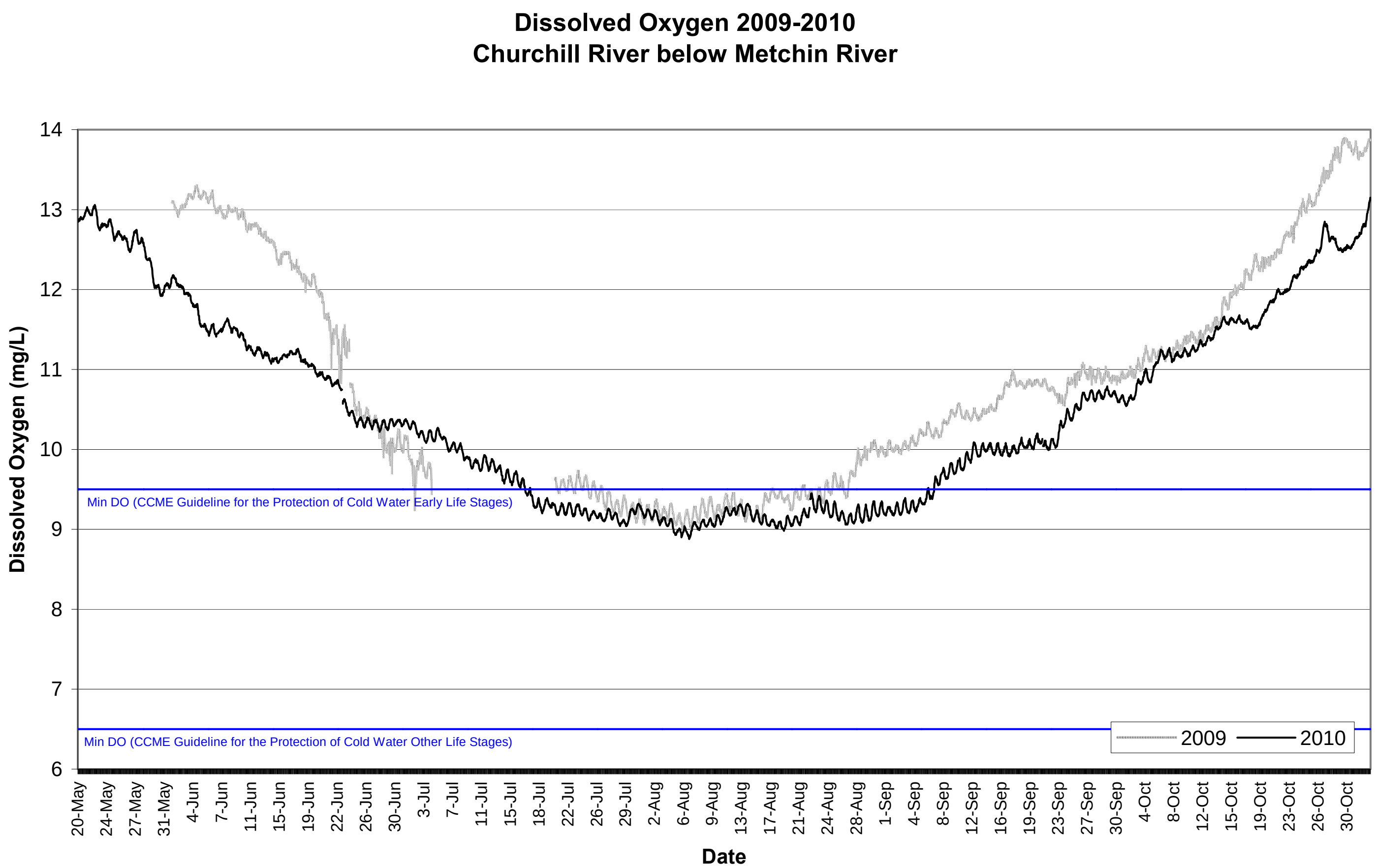


Figure 22: Dissolved oxygen at Churchill River below Metchin River

- Turbidity values at the station generally remain at or near 0.0NTU for the majority of the deployment season (Figure 23).
- During the month of June, there are however a number of recorded spikes below 50NTU (and one spike to just over 200NTU). This appears to be a similar trend in 2009. As was discussed in the May-June Monthly Deployment report, it is unknown what exactly may have caused these increases but may have resulted due to the rapidly decreasing stage level which left the instrument in a shallow water environment.

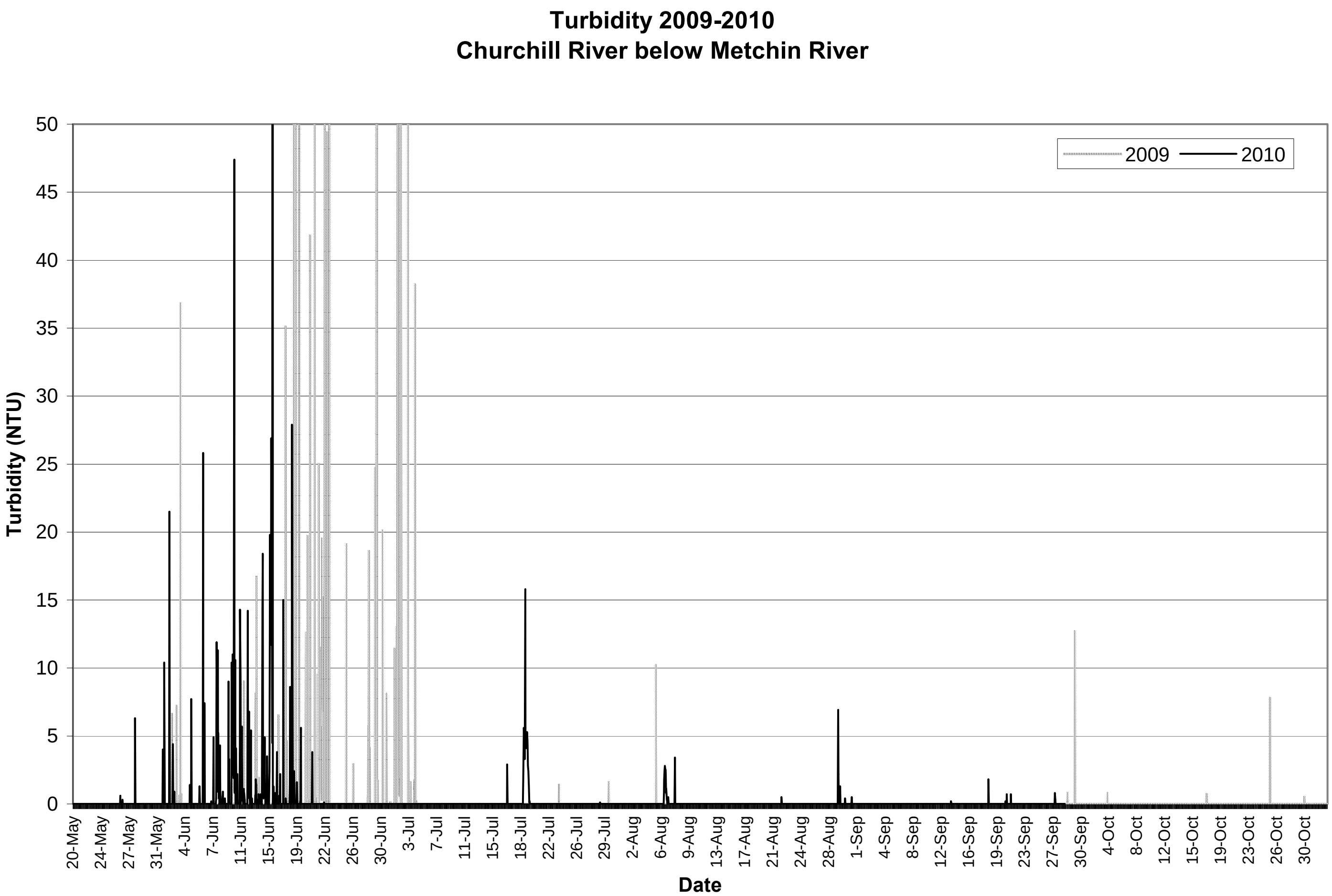


Figure 23: Turbidity at Churchill River below Metchin River

- Stage level is decreasing for much of the 2010 deployment season (Figure 24).
- Churchill Falls is the closest weather station to this monitoring site however precipitation data from Churchill Falls is largely unavailable for the 2010 deployment season.

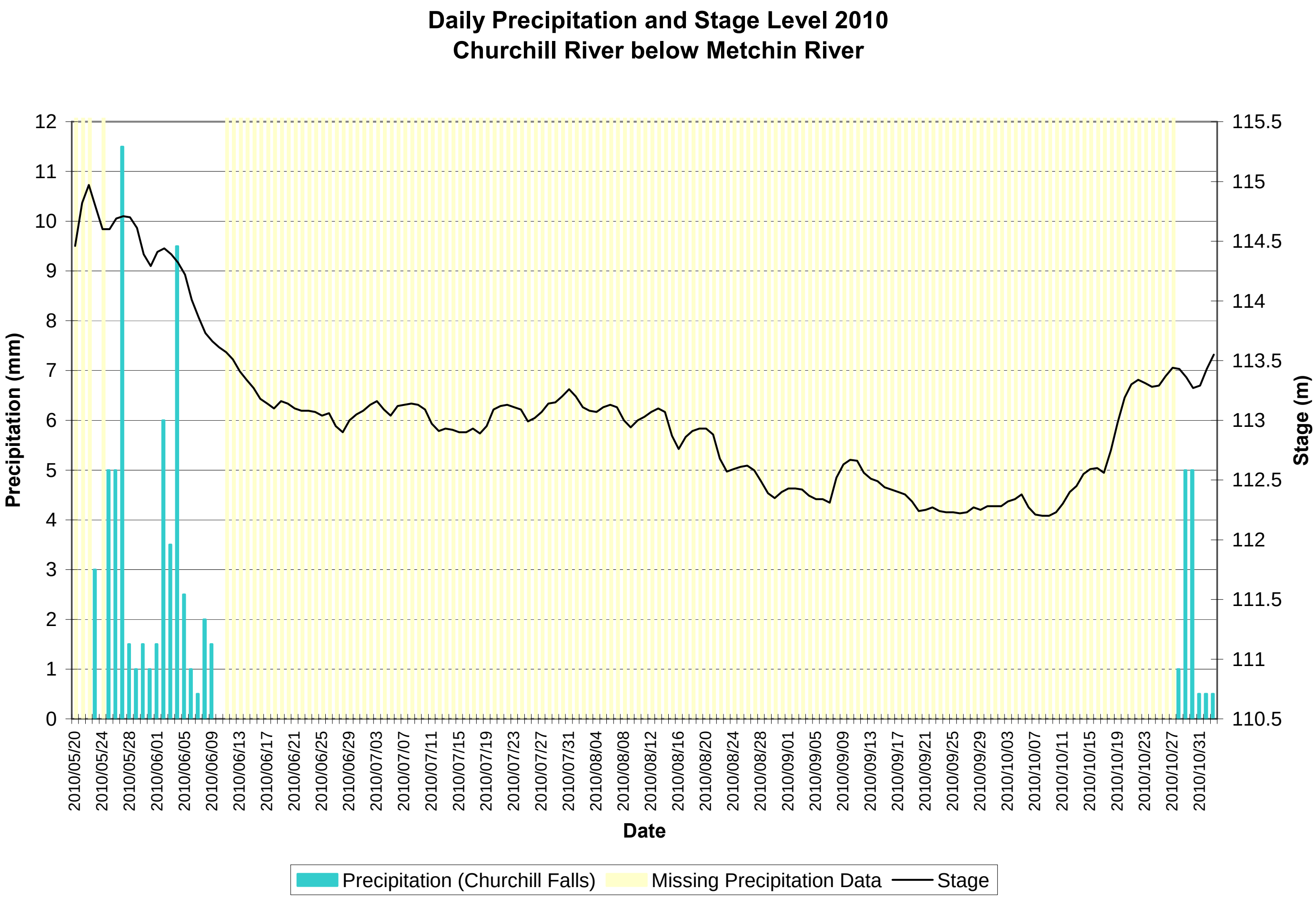


Figure 24: Average daily precipitation and stage level at Churchill River below Metchin River

Multi-Station Comparison

- Water temperature at each of the four stations shows a similar trend throughout the 2010 deployment season, displaying both seasonal and diurnal fluctuations as well as responses to changes in air temperatures.

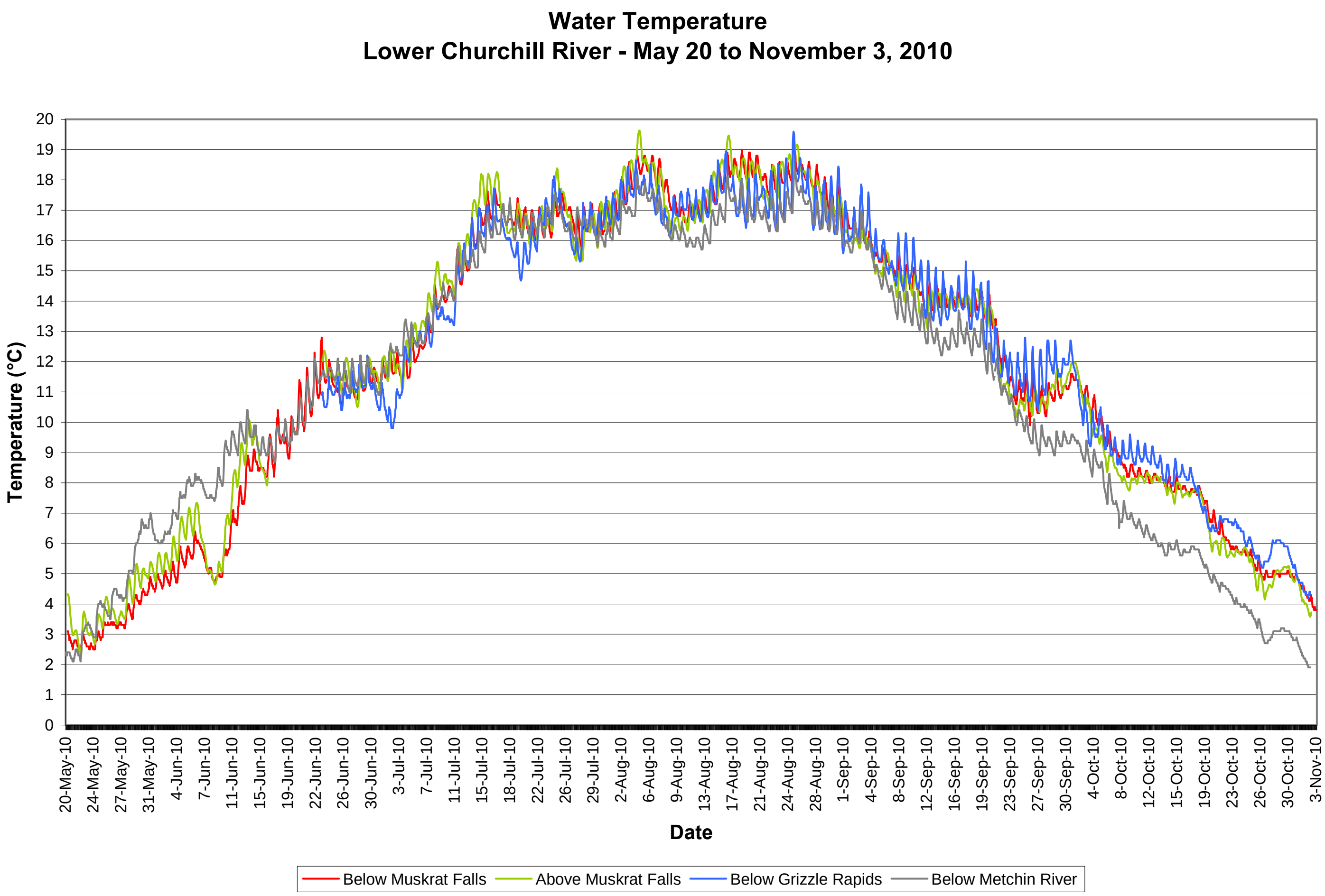


Figure 25: Water temperature at four monitoring stations along the Lower Churchill River

- pH values are similar at the four monitoring sites throughout the 2010 deployment season (Figure 26).
- Values at the station below Grizzle Rapids appear to fluctuate diurnally more significantly than the other stations.
- It remains uncharacteristic for pH values to drop off so rapidly in early October at the station above Muskrat Falls.

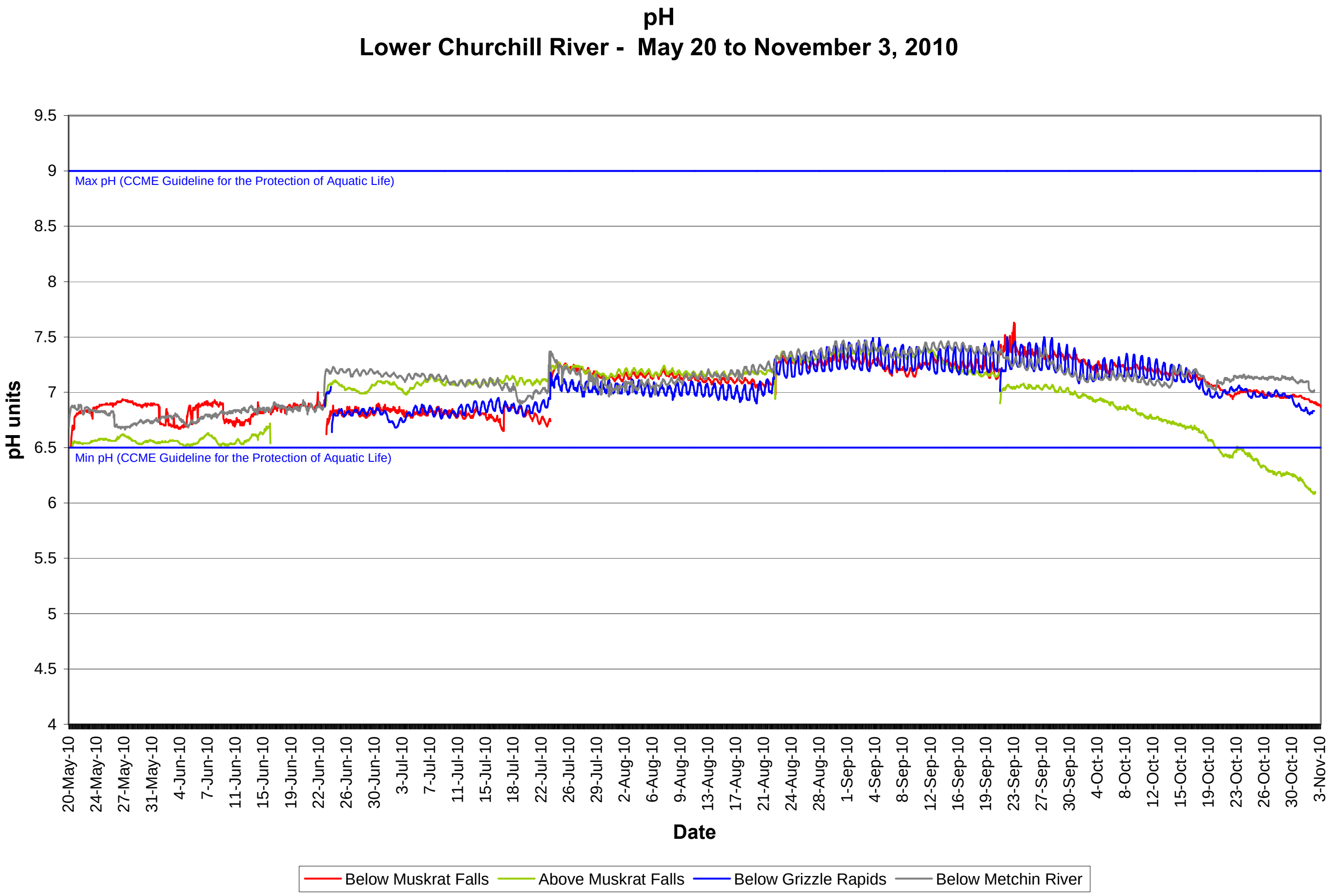


Figure 26: pH at four monitoring stations along the Lower Churchill River

- Specific conductivity trends are similar along the Lower Churchill River at the four monitoring stations (Figure 27).
- Specific conductivity at the station below Metchin River is noticeably higher in the spring and early summer months when compared to the other stations. This station also has more instances of short but significant spikes in conductivity.

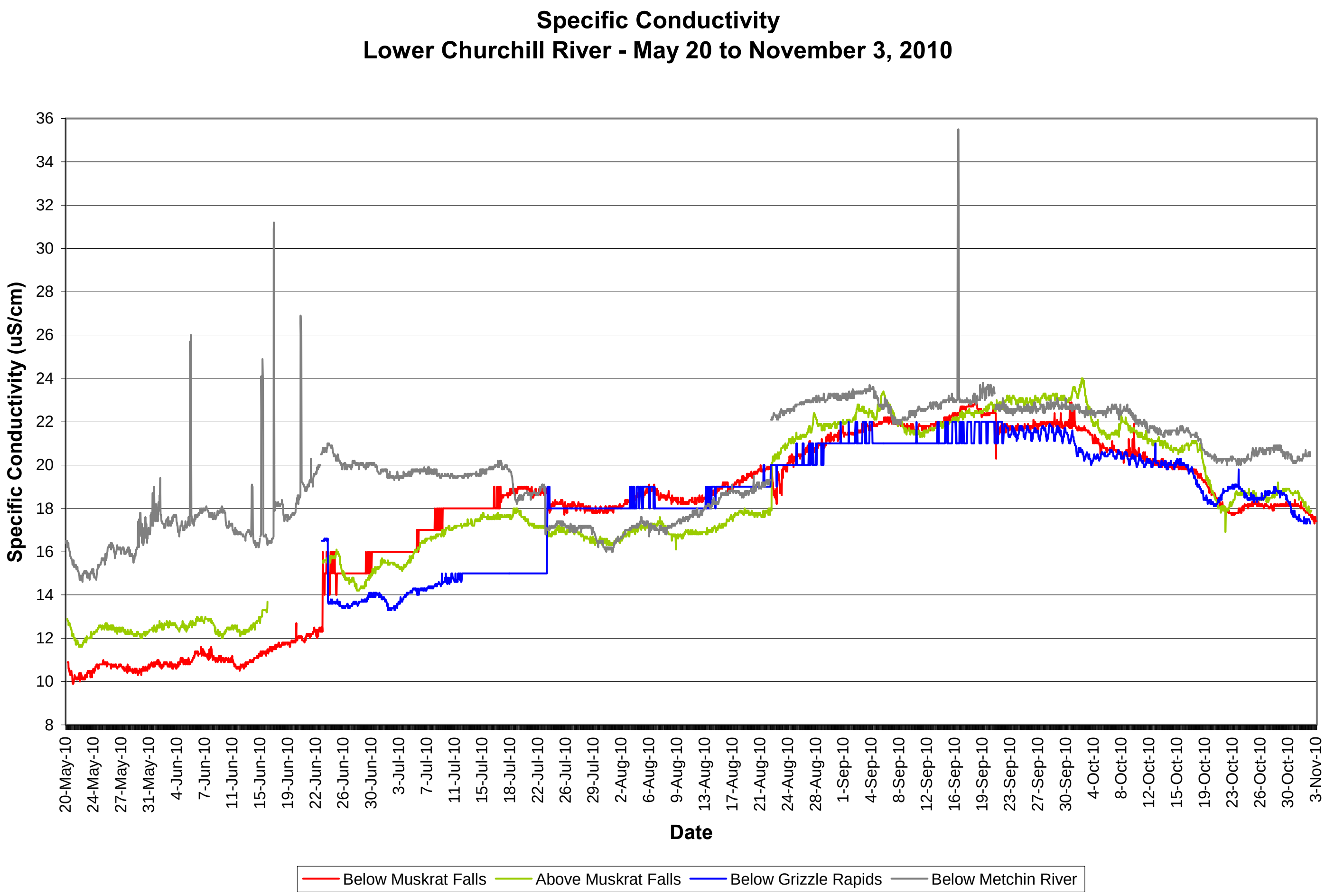


Figure 27: Specific conductivity at four monitoring stations along the Lower Churchill River

- Dissolved oxygen content and percent saturation values are very similar at stations above Muskrat Falls, below Grizzle Rapids and below Metchin River.
- Values at the station below Muskrat Falls are on average 1.5mg/L higher than at the three upstream stations. This is likely due to the location of Muskrat Falls upstream from the station. Water as it moves over Muskrat Falls is aerated and this increases the amount of oxygen in the water. The station below Muskrat Falls is the only station where dissolved oxygen content does not fall below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value at 9.5 mg/l during any part of the season. Guidelines are indicated in orange on Figure 28.

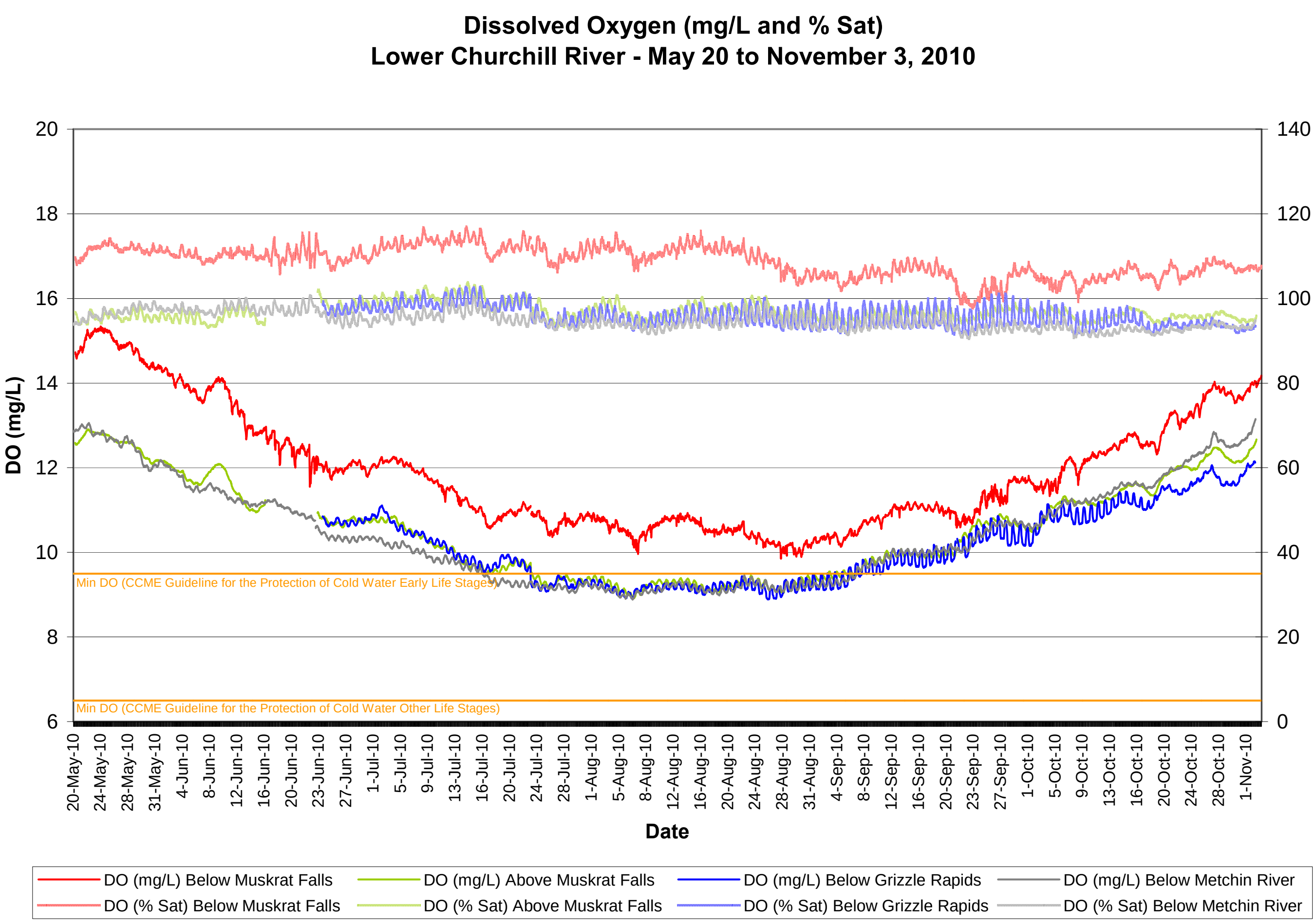


Figure 28: Dissolved oxygen and percent saturation at four monitoring stations along the Lower Churchill River

- Turbidity values at stations below Grizzle Rapids and below Metchin River are generally 0.0NTU with minimal, short lived turbidity events (Figure 29a&b).
- Figure 29a shows turbidity data on a scale from 0 to 500NTU to illustrate the more significant events. Figure 5b displays the same data on a smaller scale, 0 to 100NTU, to clearly show the background turbidity values throughout the deployment season.
- In the lower reaches of the Churchill River, at the station above and below Muskrat Falls, the water quality is generally more turbid and the water is visibly cloudy. Median turbidity values at these two station range between 4 and 5NTU for the 2010 deployment season. Increases in turbidity often correspond with weather related events in the area and can be tracked at both stations (given their close proximity (>7km).

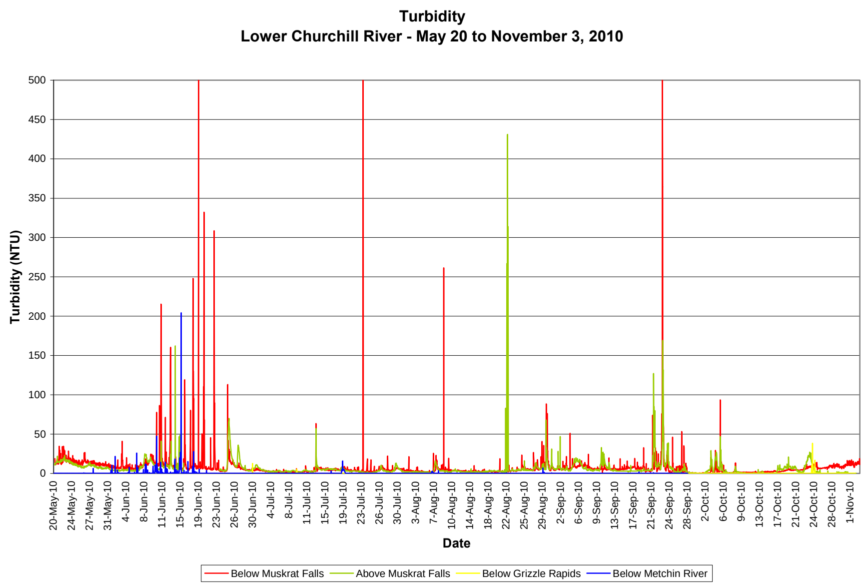


Figure 29a: Turbidity (0 to 500 NTU) at four monitoring stations along the Lower Churchill River

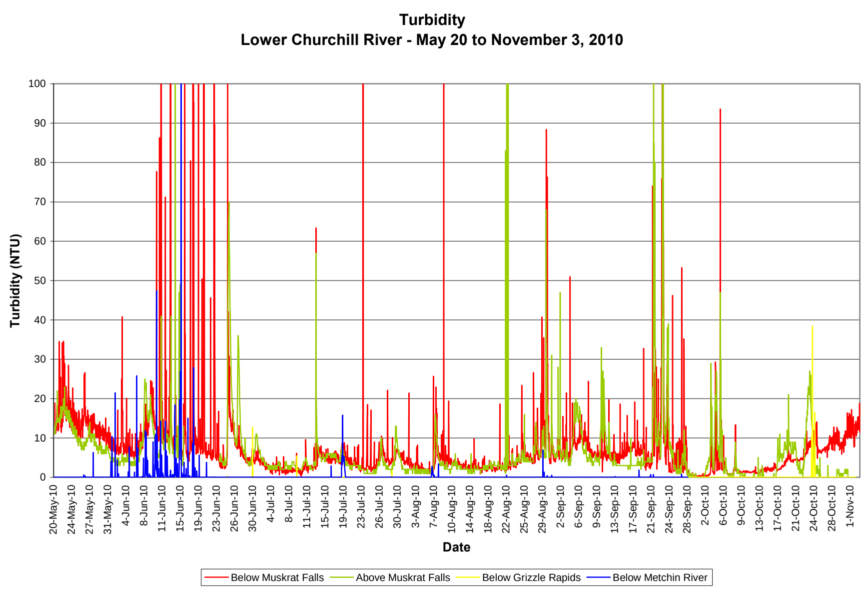


Figure 29b: Turbidity (0 to 100NTU) at four monitoring stations along the Lower Churchill River

- Stage data from the station above Grizzle Rapids is included for discussion purposes in Figure 30 as the majority of the stage data from the station below Grizzle Rapids is unavailable for this period due to a transmission error.
- Increasing and decreasing trends in water level are clearly related among the 5 stations depicted on Figure 30. There is a noticeable time lag of about 12 hours between the station below Metchin River (upstream) and the stations downstream (above and below Muskrat Falls).
- Seasonal lows for all stations were recorded in late September.

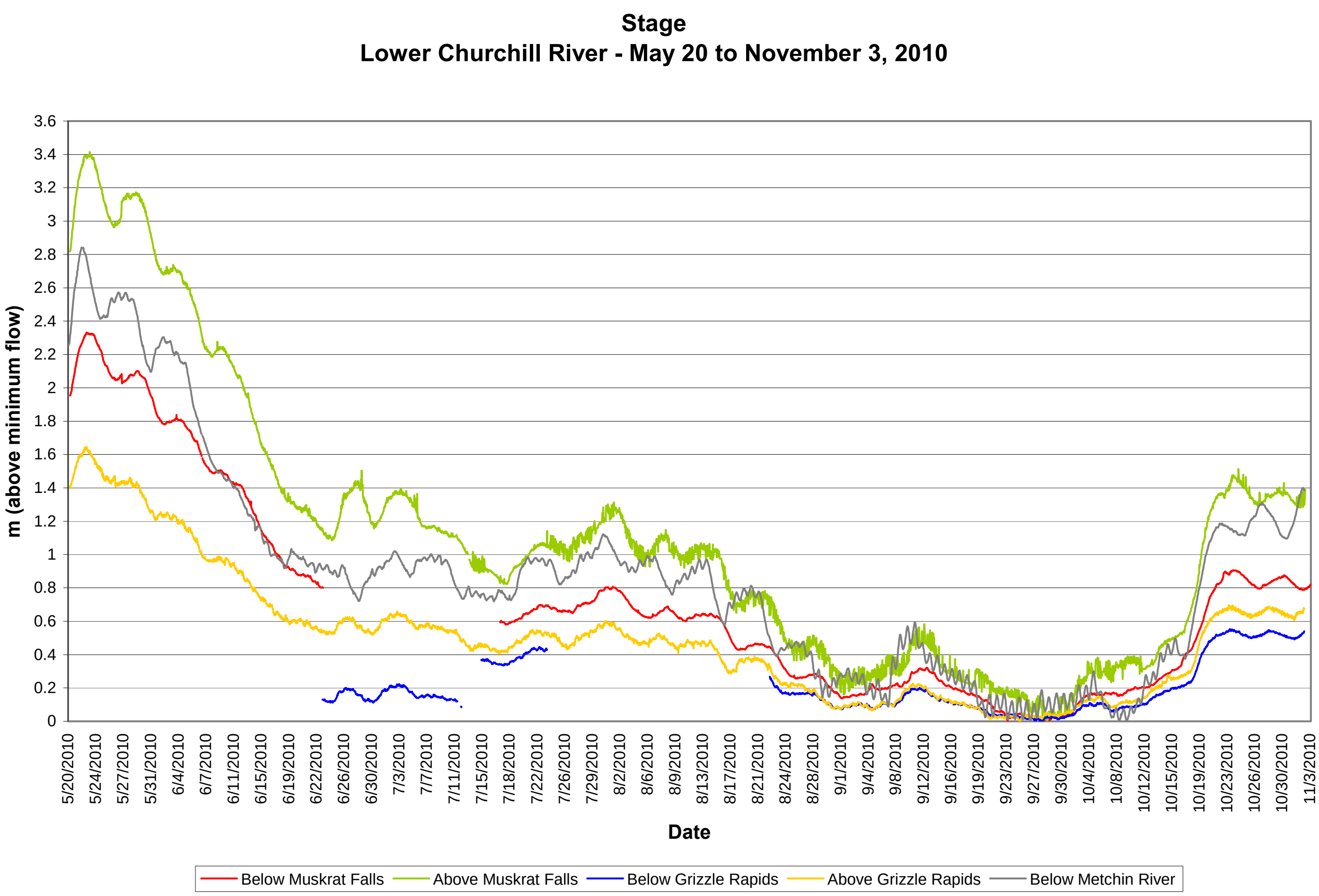


Figure 30: Stage at five monitoring stations along the Lower Churchill River

Conclusions

- Water quality monitoring instruments were successfully deployed on the Lower Churchill River at stations above and below Muskrat Falls, and below Metchin River from May 20 to November 2/3, 2010 and at the station below Grizzle Rapids from June 23 to November 2, 2010.
- 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. The four stations continue to perform well at capturing water quality baseline data along different reaches of the river.
- Most values recorded were within ranges as suggested by the CCME Guidelines for the Protection of Aquatic Life for pH. pH values did fall below the guideline at the station above Muskrat Falls during the second half of the deployment period. Corrected pH values at this station suggest this was a result of sensor drift and biofouling.
- At stations above Muskrat Falls, below Grizzle Rapids and below Metchin River, dissolved oxygen content did fall below the minimum CCME Guideline for the Protection of Aquatic Life during early life stages (9.5mg/L) during the warmest part of the season (later July to early September). All values at all stations remained above the minimum CCME Guideline for the Protection of Aquatic Life during other life stages (6.5mg/L)
- Regular visits on a near 30 day deployment schedule have been adhered to for the most part. This has provided good quality data with limited drift.
- A transmission error occurred at the station below Grizzle Rapids which prevented data from successfully being transmitted to the website in real time for much of the 2010 deployment season. EC is responsible for all communication aspects of the stations and is committed to maintaining this network. Internal log files will continue to be used to fill in gaps left by data transmission errors.

Path Forward

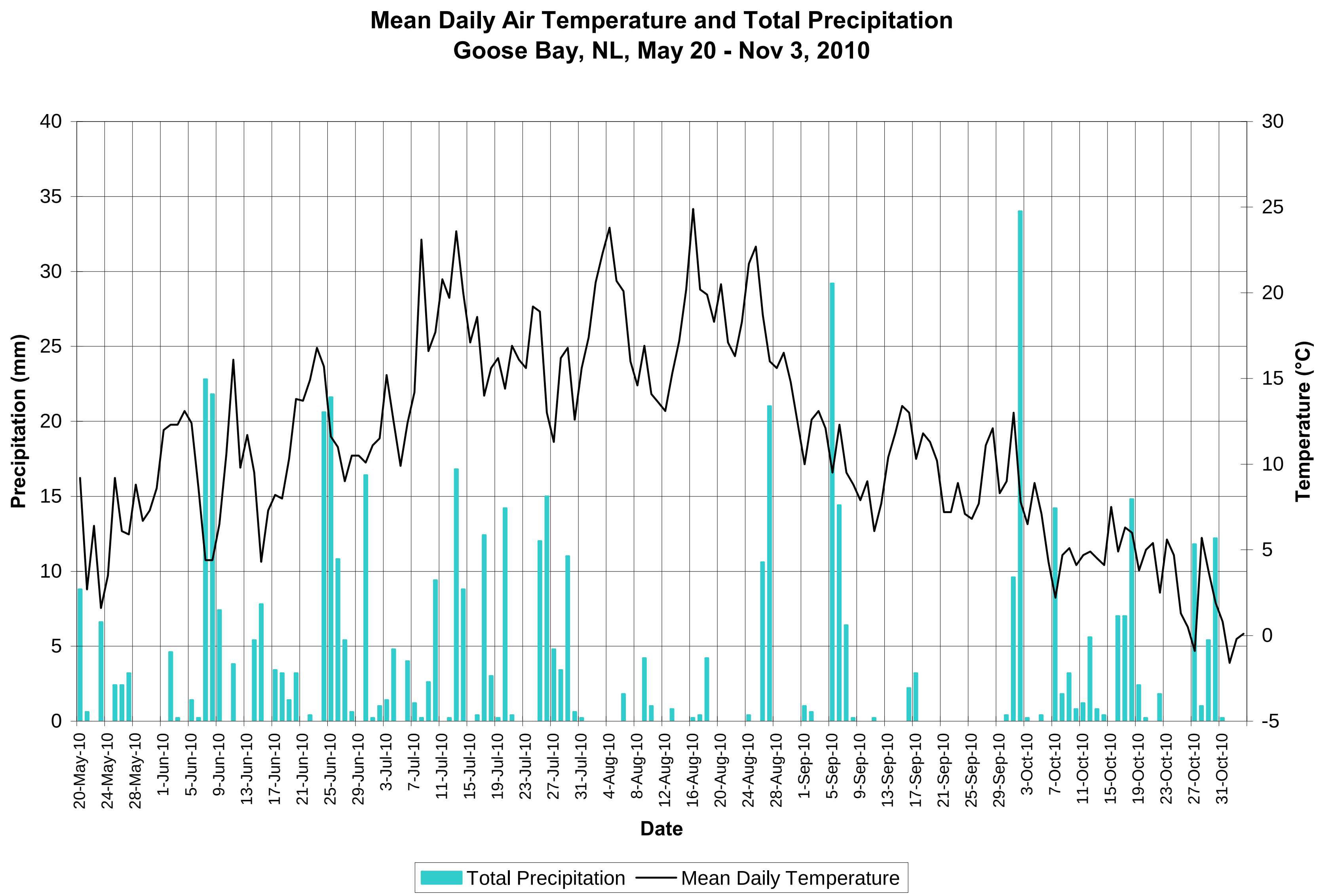
In order for this agreement to be successful, it is essential to continually evaluate and move forward. The 2010 deployment season was successful in providing baseline water quality data for the Lower Churchill Project. The following is a list of planned activities to be carried out in the upcoming year. The list also includes some multi-year activities planned in the previous year that are still in progress.

- ENVC has successfully established 2 new real time water quality monitoring stations in the Lower Churchill River and Lake Melville area. These stations are located at the mouth of the Churchill River at English Point and approximately 70km east of Goose Bay on Lake Melville east of Little River. Even though these stations are owned and operated by ENVC, when the monitoring season commences in 2011, Nalcor will be provided with data and monthly reports from these stations.
- Deploy real time water quality instruments in spring 2011 when ice conditions allow.
- ENVC staff will perform regular site visits throughout the 2011 deployment season for calibration and maintenance of the instruments.
- EC staff will perform regular site visits to ensure water quantity instrumentation is correctly calibrated and providing accurate measurements.

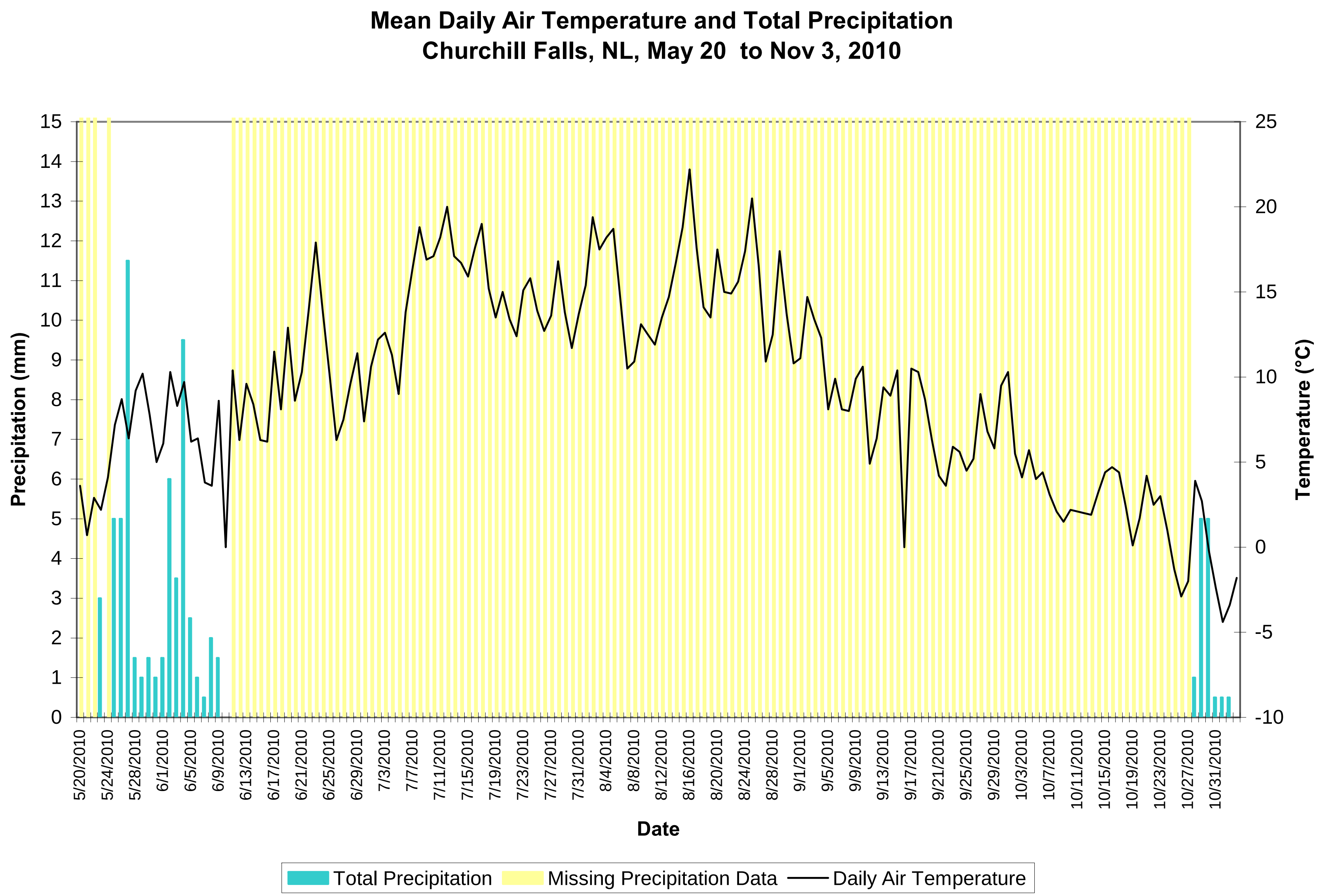
- If necessary, change or improve deployment techniques to adapt to each site, ensuring secure and suitable conditions for real time water quality monitoring.
- Nalcor will continue to be informed of data trends and any significant water quality events in the form of a monthly deployment report when 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 real time water quality data on a 3 month basis unless otherwise requested.
- Continue to maintain open communication lines between ENVC, EC and Nalcor employees involved with the agreement in order to respond to emerging issues on a proactive basis.
- Nalcor has agreed to install a new real time water quality monitoring station near the community of Rigolet. RTWQ Coordinator, Renee Paterson, will amend the agreement in the upcoming months.
- Continue to work on Automatic Data Retrieval System to incorporate new capabilities.
- Provide on-line statistical analysis of data.
- Creation of value added products using the real-time water quality data, remote sensing and water quality indices.
- ENVC will begin development of models using real time water quality monitoring data and grab sample data to estimate a variety of additional water quality parameters (*i.e.* TSS, major ions *etc*.).

Prepared by:
Grace Gillis
Department of Environment and Conservation
Water Resources Management Division
Phone: 709.896.5542
Fax: 709.896.9566
gracegillis@gov.nl.ca

Appendix 1



Mean Daily Air Temperature and Total Precipitation
Goose Bay, NL, May 20 - Nov 3, 2010
Precipitation (mm)
Temperature (°C)
Date
Total Precipitation
Mean Daily Temperature
0
5
10
15
20
25
30
35
40
-5
20-May-10
24-May-10
28-May-10
1-Jun-10
5-Jun-10
9-Jun-10
13-Jun-10
17-Jun-10
21-Jun-10
25-Jun-10
29-Jun-10
3-Jul-10
7-Jul-10
11-Jul-10
15-Jul-10
19-Jul-10
23-Jul-10
27-Jul-10
31-Jul-10
4-Aug-10
8-Aug-10
12-Aug-10
16-Aug-10
20-Aug-10
24-Aug-10
28-Aug-10
1-Sep-10
5-Sep-10
9-Sep-10
13-Sep-10
17-Sep-10
21-Sep-10
25-Sep-10
29-Sep-10
3-Oct-10
7-Oct-10
11-Oct-10
15-Oct-10
19-Oct-10
23-Oct-10
27-Oct-10
31-Oct-10


Mean Daily Air Temperature and Total Precipitation
Churchill Falls, NL, May 20 to Nov 3, 2010
Precipitation (mm)
Temperature (°C)
Date
Total Precipitation
Missing Precipitation Data
Daily Air Temperature