



Real-Time Water Quality Annual Report

Wabush Lake Network

June 7 to
October 13, 2016



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

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Acknowledgements

The Real-Time Water Quality Monitoring Program (RTWQ) at Wabush Lake is fully funded by the Iron Ore Company of Canada (IOC). The program is made successful by a joint partnership between IOC, Environment Canada (EC), and the Newfoundland & Labrador Department of Environment and Climate Change (ECC).

Various individuals from each sector have been diligently involved to ensure this program is a successful operation, they include, Renee Paterson (ECC), Jody Wentzell (IOC), Sharlene Baird (IOC) and Howie Wills (EC). In addition to these managers, there have been a team of individuals who work together to ensure the day to day operations of these stations are providing quality data. Maria Murphy (ECC) was responsible for these water quality stations during 2016; responsibilities included deployment and removal of instruments, maintenance and calibration of the instruments and preparation of monthly deployment reports. Kelly Maher (ECC) is acknowledged for her assistance during deployment and removal procedures in 2016. Ryan Pugh and Tara Clinton are acknowledged for their role in performing Performance Testing and Evaluation (PTE) and in-house servicing of the instruments during Winter 2016-2017.

EC staff are essential in the operation of the data logging/communication aspect of the network. Staff of the Meteorological Service of Canada Division – Water Survey of Canada, visit the stations regularly to ensure that the data logging and data transmitting equipment is working properly. EC is also the lead on dealing with stage and flow issues.

Introduction

- The real-time water quality monitoring network on Wabush Lake was established during the summer of 2007, a partnership between the Newfoundland & Labrador Department of Environment and Climate Change (ECC) and the Iron Ore Company of Canada (IOC).
- The Wabush Lake network consists of two water quality/quantity stations, one located downstream of the IOC tailings disposal area and one located upstream of the same area (Figure 1). These stations measure water quality parameters including water temperature, pH, specific conductivity, dissolved oxygen, turbidity, as well as water quantity parameters, stage, and flow. Parameters are recorded on an hourly basis during the deployment period.
- The official name of each station on Wabush Lake is *Wabush Lake at Dolomite Road* and *Wabush Lake at Lake Outlet*, hereafter referred to as the Dolomite Road station and the Julienne Narrows station.
- On June 8th, 2016, a new station was commissioned under this agreement. This station is located at *Dumbell Stream above Dumbell Lake*, hereafter referred to as Dumbell Stream. This station was commissioned as the result of a proposed mine expansion in the area.

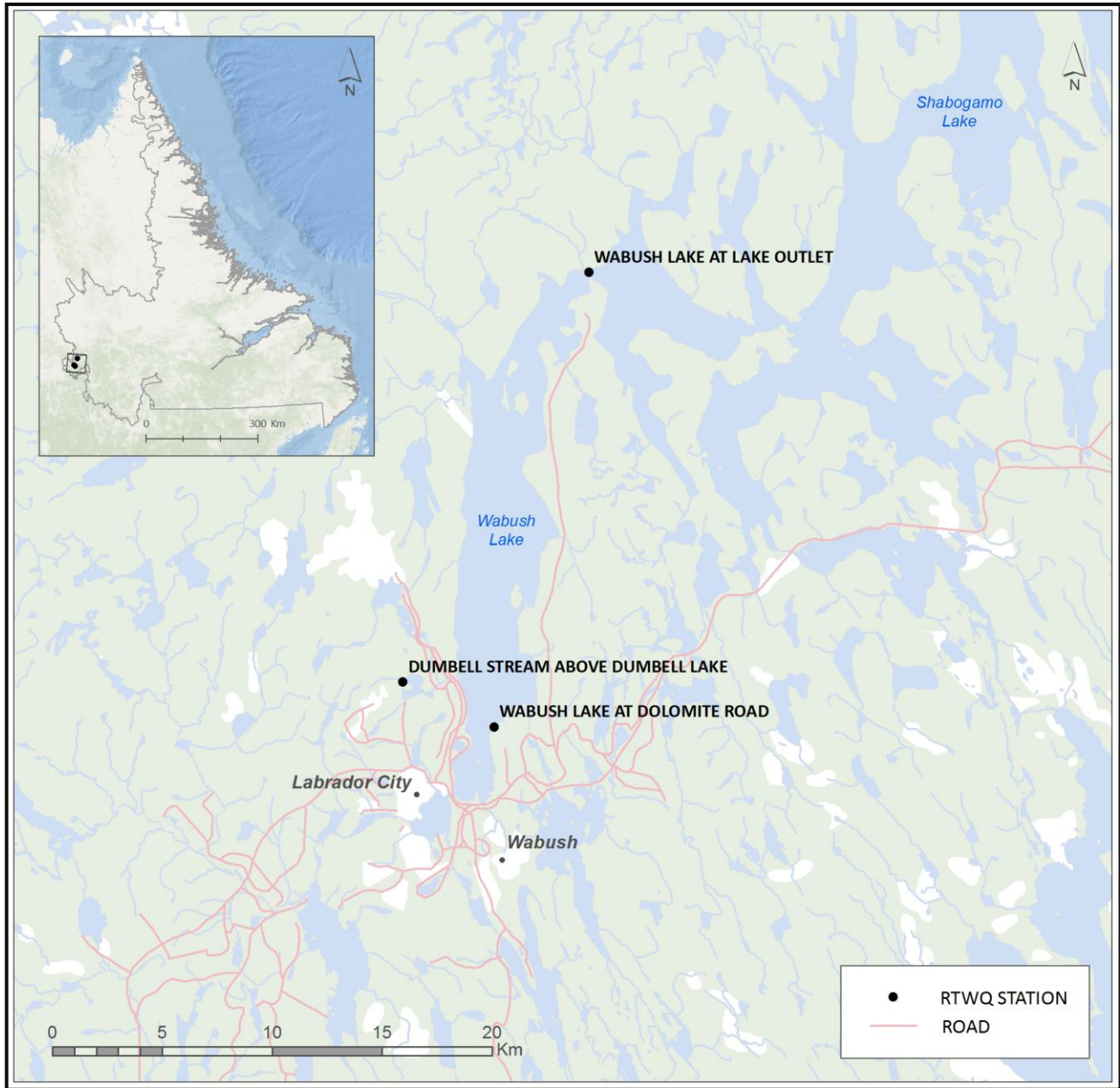


Figure 1: Map of Wabush Lake area in Western Labrador showing three RTWQ Monitoring Stations

- Initial deployment for 2016 was on June 7th (Dolomite Road), June 11th (Julienne Narrows), and June 8th (Dumbell Stream). Instruments were removed for the winter season on October 12th (Dolomite Road), October 9th (Julienne Narrows) and October 13th (Dumbell Stream). The following report depicts and discusses water quality events throughout this time period.
- The purpose of this network is to monitor, process, and distribute water quality/quantity data to IOC, ECC and EC, for assessment and management of water resources, as well as to provide an early warning for any potential or emerging water issues so mitigative measures can be implemented in a timely manner.
- ECC provides IOC with monthly and annual deployment reports.
- It is important to note that unless otherwise stated on the graphs, small gaps in data are due to the removal of the instrument for maintenance and calibration.

Maintenance and Calibration

- To ensure accurate data collection, maintenance and calibration of the water quality instrumentation are performed preferably on a monthly basis.
- 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, ECC staff carefully calibrate each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity.
- Installation and removal dates for the 2016 season are summarized in the table below.

Table 1: Water quality instrument deployment start and end dates for 2016

Installation	Removal	Deployment duration (days)
June 7-11	July 20	39-43
July 20-21	August 30-31	40-42
August 31	October 12-13	42-43

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.
- At deployment and removal, a QA/QC 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 QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 2).

Table 2: Ranking classifications for deployment and removal

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

- It should be noted that the temperature sensor on any 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 water quality stations for the three deployment periods from June 7th to October 13th, 2016 are summarized in Table 3.
- For additional information and explanations of ranking including “N/A” rankings, please refer to the monthly deployment reports.

Table 3: Comparison rankings IOC RTWQ stations June 7 – October 13, 2016

	Date		Instrument #	Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Dolomite Road	07-Jun-16	Deployment	44568	Good	Excellent	Good	Fair	Excellent
	20-Jul-16	Removal		Good	Excellent	Fair	Fair	Excellent
	21-Jul-16	Deployment	47568	Good	Excellent	Marginal	Fair	N/A
	30-Aug-16	Removal		Good	Excellent	Fair	Excellent	N/A
	31-Aug-16	Deployment	44567	Excellent	Excellent	Good	Excellent	Excellent
	12-Oct-16	Removal		Excellent	Good	Poor	Fair	N/A
Julienne Narrows	11-Jun-16	Deployment	44568	Good	Excellent	Fair	Fair	Fair
	20-Jul-16	Removal		Excellent	Fair	Marginal	Excellent	Excellent
	21-Jul-16	Deployment	44567	Fair	Excellent	Marginal	Marginal	Poor
	30-Aug-16	Removal		N/A	N/A	N/A	N/A	N/A
	31-Aug-16	Deployment	44422	Poor	Excellent	Fair	Good	Excellent
	12-Oct-16	Removal		N/A	N/A	N/A	N/A	N/A
Dumbell Stream	08-Jun-16	Deployment	41482	Good	Excellent	Excellent	Excellent	Excellent
	20-Jul-16	Removal		Good	Excellent	Fair	Poor	Excellent
	20-Jul-16	Deployment	44422	Excellent	Good	Fair	Excellent	Excellent
	31-Aug-16	Removal		Good	Excellent	Good	Excellent	Excellent
	31-Aug-16	Deployment	44568	Good	Excellent	Excellent	Fair	Excellent
	13-Oct-16	Removal		Excellent	Good	Marginal	Poor	N/A

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 7th, 2016 to October 13th, 2016 at the three RTWQ stations in Lab West.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.
- The instrument was deployed at Dumbell Stream on June 8th. However, there were a number of transmission issues, and therefore data was only available beginning on the 10th of June.

Wabush Lake Network

- Water temperature ranged from 5.00 to 20.30°C at Julienne Narrows, during the 2016 deployment season. The median value was 13.20 °C (Figure 2).
- Water temperature ranged from 7.40 to 20.40°C at Dolomite Road, during the 2016 deployment season. The median value was 14.50 °C (Figure 2).
- Water temperature is typically higher at Dolomite Road than Julienne Narrows.

**Water Temperature: Wabush Lake Network
June 7 to October 12, 2016**

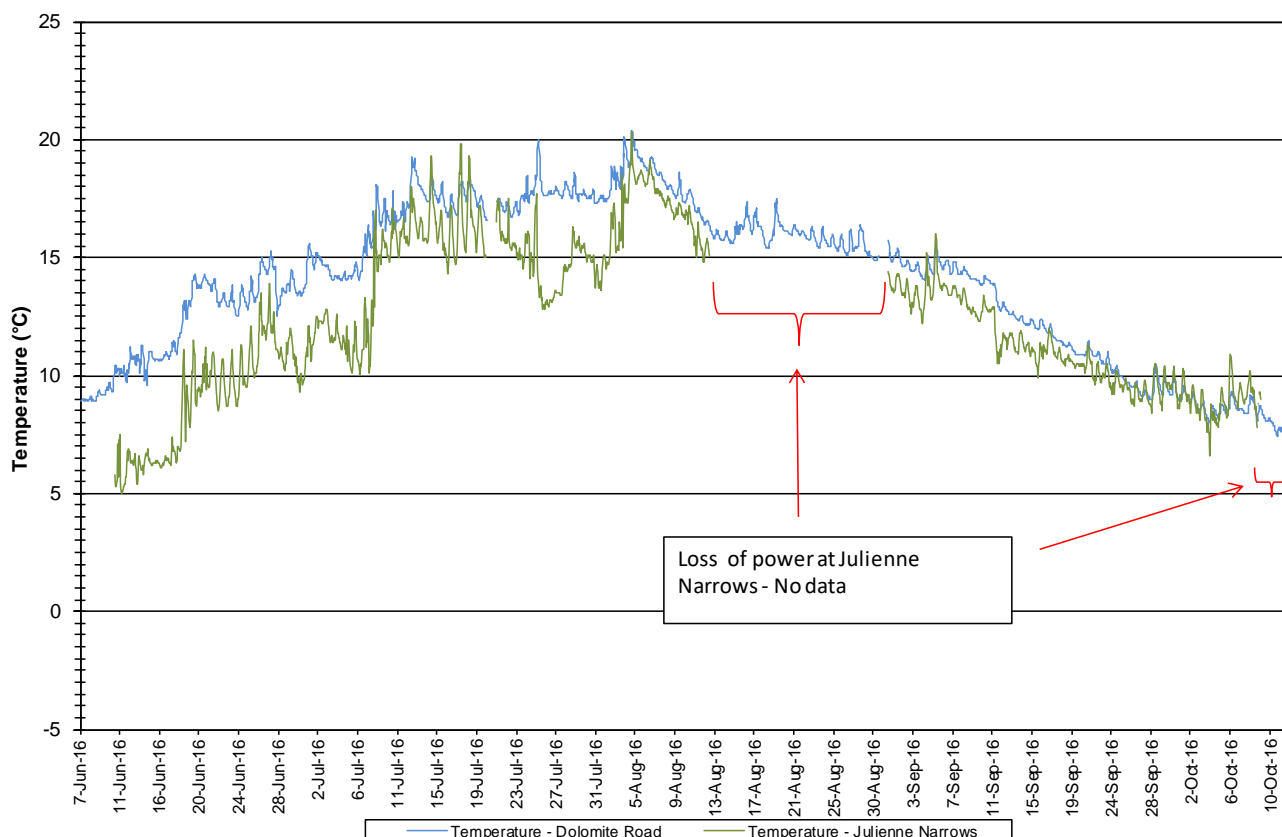
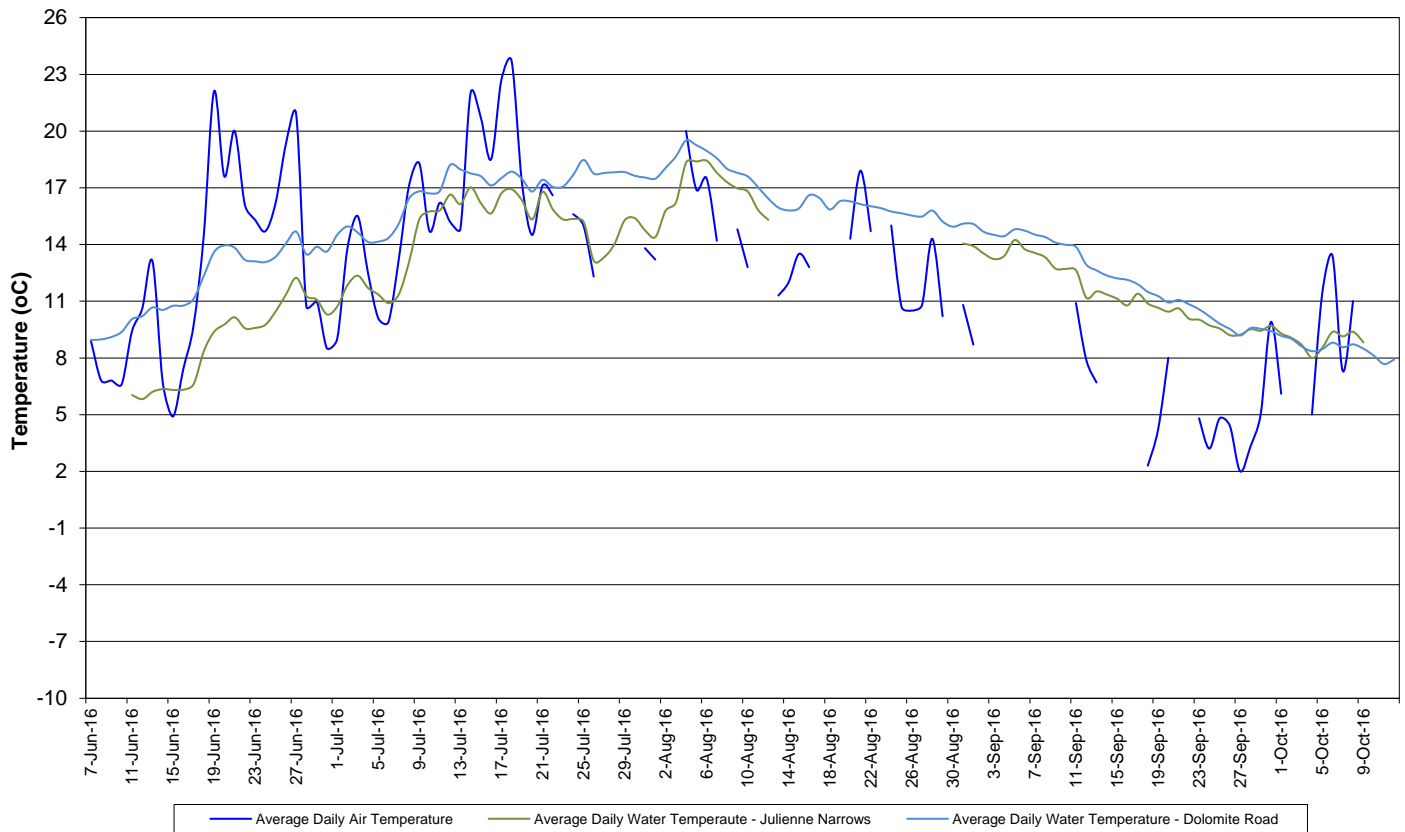


Figure 2: Water temperature – Wabush lake network

- Water temperature values show a typical seasonal trend, warm in the summer and decreasing into the fall season. Water temperature fluctuations correspond moderately well with the ambient air temperature recorded by Environment Canada. It is important to note that weather data was collected at Churchill Falls (Figure 3).

**Average Daily Air and Water Temperature: Wabush Lake Network
June 7 to October 12, 2016**



**Figure 3: Average Daily Air and Water Temperatures – Wabush Lake network
(Weather data collected at Churchill Falls)**

- pH ranges from 7.56 to 8.71 pH units at Julienne Narrows, and from 6.96 to 7.87 pH units at Dolomite Road (Figure 4), throughout the 2016 deployment season. The median pH is 8.03 and 7.47 units respectively.
- pH fluctuates daily at both stations. Peaks are observed during late afternoon and early evening.
- All values during the deployment are within the CCME Water Quality Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units).
- At Julienne Narrows, there is a slight decrease after the first deployment period; it is then relatively stable for the remainder of the season.
- At Dolomite Road, pH increases slightly during the first deployment period; it is then relatively stable for the remainder of the season.

**Water pH: Wabush Lake Network
June 7 to October 12, 2016**

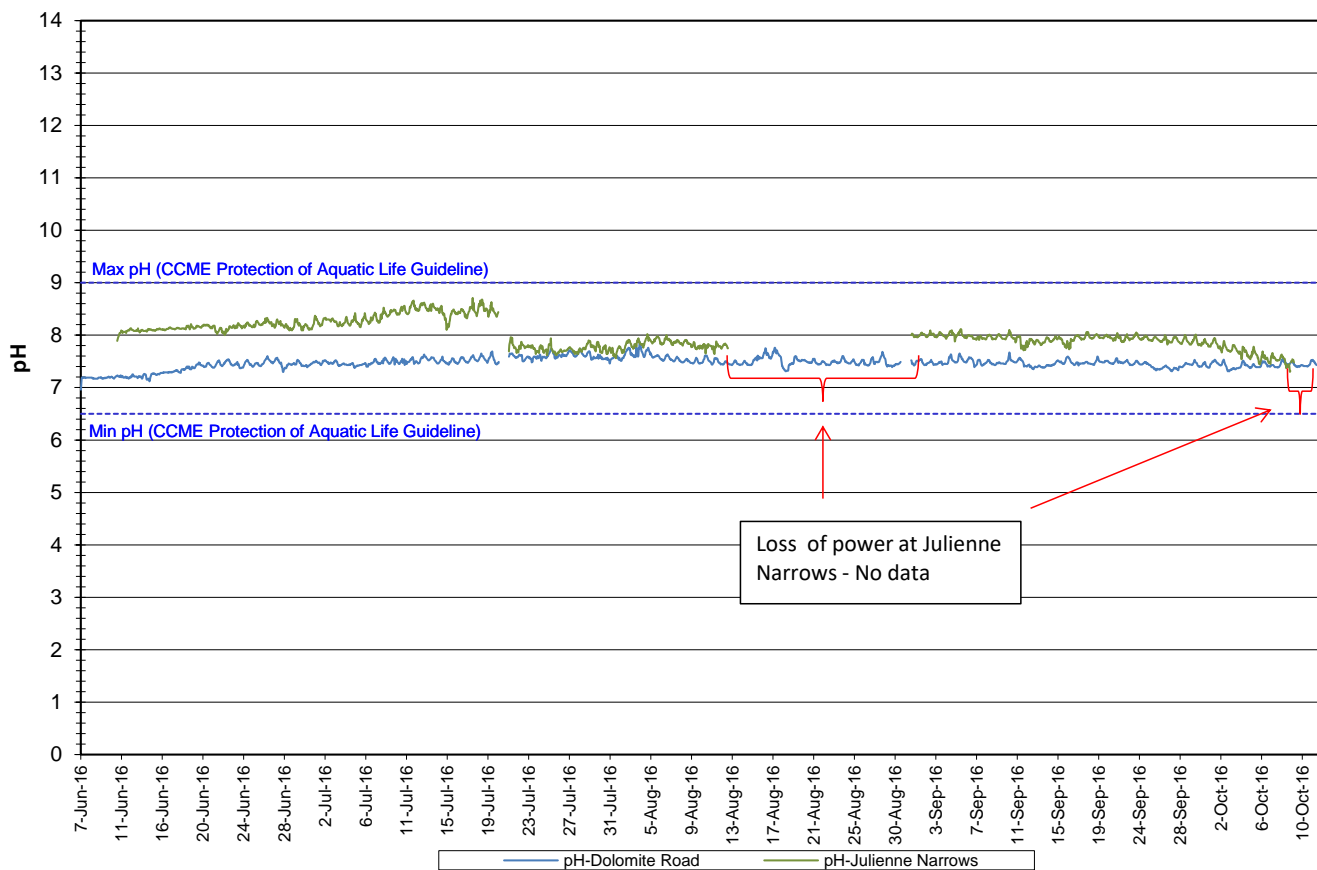


Figure 4: pH – Wabush Lake Network

- Throughout the 2016 deployment season, specific conductivity ranged from 73.1 to 119.2 $\mu\text{S}/\text{cm}$ at Julienne Narrows, and from 36.4 to 58.6 $\mu\text{S}/\text{cm}$ at Dolomite Road (Figure 5).
- Daily fluctuations are evident at the Julienne Narrows station. This can be attributed to varying contributions of iron ore tailings deposited into Wabush Lake upstream of Julienne Narrows and downstream of Dolomite Road. This can also explain the difference in specific conductivity levels between the two stations.
- At Julienne Narrows, conductivity decreases during the first month of the deployment season, with small fluctuations; it then fluctuates greatly for the remainder of the season.
- At Dolomite Road, conductivity gradually increases over the course of the 2016 deployment season.
- Stage decreased gradually at both stations.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Specific Conductivity and Stage: Wabush Lake Network
June 7 to October 12, 2016**

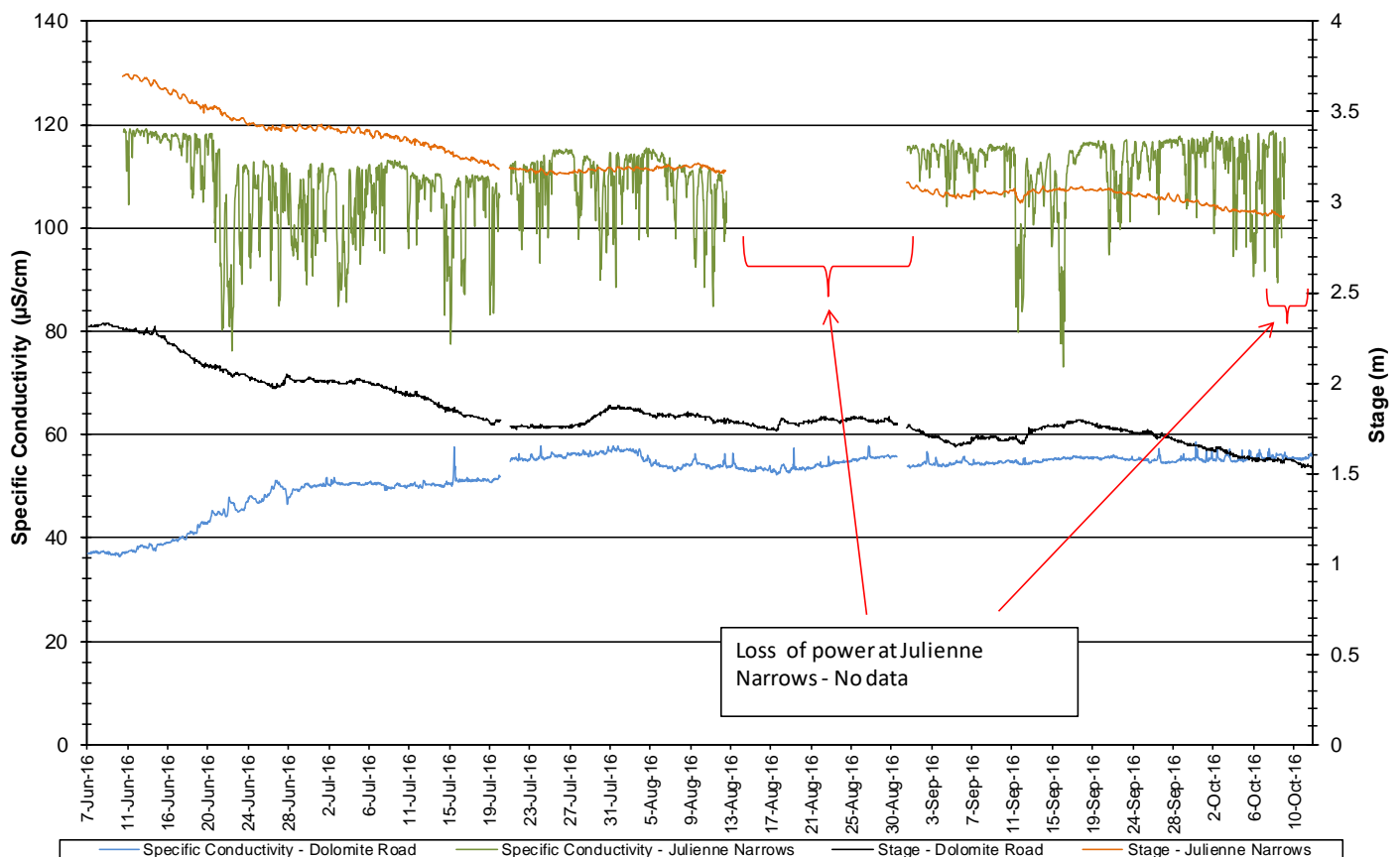


Figure 5: Specific Conductivity – Wabush Lake Network

- At the Julienne Narrows station, the saturation of dissolved oxygen ranged from 86.7 to 113.1% and a range of 8.34 to 11.78 mg/l was found in the concentration of dissolved oxygen with a median value of 10.11 mg/l (Figure 6).
- At the Dolomite Road station, the saturation of dissolved oxygen ranged from 78.8 to 104.8% and a range of 7.71 to 11.29 mg/l was found in the concentration of dissolved oxygen with a median value of 9.12 mg/l (Figure 6).
- Dissolved oxygen fluctuated daily at both stations with decreases observed at night.
- Dissolved oxygen decreases during the summer months throughout the time when water temperature is warmest. Dissolved oxygen then increases during the last deployment period of the season, when water temperature is decreasing in the fall.
- All values were above the CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages of 6.5 mg/l. Most values recorded were below the minimum CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l, at Dolomite Road. Most values recorded were above the minimum CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l at Julienne Narrows. The guidelines are indicated in blue on Figure 6.

**Dissolved Oxygen Concentration and Saturation: Wabush Lake Network
June 7 to October 12, 2016**

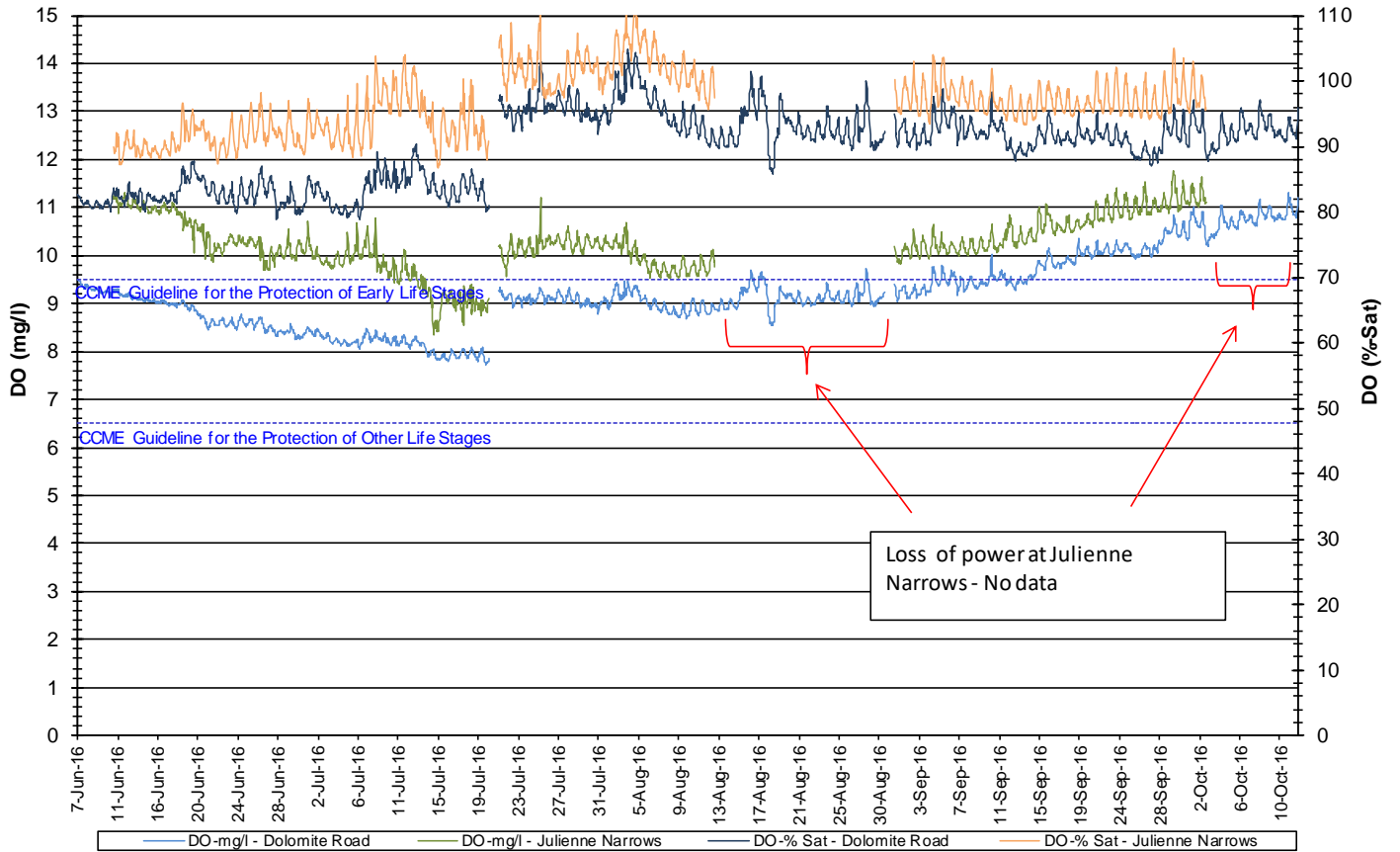


Figure 6: Dissolved Oxygen and Percent Saturation – Wabush Lake Network

- At the Julienne Narrows station, turbidity values range from 0.0 to 502.0 NTU with a median value of 0.0 NTU (Figure 7a and 7b).
- Turbidity readings >0NTU occur occasionally and for small periods of time. Some turbidity spikes correspond with precipitation.
- It is important to note that weather data was collected at Churchill Falls.

**Water Turbidity: Julienne Narrows
June 11 to October 12, 2016**

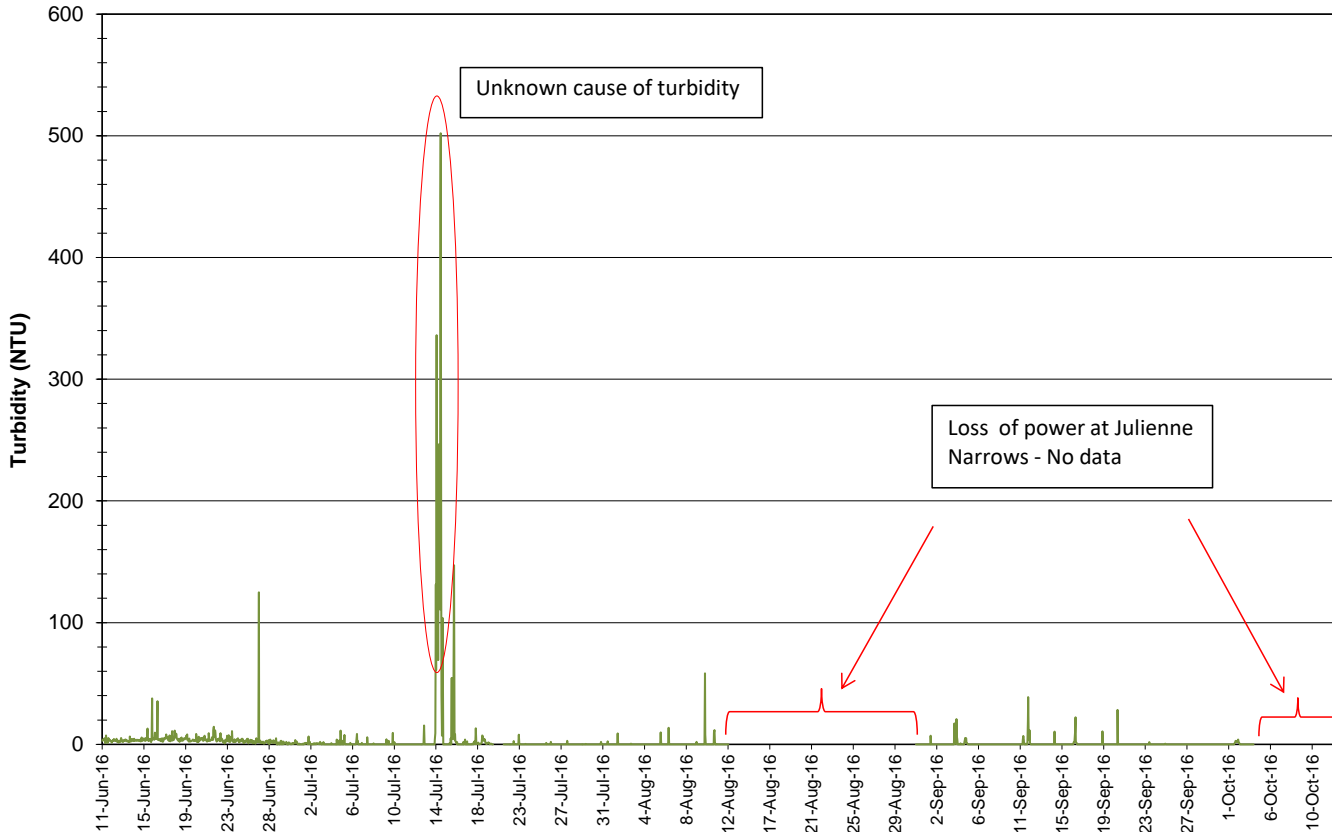


Figure 7a: Turbidity at Julienne Narrows

**Water Turbidity <130 NTU: Julienne Narrows
June 11 to October 12, 2016**

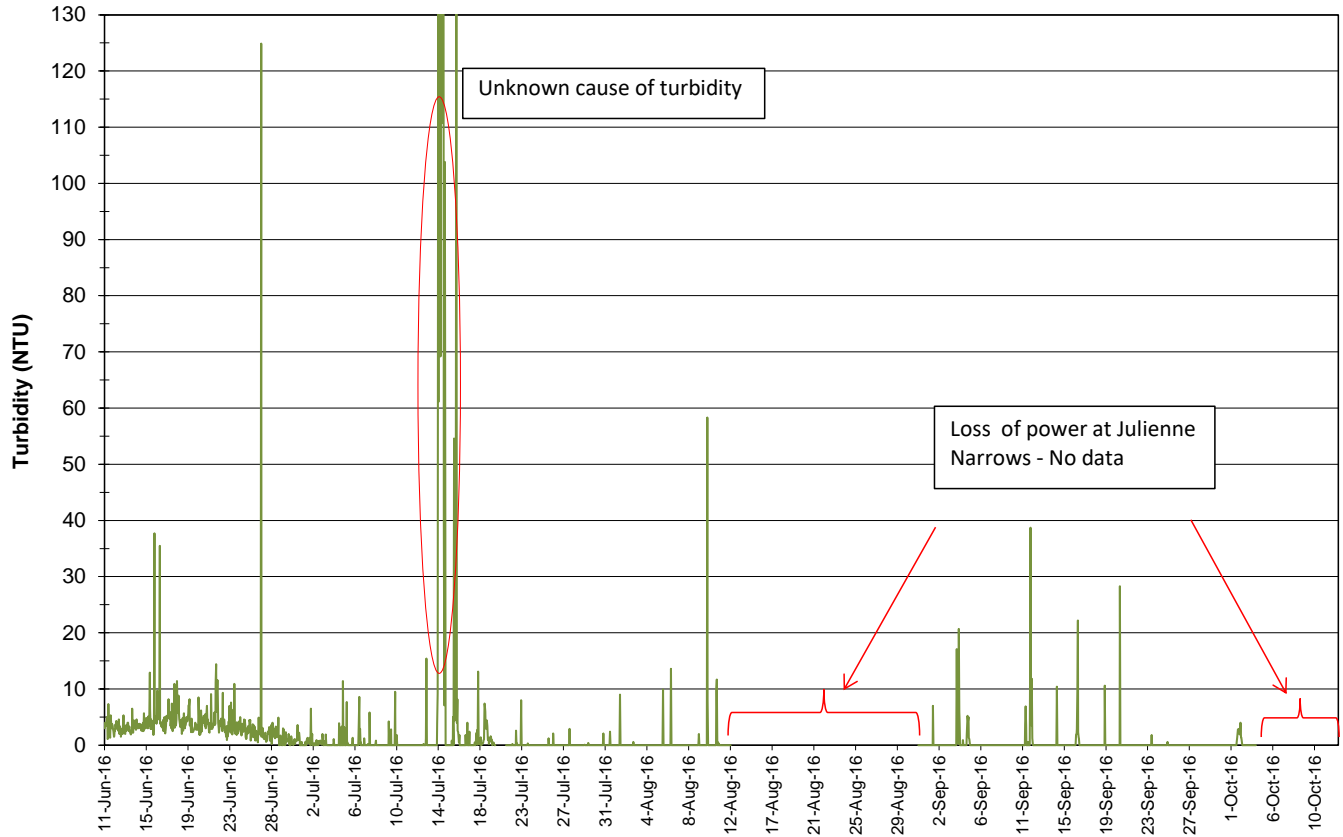


Figure 7b: Turbidity at Julienne Narrows below 130 NTU

- At the Dolomite Road station, turbidity values range from 0.0 to 9.9 NTU, with a median value of 0.0 NTU (Figure 8).
- Turbidity readings >0NTU occur occasionally and for small periods of time.
- It is important to note that weather data was collected at Churchill Falls.

**Water Turbidity: Dolomite Road
June 7 to October 12, 2016**

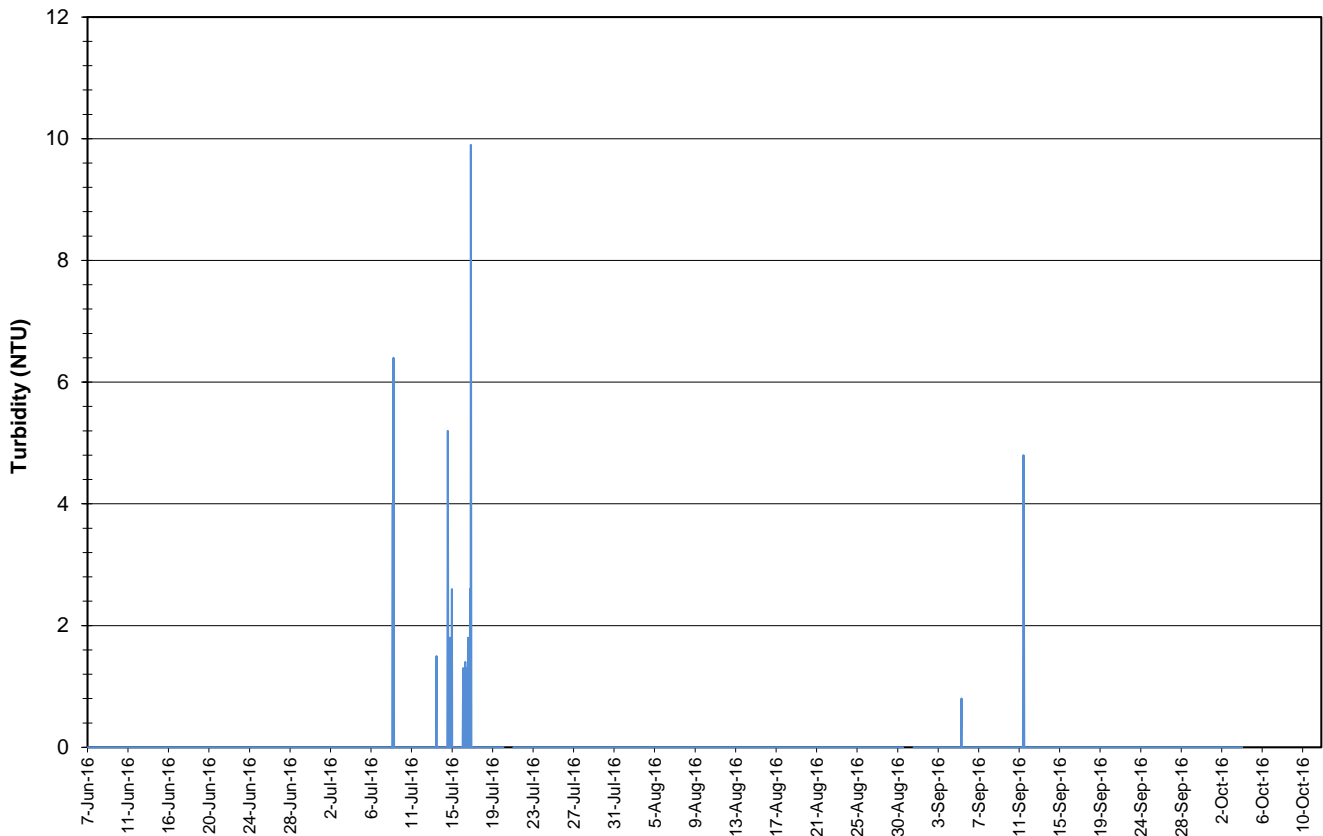


Figure 8: Turbidity at Dolomite Road

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Julienne Narrows (Figure 9).
- Stage decreases over the course of the deployment season, with precipitation occurring frequently.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Daily Precipitation and Average Daily Stage Level: Julienne Narrows
June 11 to October 12, 2016**

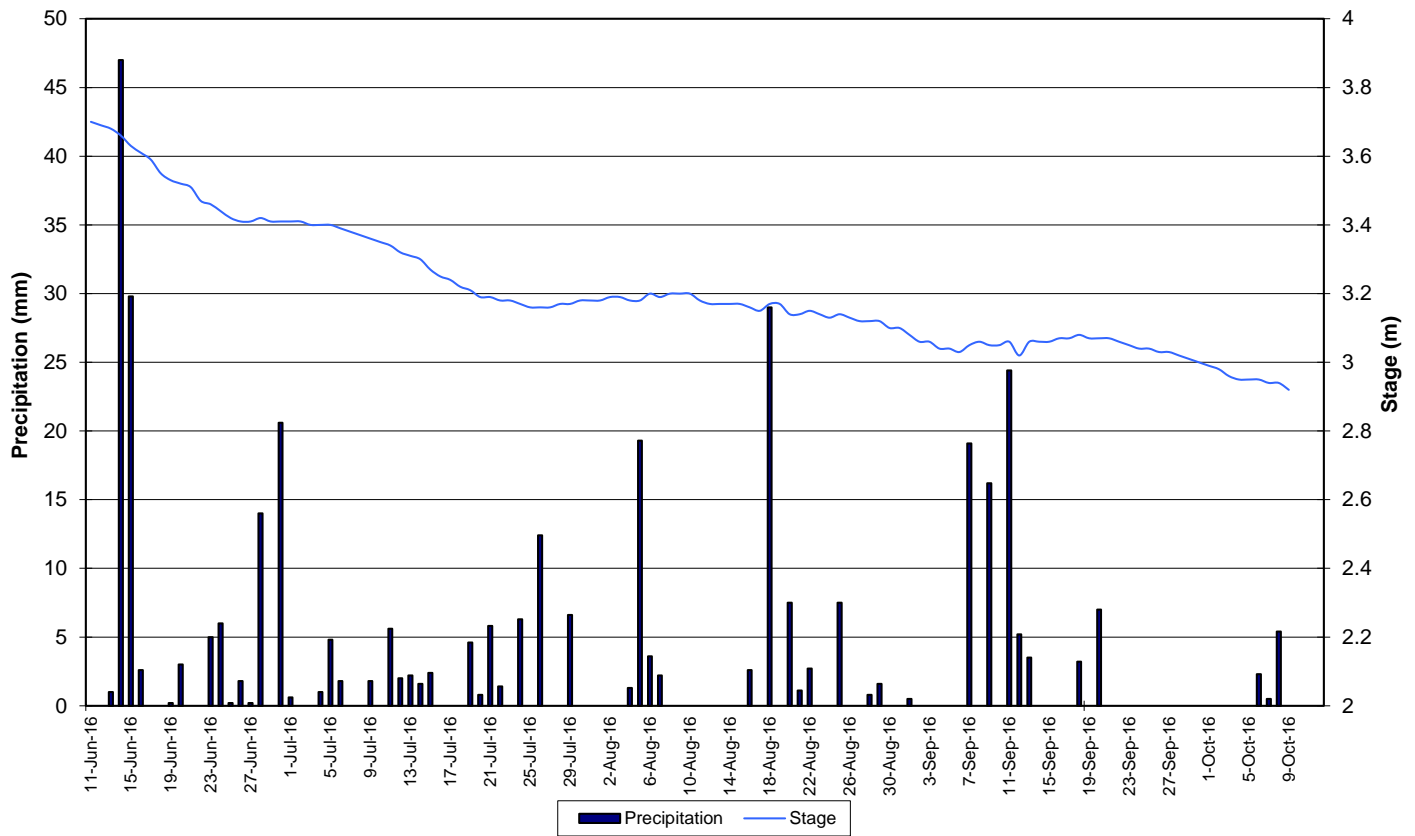


Figure 9: Stage and Precipitation at Julienne Narrows

- Stage and precipitation are graphed below to show the relationship between rainfall and water level, at Dolomite Road (Figure 10).
- Stage decreases over the course of the deployment season, with precipitation occurring frequently.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Daily Precipitation and Average Daily Stage Level: Dolomite Road
June 7 to October 12, 2016**

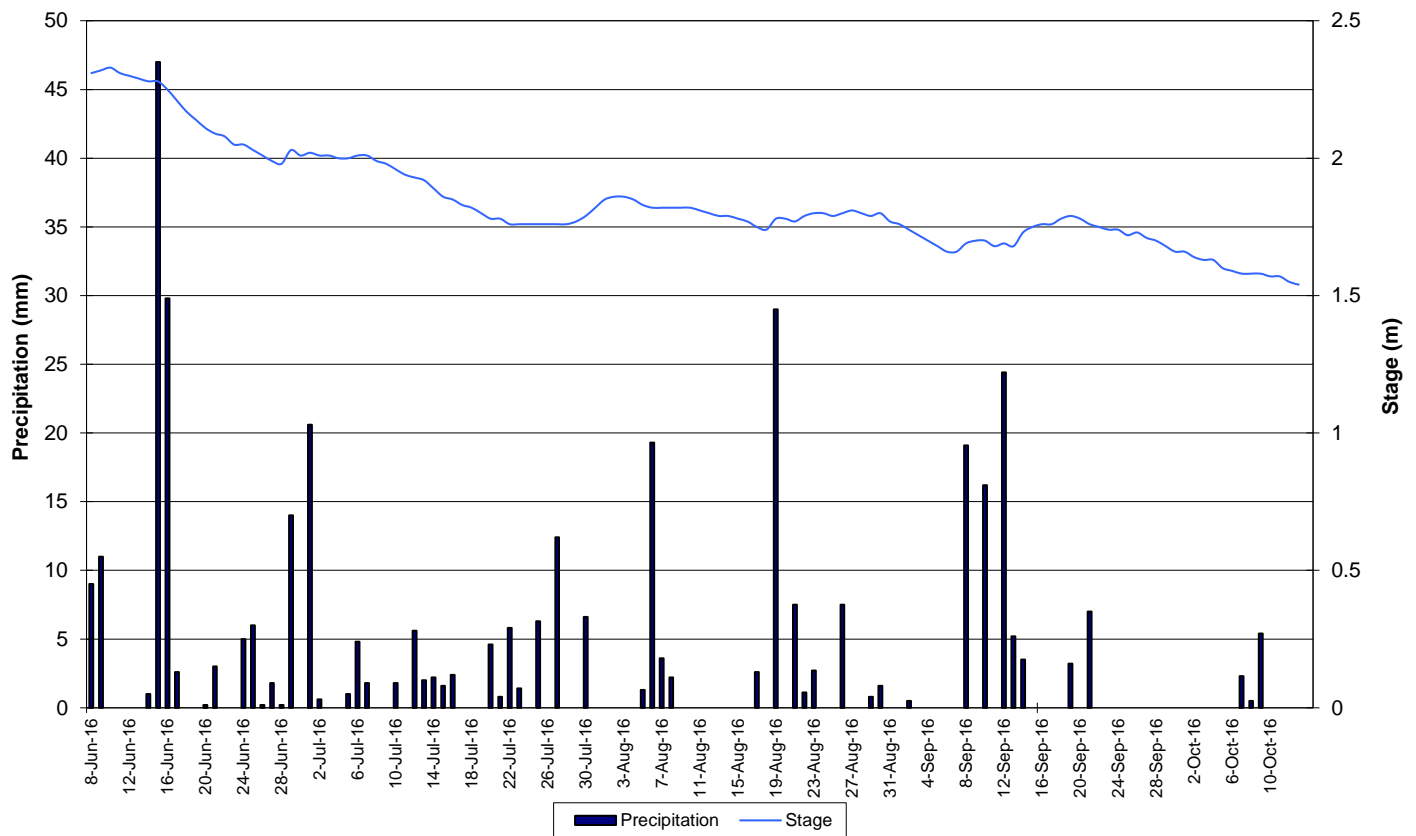


Figure 10: Stage and Precipitation at Dolomite Road

Dumbell Stream

- Water temperature ranged from 1.61 to 8.94°C at Dumbell Stream, during the 2016 deployment season. The median value was 4.43 °C (Figure 11).

**Water Temperature: Dumbell Stream above Dumbell Lake
June 10 to October 13, 2016**

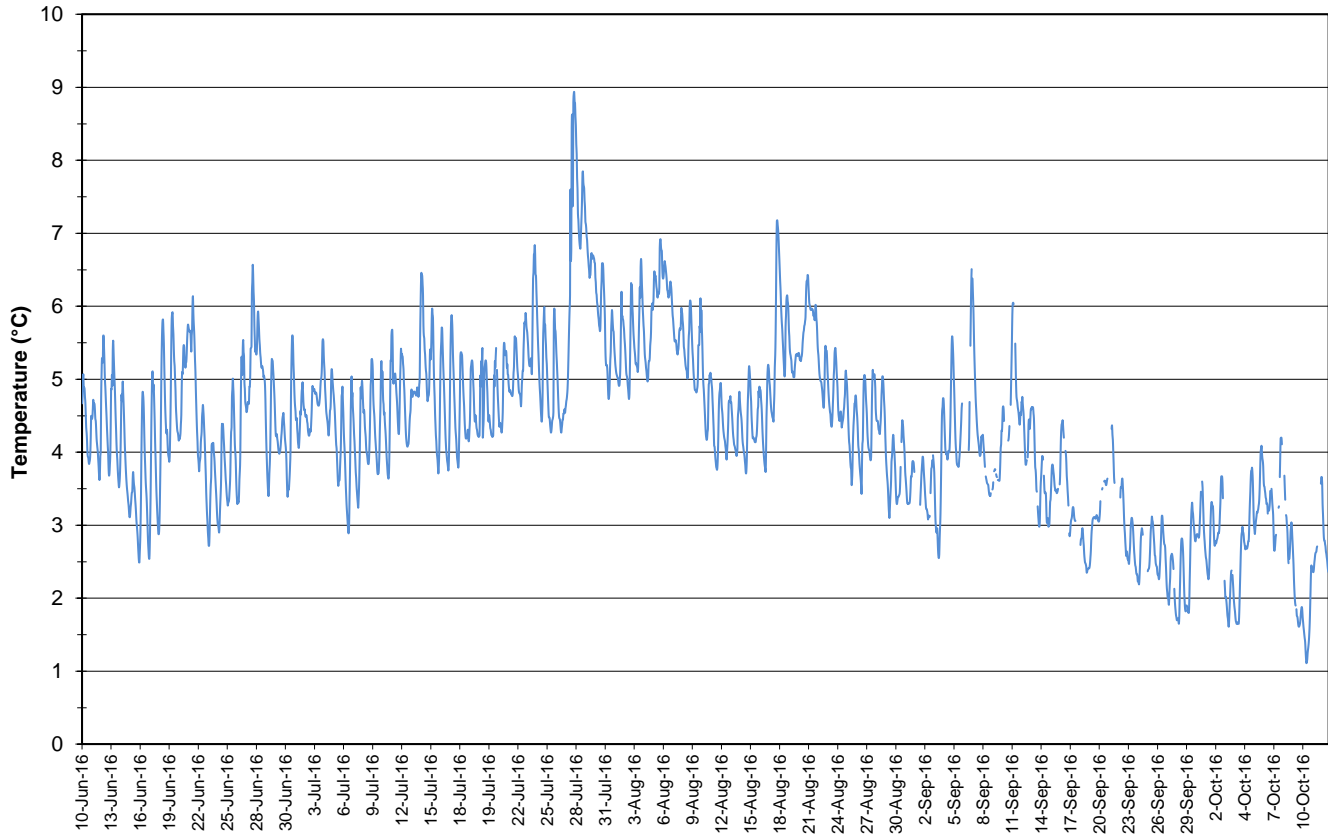
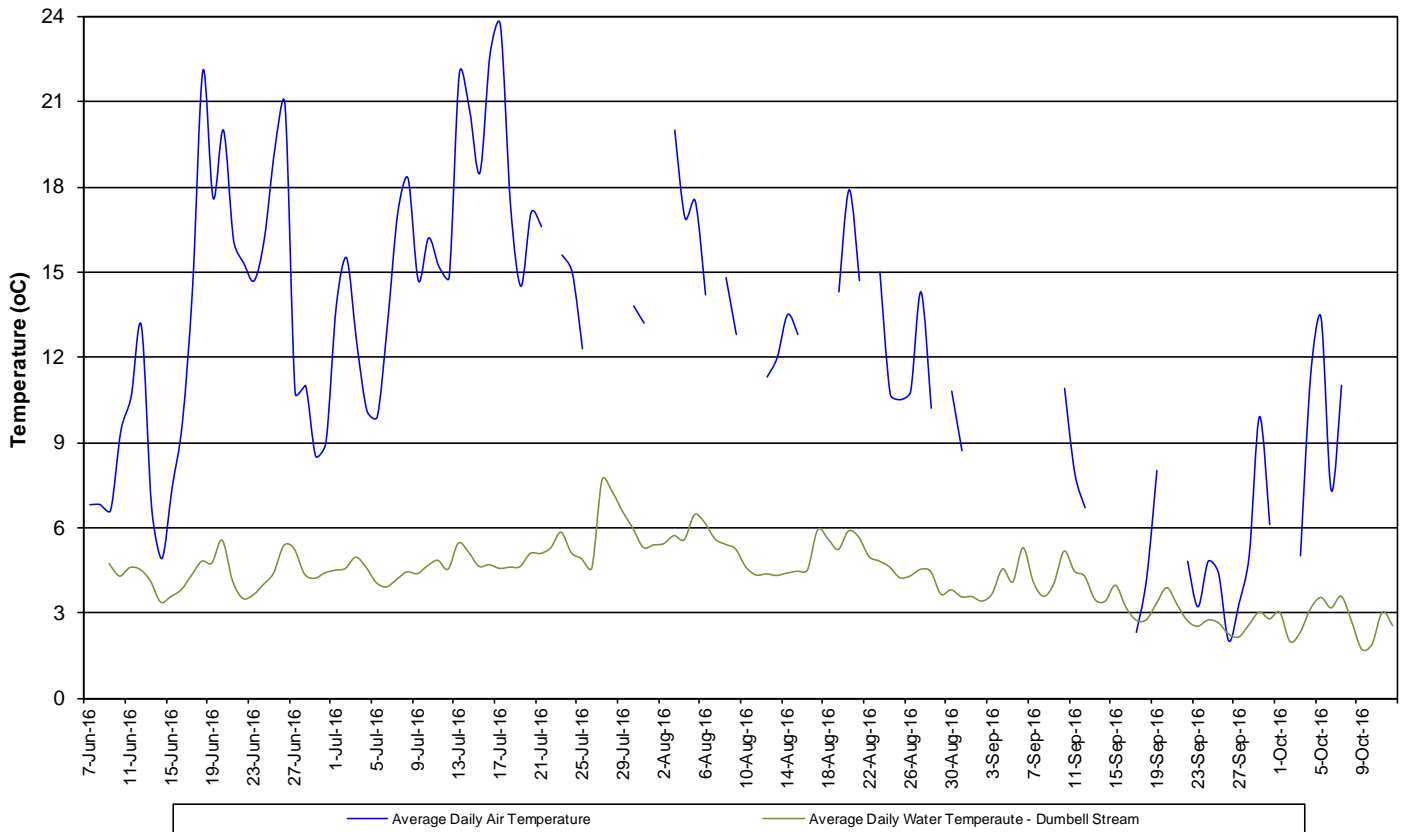


Figure 11: Water Temperature – Dumbell Stream

- Air temperature values show a typical seasonal trend, warm in the summer and decreasing into the fall season. Water temperature fluctuations correspond moderately well with the ambient air temperature recorded by Environment Canada. It is important to note that weather data was collected at Churchill Falls (Figure 12).

**Average Daily Air and Water Temperature: Dumbell Stream
June 8 to October 13, 2016**



**Figure 12: Average Daily Air and Water Temperatures – Dumbell Stream
(Weather data collected at Churchill Falls)**

- pH ranges from 7.44 to 7.91 pH units at Dumbell Stream (Figure 13), throughout the 2016 deployment season. The median pH is 7.74 units.
- pH fluctuates daily. Peaks are observed during late afternoon and into early evening. pH increases slightly over the course of the deployment season.
- All values during the deployment are within the CCME Water Quality Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units).

**Water pH: Dumbell Stream above Dumbell Lake
June 10 to October 13, 2016**

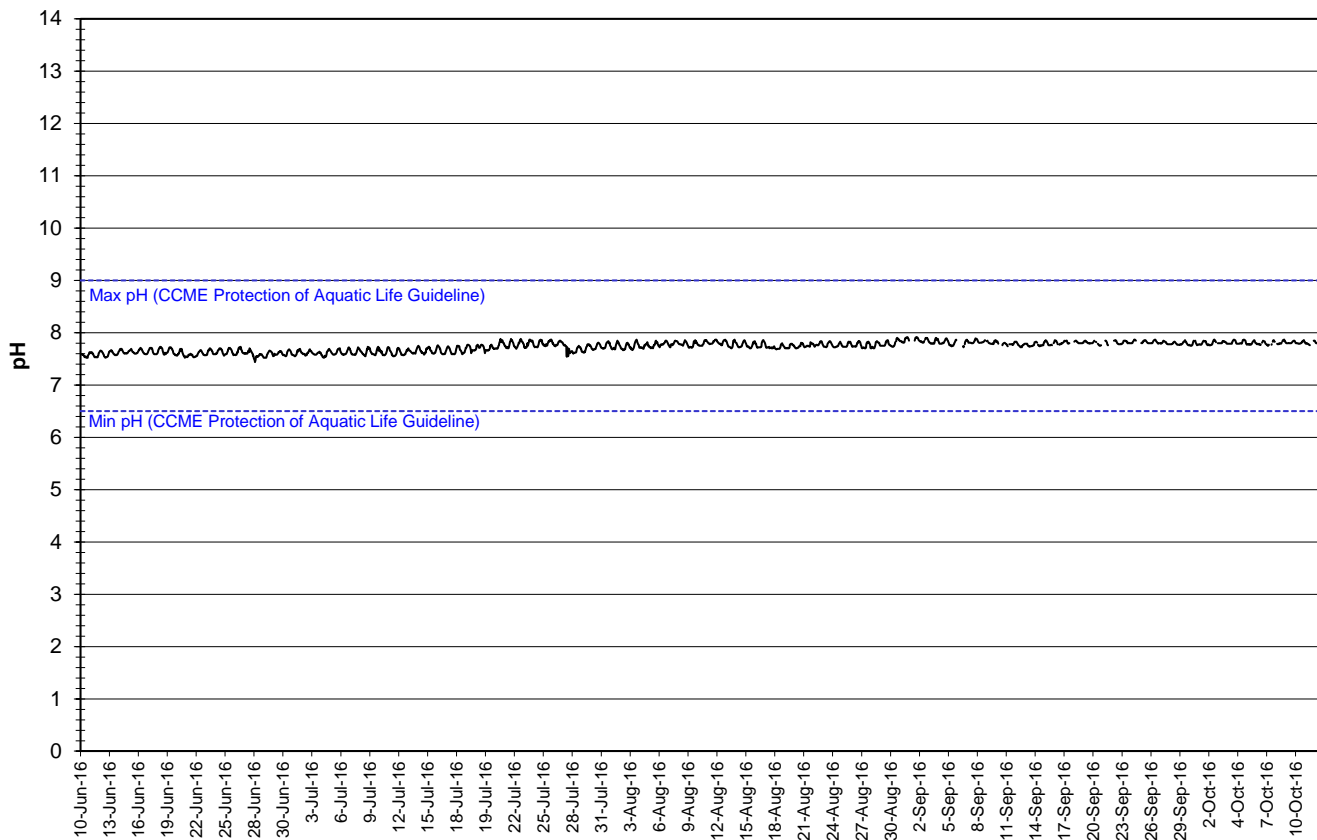


Figure 13: pH – Dumbell Stream

- Throughout the 2016 deployment season, specific conductivity ranged from 41.2 to 74.2 $\mu\text{S}/\text{cm}$ at Dumbell Stream (Figure 14).
- Decreases in conductivity correspond with increases in stage. As more water is added to the system from precipitation, the solids in the water are diluted, decreasing conductivity.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

**Specific Conductivity of Water and Stage Level: Dumbell Stream above Dumbell Lake
June 10 to October 13, 2016**

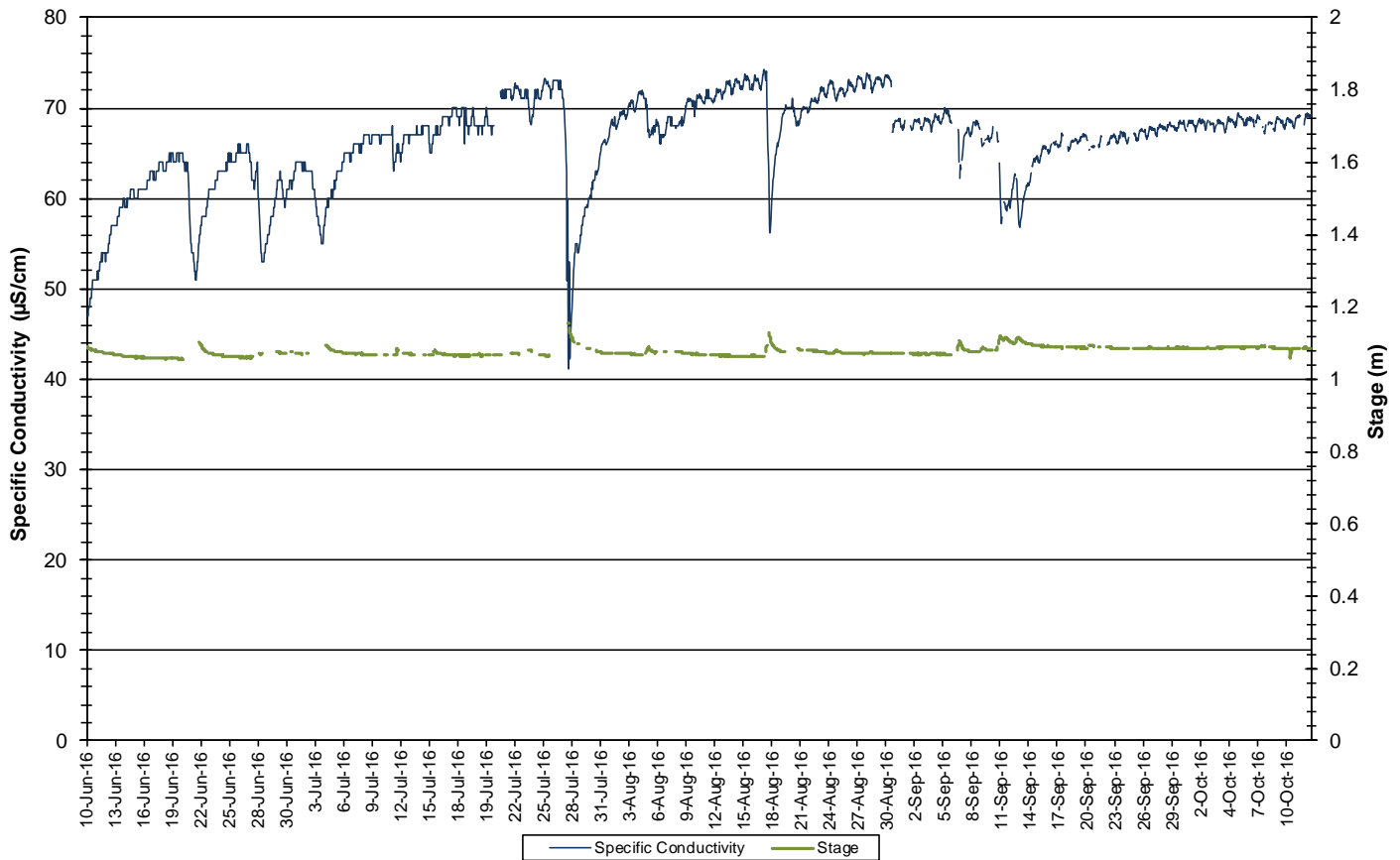


Figure 14: Specific Conductivity – Dumbell Stream

- At Dumbell Stream, the saturation of dissolved oxygen ranged from 81.4 to 98.1% and a range of 10.27 to 13.53 mg/l was found in the concentration of dissolved oxygen with a median value of 11.69 mg/l (Figure 15).
- Dissolved oxygen fluctuated daily with decreases observed at night.
- Dissolved oxygen decreases during the summer months throughout the time when water temperature is warmest. Dissolved oxygen then increases during the last deployment period of the season, when water temperature is decreasing in the fall.
- All values were above the CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages of 6.5 mg/l and the minimum CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 15.

**Dissolved Oxygen Concentration and Saturation: Dumbell Stream at Dumbell Lake
June 10 to October 13, 2016**

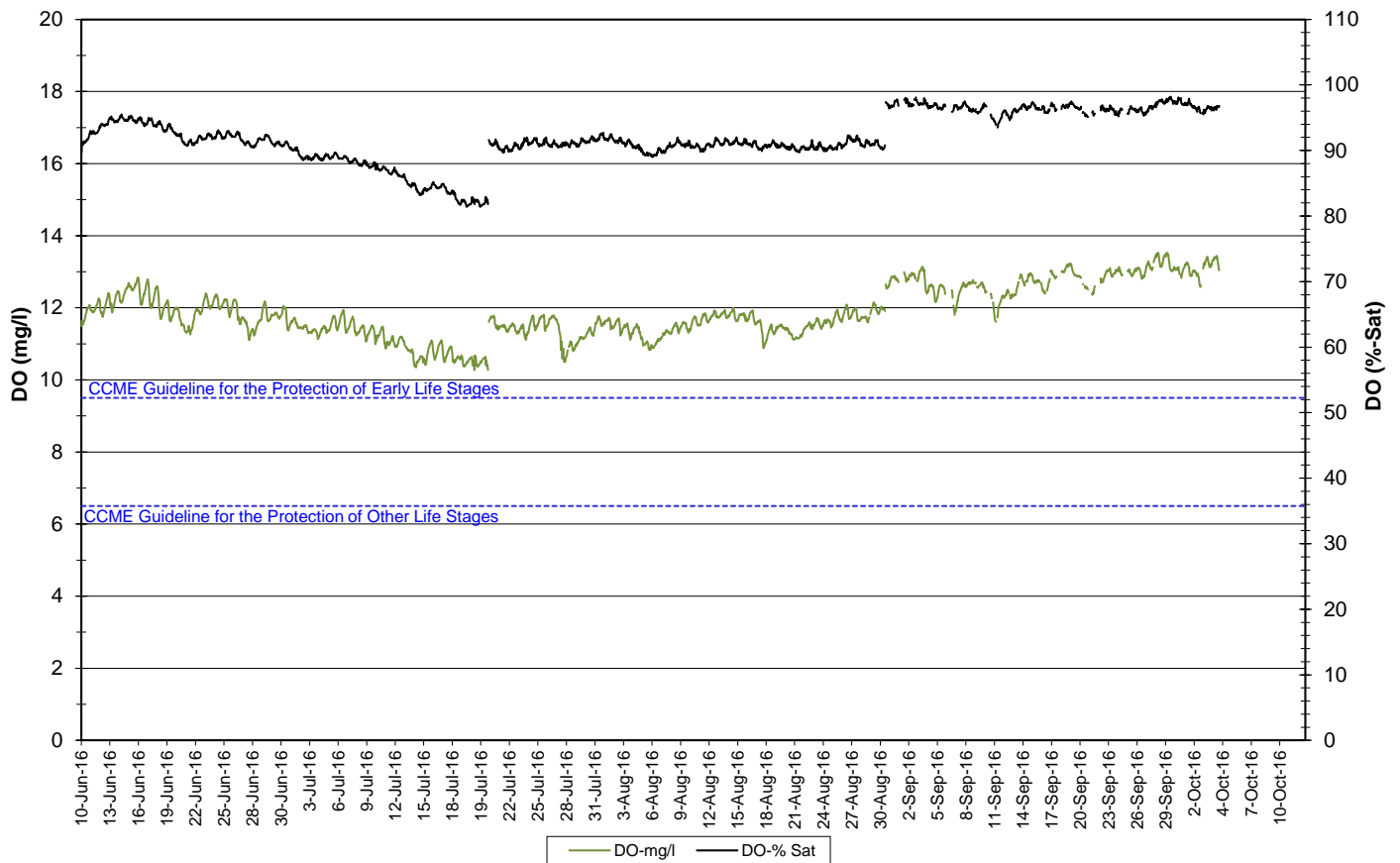


Figure 15: Dissolved Oxygen and Percent Saturation – Dumbell Stream

- At the Dumbell Stream station, turbidity values range from 0.0 to 36.8 NTU, with a median value of 0.0 NTU (Figure 16).
- Turbidity readings >0NTU occur occasionally and for small periods of time. Turbidity spikes that correspond with precipitation in the area are identified on the graph in red. The cause of turbidity spikes on other days is unknown.
- It is important to note that weather data was collected at Churchill Falls.

**Water Turbidity: Dumbell Stream above Dumbell Lake
June 10 to October 13, 2016**

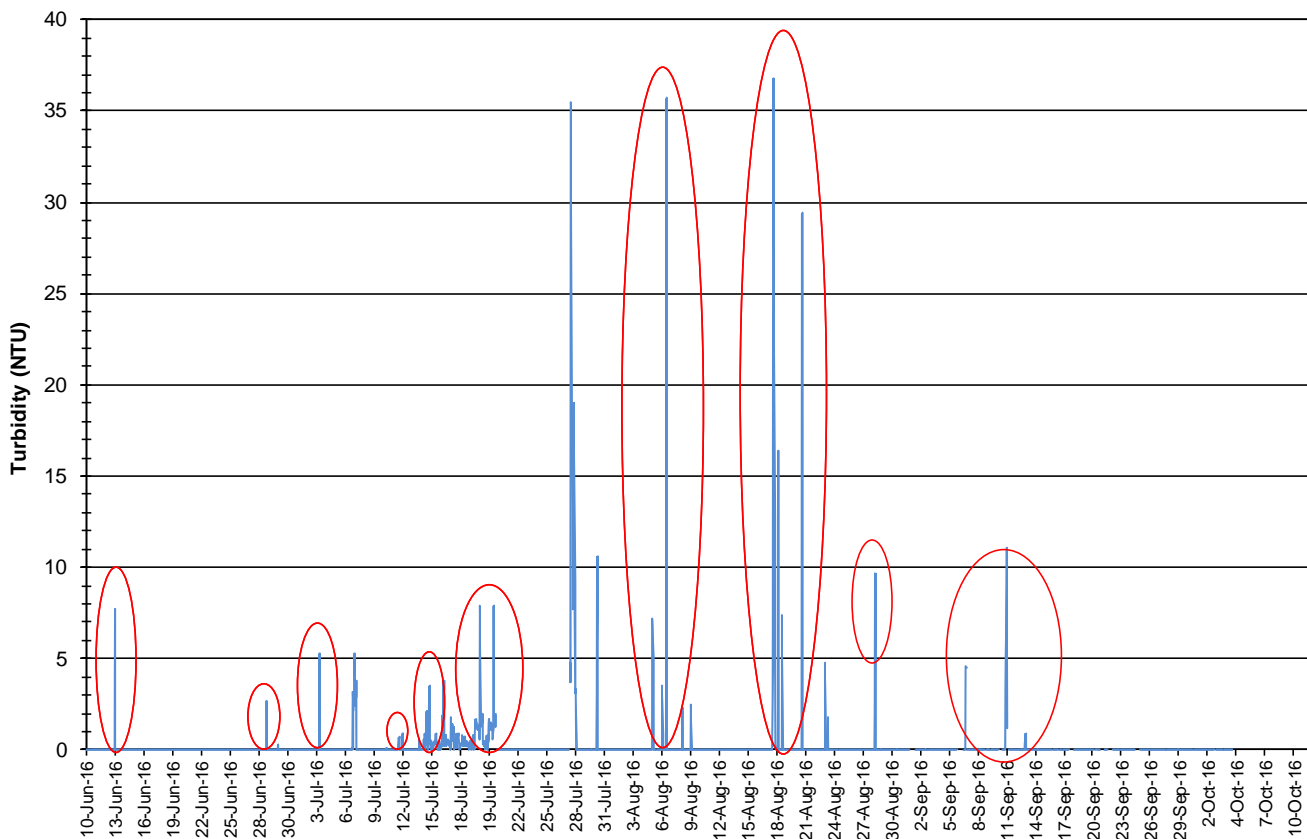


Figure 16: Turbidity at Dumbell Stream

Conclusions

- Instruments at the water quality monitoring stations in Labrador West were deployed between June 7th - October 13th, 2016. They were then removed for the winter season.
- Regular visits on a near 40 day deployment schedule have been adhered to for the most part.
- In most cases, weather related events or increases/decreases in water level could be used to explain the fluctuations.
- Most values recorded were within ranges as suggested by the CCME Water Quality Guidelines for the Protection of Aquatic Life.
- The instruments performed well for the 2016 except for a few minor issues. These instruments will undergo PTE's during the winter.
- Water temperature followed the seasonal trend of increasing during the summer and decreasing into the fall. Water temperature corresponded with air temperature.
- All pH values were within the acceptable range of the CCME Water Quality Guidelines for Protection of Aquatic Life.
- Specific conductivity differed between the two Wabush Lake stations. This can be attributed to varying concentrations of iron ore tailings, which are deposited into Wabush Lake downstream of Dolomite Road and upstream of Julienne Narrows. Noted decreases in conductivity at Dumbell Stream can be attributed to increases in stage at the time.
- In some cases, dissolved oxygen values were below the minimum CCME Water Quality Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l at the two Wabush Lake stations, while all values at Dumbell Stream were above the guideline. All values were above the CCME Water Quality Guideline for the Protection of Aquatic Life for Cold water Biota at Other Life Stages of 6.5 mg/l.
- At Julienne Narrows, turbidity values were generally below 100 NTU with a few large spikes. Turbidity at Dolomite Road was zero for the majority of the season. Turbidity at Dumbell Stream was also low, with values remaining below 40 NTU.

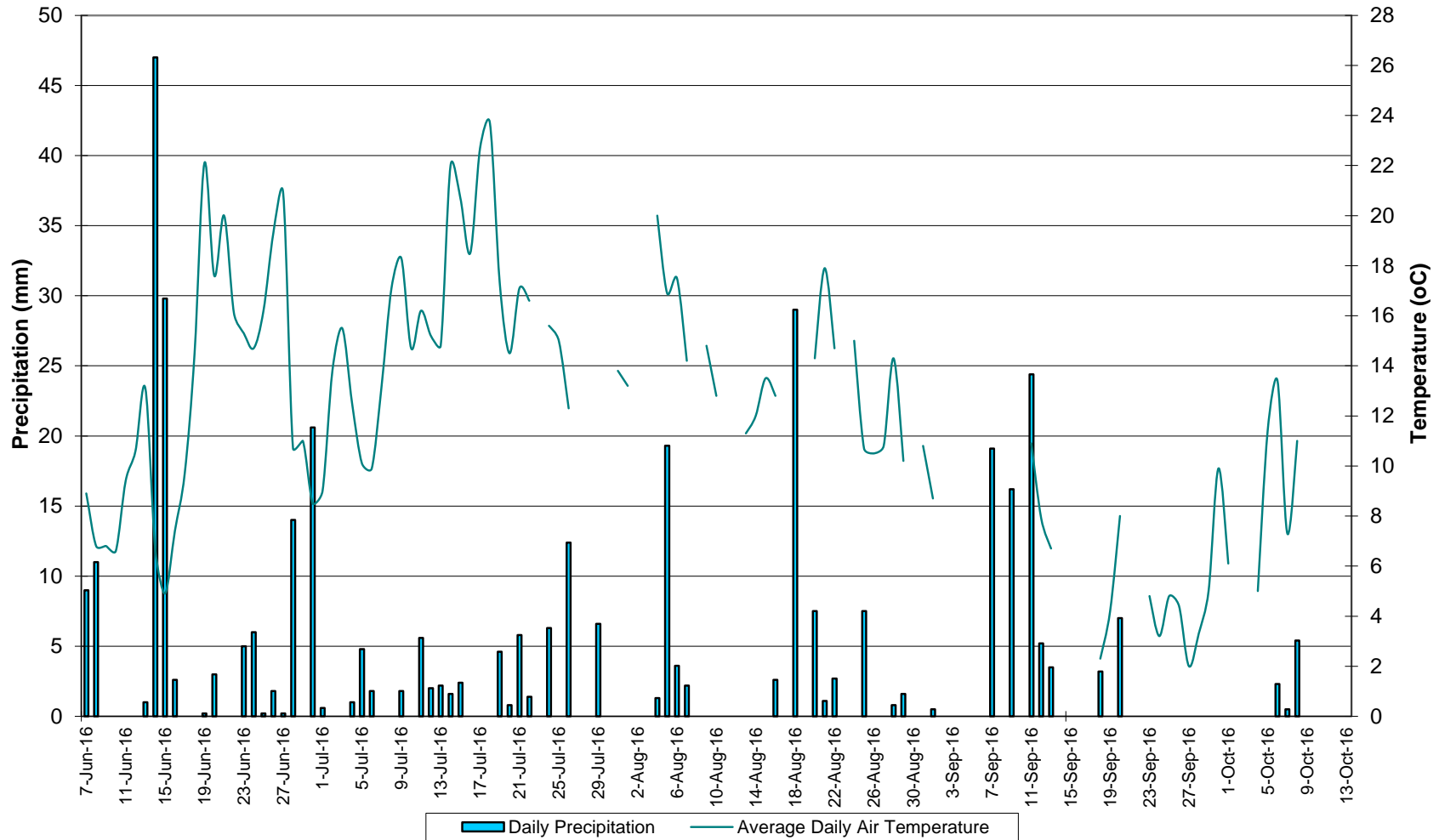
Path Forward

- Both field instruments will undergo Proficiency, Testing, and Evaluation (PTE) during the winter of 2016-2017. ECC will inform IOC of any instrument performance issues.
- ECC staff will deploy real time water quality instruments in spring 2017 when ice conditions allow and perform regular site visits throughout the 2017 deployment season for calibration and maintenance of the instruments.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- ECC will update IOC staff on any changes to procedures with handling, maintenance and calibration of the real-time instruments.
- ECC will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- Open communication will continue to be maintained between ECC, EC and IOC employees involved with the agreement, in order to respond to emerging issues on a proactive basis.
- IOC will continue to be informed of data trends and any significant water quality events in the form of email and/or monthly deployment reports, when the deployment season begins. IOC will also receive an annual report, summarizing the events of the deployment season.

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Appendix 1

Average Daily Air Temperature and Daily Precipitation: Churchill Falls, NL June 7 to October 13, 2016



Appendix 2
Dumbell Stream above Dumbell Lake
Photos



