



Real-Time Water Quality Deployment Report

Iron Ore Company of Canada
Labrador West Network

July 19 to
September 13, 2017



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

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General

- The Water Resources Management Division, in partnership with the Iron Ore Company of Canada (IOC) and Environment and Climate Change Canada (EC), maintain two real-time water quality (RTWQ) and water quantity stations at Wabush Lake.
- The official name of each station is *Wabush Lake at Dolomite Road* and *Wabush Lake at Lake Outlet*, hereafter referred to as the Dolomite Road station and the Julianne Narrows station.
- These stations are situated upstream (Dolomite Road) and downstream (Julienne Narrows) of the IOC tailings disposal area in Wabush Lake.
- On June 8th, 2016, an additional station was commissioned under this agreement. This station is located at *Dumbell Stream above Dumbell Lake*, hereafter referred to as Dumbell Stream.
- On June 12th, 2017 a new station was commissioned under this agreement. This station is located at *Pumphouse Stream above Drum Lake*. Hereafter referred to as Pumphouse Stream.
- Water Resources Management Division staff monitor the real-time graphs regularly. They will inform IOC of any significant water quality events by email notification and by monthly deployment reports.
- Between July 19th and 20th, 2017, real-time water quality monitoring instruments were deployed at the four IOC stations. The instruments were deployed for a period of 55 days at Dolomite Road, Dumbell Stream and Pumphouse Stream and 53 days at Julianne Narrows. The instruments were removed on September 12th and 13th. This was the second deployment for 2017.



Figure 1: RTWQ Monitoring Stations in Labrador West

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 each 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 19 and September 13, 2017 is summarized in Table 2.

Table 2: QA/QC comparison rankings for IOC stations between July 19 and September 13, 2017.

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Dolomite Road	July 19, 2017	Deployment	Excellent	Good	Excellent	Marginal	Excellent
	Sept 13, 2017	Removal	Excellent	Excellent	Marginal	Good	Excellent
Julienne Narrows	July 20, 2017	Deployment	Excellent	Good	Fair	Fair	Excellent
	Sept 12, 2017	Removal	Good	Excellent	Excellent	Excellent	Excellent
Dumbell Stream	July 19, 2017	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	Sept 13, 2017	Removal	Excellent	Excellent	Fair	Marginal	Excellent
Pumphouse Stream	July 19, 2017	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	Sept 13, 2017	Removal	Good	N/A	Fair	Fair	Poor

■ Dolomite Road

At deployment, temperature, pH, conductivity and turbidity, ranked either 'excellent' or 'good'. Dissolved oxygen ranked 'marginal'. The field instrument read a value of 9.95 mg/l, while the QA/QC instrument read a value of 8.99 mg/l.

At removal, temperature, pH, dissolved oxygen and turbidity, ranked either 'excellent' or 'good'. Conductivity ranked 'marginal'. The field instrument read a value of 49.2 µs/cm, while the QA/QC instrument read a value of 40.8 µs/cm.

■ Julienne Narrows

At deployment, temperature, pH, and turbidity ranked either 'excellent' or 'good'. Conductivity ranked 'fair'. The field instrument read a value of 100.2 µs/cm, while the QA/QC instrument read a value of 114.0 µs/cm. Dissolved oxygen ranked 'fair'. The field instrument read a value of 10.04 mg/l, while the QA/QC instrument read a value of 9.27 mg/l.

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

■ Dumbell Stream

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

At removal, temperature, pH, and turbidity ranked 'excellent'. Conductivity ranked 'fair'. The field instrument read a value of 71.9 µs/cm, while the QA/QC instrument read a value of 64.7 µs/cm. Dissolved oxygen ranked 'marginal', the field instrument read a value of 10.87 mg/l, while the QA/QC instrument read a value of 11.75 mg/l.

■ Pumphouse Stream

At deployment, all parameters ranked 'excellent'.

At removal, temperature ranked 'good'. pH was not ranked due to sensor drift. Conductivity ranked 'fair'. The field instrument read a value of 90.8 µs/cm, while the QA/QC instrument read a value of 79.9 µs/cm. Dissolved Oxygen ranked 'fair'. The field instrument read a value of 8.76 mg/l, while the QA/QC instrument

read a value of 9.35 mg/l. Turbidity ranked 'poor'. The field instrument read a value of 13.5 NTU, while the QA/QC instrument read a value of 1.5 NTU.

- There are a few circumstances which may cause less than ideal QA/QC rankings to 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 or more of the sensors.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from July 19, 2017 to September 13, 2017 at the IOC RTWQ monitoring stations in Labrador West.
- 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.

Wabush Lake Network

- Water temperature ranged from 12.00 to 18.10°C at Dolomite Road and 11.50 to 17.20°C at Julienne Narrows during this deployment period (Figure 2). Water temperature at Dolomite Road is slightly higher than at Julienne Narrows.

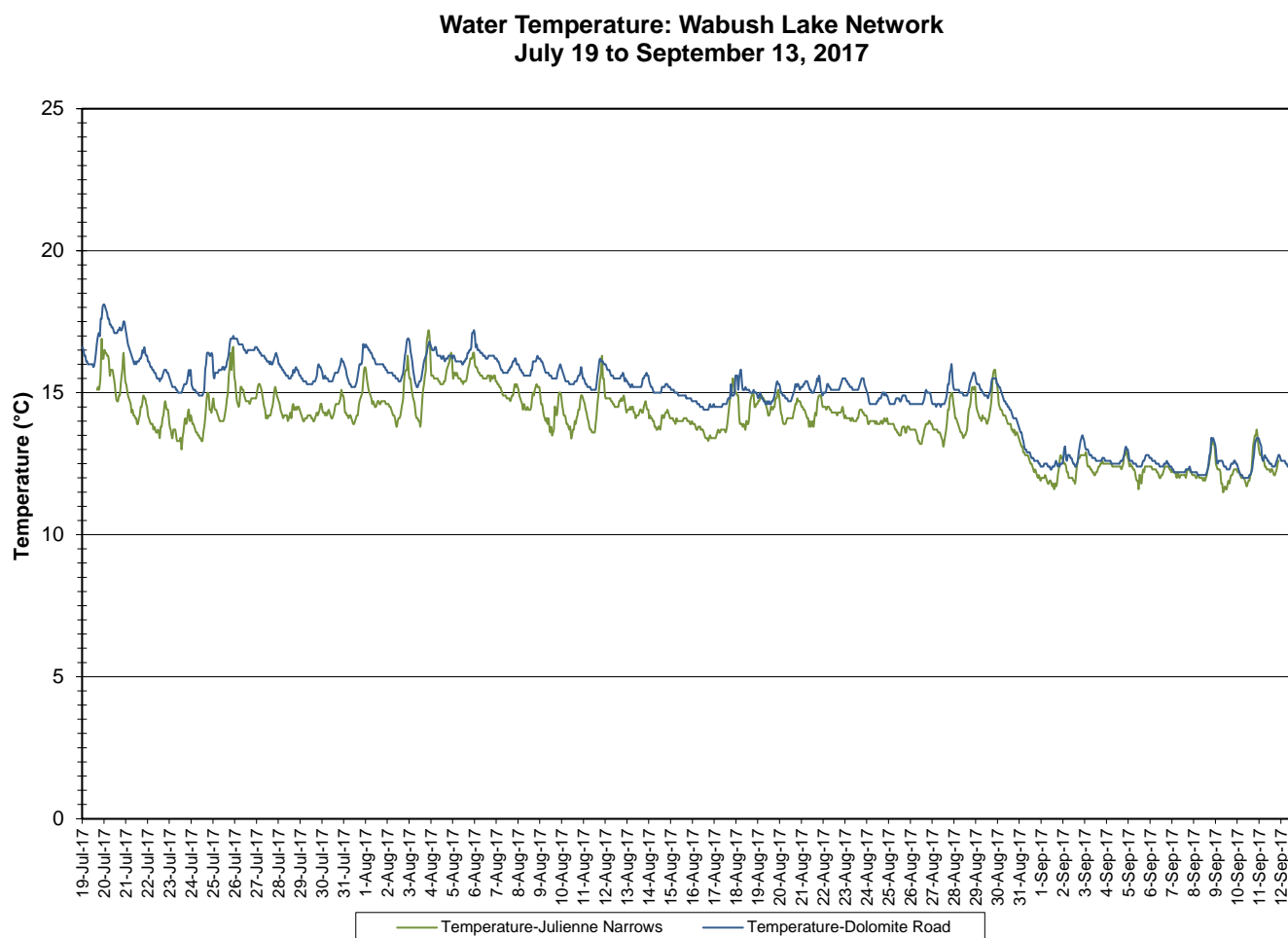


Figure 2: Water temperature - Wabush Lake network

- Water temperature decreased during the later portion of the deployment period, which corresponds with decreasing ambient air temperature at this time (Figure 3).

**Average Daily Air and Water Temperature: Wabush Lake Network
July 19 to September 13, 2017**

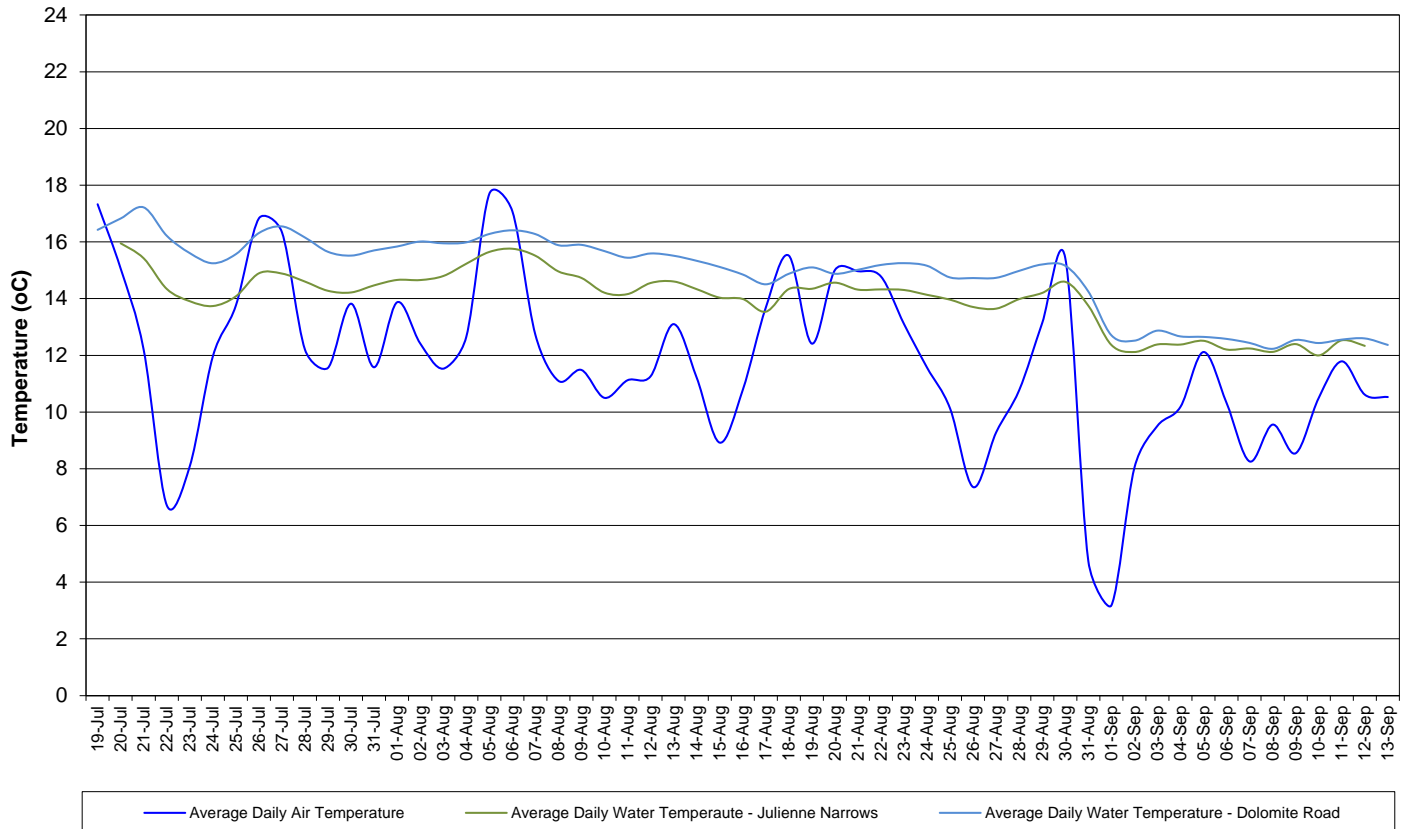


Figure 3: Average daily air and water temperatures – Wabush Lake network

- pH ranges from 7.12 to 8.08 pH units at Dolomite Road, and from 7.60 to 8.20 pH units at Julienne Narrows throughout the deployment period (Figure 4). The median pH is 7.50 and 7.82 units respectively.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly throughout the day and night.
- A decrease in stage is noticeable at Julienne Narrows on the 25th of August due to a correction performed by WSC staff to the equipment.
- 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.

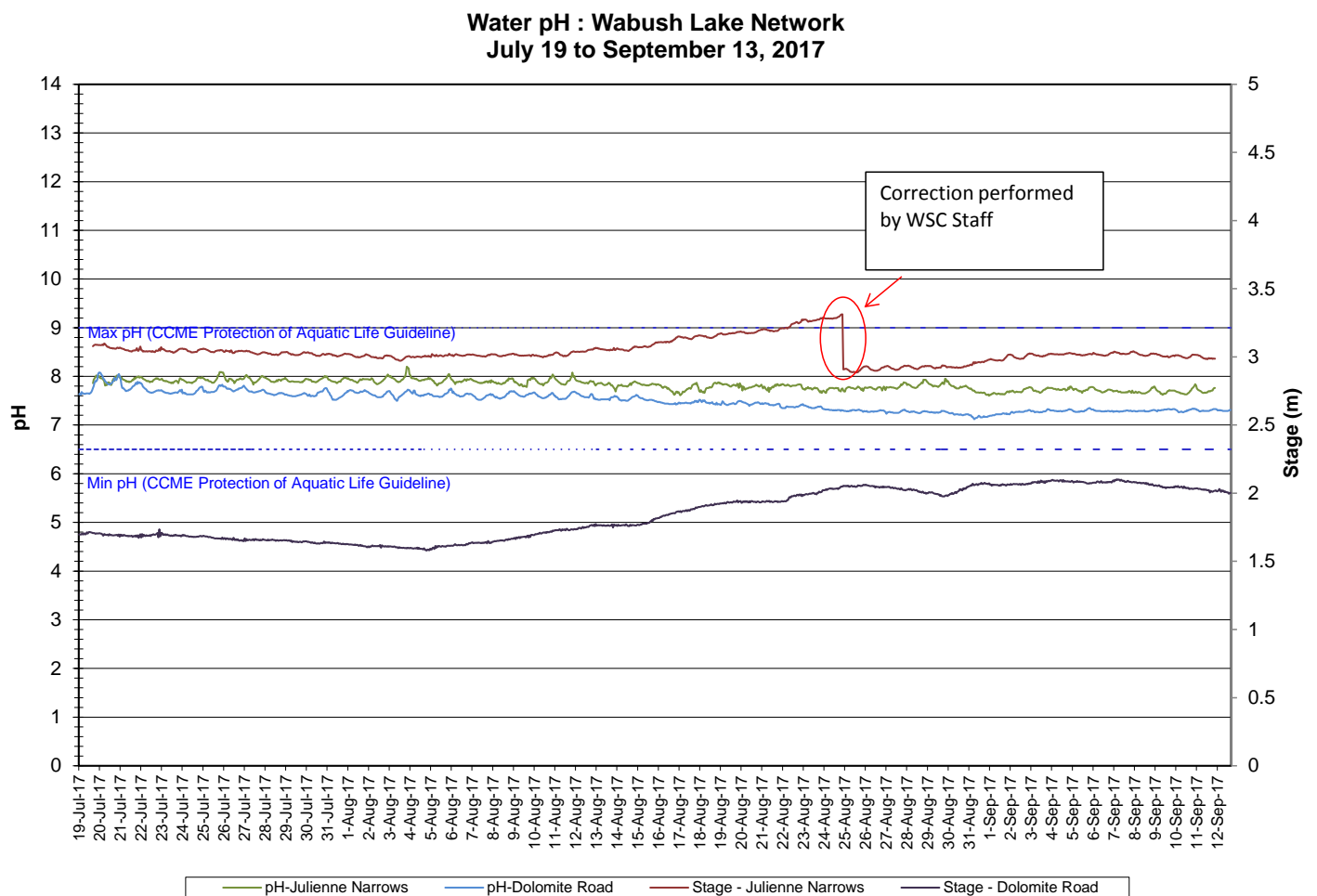


Figure 4: pH – Wabush Lake network

- Specific conductivity ranged from 42.6 to 63.4 $\mu\text{S}/\text{cm}$ at Dolomite Road and from 73.3 to 105.2 $\mu\text{S}/\text{cm}$ at Julienne Narrows throughout the deployment period (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.
- Specific conductance decreases at Dolomite Road after the 16th of August, as stage rises. This occurs when an increased amount of water is introduced into the system and the amount of solids is diluted.
- 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.

**Specific Conductivity and Stage: Wabush Lake Network
July 19 to September 13, 2017**

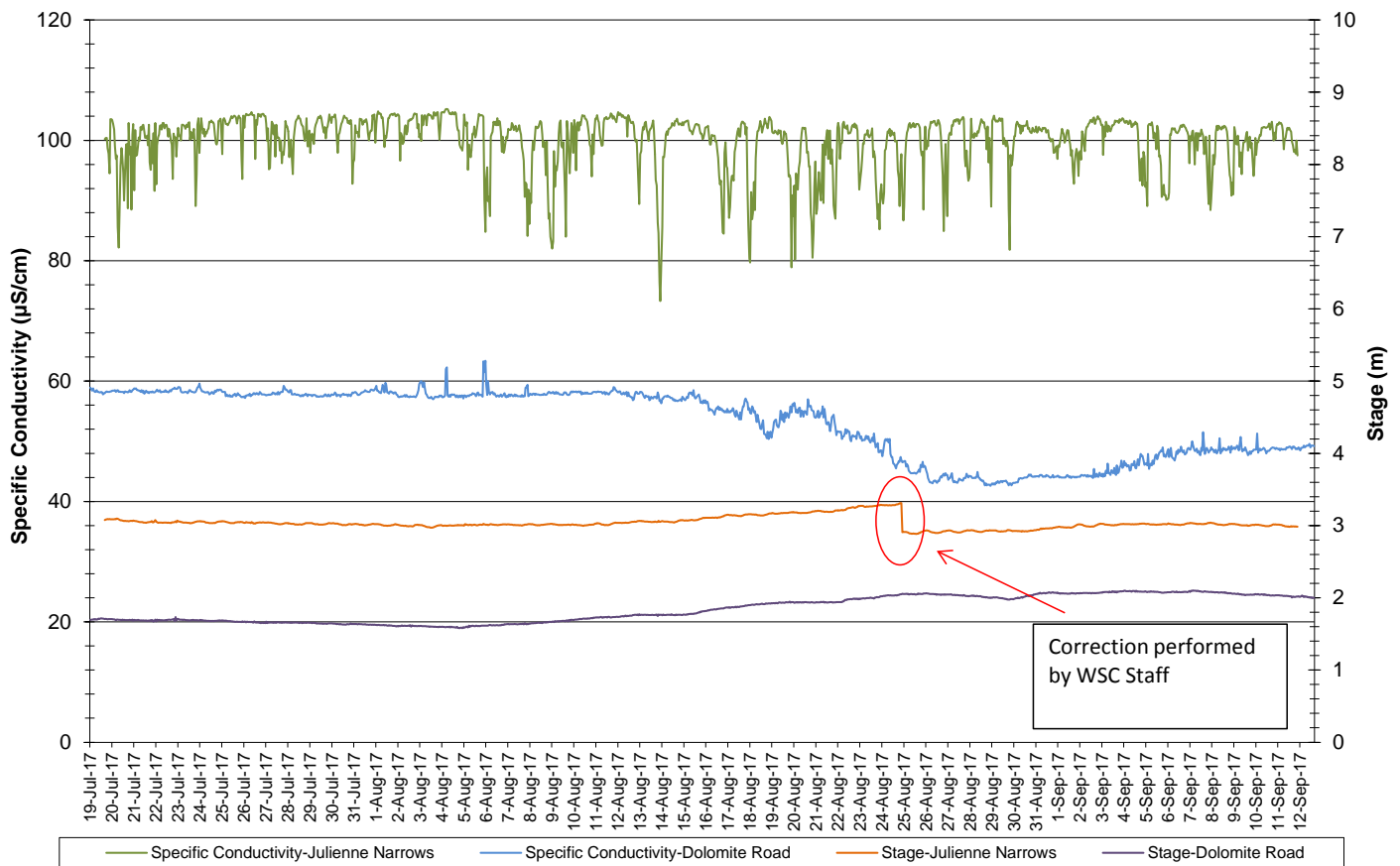


Figure 5: Specific conductivity – Wabush Lake network

- At the Dolomite Road station, the saturation of dissolved oxygen ranged from 86.8 to 108.2% while the dissolved oxygen content ranged from 10.16 to 9.10 mg/l with a median value of 9.52 mg/l (Figure 6).
- At the Julienne Narrows station, the saturation of dissolved oxygen ranged from 89.8 to 110.7% while the dissolved oxygen content ranged from 9.30 to 10.63 mg/l with a median value of 9.83 mg/l (Figure 6).
- 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.
- Almost 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 most values recorded at Dolomite Road were below the guideline. The guidelines are indicated in blue on Figure 6.
- Dissolved oxygen increased slightly at both stations towards the end of this deployment period, as water temperature cooled into fall. Dissolved oxygen fluctuated daily with decreases observed at night.

**Dissolved Oxygen : Wabush Lake Network
July 19 to September 13, 2017**

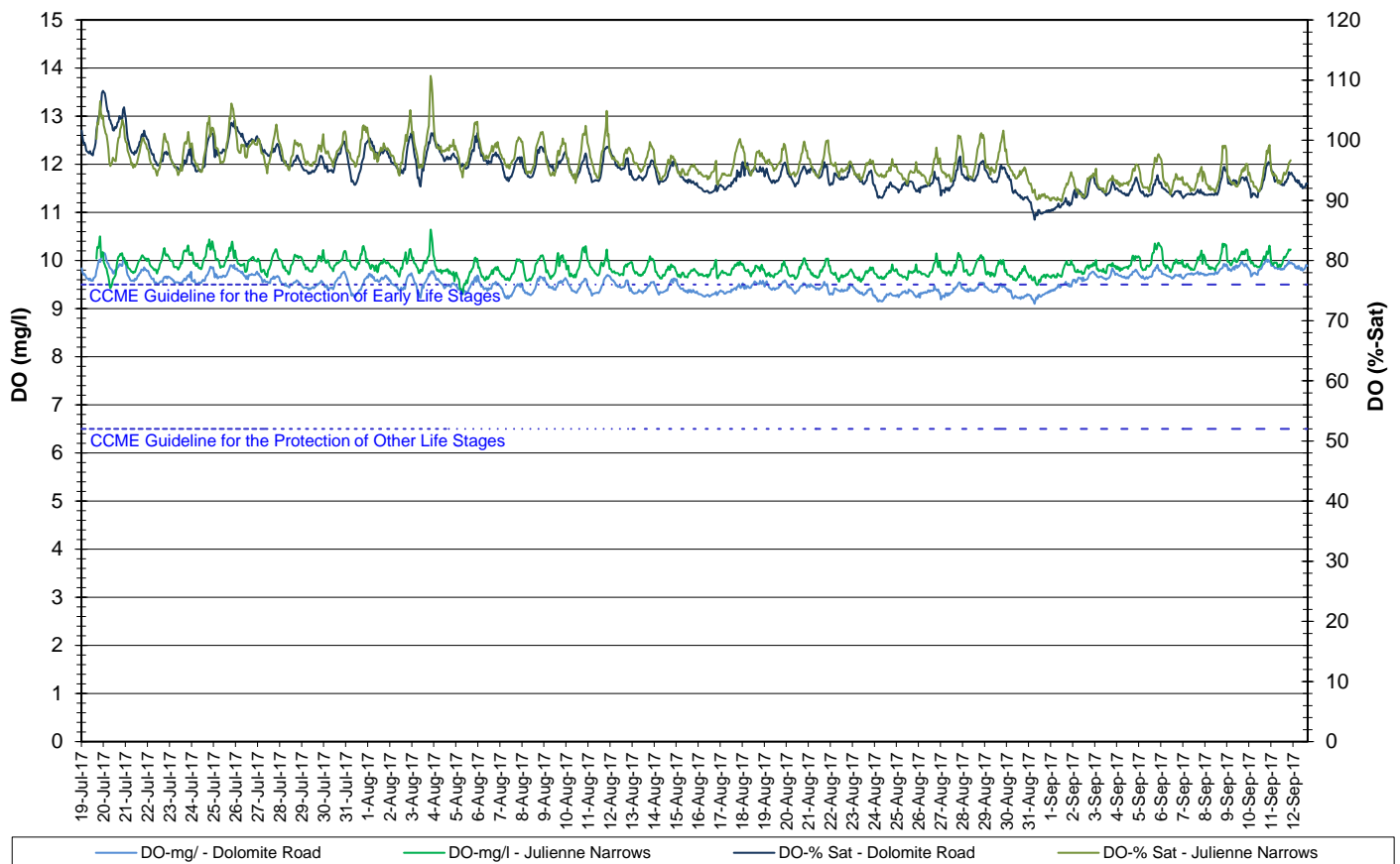


Figure 6: Dissolved oxygen and percent saturation – Wabush Lake Network

- At the Julianne Narrows station, turbidity values range from 0.0 to 24.1 NTU throughout the deployment period (Figure 7). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events. They are indicated on Figure 7 in red.

**Water Turbidity: Julianne Narrows
July 20 to September 12, 2017**

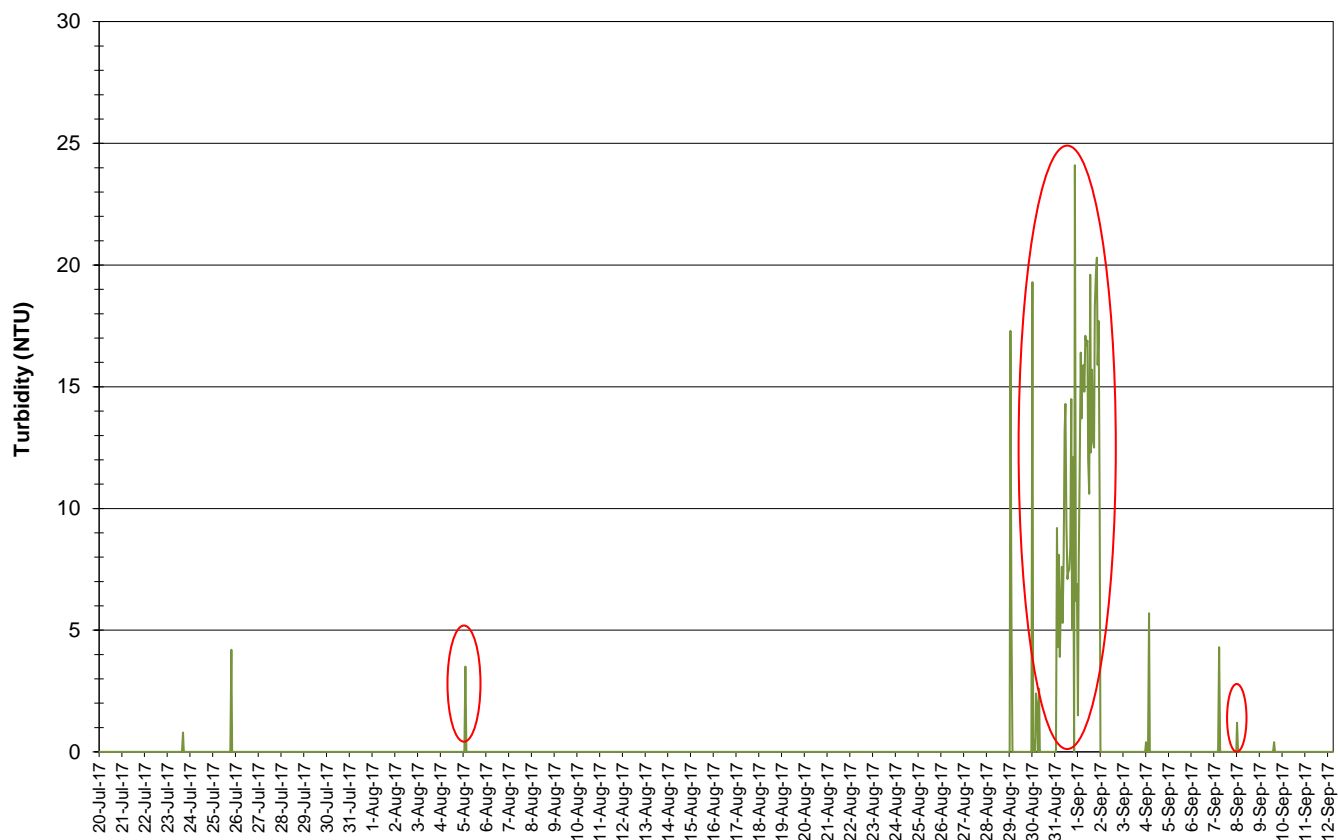


Figure 7: Turbidity – Julianne Narrows

- At the Dolomite Road station, turbidity values ranged from 0.0 NTU to 2.7 NTU, throughout the deployment period (Figure 8).
- The few spikes can be attributed to precipitation events; they are identified on Figure 8 in red.

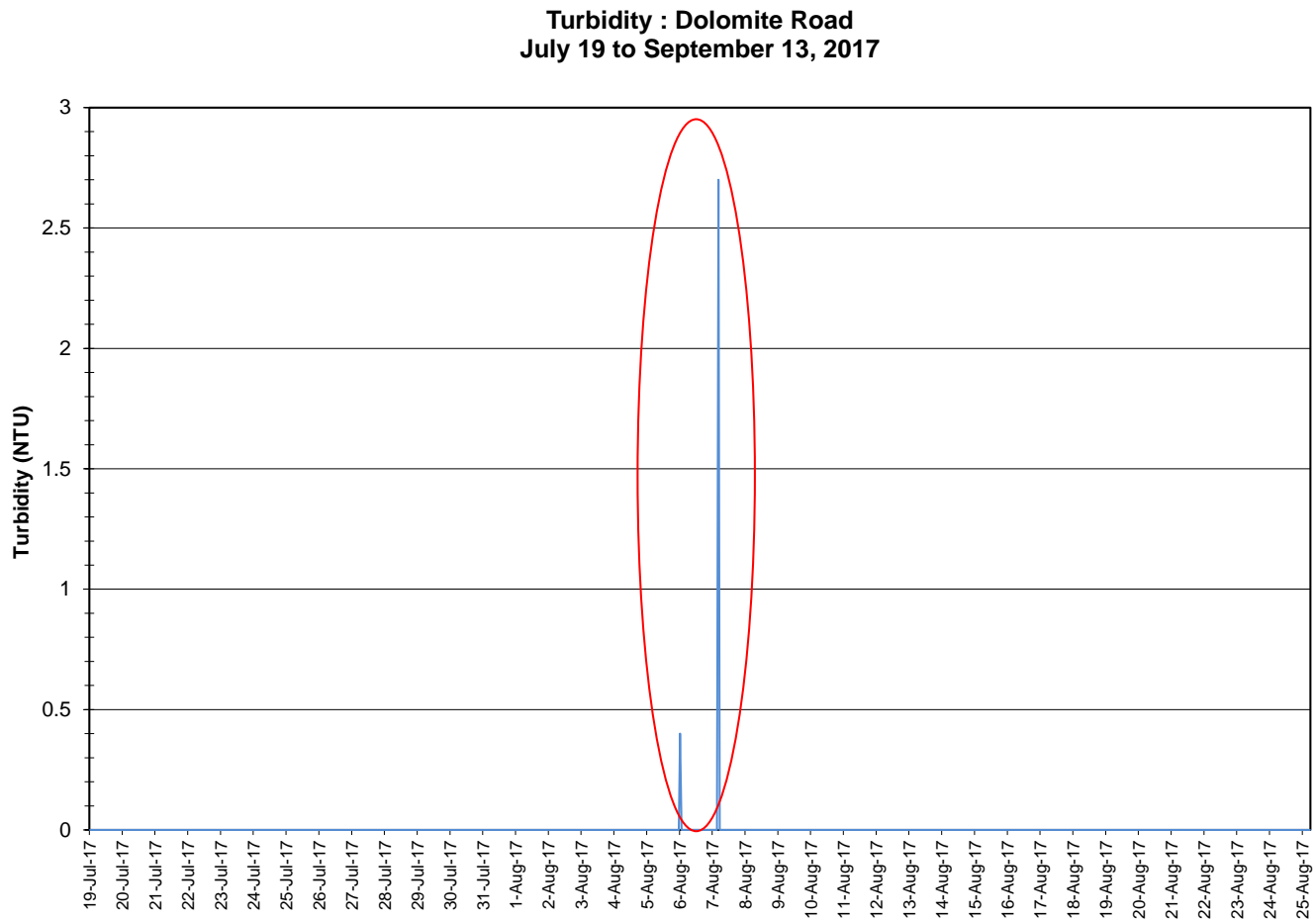


Figure 8: Turbidity – Dolomite Road

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dolomite Road (Figure 9).
- Overall, stage increases throughout the deployment period with precipitation events causing periodic increases in stage.
- 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.

**Daily Precipitation and Average Daily Stage Level: Dolomite Road
July 19 to September 13, 2017**

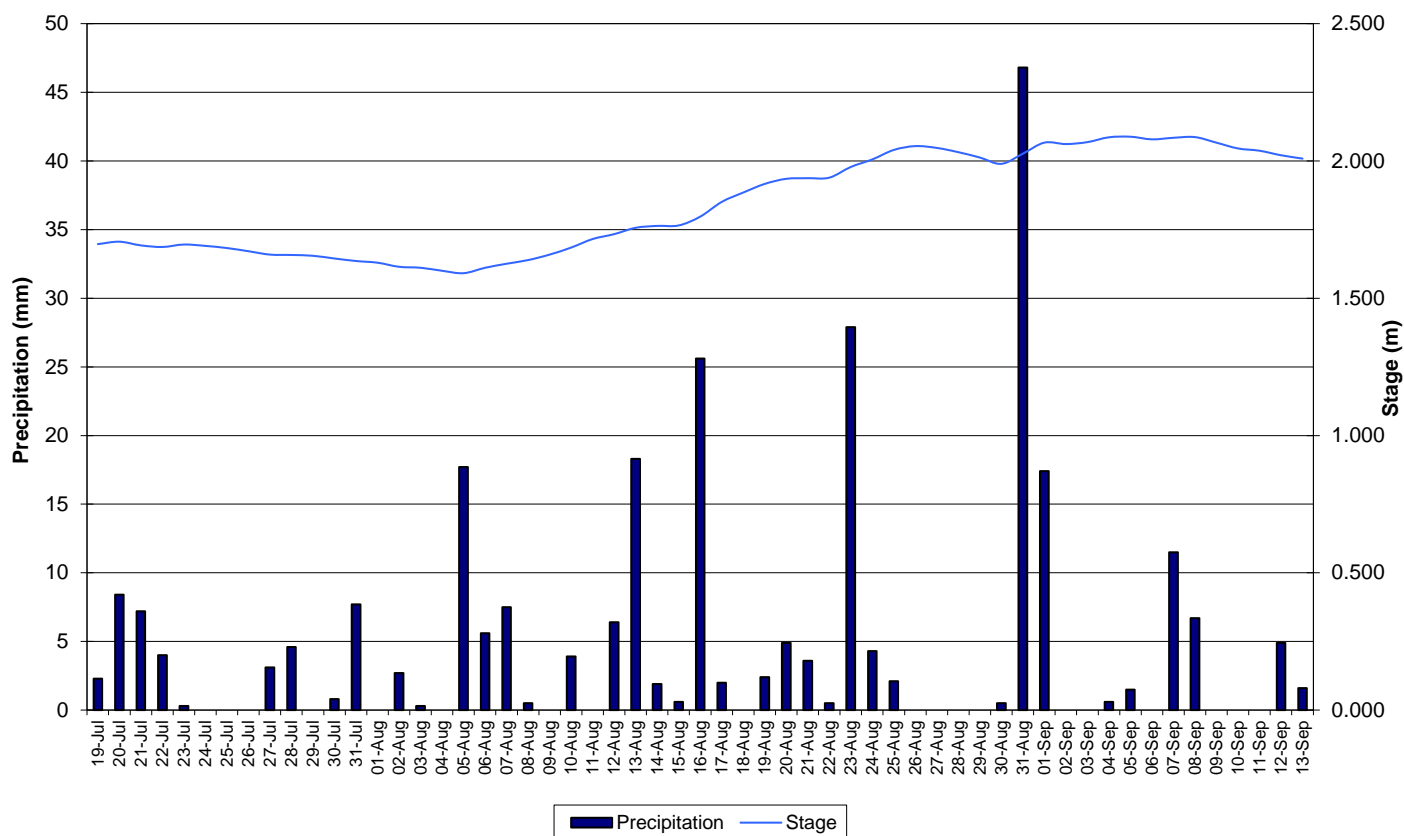


Figure 9: Precipitation and Stage –Dolomite Road

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Julianne Narrows (Figure 10).
- Overall, stage was relatively stable throughout the deployment period, with precipitation events causing periodic increases in stage.
- There was a correction in stage by EC at the end of August. It is identified on Figure 10 in red.
- 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.

**Daily Precipitation and Average Daily Stage Level: Julianne Narrows
July 20 to September 13, 2017**

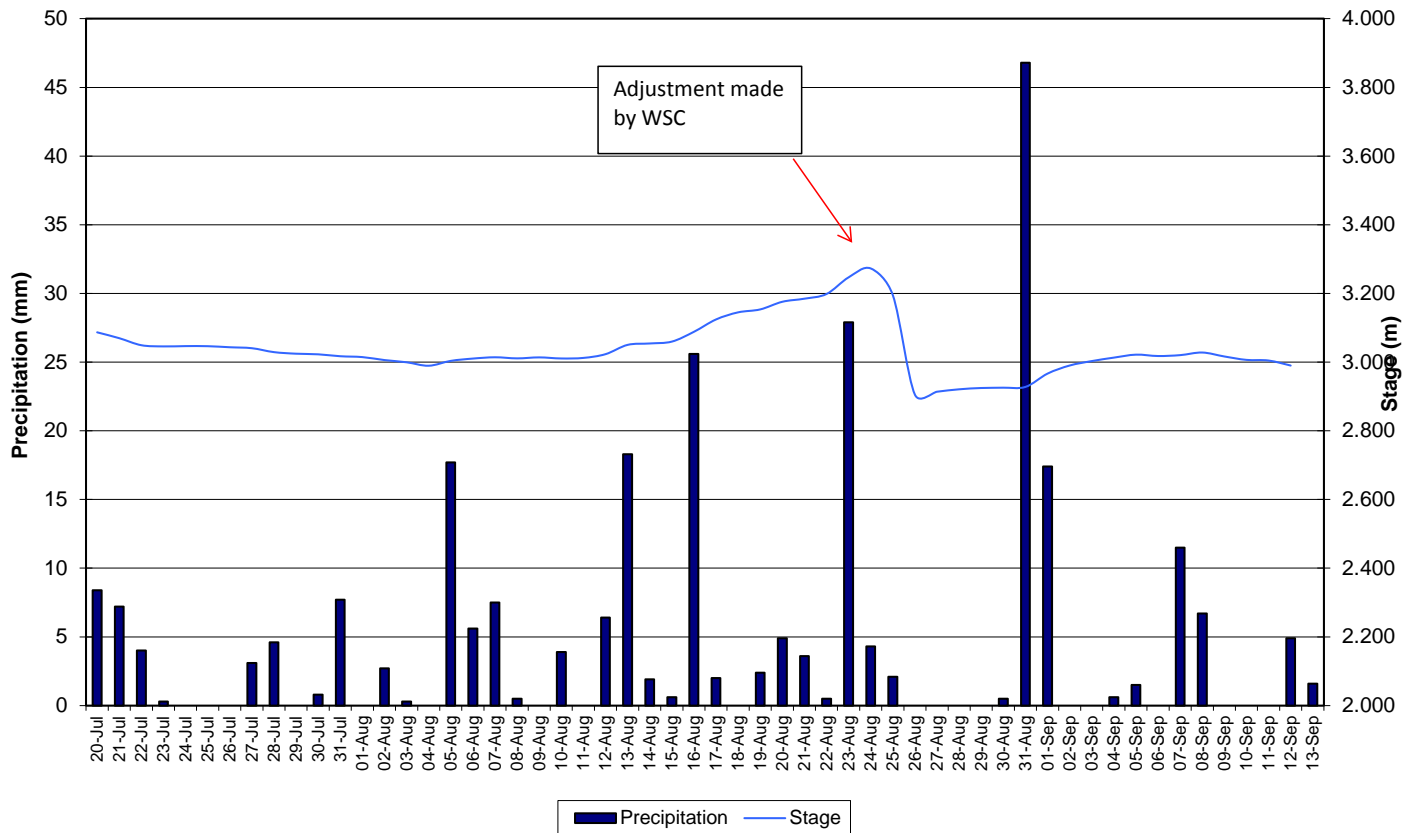


Figure 10: Precipitation and Stage –Julienne Narrows

Dumbell Stream

- Water temperature ranged from 3.36 to 9.89°C during this deployment period (Figure 11).
- Water temperature generally fluctuated within this range for the deployment period. This area is very shaded. Temperature did not correspond with increasing ambient air temperature (Figure 12).

**Water Temperature : Dumbell Stream above Dumbell Lake
July 19 to September 13, 2017**

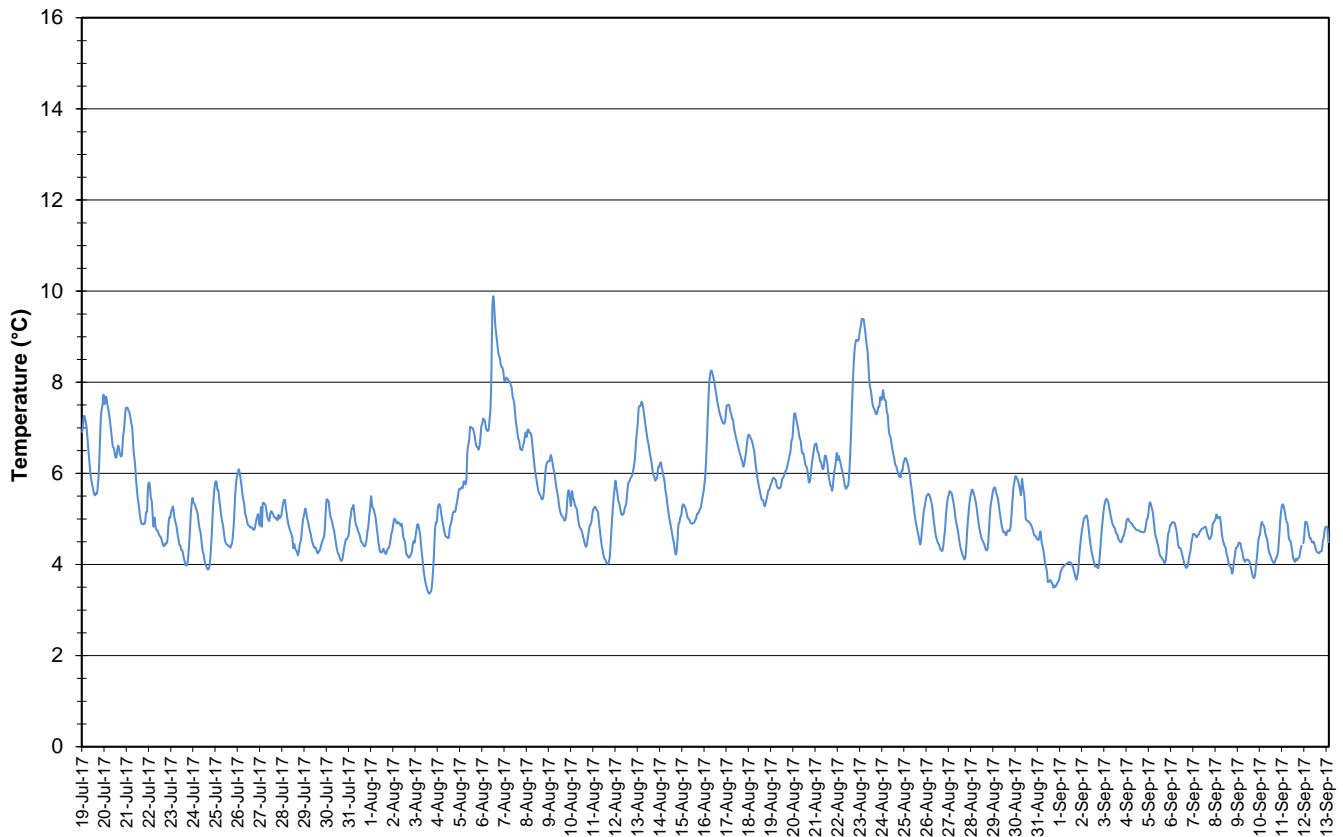


Figure 11: Water Temperature – Dumbell Stream

**Average Daily Air and Water Temperature: Dumbell Stream
July 19 to September 13, 2017**

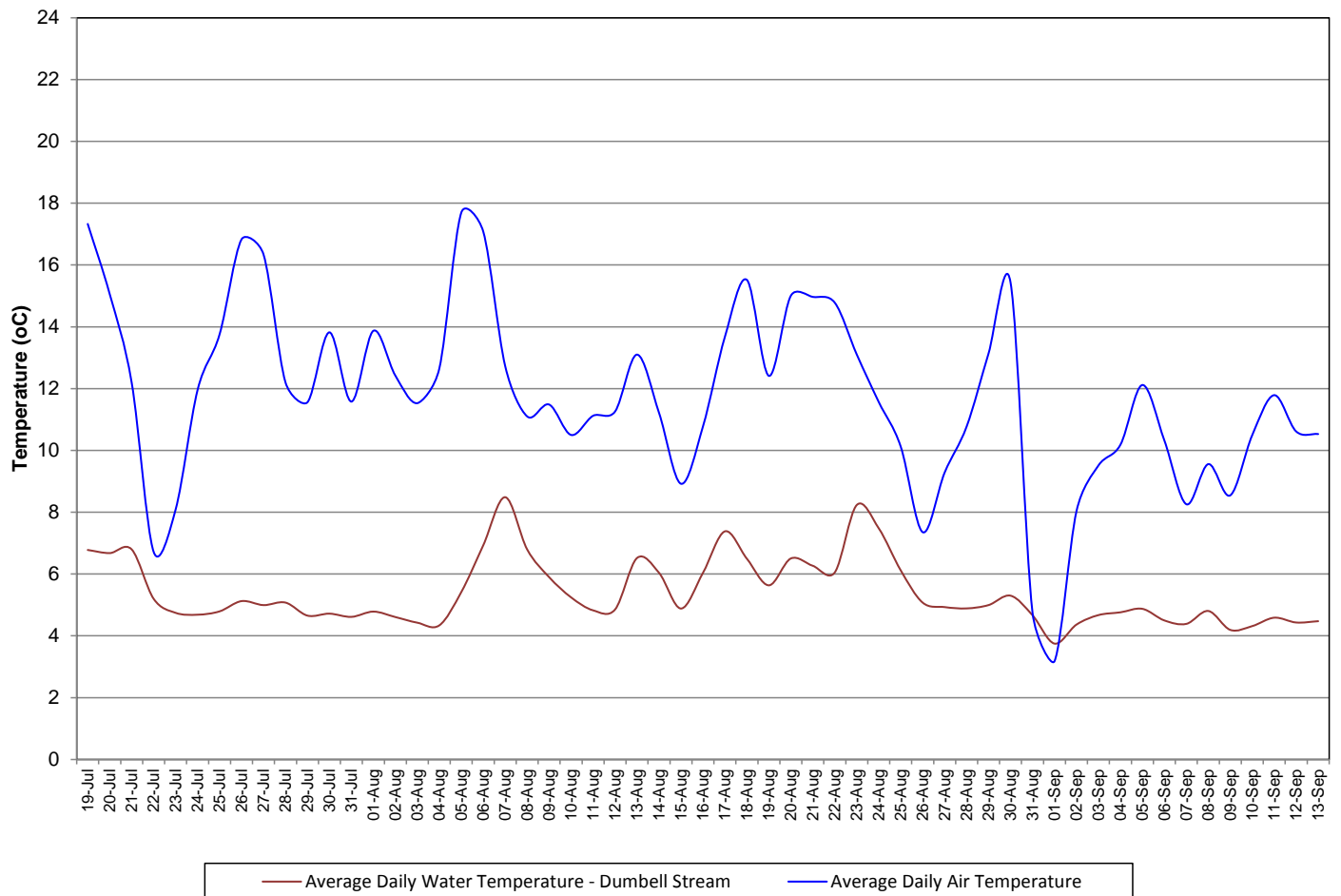


Figure 12: Average daily air and water temperatures – Dumbell Stream

- pH ranged from 7.23 to 7.79 pH units (Figure 13). The median pH was 7.54.
- There are three noticeable decreases in pH during this deployment period. They occur during high precipitation events. This is a very small stream and is very susceptible to fluctuations during precipitation events.
- All values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly throughout the day and night.

**Water pH : Dumbell Stream above Dumbell Lake
July 19 to September 13, 2017**

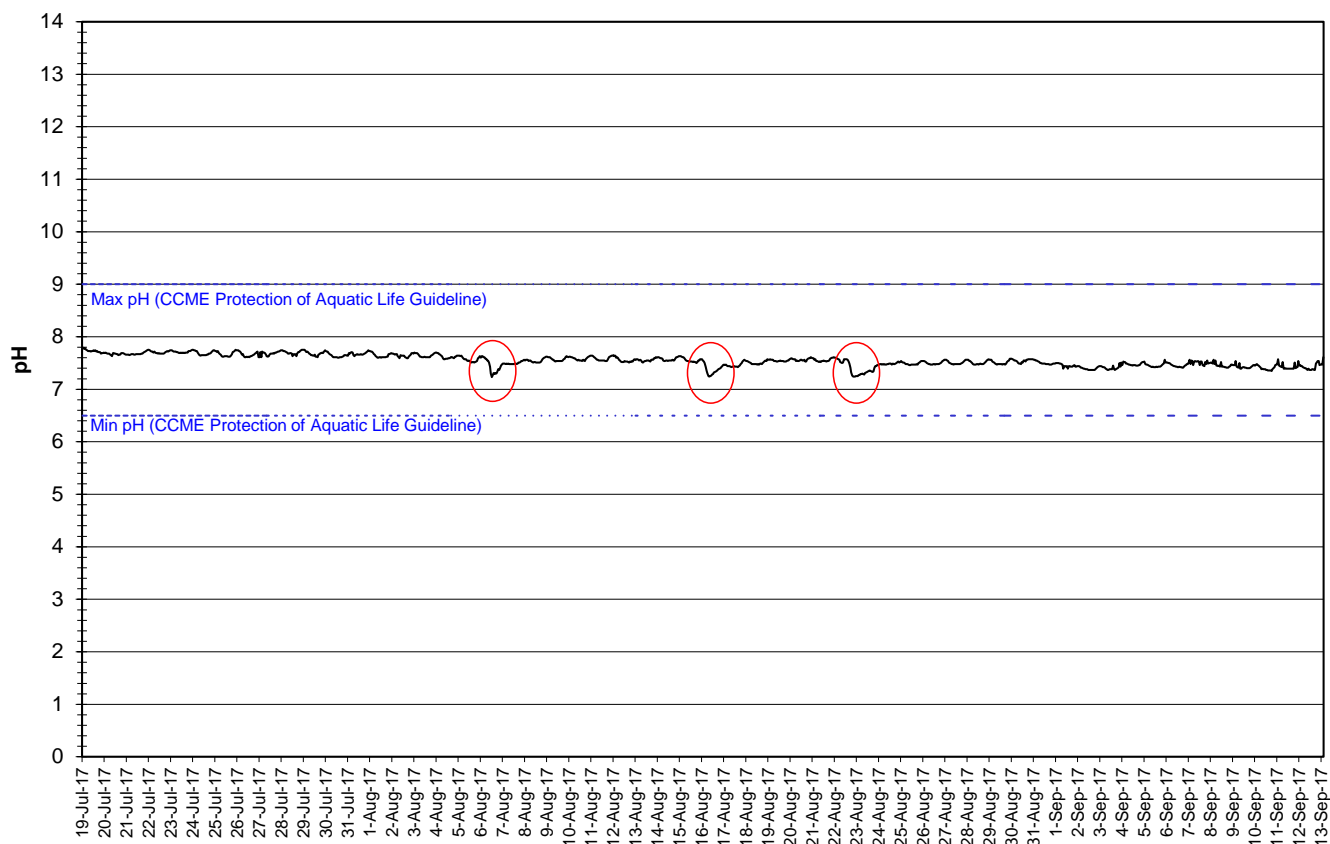


Figure 13: Water pH – Dumbell Stream

- Specific conductivity ranged from 42.0 to 74.9 $\mu\text{S}/\text{cm}$, throughout the deployment period (Figure 14).
- Decreases in specific conductivity correspond to increases in stage. As more water is added to the system from precipitation, the solids in the water are diluted, decreasing conductivity. These decreases are indicated in red on figure 14.
- 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.

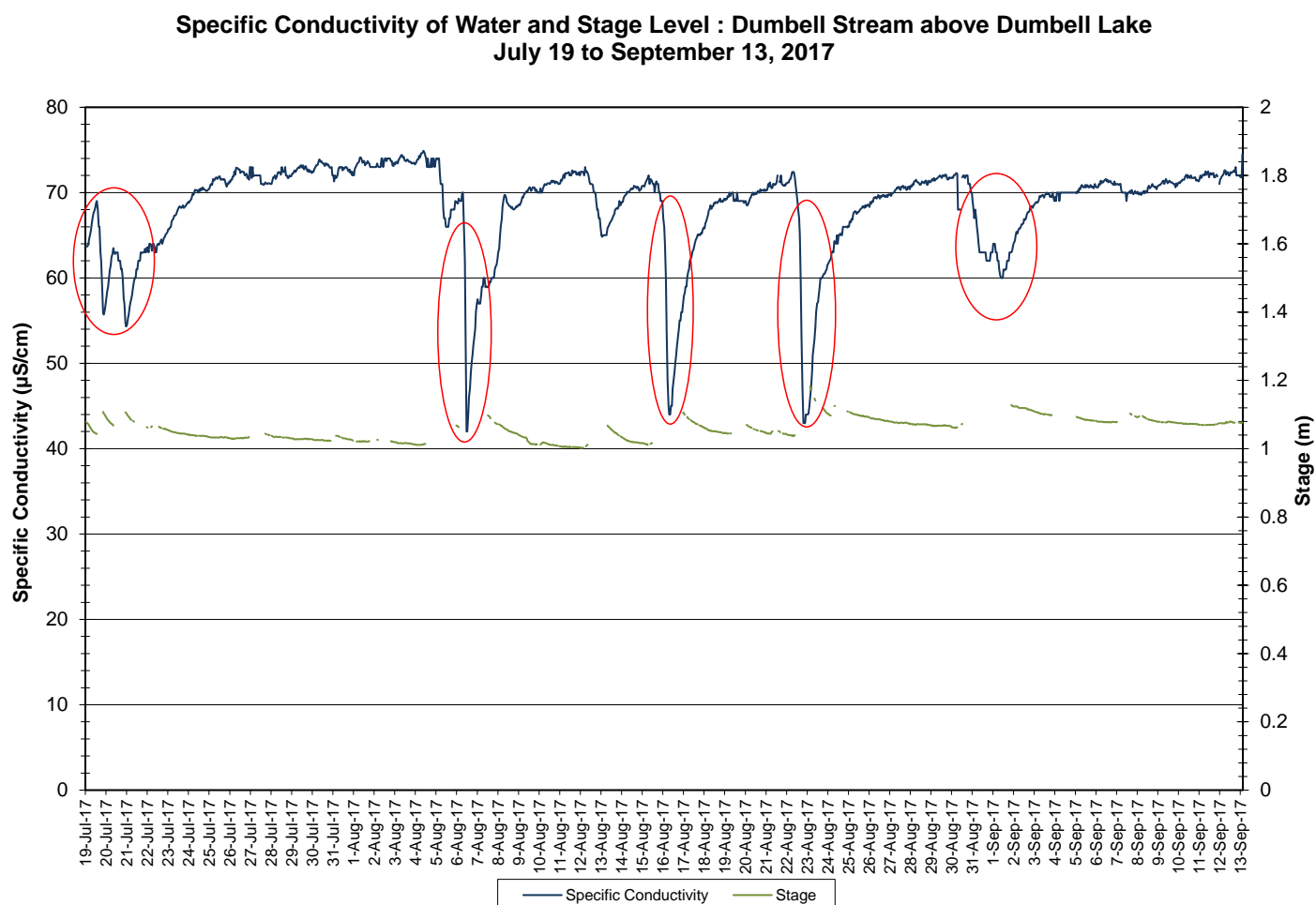


Figure 14: Specific Conductivity – Dumbell Stream

- The saturation of dissolved oxygen ranged from 84.6 to 87.9% while the dissolved oxygen content ranged from 9.68 to 11.55 mg/l with a median value of 10.95 mg/l (Figure 15).
- 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/l. The guidelines are indicated in blue on Figure 15.
- Noticeable decreases in dissolved oxygen correspond with rises in temperature at the same time. They are indicated on Figure 15 in red.
- Dissolved oxygen fluctuated daily with decreases observed at night.

**Dissolved Oxygen Concentration and Saturation : Dumbell Stream at Dumbell Lake
July 19 to September 13, 2017**

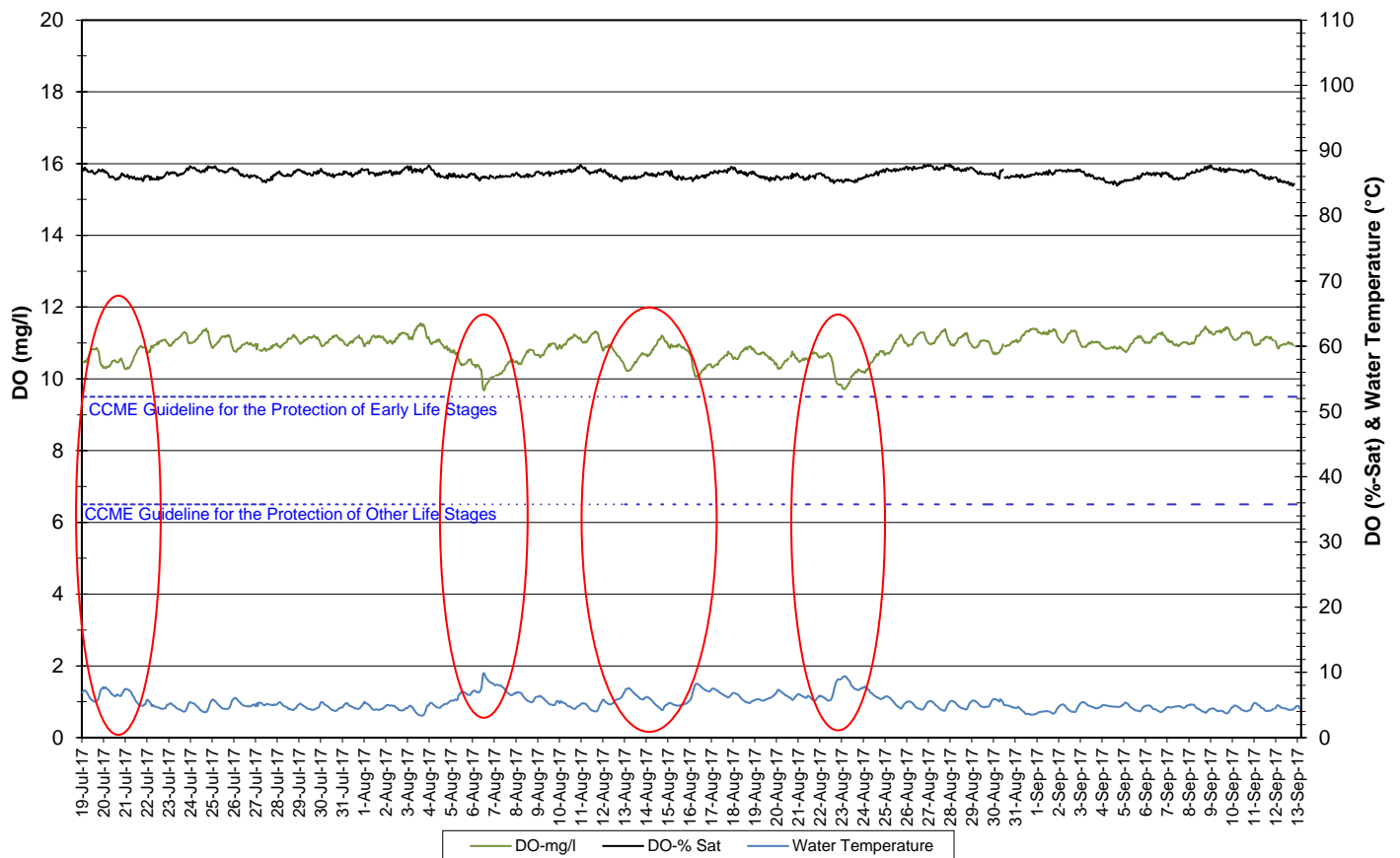


Figure 15: Dissolved Oxygen – Dumbell Stream

- Turbidity values range from 0.0 to 386.9 NTU throughout the deployment period (Figure 16). The median value was 0.0 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events. They are indicated on the Figure 16 in red.

**Water Turbidity : Dumbell Stream above Dumbell Lake
June 19 to September 13, 2017**

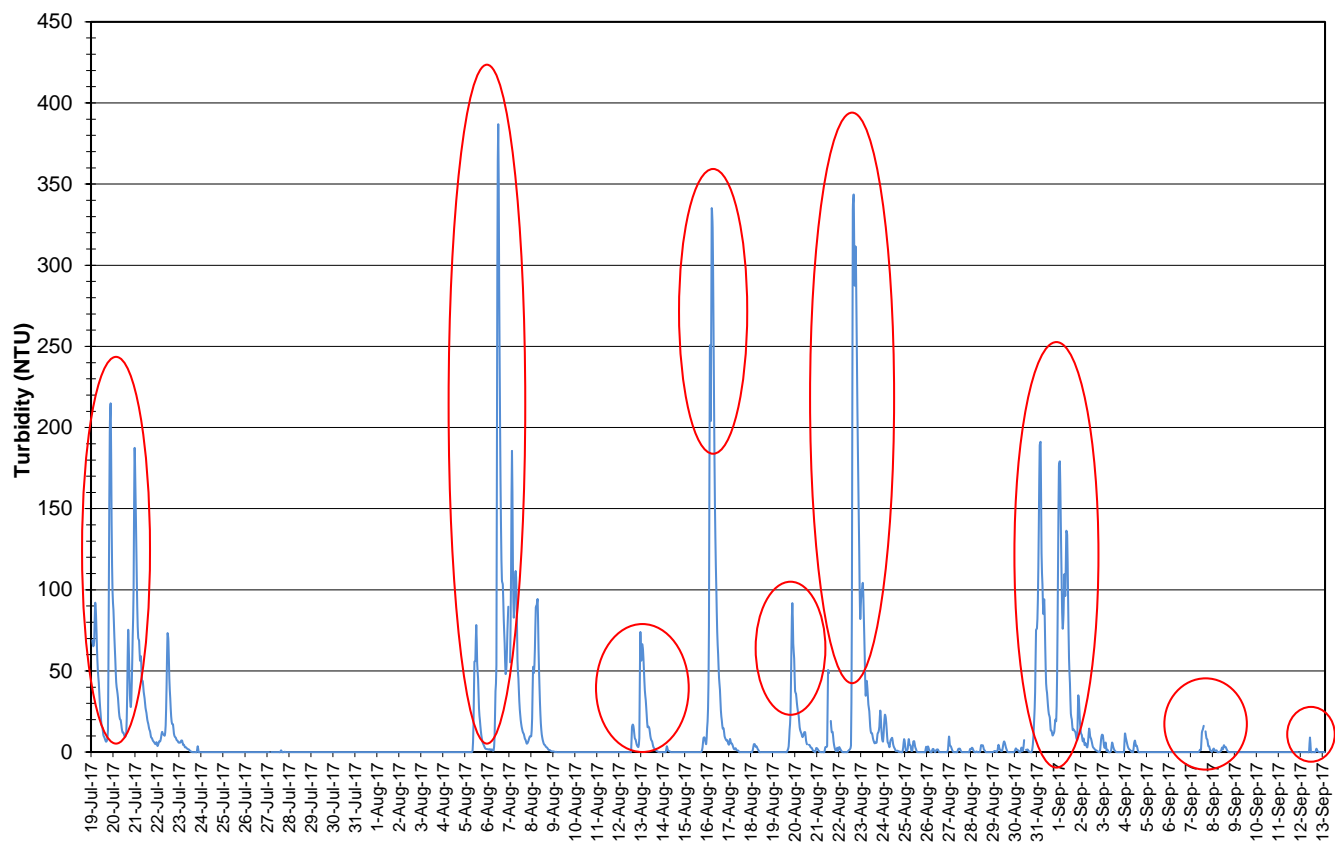


Figure 16: Turbidity – Dumbell Stream

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Dumbell Stream (Figure 17).
- Overall, stage is relatively stable throughout the deployment period, with precipitation events causing periodic increases in stage.
- 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.

**Daily Precipitation and Average Daily Stage Level: Dumbell Stream
July 19 to September 13, 2017**

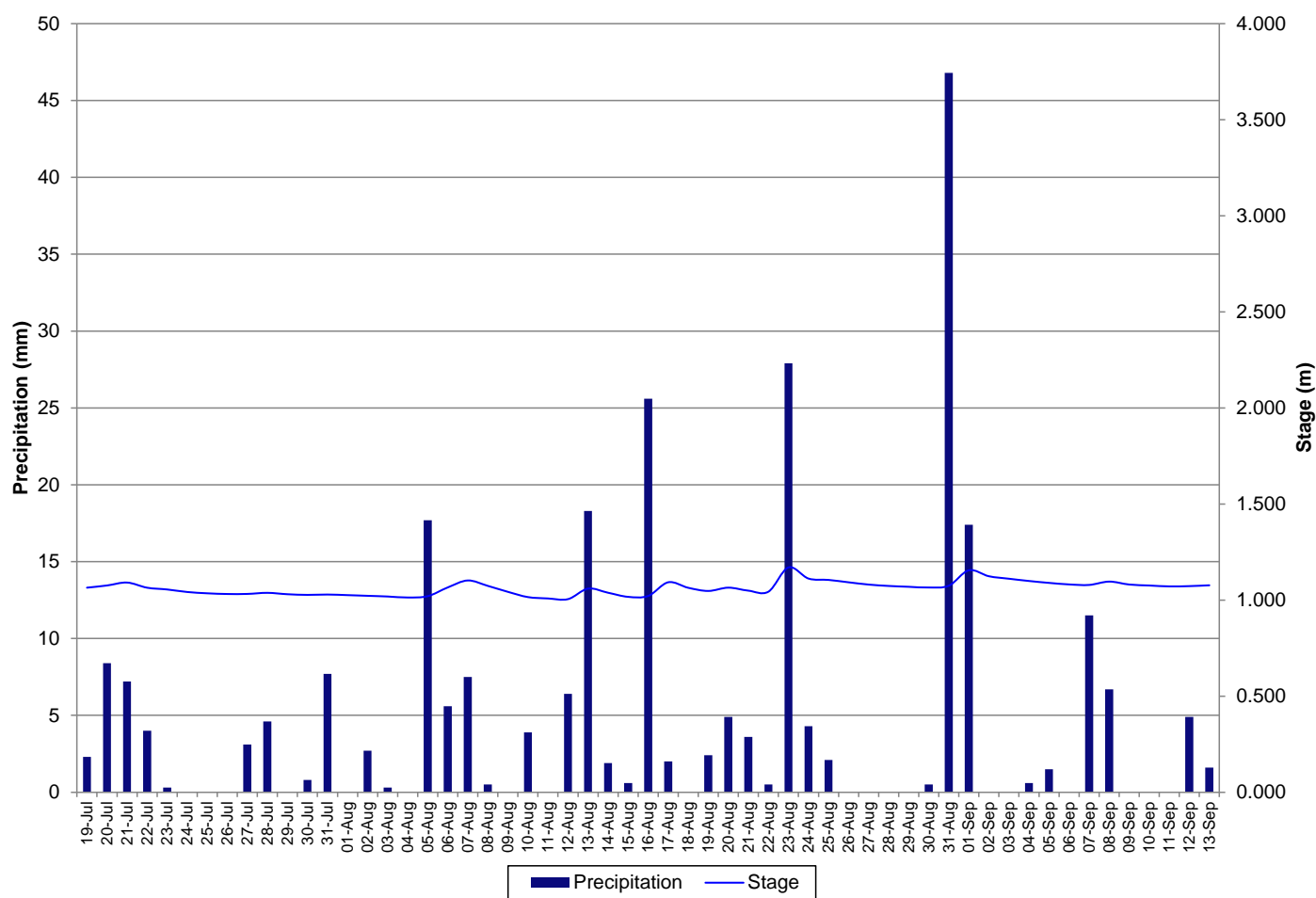


Figure 17: Precipitation and Stage –Dumbell Stream

Pumphouse Stream

- Water temperature ranged from 6.00 to 17.20°C during this deployment period (Figure 18).
- Water temperature decreased over the course of this deployment period, corresponding to decreasing ambient air temperatures into fall (Figure 19).

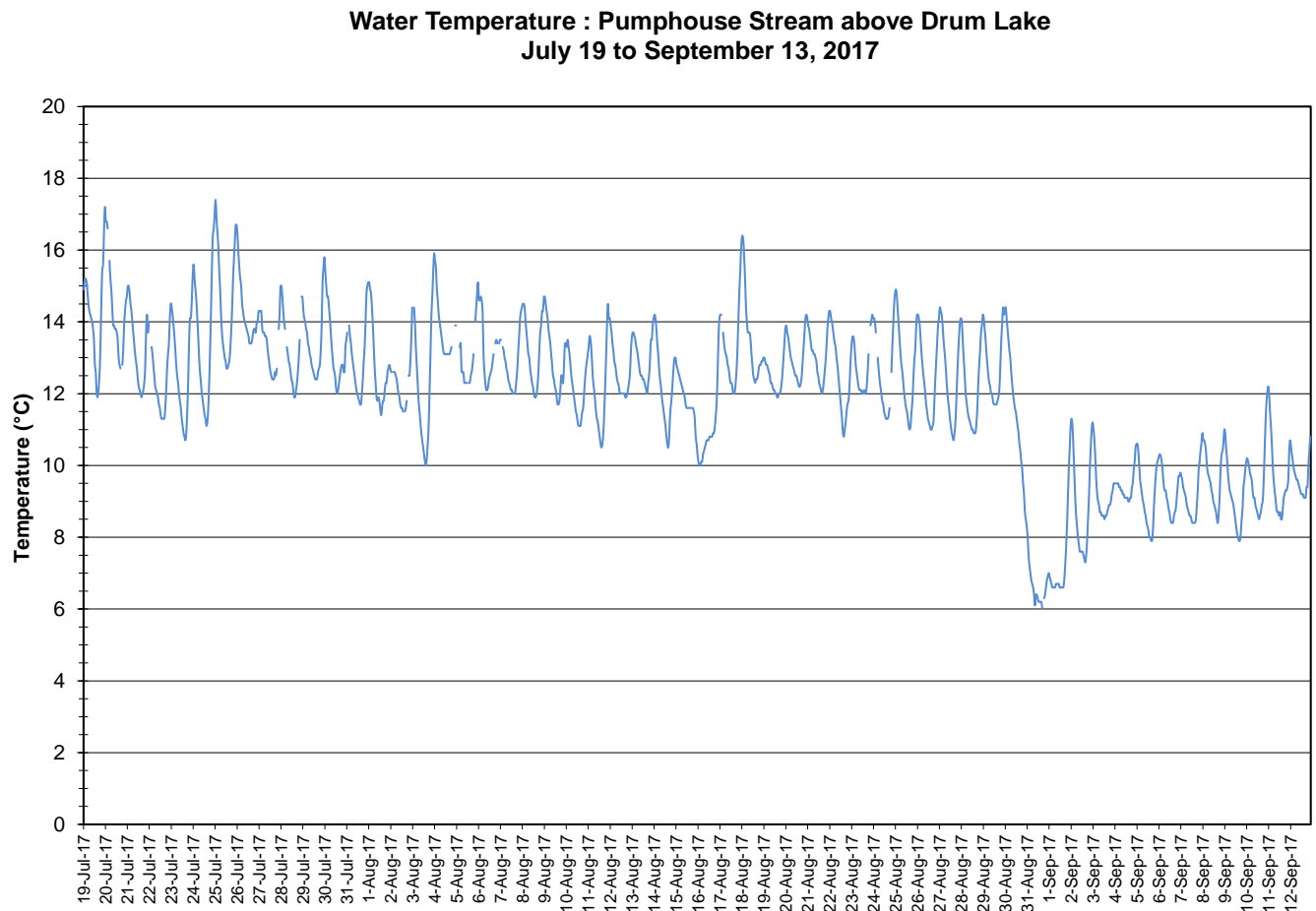


Figure 18: Water Temperature – Pumphouse Stream

**Average Daily Air and Water Temperature: Pumphouse Stream
July 19 to September 13, 2017**

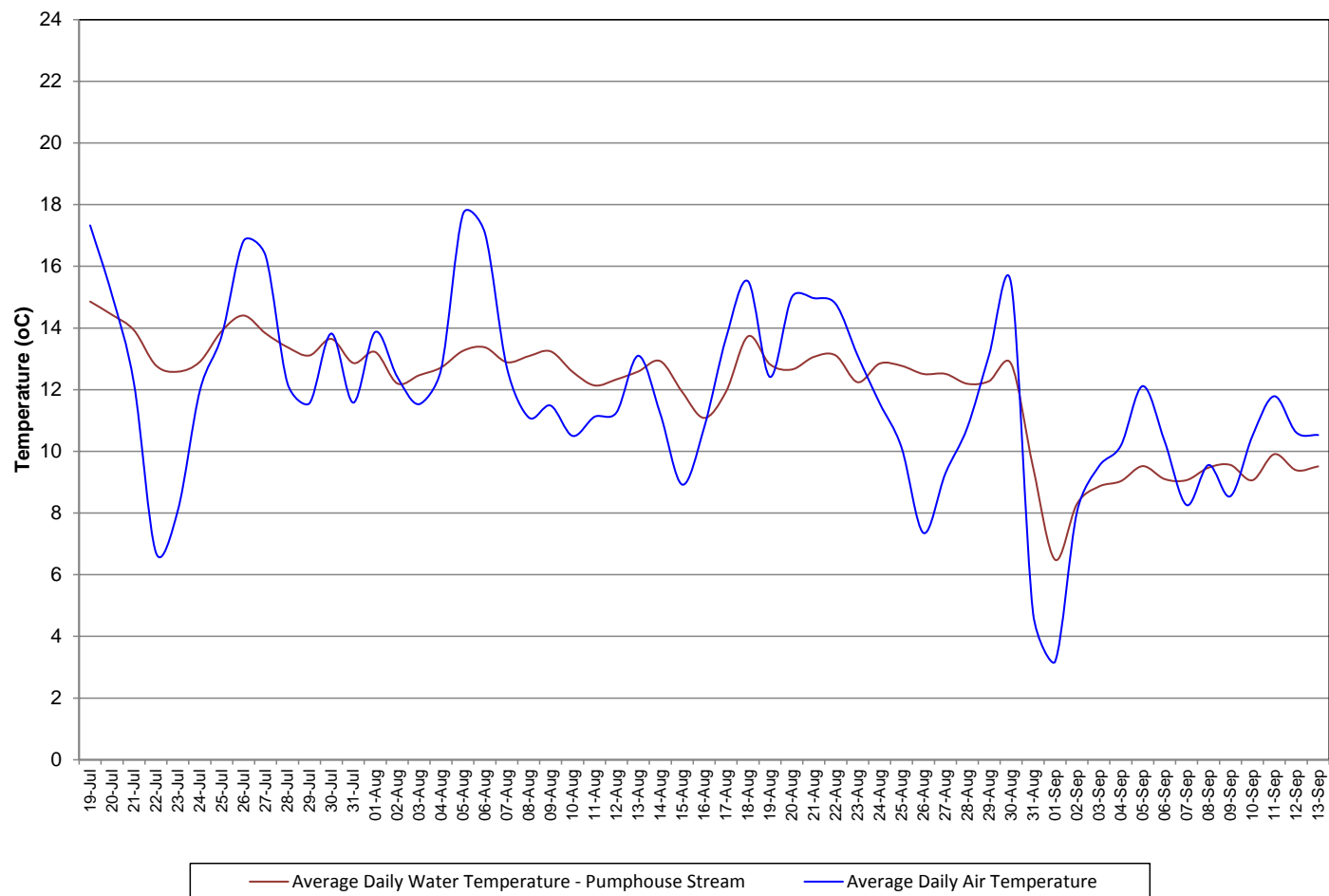


Figure 19: Average daily air and water temperatures – Pumphouse Stream

- pH ranged from 6.88 to 7.21 pH units (Figure 20). The median pH was 7.10.
- A large portion of the pH data was removed due to sensor drift. The remaining values during the deployment are within the CCME Guidelines for the Protection of Aquatic Life (between 6.5 and 9 pH units). pH fluctuates slightly throughout the day and night.

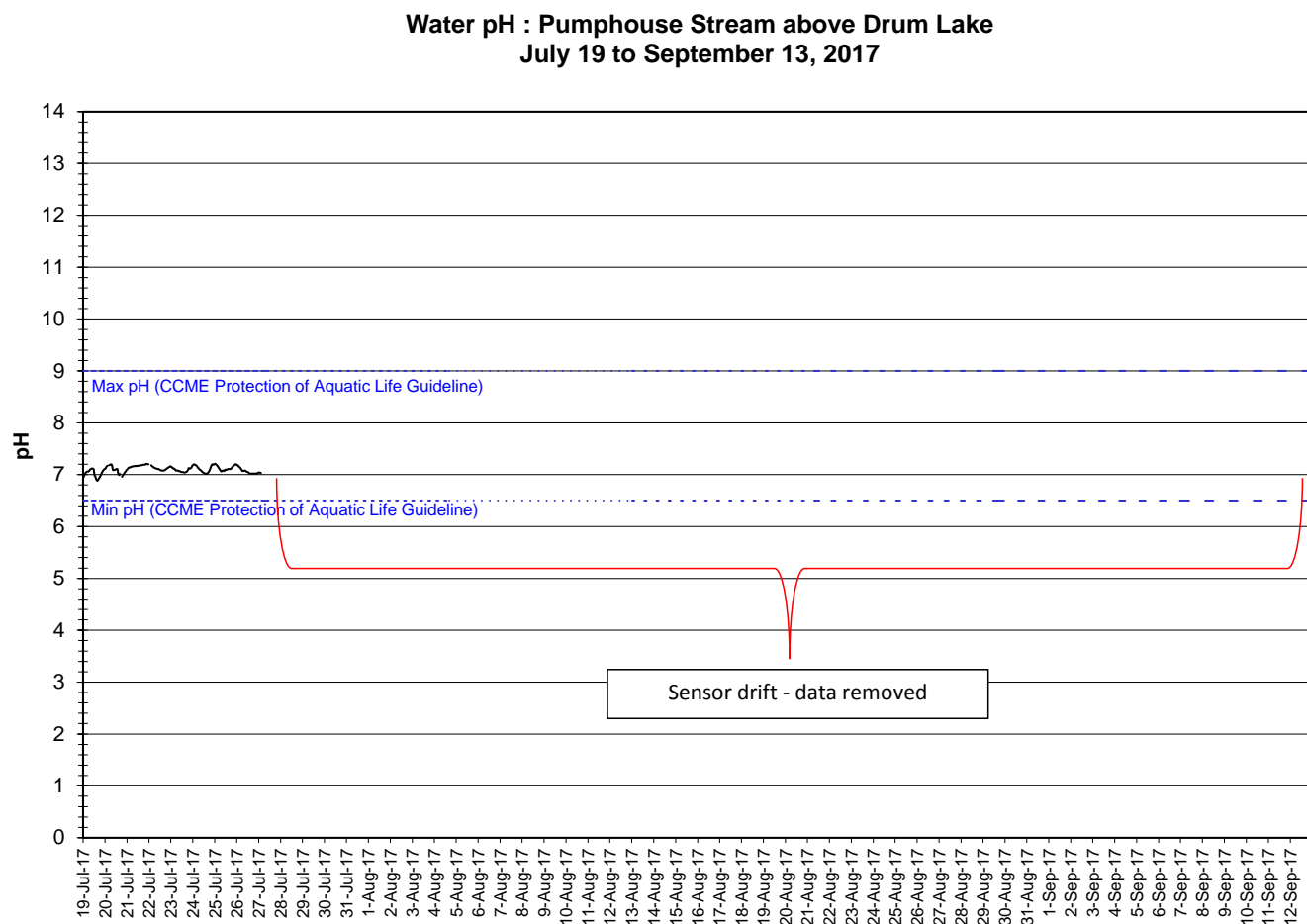


Figure 20: Water pH – Pumphouse Stream

- Specific conductivity ranged from 44.3 to 136.0 $\mu\text{S}/\text{cm}$, throughout the deployment period (Figure 21).
- Decreases in specific conductivity correspond to increases in stage. As more water is added to the system from precipitation, the solids in the water are diluted, decreasing conductivity. They are indicated on Figure 21 in red.
- There is a significant increase in stage during this deployment period due to a correction performed on the equipment by WSC staff. A close up version of the graph is shown below to demonstrate changes in stage.
- 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.

**Specific Conductivity of Water and Stage Level : Pumphouse Stream above Drum Lake
July 19 to September 13, 2017**

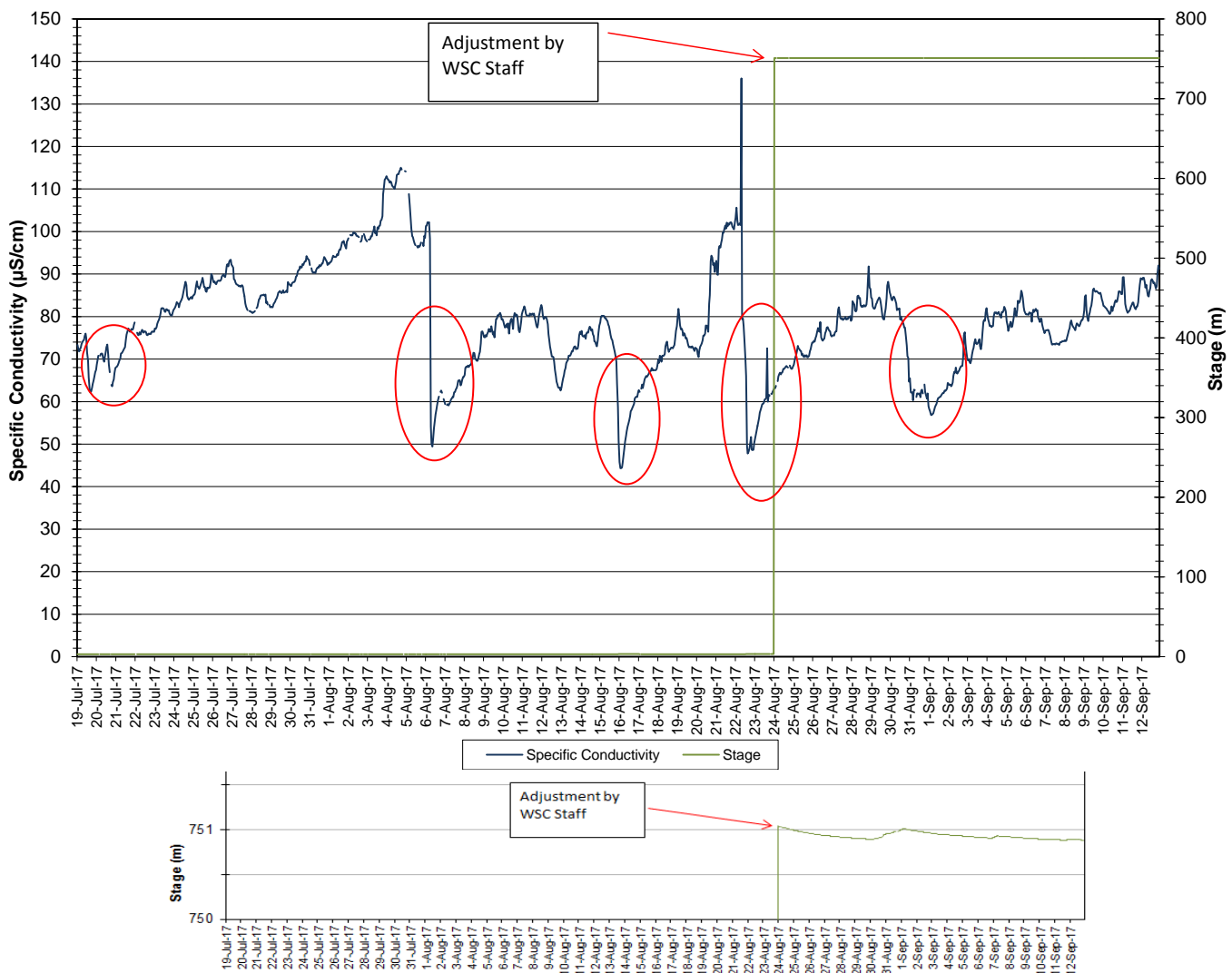


Figure 21: Specific Conductivity and Stage – Pumphouse Stream

- The saturation of dissolved oxygen ranged from 62.2 to 85.8% while the dissolved oxygen ranged from 6.84 to 9.54 mg/l with a median value of 8.27 mg/l (Figure 22).
- All values recorded at Pumphouse 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. Almost all values were below the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota of Early Life Stages of 9.5 mg/l. The guidelines are indicated in blue on Figure 22.
- Noticeable decreases in dissolved oxygen correspond with rises in temperature at the same time. They are indicated on Figure 22 in red.
- Dissolved oxygen fluctuated daily with decreases observed at night.

**Dissolved Oxygen Concentration and Saturation : Pumphouse Stream above Drum Lake
July 19 to September 13, 2017**

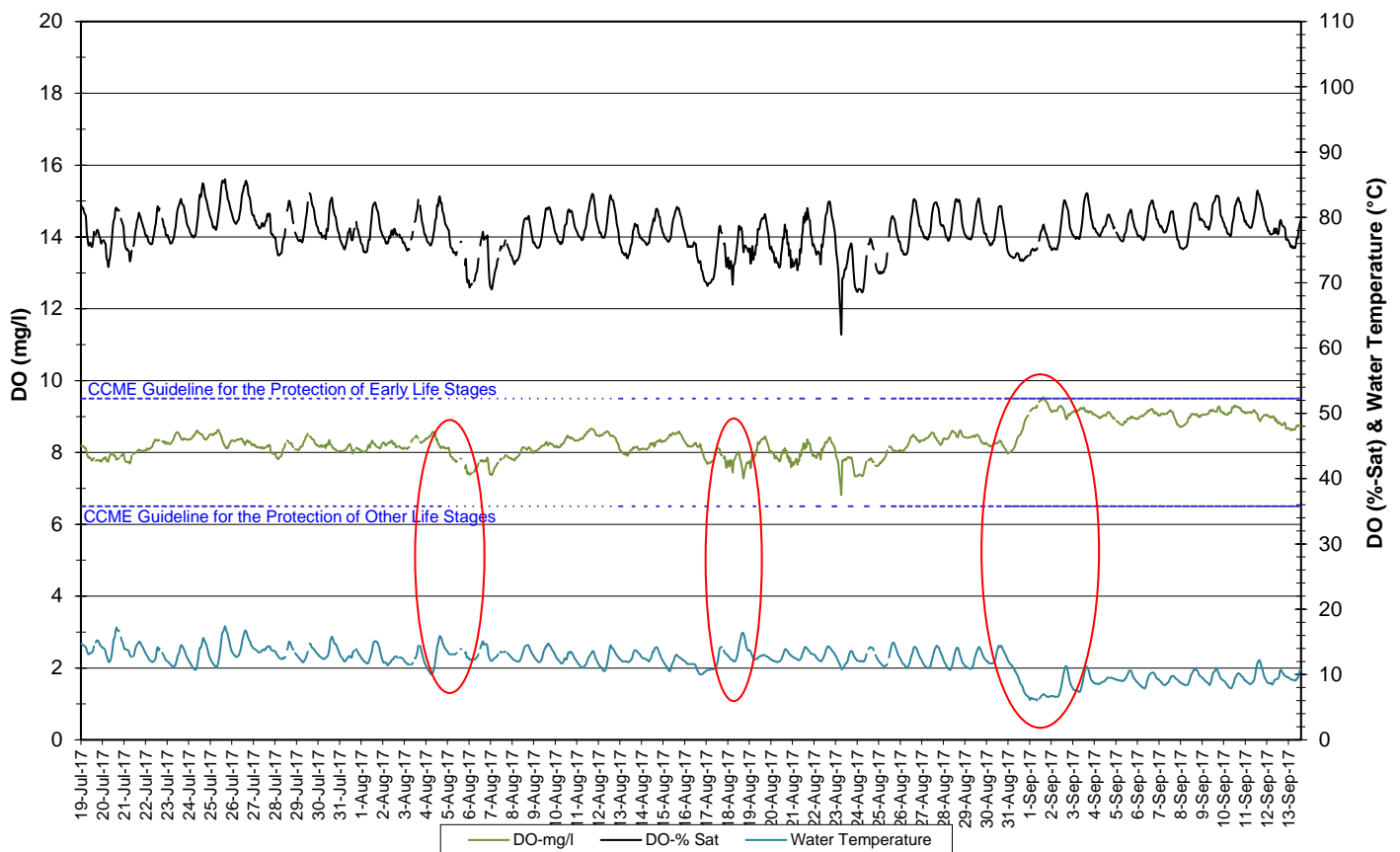


Figure 22: Dissolved Oxygen – Pumphouse Stream

- Turbidity values range from 0.0 to 737.0 NTU throughout the deployment period (Figure 23). The median value was 3.5 NTU.
- In some instances, turbidity spikes can be attributed to precipitation events. They are indicated on Figure 23 in red.

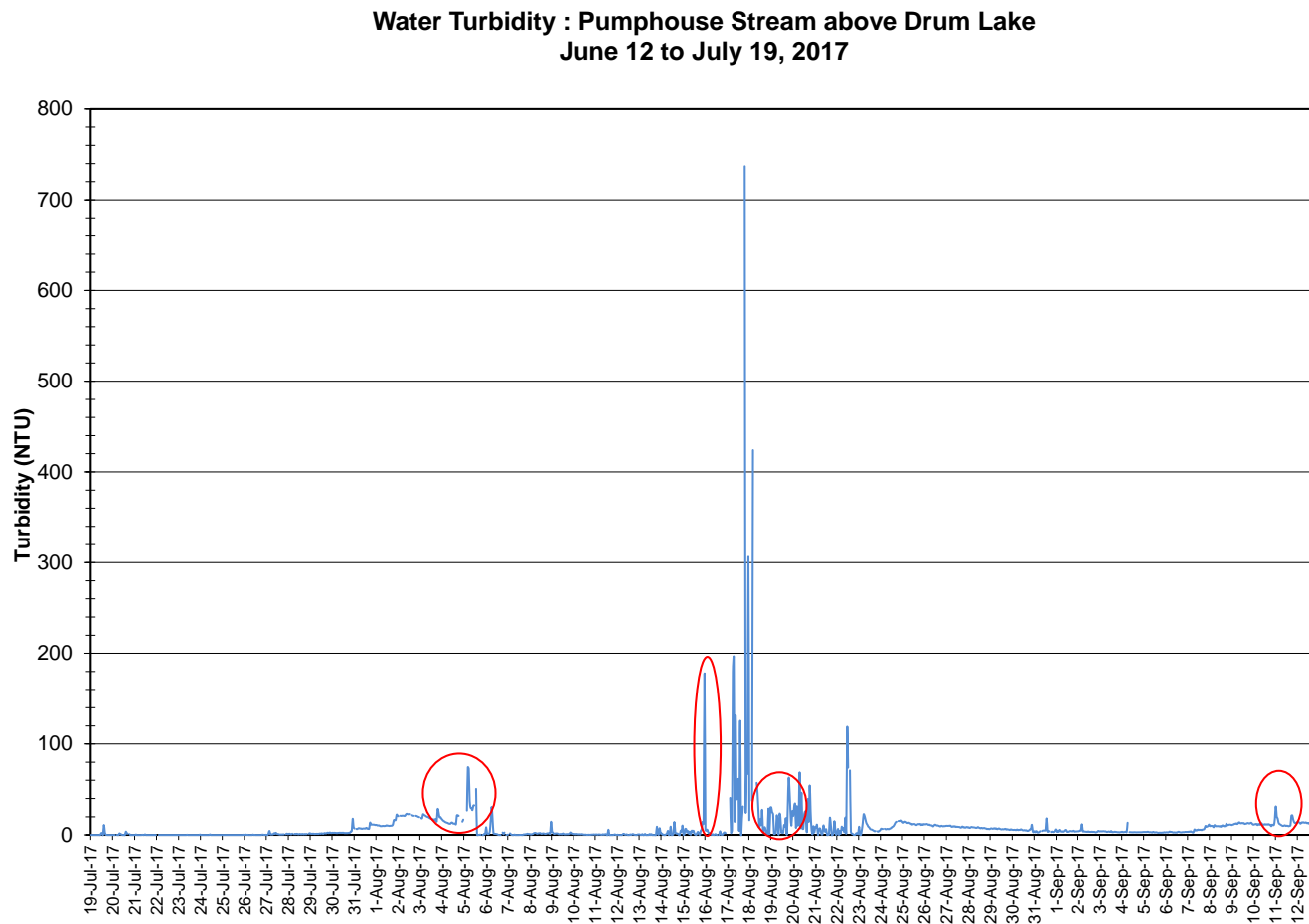


Figure 23: Turbidity – Pumphouse Stream

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Pumphouse Stream (Figure 24).
- There was a correction in stage by EC at the end of August. It is identified on Figure 24 in red.
- 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.

**Daily Precipitation and Average Daily Stage Level: Pumphouse Stream
July 19 to September 13, 2017**

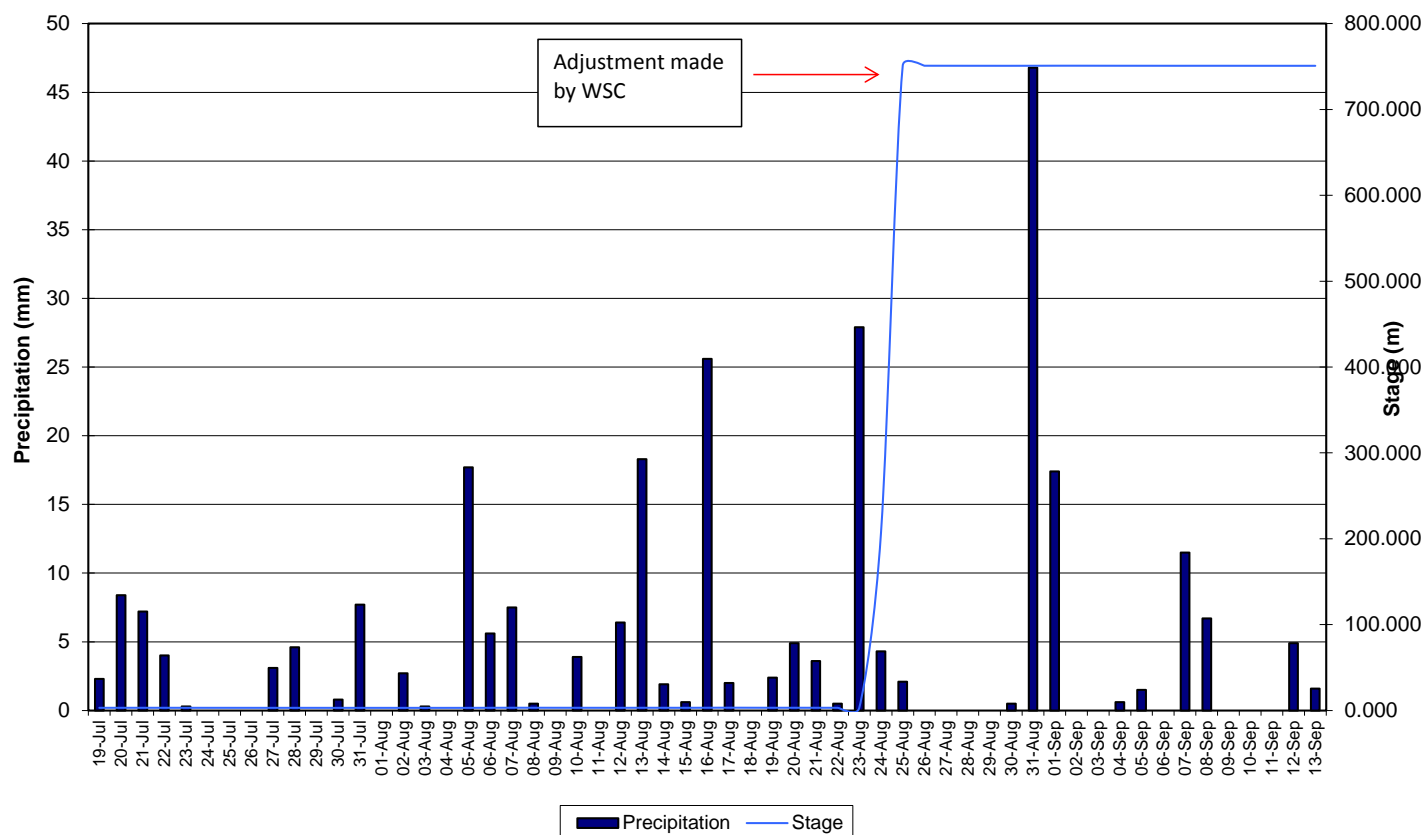


Figure 24: Precipitation and Stage –Pumphouse Stream

Conclusions

- Instruments were deployed July 19th and removed by September 13th, 2017.
- In most cases, precipitation events or increase/decreases in water level could be used to explain the data 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 Julianne Narrows, Dolomite Road and Pumphouse Stream. The temperature typically ranged between 6.00 and 18.10° C, at these three stations, while Dumbell ranged lower at 3.36 to 9.89° C.
- pH values were all within the recommended CCME Guidelines for the Protection of Aquatic Life. pH ranged between 6.88 and 8.20. Fluctuations were noted between day and night. There were some noticeable decreases in pH at Dumbell Stream due to precipitation events. A large portion of data was removed from the Pumphouse Stream dataset due to sensor drift.
- 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 42.6 µs/cm to 105.2 µs/cm at the Wabush Lake stations, 42.0 to 74.9 µs/cm at Dumbell Stream and 44.3 to 136.0 µs/cm at Pumphouse Stream.
- At all four stations, 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. When dissolved oxygen values are compared to the CCME Guideline for the Protection of Aquatic Life for Cold Water Biota at Early Life Stages of 9.5 mg/L, Dolomite Road and Pumphouse Stream were generally below the guideline while Julianne Narrows was generally above the guideline. This is not uncommon as water temperatures were warmest during this summer period. All values from Dumbell Stream were above the 9.5 mg/L guideline.
- Turbidity at Dolomite Road remained at 0.0 NTU for the majority of the deployment period. The median value was 0.0 NTU. Turbidity values at Julianne Narrows were higher than at Dolomite Road with a few large spikes.
- Turbidity at Dumbell Stream fluctuated for the majority of the deployment period. There were a few spikes during the deployment period which can be attributed to precipitation. The median value was 0.0 NTU.
- Turbidity at Pumphouse Stream had some high spikes. Several can be attributed to precipitation events. The median value was 3.5 NTU.
- Stage increased at Dolomite Road and was relatively stable at Julianne Narrows during this deployment period. Stage was relatively stable at Dumbell Stream, with small increases noted after precipitation events. At Pumphouse Stream, stage was stable and a major adjustment was performed by WSC staff in August.
- 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: Moosehead Lake
July 19 to September 13, 2017**

