Real-Time Water Quality Annual Report

Flora Creek below TLH

June 12 to
October 16, 2019

Newfoundland Labrador

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

Contents

List of Tables

List of Figures

Acknowledgements

The Real-Time Water Quality Monitoring station (RTWQ) at Flora Creek is funded by Tacora Resources, Inc. The program is a joint partnership between Tacora Resources, Environment and Climate Change Canada (ECCC), and the Newfoundland & Labrador Department of Municipal Affairs and Environment (MAE).

Various individuals from each sector have been diligently involved to ensure this program is a successful operation including, various WRMD staff (MAE), Mike Twite (Tacora Resources, Inc.), and various WSC staff (ECCC). In addition to these managers, there have been a team of individuals who work together to ensure the day to day operation of this station is providing quality data. Maria Murphy (MAE) was responsible for this water quality station during 2019; responsibilities included deployment and removal of the instrument, maintenance and calibration of the instrument and preparation of monthly deployment reports. Brenda Congram (MAE) is acknowledged for her assistance during deployment and removal procedures in 2019.

ECCC 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 station regularly to ensure that the data logging and data transmitting equipment is working properly. ECCC is also the lead on dealing with water stage and flow issues.

Introduction

- The real-time water quality monitoring station on Flora Creek was established during the summer of 2014 as a partnership between the Newfoundland & Labrador Department of Municipal Affairs and Environment (MAE) and Cliffs Natural Resources. In 2017, the mine was sold and the partnership transferred to Tacora Resources and the Newfoundland & Labrador Department of Municipal Affairs and Environment.
- The official name of the station is Flora Creek below TLH, also referred to as the Flora Creek station.
- This station measures water quality parameters water temperature, pH, specific conductivity, dissolved oxygen and turbidity, as well as water quantity parameters stage and flow. Parameters are recorded on an hourly basis during the deployment period.

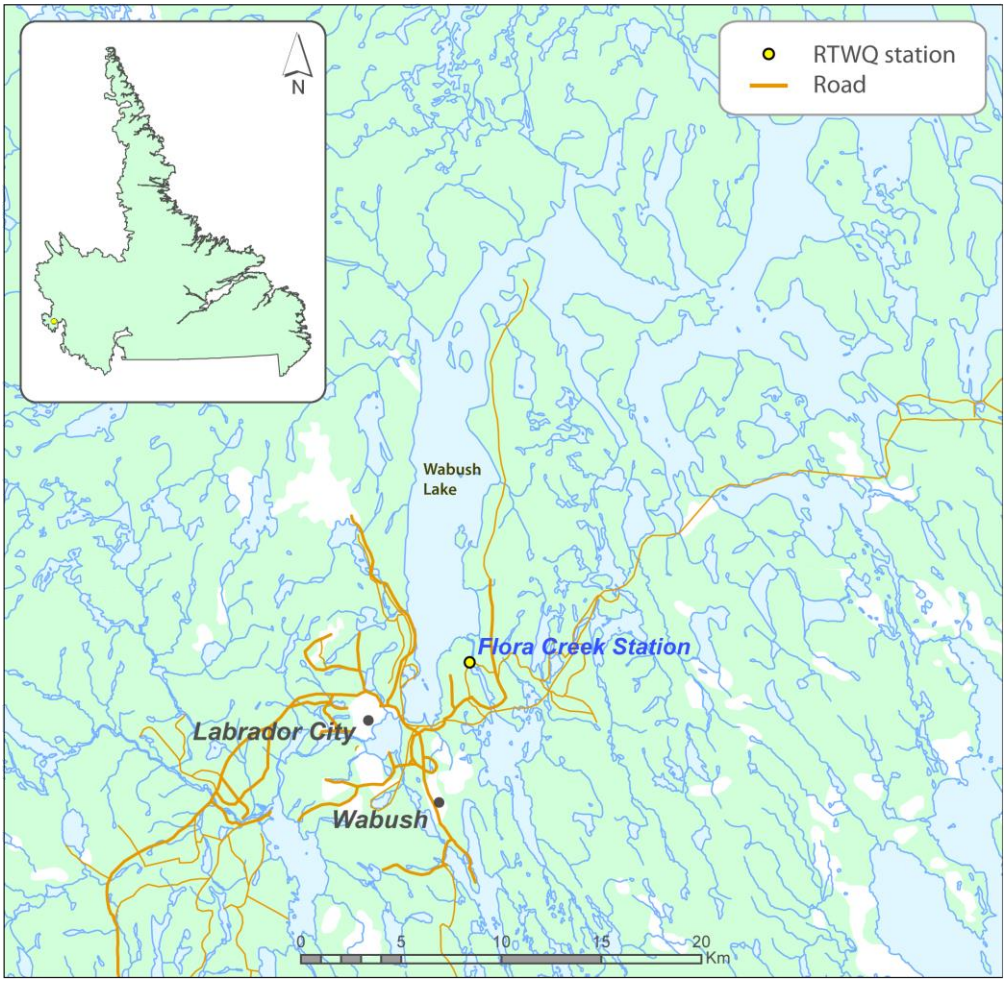


Figure 1: Map of Western Labrador area showing the RTWQ Flora Creek station.

- The purpose of this network is to monitor, process, and distribute water quality/quantity data to Tacora Resources, MAE and ECCC, for assessment and management of water resources, as well as to provide an early warning for any potential or emerging water issues. Therefore, mitigative measures can be implemented in a timely manner.
- MAE provides Tacora Resources with monthly and annual deployment reports. Data is available in near real-time on the Department of Municipal Affairs and Environment's website.
- A RTWQ monitoring instrument has been deployed at this station each season since 2014, near a continuously evolving mine site. There are some small gaps in data on the graphs included in this report. Unless otherwise stated, these gaps indicate the time frame where the instrument was removed from the water for calibration and maintenance.
- The initial deployment for the 2019 season was on June 12th. The instrument was removed for the winter season on October 16th. The following report depicts and discusses water quality events throughout this time period.

Maintenance and Calibration

- To ensure accurate data collection, maintenance and calibration of the water quality instrumentation is performed normally approximately every 45 days.
- 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, MAE staff carefully calibrate each sensor attachment for pH, specific conductivity, dissolved oxygen and turbidity to ensure accurate data collection.
- Installation and removal dates for the 2019 season are summarized in the table below.

Table 1: Water quality instrument deployment start and end dates for 2019

Installation	Removal	Deployment duration (days)
June 12	July 16	34
July 16	August 28	41
August 28	October 16	49

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 adjacent to 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

	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. Since 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 Flora Creek water quality station for the three deployment periods from June 12th to October 16th, 2019, are summarized in Table 3.
- For additional information and explanations of rankings, please refer to the 2019 monthly deployment reports.

Table 3: QA/QC comparison rankings for Flora Creek June 12 – October 16, 2019

	Date		Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Flora Creek	12-Jun-19	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	16-Jul-19	Removal	Good	Good	Excellent	Excellent	Excellent
	16-Jul-19	Deployment	Excellent	Good	Excellent	Fair	Excellent
	28-Aug-19	Removal	Excellent	Excellent	Excellent	Fair	Excellent
	28-Aug-19	Deployment	Excellent	Fair	Excellent	Excellent	Poor
	16-Oct-19	Removal	Excellent	Good	Excellent	Excellent	Excellent

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 12th, 2019 to October 16th, 2019 at Flora Creek.
- 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.

Flora Creek below TLH

- Water temperature ranged from 4.53 to 22.52°C during the 2019 deployment season. The median value was 13.98 °C (Figure 2).
- Water temperature increases at the beginning of the season and decreases during the later portion of the season; this is expected as ambient air temperature is warmer in the summer and cooler in the fall.

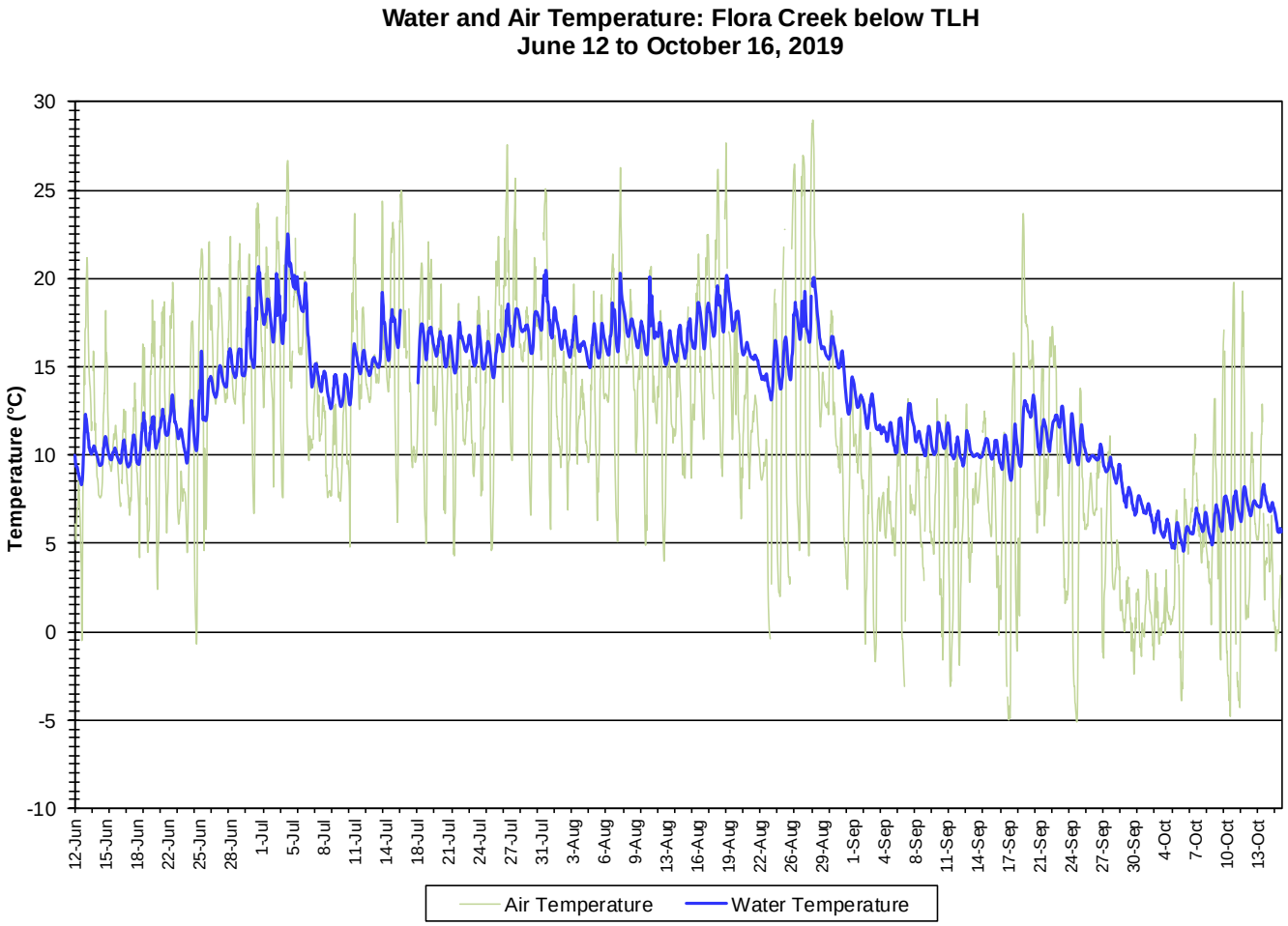


Figure 2: Water and Air Temperature – Flora Creek below TLH

(Weather data collected from climate station near Moosehead Lake)

- pH ranges from 7.02 to 7.80 pH units at Flora Creek, throughout the 2019 deployment season(Figure 3). The median pH is 7.51.
- There is a noticeable rise in pH during the first few days of the first deployment period, for unknown reasons. pH values did return to normal. This event is identified on the graph (Figure 3) in red.
- pH increases slightly over the course of the 2019 deployment season. pH fluctuates daily. 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).

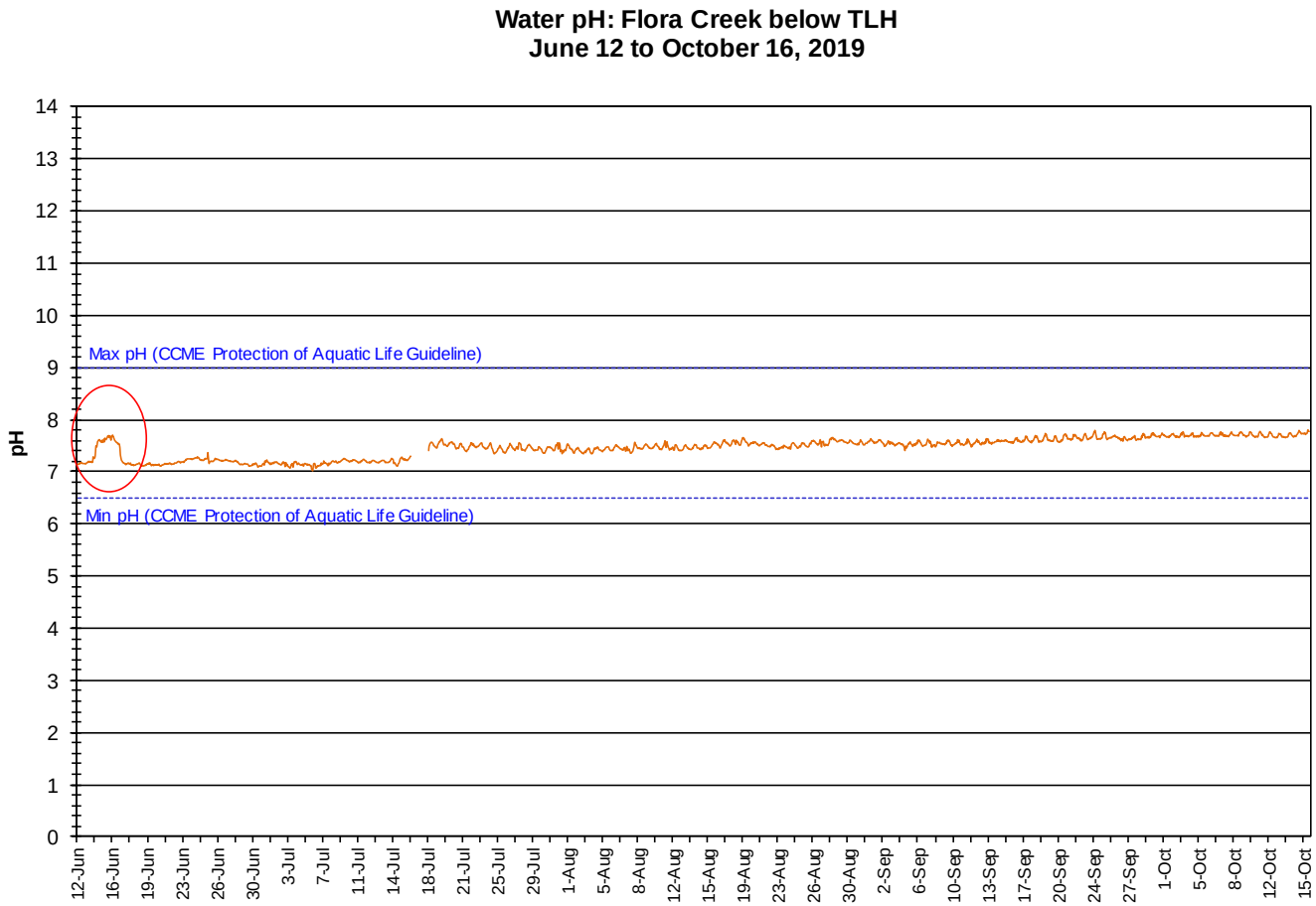


Figure 3: pH – Flora Creek below TLH

- Throughout the 2019 deployment season, specific conductivity ranged from 52.6 to 64.2 µs/cm, with a median value of 59.8 µs/cm at Flora Creek (Figure 4).
- Conductivity increased overall during the 2019 deployment season.
- 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.

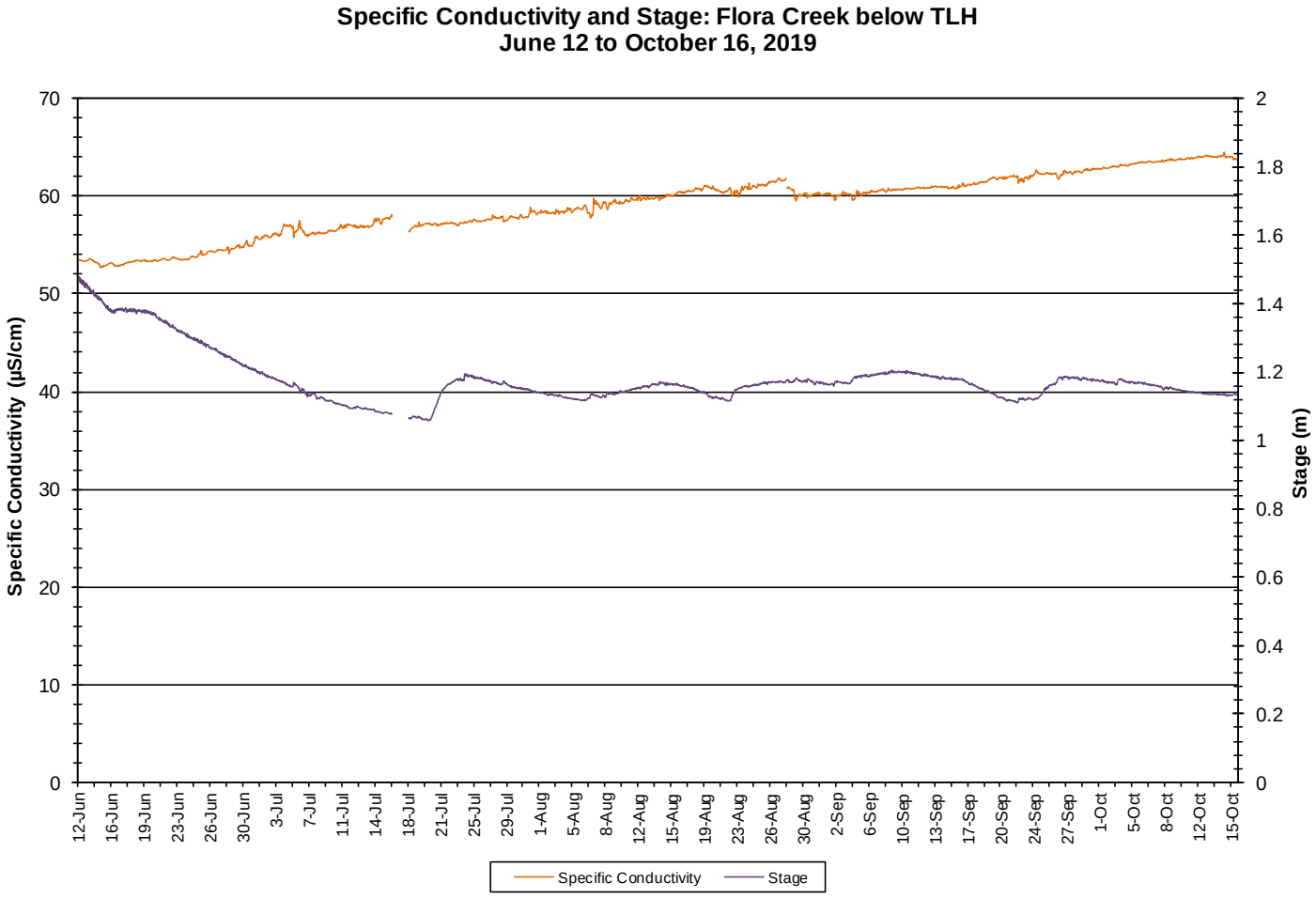


Figure 4: Specific Conductivity and Stage – Flora Creek below TLH

- The saturation of dissolved oxygen ranged from 87.6 to 104.5%, while the dissolved oxygen content ranged from 8.28 to 11.87 mg/l, with a median value of 9.73 mg/l (Figure 5).
- Dissolved oxygen fluctuated daily with decreases observed at night.
- Dissolved oxygen decreases during the first portion of the deployment season when water temperature increases. It then increases during the last deployment period of the season, when water temperatures cool into 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. The majority of 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. The guidelines are indicated in blue on Figure 5.

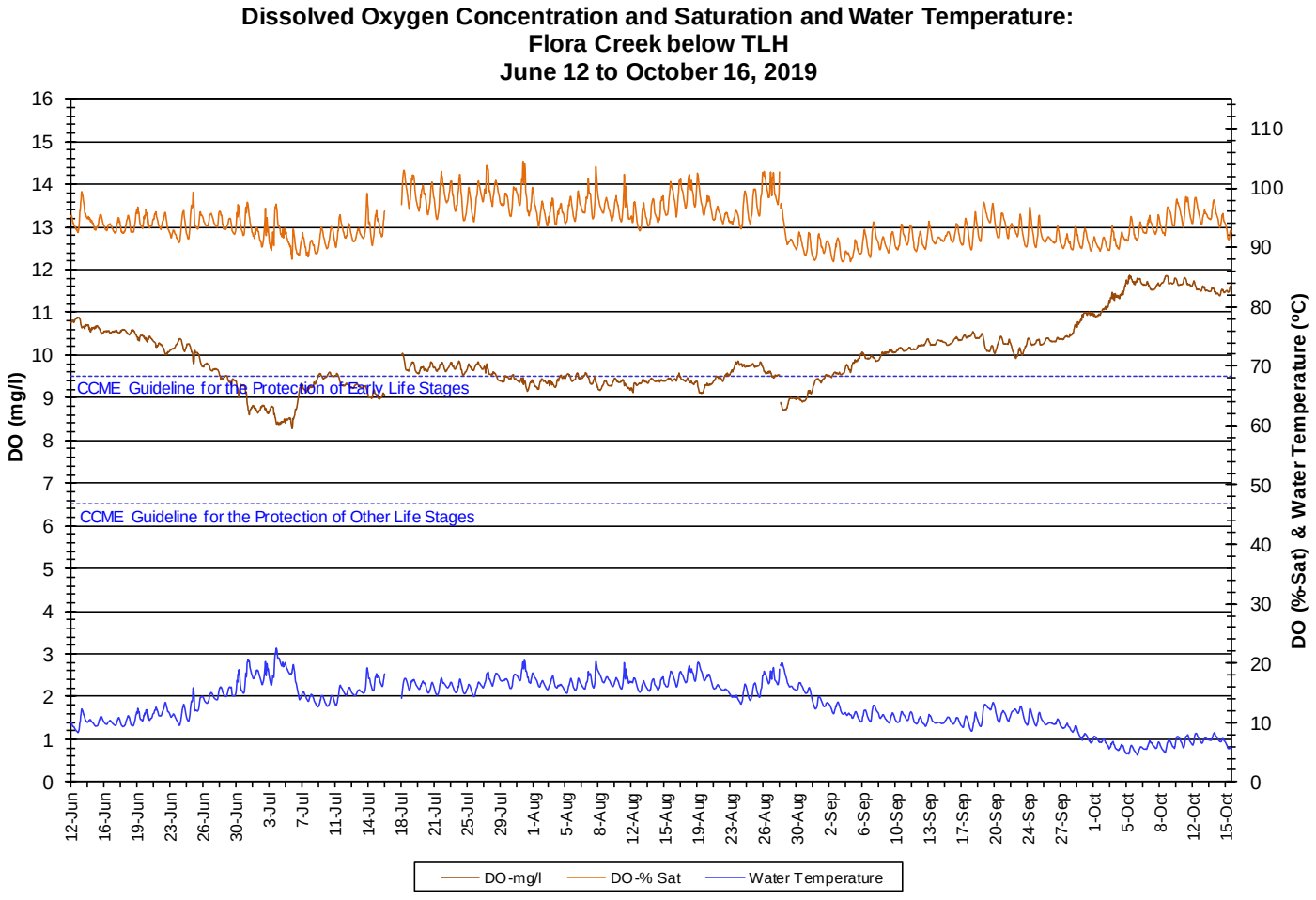


Figure 5: Dissolved Oxygen Concentration and Saturation and Water Temperature – Flora Creek below TLH

- At the Flora Creek station, turbidity values range from 26.0 to 440.2 NTU with a median value of 79.6 NTU (Figure 6). This station was somewhat turbid for the entire season.
- Turbidity at the beginning of the season was very high and decreased over time; this was due to the late winter melt/freshet. This is a typical trend noticed each year since the instrument was first deployed in 2014.
- After the significant decrease in the beginning of the season, turbidity readings were generally below 100 NTU with some spikes noted after significant precipitation events.

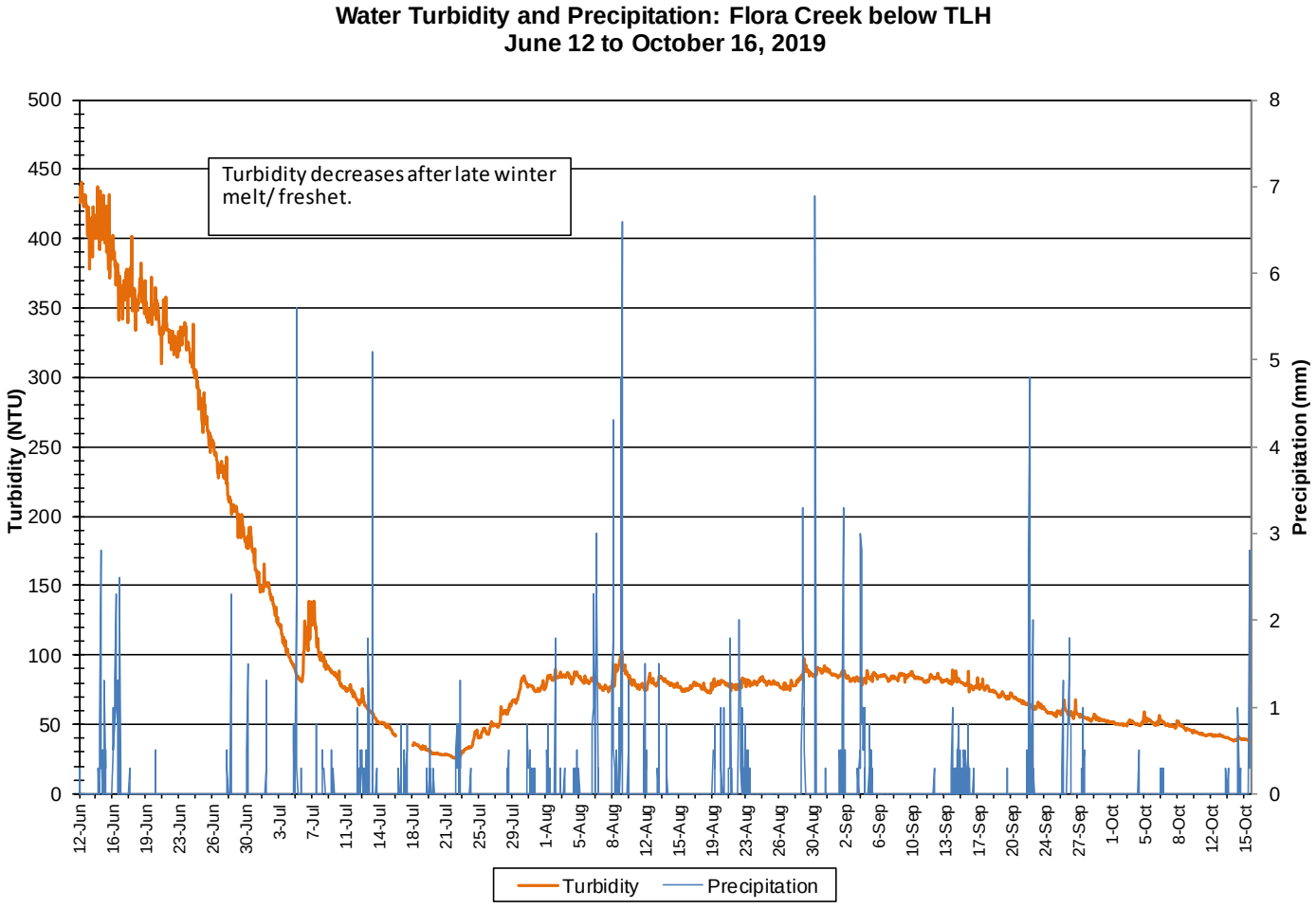


Figure 6: Turbidity and Precipitation - Flora Creek below TLH

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Flora Creek (Figure 7).
- Stage decreases during the first deployment; it then fluctuates within a small range with varying precipitation levels.
- 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.

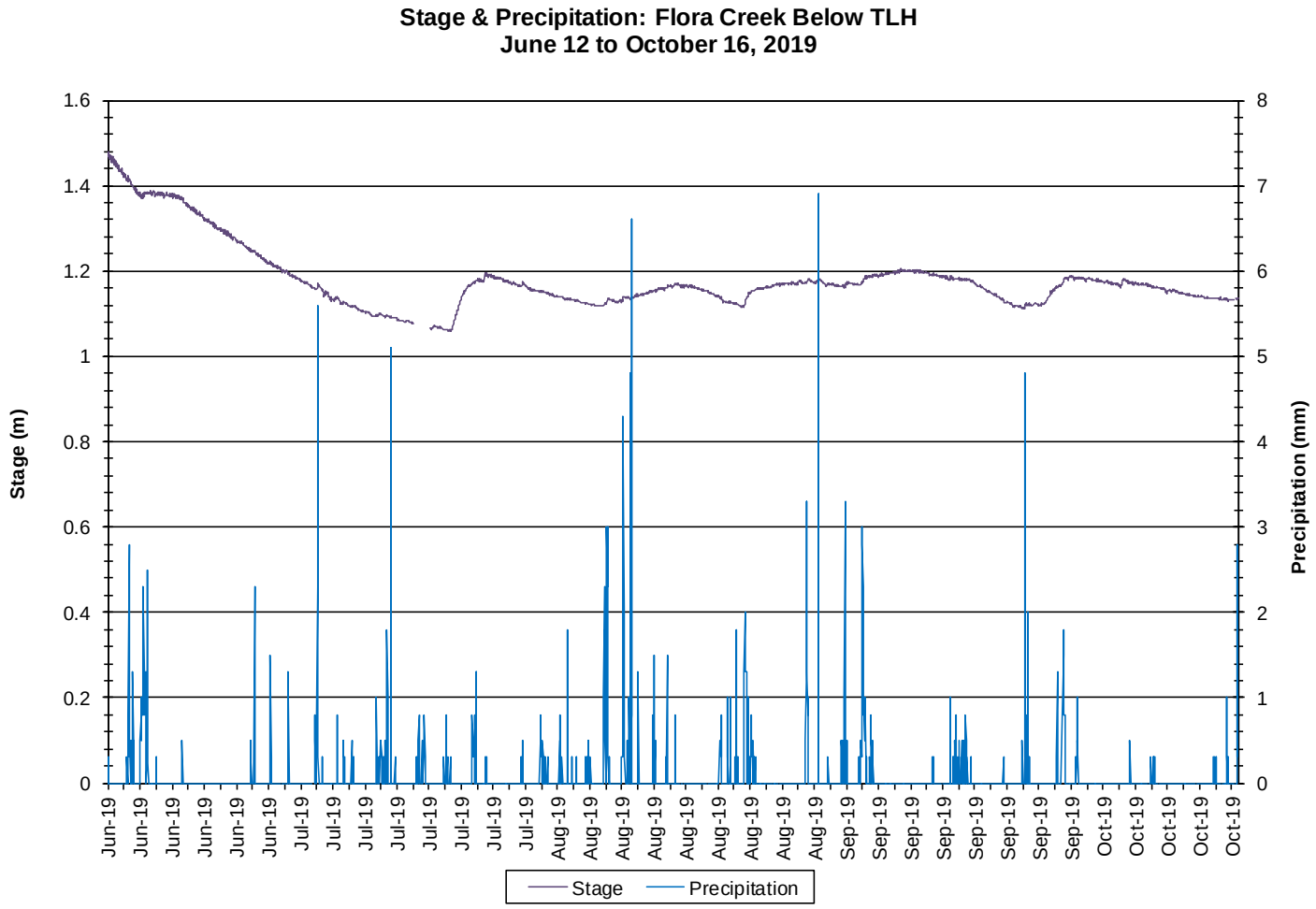


Figure 7: Stage and Precipitation - Flora Creek below TLH

(Weather data collected from climate station near Moosehead Lake)

Conclusions

- The instrument at the water quality monitoring station on Flora Creek was deployed on June 12th, 2019 and removed on October 16th, 2019 for the winter season.
- Deployment periods ranged from 34 to 49 days.
- In most cases, weather related events or increases/decreases in water level explain the data fluctuations.
- Most values recorded were within ranges as suggested by the CCME Water Quality Guidelines for the Protection of Aquatic Life.
- The instrument performed well for the 2019 season with no issues.
- 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 increased during the 2019 deployment season.
- When the water was warmest, 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. 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.
- This station tends to have high turbidity values. As usual, a decrease was noted after the late winter melt/freshet.

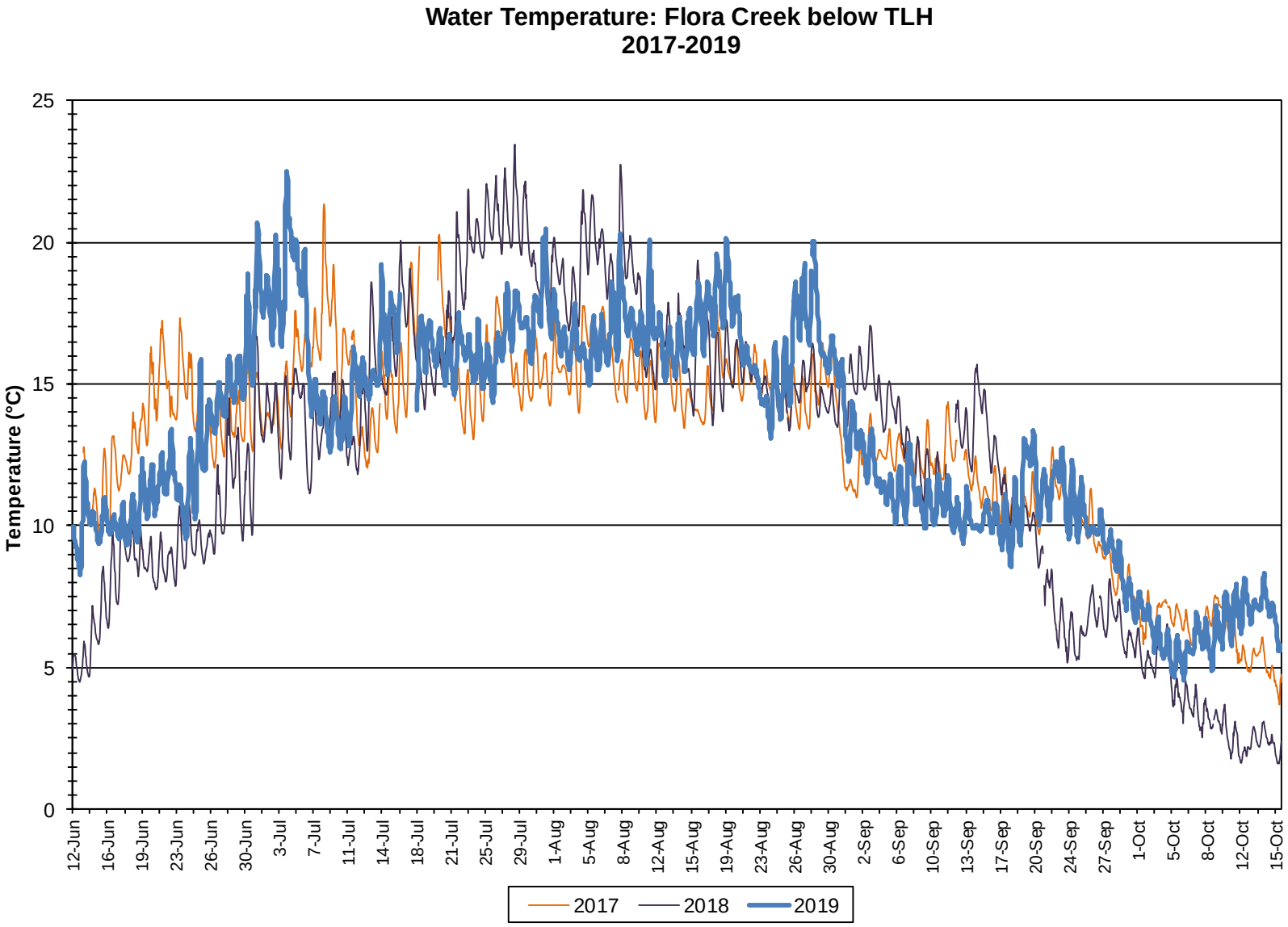
Path Forward

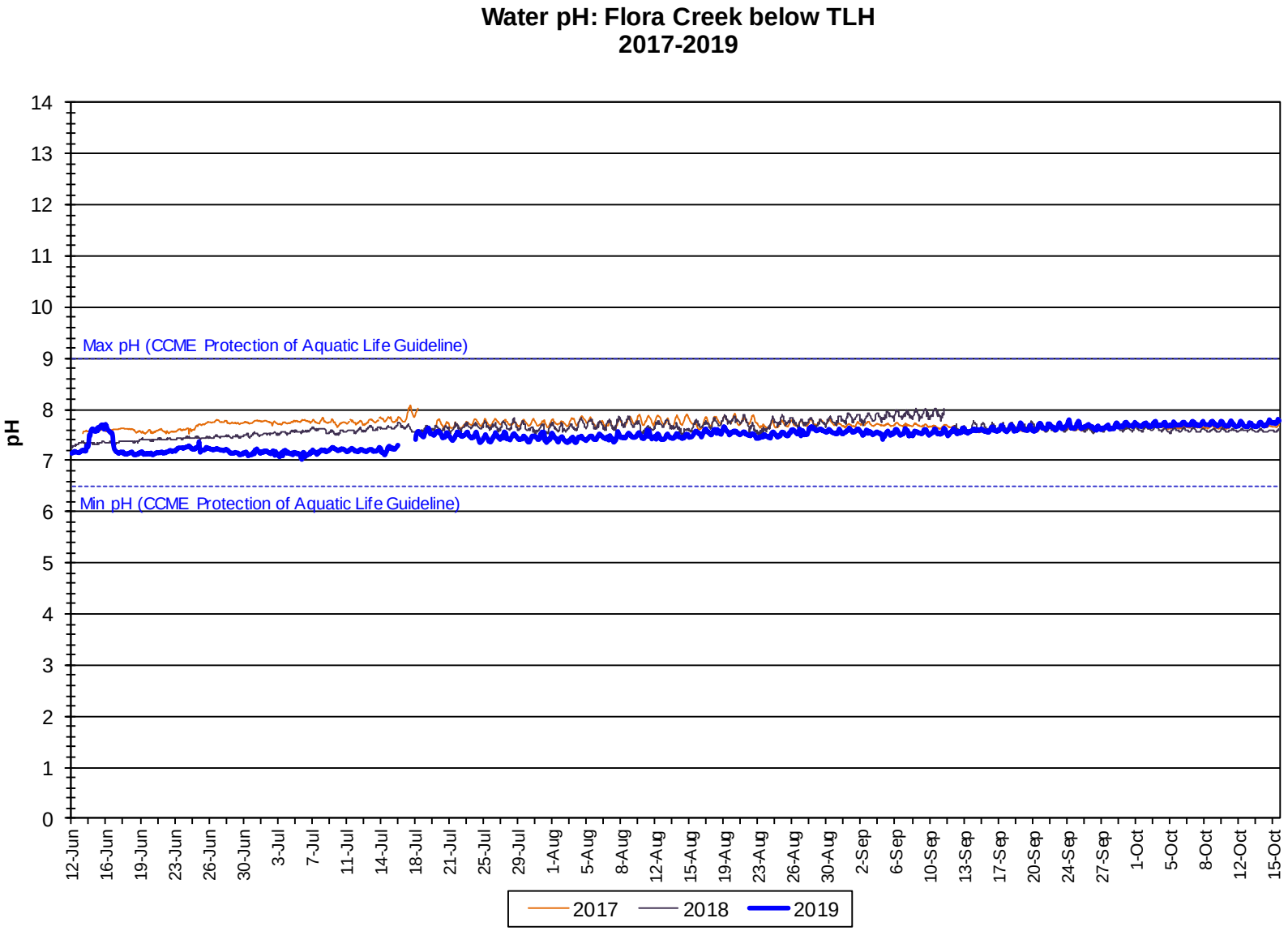
- The field instrument will undergo proficiency testing and evaluation during the winter of 2019-2020. MAE will inform Tacora Resources of any instrument performance issues.
- MAE staff will deploy real time water quality instruments in spring 2020, when ice conditions allow and perform regular site visits throughout the 2020 deployment season for calibration and maintenance of the instruments.
- If necessary, deployment techniques will be evaluated and modified, ensuring secure and suitable conditions for RTWQ monitoring.
- MAE will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- Open communication lines will continue to be maintained between MAE, ECCC and Tacora Resources in order to respond to emerging issues on a proactive basis. Tacora Resources will receive monthly deployment reports and an annual report, summarizing the events of the deployment season.

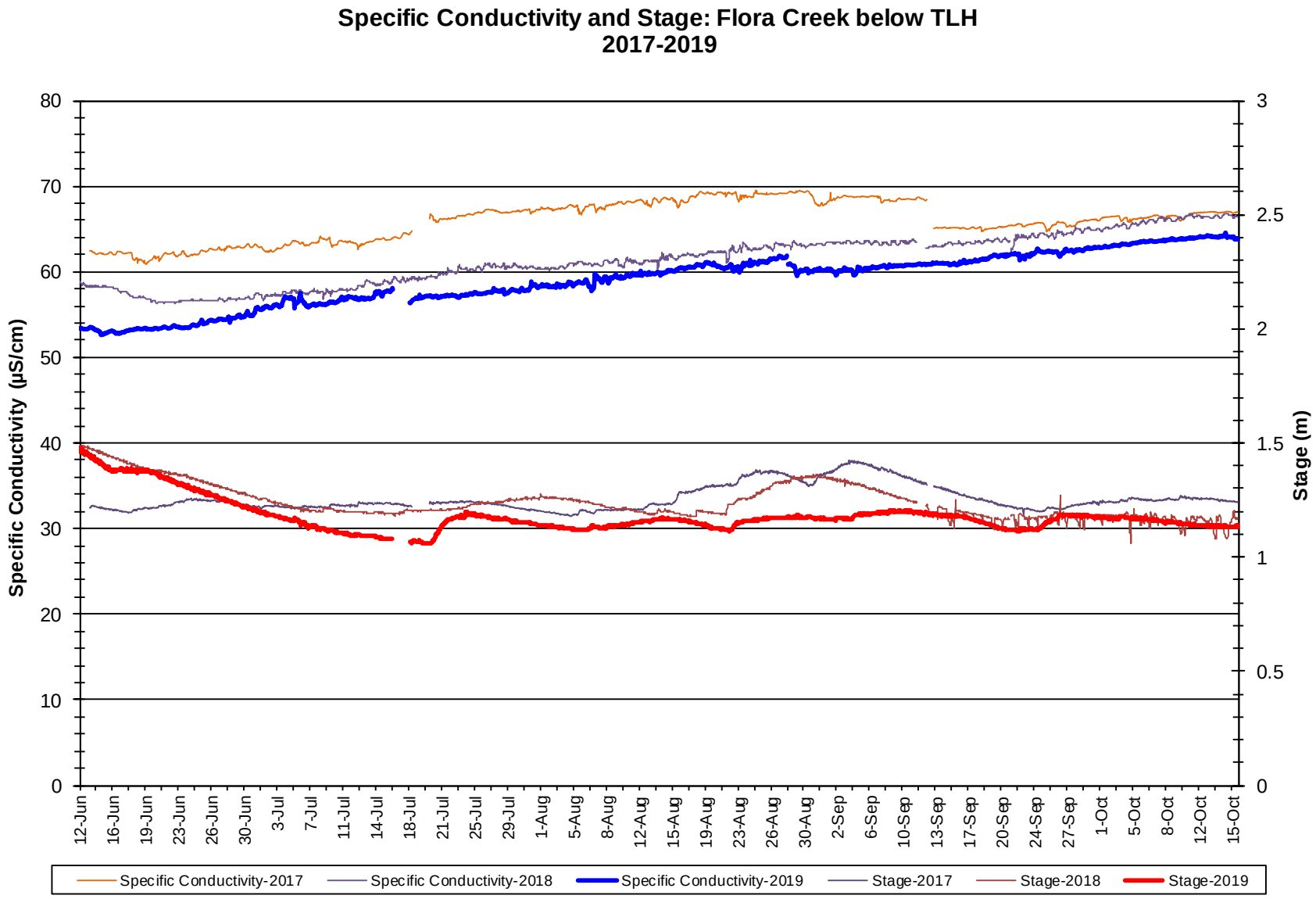
Prepared by:
Maria Murphy
Department of Municipal Affairs and Environment
Water Resources Management Division
Phone: 709.896.7981

Appendix 1

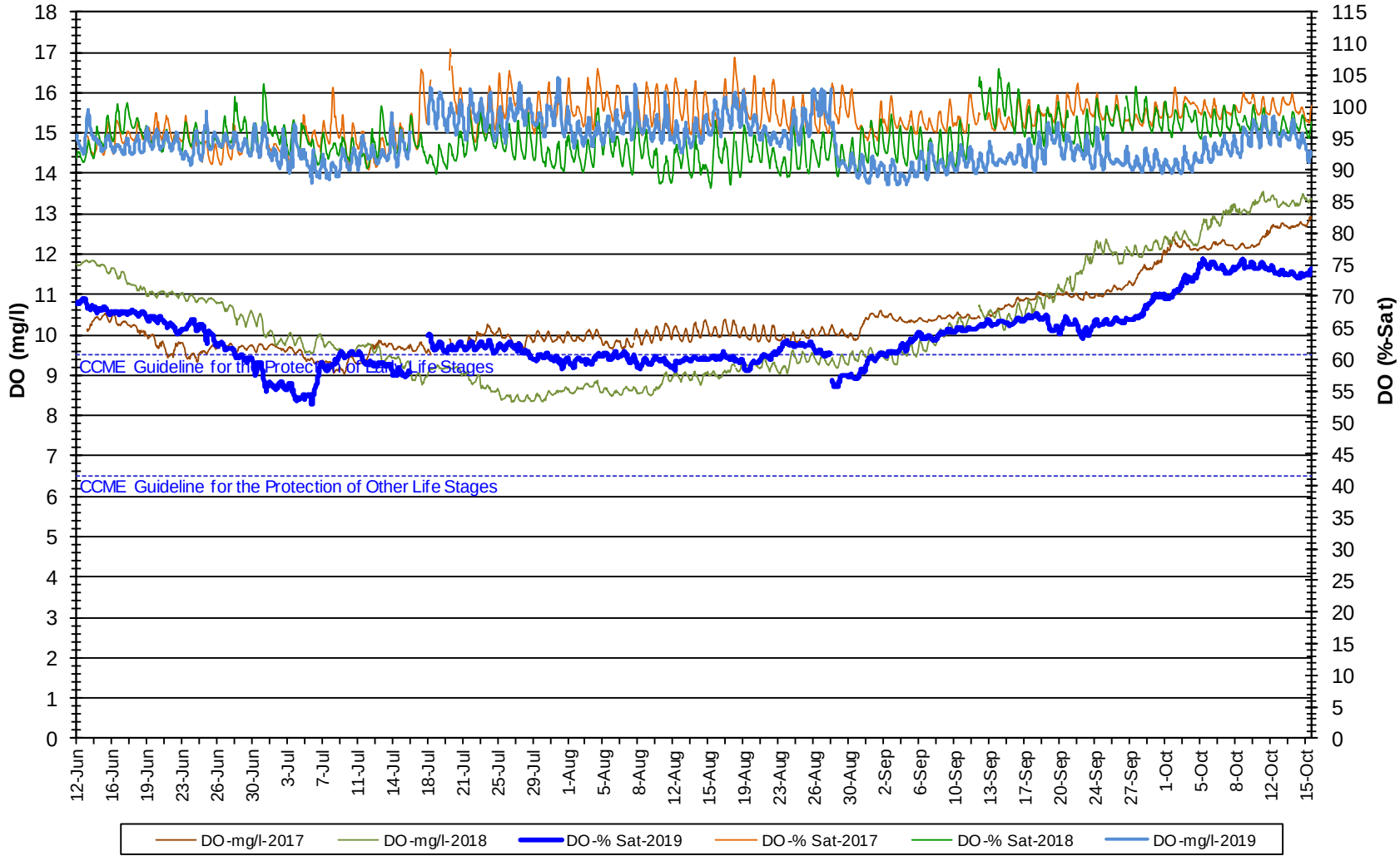
3 Year Comparisons

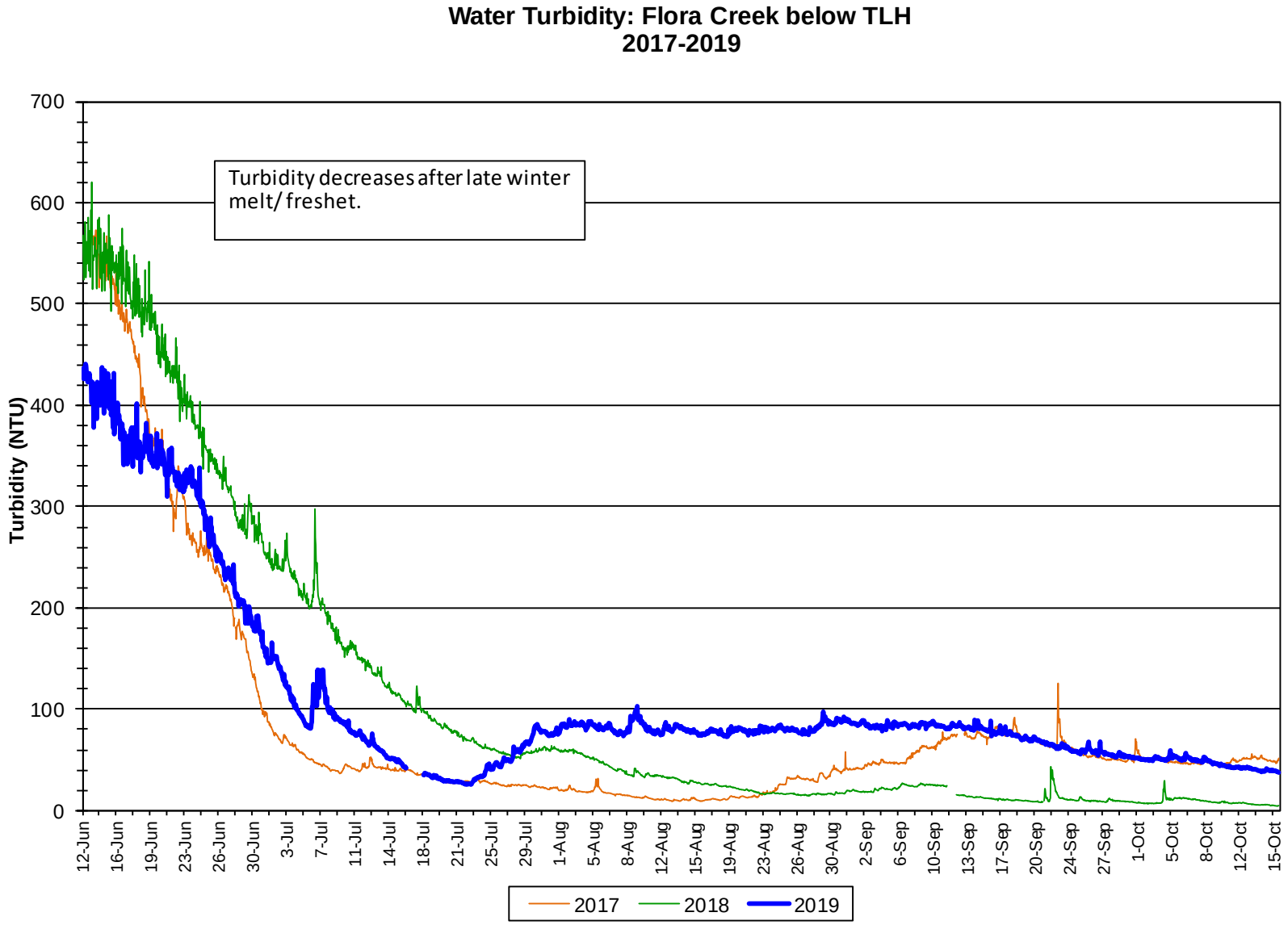

Water Temperature: Flora Creek below TLH
2017-2019
Temperature (°C)
25
20
15
10
5
0
12-Jun
16-Jun
19-Jun
23-Jun
26-Jun
30-Jun
3-Jul
7-Jul
11-Jul
14-Jul
18-Jul
21-Jul
25-Jul
29-Jul
1-Aug
5-Aug
8-Aug
12-Aug
15-Aug
19-Aug
23-Aug
26-Aug
30-Aug
2-Sep
6-Sep
10-Sep
13-Sep
17-Sep
20-Sep
24-Sep
27-Sep
1-Oct
5-Oct
8-Oct
12-Oct
15-Oct
2017
2018
2019


Water pH: Flora Creek below TLH
2017-2019
pH
Max pH (CCME Protection of Aquatic Life Guideline)
Min pH (CCME Protection of Aquatic Life Guideline)
2017
2018
2019

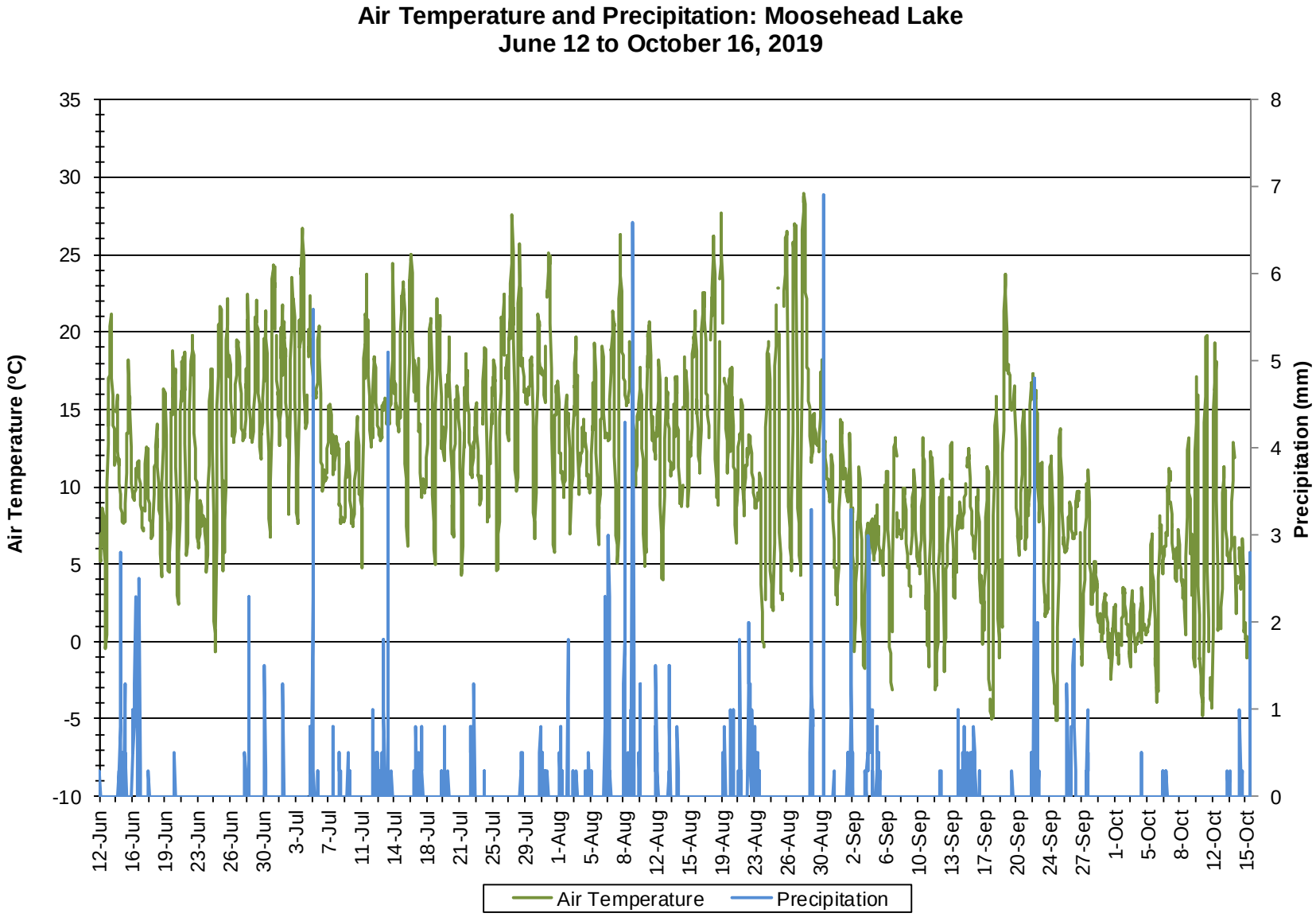

Specific Conductivity and Stage: Flora Creek below TLH
2017-2019
Specific Conductivity (µS/cm)
Stage (m)
0
10
20
30
40
50
60
70
80
0
0.5
1
1.5
2
2.5
3
12-Jun
16-Jun
19-Jun
23-Jun
26-Jun
30-Jun
3-Jul
7-Jul
11-Jul
14-Jul
18-Jul
21-Jul
25-Jul
29-Jul
1-Aug
5-Aug
8-Aug
12-Aug
15-Aug
19-Aug
23-Aug
26-Aug
30-Aug
2-Sep
6-Sep
10-Sep
13-Sep
17-Sep
20-Sep
24-Sep
27-Sep
1-Oct
5-Oct
8-Oct
12-Oct
15-Oct
Specific Conductivity-2017
Specific Conductivity-2018
Specific Conductivity-2019
Stage-2017
Stage-2018
Stage-2019

Dissolved Oxygen Concentration and Saturation: Flora Creek below TLH
2017-2019




Water Turbidity: Flora Creek below TLH
2017-2019
Turbidity decreases after late winter melt/ freshet.
Turbidity (NTU)
700
600
500
400
300
200
100
0
12-Jun
16-Jun
19-Jun
23-Jun
26-Jun
30-Jun
3-Jul
7-Jul
11-Jul
14-Jul
18-Jul
21-Jul
25-Jul
29-Jul
1-Aug
5-Aug
8-Aug
12-Aug
15-Aug
19-Aug
23-Aug
26-Aug
30-Aug
2-Sep
6-Sep
10-Sep
13-Sep
17-Sep
20-Sep
24-Sep
27-Sep
1-Oct
5-Oct
8-Oct
12-Oct
15-Oct
2017
2018
2019

Appendix 2
Air Temperature and Precipitation


Air Temperature and Precipitation: Moosehead Lake
June 12 to October 16, 2019
Air Temperature (°C)
Precipitation (mm)
35
30
25
20
15
10
5
0
-5
-10
8
7
6
5
4
3
2
1
0
12-Jun
16-Jun
19-Jun
23-Jun
26-Jun
30-Jun
3-Jul
7-Jul
11-Jul
14-Jul
18-Jul
21-Jul
25-Jul
29-Jul
1-Aug
5-Aug
8-Aug
12-Aug
15-Aug
19-Aug
23-Aug
26-Aug
30-Aug
2-Sep
6-Sep
10-Sep
13-Sep
17-Sep
20-Sep
24-Sep
27-Sep
1-Oct
5-Oct
8-Oct
12-Oct
15-Oct
Air Temperature
Precipitation