Real-Time Water Quality Deployment Report

Iron Ore Company of Canada
Lab West Network

July 20 to
August 31, 2016

Newfoundland Labrador

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

Contents

General

- The Water Resources Management Division, in partnership with the Iron Ore Company of Canada (IOC) and Environment and Climate Change Canada, maintain three real-time water quality and water quantity stations in Labrador West.
- The official name of each station is *Wabush Lake at Dolomite Road*, *Wabush Lake at Lake Outlet* and *Dumbell Stream above Dumbell Lake*, hereafter referred to as the Dolomite Road station, Julienne Narrows station and Dumbell Stream station.
- The Wabush Lake network stations are situated upstream (Dolomite Road) and downstream (Julienne Narrows) of the IOC tailings disposal area in Wabush Lake.
- The station at Dumbell Stream was commissioned in June of 2016, this site was chosen to measure water quality/quantity as part of IOC's future Wabush 3 project.
- Water Resources Management Division staff monitors the real-time graphs regularly. They will inform IOC of any significant water quality events by email notification and by monthly deployment reports.
- On July 20th and 21st, 2016, real-time water quality monitoring instruments were deployed at the three IOC stations. The instrument was deployed for a period of 40 days at Dolomite Road and Julienne Narrows, and 42 days at Dumbell Stream. The instruments were removed on August 30th and 31st, 2016. This was the second deployment of the 2016 field season.

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 1).

Table 1: 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 > 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 IOC water quality stations deployed between July 20 and August 31, 2016 is summarized in Table 2.

Table 2: Comparison rankings for IOC stations between July 20 and August 31, 2016.

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Dolomite Road	July 21, 2016	Deployment	Good	Excellent	Marginal	Fair	N/A
	Aug 30, 2016	Removal	Good	Excellent	Fair	Excellent	N/A
Julienne Narrows	July 21, 2016	Deployment	Fair	Excellent	Marginal	Marginal	Poor
	Aug 30, 2016	Removal	N/A	N/A	N/A	N/A	N/A
Dumbell Stream	July 20, 2016	Deployment	Excellent	Good	Fair	Excellent	Excellent
	Aug 31, 2016	Removal	Good	Excellent	Good	Excellent	Excellent

- **Dolomite Road**

  At deployment, temperature, and pH ranked either 'good' or 'excellent'. Conductivity ranked 'marginal', the field instrument read a value of 55 µs/cm, while the QA/QC instrument read a value of 44.5 µs/cm. Dissolved oxygen ranked 'fair', the field instrument read a value of 9.23 mg/l, while the QA/QC instrument read a value of 8.60 mg/l.

  At removal, temperature, pH, and dissolved oxygen ranked either 'good' or 'excellent'. Conductivity ranked 'fair', the field instrument read a value of 56 µs/cm and the QA/QC instrument read a value of 49 µs/cm.

  Turbidity could not be ranked at either deployment or removal due to a sensor issue on the field instrument.

- **Julienne Narrows**

  At deployment, pH ranked 'excellent'. Temperature ranked 'fair', the field sonde read a value of 17.00^{o} C, while the QA/QC instrument read a value of 16.37^{o} C. Conductivity ranked 'marginal', the field instrument read a value of 112.20 µs/cm, while the QA/QC instrument read a value of 91 µs/cm. Dissolved oxygen ranked 'marginal', the field sonde read a value of 10.21 mg/l, while the QA/QC sonde read a value of 9.31 mg/l. Turbidity ranked 'poor', the field instrument read a value of 0.0 NTU, while the QA/QC instrument read a value of 12.8 NTU.

  QA/QC readings were not available for the removal portion of the deployment period due to the loss of power to the field instrument.

- **Dumbell Stream**

  At deployment, all parameters besides specific conductivity ranked either 'good' or 'excellent'. Specific conductivity ranked 'fair', the field instrument read a value of 71 µs/cm, while the QA/QC instrument read a value of 61.4 µs/cm.

  At removal, all parameters ranked either 'good' or 'excellent'.

- There are a few instances when less than ideal QA/QC rankings can be obtained. These include; the placement of the QA/QC sonde in relation to the field sonde, the amount of time each sonde was given to stabilize before readings were recorded, and deteriorating performance of one of the sensors.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from July 20, 2016 to August 31, 2016 at Dolomite Road, Julienne Narrows and Dumbell Stream.
- With the exception of water quantity data (Stage and Flow), 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.
- There is no data from Julienne Narrows after August 12th, 2016. There was a power issue at the station; the instrument was operating solely on battery power, until the batteries died.
- Turbidity data for Dolomite Road was removed due to a sensor issue.

Wabush Lake Network

- Water temperature ranged from 14.90 to 20.40°C at Dolomite Road and 12.80 to 20.30°C at Julienne Narrows during this deployment period (Figure 1). Water temperature at Dolomite Road is slightly higher than at Julienne Narrows.

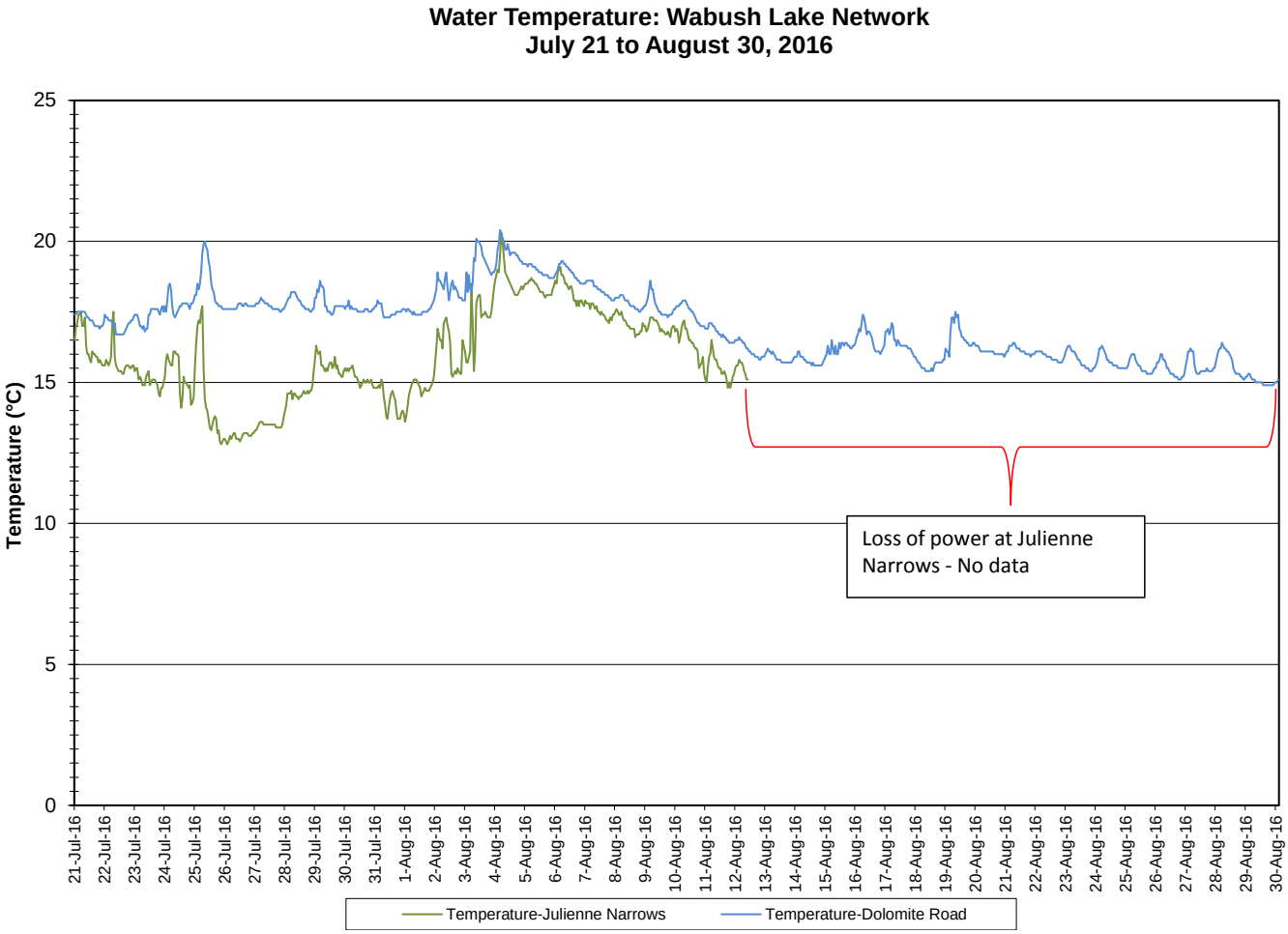

Figure 1: Water temperature - Wabush Lake network

- Water temperature decreased during the deployment period, which corresponds with decreasing ambient air temperature at this time (Figure 2).

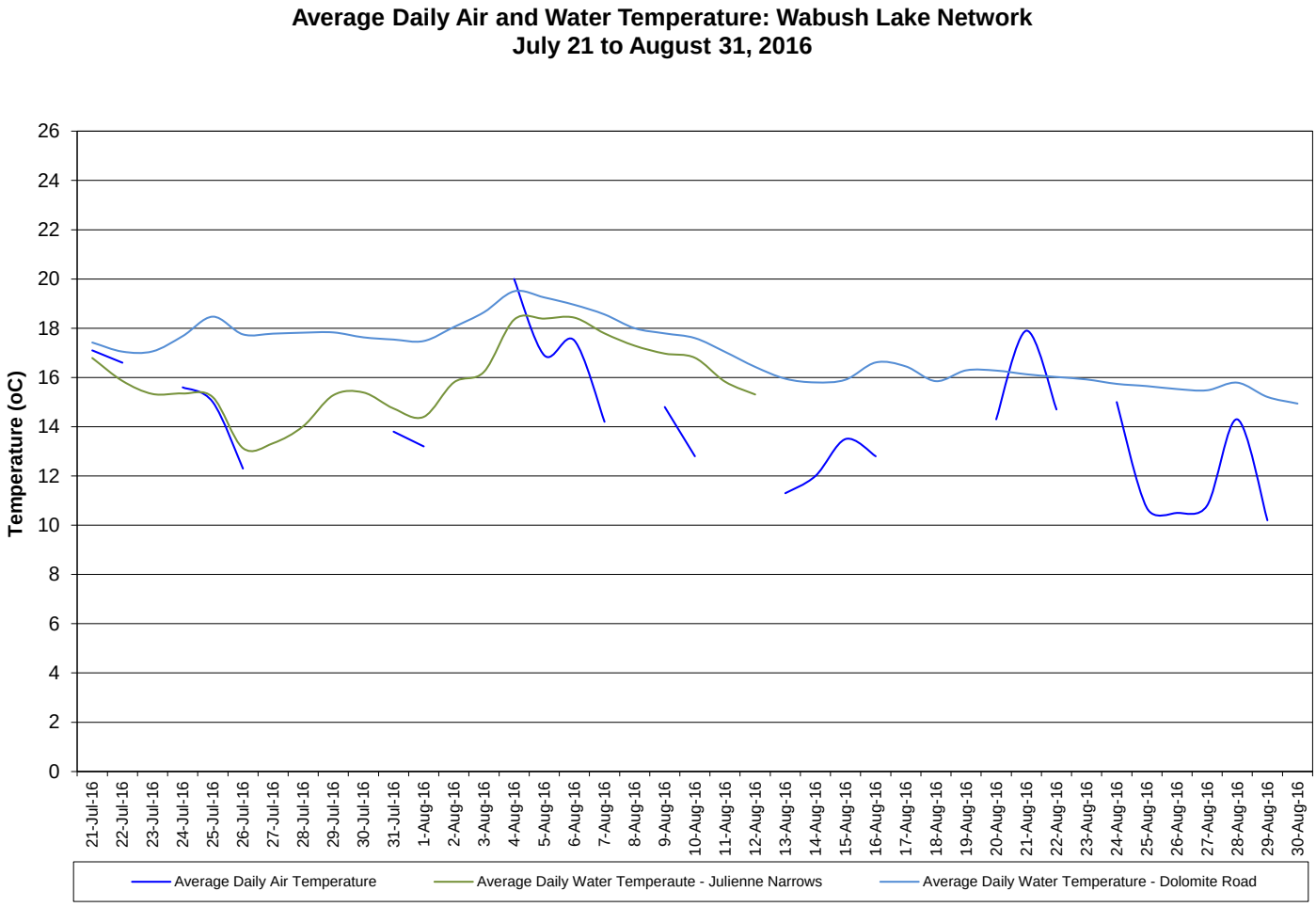

Figure 2: Average daily air and water temperatures – Wabush Lake network

(Weather data collected at Wabush Airport)

- pH ranges from 7.31 to 7.87 pH units at Dolomite Road, and from 7.56 to 8.02 pH units at Julienne Narrows, throughout the deployment period (Figure 3). The median pH is 7.54 and 7.79 units respectively.
- All values during the deployment are within the CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly during the day and night.
- A decrease in pH is noticeable at Dolomite Road on the 18th of August; you can also see that stage increases at this time, this may be caused by a significant precipitation event on the same day.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.

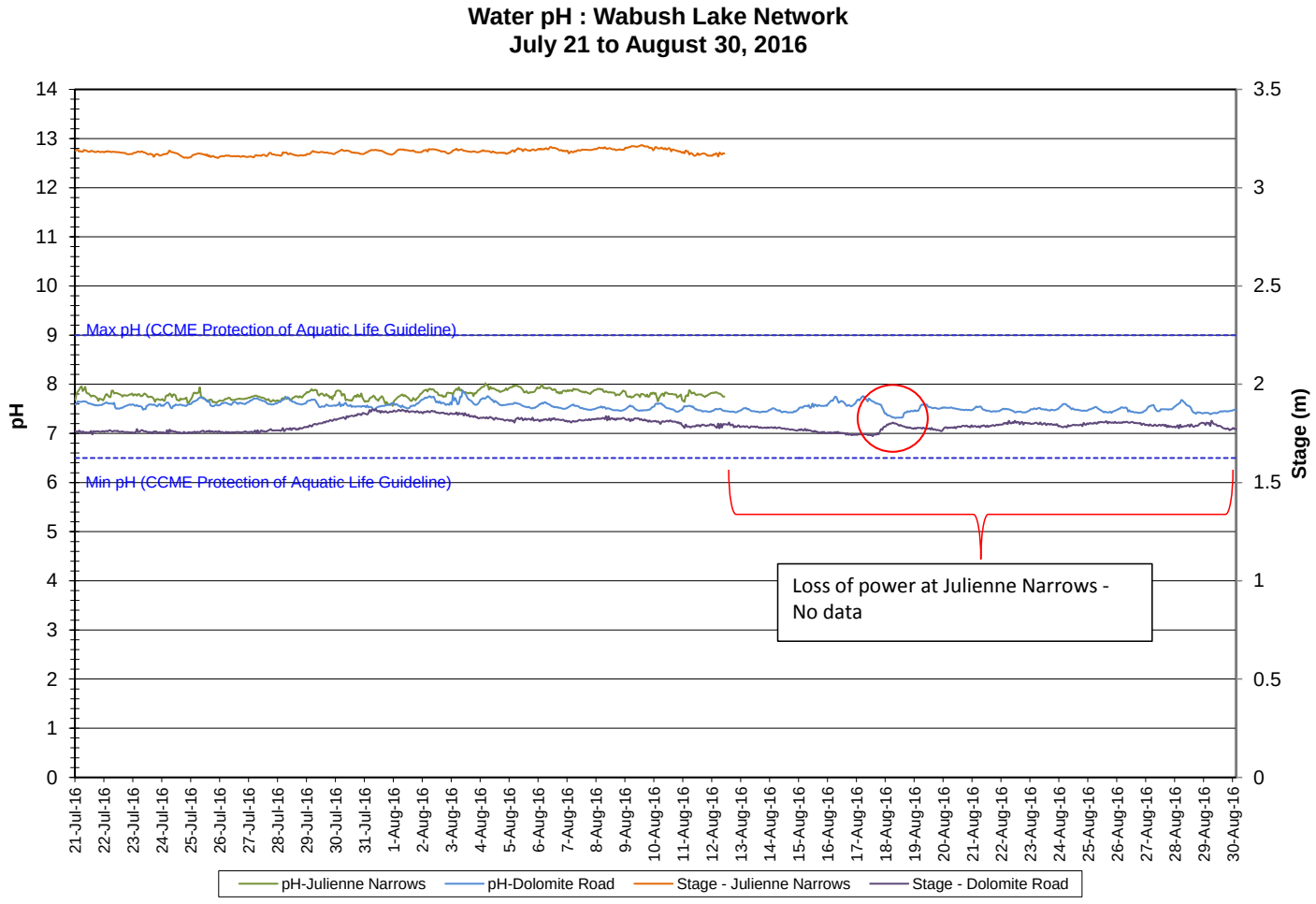

Figure 3: pH – Wabush Lake network

- Specific conductivity ranged from 52.2 to 57.8 µs/cm at Dolomite Road and from 84.8 to 115.5 µs/cm at Julienne Narrows, throughout the deployment period (Figure 4).
- 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.
- Specific conductivity decreases slightly at Dolomite Road during the month of August. Stage is relatively stable at both locations.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.

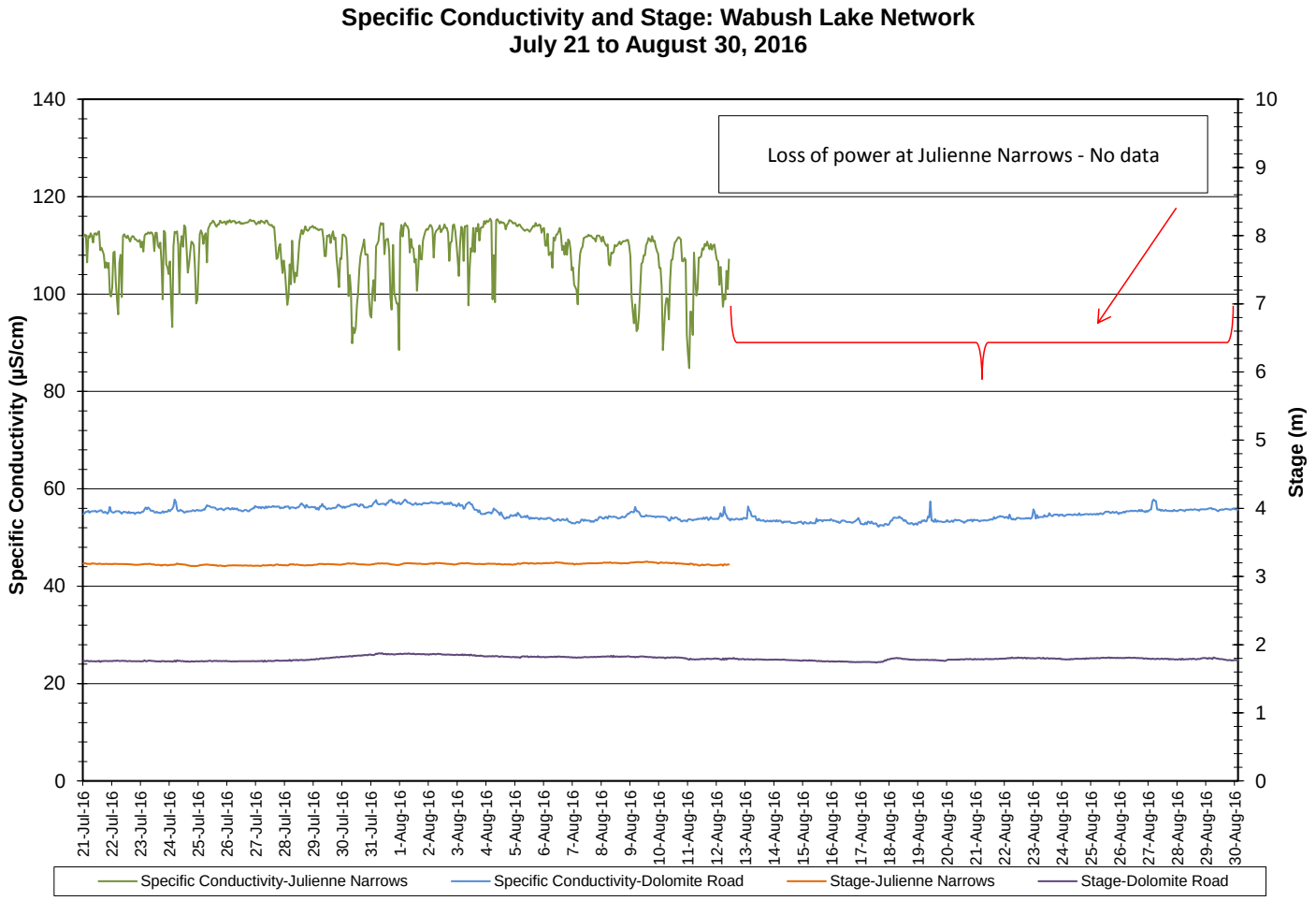

Figure 4: Specific conductivity – Wabush Lake network

- At the Dolomite Road station, the saturation of dissolved oxygen ranged from 85.9 to 104.8% and a range of 8.54 to 9.74 mg/l was found in the concentration of dissolved oxygen with a median value of 9.08 mg/l (Figure 5).
- At the Julienne Narrows station, the saturation of dissolved oxygen ranged from 95.6 to 113.1% and a range from 9.52 to 11.22 mg/l was found in the concentration of dissolved oxygen with a median value of 10.10 mg/l (Figure 5).
- All values recorded at Julienne Narrows and Dolomite Road were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Other Life Stages of 6.5 mg/l. All values recorded at Julienne Narrows were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/l, while almost all values recorded at Dolomite Road were below the guideline. The guidelines are indicated in blue on Figure 5.
- There is a noticeable decrease in dissolved oxygen at Dolomite Road on the 18th of August, on this day there was 29mm of precipitation.
- Dissolved oxygen fluctuated daily with decreases observed at night.

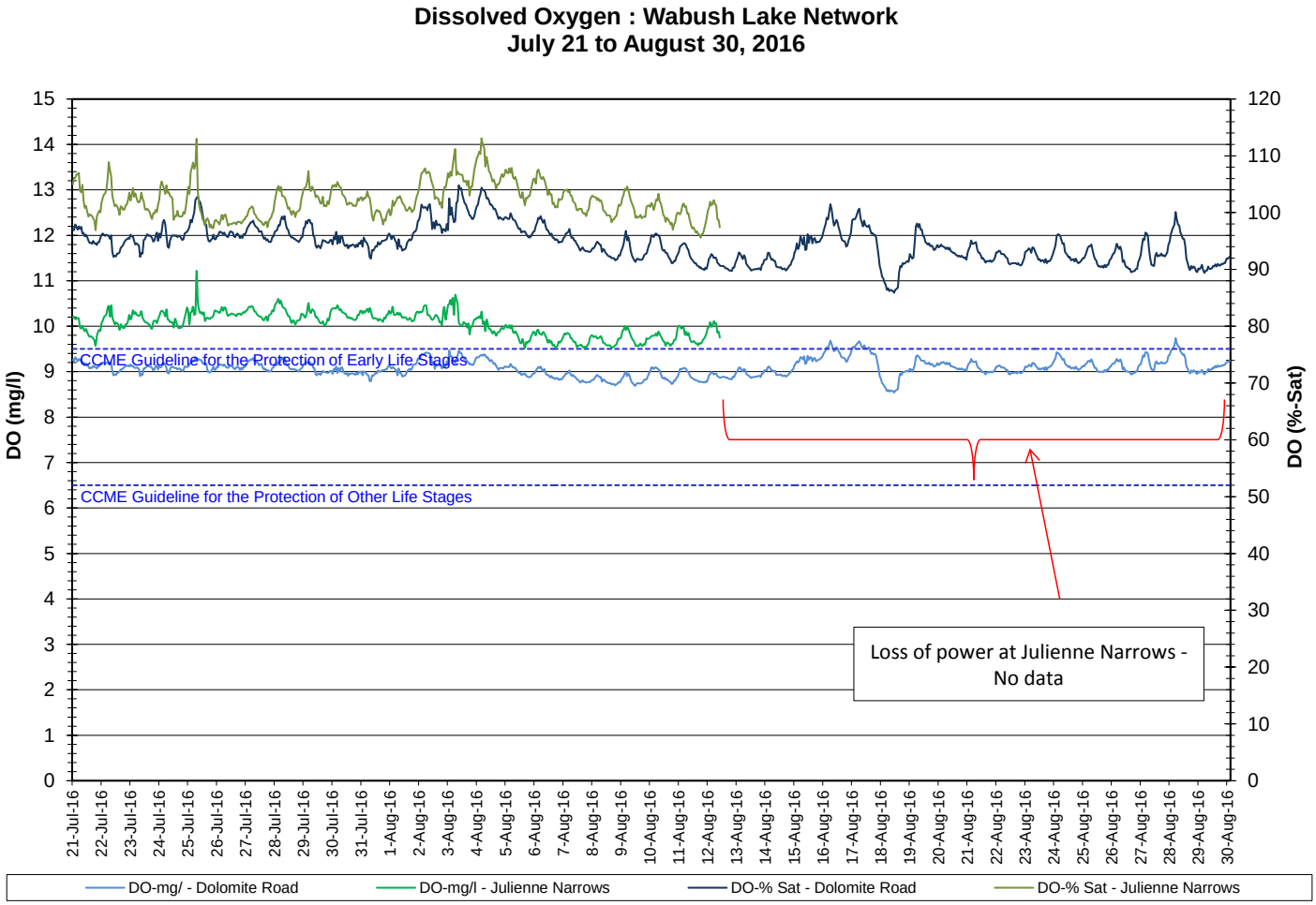

Figure 5: Dissolved oxygen and percent saturation – Wabush Lake Network

- At the Julienne Narrows station, turbidity values range from 0.0 to 58.3 NTU throughout the deployment period (Figure 6). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation at the time. They are indicated on the graph in red

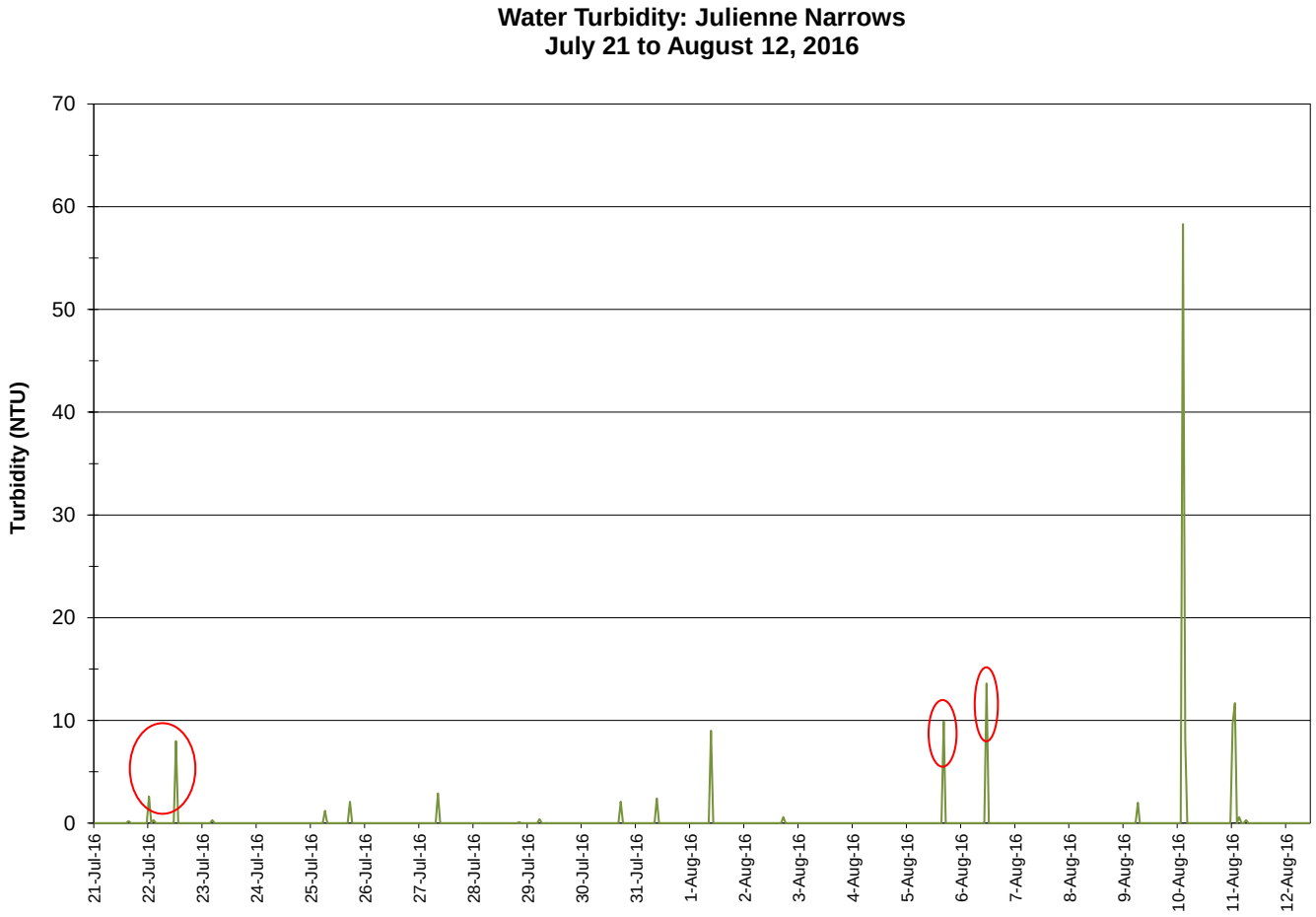

Figure 6: Turbidity – Julienne Narrows

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Julienne Narrows (Figure 9).
- Stage decreased slightly throughout the deployment period, with varying precipitation records.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.

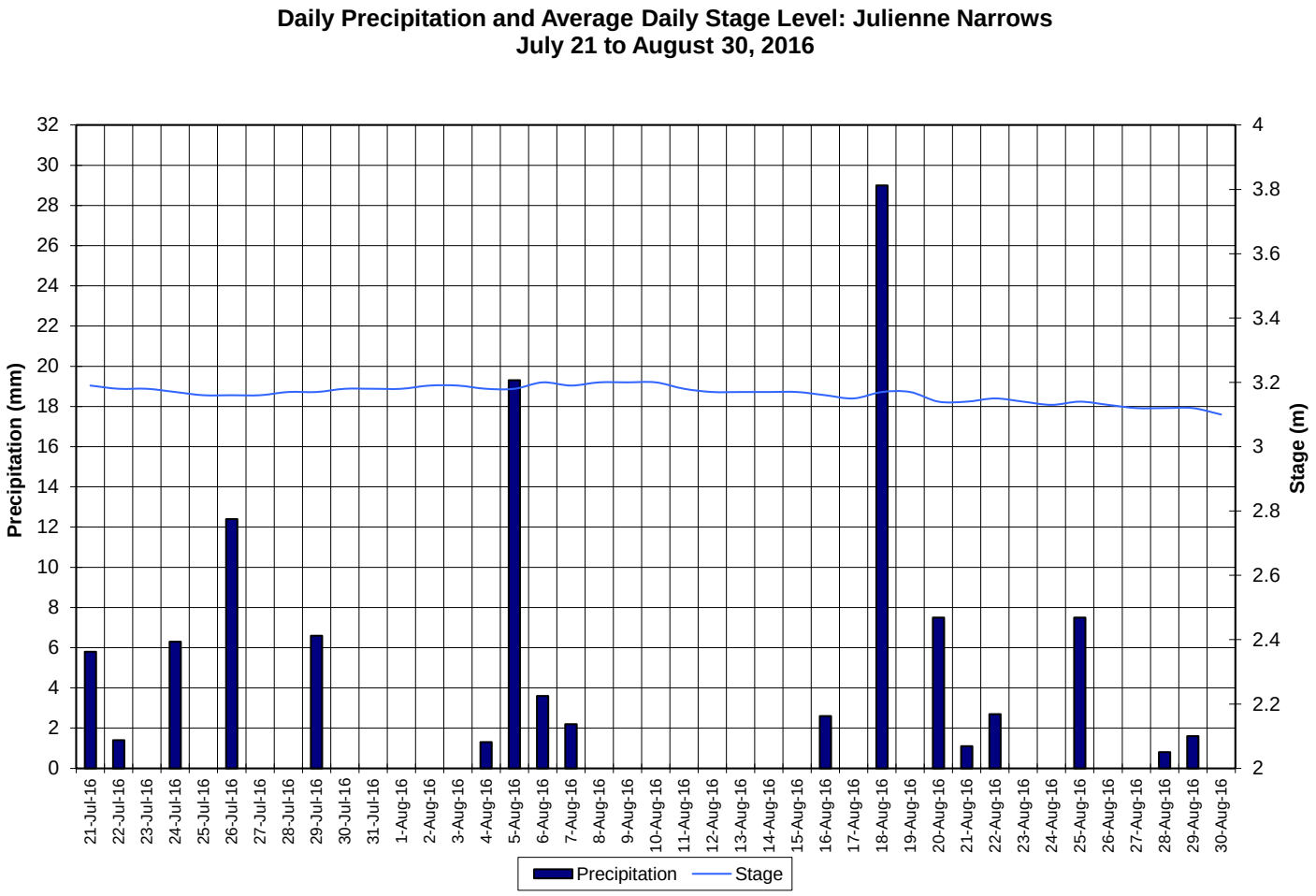

Figure 9: Precipitation and Stage –Julienne Narrows

(Weather data collected at Wabush Airport)

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dolomite Road (Figure 8).
- Stage increases slightly during the end of July/beginning of August with varying precipitation records.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.

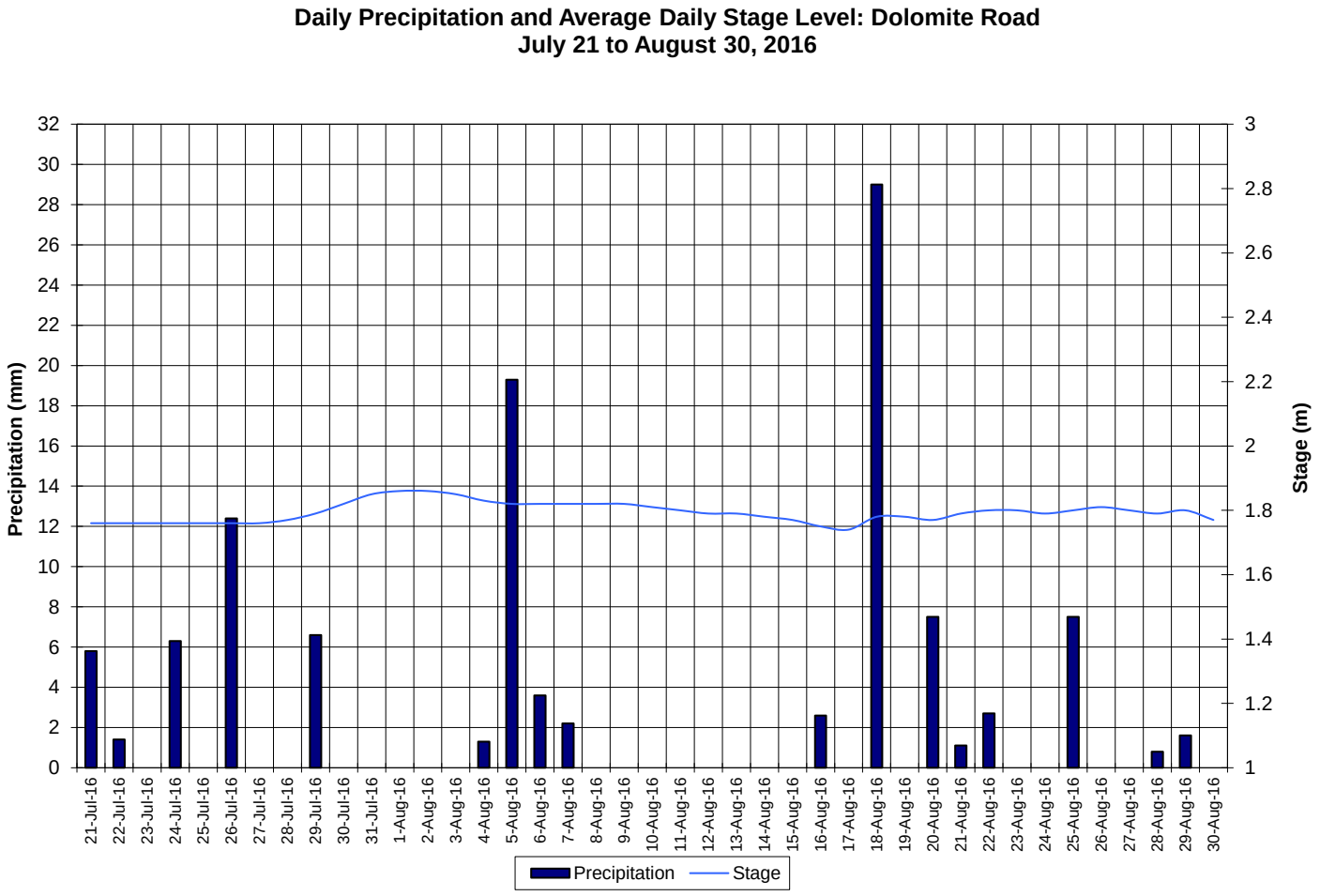

Figure 8: Precipitation and Stage –Dolomite Road

(Weather data collected at Wabush Airport)

Dumbell Stream

- Water temperature ranged from 3.1 to 8.49^{o}C during this deployment period (Figure 10).
- Water temperature generally fluctuated within this range for the deployment period, this area is very shaded. It did correspond with fluctuations in ambient air temperature (Figure 11).

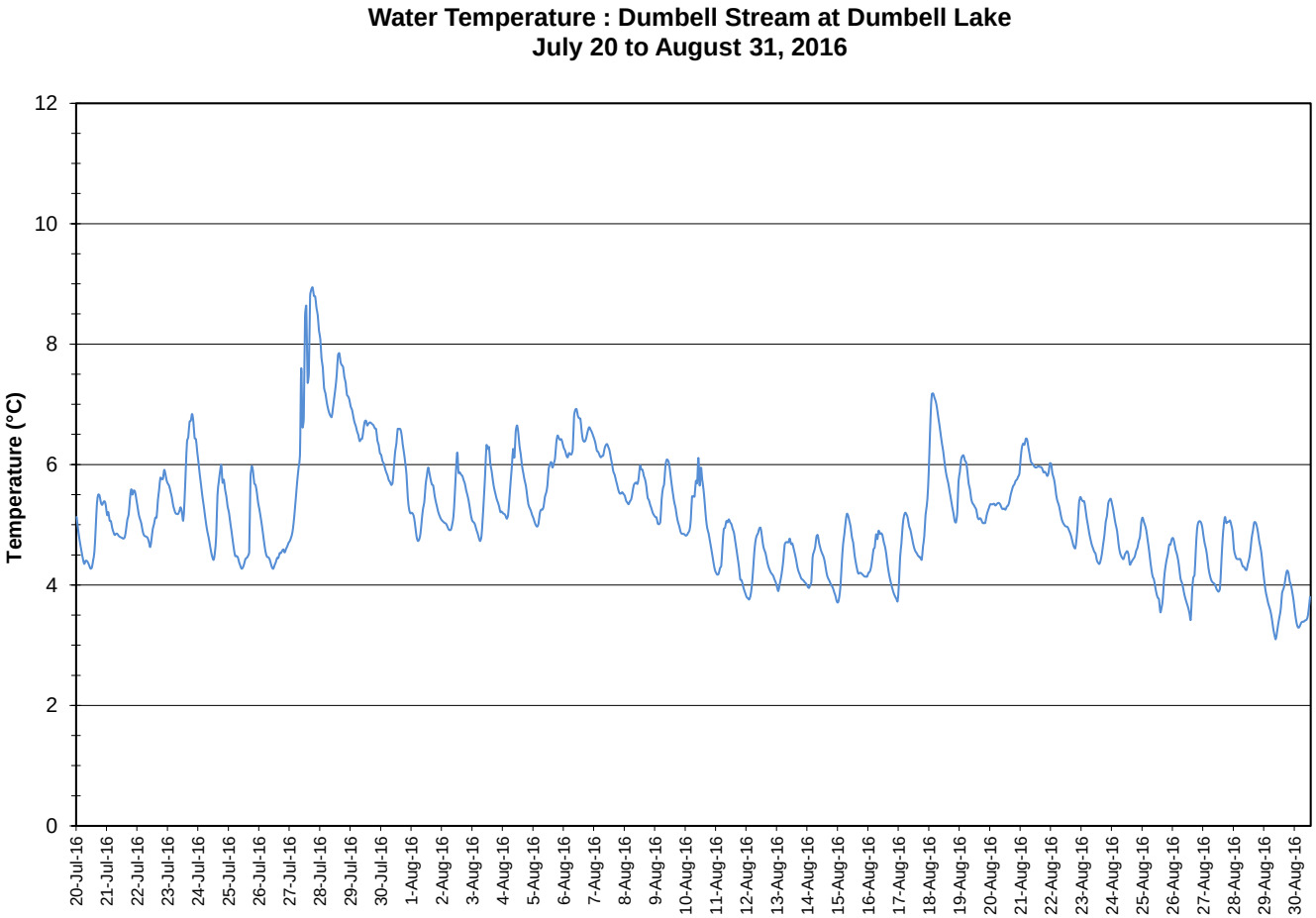

Figure 10: Water Temperature – Dumbell Stream

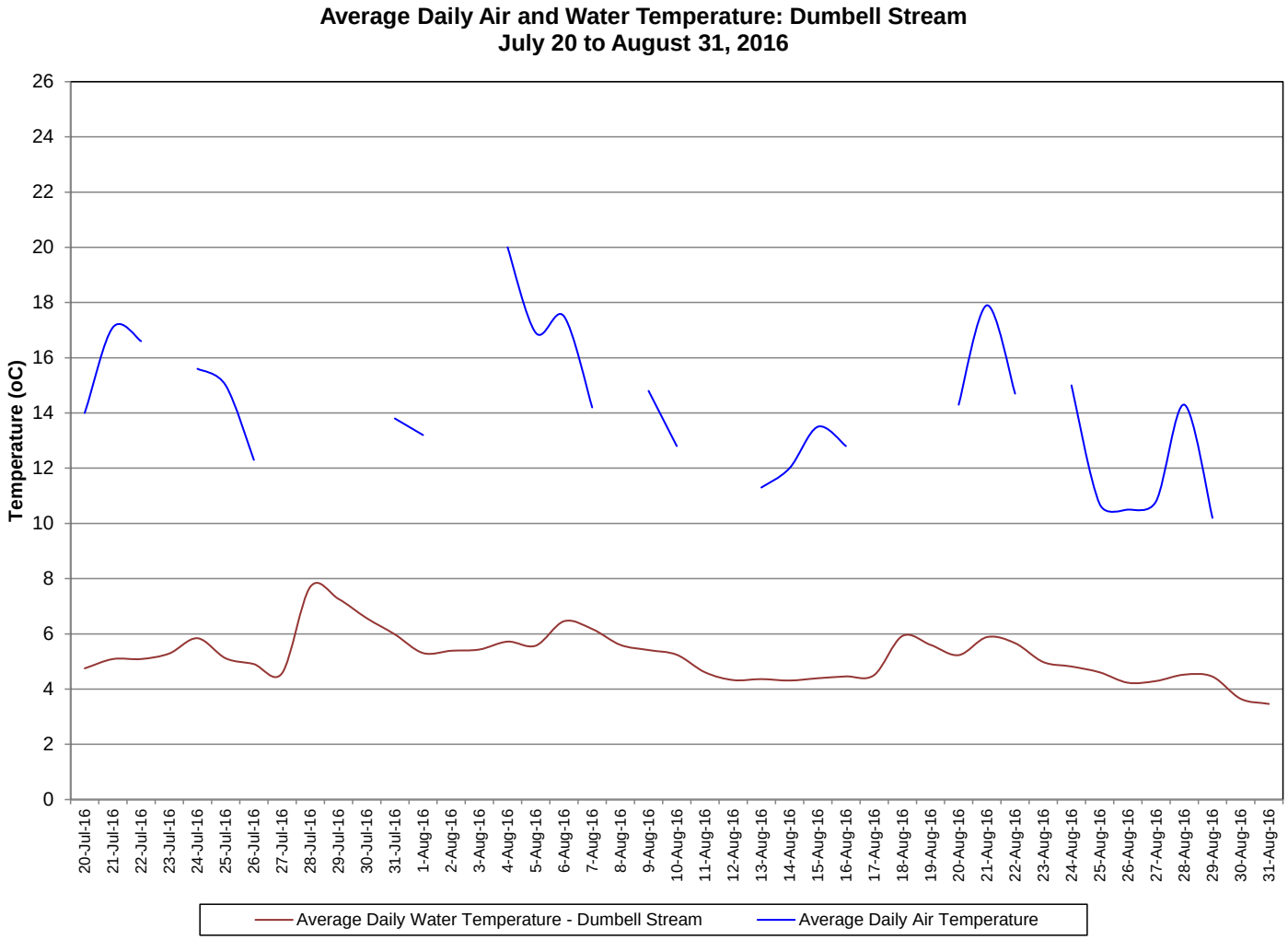

Figure 11: Average daily air and water temperatures – Dumbell Stream

(Weather data collected at Wabush Airport)

- pH ranged from 7.54 to 7.88 pH units (Figure 12). The median pH was 7.76.
- All values during the deployment are within the CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly during the day and night.

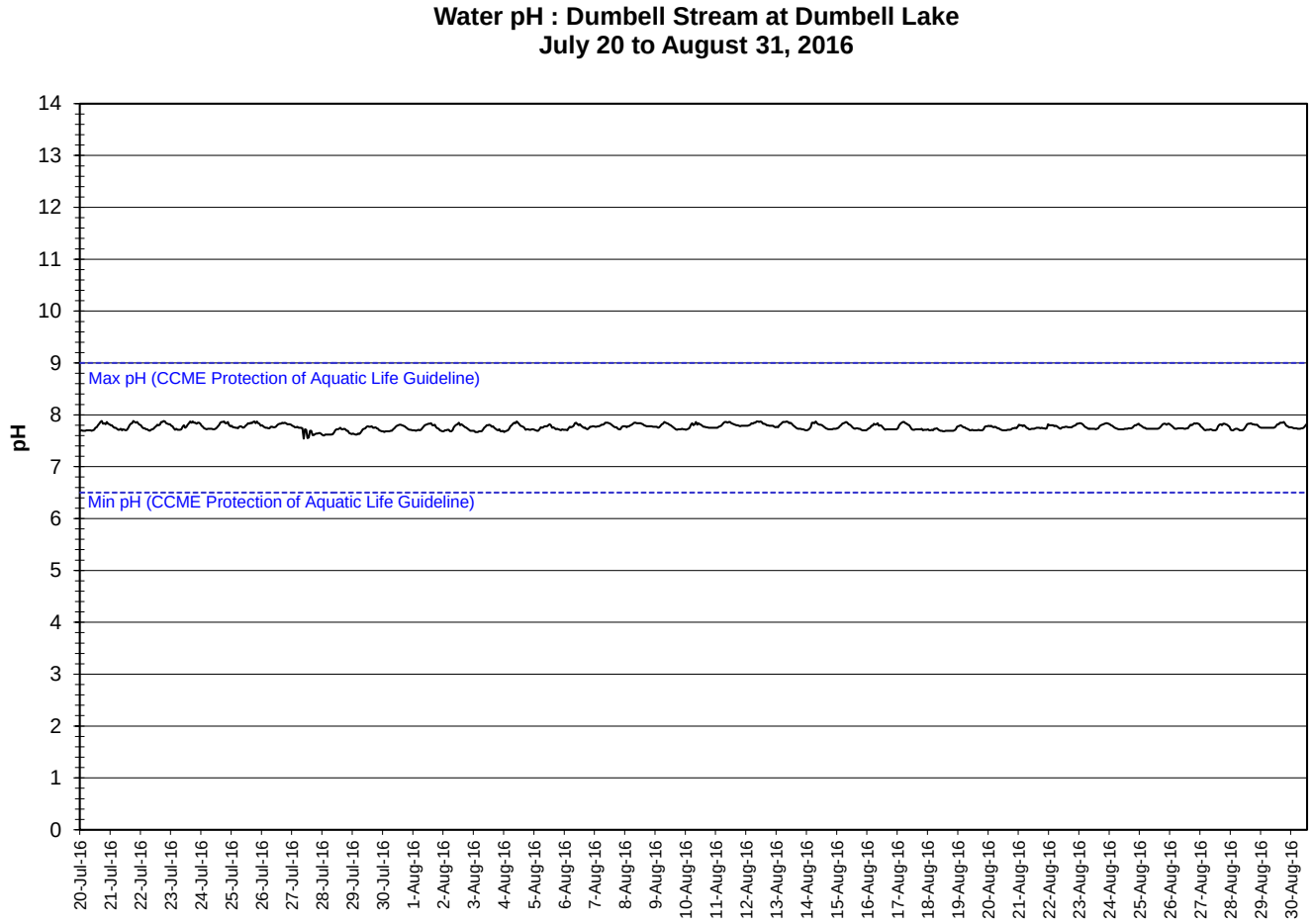

Figure 12: Water pH – Dumbell Stream

- Specific conductivity ranged from 41.2 to 74.2 µs/cm, throughout the deployment period (Figure 13).
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.
- There were a few significant decreases in specific conductivity during the deployment period, they correspond with precipitation events at the time.

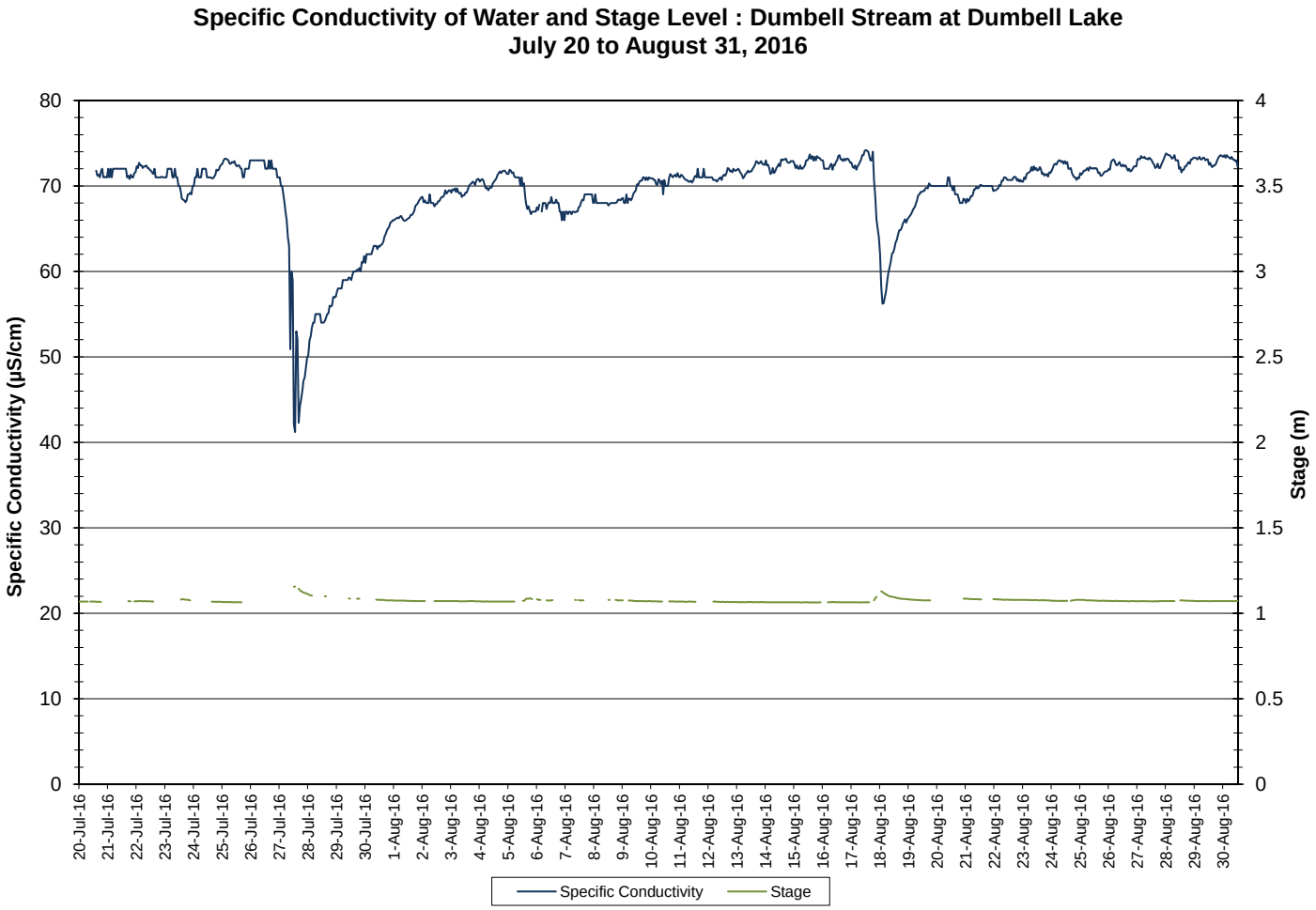

Figure 13: Specific Conductivity – Dumbell Stream

- The saturation of dissolved oxygen ranged from 89.0 to 92.7% and a range of 10.50 to 12.15 mg/l was found in the concentration of dissolved oxygen with a median value of 11.52 mg/l (Figure 14).
- All values recorded at Dumbell Stream were above the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Other Life Stages of 6.5 mg/l and the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/. The guidelines are indicated in blue on Figure 14.
- Dissolved oxygen fluctuated daily with decreases observed at night.
- There are some instances when the dissolved oxygen decreases; they are identified on the graph in red. These decreases correspond with precipitation events.

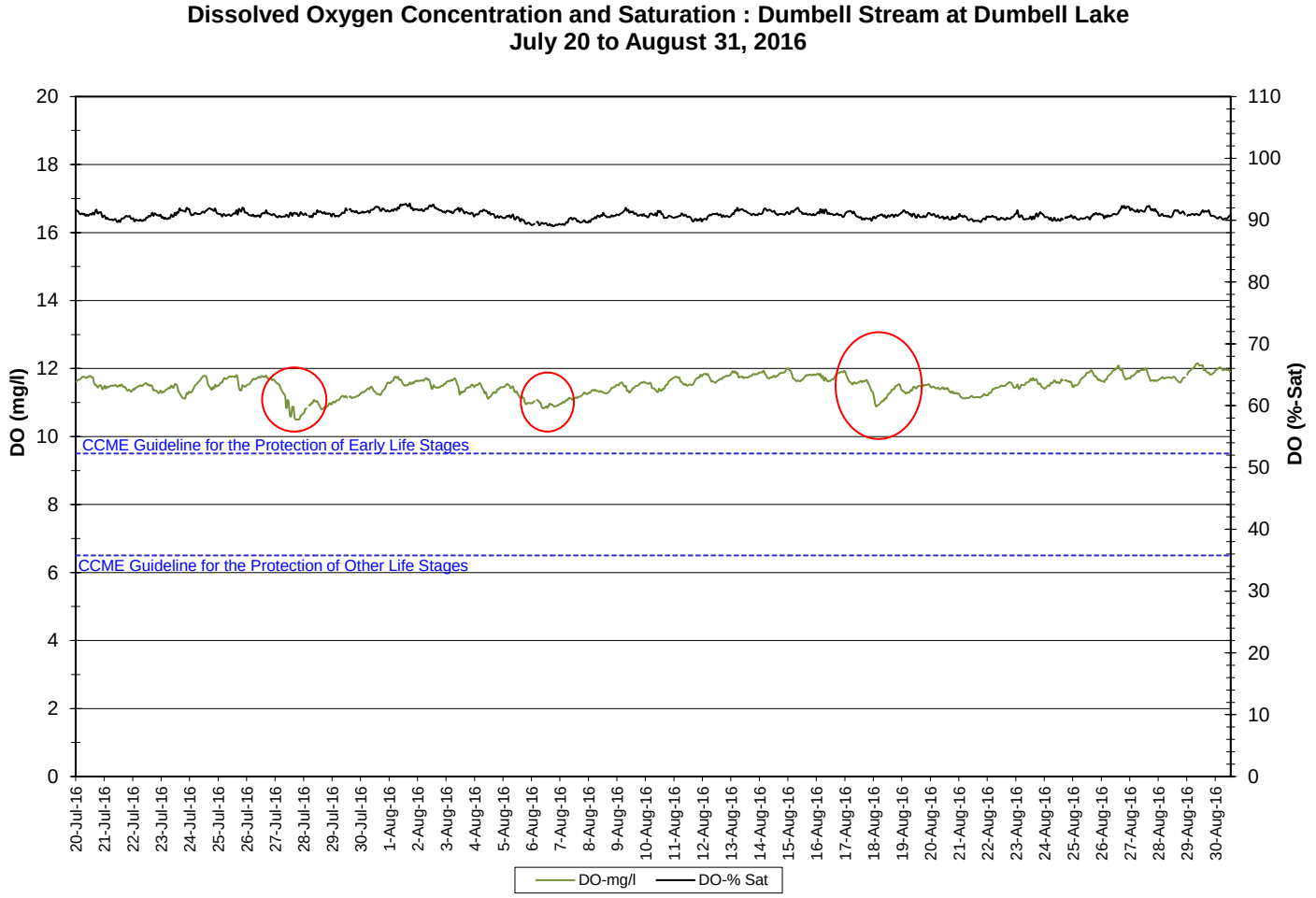

Figure 14: Dissolved Oxygen – Dumbell Stream

- Turbidity values range from 0.0 to 36.8 NTU throughout the deployment period (Figure 15). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation at the time. They are indicated on the graph in red.

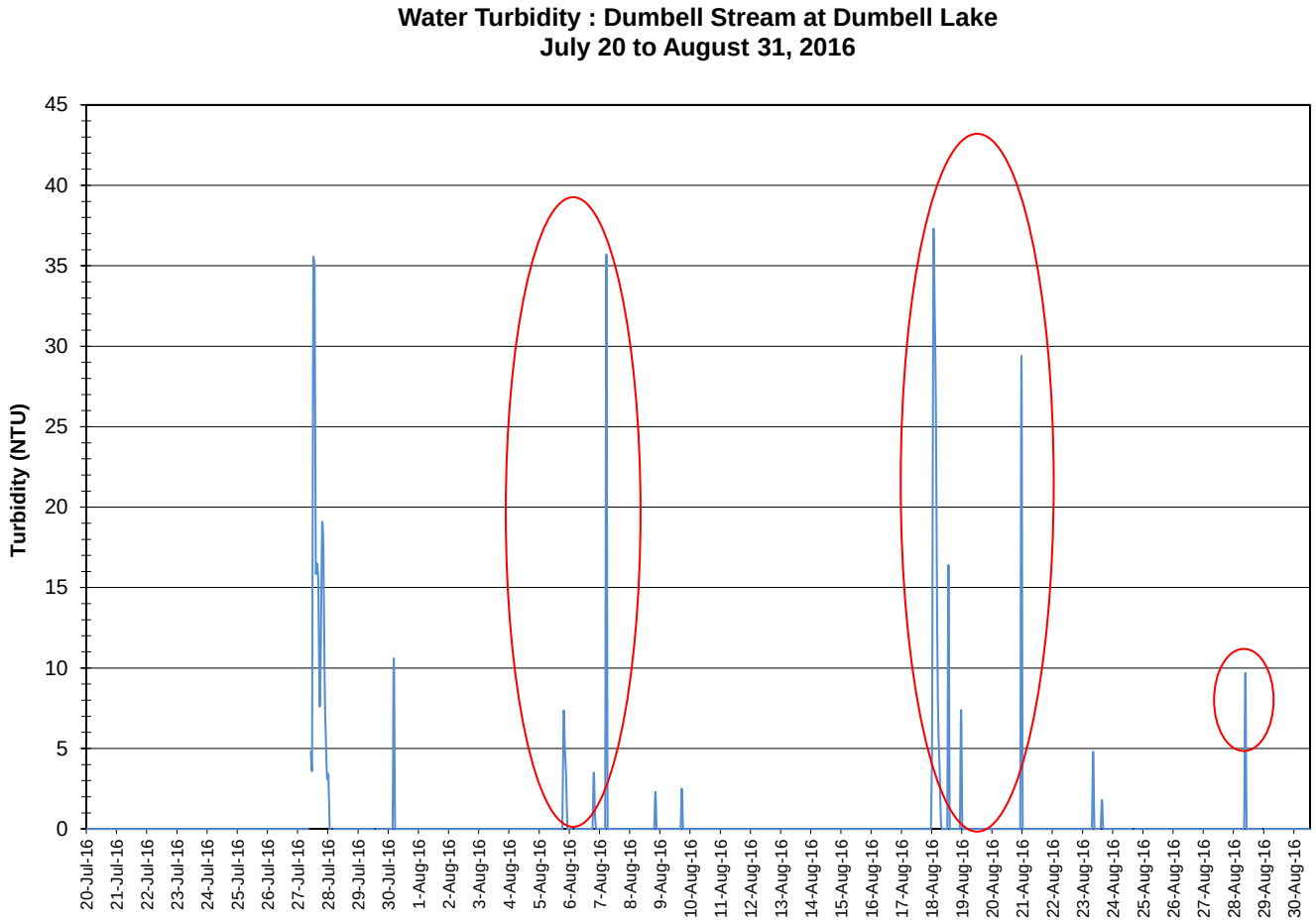

Figure 15: Turbidity – Dumbell Stream

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dumbell Stream (Figure 16).
- Stage is relatively stable throughout the deployment period, with varying precipitation records. There are slight increases after some precipitation events.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.

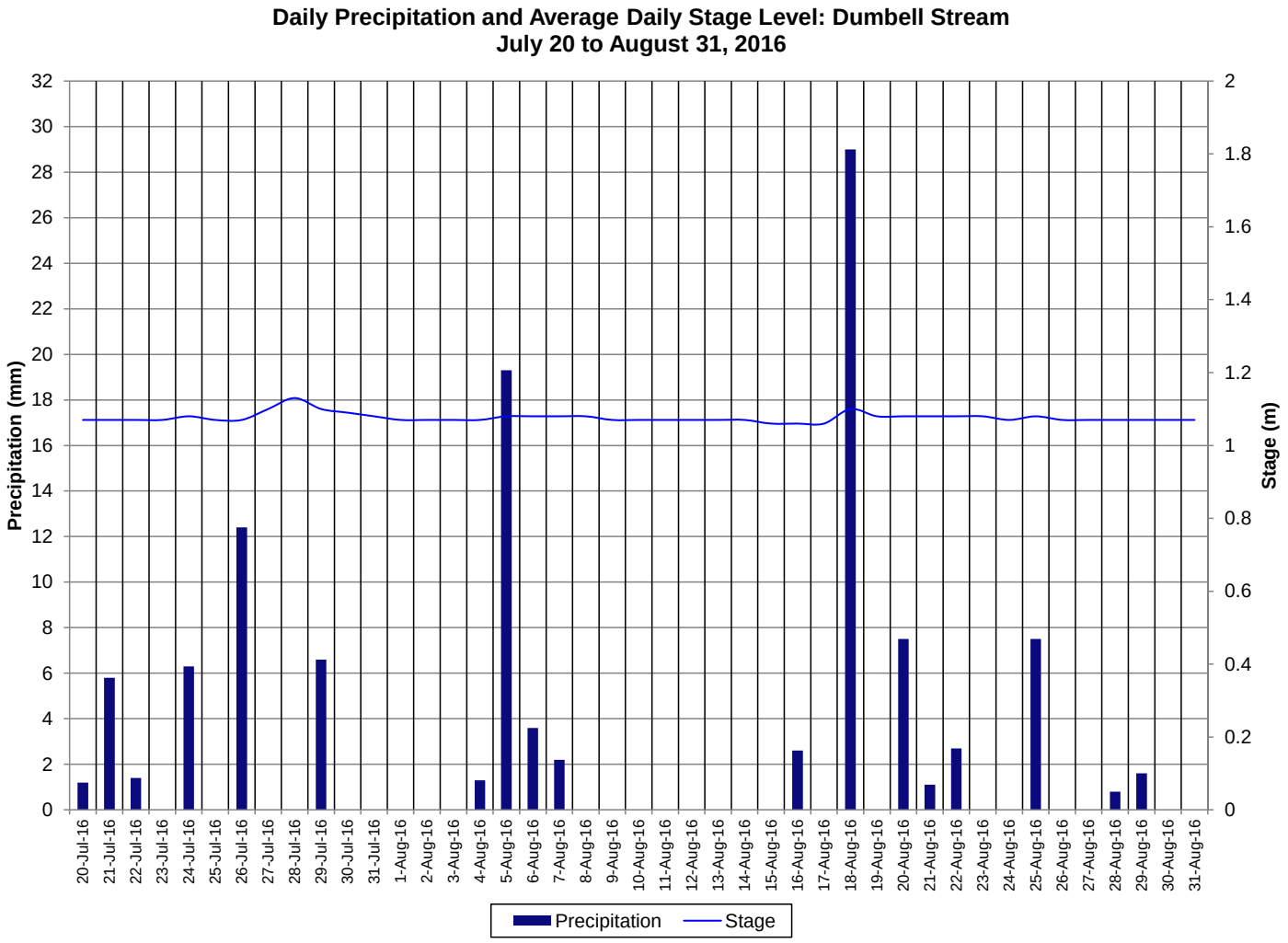

Figure 16: Precipitation and Stage –Dumbell Stream

(Weather data collected at Wabush Airport)

Conclusions

- Instruments were deployed on July 20th and 21st, and removed on August 30th and 31st, 2016.
- In most cases, weather related events or increase/decreases in water level could be used to explain the fluctuations. Most values recorded were within ranges as suggested by the CCME Guidelines for the Protection of Aquatic Life for pH and dissolved oxygen.
- Water temperature corresponded with air temperature at all three stations. The temperature typically ranged between 3.10 and 20.40^{o} C, at the three stations.
- pH values were all within the recommended CCME Guidelines for the Protection of Aquatic Life. pH ranged between 7.31 and 8.02. Fluctuations were noted between day and night.
- Specific conductivity differed between the two Wabush Lake stations. This can be attributed to varying concentrations of iron ore tailings deposited between the stations. Specific conductivity ranged from 52.2 µs/cm to 115.5 µs/cm at Julienne Narrows and Dolomite Road. Specific conductivity at Dumbell Stream ranged from 41.2 to 74.2 µs/cm.
- At Dolomite Road, all dissolved oxygen values were above the minimum CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages of 6.5 mg/l and most values were below the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l.
- At Julienne Narrows and Dumbell Stream, all dissolved oxygen values were above the minimum CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Other Life Stages of 6.5 mg/l and the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/l.
- Turbidity values at Julienne Narrows were higher than at Dolomite Road, there were a few large spikes.
- Turbidity at Dumbell Stream remained at 0.0 NTU for the majority of the deployment period. There were a few spikes and some of these corresponded with precipitation events. The median value was 0.0 NTU.
- Stage was relatively stable at all three stations; slight increases were noted after precipitation.
- With the exception of water quantity data (Stage and Flow), all data used in the preparation of the graphs and subsequent discussion 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.

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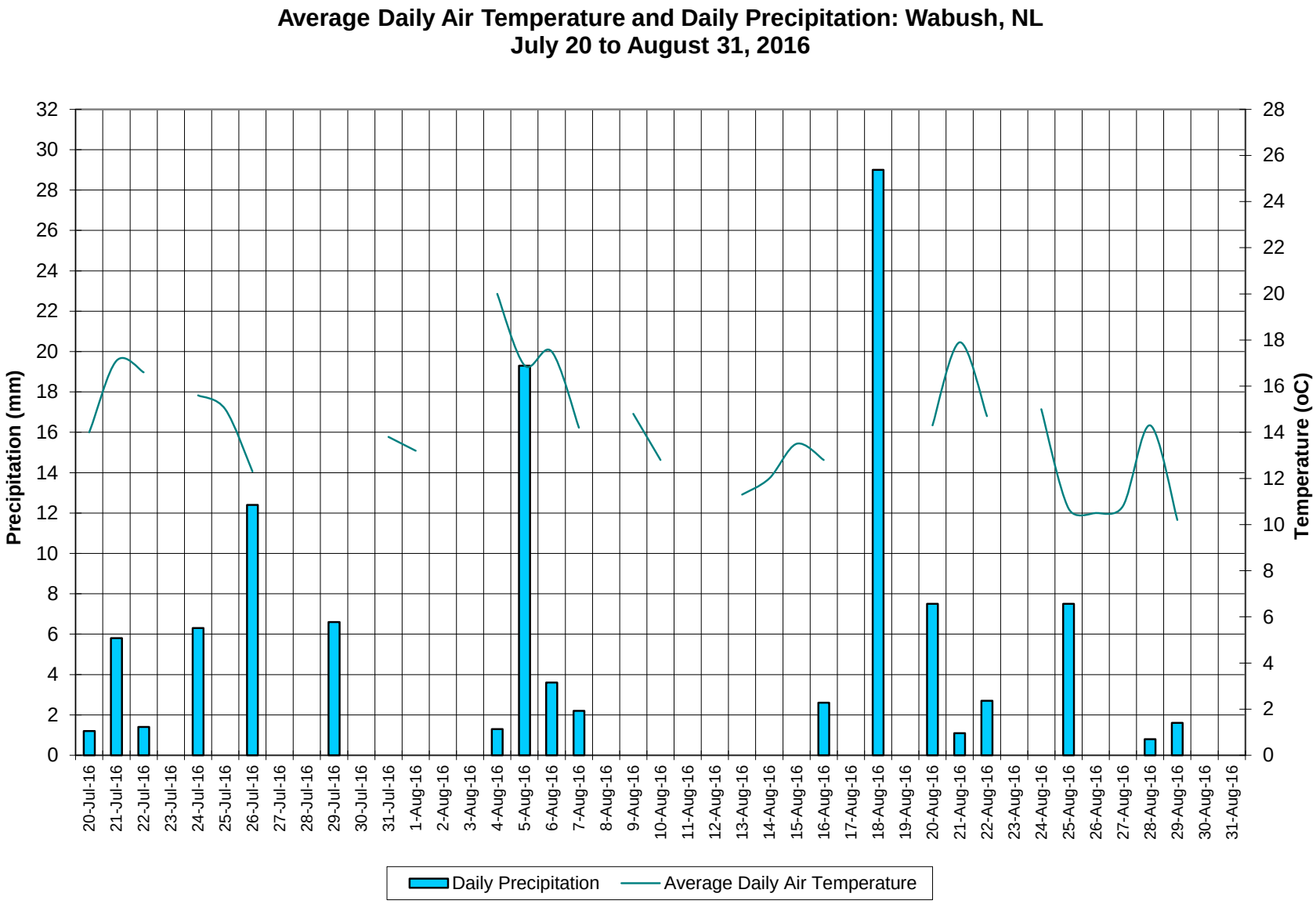
Appendix 1


Average Daily Air Temperature and Daily Precipitation: Wabush, NL
July 20 to August 31, 2016
Precipitation (mm)
Temperature (oC)
Daily Precipitation
Average Daily Air Temperature