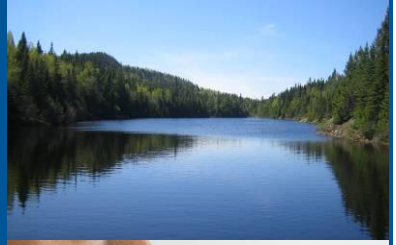







Real-Time Water Quality Annual Report

Flora Creek below TLH

June 7 to
October 19, 2022

Newfoundland Labrador

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

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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 Environment & Climate Change (ECC).

Various individuals from each sector have been diligently involved to ensure this program is a successful operation including, various WRMD staff (ECC), Sharlene Baird and Katherine Jacobs (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 (ECC) was responsible for this water quality station during 2022; responsibilities included deployment and removal of the instrument, maintenance and calibration of the instrument and preparation of monthly deployment reports. Brandon Mesher (ECC) is acknowledged for his assistance during deployment and removal procedures in 2022.

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 Environment and Climate Change and Cliffs Natural Resources. In 2017, the mine was sold and the partnership transferred to Tacora Resources and the Newfoundland & Labrador Department of Environment, Climate Change & Municipalities (currently ECC).
- 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.

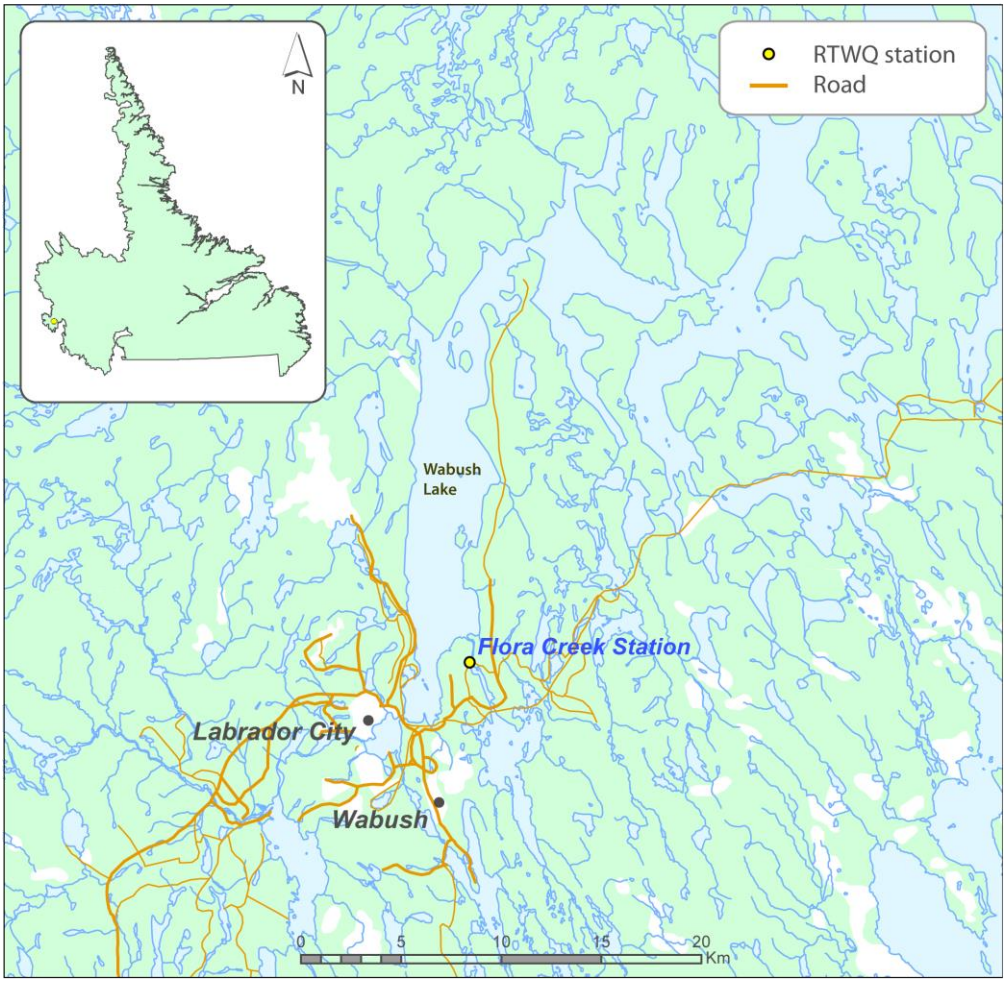

Figure 1: Map of Western Labrador area showing the RTWQ Flora Creek station.

- The purpose of this network is to monitor, process, and distribute water quality/quantity data to Tacora Resources, ECC and ECCC, for assessment and management of water resources, as well as to provide an early warning for any potential or emerging water issues so that mitigative measures can be implemented in a timely manner.
- ECC provides Tacora Resources with monthly and annual deployment reports. Data is available in near real-time on the Department of Environment & Climate Change's website.
- A RTWQ monitoring instrument has been deployed at this station each season since 2014, near a continuously evolving mine site. Unless otherwise stated, small gaps on graphs indicate the time frame where the instrument was removed from the water for calibration and maintenance.
- The initial deployment for the 2022 season was on June 7th. The instrument was removed for the winter season on October 19th. The following report depicts and discusses water quality events throughout this time period.
- The station did not transmit water quality data in real time for a large portion of this deployment season. Troubleshooting was performed on each trip and after a number of potential issues were eliminated, the station started transmitting in real time again, as of September 30, 2022.

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, ECC 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 2022 season are summarized in the table below.

Table 1: Water quality instrument deployment start and end dates for 2022

Installation	Removal	Deployment duration (days)
June 7	July 20	43
July 20	September 8	50
September 8	October 19	41

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 dependent, 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 two deployment periods from June 7 to October 19, 2022, are summarized in Table 3.
- For additional information and explanations of rankings, please refer to the 2022 monthly deployment reports.

Table 3: QA/QC comparison rankings for Flora Creek June 7 to October 19, 2022

	Date		Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Flora Creek	7-Jun-22	Deployment	Good	Good	Excellent	Excellent	N/A
	20-Jul-22	Removal	Excellent	Good	Excellent	Excellent	Excellent
	20-Jul-22	Deployment	Excellent	Excellent	Excellent	Excellent	Good
	8-Sep-22	Removal	Excellent	Fair	Excellent	Excellent	Fair
	8-Sep-22	Deployment	Excellent	Excellent	Excellent	Excellent	Good
	19-Oct-22	Removal	Excellent	Good	Good	Marginal	Fair

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from June 7th, 2022 to October 19th, 2022 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 4.80 to 21.81ºC during the 2022 deployment season. The median value was 14.53 ºC (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 and water temperature followed the air temperature trends.

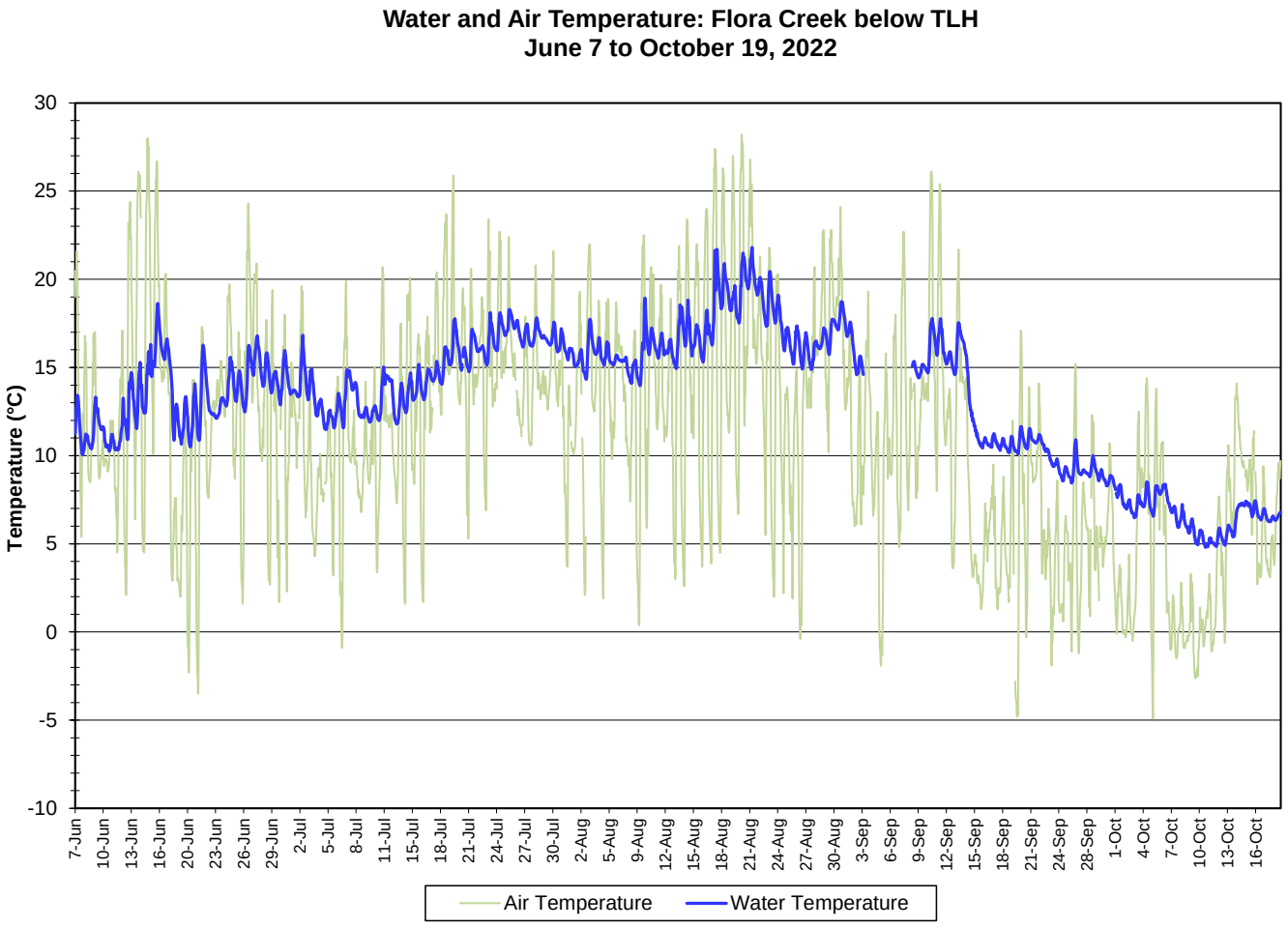

Figure 2: Water and Air Temperature – Flora Creek below TLH

(Weather data collected from climate station near Moosehead Lake)

- pH ranges from 7.17 to 8.05 pH units at Flora Creek, throughout the 2022 deployment season (Figure 3). The median pH is 7.69.
- pH increased slightly during the first deployment and then decreased slightly during the remainder of the deployment season. This may be due to a slight calibration error. 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).

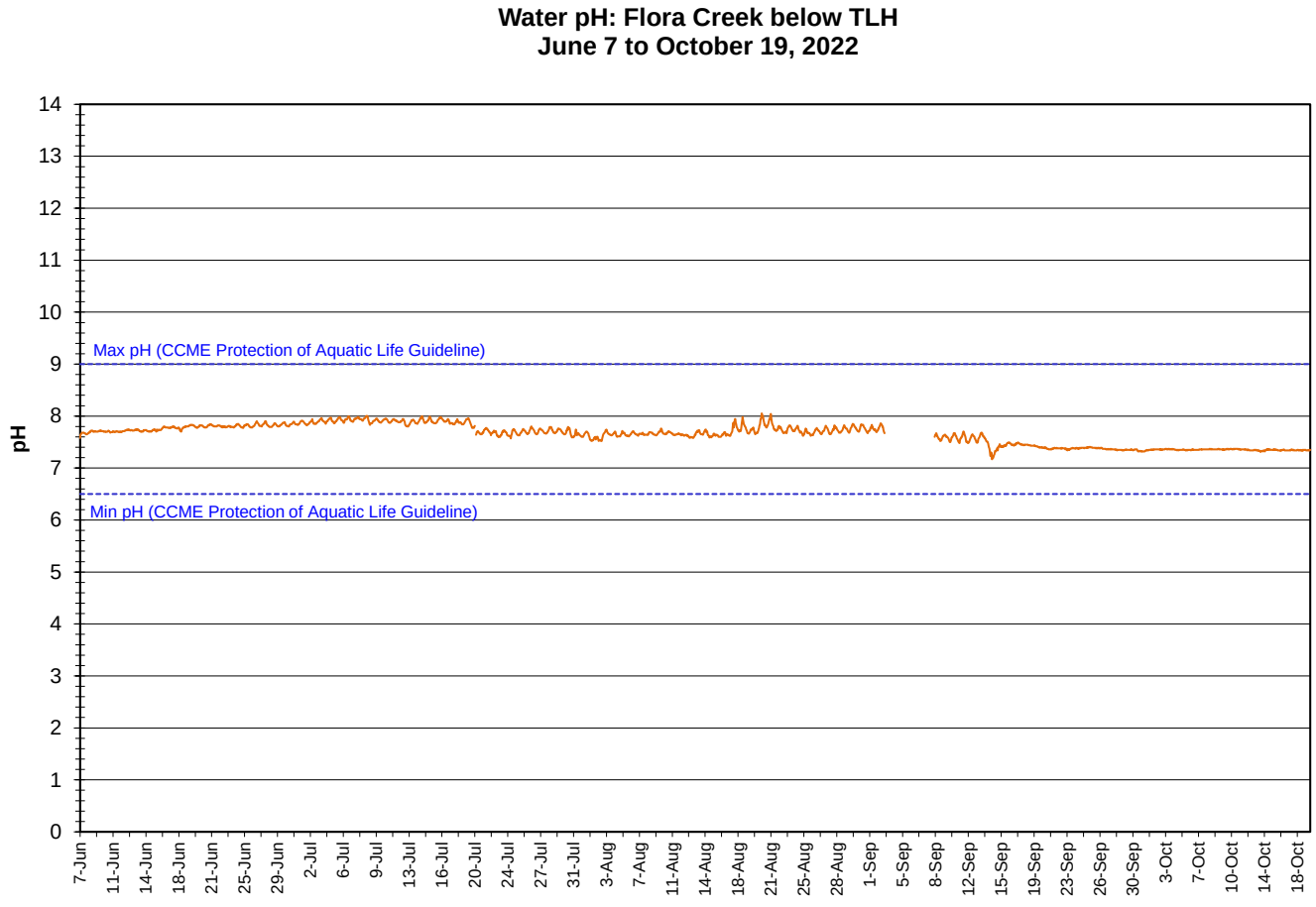

Figure 3: pH – Flora Creek below TLH

- Throughout the 2022 deployment season, specific conductivity ranged from 61.7 to 66.5 µs/cm, with a median value of 64.3 µs/cm at Flora Creek (Figure 4).
- Conductivity fluctuated within a small range throughout the deployment season, occasionally fluctuating in response to increases/decreases in stage.
- 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.

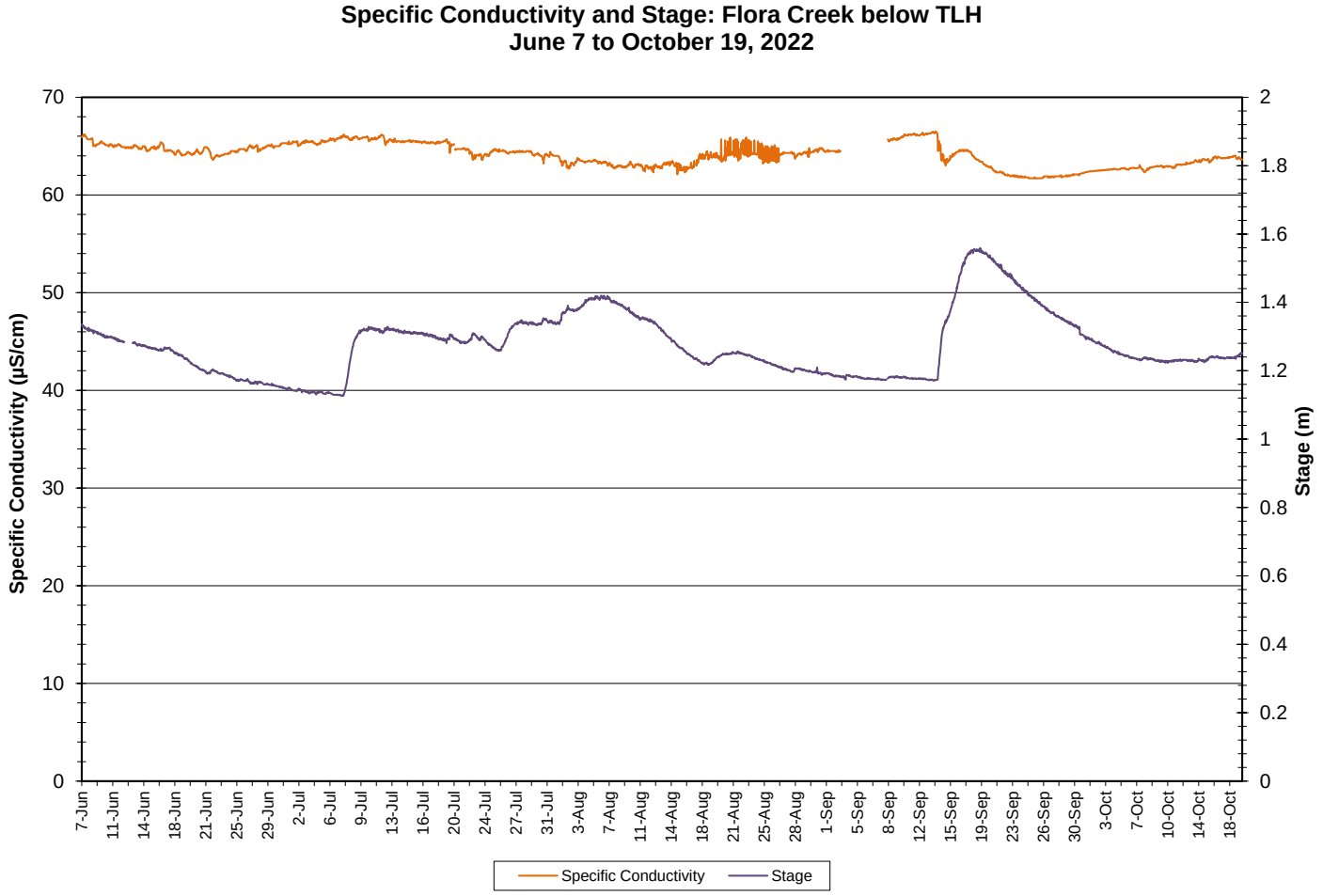

Figure 4: Specific Conductivity and Stage – Flora Creek below TLH

- The saturation of dissolved oxygen ranged from 88.0 to 104.9%, while the dissolved oxygen content ranged from 8.69 to 11.82 mg/l, with a median value of 9.84 mg/l (Figure 5).
- Dissolved oxygen fluctuated daily with decreases observed at night.
- Dissolved oxygen decreases slightly during the first two deployment periods, due to warming water temperatures into summer. It increases during the last deployment period, as 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.

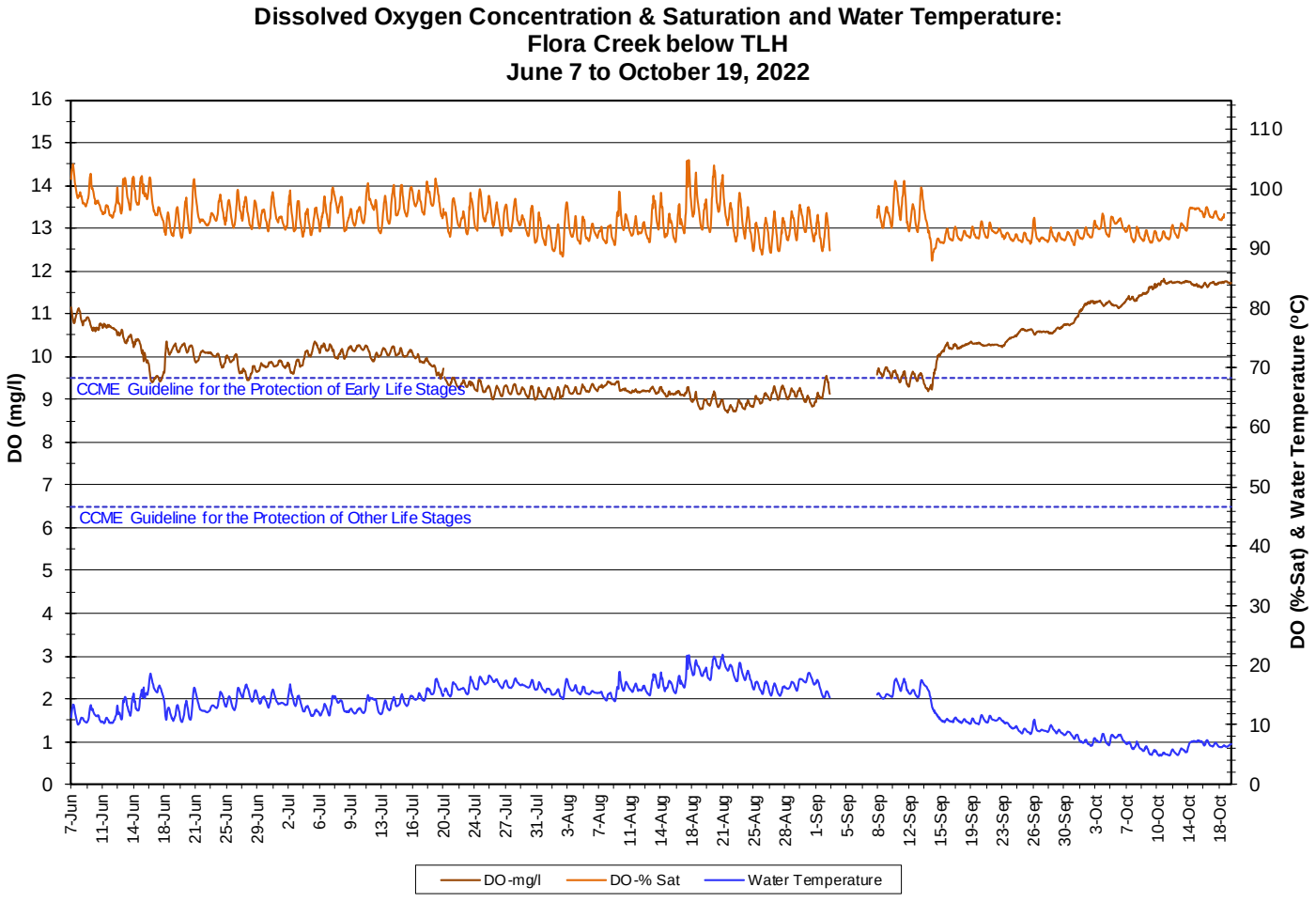

Figure 5: Dissolved Oxygen Concentration and Saturation and Water Temperature – Flora Creek below TLH

- At the Flora Creek station, turbidity values range from 5.0 to 161.2 NTU with a median value of 27.3 NTU (Figure 6a & 6b).
- This station was somewhat turbid for the entire season with values remaining below 60 NTU for a large portion of the season.
- Turbidity was high at the beginning of the season due to late winter melt/freshet. Other spikes are noted during and after significant precipitation events.

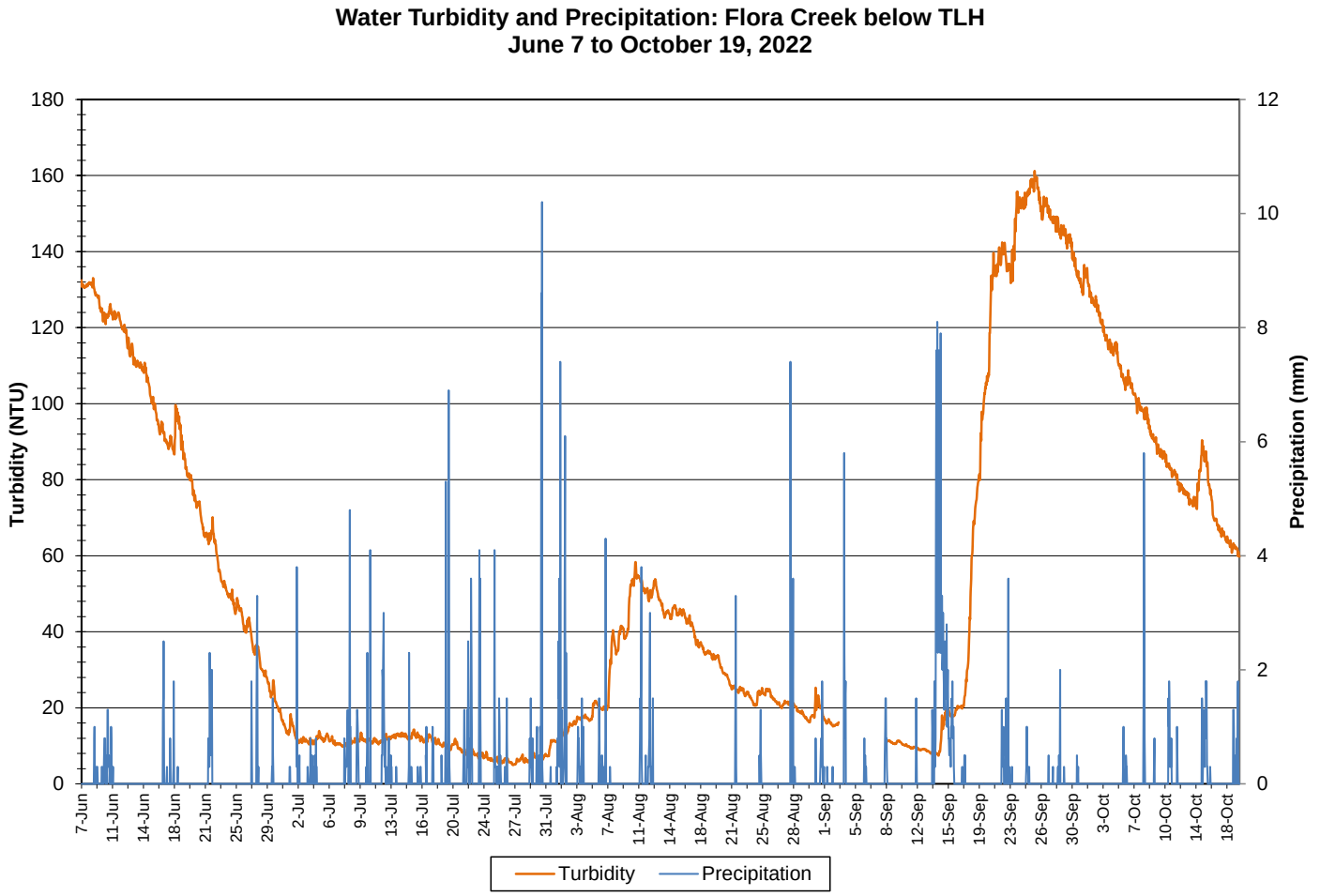

Figure 6a: Turbidity and Precipitation - Flora Creek below TLH

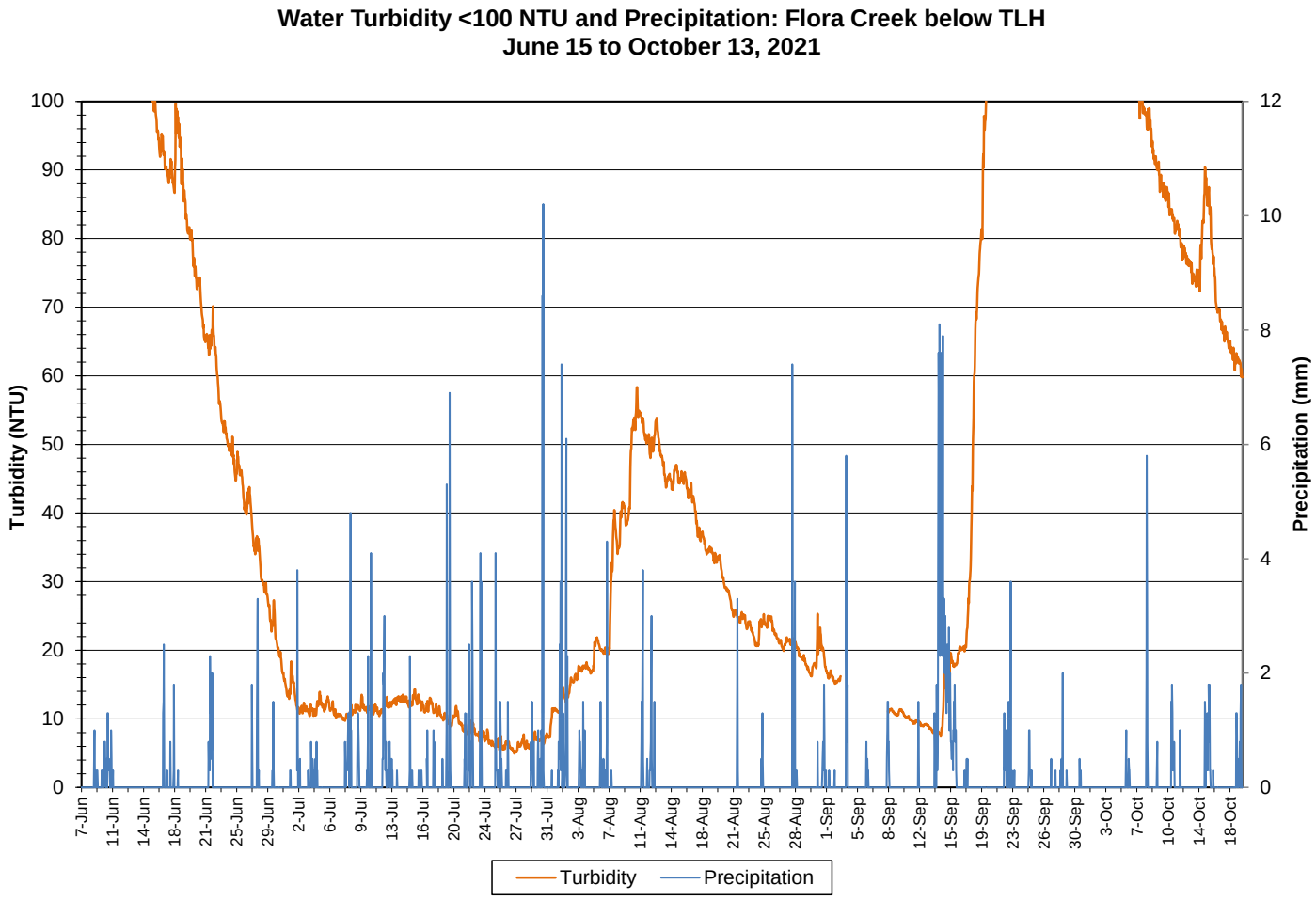

Figure 6b: Turbidity <100 NTU and Precipitation - Flora Creek below TLH

- Stage and precipitation are graphed below to show the relationship between rainfall and water level at Flora Creek (Figure 7).
- Stage decreased as the spring melt/freshet moved through. There were noticeable increases after precipitation events.
- 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.

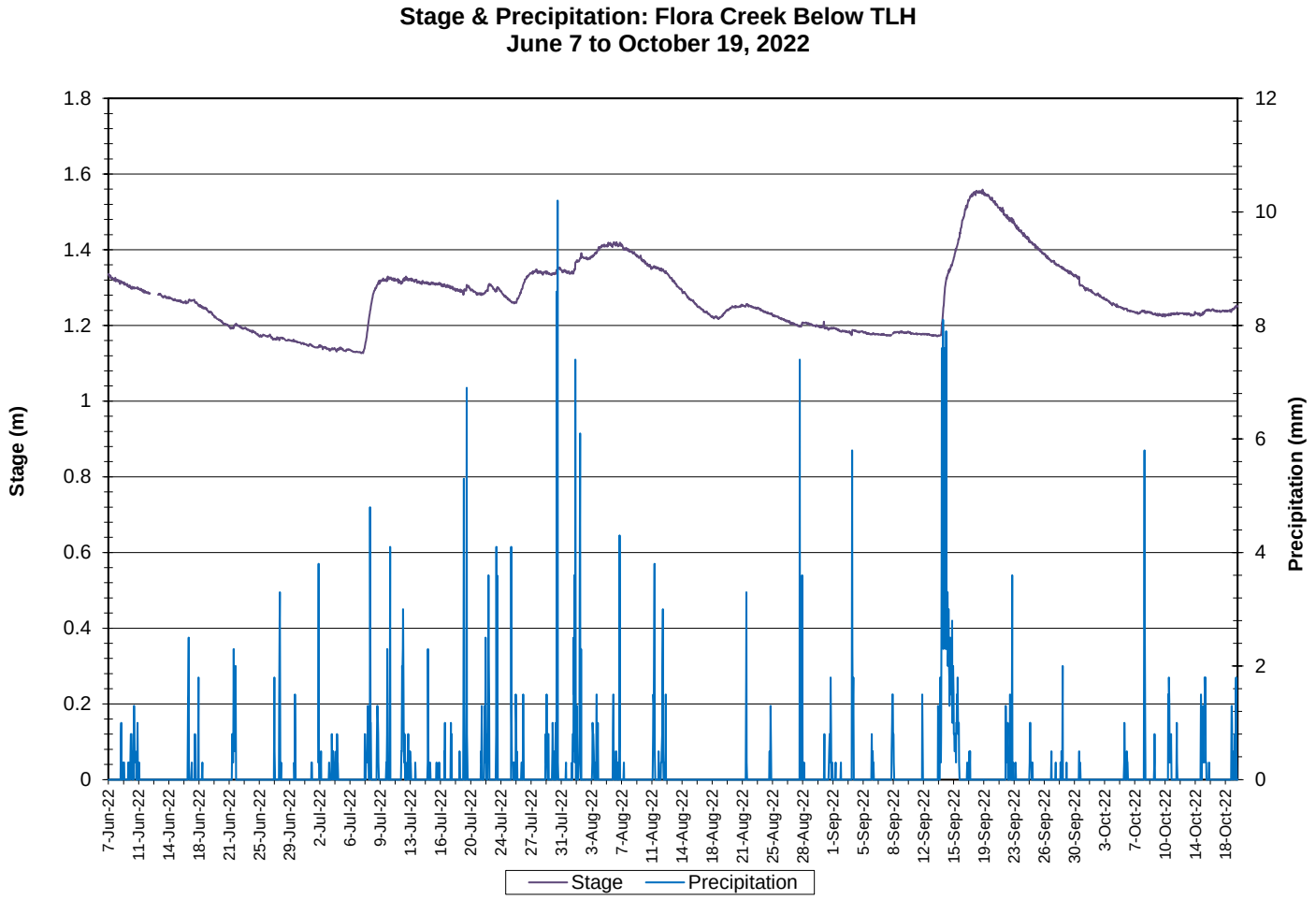

Figure 7: Stage and Precipitation - Flora Creek below TLH

(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 7th, 2022 and removed on October 19th, 2022 for the winter season.
- Deployment periods ranged from 41 to 50 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 2022 season with no issues. The station however, had issues transmitting the water quality data. A power issue was discovered and rectified, and the data transmitted from then on.
- 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 fluctuated within a small range during the 2022 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. Highest values usually occur during the late winter melt/freshet. There were also turbidity spikes noted after significant rainfall events.

Path Forward

- The field instrument will undergo proficiency testing and evaluation during the winter of 2022-2023. ECC will inform Tacora Resources of any instrument performance issues.
- ECC staff will deploy real time water quality instruments in spring 2023 when ice conditions allow and perform regular site visits throughout the 2023 deployment season for calibration and maintenance of the instrument.
- If necessary, deployment techniques will be evaluated and modified, ensuring secure and suitable conditions for RTWQ monitoring.
- ECC 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 ECC, 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.

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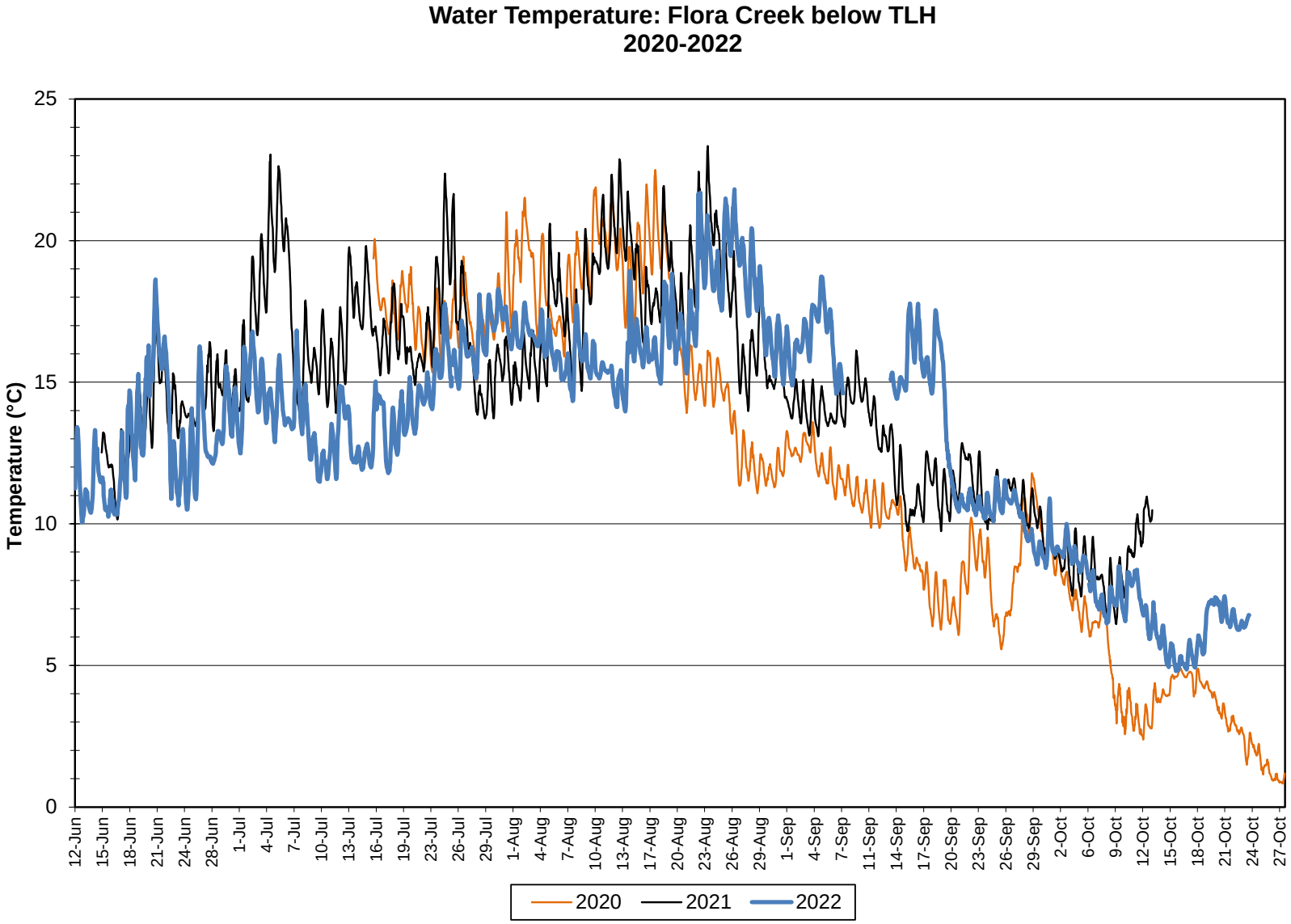
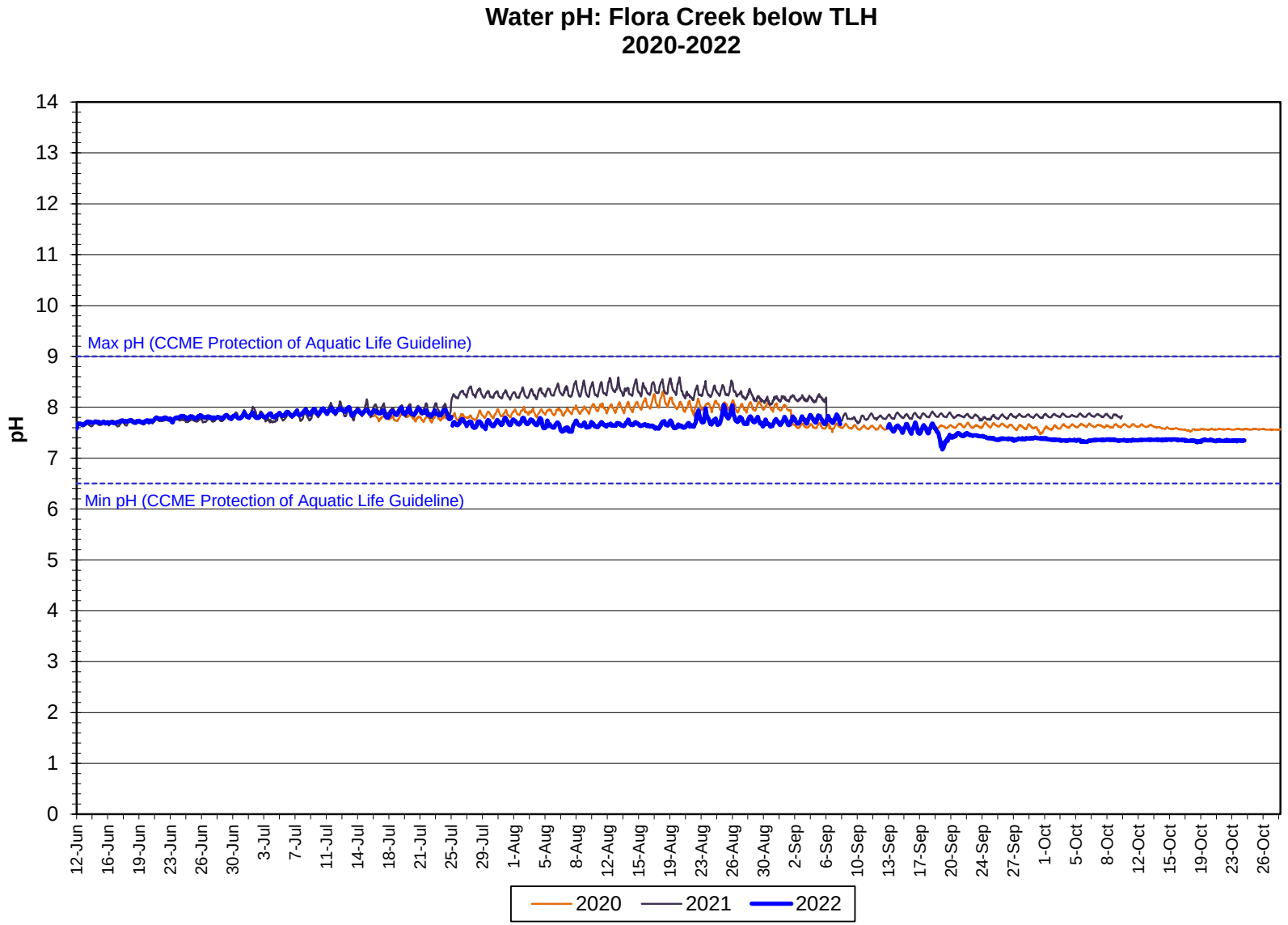
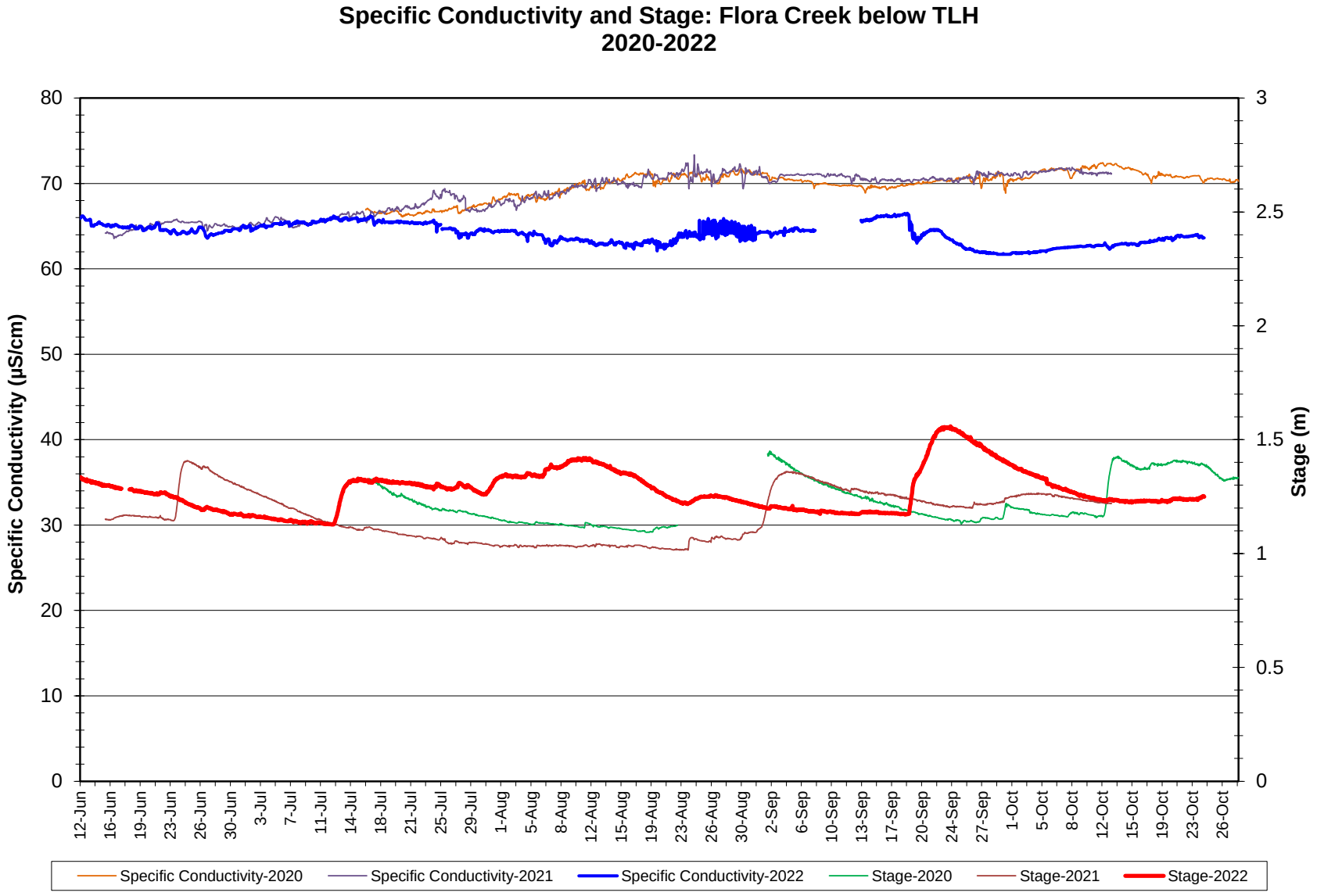
Appendix 1

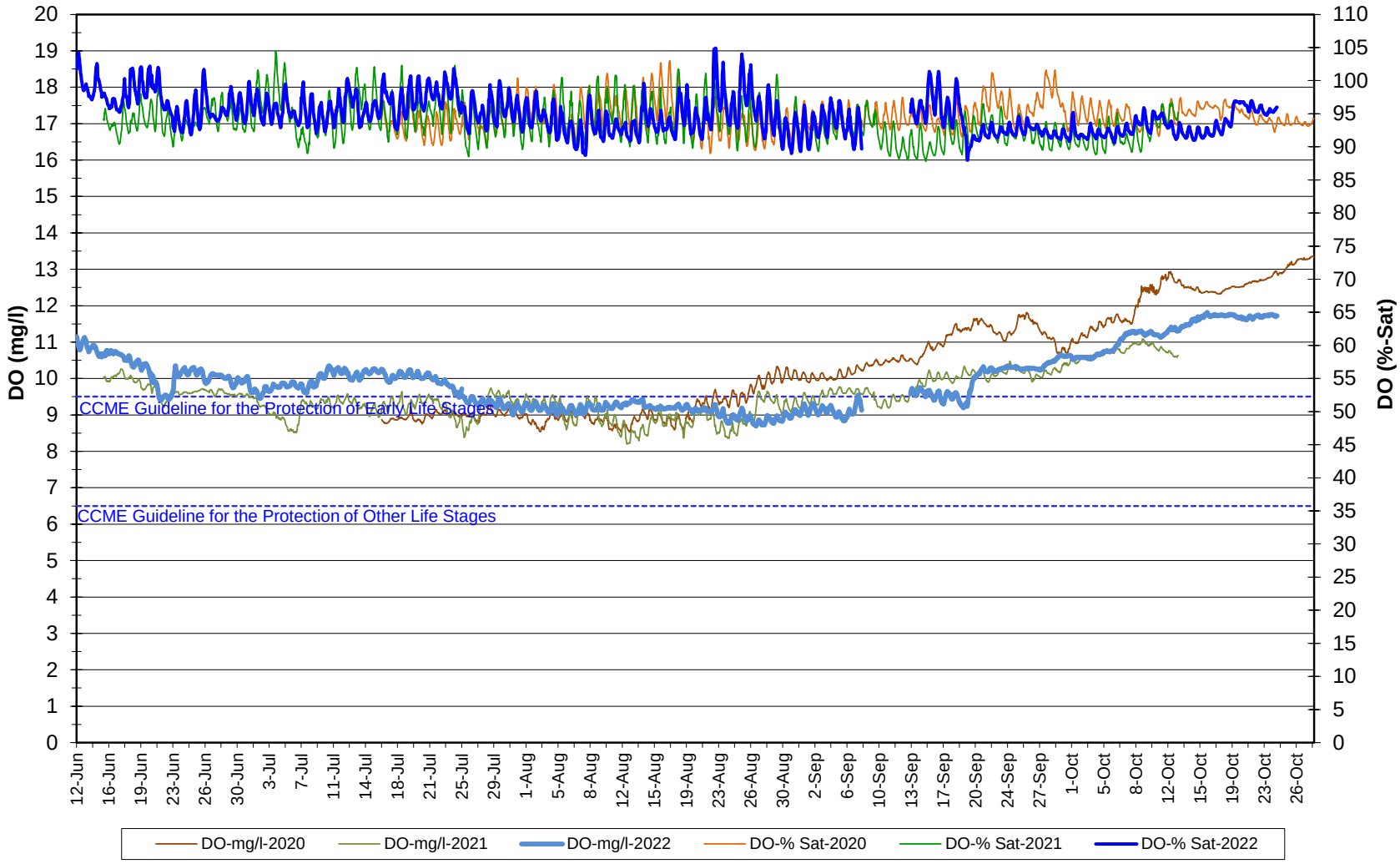
3 Year Comparisons

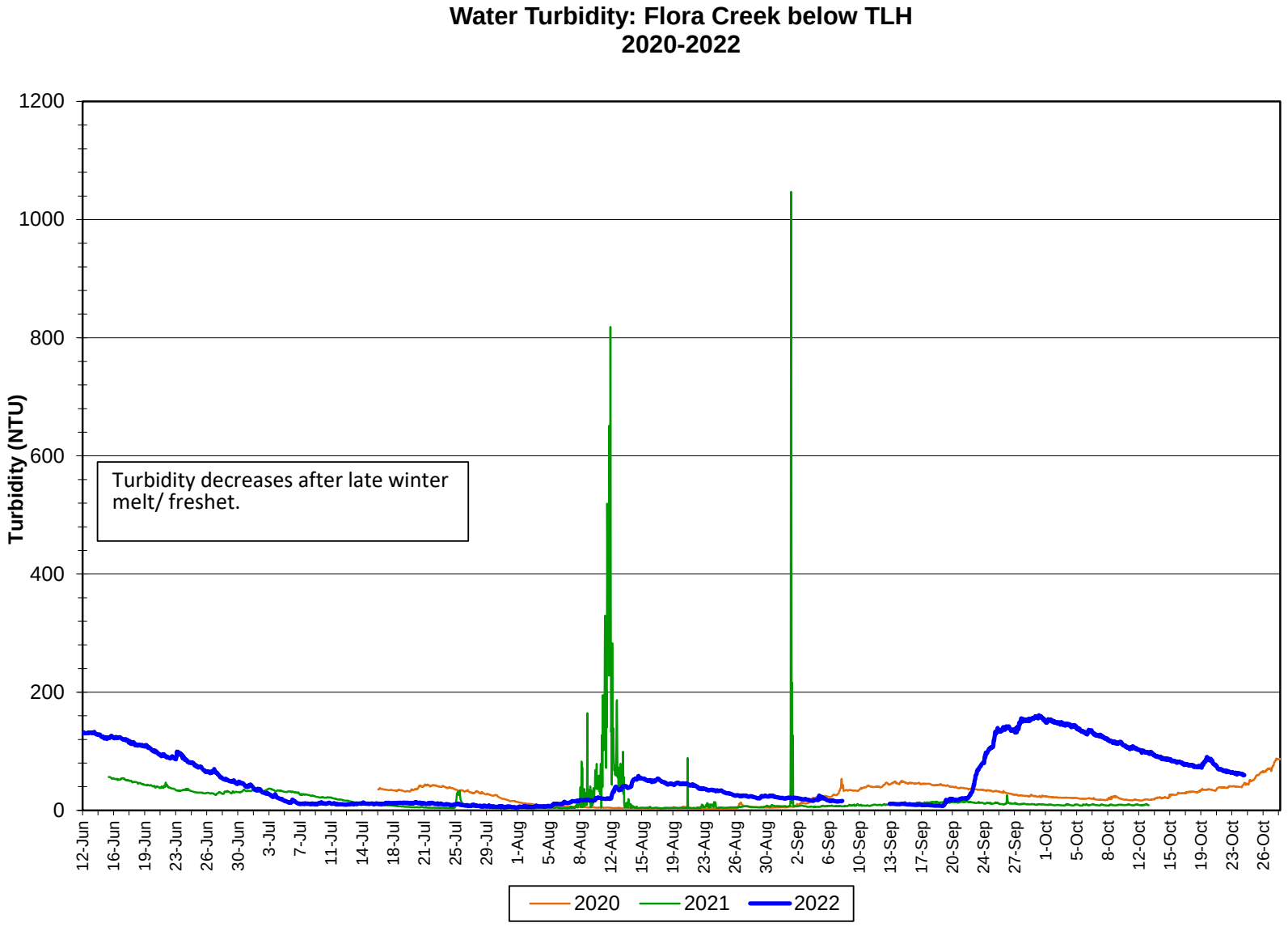

Water Temperature: Flora Creek below TLH
2020-2022
Temperature (°C)
25
20
15
10
5
0
12-Jun
15-Jun
18-Jun
21-Jun
24-Jun
28-Jun
1-Jul
4-Jul
7-Jul
10-Jul
13-Jul
16-Jul
19-Jul
23-Jul
26-Jul
29-Jul
1-Aug
4-Aug
7-Aug
10-Aug
13-Aug
17-Aug
20-Aug
23-Aug
26-Aug
29-Aug
1-Sep
4-Sep
7-Sep
11-Sep
14-Sep
17-Sep
20-Sep
23-Sep
26-Sep
29-Sep
2-Oct
6-Oct
9-Oct
12-Oct
15-Oct
18-Oct
21-Oct
24-Oct
27-Oct
2020
2021
2022


Water pH: Flora Creek below TLH
2020-2022
pH
Max pH (CCME Protection of Aquatic Life Guideline)
Min pH (CCME Protection of Aquatic Life Guideline)
2020
2021
2022


Specific Conductivity and Stage: Flora Creek below TLH
2020-2022
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
19-Oct
23-Oct
26-Oct
Specific Conductivity-2020
Specific Conductivity-2021
Specific Conductivity-2022
Stage-2020
Stage-2021
Stage-2022

Dissolved Oxygen Concentration and Saturation: Flora Creek below TLH
2020-2022




Water Turbidity: Flora Creek below TLH
2020-2022
Turbidity (NTU)
1200
1000
800
600
400
200
0
Turbidity decreases after late winter melt/ freshet.
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
19-Oct
23-Oct
26-Oct
2020
2021
2022

Appendix 2
Air Temperature and Precipitation

Average Daily Air Temperature and Precipitation: Moosehead Lake
June 7 to October 19, 2022