General

- The Water Resources Management Division staff monitors the real-time web page on a daily basis.
- NALCOR Energy will be informed of any significant water quality events in the form of a monthly deployment report.
- This monthly deployment report interprets the data from 4 water quality monitoring stations along the Lower Churchill River. These stations are located 6.15km below Lower Muskrat Falls, above Muskrat Falls, below Grizzle Rapids and below Metchin River. Stations below Lower Muskrat Falls and below Grizzle Rapids were deployed from September 22 to November 2 (41 days). Stations above Upper Muskrat Falls and below Metchin River were deployed from September 23 to November 2 (40 days). All instruments were removed for the winter season.
- A transmission error at the station below Grizzle Rapids occurred between 7:30am on October 1 and 5:30pm on October 8. On October 10, 2009 another transmission error occurred until the end of the deployment period. During these time periods, no data was sent to the real time web page. All water quality data during these periods has been recovered from the instruments internal log file. All water quantity data will be recovered from the data logger at the station during Environment Canada's next site visit (December 2009).

Quality Assurance and Quality Control

- As part of the installation and removal process, parameters are recorded from both the field sonde (in situ) and a similar, newly-calibrated QA sonde (placed side by side). The parameters from both instruments are compared and their variability is ranked as part of the QA/QC protocol (see Table 1).
- At the station below Lower Muskrat, all parameters ranked "excellent" or "good" at installation and removal except for dissolved oxygen at removal which was ranked "fair". The dissolved oxygen sensor will be recalibrated and examined before any future deployment.
- At the station above Upper Muskrat Falls, all parameters ranked "excellent" or "good" at installation and removal except for pH at removal which was ranked "poor". The pH sensor sometimes takes several minutes to stabilize in the water and it likely that QAQC measurement were recorded before the sensor had adequate time to stabilize in the water.
- At the station below Metchin River, all parameters ranked "excellent" or "good" at installation and removal except for temperature and pH at removal which were ranked "fair" and "marginal" respectively. The temperature sensor will be examined before any future deployment. Similar to the pH measurement at the Upper Muskrat Falls station, it is likely that the QA/QC sonde did not completely stabilize in the water before readings were recorded.
- At the station below Grizzle Rapids, all parameters ranked "excellent" or "good" at installation and removal.

Table 1: QA/QC Data Comparison Rankings upon installation on September 22/23 and removal on November 2, 2009.

				Instrument Comparison Ranking				
Churchill River Station	Date	Action	Instrument Serial Number	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Below Lower Muskrat Falls	22-Sep-09	Installation	44567	Excellent	Good	Excellent	Excellent	Good
	02-Nov-09	Removal		Excellent	Good	Excellent	Fair	Excellent
Above Upper Muskrat Falls	23-Sep-09	Installation	47588	Excellent	Good	Excellent	Excellent	Excellent
	02-Nov-09	Removal		Excellent	Poor	Excellent	Excellent	Good
Below Metchin River	23-Sep-09	Installation	45701	Excellent	Excellent	Excellent	Excellent	Excellent
	02-Nov-09	Removal		Fair	Marginal	Excellent	Good	Excellent
Below Grizzle Rapids	22-Sep-09	Installation	47590	Excellent	Excellent	Excellent	Excellent	Excellent
	02-Nov-09	Removal		Excellent	Good	Excellent	Excellent	Excellent

Data Interpretation

Churchill River 6.15km below Lower Muskrat Falls

Temperature

Water temperature decreases throughout the deployment period (Figure 1). This trend is expected as ambient air temperatures are also decreasing during this time of year (Appendix 1). Temperature ranges between 12.1°C and 2.8°C, averaging at 7.09°C.

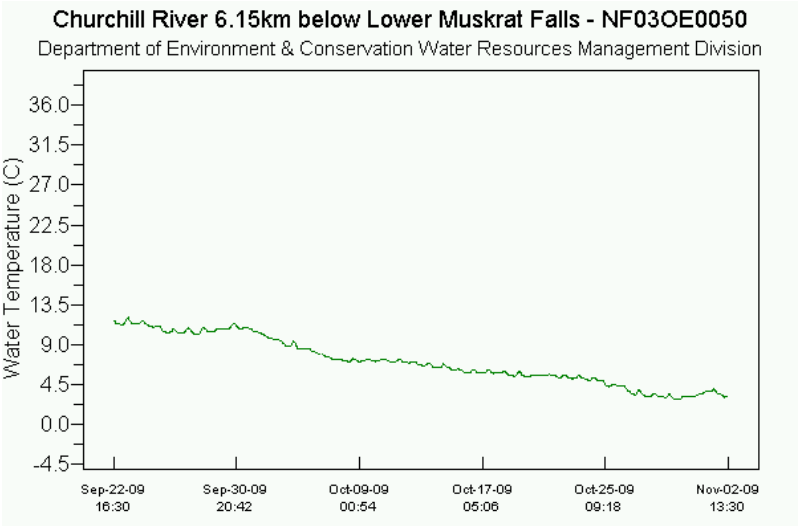

Figure 1: Water temperature for Lower Muskrat Falls Station, September 22 to November 2, 2009.

pH

pH remains stable throughout the deployment period ranging between 7.21 and 7.00 units (Figure 2). The low values at the beginning of the deployment on September 22 occur when the instrument is being deployed during the site visit. During the deployment, values range between 6.55 units and 7.07 units. All values are within the acceptable limits according to the CCME guidelines for the Protection of Aquatic Life (>6.5 and <9.0).

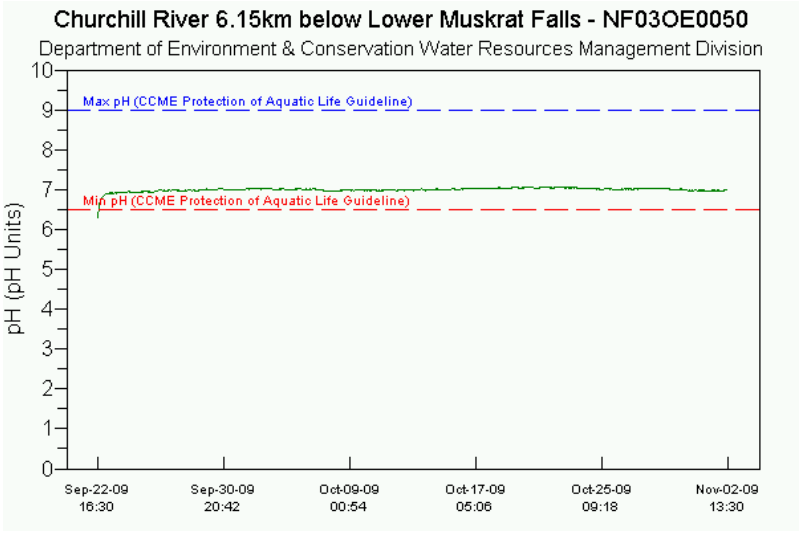

Figure 2: pH for Lower Muskrat Falls Station, September 22 to November 2, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance appears to fluctuate considerable in the first week of the deployment before stabilizing for the latter part of the deployment (Figure 3). The cause of the fluctuations is unknown. Values range between 16.3µS/cm and 20.8 µS/cm, averaging at 19.59 µS/cm.

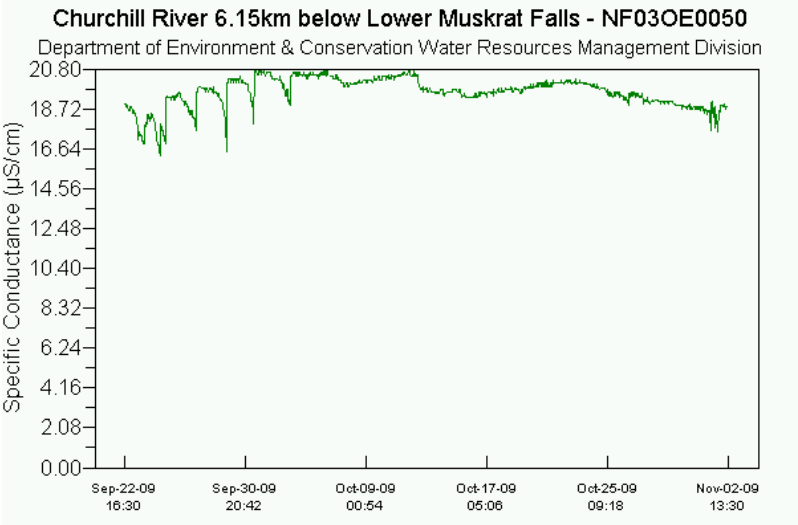

Figure 3: Specific Conductivity for Lower Muskrat Falls Station, September 23 to 22, 2009.

Total dissolved solids concentration is derived from specific conductance. Values range between 0.0122g/L and 0.0141g/L (Figure 4).

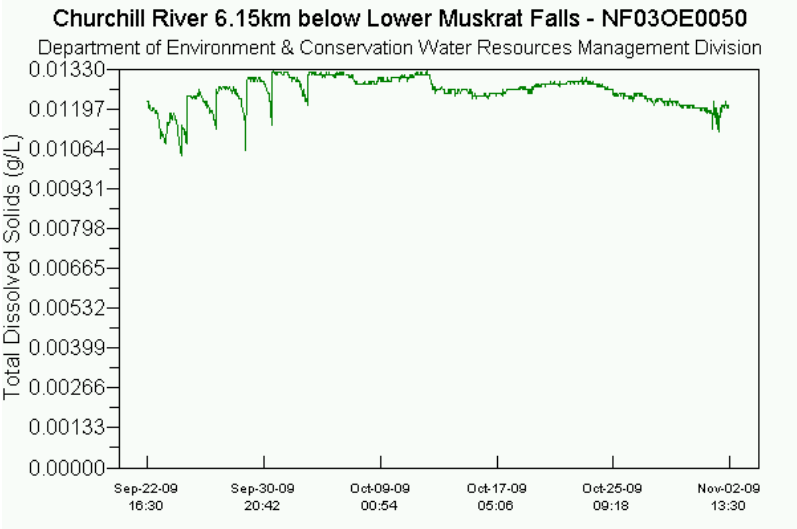

Figure 4: Total Dissolved Solid concentration for Lower Muskrat Falls Station, September 22 to November 2, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values are rising throughout the deployment period (Figure 5). This trend is expected as water and air temperatures are decreasing during this time (Figure 1, Appendix 1). Values range between 11.73mg/L and 14.72mg/L. All values are above the lower acceptable limit for dissolved oxygen content as suggested by the CCME guidelines for the Protection of Aquatic Life (>9.0mg/L)

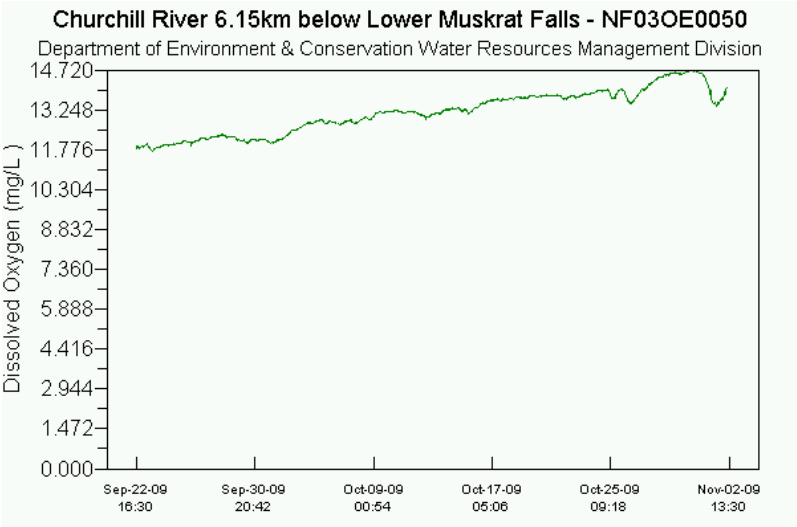

Figure 5: Dissolved Oxygen for Lower Muskrat Falls Station, September 22 to November 2, 2009.

Percent saturation values are derived from dissolved oxygen and water temperature. Between September 23 and 22, percent saturation ranges between 99.6% and 111.8% (Figure 6).

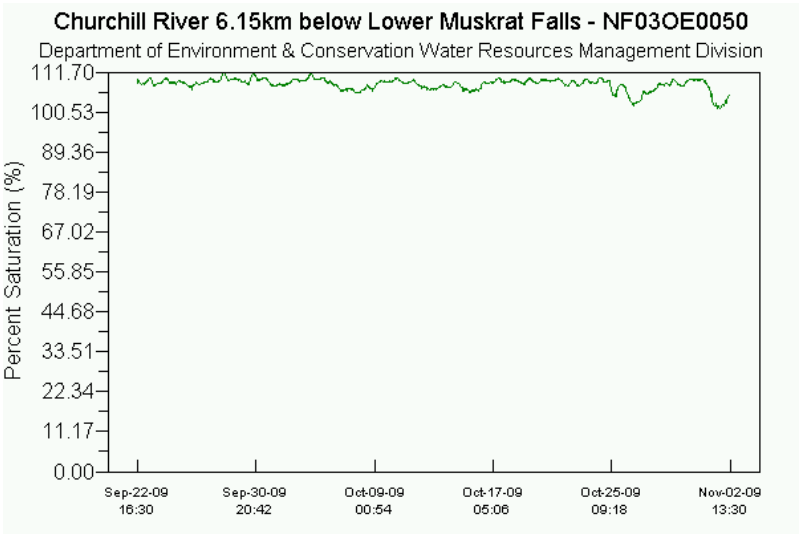

Figure 6: Percent Saturation for Lower Muskrat Falls Station, September 22 to November 2, 2009.

Turbidity

Turbidity values range between 0 and 383.6NTU throughout the deployment period (Figure 7). Turbidity values are variable throughout the deployment which is normal at this site due to the silty nature in the lower reaches of the River. The first spike indicated on the graph by the red arrows occurs between 9:30am and 4:30pm on September 30 and reaches turbidity values up to 68.7NTU. This event corresponds with a small rain fall event (2.6mm), wind and warmer than normal conditions (mean daily temperature is 13.5°). The second spike highlighted on the graph lasts for 48 hours between October 26 at 8:30am and October 28 at 8:30am with turbidity values recorded as high as 71.7NTU. This event follows a large snowfall event (24cm) in the Goose Bay area. The third spike, occurring just before instrument removal, began at 2:30am on November 1 and recorded values reaching as high as 383.6NTU. This event also corresponds with a rainfall event (5.4mm) combined with warm and windy conditions.

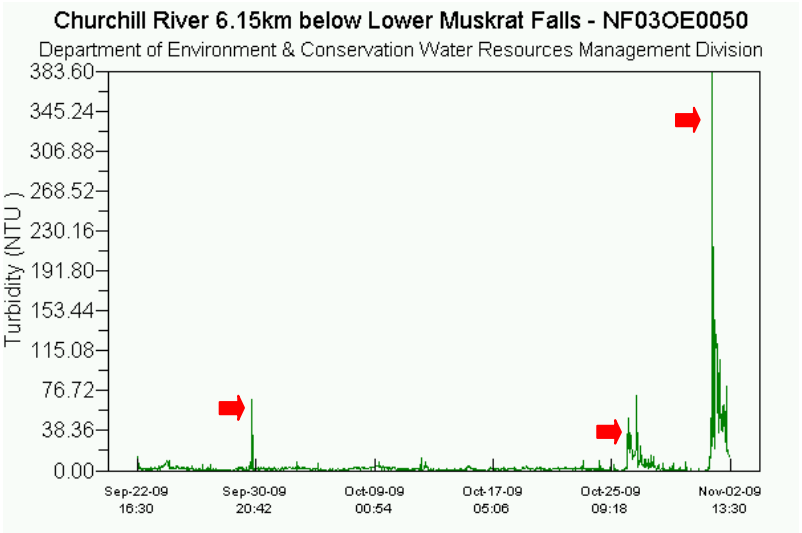

Figure 7: Turbidity for Lower Muskrat Falls Station, September 22 to November 2, 2009.

Stage

Stage remains stable throughout the deployment period ranging between 2.581m and 2.745m (Figure 8).

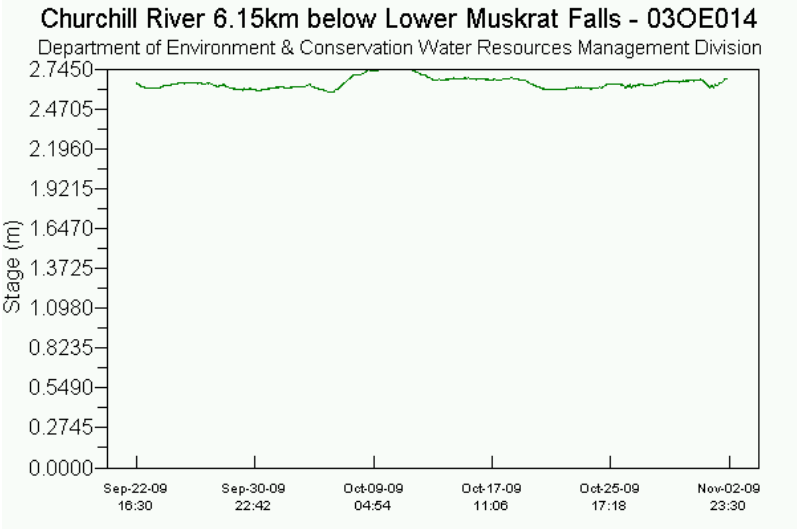

Figure 8: Stage Level for Lower Muskrat Falls Station, September 22 to November 2, 2009.

Churchill River above Upper Muskrat Falls

Temperature

Temperature values decrease throughout the deployment period ranging between 12.31°C and 2.54°C (Figure 9). This trend is expected as air temperatures are also decreasing during this time (Appendix 1).

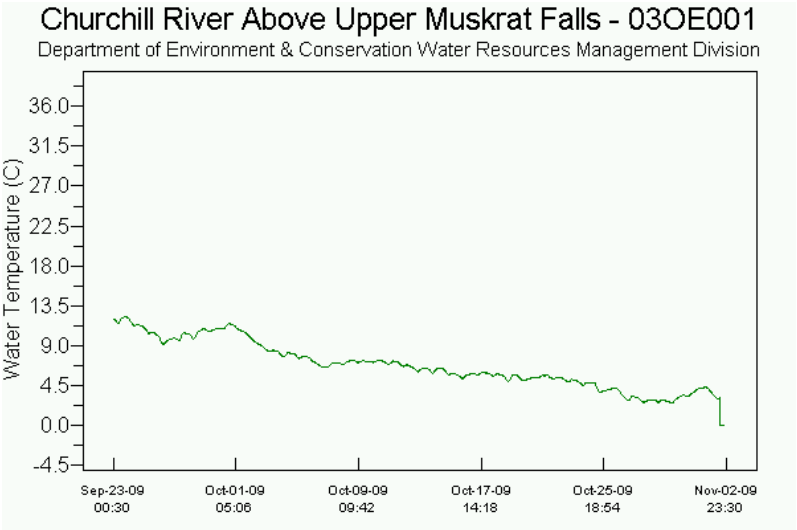

Figure 9: Water Temperature for Upper Muskrat Falls Station, September 23 to November 2, 2009.

pH

pH values at this station remain stable throughout the deployment period ranging between 6.66 and7.27 units, averaging 7.15 units (Figure 10). All values are within the acceptable limits according to the CCME Guidelines for the Protection of Aquatic Life (>6.5 and < 9.0 units).

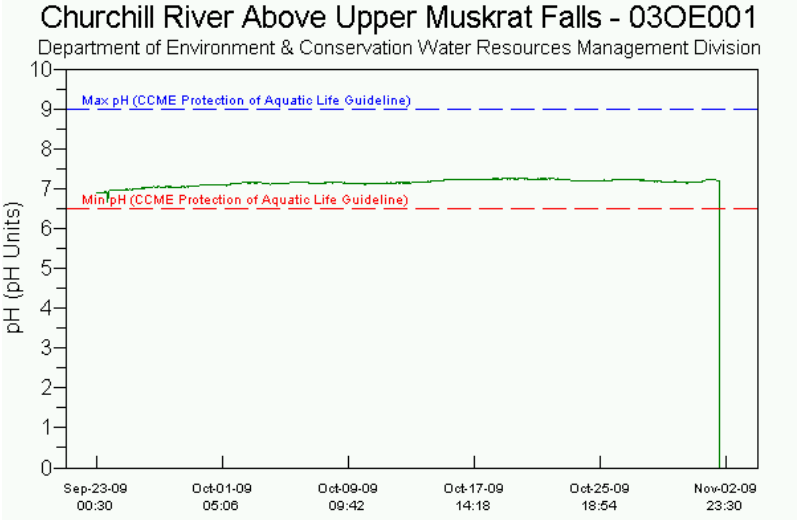

Figure 10: pH for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Specific Conductivity and Total Dissolved Solids

Specific conductance fluctuates throughout the deployment period ranging between 16.5µS/cm and 19.8µS/cm (Figure 11). There is one noticeable spike in the middle of the deployment period (circled in red) on October 10 when conductivity values jumps from around 17µS/cm to 18µS/cm. The higher value is not sustained for longer than one hour and its cause is unknown.

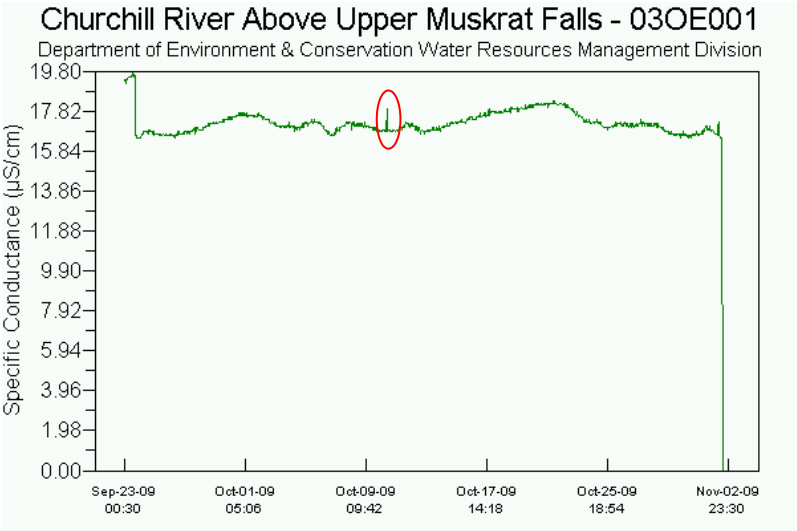

Figure 11: Specific Conductance for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Total dissolved solids concentration in the water column is derived from specific conductance. Values range between 0.0105g/L and 0.0126g/L during the deployment (Figure 12).

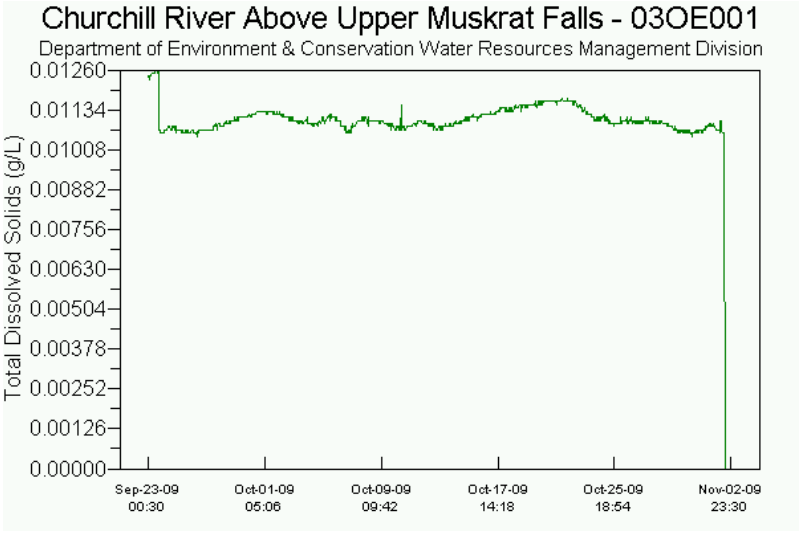

Figure 12: Total Dissolved Solids for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved Oxygen values increase during the deployment period (Figure 13). This trend is expected as water and air temperatures are decreasing during this time of year (Figure 9, Appendix 1). Values range between 10.41mg/L and 13.07mg/L, averaging 11.77mg/L. All values are above the lower acceptable limit (9.0mg/L) pertaining to the CCME Guideline for the Protection of Aquatic Life.

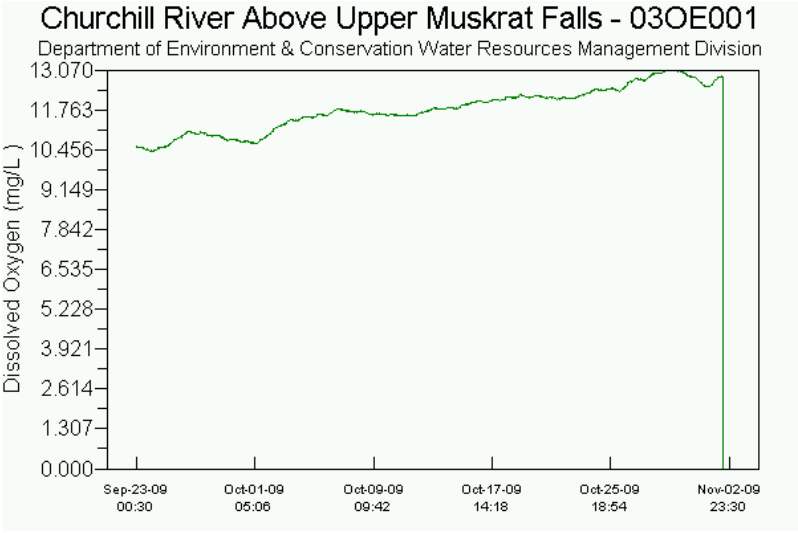

Figure 13: Dissolved Oxygen for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Percent saturation values are derived from dissolved oxygen content and water temperature. Percent saturation values remain stable throughout the deployment period with values ranging between 94.1% and 98.5% (Figure 14).

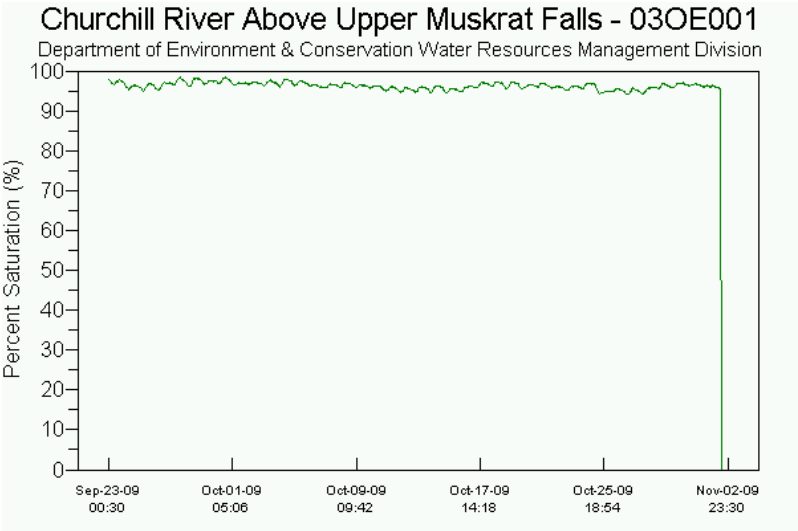

Figure 14: Percent Saturation for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Turbidity

Turbidity varies throughout the deployment period at the station above Upper Muskrat Falls with values range between 0NTU and 79NTU (Figure 15). Generally at this station, it is normal to see such variable turbidity values due to the silty nature of the river bed. Water is typically visibly cloudy at this station.

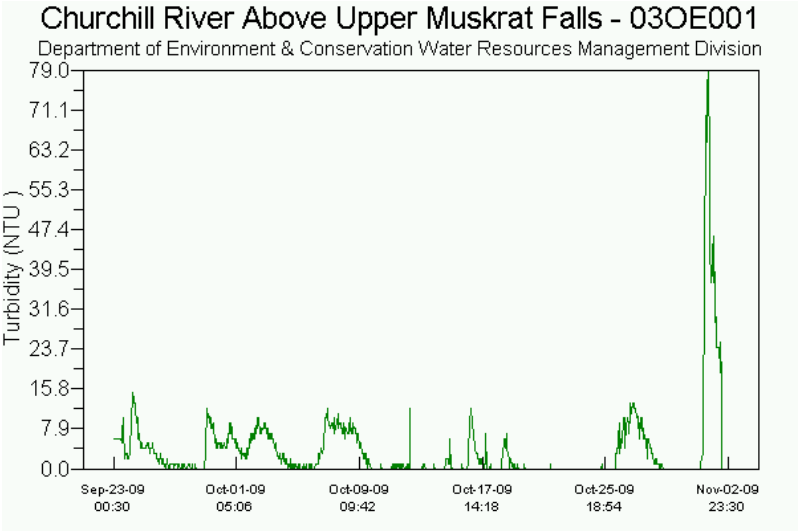

Figure 15: Turbidity for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Stage

Stage level rises and falls throughout the deployment period (Figure 16). Maximum stage level recorded was 16.196m and the minimum was 16.551m.

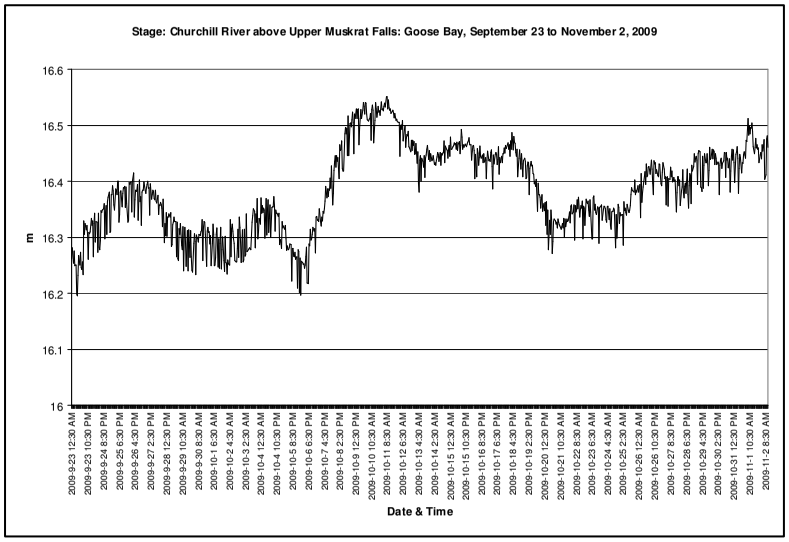

Figure 16: Stage level for Upper Muskrat Falls Station, September 23 to November 2, 2009.

Churchill River below Grizzle Rapids

Temperature

Temperature values decrease throughout the deployment period (Figure 17). This trend is expected as air temperatures are also cooling during this time (Appendix 1). Values range between 12.4°C and 3.45°C, averaging at 7.12°C.

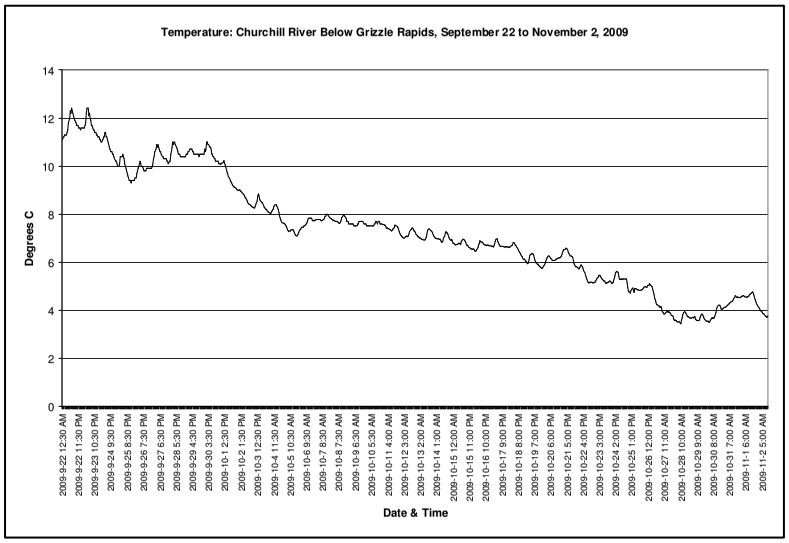

Figure 17: Temperature below Grizzle Rapids, September 23 to 22, 2009.

pH

pH values fluctuate daily throughout the deployment period ranging between 6.82 and 7.38 units (Figure 18). The large fluctuation at the beginning of the deployment occurs during the site visit when the instrument is being switched. All values are within the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0).

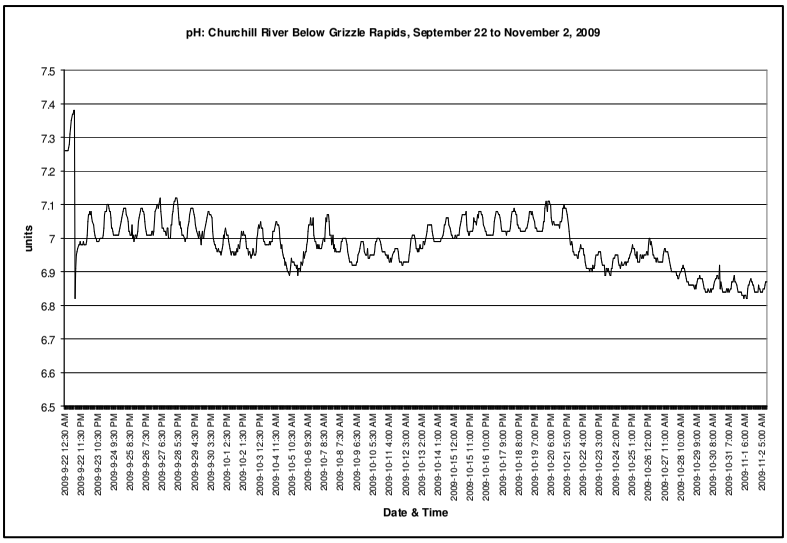

Figure 18: pH below Grizzle Rapids, September 23 to 22, 2009.

Specific Conductivity

Specific conductivity values fluctuate throughout the beginning of the deployment before the transmission errors in the beginning of October (Figure 19). The event circled in red corresponds with a 25mm+ rainfall event recorded in the area (Appendix 1) and is likely the cause of the increase in specific conductivity. During the transmission errors, specific conductivity data was downloaded from the internal log file, however, the instrument only captured values to 0 decimal places and subsequently provides much less detail for specific conductivity. Values throughout the deployment range between 18.0µS/cm and 21.1µS/cm.

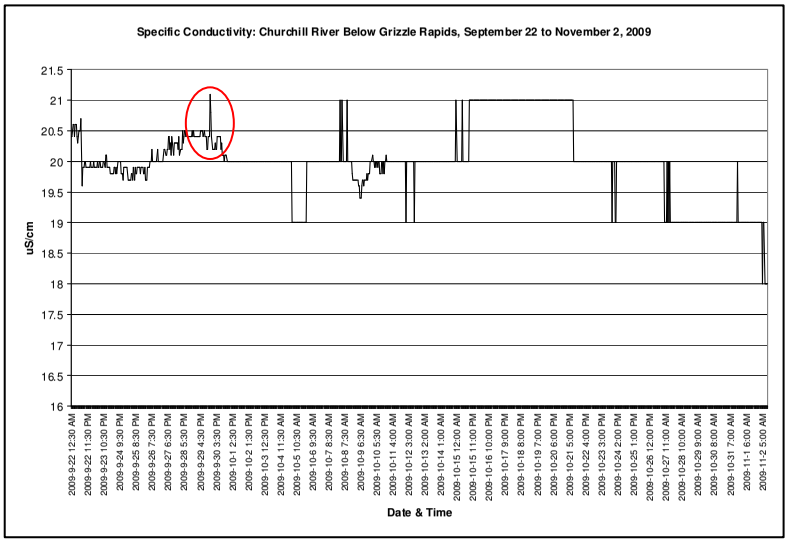

Figure 19: Specific Conductance below Grizzle Rapids, September 22 to November 2, 2009.

Total dissolved solids concentration is derived from specific conductance. Values between September 22 - October 1 and October 8 - 10 range between 0.0124g/L and 0.0135g/L (Figure 20). Values between October 1 and 8 and after October 10 are unavailable because the log file only measured values to 1 decimal place.

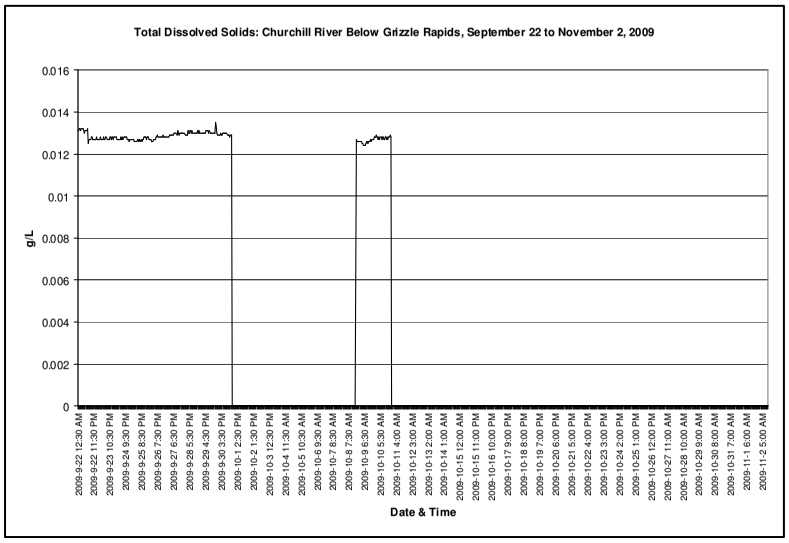

Figure 20: Total Dissolved Solids below Grizzle Rapids, September 22 to November 2, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen concentration is increasing slightly throughout the deployment period (Figure 21). This trend is expected as water and air temperatures are also decreasing during this time (Figure 17, Appendix 1). Values range between 10.42mg/L and 12.71mg/L. All values are above the minimum values for dissolved oxygen according to the CCME guidelines for the Protection of Aquatic Life (>9.0mg/L).

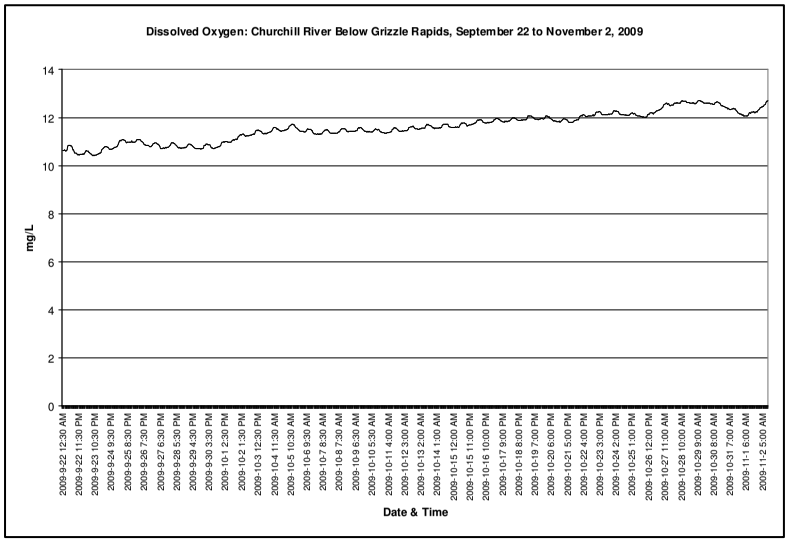

Figure 21: Dissolved Oxygen below Grizzle Rapids, September 22 to November 2, 2009.

Percent saturation values are derived from the dissolved oxygen and temperature data. Values ranges between 101.3% and 93.4% (Figure 22).

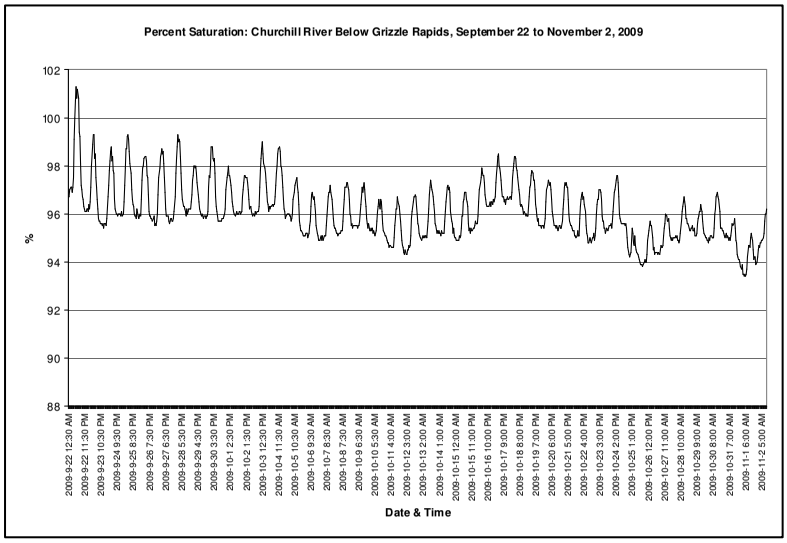

Figure 22: Percent Saturation below Grizzle Rapids, September 22 to November 2, 2009.

Turbidity

Turbidity values remain at or close to 0NTU for the entire deployment period except for 2 measurements on September 26 and October 28 up to 1.2NTU and 3.1NTU respectively (Figure 23). Neither value is sustained longer than on hour.

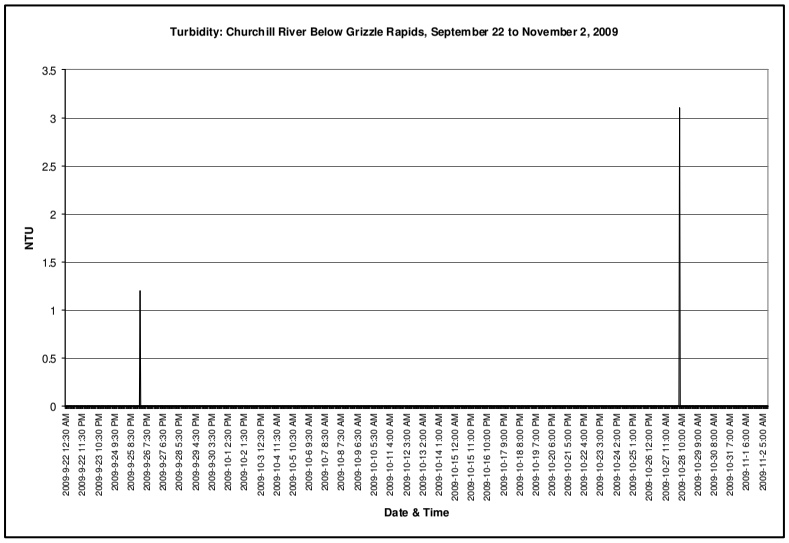

Figure 23: Turbidity below Grizzle Rapids, September 22 to November 2, 2009.

Stage

Stage level fluctuates throughout the first part of the deployment period ranging between 33.543m and 33.428m (Figure 24). Missing data will be recovered from the data logger during the next site visit by Environment Canada.

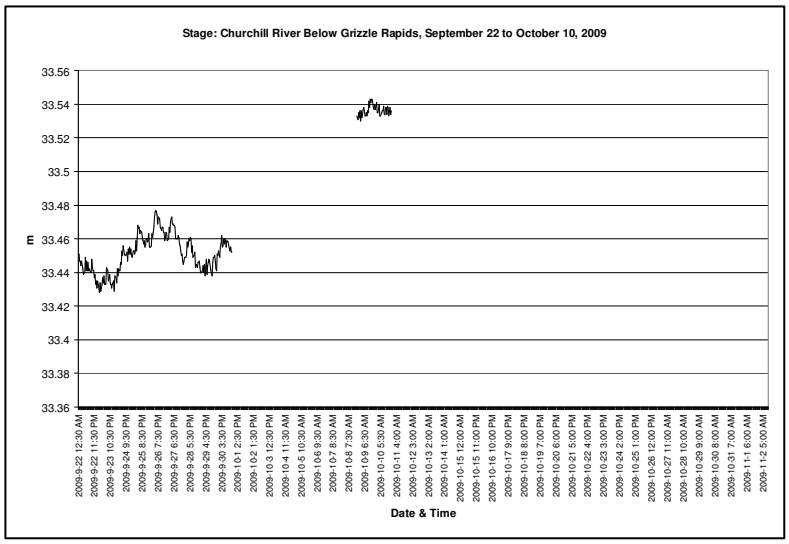

Figure 24: Stage level below Grizzle Rapids, September 22 to October 10, 2009.

Churchill River below Metchin River

Temperature

Temperature decreases throughout the deployment period (Figure 25). This trend is expected as air temperatures are decreasing during this time (Appendix 1). The temperature values between September 23 and November 2, averages 5.19°C, ranging between 9.7°C and -0.1°C.

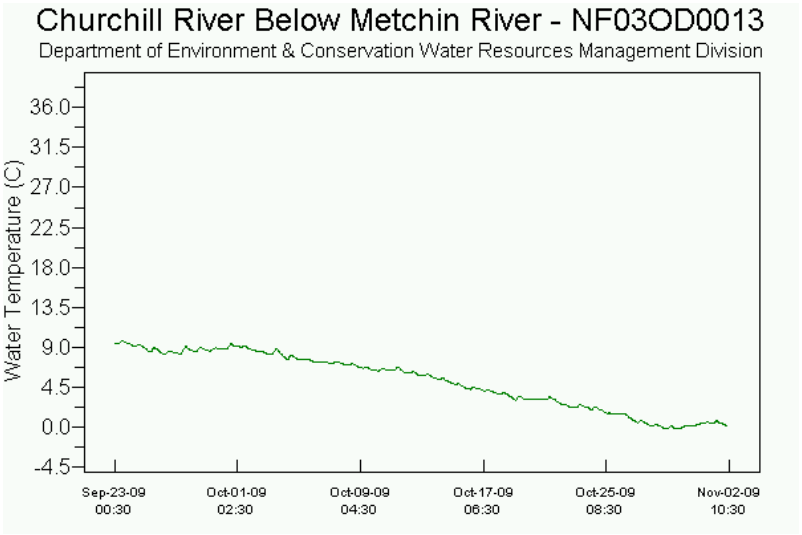

Figure 25: Water Temperature below Metchin River, September 23 to November 2, 2009.

pH

pH values remain stable throughout the deployment period ranging between 7.02 and 7.33 units, averaging at 7.27 units (Figure 26). All values are within the acceptable limits for pH according to the CCME Guideline for the Protection of Aquatic Life (>9.0 units).

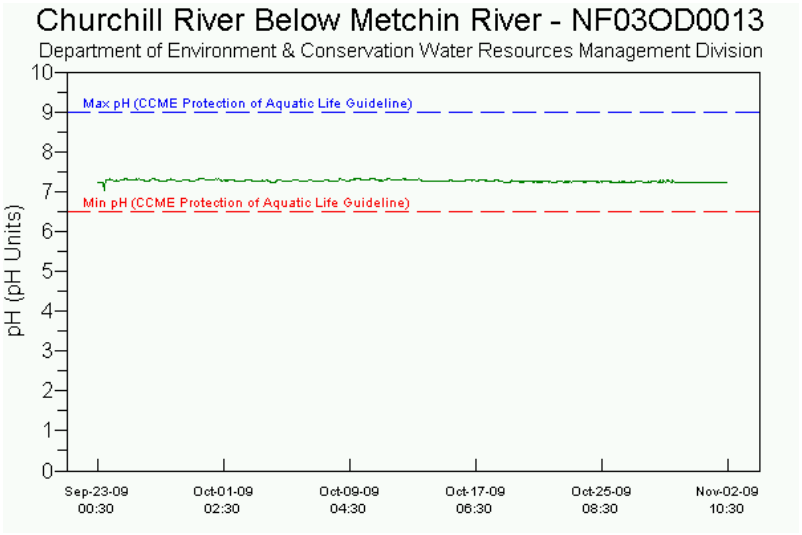

Figure 26: pH below Metchin River, September 23 to November 2, 2009.

Specific Conductivity

Specific conductivity values remain stable throughout the deployment period (Figure 27). An increase occurring on September 30 reaches up to 24µS/cm but does not last longer than one hour. Values range between 20.5µS/cm and 24µS/cm, averaging at 21.82µS/cm.

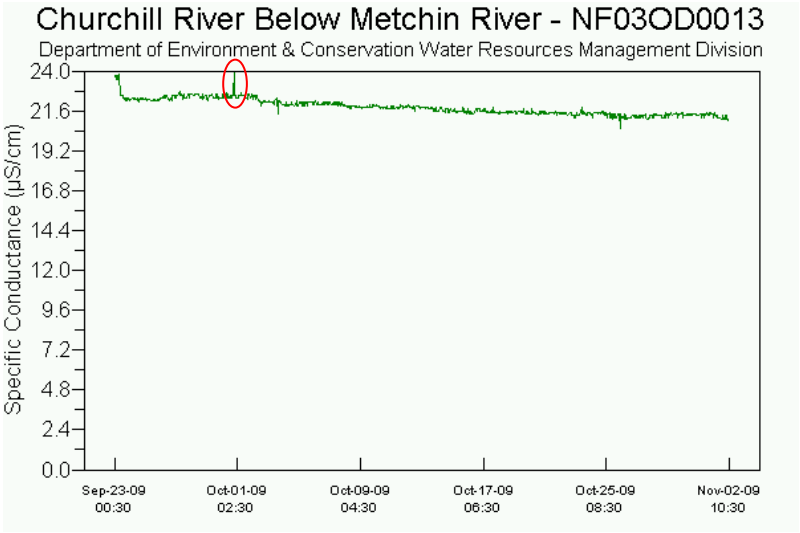

Figure 27: Specific Conductance below Metchin River, September 23 to November 2, 2009

Total Dissolved solid concentrations are derived from specific conductance. Values range between 0.0153g/L and 0.0131g/L (Figure 28).

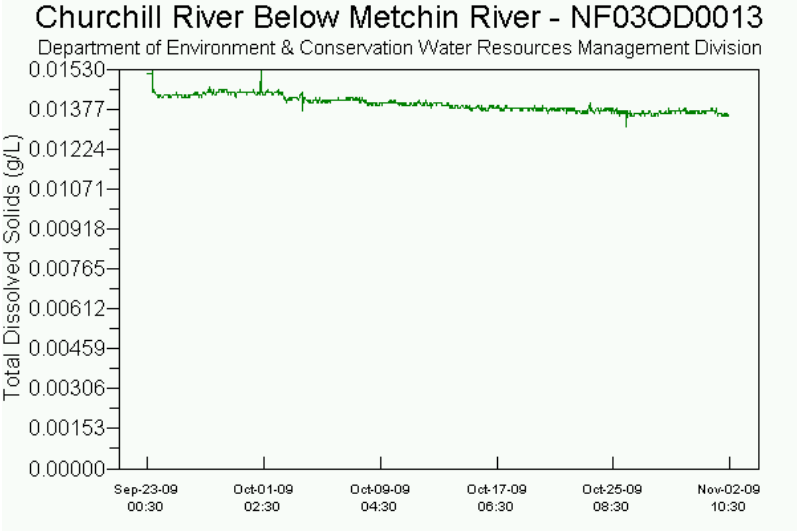

Figure 28: Total Dissolved Solids below Metchin River, September 23 to November 2, 2009.

Dissolved Oxygen and Percent Saturation

Dissolved oxygen values increase throughout the deployment period ranging between 10.55mg/L and 13.89mg/L (Figure 29). This trend is expected as water and air temperatures are decreasing during this time (Figure 25, Appendix 1). All values for dissolved oxygen are within the lower acceptable limit for dissolved oxygen content in cold waters (9.0mg/L).

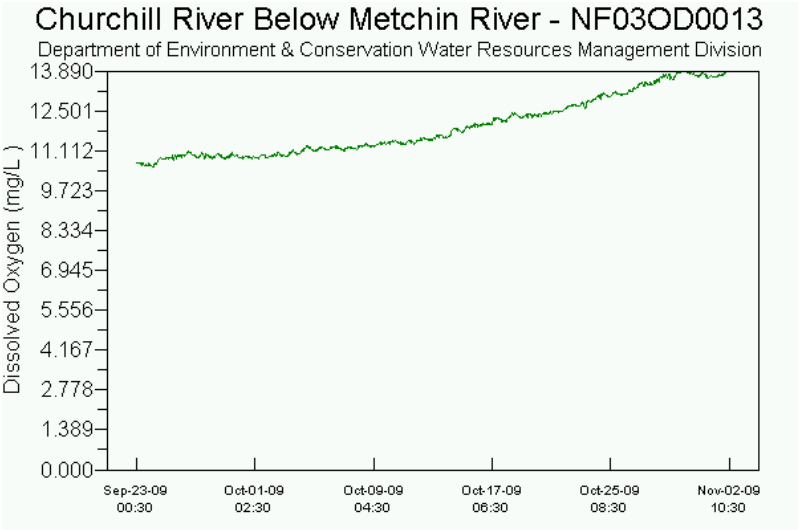

Figure 29: Dissolved Oxygen below Metchin River, September 23 to November 2, 2009.

Percent saturation values are derived from the dissolved oxygen and temperature readings. Values range between 96.0% and 91.1% (Figure 30).

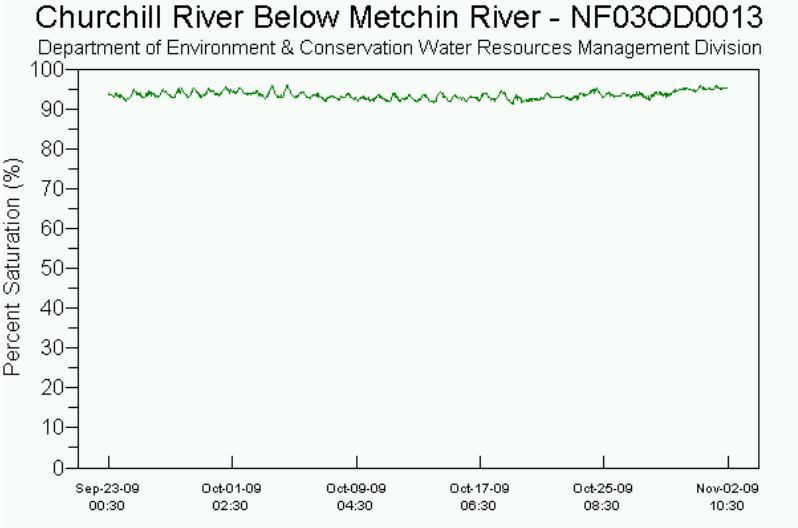

Figure 30: Percent Saturation below Metchin River, September 23 to November 2, 2009.

Turbidity

Turbidity values remain at or near 0NTU for the entire deployment period (Figure 31). Only a couple of spikes occur between September 23 and November 2, none of which last longer than one hour.

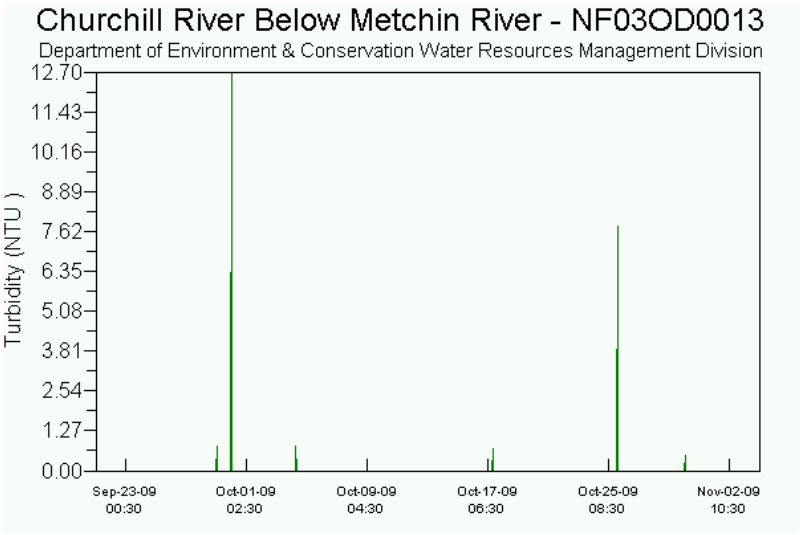

Figure 31: Turbidity below Metchin River, September 23 to November 2, 2009.

Stage

Stage levels rise and fall throughout the deployment period (Figure 32). Maximum stage level is recorded at 113.231m and the minimum level at 112.587m.

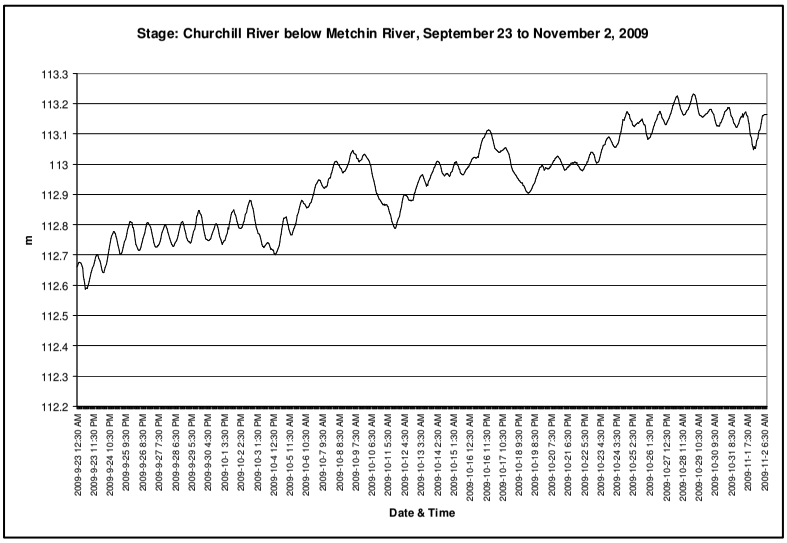

Figure 32: Stage level below Metchin River, September 23 to November 2, 2009.

Conclusions

Water quality monitoring stations located on the Lower Churchill River at 6.15km below Lower Muskrat Falls and below Grizzle Rapids were deployed between September 22 and November 2. Stations above upper Muskrat Falls and below Metchin River were deployed between September 23 and November 2. All stations reported data for water quality parameters; temperature, pH, specific conductivity (total dissolved solids), dissolved oxygen (percent saturation), and turbidity.

At the station below Grizzle Rapids, a data transmission error prevented data from being sent and graphed on the real time webpage between October 1 and 8 and after October 10. All water quality data was retrieved from the instruments internal log file. Because of an error with the log file programming, specific conductivity and total dissolved solids during the transmission error are measured to 0 decimal places. Water quantity data will be retrieved from the data logger during the next site visit by Environment Canada.

Precipitation events recorded by Environment Canada for Goose Bay and Churchill Falls can be used to explain most fluctuations in water quality. Despite all natural fluctuations in water quality along the Lower Churchill River between September 23 and November 2, all values recorded for pH and dissolved oxygen are within the recommend range as stated by the CCME Guidelines for the Protection of Aquatic Health.

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Appendix 1 – Weather Data

Table A-1: Weather for Happy Valley Goose Bay – September 23 to November 2, 2009

	Max Temp ℃	Min Temp ℃	Mean Temp ℃	Total Precip mm	Dir of Max Gust10's Deg	Spd of Max Gust km/h
23-Sep	22.4	3.6	13	17.4	33E	56E
24-Sep	6.4	1	3.7	2.4	36E	32E
25-Sep	6	-1.3	2.4	0		<31
26-Sep	12.4	-0.9	5.8	T	24E	41E
27-Sep	18.2	5.9	12.1	0	26E	32E
28-Sep	16.6	3.9	10.3	T		<31
29-Sep	14.2	8.7	11.5	T		<31
30-Sep	19.5	7.5	13.5	2.6	9E	37E
1-Oct	11.5	5.6	8.6	0.2	5	46
2-Oct	6.1	3.8	5	0.6	5	37
3-Oct	6.2	-0.3	3	0	4	32
4-Oct	6.6	-1.5	2.6	0		<31
5-Oct	6	-2.1	2	0		<31
6-Oct	5.4	2.4	3.9	26.2	6	54
7-Oct	6.7	3.8	5.3	4.8	6	50
8-Oct	7.3	2.5	4.9	1.2	7	39
9-Oct	4.7	1.3	3	T		<31
10-Oct	6	0.1	3.1	8.8		<31
11-Oct	5.8	0.2	3	3.8		<31
12-Oct	7.3	1.5	4.4	0	32	35
13-Oct	6.4	-0.9	2.8	T	28	44
14-Oct	6.1	-2.2	2	T	35	39
15-Oct	1.7	-3.9	-1.1	T	32	37
16-Oct	4.3	-2.8	0.8	0		<31
17-Oct	4.1	-2.4	0.9	0		<31
18-Oct	3.9	-5.9	-1	0		<31
19-Oct	6.3	-6	0.2	0		<31
20-Oct	3	-5.3	-1.2	0.6		<31
21-Oct	3.5	0.1	1.8	4.2		<31
22-Oct	0.1	-5.3	-2.6	0.6		<31
23-Oct	2.8	-7.2	-2.2	0		<31
24-Oct	3.5	-5.7	-1.1	0		<31
25-Oct	1.2	-1.8	-0.3	24		<31
26-Oct	0.5	-5.7	-2.6	0.8	31	80
27-Oct	-0.6	-9.2	-4.9	0	31	54
28-Oct	-1.2	-10.1	-5.7	0		<31
29-Oct	0.9	-6.5	-2.8	0		<31
30-Oct	3.9	-4.4	-0.3	0	28	33
31-Oct	9.6	1.4	5.5	5.4	22	44
1-Nov	9.6	-0.4	4.6	T	28	85
2-Nov	0.5	-9.3	-4.4	0	31	39

Table A-2: Weather for Churchill Falls – September 23 to November 2, 2009

	Max Temp ℃	Min Temp ℃	Mean Temp ℃	Total Precip mm	Dir of Max Gust10's Deg	Spd of Max Gust km/h
23-Sep	13.7	3.6	8.7	11	35	39
24-Sep	3.7	-1.1	1.3	0.5		<31
25-Sep	5.3	-0.5	2.4	0.5	29	37
26-Sep	10.4	2.5	6.5	0.5	25	35
27-Sep	16	8.2	12.1	0		<31
28-Sep	13.9	8.4	11.2	3.5		<31
29-Sep	11.9	8.2	10.1	7.5	1	44
30-Sep	14.2	4.1	9.2	4.5	21	35
1-Oct	9.7	2.6	6.2	4.5	7	48
2-Oct	4	1.6	2.8	0	7	46
3-Oct	8.5	-1.7	3.4	0		<31
4-Oct	10.1	-3.8	3.2	1.5		<31
5-Oct	4.8	1.4	3.1	3.5	12	32
6-Oct	2.6	0.8	1.7	5.5	7	33
7-Oct	4.7	1.7	3.2	0.5	7	41
8-Oct	4.4	0.6	2.5	0	8	32
9-Oct	3.7	0.1	1.9	1.5		<31
10-Oct	8.1	-0.4	3.9	0.5		<31
11-Oct	5.4	-0.8	2.3	1		<31
12-Oct	5.1	0.1	2.6	2.5	32	41
13-Oct	4	-2.2	0.9	0	29	44
14-Oct	2.2	-2.4	-0.1	2	29E	39E
15-Oct	-1.2	-4.7	-3	1	34	46
16-Oct	1.2	-6.9	-2.9	0.5		<31
17-Oct	-1.1	-3.5	-2.3	0		<31
18-Oct	-0.5	-6.4	-3.5	0		<31
19-Oct	4.8	-7.4	-1.3	0.5		<31
20-Oct	0.9	-2.1	-0.6	2		<31
21-Oct	1.5	-7.2	-2.9	1	32	39
22-Oct	-3.2	-7.3	-5.3	0	30	32
23-Oct	1.4	-6.7	-2.7	0		<31
24-Oct	1.2	-5.4	-2.1	1	12	35
25-Oct	0.8	-3.1	-1.2	8	12	37
26-Oct	0.4	-8.5	-4.1	1	33	67
27-Oct	-5.5	-9.9	-7.7	M		<31
28-Oct	-6	-15.4	-10.7	0		<31
29-Oct	0.3	-14.8	-7.3	0		<31
30-Oct	2.7	-3	-0.2	0		<31
31-Oct	8.4	0.6	4.5	5	2	59
1-Nov	5.7	-4.8	0.5	0	28	78
2-Nov	-1.8	-7.8	-4.8	0	29	44

M = Missing data

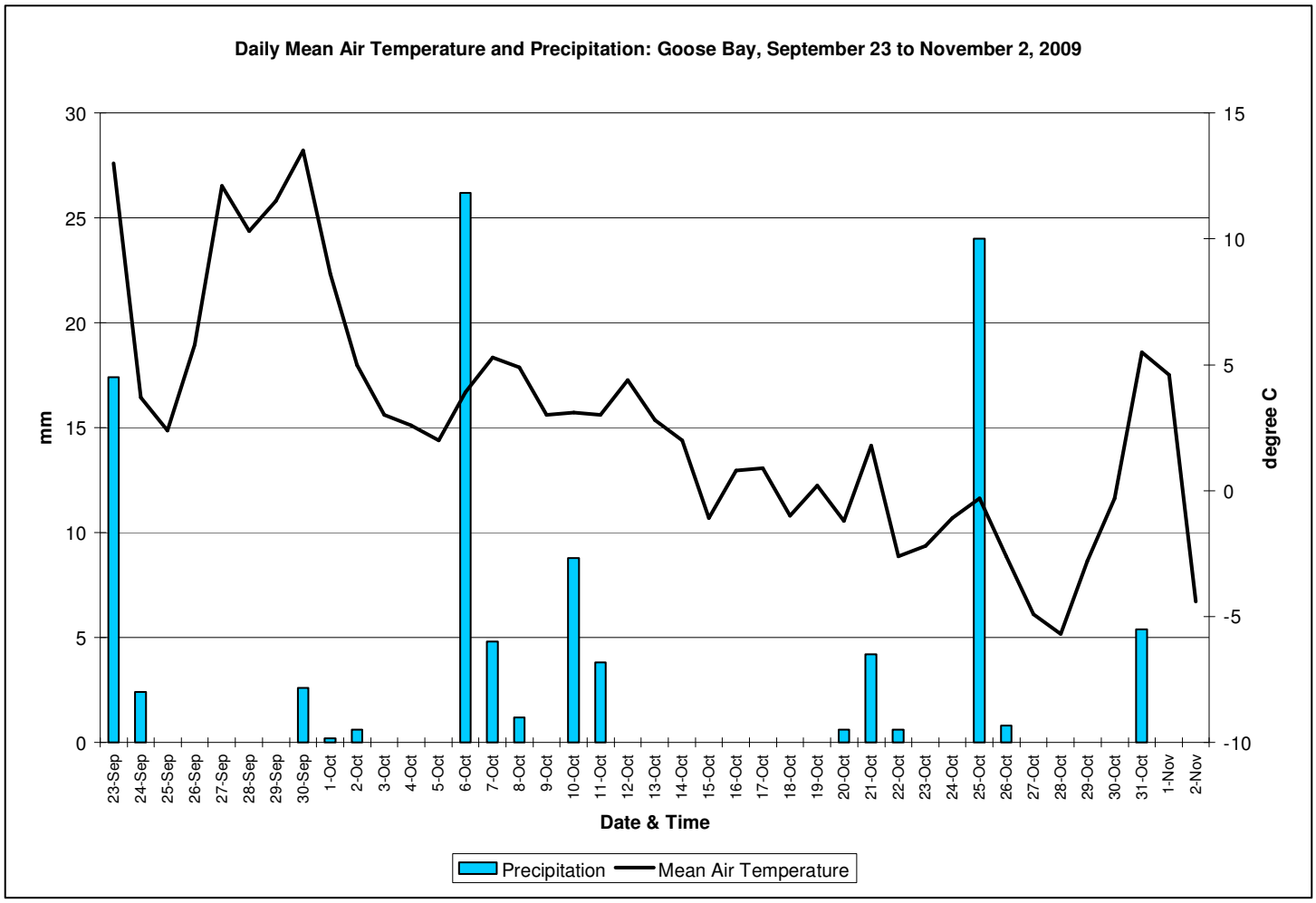

Figure A-1: Mean daily air temperature and precipitation for Happy Valley Goose Bay area, September 23 to November 2, 2009.

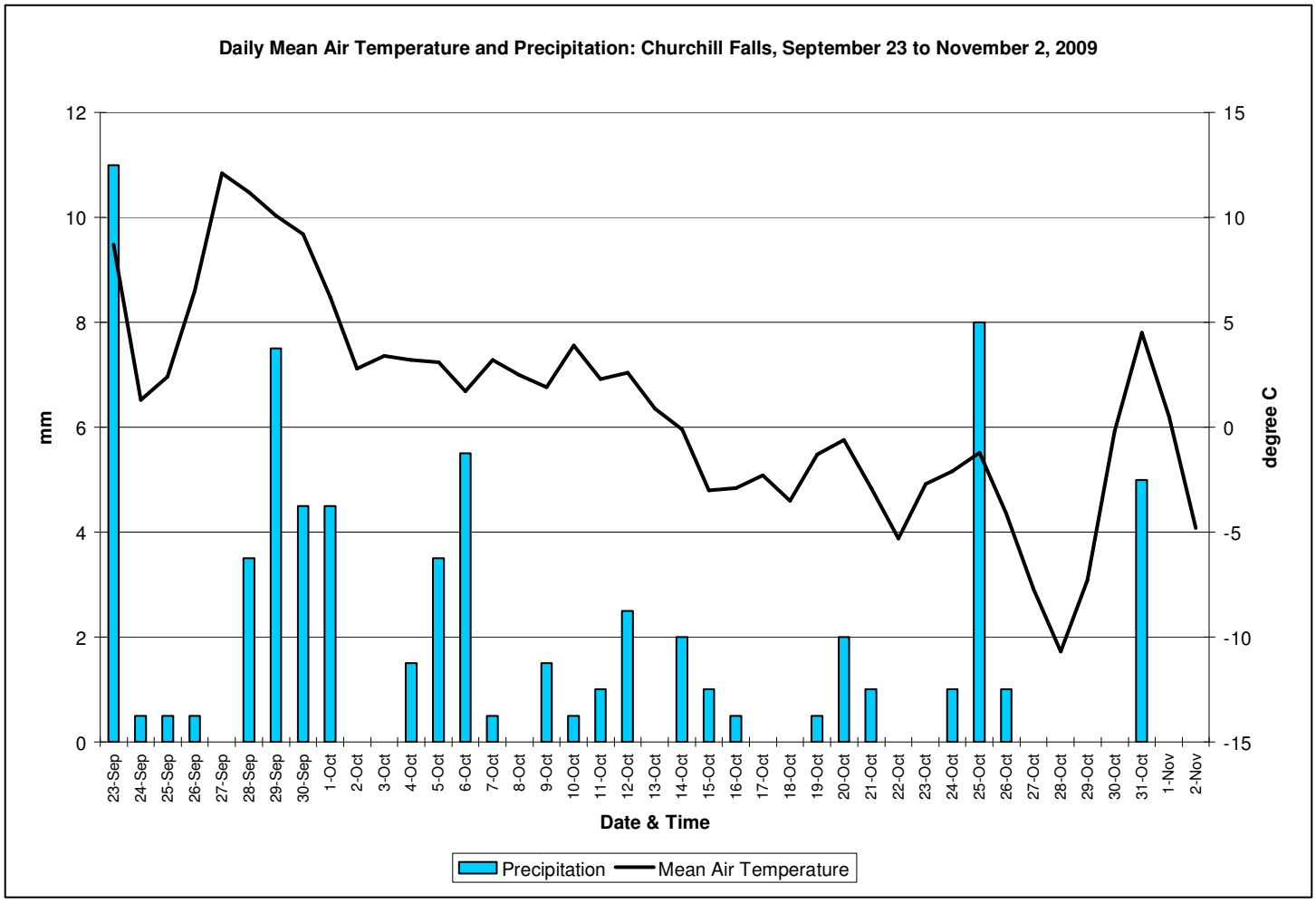

Figure A-2: Mean daily air temperature and precipitation for Churchill Falls area, September 23 to November 2, 2009.