Real-Time Water Quality Deployment Report

Lower Churchill River Network

June 24 to August 5, 2015

Newfoundland Labrador

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

Contents

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Real Time Water Quality Monitoring

- Department of Environment and Conservation staff monitors the real-time water quality data on a regular basis.
- This deployment report discusses water quality related events occurring at four stations on the Lower Churchill River: below Grizzle Rapids, above and below Muskrat Falls and at English Point.
- There was no instrument deployed at the station on Lake Melville east of Little River. Instrument deployments at this station have been suspended until a buoy system can be established at this site.
- On June 24, 2015, real-time water quality monitoring instruments were deployed at three of the Lower Churchill River Stations for a period of 41 & 42 days. The station below Lower Muskrat Falls was not deployed due to continued issues with sand at the site which could damage the instrument.

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 QAQC Instrument is temporarily deployed alongside the Field Instrument. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the Field Instrument and QAQC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Instrument Performance Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/l) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

- It should be noted that the temperature sensor on any instrument is the most important. All other parameters can be broken down into three groups: temperature 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 June 24, to August 5, 2015 are summarized in Table 2.

Table 2: Comparison rankings for Lower Churchill River stations June 24 to August 5, 2015

Churchill River Station and Instrument Number	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Grizzle Rapids (45699)	June 24, 2015	Deployment	Good	Fair	Excellent	Excellent	Excellent
	August 5, 2015	Removal	Excellent	Good	Excellent	Good	Excellent
Above upper Muskrat Falls (45700)	June 24, 2015	Deployment	Good	Fair	Excellent	Good	Marginal
	August 5, 2015	Removal	Good	Excellent	Excellent	Excellent	Excellent
Below Muskrat Falls	Not deployed	Deployment	N/A	N/A	N/A	N/A	N/A
	Not deployed	Removal	N/A	N/A	N/A	N/A	N/A
At English Point (43820)	June 25, 2015	Deployment	Excellent	Good	Excellent	Excellent	Poor
	August 5, 2015	Removal	Excellent	Excellent	Good	Good	Excellent

- At the station below Grizzle Rapids, temperature, conductivity, dissolved oxygen, and turbidity all rank as 'good' or 'excellent' at deployment. pH ranks as 'fair'. The field pH value was 6.83 and the QA/QC value was 6.31, while the grab sample value was 7.41. The difference between the readings is likely due to the QA/QC sonde not being acclimatized to the water conditions. Upon removal, temperature, pH, conductivity, dissolved oxygen, and turbidity all rank as 'good' or 'excellent'.
- At the station above Muskrat Falls, temperature, conductivity and, dissolved oxygen, rank 'good' or 'excellent' at deployment. pH ranks as 'fair' and turbidity ranks as 'marginal'. The field pH value was 6.20 and the QA/QC value was 6.78, while the grab sample value was 7.20. The difference between the readings is likely due to the QA/QC sonde not being acclimatized to the water conditions. The field turbidity value was 11.0 NTU and the QA/QC value was 2.4NTU, while the grab sample value was 2.4NTU. This discrepancy in the values can be attributed to the field and QA/QC sonde not being located in the same location. Upon removal, temperature, pH, conductivity, dissolved oxygen and turbidity all rank as 'good' or 'excellent'

- At the station at English Point, temperature, pH, conductivity, and dissolved oxygen all rank as 'good' or 'excellent' while turbidity ranks as 'poor'. The field turbidity value was 18.9NTU and the QA/QC value was 7.2NTU, while the grab sample value was 4.6NTU. This discrepancy is likely due to sediment being suspended and disturbed around the field sonde as the value was being recorded. Upon removal, temperature, pH, conductivity, dissolved oxygen, and turbidity ranked 'good' or 'excellent'.

Data Interpretation

- The following graphs and discussion illustrate water quality related events occurring from June 24 to August 5, 2015 on the Lower Churchill River Network.
- With the exception of water quantity data (stage & flow), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- The below Muskrat Falls station is experiencing issues with the sediment in the area. The sonde has been repeatedly buried in sand during deployment. To prevent damage to the sonde, this station was not deployed during this period. The instrument will be redeployed should conditions improve in the 2015 field season.

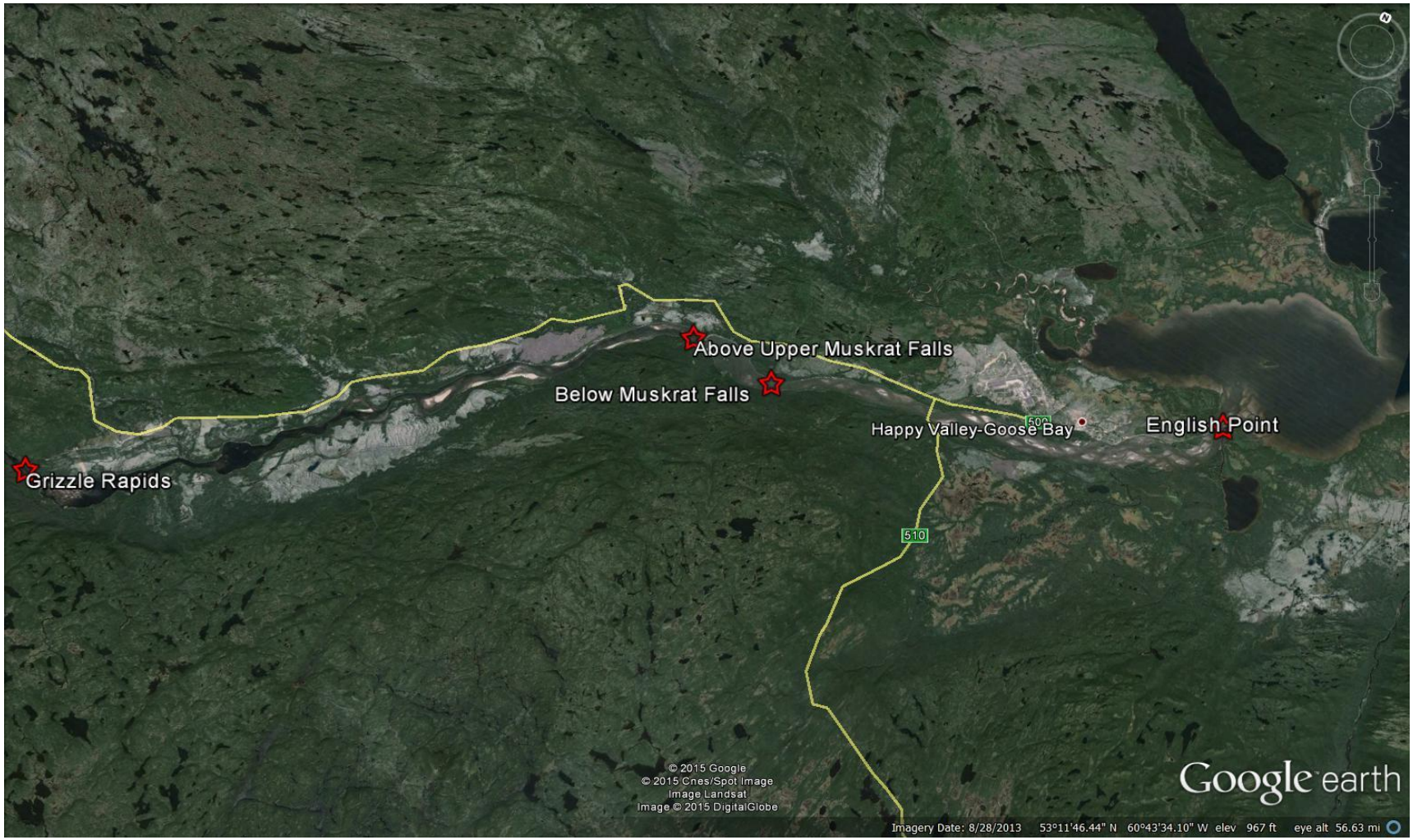

Figure 1: Lower Churchill Network- Station Locations

Churchill River below Grizzle Rapids

Water Temperature

- Water temperature ranges from 8.60°C to 18.20°C with a median value of 14.80°C (Figure 2).
- Water temperature is gradually increasing throughout the deployment period. This trend is expected as air temperatures warm through the summer months.

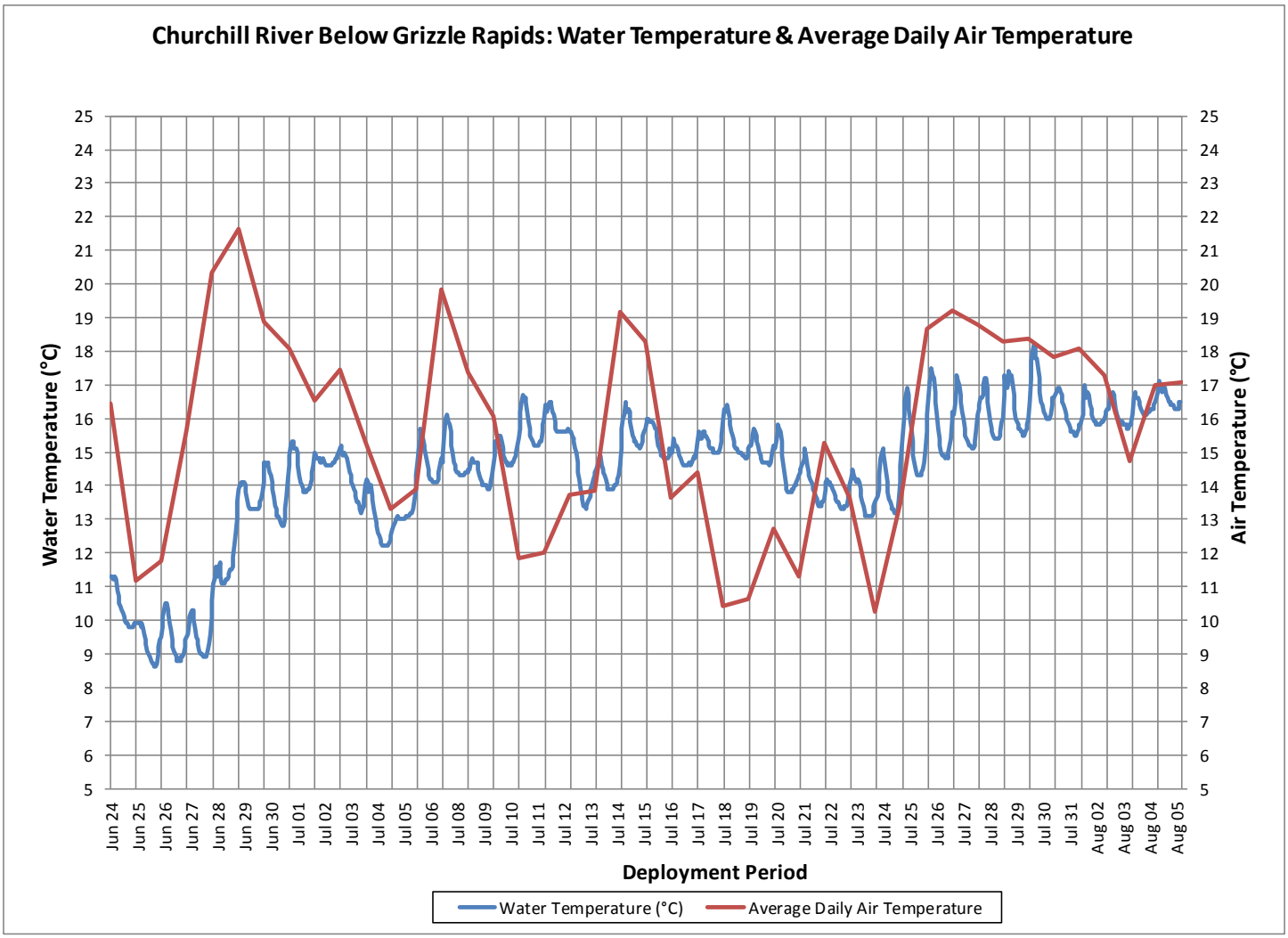

Figure 2: Water Temperature & Daily Average Air Temperature (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

pH

- pH ranges between 6.83 and 7.30 pH units with a median value of 7.09 (Figure 3).
- pH values are stable and fall within the CCME Protection of Aquatic Life Guidelines.
- Photosynthesis uses up hydrogen molecules, which causes the concentration of hydrogen ions to decrease and therefore the pH to increase. For this reason, pH may be higher during daylight hours and during the growing season, when photosynthesis is at a maximum. This is illustrated by the diurnal fluctuations in Figure 3.

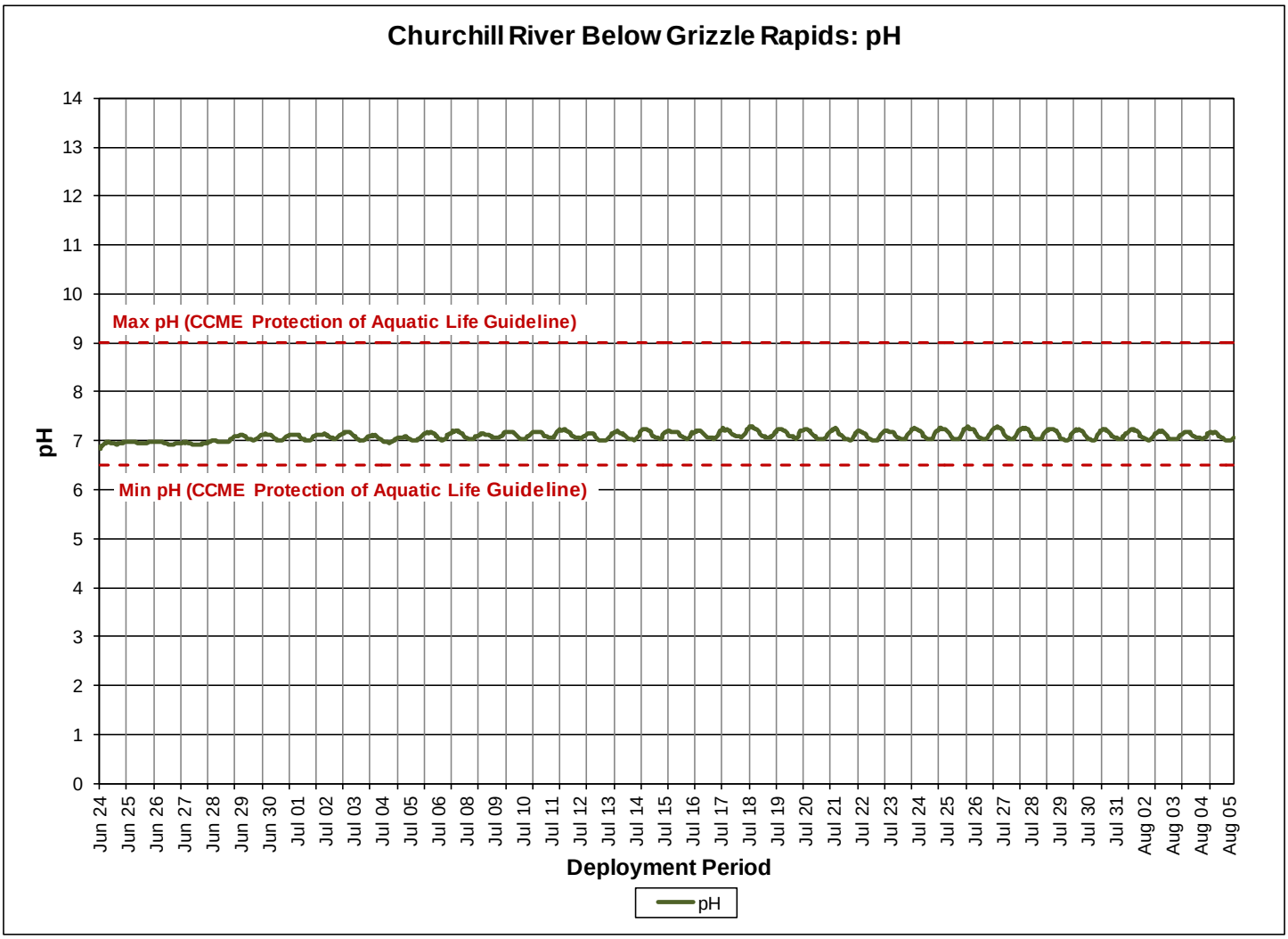

Figure 3: pH at Churchill River below Grizzle Rapids

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 14.3µS/cm to 18.8µS/cm with a median of 16.7µS/cm. (Figure 4).
- TDS (total dissolved solids) ranges from 0.0091 g/L to 0.0121 g/L with a median of 0.0107 g/L (Figure 4).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inversed. When stage level rises, the specific conductance levels drops in response as the increased amount of water in the river system dilutes the solids that are present. These parameters all remain relatively stable throughout the deployment period due to a stable stage level and minimal effects from precipitation events.
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

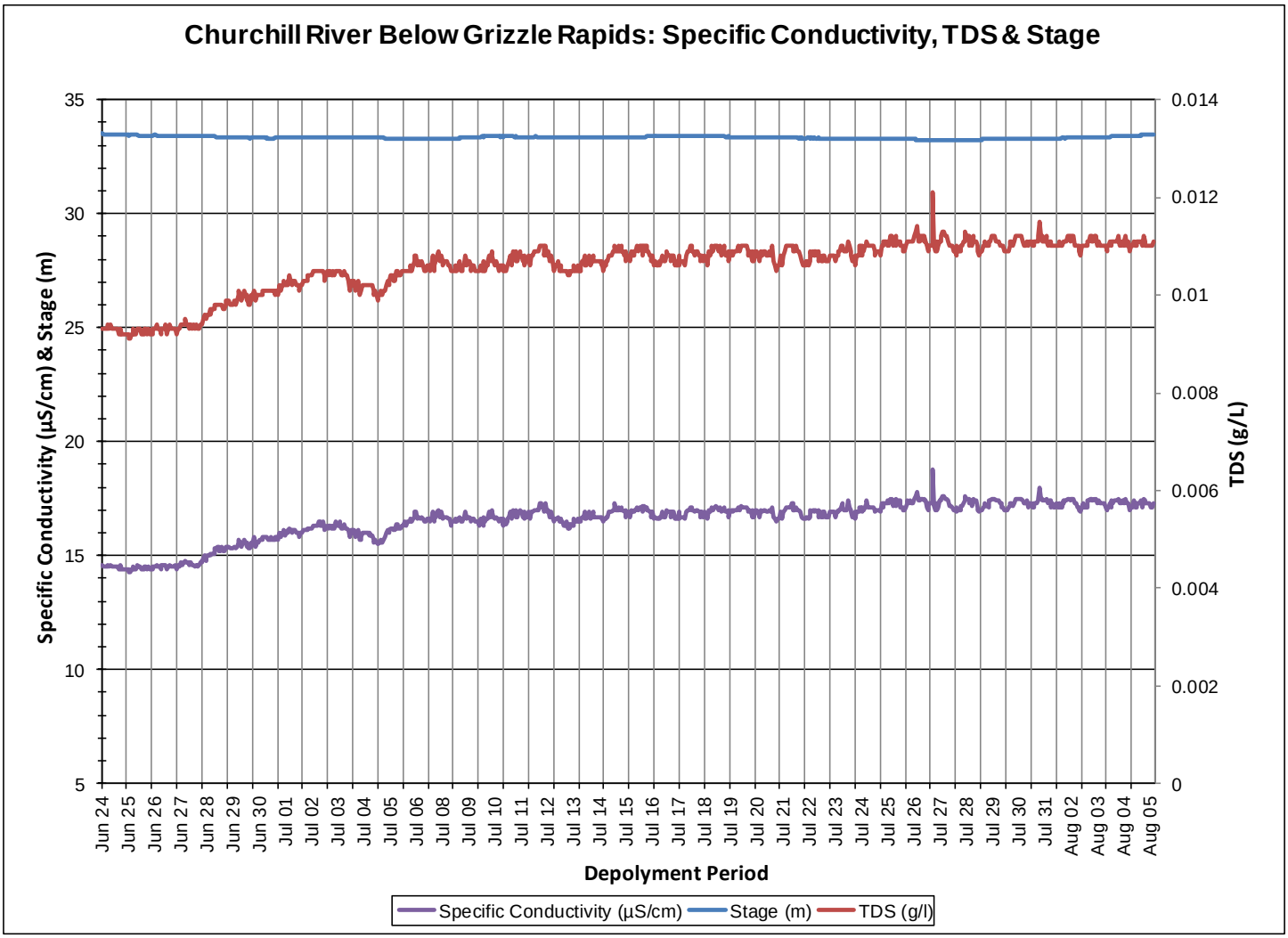

Figure 4: Specific Conductivity, TDS, and stage at Churchill River below Grizzle Rapids

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.35mg/l and 11.34mg/l with a median value of 9.95mg/l. The saturation of dissolved oxygen ranges from 94.3% to 103.7% with a median value of 97.7% (Figure 5).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages. However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Life Stages during late July and early August.

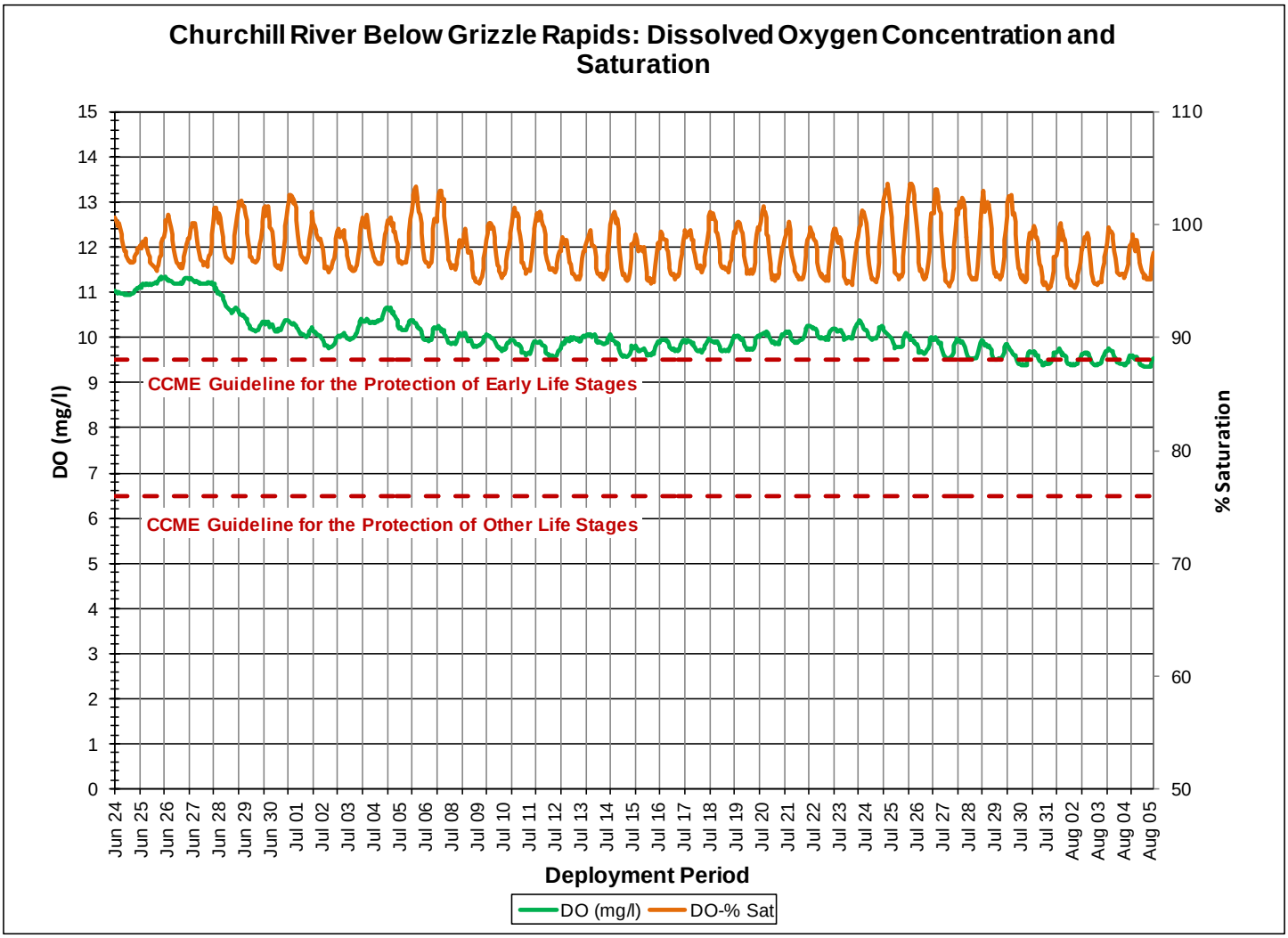

Figure 5: Dissolved Oxygen at Churchill River below Grizzle Rapids

Turbidity, Stage & Total Daily Precipitation

- Turbidity ranges between 0.0NTU and 8.6NTU with a median value of 0.0NTU (Figure 6). A median value of 0.0NTU indicates this station has low background turbidity.
- The turbidity sensor on this instrument can read values between 0NTU and 3000NTU. However a reading of 3000 NTU is always identified as an error reading and should not be used as a valid reading or included in any statistical analysis.
- The majority of turbidity events in the deployment period correlate to larger precipitation events. Precipitation can increase the presence of suspended material in water. There is an extended period from July 17 to July 28th where turbidity is unstable. This data was caused by sediment build up and is not reflective of the water quality.
- Stage ranges between 33.20m and 33.51m (Figure 6).
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

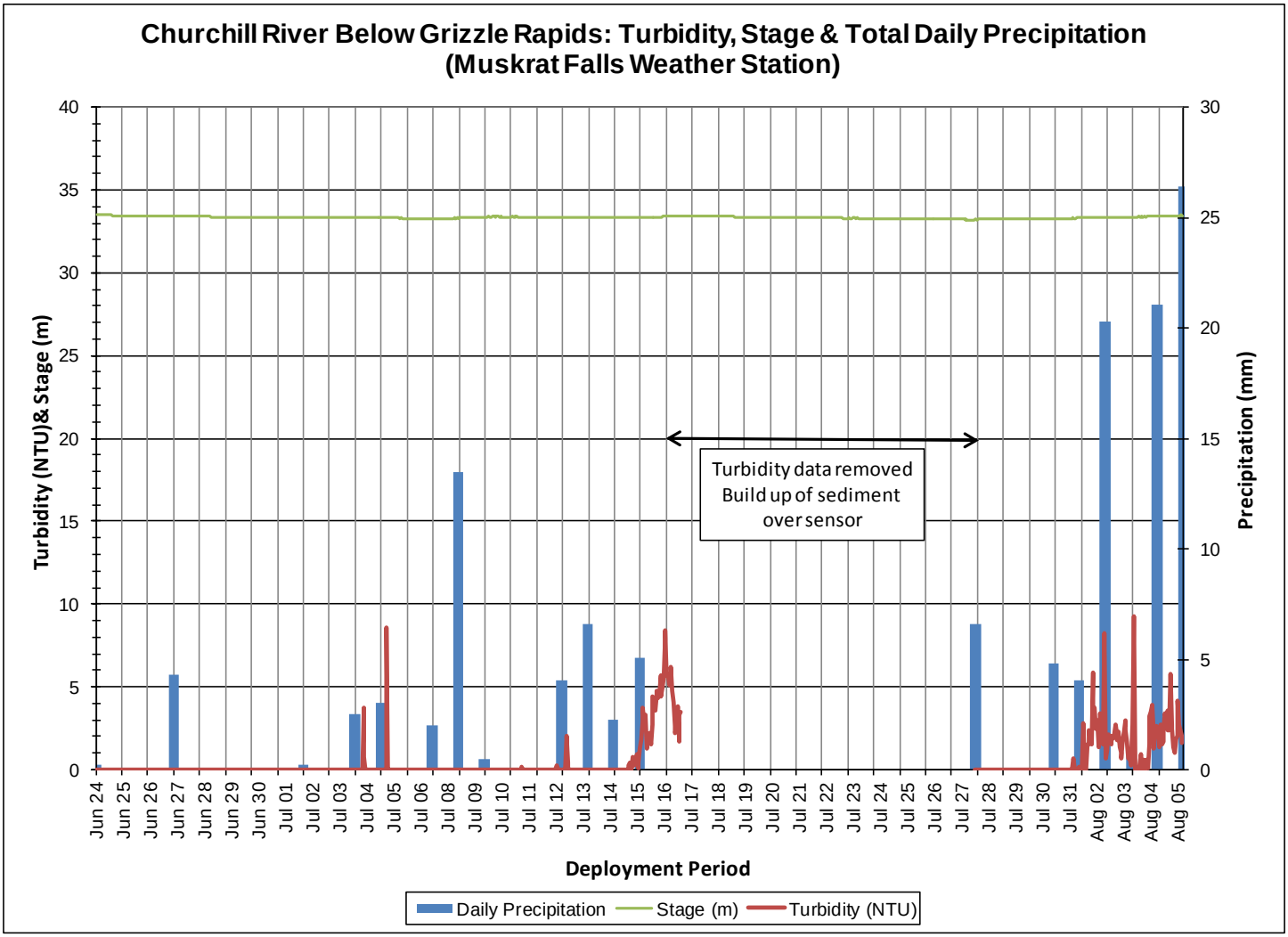

Figure 6: Turbidity, Stage, & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River below Grizzle Rapids

Churchill River above upper Muskrat Falls

Water Temperature

- Water temperature ranges from 10.06°C to 18.12°C with a median value of 14.67°C (Figure 7).
- Water temperature is gradually increasing throughout the deployment period. This trend is expected as air temperatures warms in the summer months.

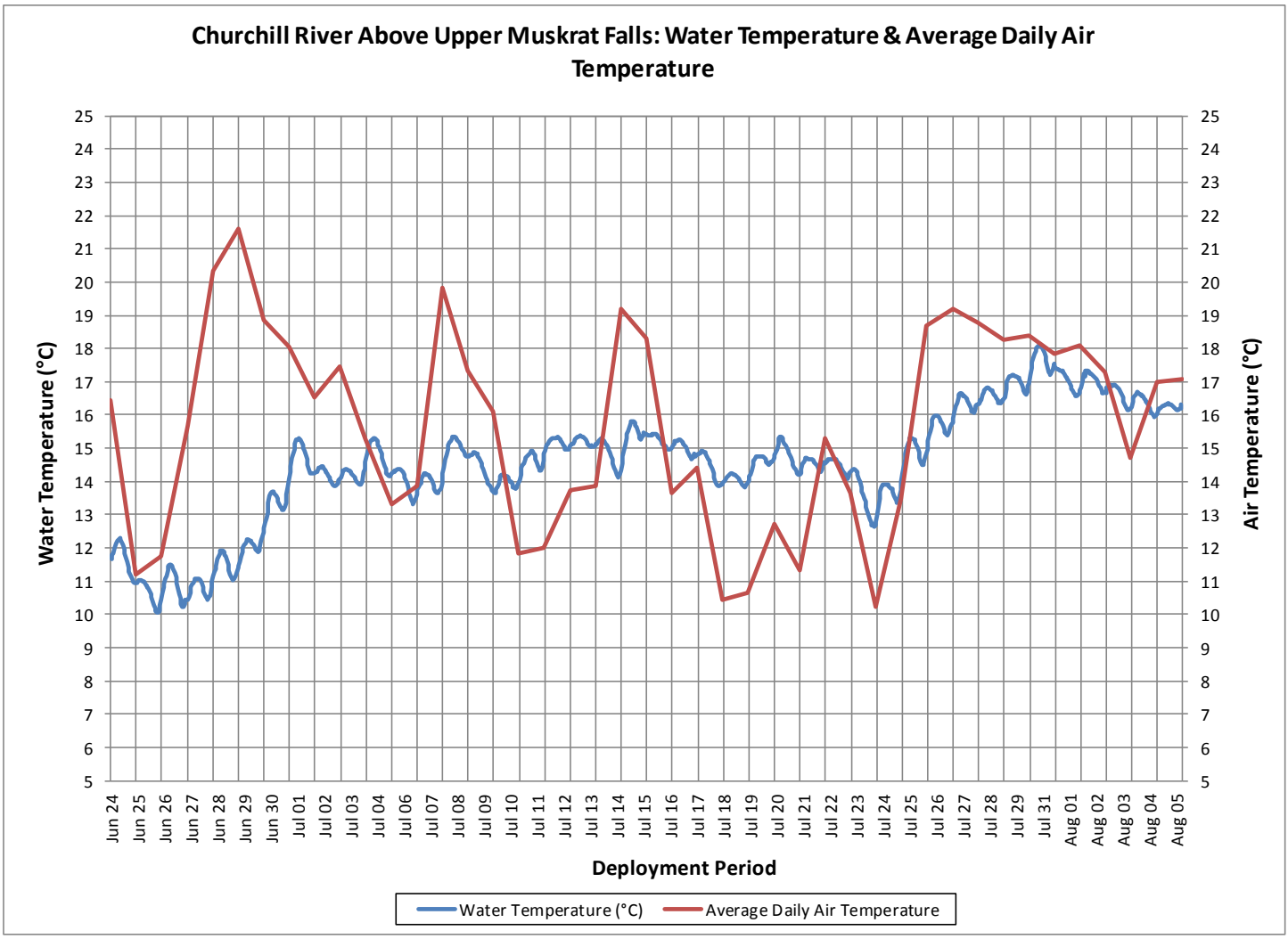

Figure 7: Water Temperature & Average Daily Air Temperature (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

pH

- pH ranges between 6.54 and 7.08 pH units with a median value of 6.99 (Figure 8).
- pH values are relatively stable and fall within the CCME Protection of Aquatic Life Guidelines .

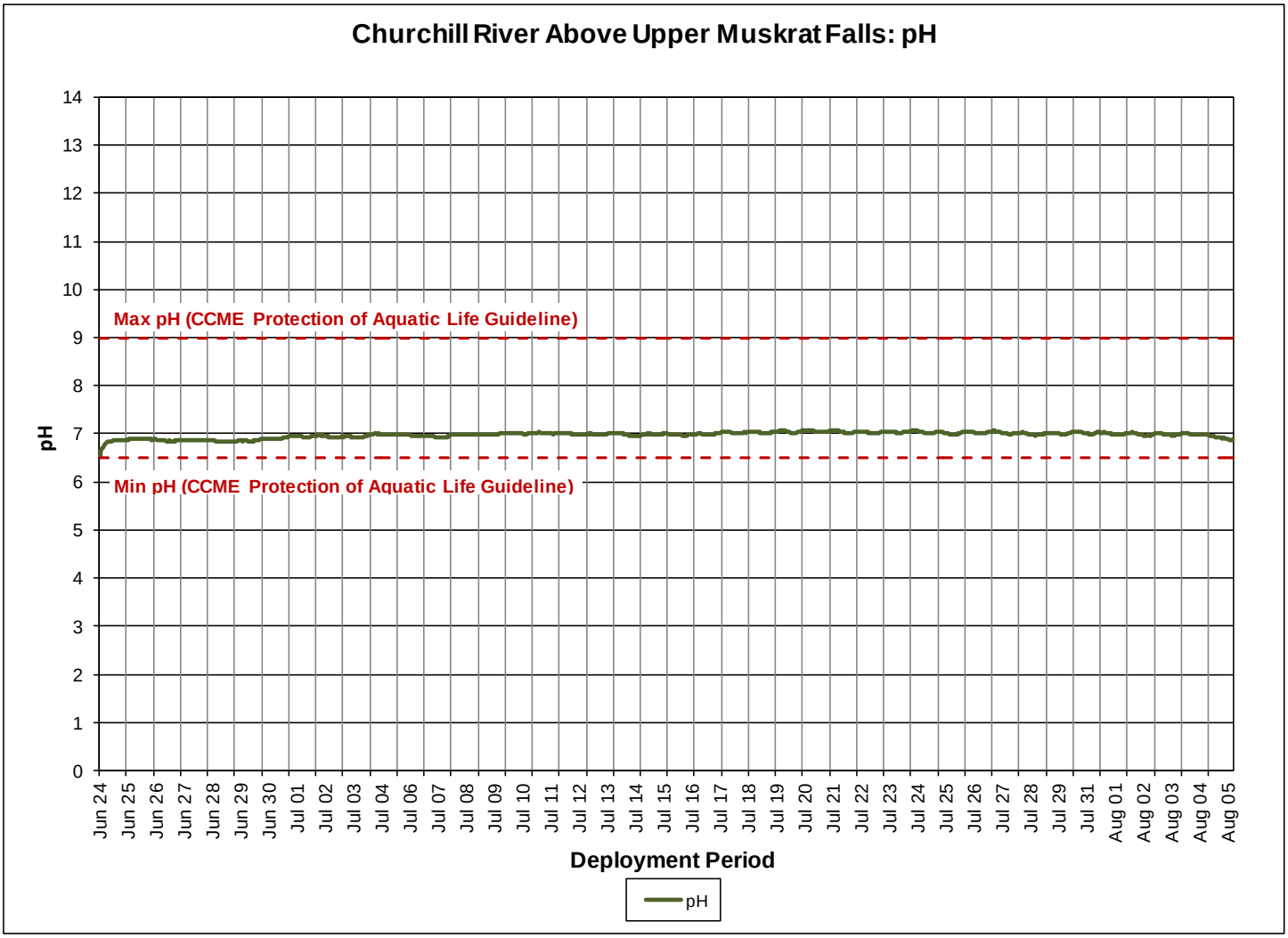

Figure 8: pH at Churchill River above Upper Muskrat Falls

Specific Conductivity, TDS and Stage

- Specific conductivity ranges from 14.7µS/cm to 18.6µS/cm with a median of 17.2µS/cm. (Figure 9).
- TDS (total dissolved solids) ranges from 0.0094 g/L to 0.0119 g/L with a median of 0.0110 g/L (Figure 9).
- Specific conductivity and TDS have a direct relationship but are two separate parameters. Specific conductivity is the ability of the water to conduct electricity. Therefore the value of TDS can be estimated by the conductivity of the water.
- The relationship between conductivity and stage are inversed. When stage level rises, the specific conductance levels drops in response as the increased amount of water in the river system dilutes the solids that are present.

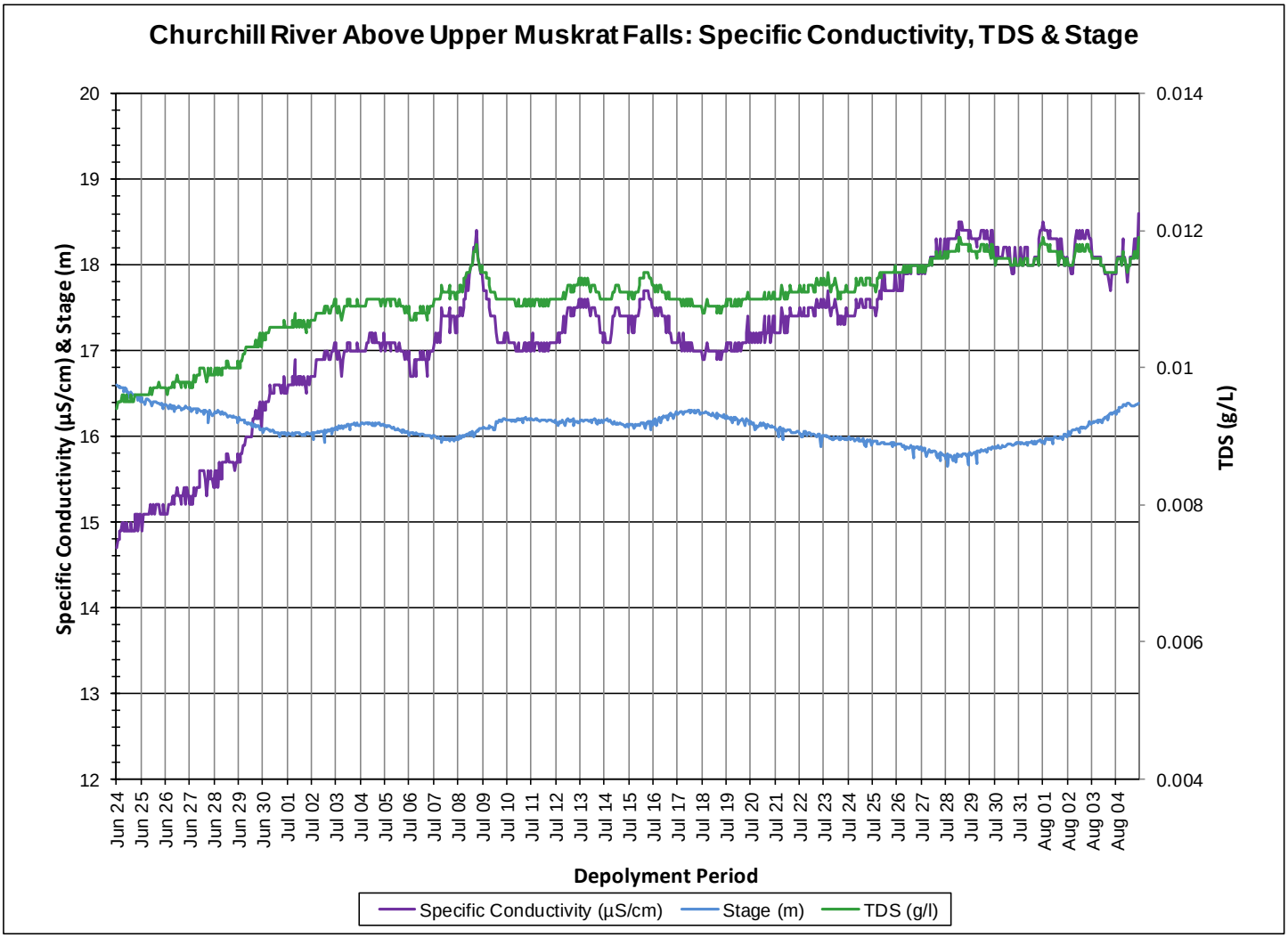

Figure 9: Specific Conductivity, TDS, and Stage at Churchill River above Upper Muskrat Falls

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.37mg/l and 11.36mg/l with a median value of 10.12mg/l. The saturation of dissolved oxygen ranges from 96.1% to 103.2% with a median value of 98.9% (Figure 10).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages. However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Stages during late July and early August.

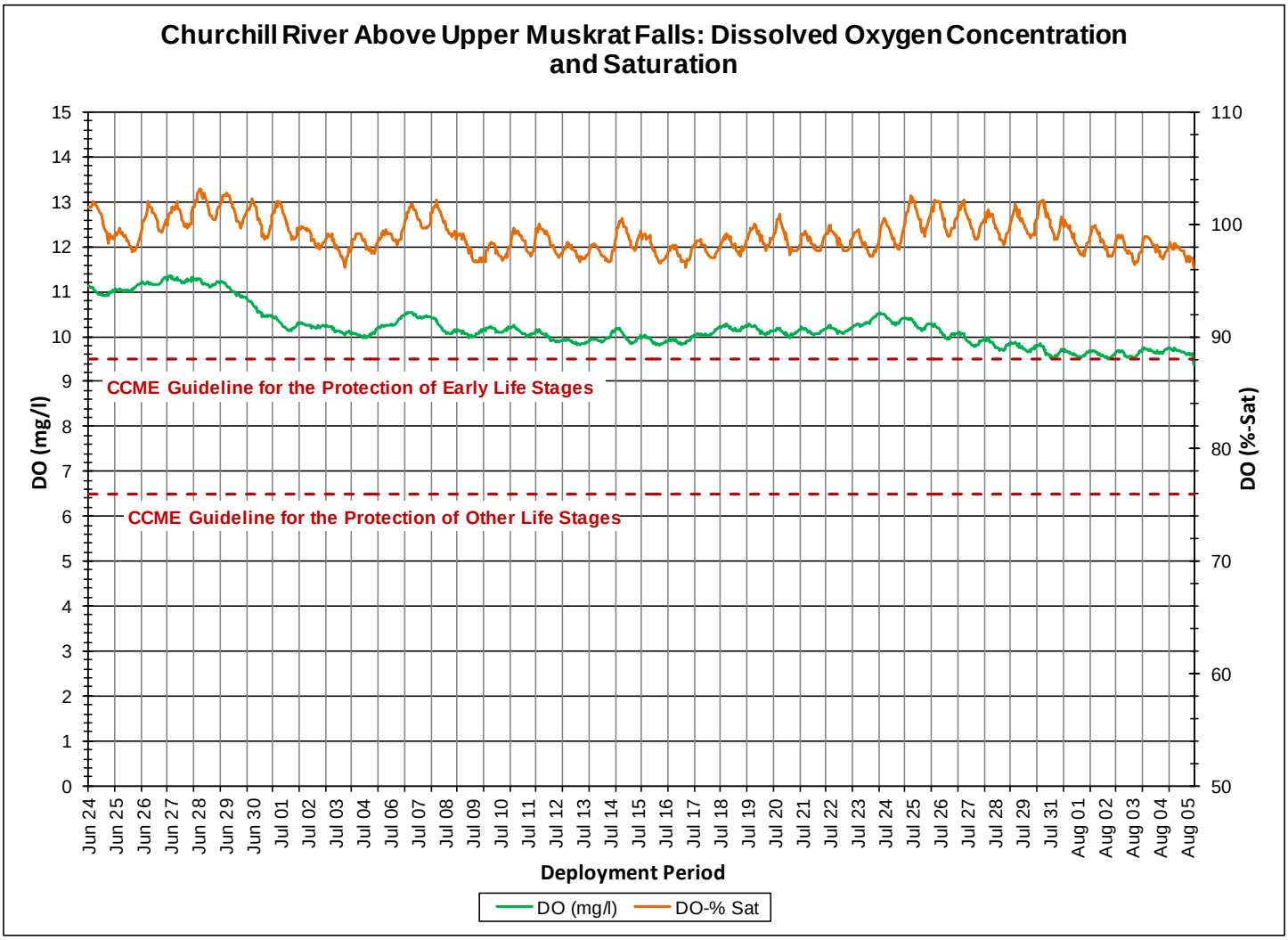

Figure 10: Dissolved oxygen at Churchill River above Upper Muskrat Falls

Chlorophyll

- Chlorophyll ranges between 3.7ug/L and 9.1ug/L, with a median value of 5.9ug/L (Figure 11).
- Chlorophyll is found within living cells of photosynthetic organisms like phytoplankton and cyanobacteria. The amount of chlorophyll found in water can be used to understand the general biological health of an ecosystem. Chlorophyll can also be used to identify algal bloom events and is an indicator of nutrient loading in ecosystems.
- Chlorophyll values at the station above Upper Muskrat Falls indicate a Mesotrophic to Eutrophic aquatic ecosystem (2.6.-7.3 ug/L and 7.3-20ug/L). Mesotrophic and Eutrophic water ecosystems have moderate productivity with medium levels of nutrients, and moderate macrophyte (submergent, emergent, and floating) coverage.

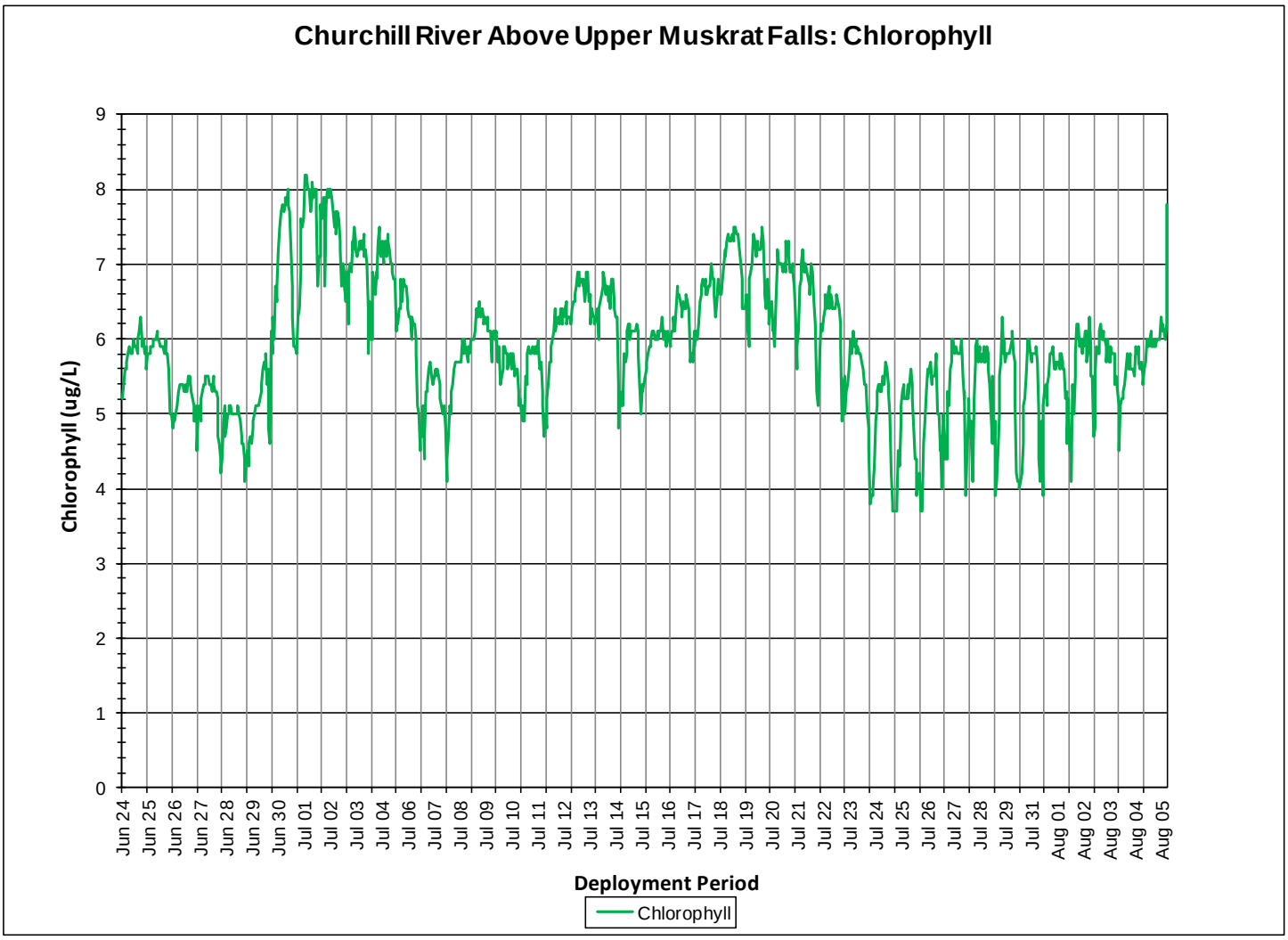

Figure 11: Chlorophyll at Churchill River above Upper Muskrat Falls

Stage, Flow, Turbidity and Precipitation

- Turbidity ranges between 2.1NTU and 428.0NTU with a median value of 7.8NTU (Figure 12).
- The turbidity sensor on this instrument can read values between 0NTU and 3000NTU. However a reading of 3000 NTU is always identified as an error reading and should not be used as a valid reading or included in any statistical analysis.
- The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events. Precipitation can increase the presence of suspended material in water.
- Precipitation occurs on 19 of the days in the deployment period and amounts are generally low, with the exception of the 3 days with totals on each day just over 20mm (August 2, 4, and 5th).
- Stage ranges between 15.65m and 16.60m, and streamflow ranges from 1134.66m^3/s to 1652.31 m^3/s (Figure 13).
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

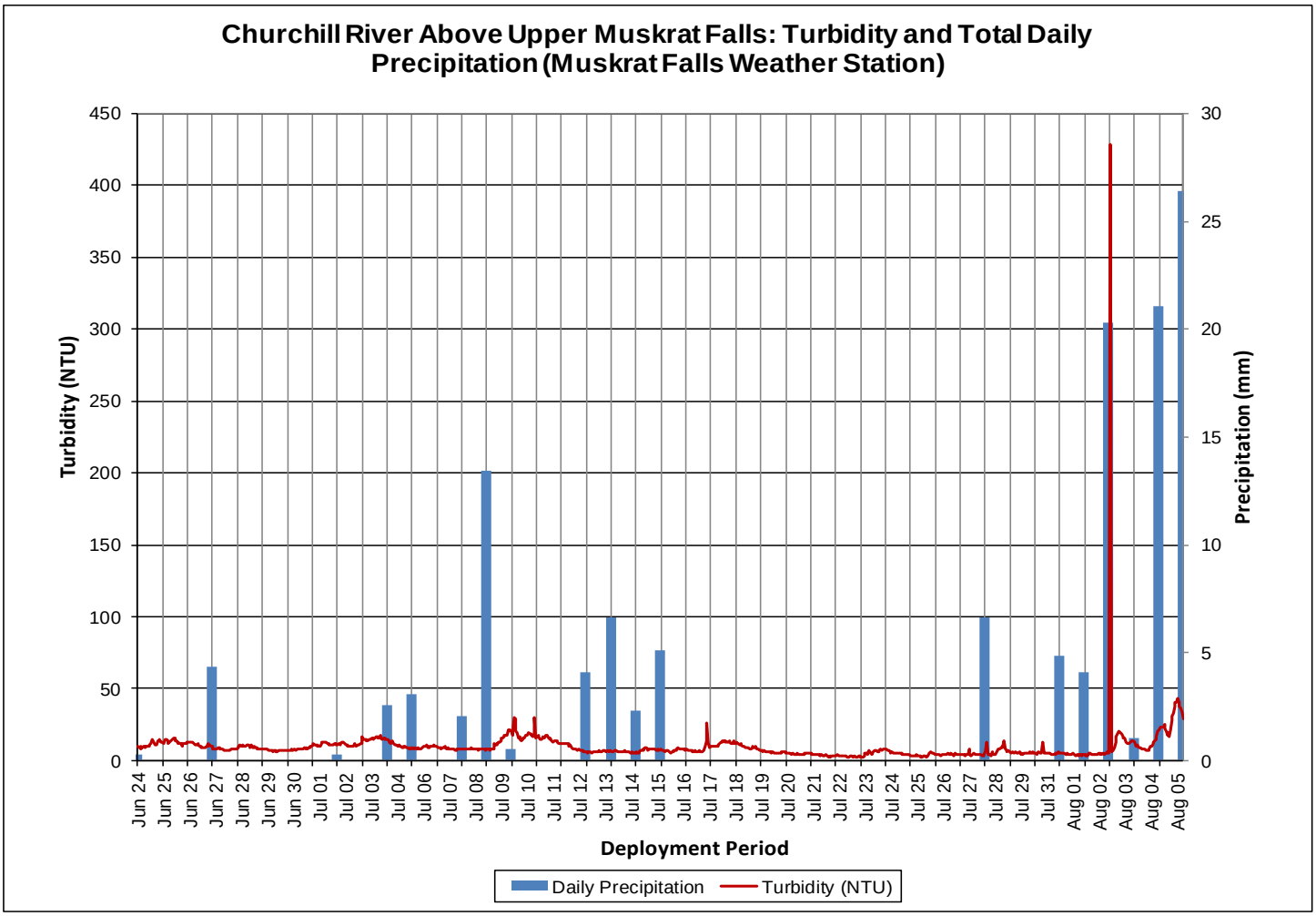

Figure 12: Turbidity and Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

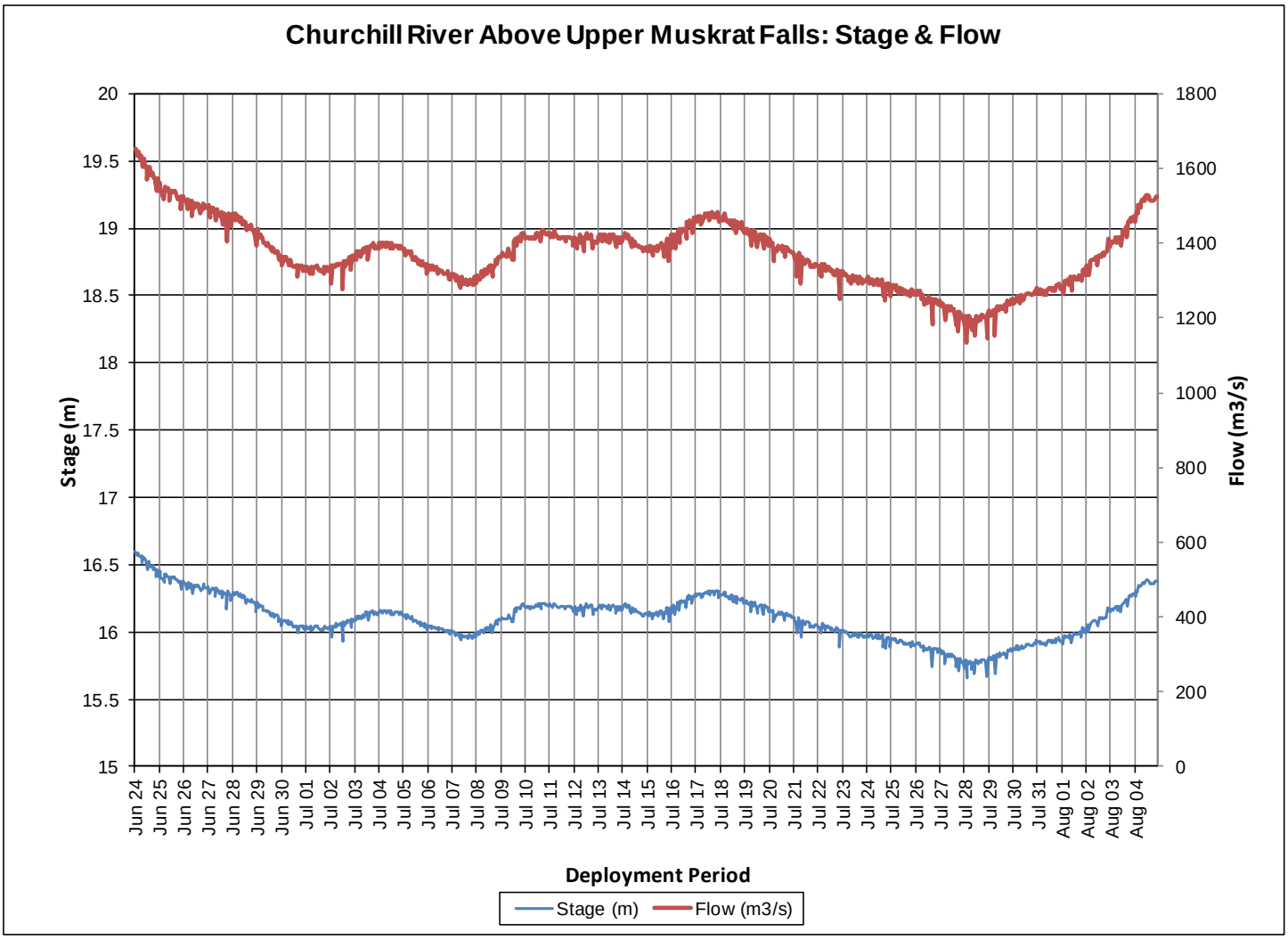

Figure 13: Stage and Flow at Churchill River above Upper Muskrat Falls

Churchill River below Muskrat Falls

- The sonde located at this station has been repeatedly buried in sand during 2014. The decision to not redeploy the sonde until sand conditions in the area improve was made in August, 2014. The station will be redeployed in the 2015 field season if conditions have improved enough to permit deployment.
- Stage and precipitation (Muskrat Falls Weather Station) were graphed for below Muskrat Falls station (Figure 14). Stage remains relatively stable throughout the deployment period. Precipitation occurs on 19 of the days in the deployment period and amounts are generally low, with the exception of the 3 days with totals on each day just over 20mm (August 2, 4, and 5th).
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request

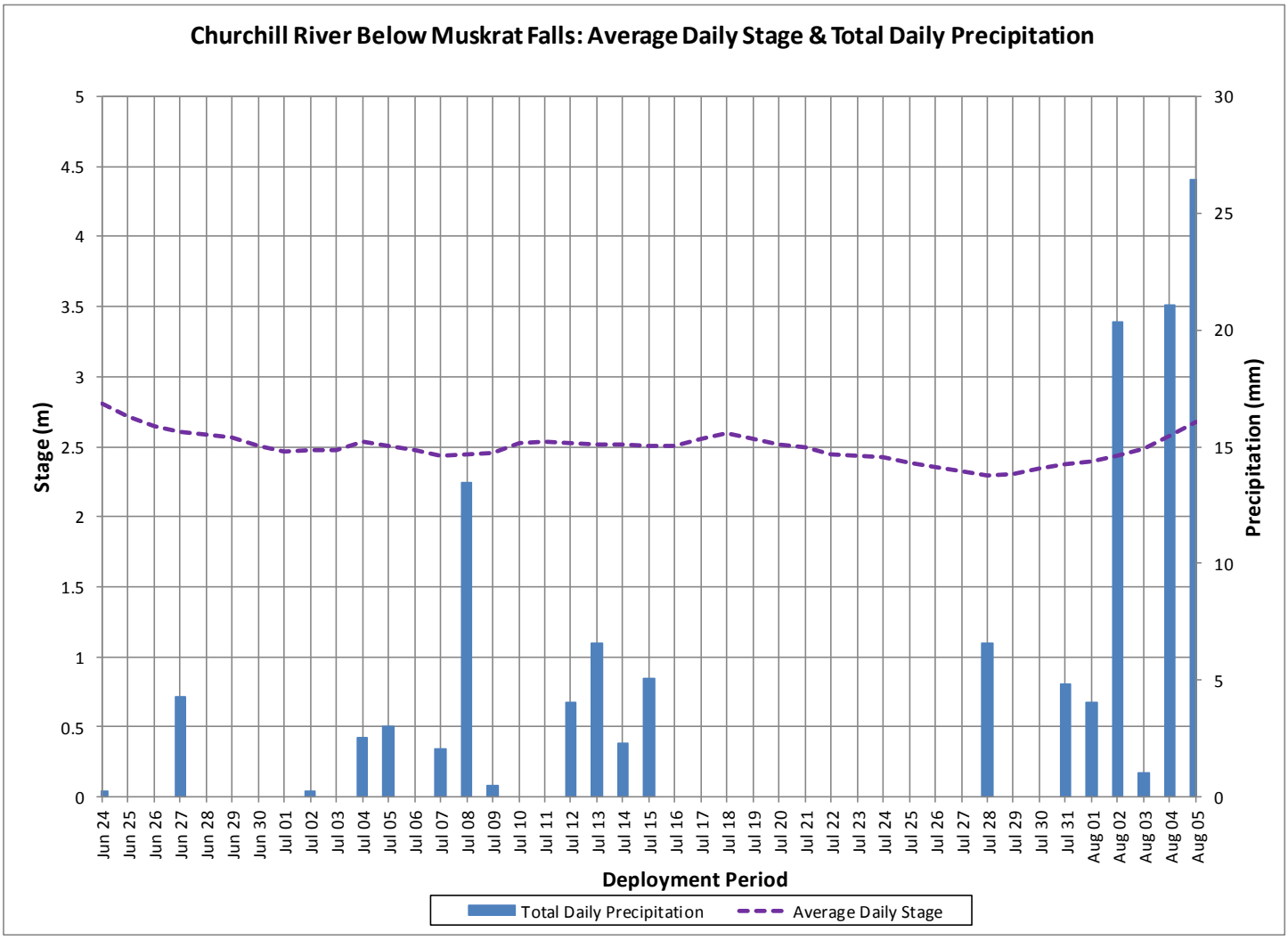

Figure 14: Stage & Total Daily Precipitation (Muskrat Falls Weather Station) at Churchill River above Upper Muskrat Falls

Churchill River at English Point

Water Temperature

- Water temperature ranges from 11.00°C to 19.50°C with a median value of 15.40°C (Figure 15).
- Water temperature is steadily increasing throughout this deployment period. This trend is expected as ambient air temperatures warm into the summer months. Water temperature fluctuates diurnally.

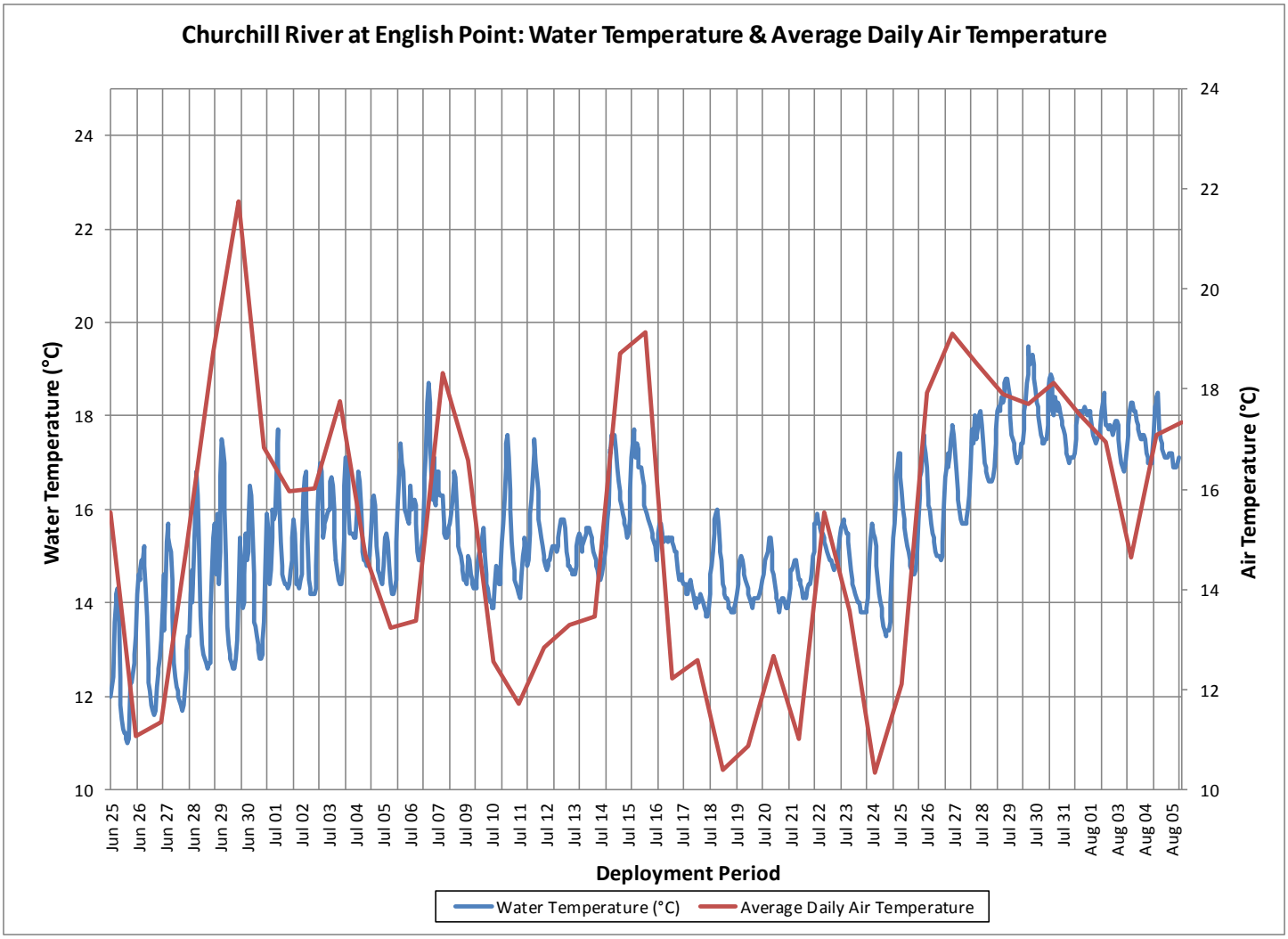

Figure 15: Water Temperature & Daily Average Air Temperature (Mud Lake Weather Station) at Churchill River at English Point

pH

- pH ranges between 6.70 and 7.39 pH units with a median value of 6.93 (Figure 16).
- All pH values recorded during this deployment period remain within the CCME protection of Aquatic Life Guidelines.

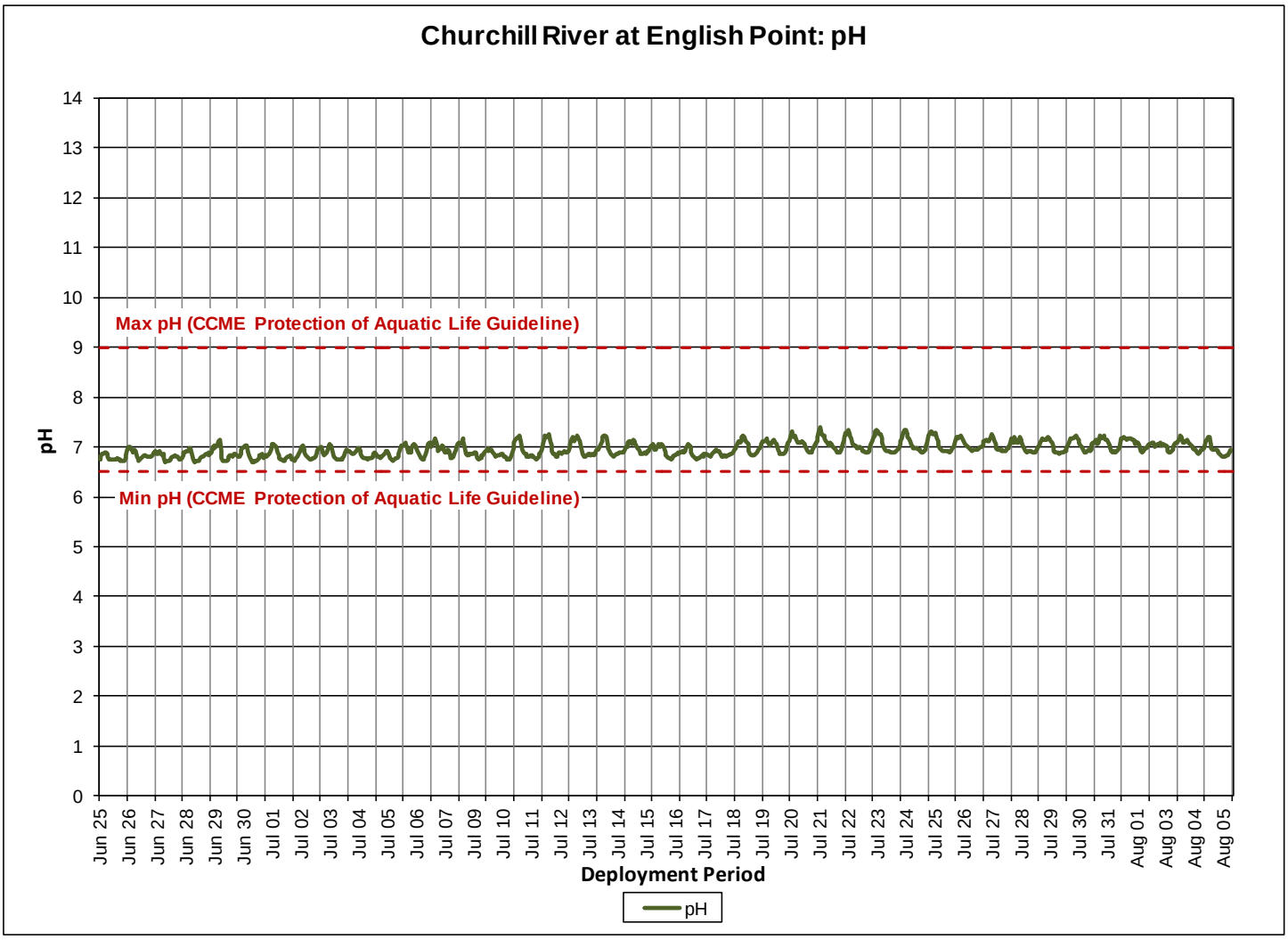

Figure 16: pH at Churchill River at English Point Station

Specific Conductivity and TDS

- Specific conductance ranges between 18.5µS/cm and 59.8µs/cm during the deployment period, with a median of 30.7µS/cm (Figure 14).
- TDS ranges between 0.0118 g/mL to 0.0383 g/mL during the deployment period, with a median of 0.0197 g/mL (Figure 17).
- Specific conductivity fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean on Lake Melville. As the tide comes in, the specific conductivity increases as the dissolved solids and salinity increase, and vice versa as the tide goes out. This increase and decrease in specific conductivity and stage occurs twice daily. This pattern is generally consistent throughout the deployment period (Figure 17).

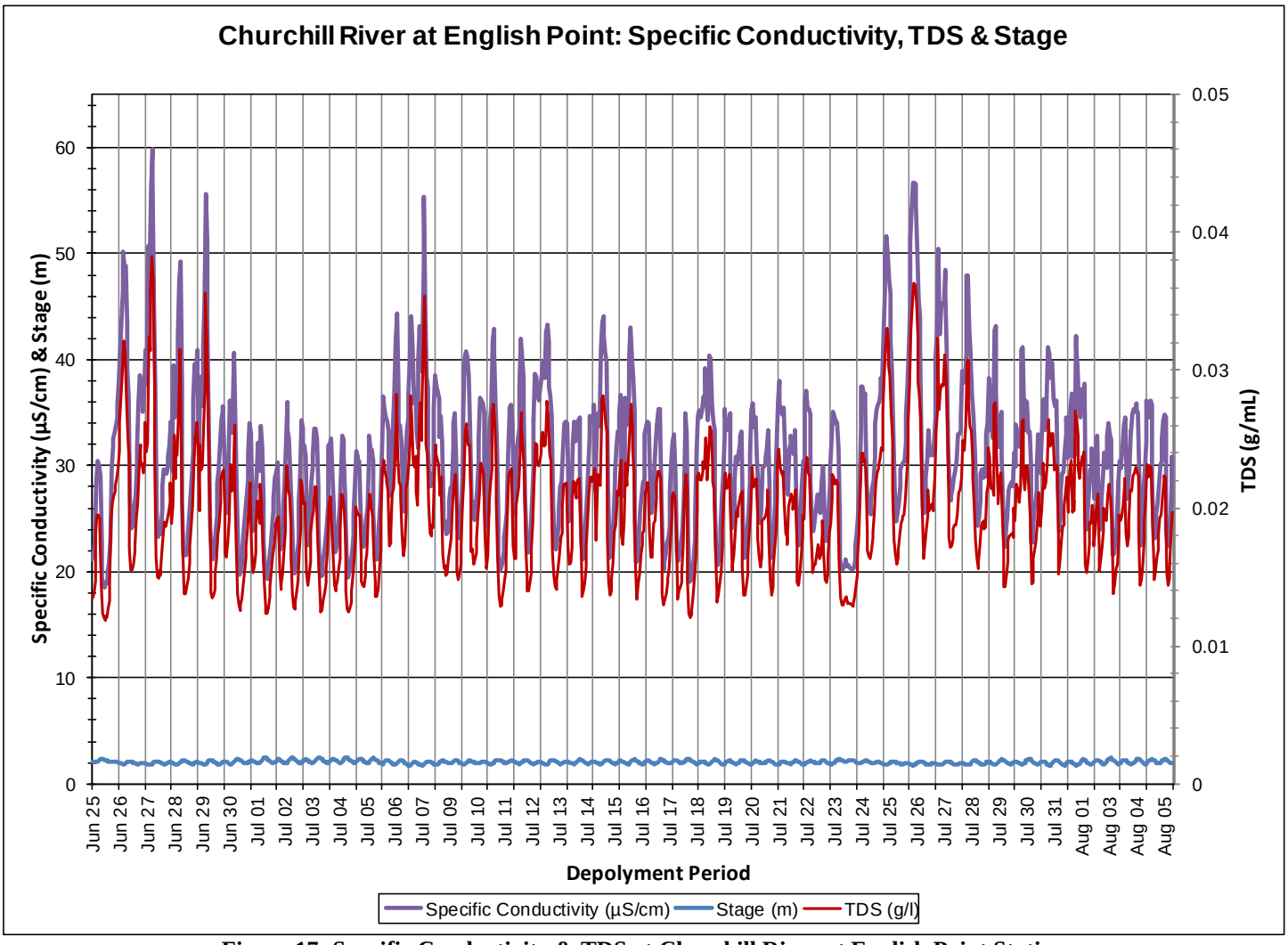

Figure 17: Specific Conductivity & TDS at Churchill River at English Point Station

Dissolved Oxygen

- Dissolved oxygen content ranges between 9.08mg/l and 11.40mg/l during the deployment period. The saturation of dissolved oxygen ranges from 91.2% to 112.6% (Figure 18).
- There is an evident relationship between water temperature and dissolved oxygen. Over the deployment period the dissolved oxygen levels are slowly falling as temperatures rise into the summer season. The dissolved oxygen also follows a diurnal pattern as the water temperature rises and falls under the influence of the ambient air temperature. Generally there is more dissolved oxygen present in a waterbody during cooler temperatures.
- The dissolved oxygen levels remained above the CCME Guidelines for the Protection of Other Life Stages (Figure 18). However, the dissolved oxygen levels dipped slightly below the CCME Guideline for the Protection of Early Life Stages during late July and Early August

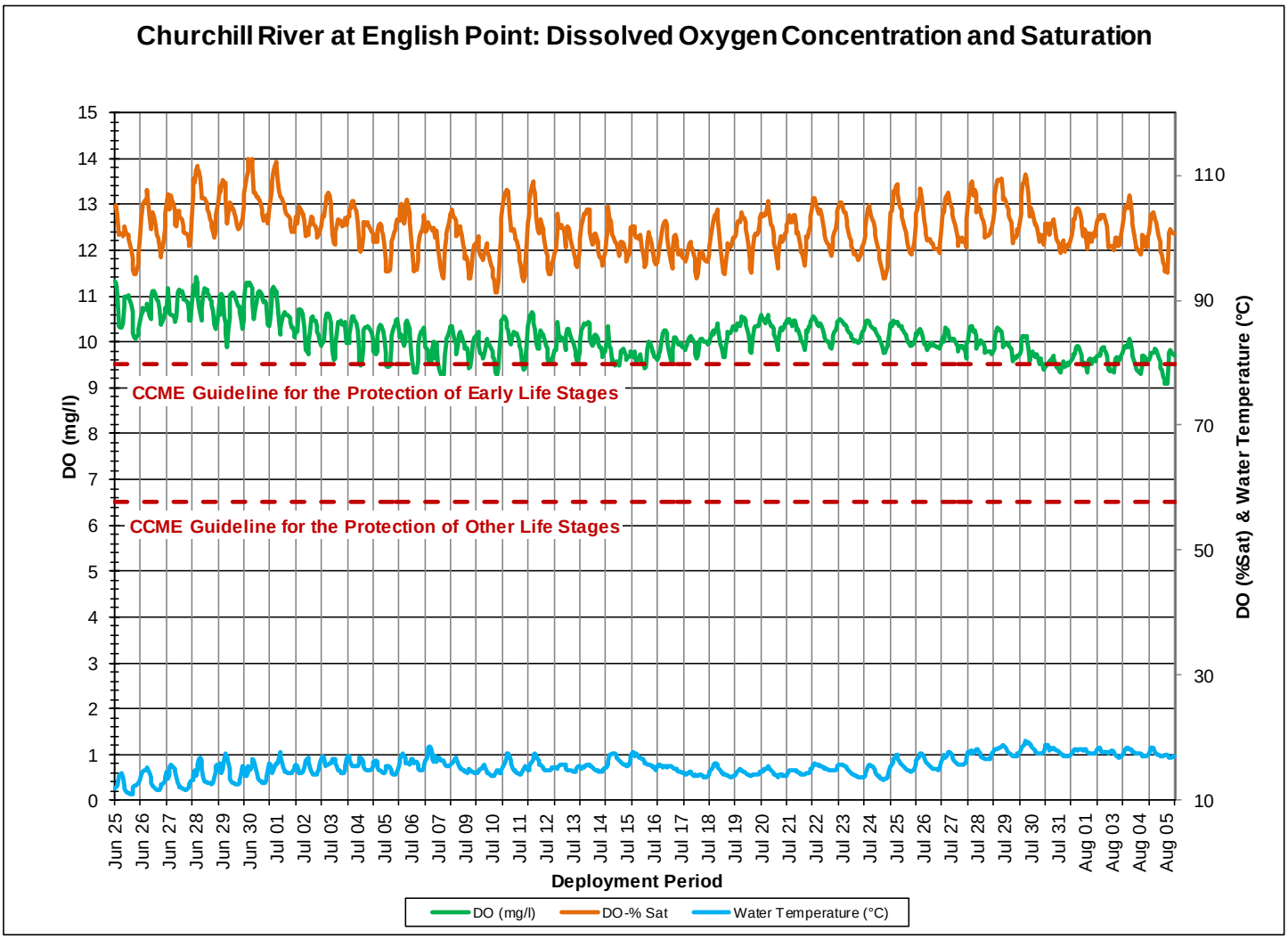

Figure 18: Dissolved Oxygen at Churchill River at English Point Station

Turbidity

- Turbidity ranges from 2.1NTU to 201.3NTU during the deployment period, with a median value of 10.6NTU (Figure 19).
- The majority of turbidity events in the deployment period correlate with increases in stage and larger precipitation events. Precipitation can increase the presence of suspended material in water (Figure 19).
- Precipitation occurs on 21 of the days in the deployment period and amounts are generally low, with the exception of the 21.59mm of precipitation on July 8th, 2015 (Figure 19).
- Stage fluctuates considerably at this location due to the tidal influences of the Atlantic Ocean. As the tide comes in, the stage level increases causing tide related turbidity events, and vice versa as the tide goes out. This pattern is generally consistent throughout the deployment period (Figure 20).
- Stage ranges between 1.73m and 2.49m, with a median value of 2.03m (Figure 20).
- Water Survey of Canada (Environment Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request.

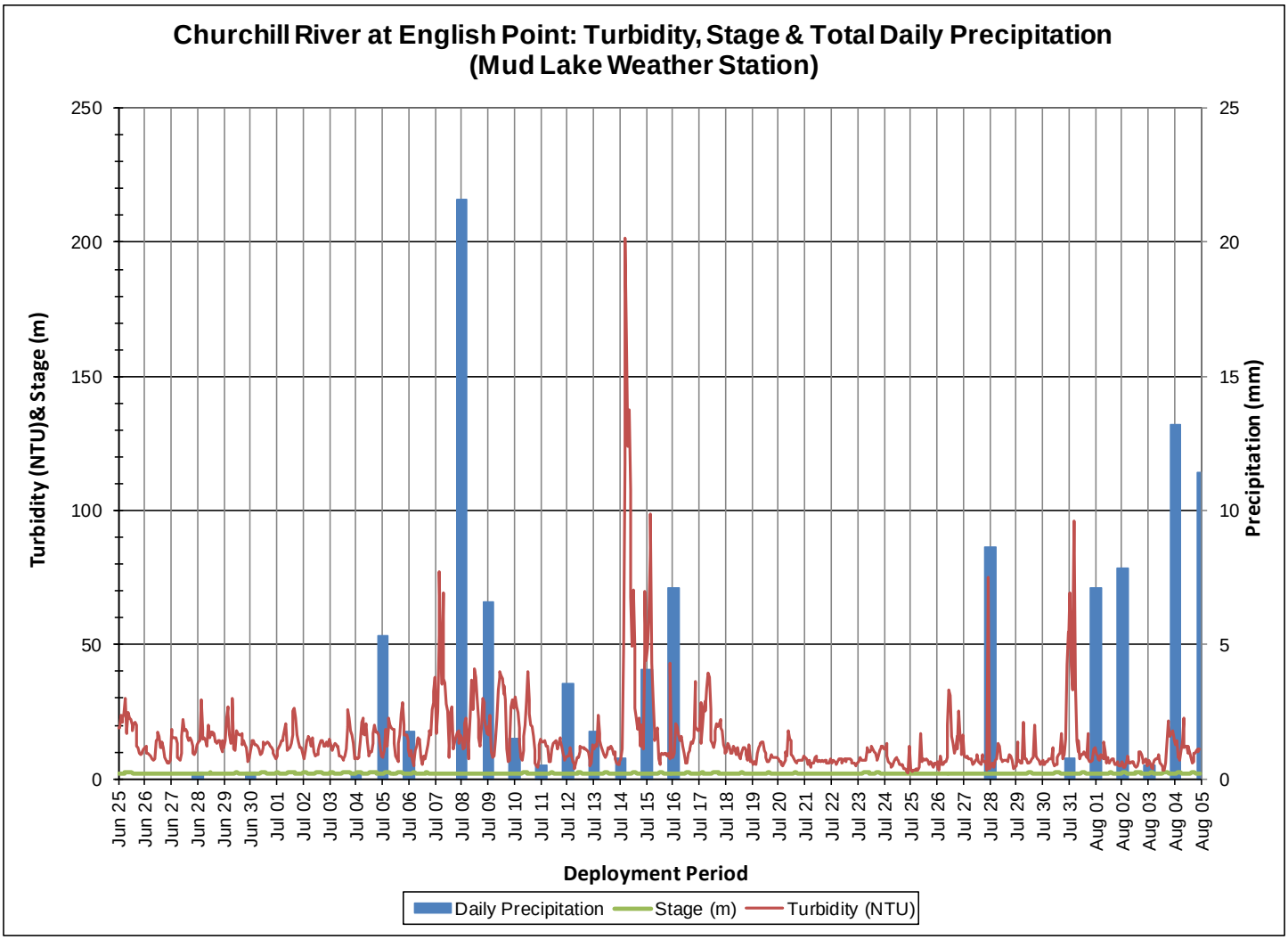

Figure 19: Turbidity, Stage & Total Precipitation (Mud Lake Weather Station) at Churchill River at English Point Station

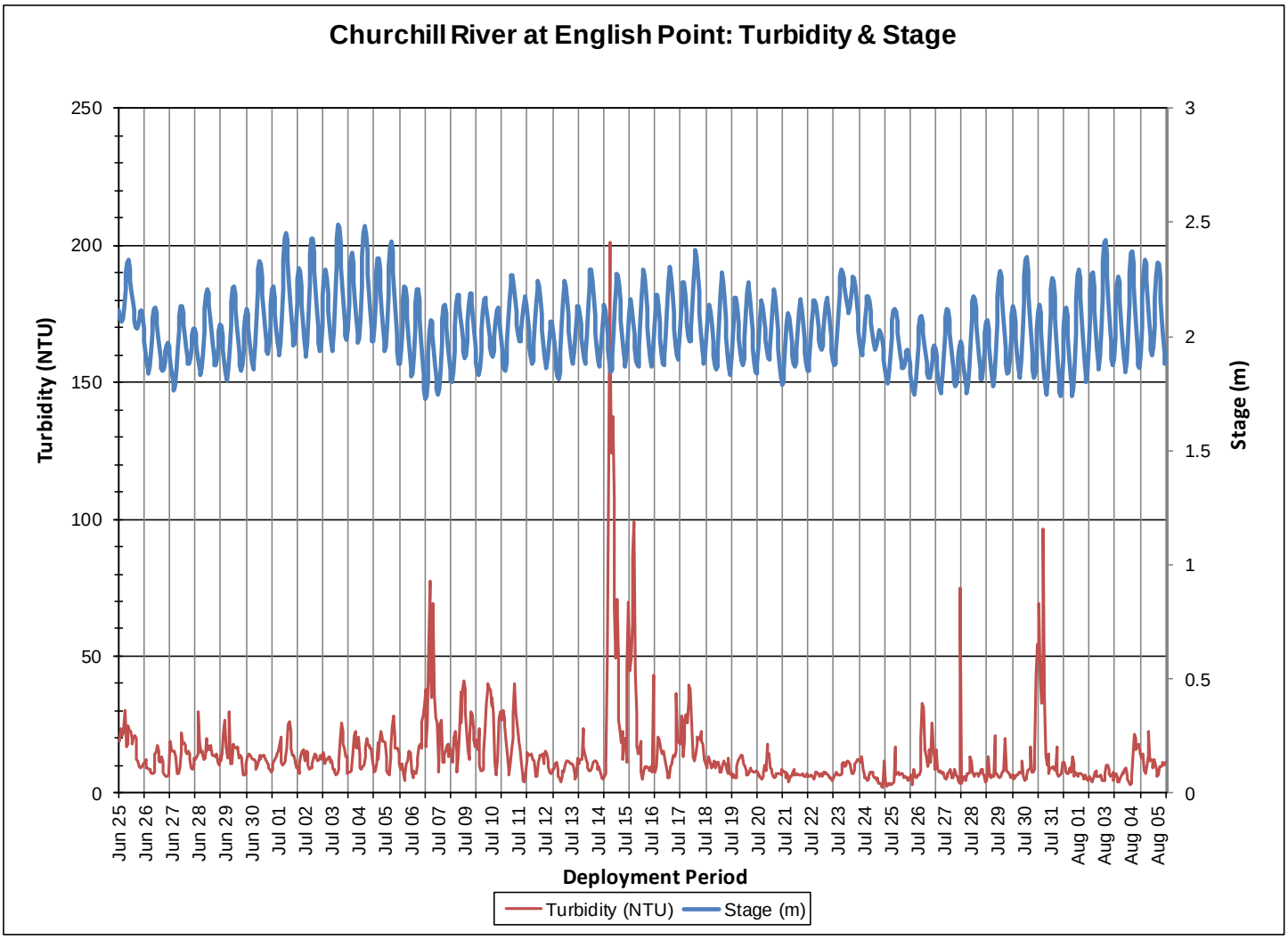

Figure 20: Turbidity & Stage at Churchill River at English Point Station

Conclusions

- Instruments at three water quality monitoring stations on the Lower Churchill River were deployed from June 24 to August 5, 2015. The Lower Muskrat Falls station was not deployed.
- Stage levels are generally stable at all stations throughout the deployment as the spring melt ends and we head into the summer months. Water level changes at the each of the stations ranged between 0.31 and 0.95m.
- Water temperature was increasing at all stations throughout the deployment period due to the increasing ambient air temperatures in the region during the summer months. Water temperature typically ranged between 8.60°C and 19.50°C.
- pH is generally neutral and stable at stations along the Lower Churchill River ranging between 6.70 and 7.39 pH units. The pH values at all stations were within the recommended CCME Guidelines for the Protection of Aquatic Life.
- Specific conductivity was relatively stable at the stations below Grizzle Rapids and above upper Muskrat Falls regardless of the fluctuating stage levels. All stations showed little variation in values except at English Point, which is influenced by the tides in Lake Melville. Specific conductivity values at the station at English Point ranged higher at 18.5µS/cm to 59.8µS/cm.
- Dissolved oxygen was decreasing slightly throughout the deployment period at all stations. Values ranged between 9.08mg/l and 11.40mg/l.
- Turbidity events occurred at all stations and were mainly related to large rainfall events. At the below Grizzle Rapids station there is a median turbidity value of 0.0NTU which indicates a low background turbidity at this location. Turbidity at all stations ranged from 0.0 to 428.0NTU. Both above Upper Muskrat Falls and English Point have known consistent turbidity at these stations due to substrate at the locations, mixing due to Muskrat Falls, tidal wave action, and precipitation events.

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  - Online: http://www.ott.com/download/fluorescence-white-paper/
- Environment Canada. Water Quality. Fresh Water Quality Monitoring Date modified: 2015-11-26
  - Online:https://www.ec.gc.ca/eaudouce-freshwater/default.asp?lang=En&n=8C50C138-1&printfullpage=true#wsA92C85CB
- Volunteers Contributing to Our Understanding of Water Quality. Trophic State Equations
  - Online: http://www.secchidipin.org/index.php/monitoring-methods/trophic-state-equations/

APPENDIX A-Station Comparisons

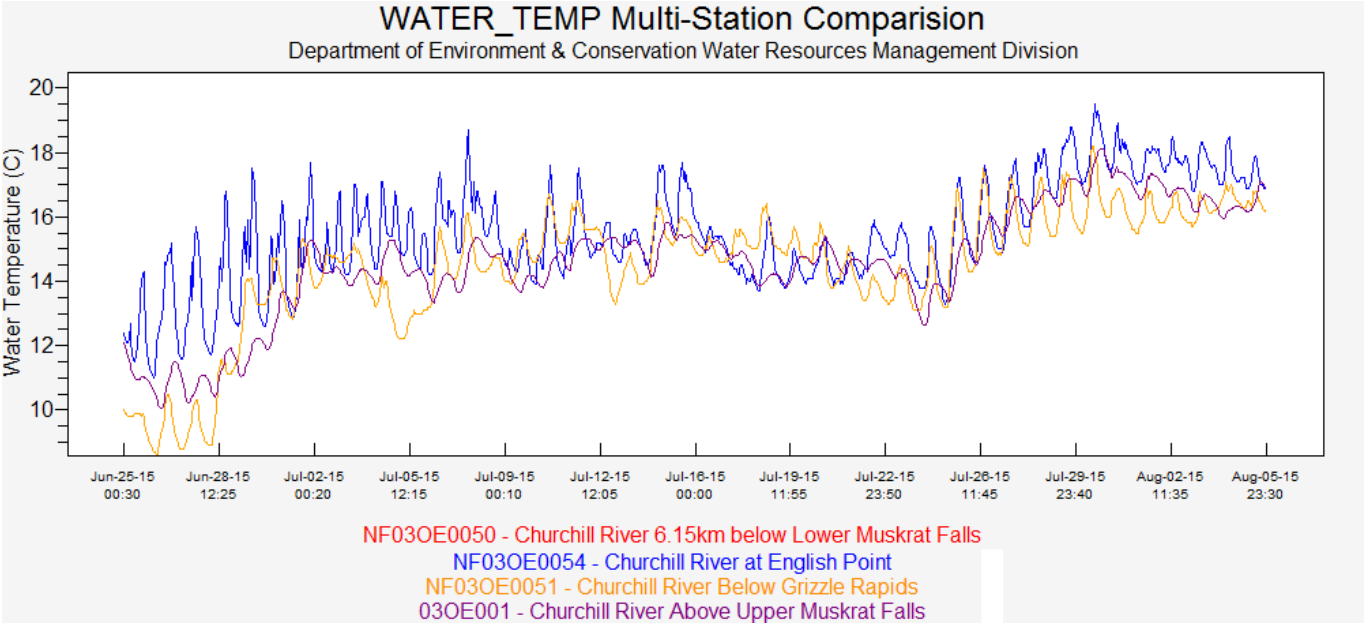

Figure A1: Comparison of Water Temperature at the Real-Time Stations on Churchill River (Below Muskrat Falls Station sonde was not deployed)

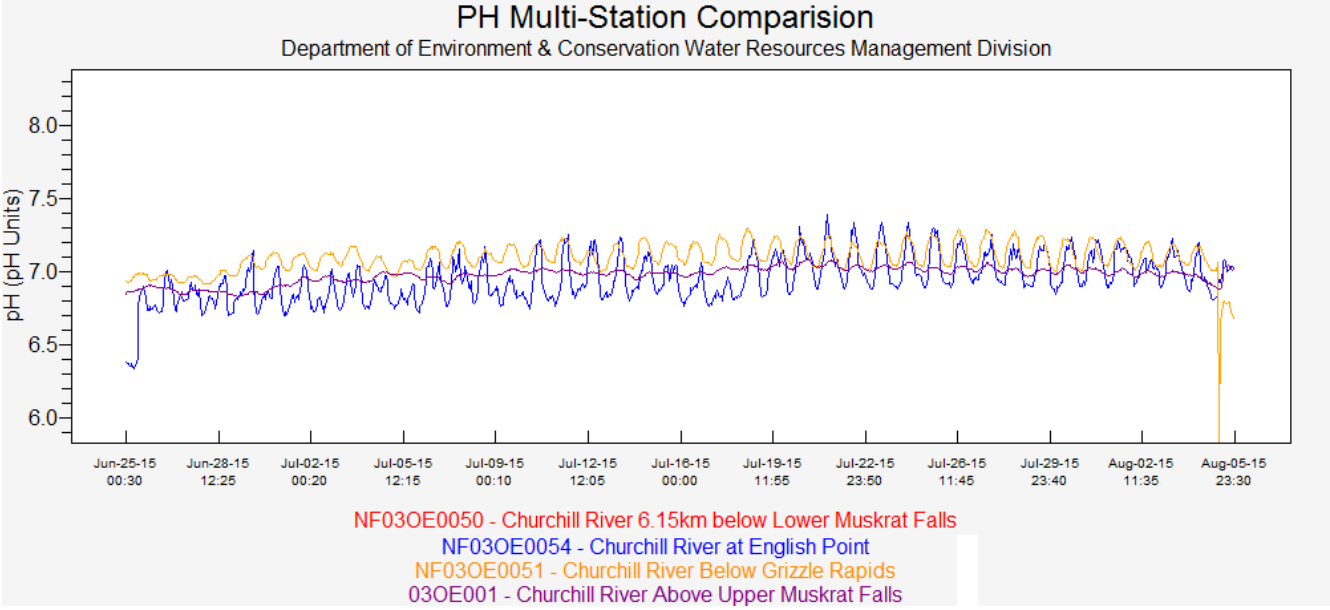

Figure A2: Comparison of pH at the Real-Time Stations on Churchill River (Below Muskrat Falls Station sonde was not deployed)

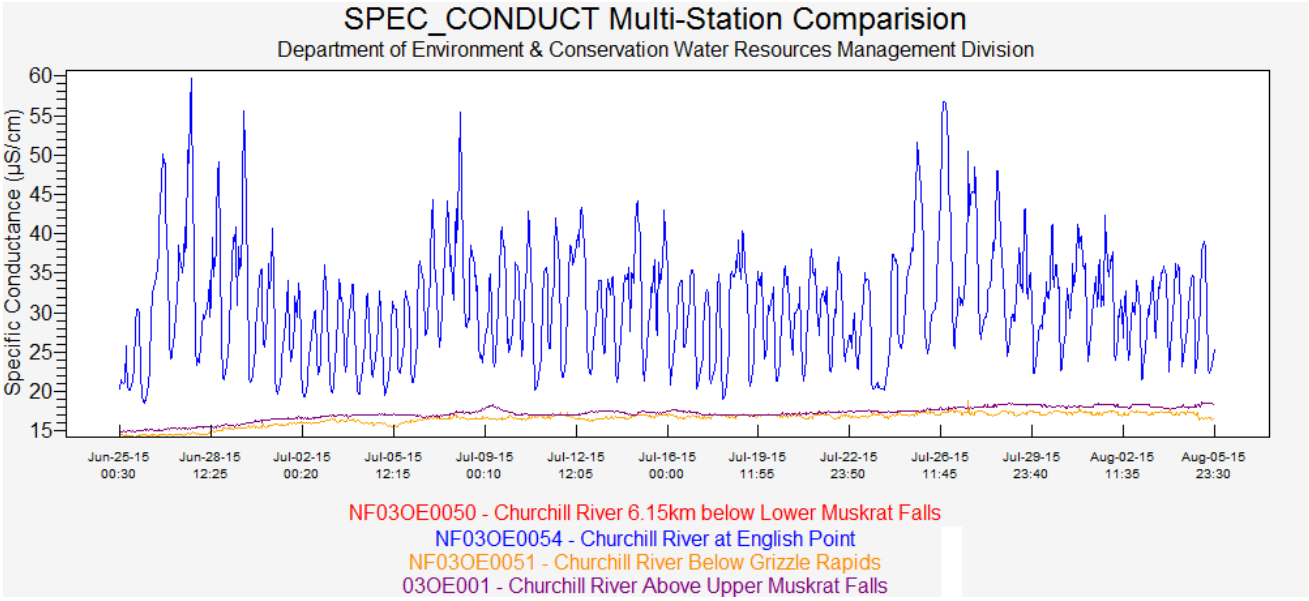

Figure A3: Comparison of Specific Conductivity at the Real-Time Stations on Churchill River (Below Muskrat Falls Station sonde was not deployed)

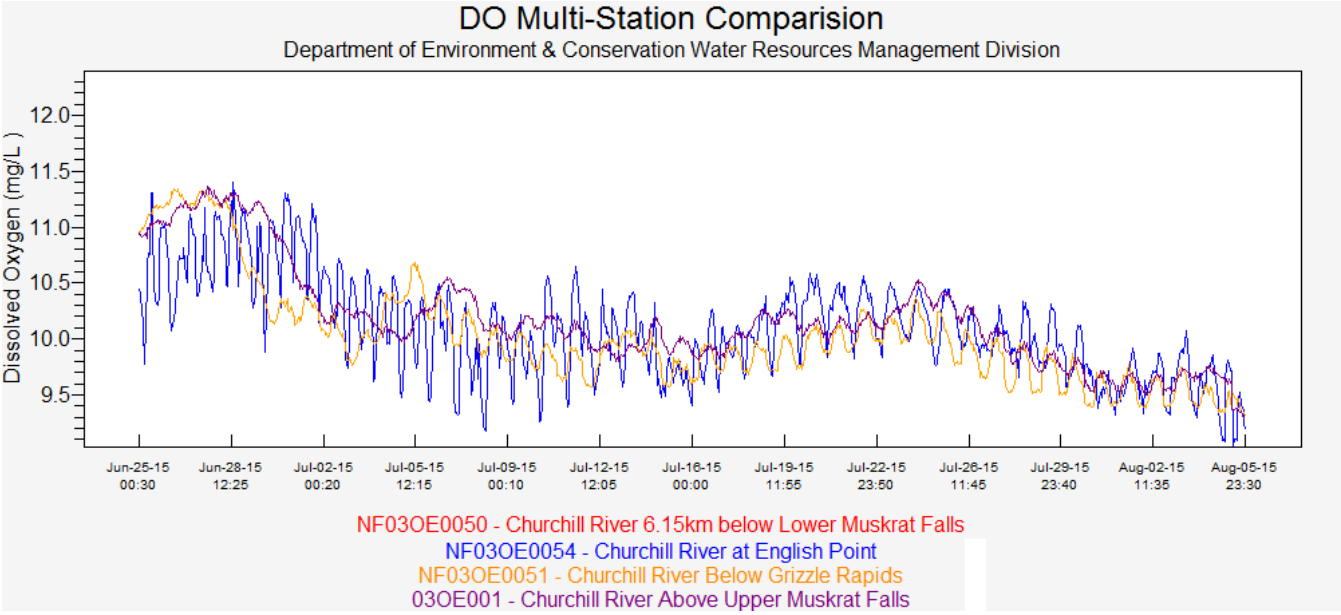

Figure A4: Comparison of Dissolved Oxygen at the Real-Time Stations on Churchill River (Below Muskrat Falls Station sonde was not deployed)

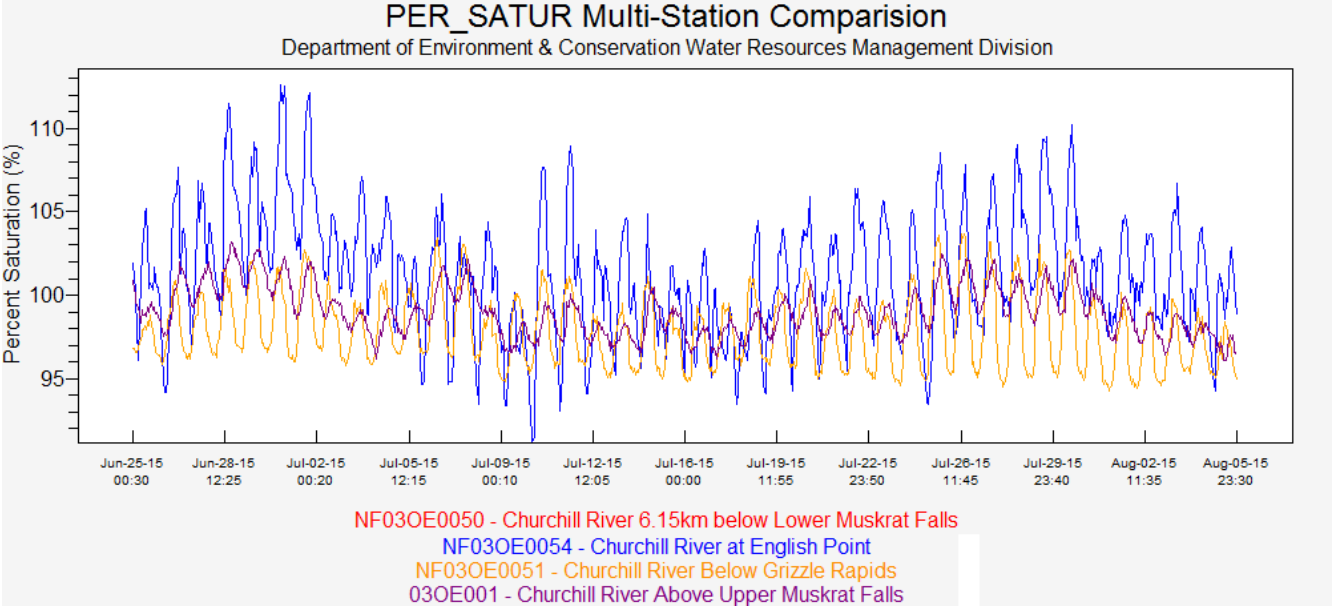

Figure A5: Comparison of Dissolved Oxygen (% Sat) at the Real-Time Stations on Churchill River (Below Muskrat Falls Station sonde was not deployed)

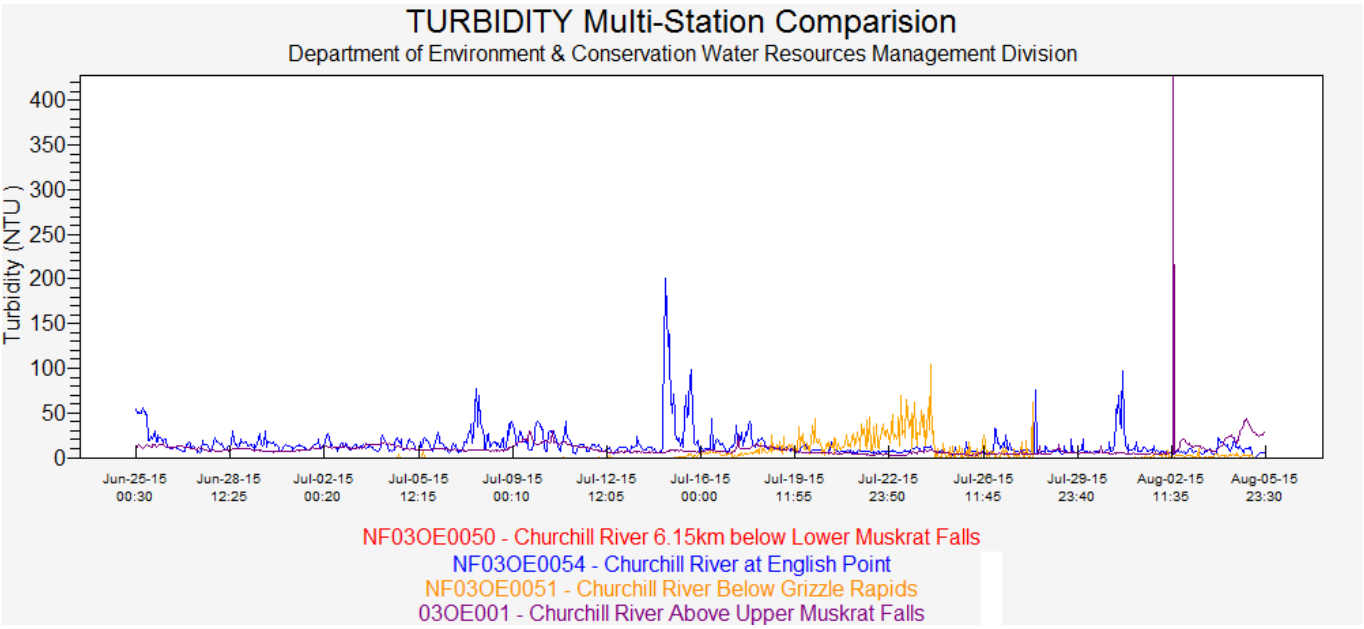

Figure A6: Comparison of Turbidity at the Real-Time Stations on Churchill River (Below Muskrat Falls Station sonde was not deployed)

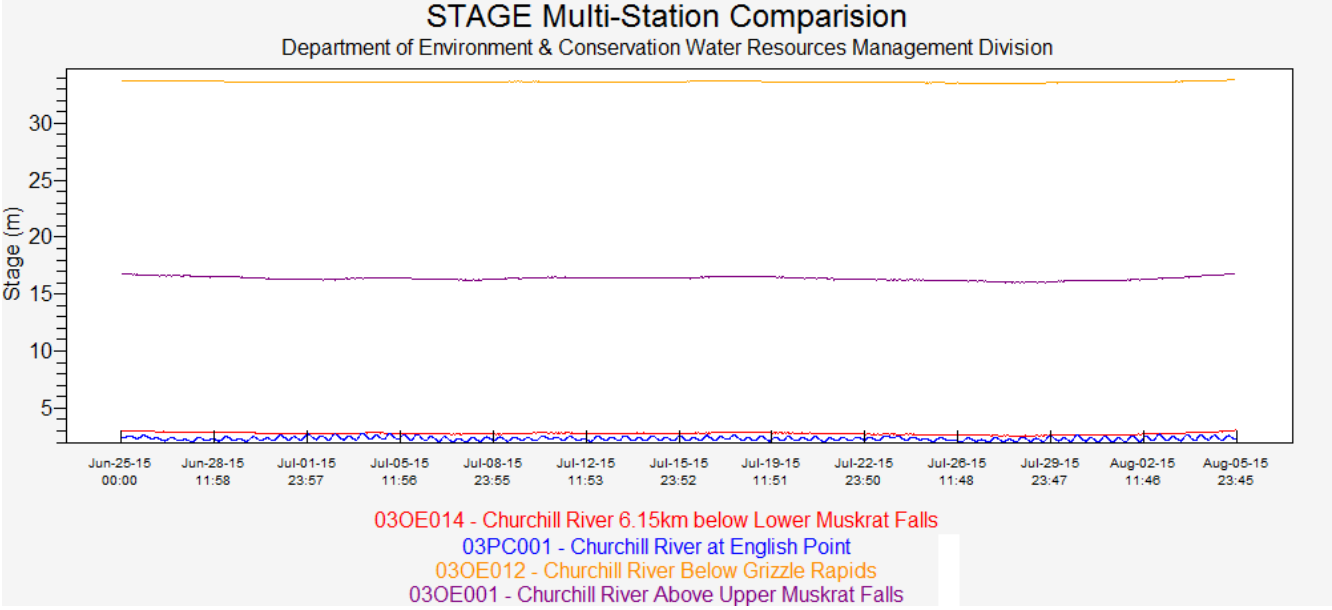

Figure A7: Comparison of Stage at the Real-Time Stations on Churchill River

APPENDIX B- Grab Sample Results

REPORT OF ANALYSIS

Lab Report Number: 1511805

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184521	WS-S-0000 Grizzle Rapids	2015-6307-00-SI-SP	2015-06-24	Alkalinity as CaCO3	mg/L	5	9
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	33
				Conductivity	uS/cm	5	20
				Dissolved Organic Carbon	mg/L	0.5	4.5
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.05	0.09
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.41
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	13
				Total Kjeldahl Nitrogen	mg/L	0.07	0.28
				Total Organic Carbon	mg/L	0.5	5.0
				Total Phosphorus	mg/L	0.05	<0.05
				Turbidity	NTU	0.1	0.7
				Aluminum	mg/L	0.01	0.06
				Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001

Sample comment:

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Nadine Pinsonneault

REPORT OF ANALYSIS

Lab Report Number: **1511805**

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184521	WS-S-0000	2015-6307-00-SI-SP	2015-06-24	Copper	mg/L	0.001	<0.001
	Grizzle Rapids			Iron	mg/L	0.03	0.11
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.010
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	<3

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

REPORT OF ANALYSIS

Lab Report Number: 1511805

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184522	WS-S-0000 CR @ Upper MF	2015-6308-00-SI-SP	2015-06-24	Alkalinity as CaCO3	mg/L	5	12
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	36
				Conductivity	uS/cm	5	19
				Dissolved Organic Carbon	mg/L	0.5	5.0
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.05	<0.05
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	7.03
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	12
				Total Kjeldahl Nitrogen	mg/L	0.07	0.16
				Total Organic Carbon	mg/L	0.5	5.0
				Total Phosphorus	mg/L	0.05	<0.05
				Turbidity	NTU	0.1	2.4
				Aluminum	mg/L	0.01	0.31
				Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001

Sample comment:

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

Exova

REPORT OF ANALYSIS

Lab Report Number: 1511805

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184522	WS-S-0000	2015-6308-00-SI-SP	2015-06-24	Copper	mg/L	0.001	0.001
	CR @ Upper MF			Iron	mg/L	0.03	0.36
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.011
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	30

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

Exova

REPORT OF ANALYSIS

Lab Report Number: 1511805

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184523	WS-S-0000 CR Below MF	2015-6309-00-SI-SP	2015-06-24	Alkalinity as CaCO3	mg/L	5	9
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	<1
				Colour	TCU	2	36
				Conductivity	uS/cm	5	16
				Dissolved Organic Carbon	mg/L	0.5	5.1
				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.05	0.18
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	6.86
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	10
				Total Kjeldahl Nitrogen	mg/L	0.07	0.31
				Total Organic Carbon	mg/L	0.5	5.5
				Total Phosphorus	mg/L	0.05	<0.05
				Turbidity	NTU	0.1	3.8
				Aluminum	mg/L	0.01	0.31
				Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001

Sample comment:

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

REPORT OF ANALYSIS

Lab Report Number: **1511805**

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Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184523	WS-S-0000	2015-6309-00-SI-SP	2015-06-24	Copper	mg/L	0.001	<0.001
	CR Below MF			Iron	mg/L	0.03	0.33
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.011
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	11

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

REPORT OF ANALYSIS

Lab Report Number: 1511805

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184525	WS-S-0000 English Point	2015-6311-00-SI-SP	2015-06-25	Alkalinity as CaCO3	mg/L	5	8
				Bromide	mg/L	0.25	<0.25
				Chloride	mg/L	1	2
Sample comment:				Colour	TCU	2	39
				Conductivity	uS/cm	5	24
				Dissolved Organic Carbon	mg/L	0.5	4.6
Report comment:				Fluoride	mg/L	0.10	<0.10
				Hardness as CaCO3	mg/L	1	5
				N-NH3 (Ammonia)	mg/L	0.05	<0.05
				N-NO2 (Nitrite)	mg/L	0.10	<0.10
				N-NO3 (Nitrate)	mg/L	0.10	<0.10
				pH		1.00	6.99
				Sulphate	mg/L	1	<1
				Total Dissolved Solids (COND - CALC)	mg/L	1	16
				Total Kjeldahl Nitrogen	mg/L	0.07	0.12
				Total Organic Carbon	mg/L	0.5	5.2
				Total Phosphorus	mg/L	0.05	<0.05
				Turbidity	NTU	0.1	4.6
				Aluminum	mg/L	0.01	0.39
				Antimony	mg/L	0.0005	<0.0005
				Arsenic	mg/L	0.001	<0.001
				Barium	mg/L	0.01	<0.01
				Boron	mg/L	0.01	<0.01
				Calcium	mg/L	1	2
				Cadmium	mg/L	0.0001	<0.0001
				Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

REPORT OF ANALYSIS

Lab Report Number: **1511805**

Cient:	Department of Environment	**COC Number:**	3400
Attention:	Ms. Annette Tobin	**Date Reported:**	2015-07-14
Client Project:	Happy Valley - Goose Bay	**Date Submitted:**	2015-06-27
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1184525	WS-S-0000 English Point	2015-6311-00-SI-SP	2015-06-25	Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.44
				Lead	mg/L	0.001	<0.001
Sample comment:				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	0.02
				Mercury	mg/L	0.0001	<0.0001
Report comment:				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.013
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	1	11

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL: Nadine Pinsonneault

APPENDIX C-Quality Assurance / Quality Control Procedures

- As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the beginning and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].
- At the beginning of the deployment period, a newly calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is temporarily deployed *in-situ* and along side the newly calibrated Field Sonde. A grab sample is also taken from the water body at this time and sent away to a laboratory for analysis. Field Sonde performance ratings for *temperature (^oC)* and *Dissolved Oxygen (% saturation)* are based on differences recorded by the Field Sonde and QA/QC Sonde. Field Sonde performance ratings for *specific conductivity (µS/cm), pH (unit)* and *turbidity (NTU)* are based on differences between Field Sonde readings and grab sample results.
- At the end of the deployment period, water quality parameters are recorded by the Field Sonde before and after a thorough cleaning of its probes. Error caused by *bio-fouling* (E_f) is assessed by comparing these readings with readings made by a newly calibrated QA/QC Sonde, which is temporarily deployed *in-situ* and along side the Field Sonde. An assessment of *instrument drift error* (E_d) is made during laboratory calibration of the Field Sonde, and the two error values are added to give an estimate of total error ($E_t = E_f + E_d$). If E_t exceeds a predetermined data correction criterion, a correction factor is applied to the dataset based on linear interpolation of E_t. The Field Sonde performance is also rated at the end of the deployment period, based on the E_t value.
- Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (^{o}C)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
pH (unit)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Sp. Conductance (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Sp. Conductance > 35 µS/cm (%)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Dissolved Oxygen (mg/l) (% Sat)	≤ ±0.3	> ±0.3 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Turbidity <40 NTU (NTU)	≤ ±2	> ±2 to 5	> ±5 to 8	> ±8 to 10	> ±10
Turbidity > 40 NTU (%)	≤ ±5	> ±5 to 10	> ±10 to 15	> ±15 to 20	> ±20

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at *http://pubs.water.usgs.gov/tm1d3*

APPENDIX D-Water Parameter Description

- ***Dissolved Oxygen*** - The amount of Dissolved Oxygen (DO) (mg/l or % saturation) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).
- ***Flow*** – Flow (m3/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.
- ***pH*** - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).
- ***Specific conductivity*** - Specific conductivity (μS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).
- ***Stage*** – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.
- ***Temperature*** - Essential to the measurement of most water quality parameters, temperature (oC) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).
- ***Total Dissolved Solids*** - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).
- ***Turbidity*** - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965)