Real-Time Water Quality Report

Canada Fluorspar (NL) Inc, Real-Time Water Quality Stations

Deployment Period
May 13, 2020 to July 2, 2020

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

Prepared by:

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General

The Water Resources Management Division (WRMD), in partnership with Water Survey of Canada (WSC) -Environment and Climate Change Canada (ECCC), maintain real-time water quality and water quantity monitoring stations on Outflow of Grebes Nest Pond and Outflow of Unnamed Pond south of Long Pond, brooks that are within the site of Canada Fluorspar (NL) Inc, St. Lawrence, Newfoundland & Labrador.

Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

Outflow of Grebes Nest Pond

The Outflow of Grebes Nest Pond station is established downstream of the pit dewatering effluent outfall and upstream of John Fitzpatrick Pond. The stream is approximately 1.0 to 2.0 meters wide and sustains a sufficient pool for the instrumentation to be placed in (Figure 2). The pool depth is approximately 0.5 to 1.0 metres. The GPS coordinates for this site are as follows**: N46° 54’ 35.9” W055° 27’ 45.6”**.

The station hut was placed on the north bank looking downstream approximately 5 metres from the stream. This station will provide real-time water quality and quantity data to ensure emerging issues associated with the open pit (from both the construction and operational phases)are detected, to allow the appropriate mitigation measures to be implemented in a timely manner, thus reducing any adverse effect on the downstream systems.

Outflow of Unnamed Pond south of Long Pond

The Outflow of Unnamed Pond south of Long Pond is established downstream of the Tailings Management Facility (TMF). This station will provide near real-time water quality and quantity data to ensure emerging issues associated with the TMF are detected, to allow the appropriate mitigation measures to be implemented in a timely manner, thus reducing any adverse effect on the downstream systems. The location of Outflow of Unnamed Pond south of Long Pond was selected due to accessibility to the brook and the sufficient pool available to place the water quality and quantity instruments (See Figure 3). The stream originates from a small unnamed pond and meanders through a marsh environment alongside the TMF. The stream is approximately 1.0 to 2.0 meters wide. Where the instrument is deployed, there is a depth of approximately 1.0 to 1.5 meters. The GPS coordinates for this site are as follows: **N46° 54' 14.1" W055° 26' 37.5"**. The station hut was placed on the right bank looking downstream approximately 8 meters from the stream (Figure 3).

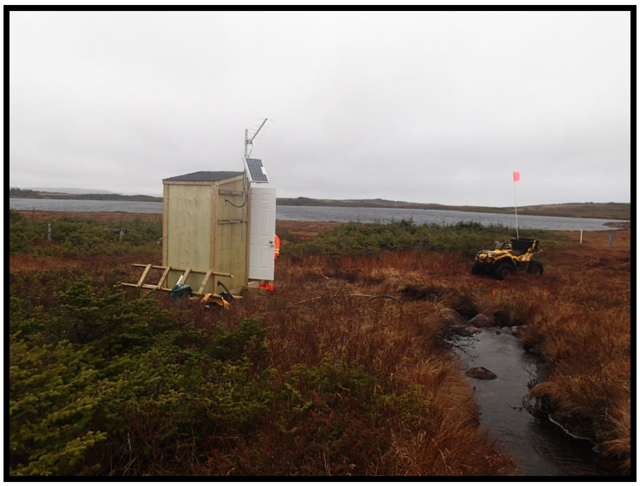

Figure 2: Real-Time Water Quality and Quantity Station at Outflow of Grebes Nest Pond.

Figure 3: Real-Time Water Quality and Quantity Station at Outflow of Unnamed Pond south of Long Pond.

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 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 the parameters on the Field Sonde and QA/QC Sonde at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

WRMD staff (Environment, Climate Change & Municipalities (ECCM)) are responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Tara Clinton is MAE's main contact for the real-time water quality monitoring operation at Canada Fluorspar (NL) Inc, and is responsible for maintaining and calibrating the water quality instrument, as well as grooming, analyzing and reporting on water quality data recorded at the station.

WSC staff have an essential role in the data logging/communication aspect of the network and the maintenance of the water quantity monitoring equipment. WSC staff visit the site regularly to ensure the data logging and data transmitting equipment are working properly. WSC is responsible for handling stage and streamflow issues. The quantity data is raw data that is transmitted via satellite and published online along with the water quality data on the Real-Time Stations website. Quantity data has not been corrected or groomed when published online or used in the monthly reports for the stations. WSC is responsible for QA/QC of water quantity data. Corrected stage and streamflow data can be obtained upon request to WSC.

Table 1: Instrument Performance 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 divided into subgroups of: temperature dependent temperature compensated and temperature independent. Due to the temperature sensor's location on the sonde, the entire sonde must be at a constant temperature before the temperature 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.

Table 2: Instrument performance rankings

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Grebes Nest Pond	May 13	Deployment	Good	Good	Excellent	Excellent	Poor
	July 2	Removal	Good	Good	Excellent	Excellent	Poor
Unnamed Pond	May 13	Deployment	Marginal	Good	Excellent	Excellent	Excellent
	July 2	Removal	Fair	Good	Excellent	Excellent	Excellent

At deployment of the field instrument at Outflow of Grebes Nest Pond site, the water temperature, pH, specific conductivity and dissolved oxygen data ranked 'Excellent' to 'Good' against the QA sonde data. During removal of the instrument, the ranking for water temperature, pH, conductivity and dissolved oxygen were 'Excellent' or 'Good' against the QA data. The turbidity data ranked 'Poor' against the QA values. At both the deployment and removal, the brook was experiencing high flow along with extremely turbid water with foam. It is likely that these conditions impacted the ranking for turbidity.

At deployment and removal of the field instrument at Outflow of Unnamed Pond south of Long Pond, the data ranked 'Excellent' or 'Good' for pH, specific conductivity, dissolved oxygen and turbidity. Water temperature ranked as 'Marginal' at deployment and then 'Fair' at removal. After a lab evaluation it was determined that the temperature probe on the QA instrument was slightly off calibration.

Concerns or Issues during the Deployment Period

During the deployment at Outflow to Unnamed Pond south of Long Pond, there were intermittent issues with transmission. When graphed, the data will display the missing data with gaps on the line graph. Daily averaged stage levels are displayed alongside the water quality parameters to assist in explaining certain changes in the water quality.

The water supply for Outflow to Grebes Nest Pond station originates at the bottom of an open pit mine. There is also a small influence from runoff and precipitation. The pit water is pumped from the open mine pit into geo bags that strain out the majority of the sediment and then the water is gravity fed into Outflow to Grebes Nest Pond. The water supply is intermittent as the pit water is pumped when water levels reach a certain height in the open pit mine. Therefore, the lack of consistent flow can result in significant stage level fluctuation across a deployment and have an effect on water quality.

Please note that the stage data in this document is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

Outflow of Grebes Nest Pond

Water Temperature

Water temperature ranged from 3.61°C to 14.8°C during the deployment period (Figure 4). The average water temperature for the deployment is 8.9°C.

Outflow to Grebes Nest Pond station does not have consistent flow, thus the stage data can fluctuate significantly across a deployment. Stage fluctuations can influence water temperature as indicated in Figure 4 on June 20th; when the stage decreased, the water temperature increased for the same period.

Water temperature displayed the natural diurnal pattern representing the influence of air temperature on the brook, with the high temperatures during the daylight hours and the low temperatures representing the nighttime hours (Figure 5). Over the entire deployment there was a gradual increase in water temperature. This was a result of the increasing air temperatures as the seasons adjust from Spring into Summer. Outside of the diurnal movement of the water temperature, the data does indicate small influences from the stage changes.

These stage changes could be a result of precipitation or an increase in the amount of water pumped into the brook. Generally, if the stage increases occur during low air temperature events it was likely a result of rainfall. Please note that the stage data in this document is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

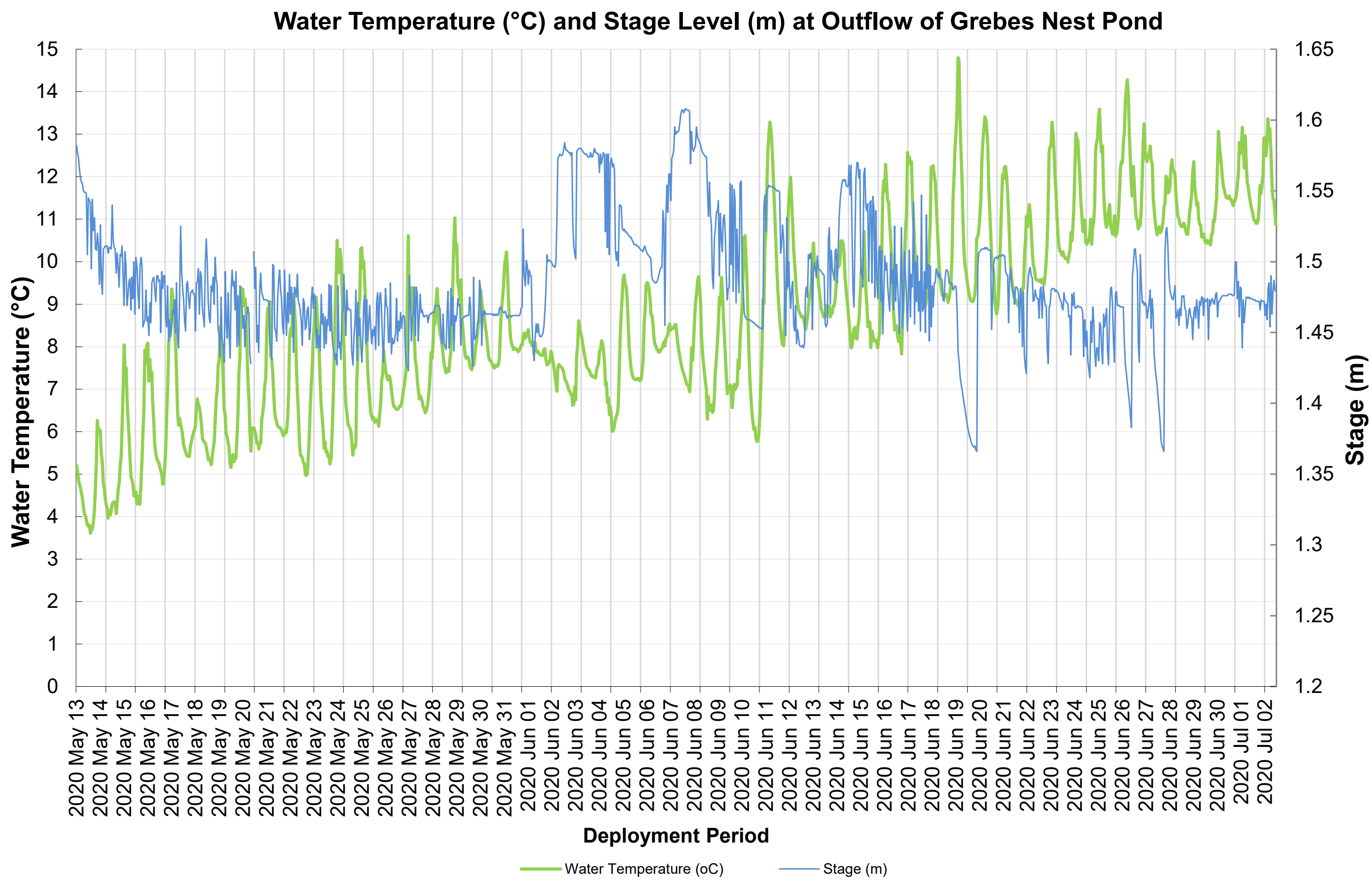

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

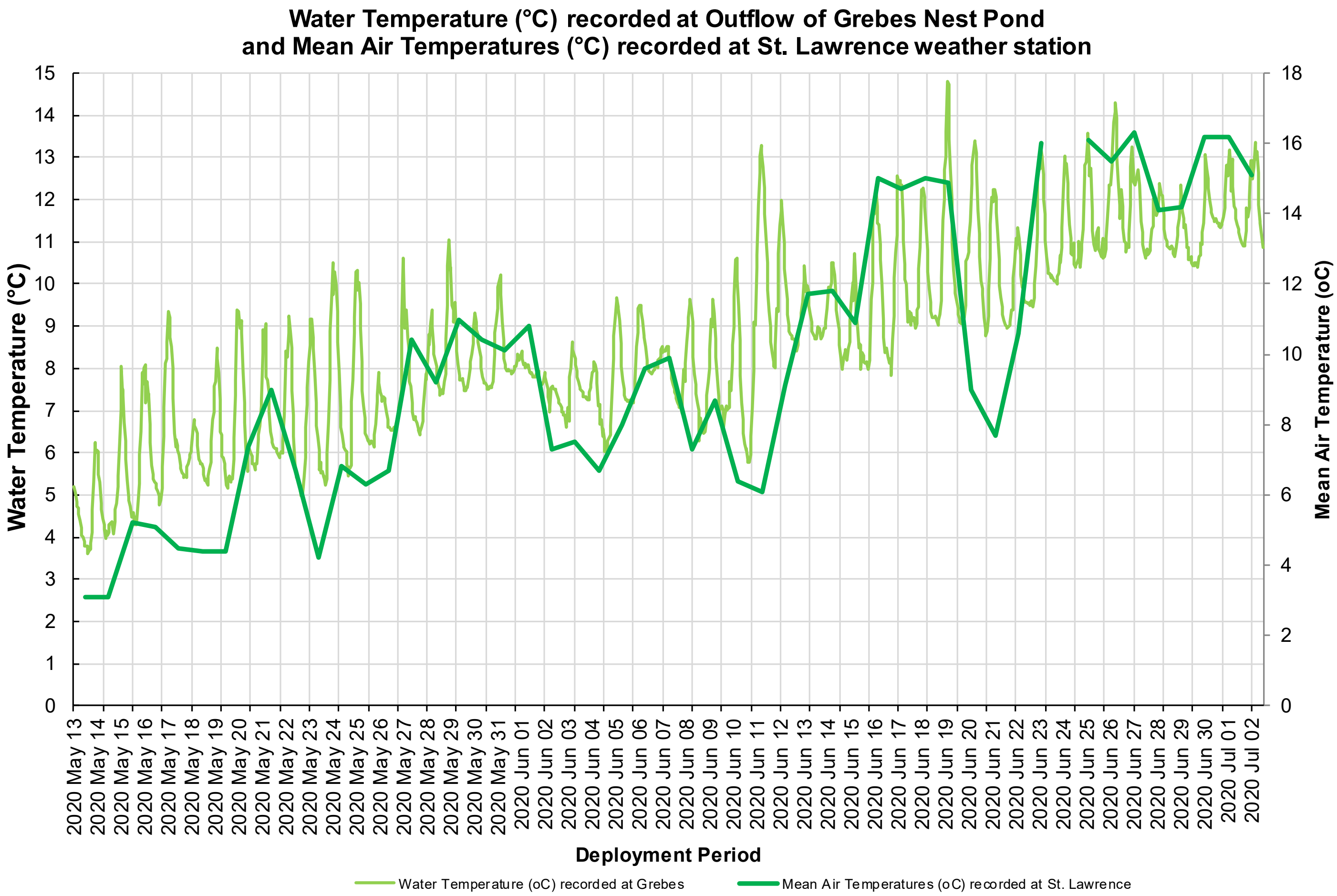

Figure 5: Water temperature (°C) and Mean Air Temperature (°C) at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 7.25 pH units and 8.21 pH units. The pH data remained within the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life for the duration of the deployment.

pH data displayed on Figure 6 is constant throughout the deployment. Small changes in pH could have been a result of rainfall, which can lower pH, or could be a result of the flow differences from the inconsistency of pumping water into the brook.

Please note that the stage data in this document is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

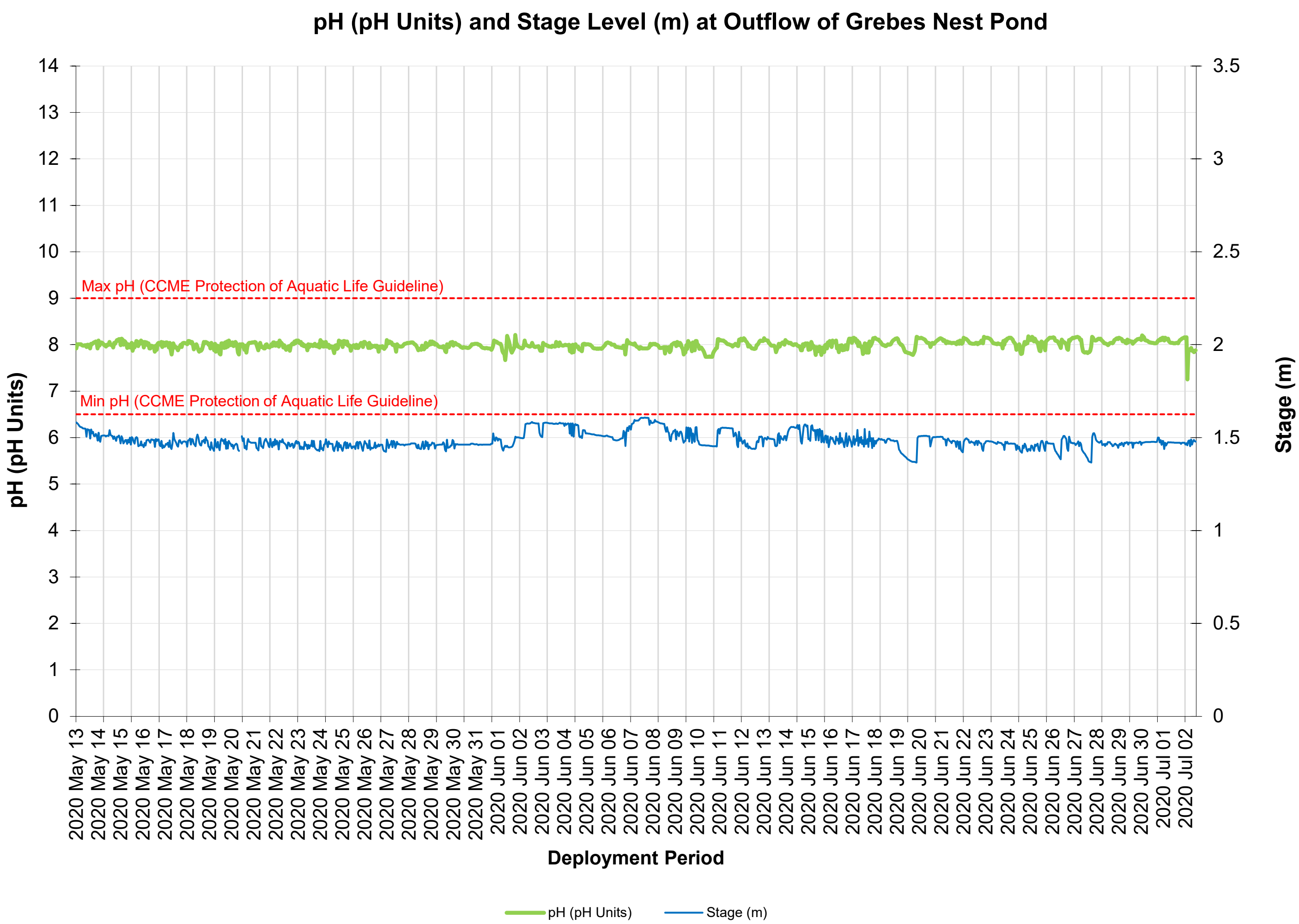

Figure 6: pH (pH units) values

Specific Conductivity

The conductivity levels were within 202.38 µS/cm and 359.47 µS/cm during this deployment period (Figure 6). The specific conductivity probe measured the diluted salts and inorganic materials present in the brook. The conductivity in a brook can be diluted by rainfall or increased by rainfall if there is runoff occurring.

Across the deployment period, the conductivity in the brook fluctuated with the changes in stage level. During stage increases, the conductivity levels responded by decreasing as the diluted salts and inorganic matter present in the brook were flushed through.

With minimal to no stage increases, diluted salts and inorganic material will accumulate in the brook, increasing the conductivity data. Until there is a sufficient increase in stage flow to flush the system, conductivity will remain high.

Please note that the stage data in this document is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

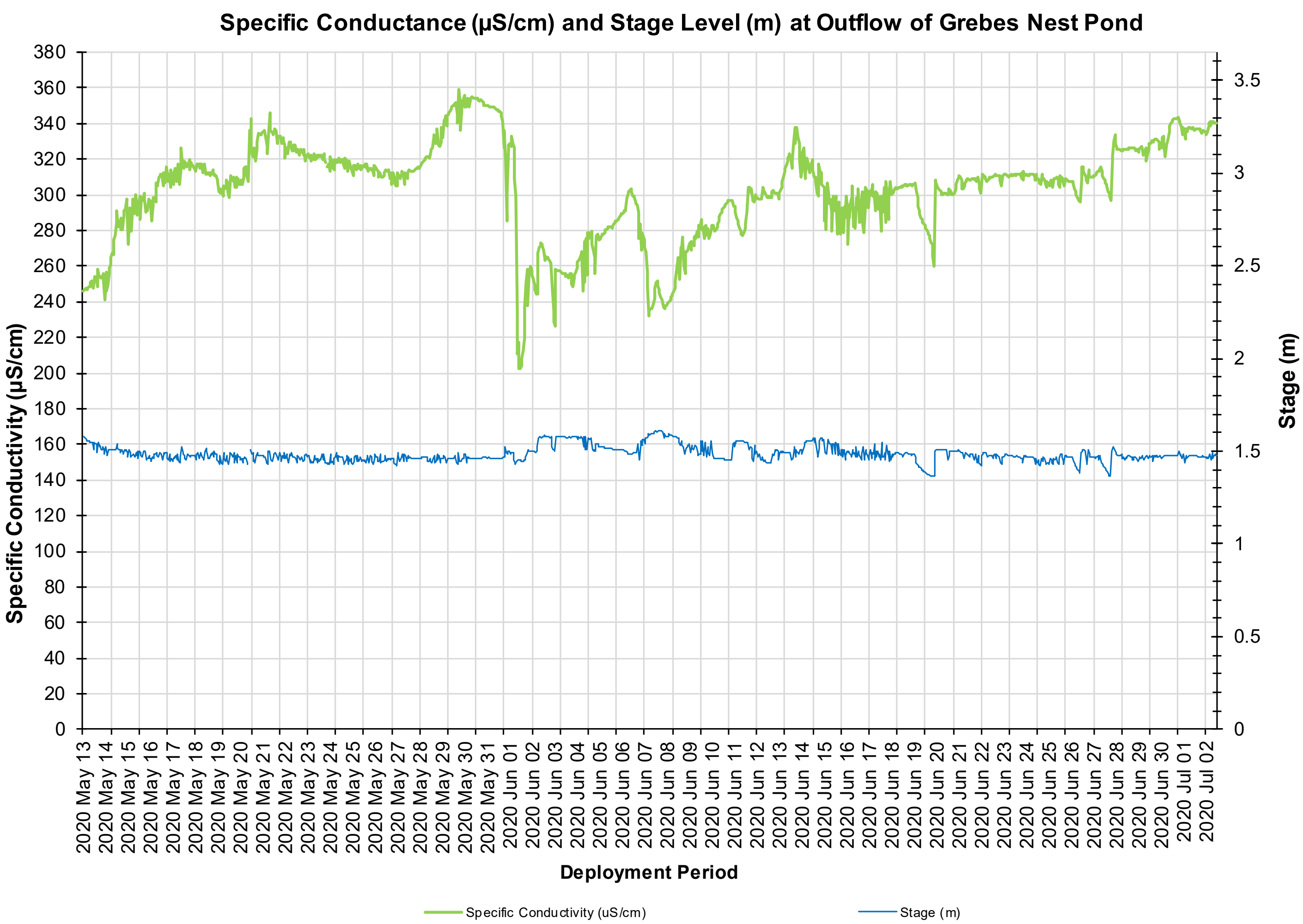

Figure 6: Specific conductivity (µS/cm) values

Dissolved Oxygen

The water quality instrument directly measures dissolved oxygen (mg/L) with the dissolved oxygen probe. The instrument then calculates percent saturation (% Sat) taking into account the water temperature.

During the deployment, the dissolved oxygen concentration levels ranged within a minimum of 9.93 mg/L to a maximum of 13.06 mg/L. The percent saturation levels for dissolved oxygen ranged within 86.1% Saturation to 111.8% Saturation (Figure 7).

Due to the intermittent stream flow at this brook, dissolved oxygen concentration does not always display the expected diurnal pattern that accompanies natural ambient waterways. This was evident from May 28th to June 1st, as the DO mg/L data displayed minimal variation. Water temperature is included with dissolved oxygen as it directly influences the water column's ability to store dissolved oxygen. This relationship is shown in Figure 7 on June 11th; as the water temperature increases, the dissolved oxygen decreases and vs versa.

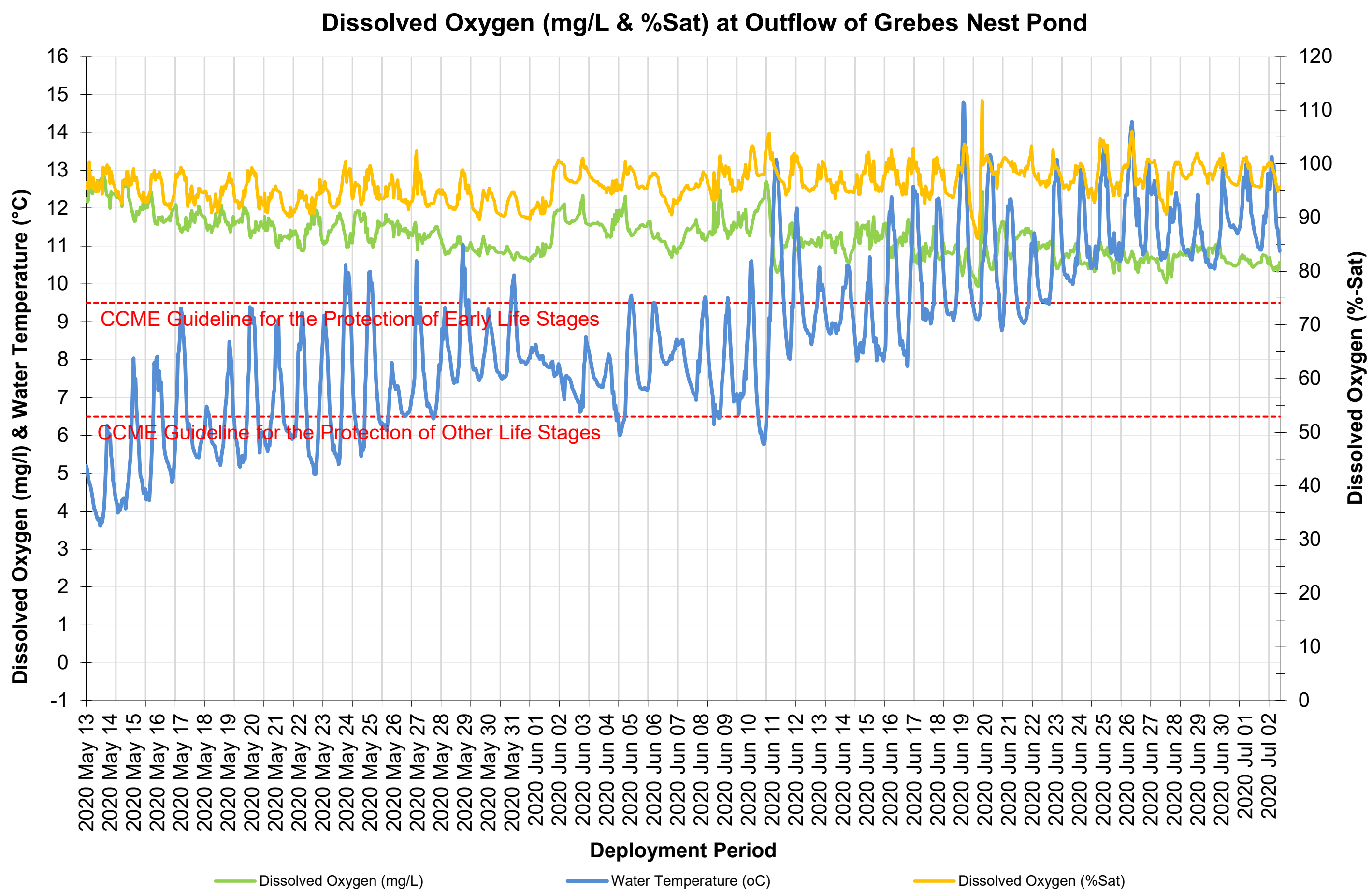

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values and Water Temperature (°C)

Turbidity

Turbidity levels during the deployment ranged within 0.6 NTU and 1064.1 NTU (Figure 8). The deployment data had a median of 12.6 NTU.

Outflow to Grebes Nest Brook, is fed via a sump pump from a pit mine. The pit water is fed through a geo bag before it gravity flows into the Outflow of Grebes Nest Brook. Based on the nature of the water pumped into the brook, it would be expected for the turbidity at this site to fluctuate throughout the deployment. Turbidity can also increase in the water column through evaporation. If the brook is not replenished with rainfall or pumped water, the water can become stagnant. Evaporation decreases the water level, concentrating sediments in the remaining water.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

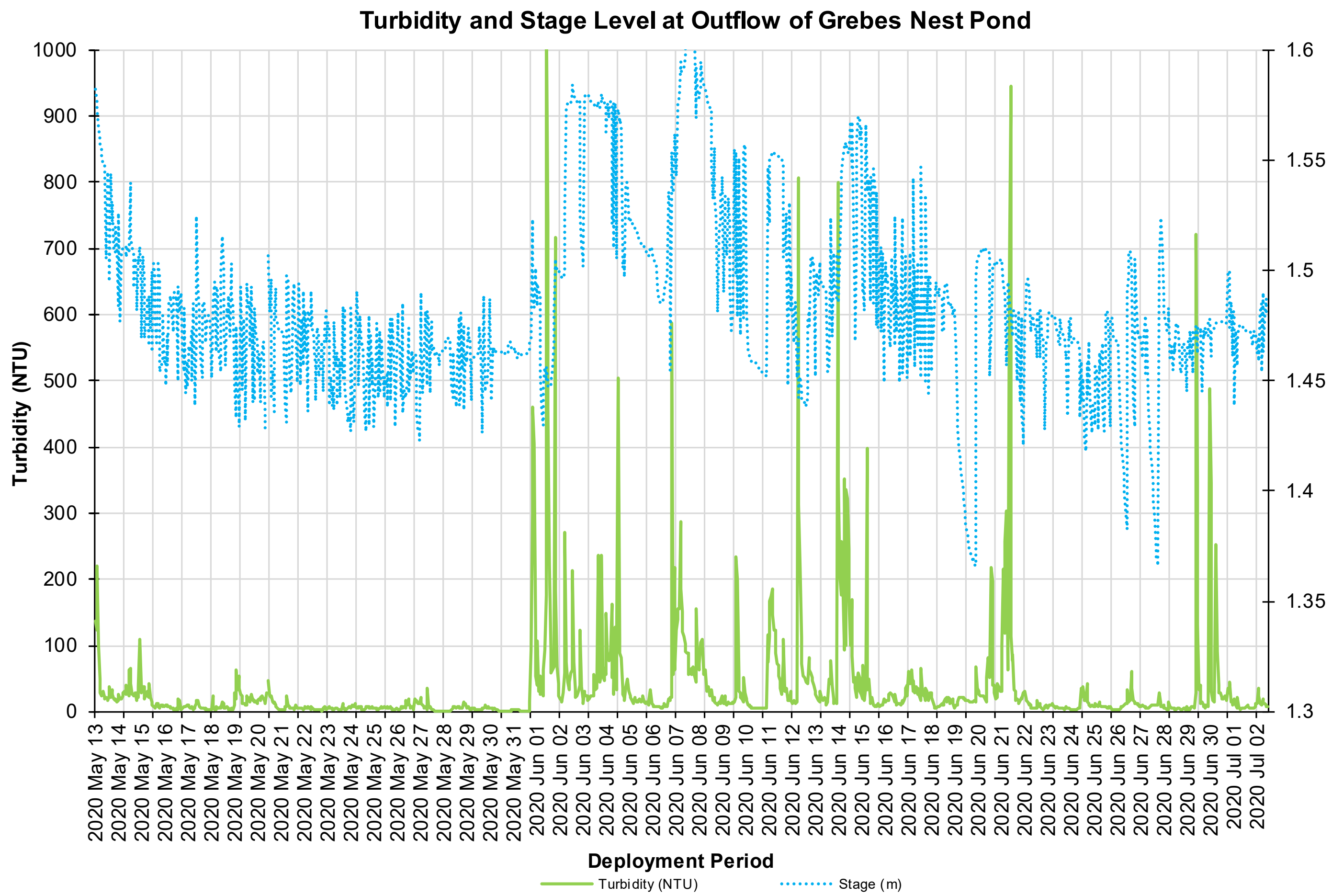

Figure 8: Turbidity (NTU) values.

Conclusion

Outflow of Grebes Nest Pond currently flows through an evolving mine site. Grebes Nest Pond has been dewatered for mining purposes and no longer exists. The water supply for Outflow of Grebes Nest Pond station has changed. The water supply is pit water pumped via a sump pump into a geo bag, that is then gravity fed into Outflow of Grebes Nest Pond. The geo-bag is used to strain out the sediment-laden water that is pumped from the open pit mine.

Water temperature fluctuated with stage changes, but continued to increase into the deployment, as the air temperatures increased with the season. pH levels at Grebes Nest station were consistent during the deployment.

Stage level did impact the specific conductivity data at Grebes Nest. As the stage level increased, the conductivity decreased. However, the data remained within the range of 200µS/cm to 360µS/cm, showing that there was not a significant change in the conductivity throughout the deployment.

Outflow to Grebes Nest Pond station does not always have consistent flow. The dissolved oxygen concentration can thus change quickly over a few hours or days. During this deployment, dissolved oxygen remained consistent until June 10, 2020 when the air/water temperatures increased as the seasons changed, leading to a decrease in dissolved oxygen concentrations.

This brook has significant fluctuations in turbidity and the turbidity levels will increase in either high or low stage events due to the influence of the upstream sedimentation pond. This deployment had high turbidity events throughout June.

Overall, the water quality parameters recorded at Outflow of Grebes Nest Pond displayed events expected of a brook in an environment influenced heavily by anthropogenic activities.

Outflow of Unnamed Pond south of Long Pond

Water Temperature

Water temperature ranged from 6.23ºC to 24.13ºC during the deployment period (Figure 9). The water temperature increased across the deployment, fluctuating as the air temperatures increased with the warmer climatic change into Summer (Figure 9).

Water temperature displayed the natural diurnal pattern representing the influence of air temperature on the brook, with the high temperatures during the daylight hours and the low temperatures representing the nighttime hours (Figure 10). Outside of the diurnal movement of the water temperature, the data does indicate small influences from the stage changes.

These stage changes could be a result of precipitation. Generally, if the stage increases occur during low air temperature events it was likely a result of rainfall. Please note that the stage data in this document is raw data. The data has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

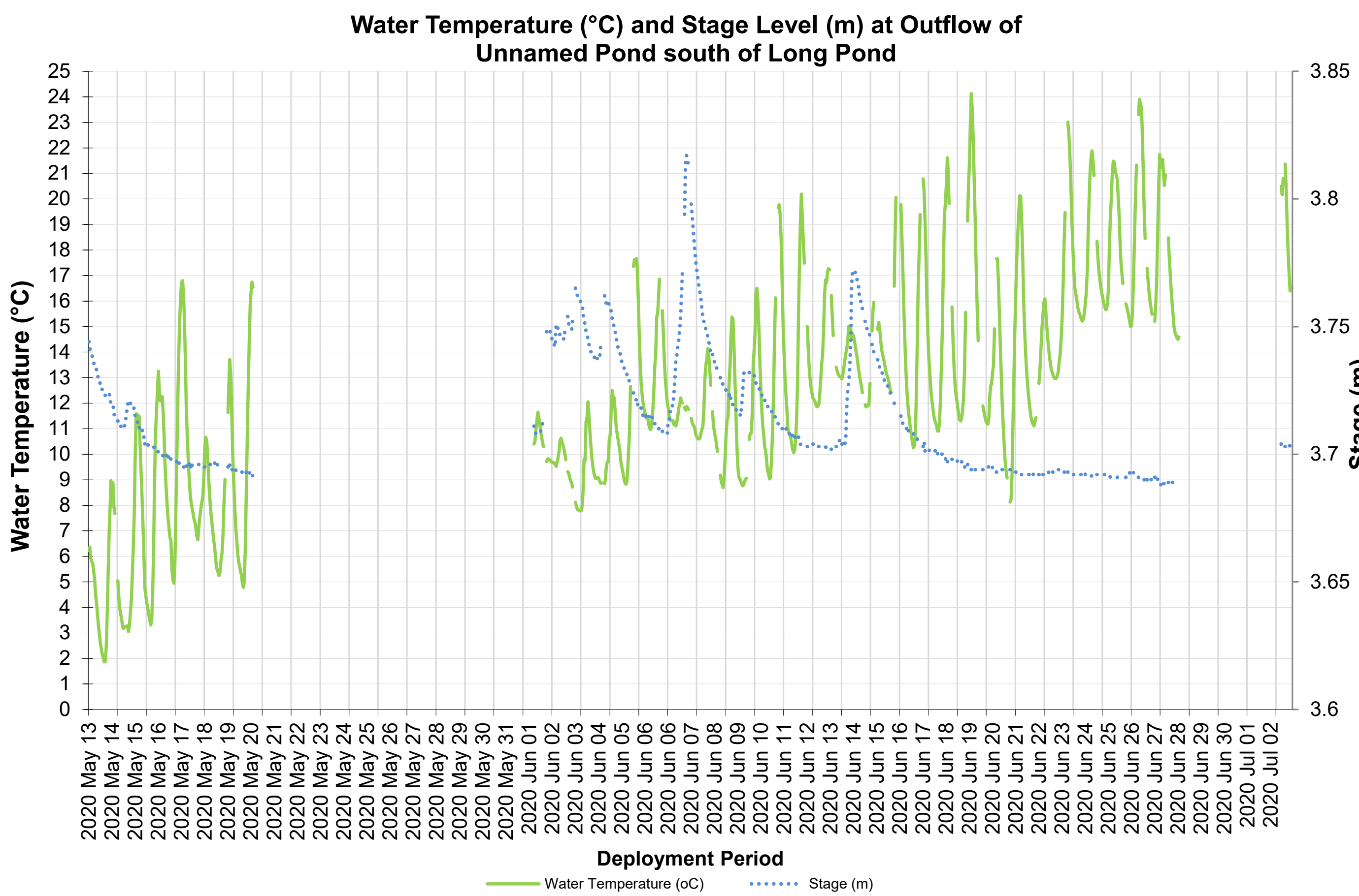

Figure 9: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

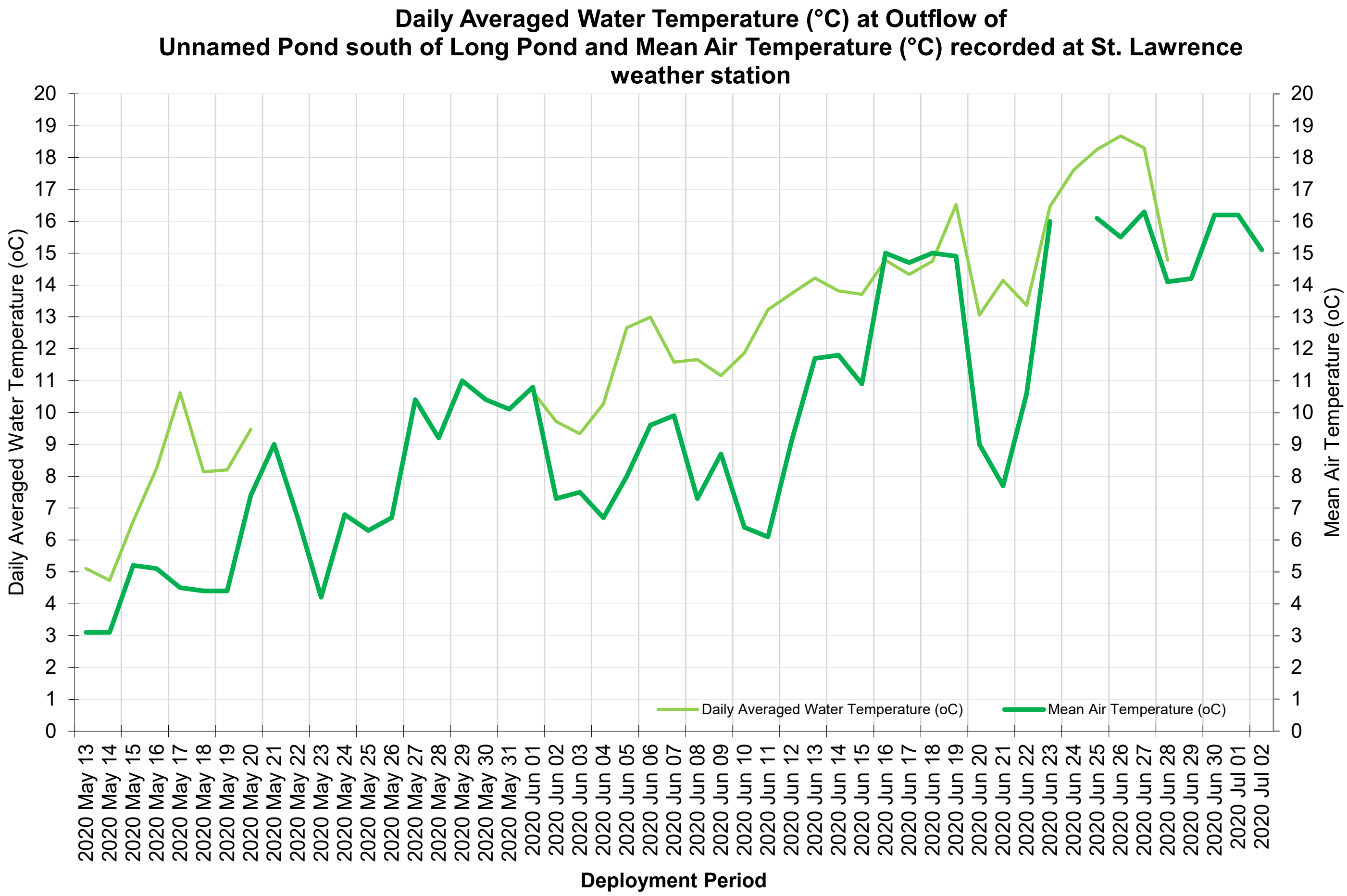

Figure 10: Water temperature (°C) and Mean Air Temperature (°C) at Outflow of Unnamed Pond south of Long Pond

pH

Throughout this deployment period, pH values ranged within 7.53 pH units and 7.87 pH units (Figure 11), remaining within the Canadian Council of Ministers of the Environment (CCME) guidelines for aquatic life. The guidelines provide the overall range for the protection of aquatic life across all waterways in Canada; every brook is different with its own specific natural background range.

Small decreases in pH during stage peaks are evident on Figure 11 on June 7th and again on June 14th, 2020. The pH values returned to background levels shortly after each event, and overall the pH data was consistent across deployment. Natural processes such as rainfall, snowmelt and surrounding runoff will alter the pH of a brook for a period; however, it is the persistent long-term changes in pH that create the most damage to the natural aquatic environment.

Please note the daily averaged stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

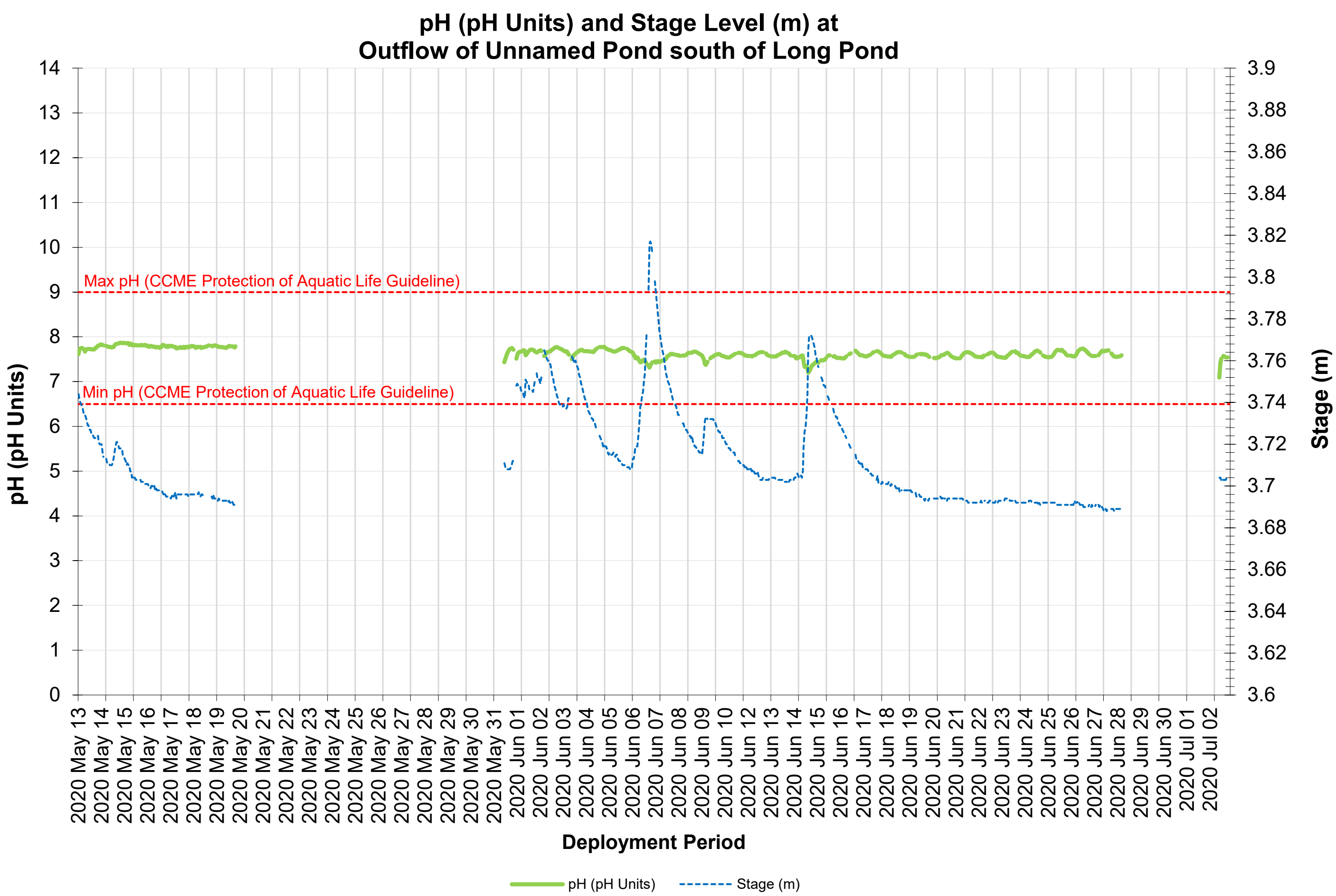

Figure 11: pH (pH units) at Outflow of Unnamed Pond south of Long Pond

Specific Conductivity

The conductivity levels ranged between 165.21 µS/cm and 202.23 µS/cm during deployment (Figure 12). The deployment period had a median of 153.28 µS/cm.

Changes in stage will influence the conductivity data (Figure 12). The extra volume of water during a stage increase will dilute the particle matter present in a water column. When stage level drops – either through evaporation or headwater interference - the conductivity levels will increase. Suspended solids are concentrated in the water column as the volume of water reduces. This relationship between stage and conductivity can be noted on Figure 12, on June 7 and again on June 14, 2020. The conductivity data dropped for a short period before returning to previous level.

Please note the daily averaged stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

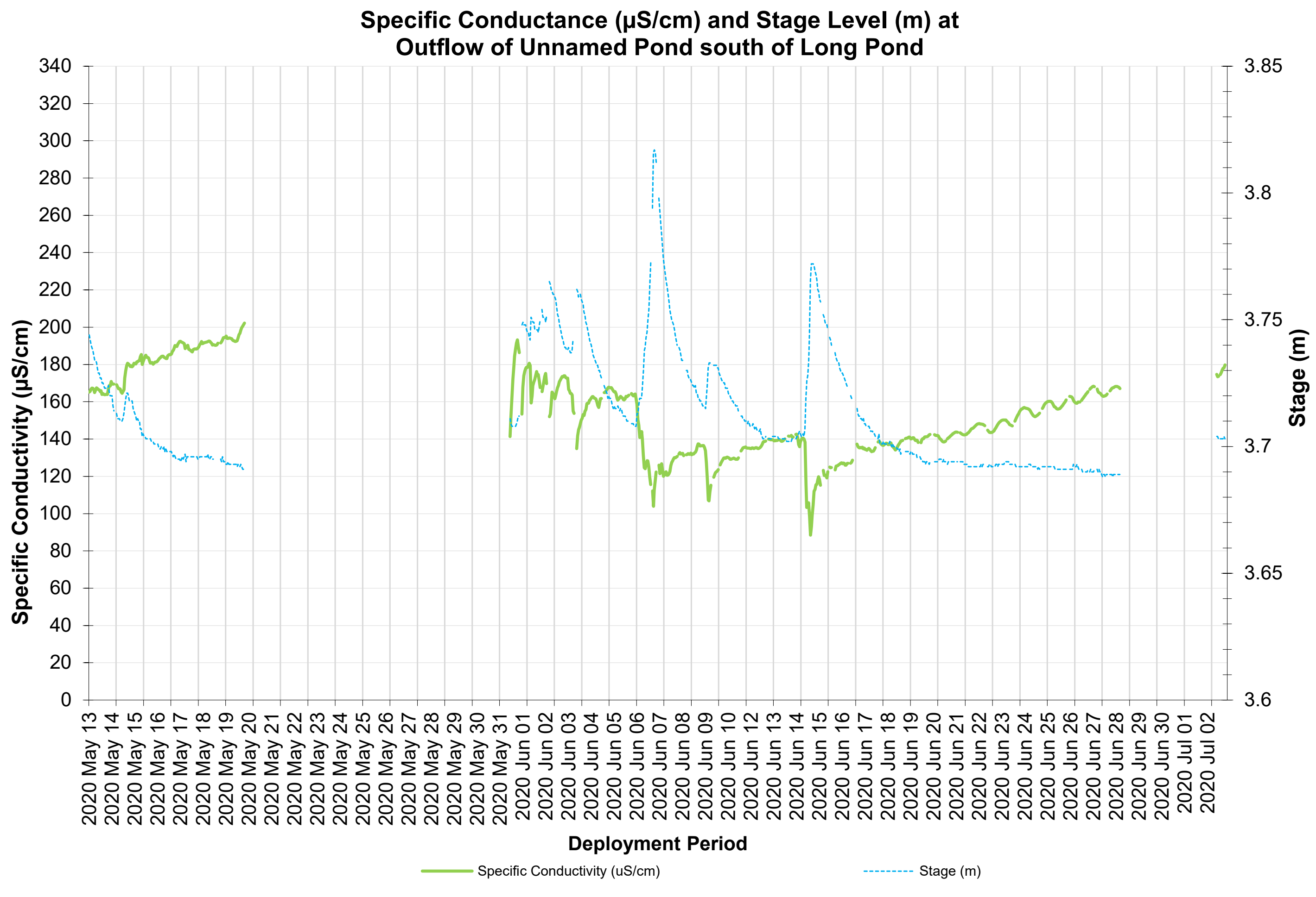

Figure 12: Specific conductivity (µS/cm) at Outflow of Unnamed Pond south of Long Pond

Dissolved Oxygen

The water quality instrument directly measures dissolved oxygen (mg/L) with the dissolved oxygen probe. The instrument then calculates percent saturation (% Sat) taking into account the water temperature. During this deployment, the dissolved oxygen levels where within 9.54 mg/L and 13.44 mg/L for concentration and 95.3 % Sat and 106.4 % Sat for percent saturation.

There is a natural diurnal pattern present in aquatic environments with dissolved oxygen. Oxygen concentration levels will fluctuate throughout night and day. Cooler night temperatures influence higher dissolved oxygen concentrations and warmer day light temperature influence lower concentrations. The movement in the diurnal pattern is evident on Figure 13. All other prominent dips/peaks - outside of the diurnal pattern - are a result of fluxes in water temperature or influences from rainfall/runoff.

Due to transmission issues there were gaps in the data for dissolved oxygen, therefore prominent changes in the concentration of oxygen were difficult to determine. However, there was evidence of dissolved oxygen concentration decreasing throughout the deployment, which would be expected as the air temperature increases with the change in season into Summer (Figure 10).

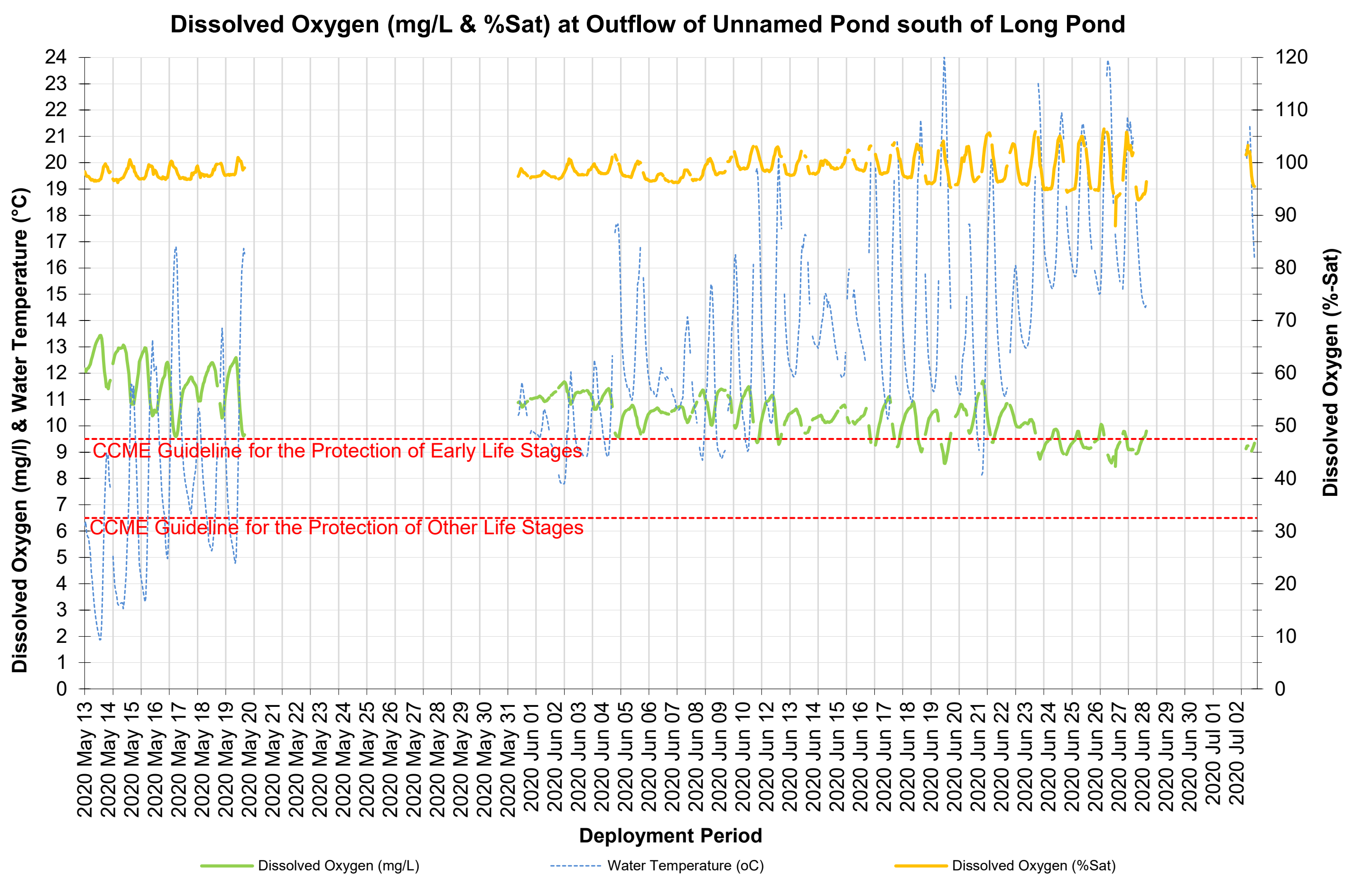

Figure 13: Dissolved Oxygen (%Sat & mg/L) at Outflow of Unnamed Pond south of Long Pond

Turbidity

Turbidity levels during the deployment ranged within 24 NTU and 149.8 NTU (Figure 14). The deployment data had a median of 32.6 NTU.

The turbidity remained above 20 NTU, indicating a high amounts of sediment or suspended material present throughout the deployment. Recorded stage events seemed to flush the brook and reduce the turbidity for a period before increasing again shortly after. The data during the deployment indicated that there was a build-up of suspended material (i.e. sediment or silt) around the sensor, which likely was the cause of the high cluster of turbidity on May 31 to June 6, 2020. Stage data indicated that on June 6, 2020 there was an increase in flow, which likely flushed the suspended material from the brook, hence reducing turbidity levels for the remainder of deployment.

Please note the daily averaged stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

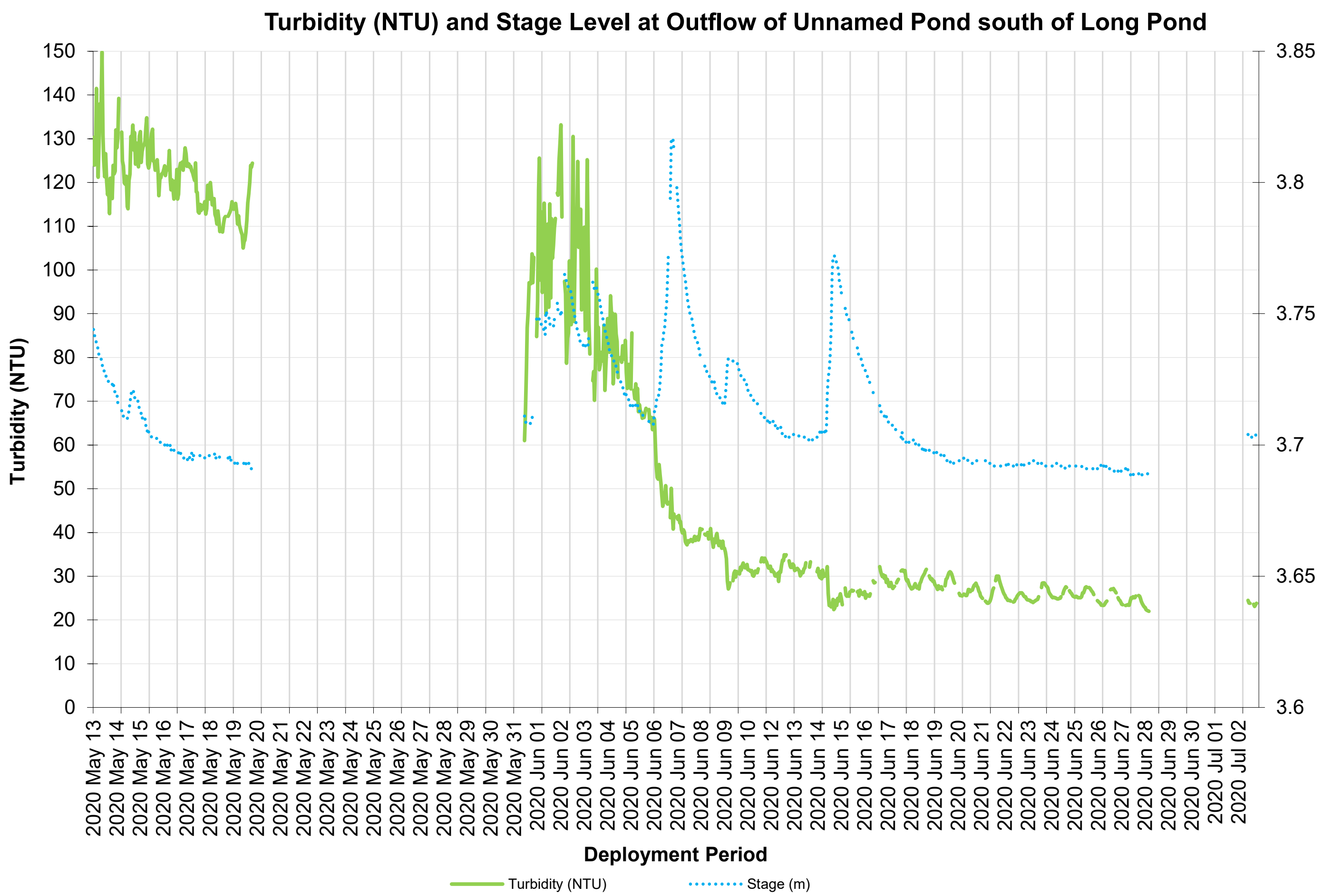

Figure 14: Turbidity (NTU) at Outflow of Unnamed Pond south of Long Pond

Daily Averaged Stage Level and Total Precipitation

Please note the stage data on the graph below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

Stage is an estimation of water level at the station and can explain fluctuations occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage will increase during rainfall events (Figure 15) and during any surrounding snow or ice melt. However, direct snowfall will not cause stage to rise significantly.

Large peaks in stage correspond with the total precipitation events as noted on Figure 15. Total Precipitation data was obtained from Environment Canada's St. Lawrence weather station. It should be noted that precipitation data was not available prior to June 25th. Total precipitation ranges for the deployment period were a minimum of 0.0 mm and maximum of 48.1 mm on December 3rd, 2018.

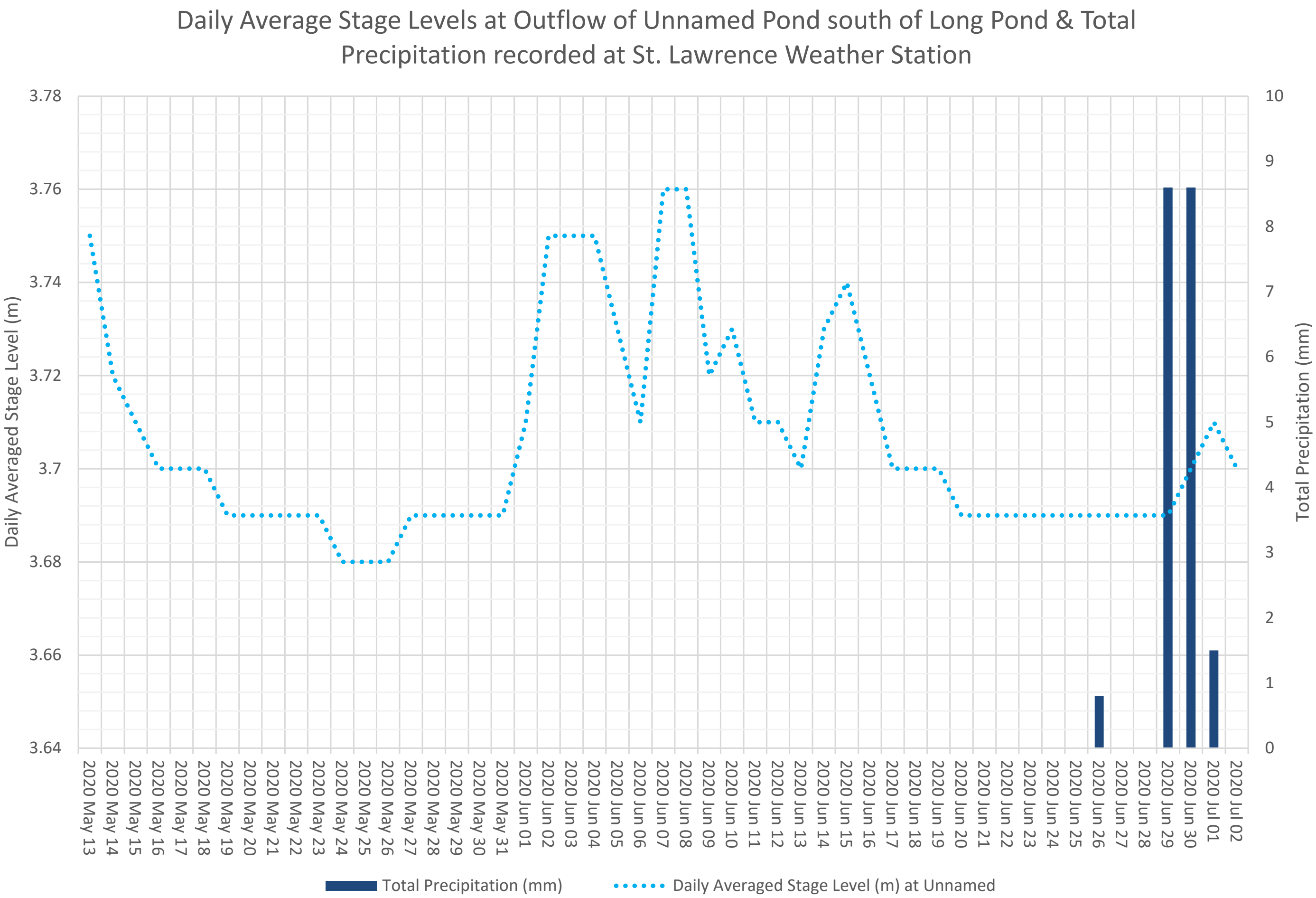

Figure 15: Daily averaged stage values and total precipitation.

Conclusion

The Outflow of Unnamed Pond south of Long Pond is established downstream of the Tailings Management Facility (TMF), to assist in capturing any emerging water quality issues with the management of the tailings facility. The Outflow of Unnamed Pond South of Long Pond also flows through undeveloped area that includes natural wetlands and marshlands. This station is the furthest away from the anthropogenic activities that are occurring on the Canada Fluorspar mine site.

As with many shallow brooks and streams, precipitation and runoff events play a significant role in influencing water quality. Increasing water temperatures during the deployment were representative of the climate for the time of year. The pH values were consistent for this brook with any significant changes in pH data corresponding to a rise in the stage.

Conductivity levels responded to stage fluctuations by decreasing during high stage events and increasing during periods of low stage. The changes in dissolved oxygen levels are a result of the warmer water temperatures. Oxygen levels decreased slightly across deployment as the air temperature increased with the climatic change into summer.

This deployment had a higher maximum for turbidity compared to previous deployments. However, the median was not significantly different from the previous deployment. This deployment had a turbidity median of 32.6 NTU while the previous deployment's median was 33.5 NTU. Stage increases on June 6 resulted in flushing the brook and lowering the turbidity values for the rest of the deployment.

Unfortunately, a significant portion of the data for precipitation was missing. Therefore it is not available to compare against the other parameters to determine the relationship. Generally, precipitation can influence change to water quality conditions. Majority of the changes are natural and quick adjustments in levels before the data returns to background levels. The health of a waterway can be determined by how quickly the parameters return to background data after a water quality event, such as precipitation, run off or snowmelt.