Real-Time Water Quality Report

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

Deployment Period
May 10, 2017 to June 20, 2017

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

Prepared by:

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General

The Water Resources Management Division (WRMD), in partnership with Water Survey of Canada - Environment and Climate Change Canada (WSC-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.

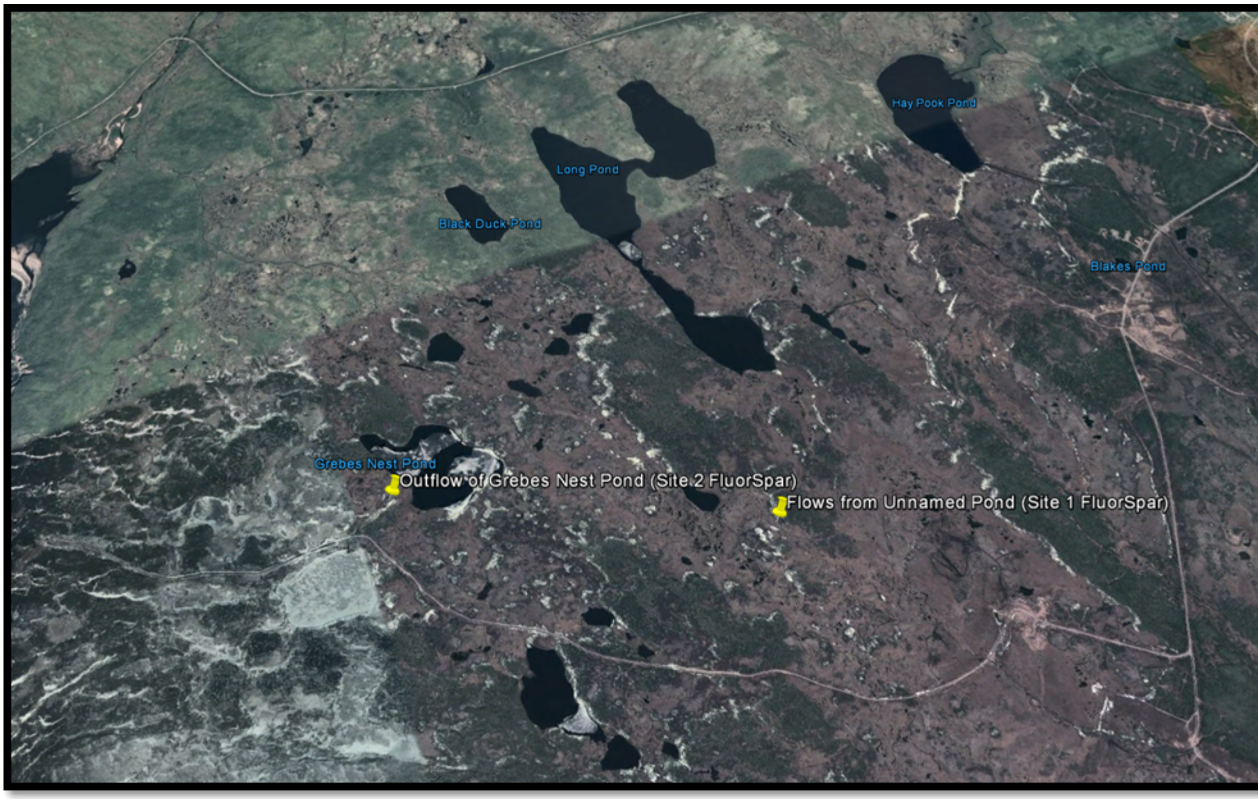

Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

The real-time water quantity/quality station downstream from Grebes Nest Pond was labeled "Outflow of Grebes Nest Pond". The location of Outflow of Grebes Nest Pond station is established downstream of the pit dewatering effluent outfall upstream of John Fitzpatrick Pond. The stream is approximately 1.0 to 2.0 meters wide. The brook 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 left 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.

The real-time water quantity/quality station labeled "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 initiates from a small unnamed pond and meanders through a marsh environment alongside 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).

Outflow of Grebes Nest station was installed before Outflow of Unnamed Pond south of Long Pond due to weather constraints and the logistics of installing the station hut at Outflow of Unnamed Pond. This report covers the period from the deployment of Outflow of Grebes Nest Pond station on May 10th, 2017 to removal on June 20th, 2017. It was determined in January that the ice conditions at each of the stations could potentially damage the instruments, so the instruments were removed for the winter season and were redeployed once the brooks were ice-free in May.

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 alongside 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 (Municipal Affairs and Environment (MAE)) is responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Tara Clinton, under the supervision of Renee Paterson, 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 (Environment and Climate Change Canada (ECCC)) under the management of Howie Wills, play an essential role in the data logging/communication aspect of the network and the maintenance of the water quantity monitoring equipment. WSC-ECCC 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 dependant, 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 10	Deployment	Good	Excellent	Fair	Excellent	Excellent
	June 20	Removal	Fair	Excellent	Good	Fair	Fair
Unnamed Pond	May 10	Deployment	Marginal	Excellent	Good	Excellent	Excellent
	June 20	Removal	Excellent	Good	Excellent	Excellent	Fair

At deployment of the field instrument, at Outflow of Grebes Nest Pond site, the ranking of the field data against the QAQC data was: 'Good' for water temperature and 'Excellent' for pH, dissolved oxygen and turbidity data. Specific conductivity data ranked 'Fair' against the QA data. All rankings for the water quality parameters were acceptable for the initial deployment of the field instrument at this station. During removal of the instrument the rankings for the data were, 'Fair' for the temperature, dissolved oxygen and turbidity data, the pH data ranked as 'Excellent' and conductivity data ranked as 'Good'. During removal of the instrument it was evident that there was a lot of silt and fouling on the sensors.

At deployment of the field instrument at Outflow of Unnamed Pond south of Long Pond the data ranked as the following; water temperature ranked as 'Marginal' during deployment, this was linked to an issue with the QA sonde and not the field sonde. pH, dissolved oxygen and turbidity data ranked as 'Excellent' and conductivity data ranked against the QA sonde as 'Good'. Despite the water temperature ranking, all the other water quality parameters were of acceptable range for deployment. At the end of the deployment the data was ranked again to compare, and the rankings for all the parameters where acceptable.

Concerns or Issues during the Deployment Period

During the site visit to Outflow of Grebes Nest Pond in May 2017, it was observed that there was no longer water flowing in this brook. Several sections of the brook upstream from the station had completely dried up. Canada Fluorspar had dewatered Grebes Nest Pond for mining and at this time it was decided that the only way to maintain flow in the brook would be to draw water from a small pond just upstream from what was Grebes Nest Pond.

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 3.41°C to 14.26°C during the deployment period (Figure 4). The water temperature at the station displays diurnal variations of the temperature. During high stage events throughout deployment the water temperature responded by dipping slightly during that timeframe, this is a normal occurrence. Toward the end of the deployment the water temperatures started to increase, this mirrors the air temperatures at this time as well (Appendix A).

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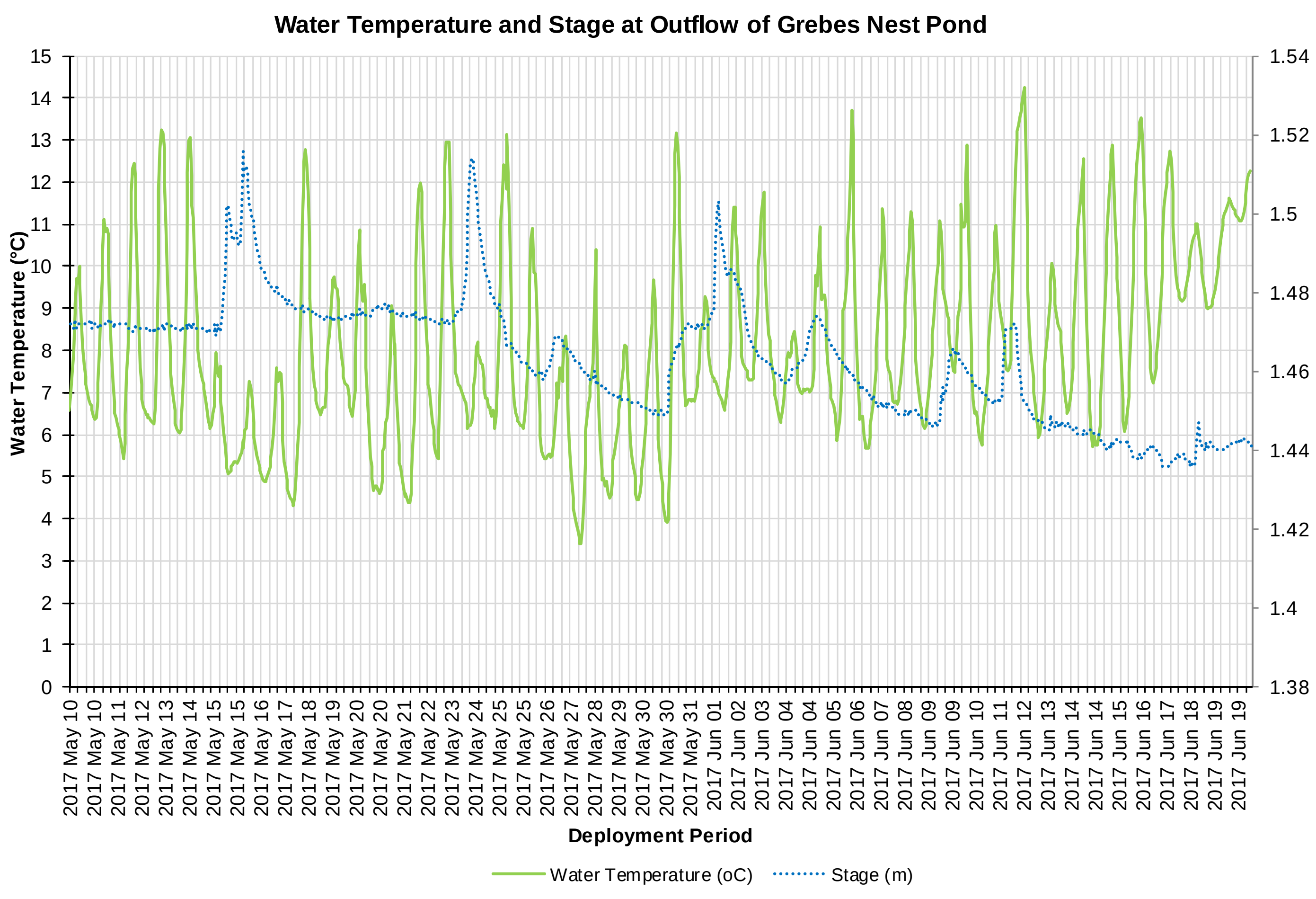

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 5.60 pH units and 6.40 pH units (Figure 5) and are reasonably consistent. The pH data remained below the minimum Guideline for Protection of Aquatic Life. The Canadian Council of Ministers of the Environment (CCME) guidelines is just a basis by which to compare the pH data within a dataset. Every brook is different with its own natural background range. It is not uncommon for Newfoundland and Labrador waters to be below the CCME pH guideline.

Generally pH data dips during high stage events, however on May 15th and 16th the pH data increased; there was a significant rainfall on these days which may have flushed material into the brook. There were also increases in conductivity and turbidity during the same timeframe. For all other high stage events the pH data does decrease slightly, which would be expected during rainfall events. Natural processes such as rainfall and snow melt will alter the pH of a brook for a period of time.

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.

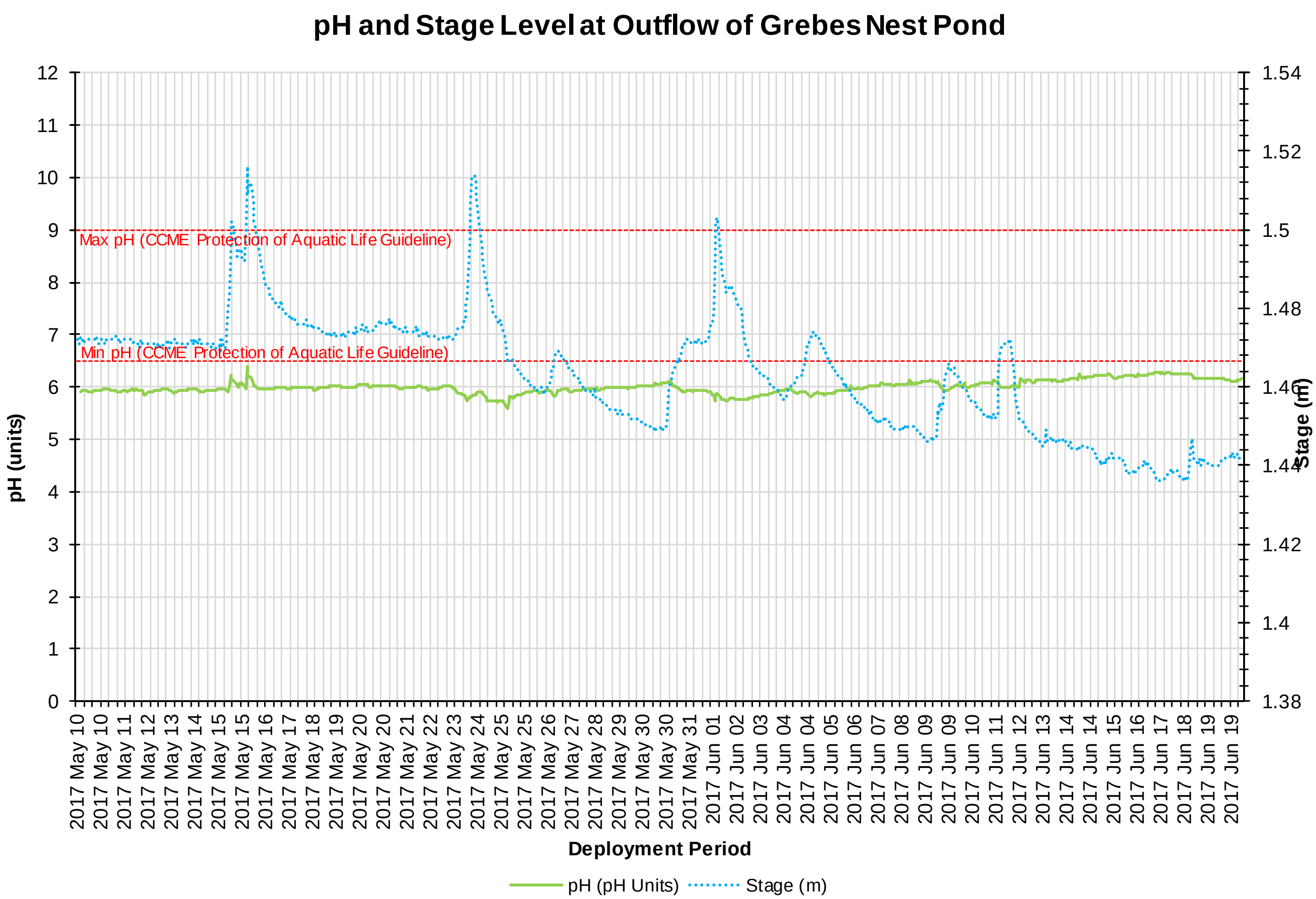

Figure 5: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were within 53.5 µS/cm and 83.6 µS/cm during the deployment period. Total Dissolved Solids or TDS (a calculated value) ranged from 0.0300 g/L to 0.0500 g/L (Figure 6). TDS is a calculated measurement that the instrument provides once conductivity levels have been recorded. TDS was not included on this graph.

The relationship between conductivity and stage level is generally inversed. When stage levels rise, the specific conductance levels drop in response, as the increased amount of water in the river system dilutes the solids that are present. This is evident on Figure 6 in several places but most noticeably on May 24th and June 1st, 2017.

It is also common to see an increase in conductivity with an increase in stage. This is evident on May 15th May 27th, June 9th and June 11th, 2017 where there is a spike in conductivity and an increase in stage. Furthermore, air temperature increases did indicate that there may have been rainfall on those dates (Appendix A). Rainfall can flush organic and inorganic matter into the brook, increasing the conductivity levels for a short period of time (Figure 9, Precipitation graph).

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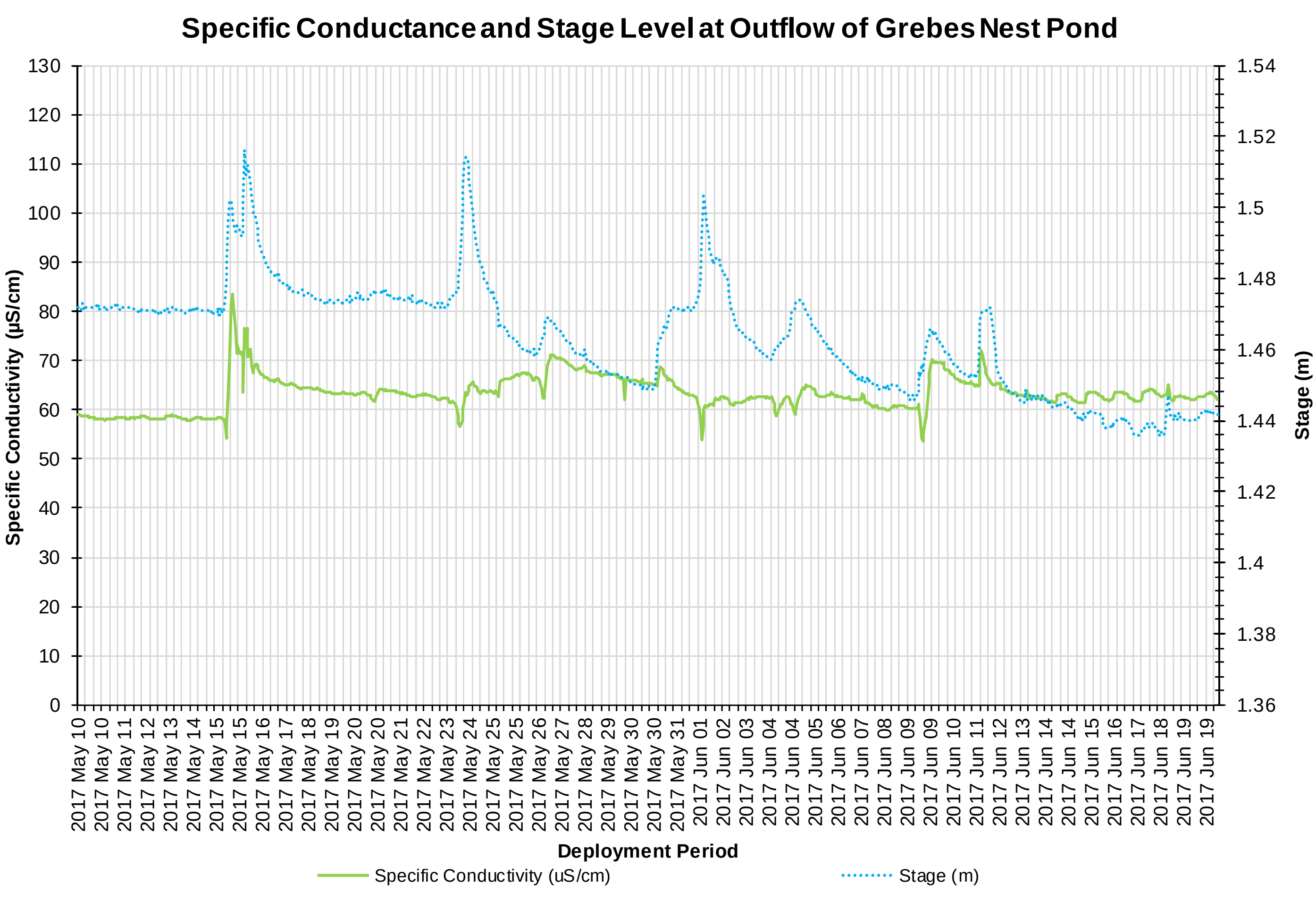

Figure 6: Specific conductivity (µS/cm) and stage (m) values

Dissolved Oxygen

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

During the deployment the dissolved oxygen concentration levels ranged within a minimum of 7.40 mg/L to a maximum of 12.23 mg/L. The percent saturation levels for dissolved oxygen ranged within 67.2% Saturation to 115.1% Saturation (Figure 7).

As the climate changed from winter to spring, there was a natural increase in water temperature, the water temperature increase influenced the dissolved oxygen to slightly decrease. This is evident during the higher temperature events, on May 25th and toward the end of the deployment, as the dissolved oxygen concentration dipped below the CCME guideline for the Protection of Early Life Stages (9.5mg/L).

The CCME guidelines for the Protection of Aquatic Life provide natural guidance. There are many occasions that natural brook environments move within these guidelines. Every brook is different with its own natural background range for dissolved oxygen. It is not uncommon for Newfoundland and Labrador waters to be within or above the CCME guideline.

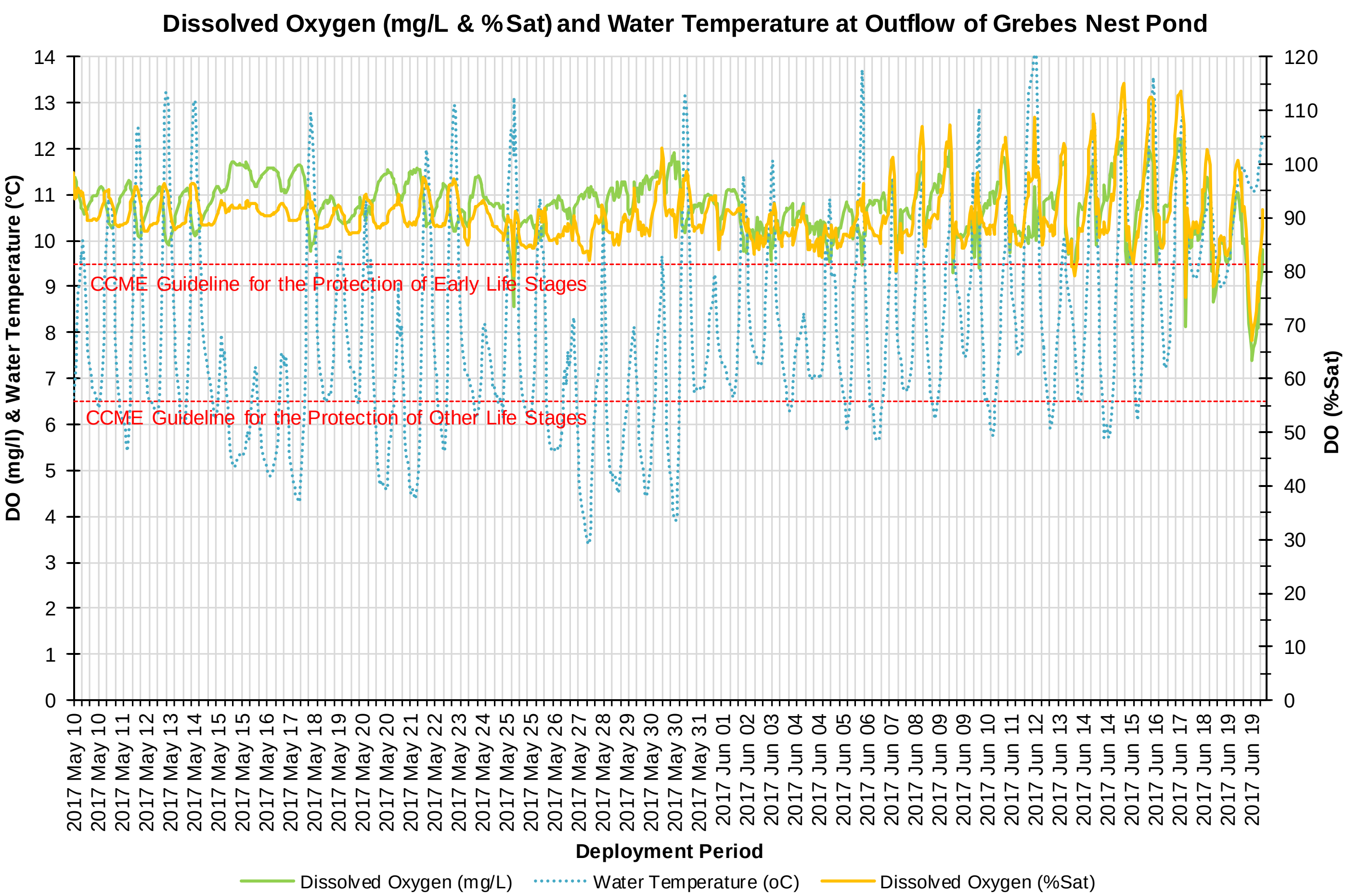

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 3.8 NTU and 1314.4 NTU (Figure 8). The deployment data had a median of 20.8 NTU.

During rainfall or runoff, higher turbidity readings are expected. Generally the turbidity levels increase for a short period of time and then return to within the range of the baseline. However if - after a turbidity event - the values do not decrease and there is greater frequency and higher values being recorded then these outcomes would be of concern.

At this station, the higher turbidity events throughout the deployment period correlate with increases in stage potentially from precipitation. Rainfall and subsequent runoff can increase the presence of suspended material in water. The turbidity data does return to lower levels after the high peaks, as noted on Figure 8.

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.

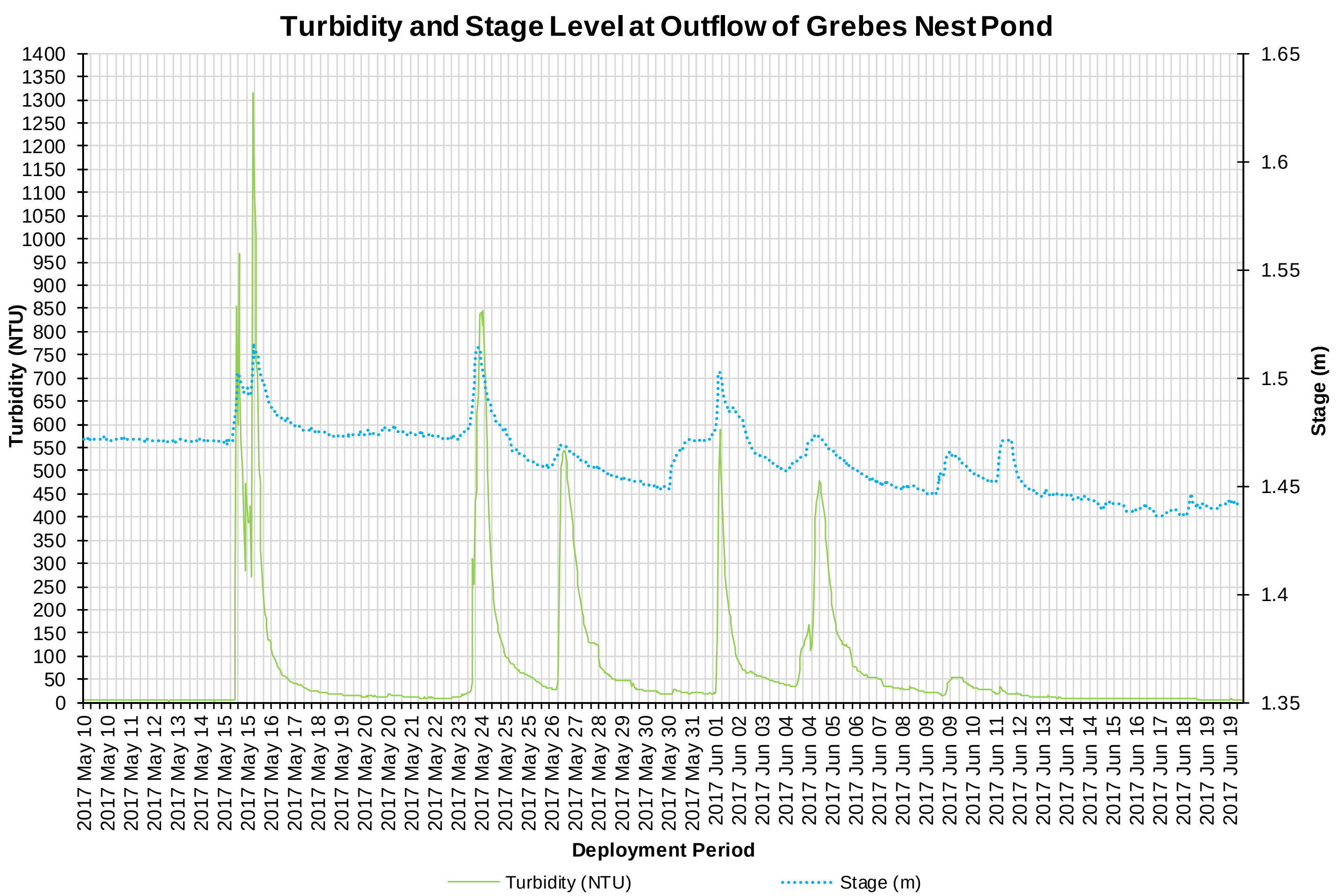

Figure 8: Turbidity (NTU) and stage level (m) values.

Stage and Precipitation

Please note the stage data graphed 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 important to display as it provides an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage will increase during rainfall events (Figure 9) and by snow or ice melting and collecting in the brook as runoff. However, direct snowfall will not cause them to rise significantly.

During the deployment period, the stage values ranged from 1.44m to 1.52m. The larger peaks in stage corresponded with substantial rainfall events as noted on Figure 9. Precipitation data was obtained from Environment Canada's St. Lawrence weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 22.8 mm on May 15th, 2017. High precipitation was also recorded on May 24th, 2017 and June 1st, 2017.

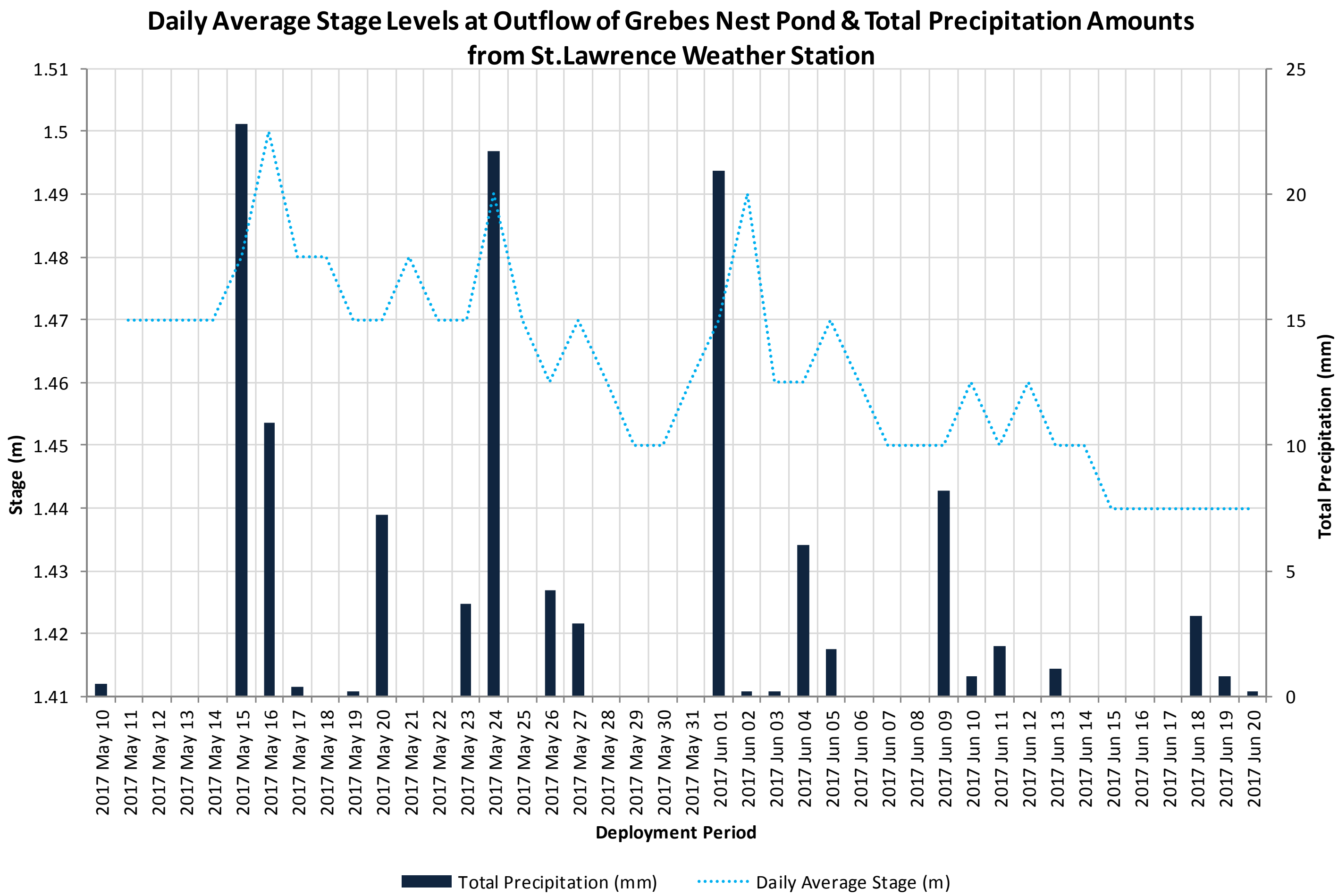

Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond flows through a developing mine site. At this phase of the mines progress, the natural environment is constantly being disturbed by construction activities. Grebes Nest Pond had been dewatered for mining purposes and no longer exists. At this time the brook is being flushed through with water from John Fitzpatrick's pond. John Fitzpatrick is the pond that Outflow of Grebes Nest brook flows directly into. This is a short term situation.

The brook's watershed is bordered by marshland, which can also influence the material present in the water column. These factors combined can impact the water quality parameters during climatic events such as precipitation, snow and spring thaw melt.

When reviewing the graphs as a whole it is evident that the larger precipitation events did create varying effects with the water quality parameters including pH, conductivity, dissolved oxygen and turbidity. The movement in the water temperature data indicates that, air temperatures influenced the drop in the water temperature, which in turn, influenced the dissolved oxygen concentration in the brook. Shallower brooks are highly influenced by air temperatures.

For most of the deployment period the pH values were reasonably consistent however there was an increase in pH during a high stage event on May 15th, 2017. May 15th, also had high specific conductivity and turbidity values and reduced dissolved oxygen levels. These changes in water quality are likely a result of the significant rainfall that occurred on May 15th, 2017 and in turn, subsequent runoff from the surrounding area. All parameters returned to base levels after a couple of days.

The water quality data for Outflow of Grebes Nest Pond was as expected of an impacted brook. After perturbations in the data, the parameters did return to the previous levels observed. Overall the water quality parameters recorded at Outflow of Grebes Nest Pond displayed events expected of a brook in an environment influenced by anthropogenic activities.

Outflow of Unnamed Pond south of Long Pond

Water Temperature

Water temperature ranged from 3.34°C to 21.53°C during this deployment period (Figure 10). As the deployment period continued there was a slight increase in water temperature. The increase in water temperature would be expected as the air temperature increased with the summer climate (Appendix A).

Outflow of Unnamed Pond is a shallow brook and it is more likely to be influenced by air temperature changes and climatic changes. The natural diurnal variation of the water temperature is evident for the most part.

On May 15-17th and May 24-25th, 2017 there was a decrease in water temperature for a short period of time. The weather station in St. Lawrence indicates that there was a decrease in air temperature (Appendix A) and a rainfall event during these same time frames (Figure 15). These factors were likely the cause of the movement in water temperature.

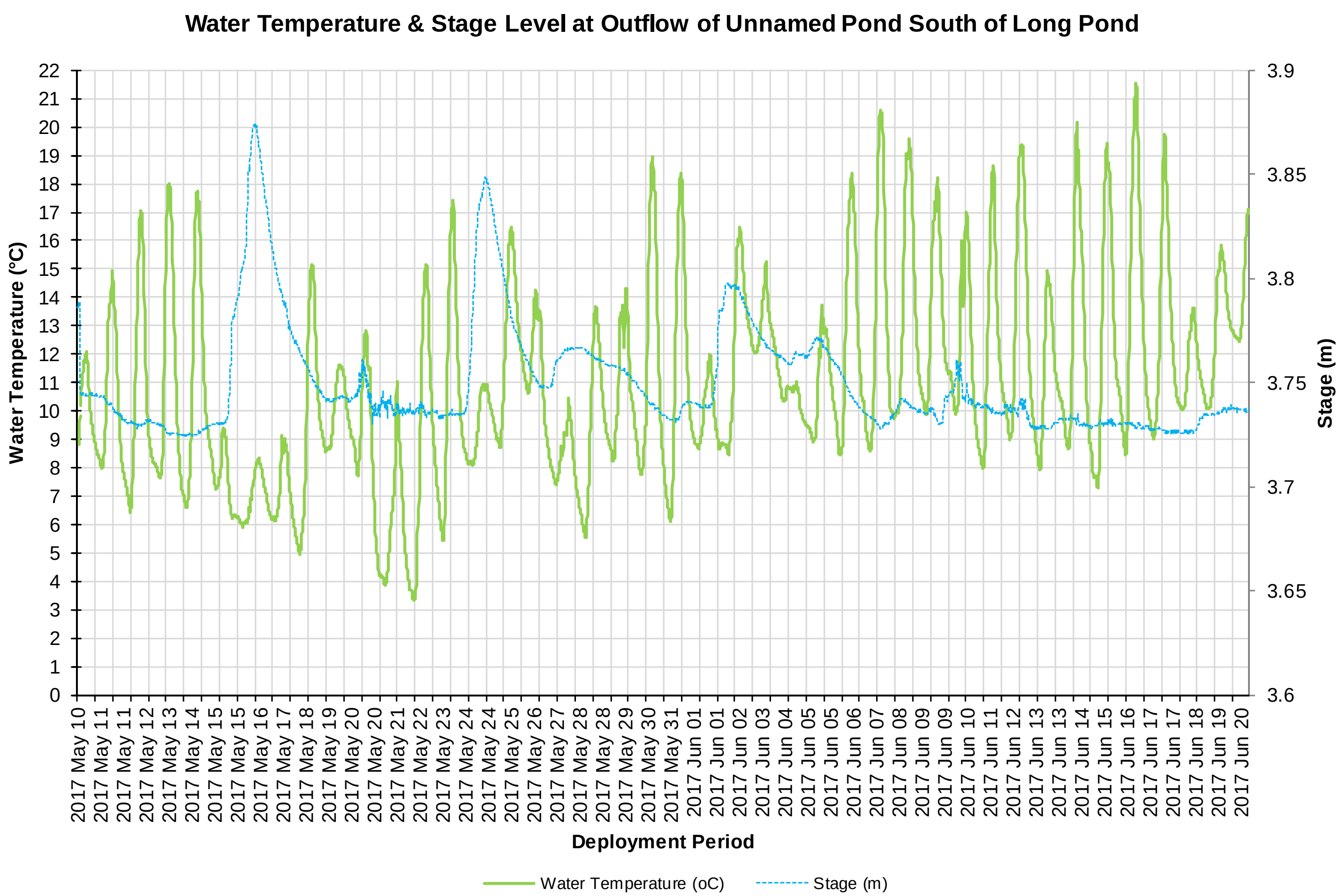

Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout the deployment period, pH values ranged between 5.38 pH units and 6.65 pH units (Figure 11). The pH levels are reasonably consistent during the deployment and remained below the minimum Guideline for Protection of Aquatic Life, until June 14th were the levels increased slightly. The Canadian Council of Ministers of the Environment (CCME) guidelines is just a basis by which to compare any dramatic change in the pH data within a dataset. Every brook is different with its own natural background range. It is not uncommon for Newfoundland and Labrador waters to be below the CCME pH guideline.

Natural processes such as rainfall and snow melt will alter the pH of a brook for a period of time. This is evident on Figure 11, during and after high stage levels the pH data decreased slightly for short period of time. This is a natural process.

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.

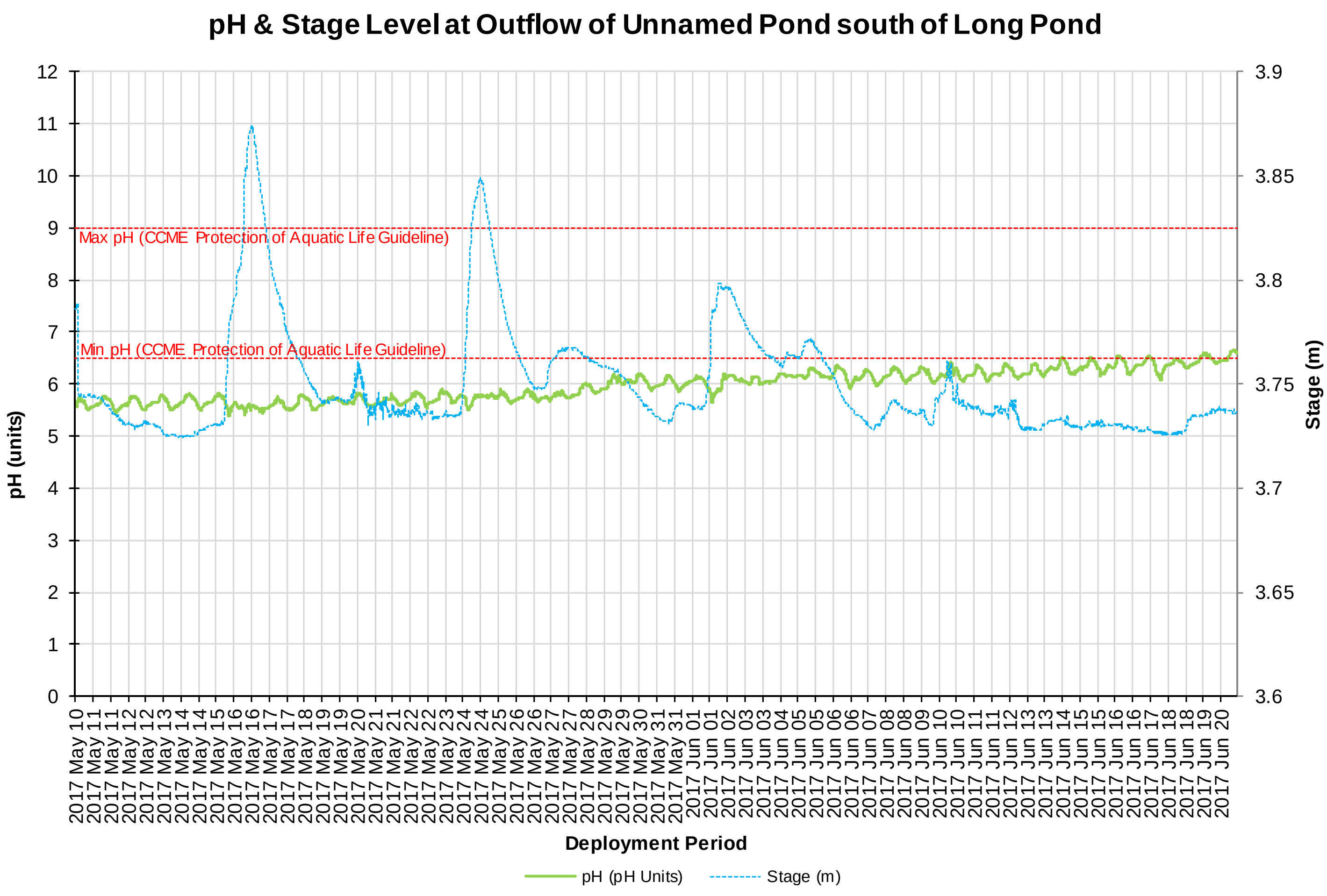

Figure 11: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were between 43.7 µS/cm and 96.3 µS/cm during this deployment period (Figure 12). There is a general relationship between conductivity and stage, whereby the interaction between the two water quality parameters is inversed. For example, when stage levels rise, the specific conductance levels will decrease in response. As the stage level increases, the increased amount of water in the river dilutes the suspended solids that are present (Figure 12).

However, during high stage events it is also possible to see an increase in conductivity; these events are generally caused by additional material being flushed into the water column. This was evident on May 15 -16th and May 24 -25th 2017 with a small spike in conductivity occur during a spike in stage. The St. Lawrence weather station data indicated rainfall during this time frame. The higher conductivity is a result of additional material present in the brook at that time, there was a significant increase in material at this time (Figure 15).

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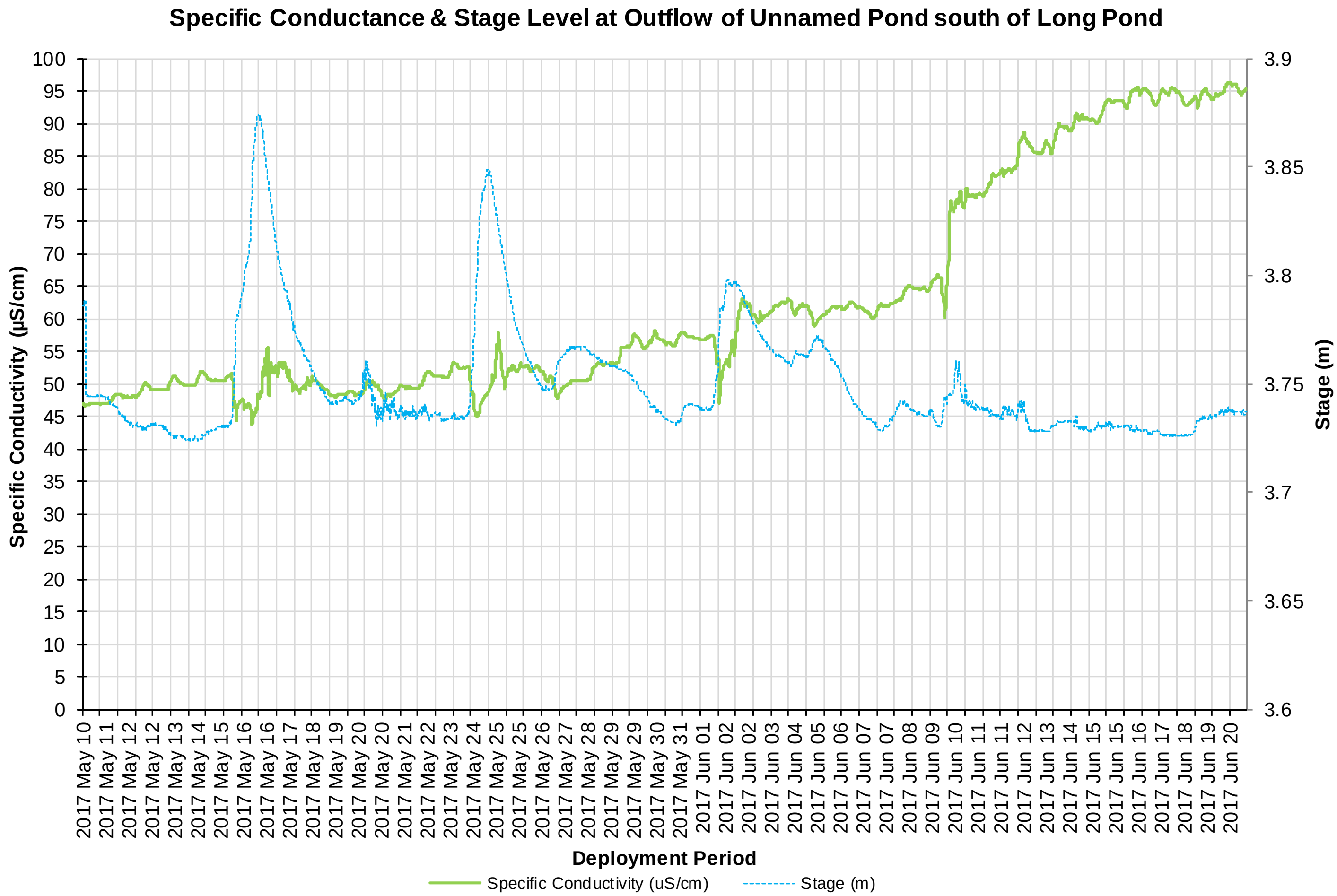

Figure 12: Specific conductivity (µS/cm) and stage (m) values

Dissolved Oxygen

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

During the deployment the dissolved oxygen concentration levels ranged within a minimum of 8.88 mg/L to a maximum of 12.91 mg/L. The percent saturation levels for dissolved oxygen ranged within 92.1% Saturation to 105.6% Saturation (Figure 13).

The flattening of the dissolved oxygen concentration levels on May 15th to May 16th, 2017 are likely a result of the precipitation that occurred during those same dates.

There was a natural diurnal pattern with dissolved oxygen, as the water temperatures decreased in the evening the dissolved oxygen increased, and as the water temperatures increased during daylight hours the dissolved oxygen levels decreased. This is evident on Figure 13. The lower dips in dissolved oxygen are likely linked to slightly warmer temperatures for that time frame.

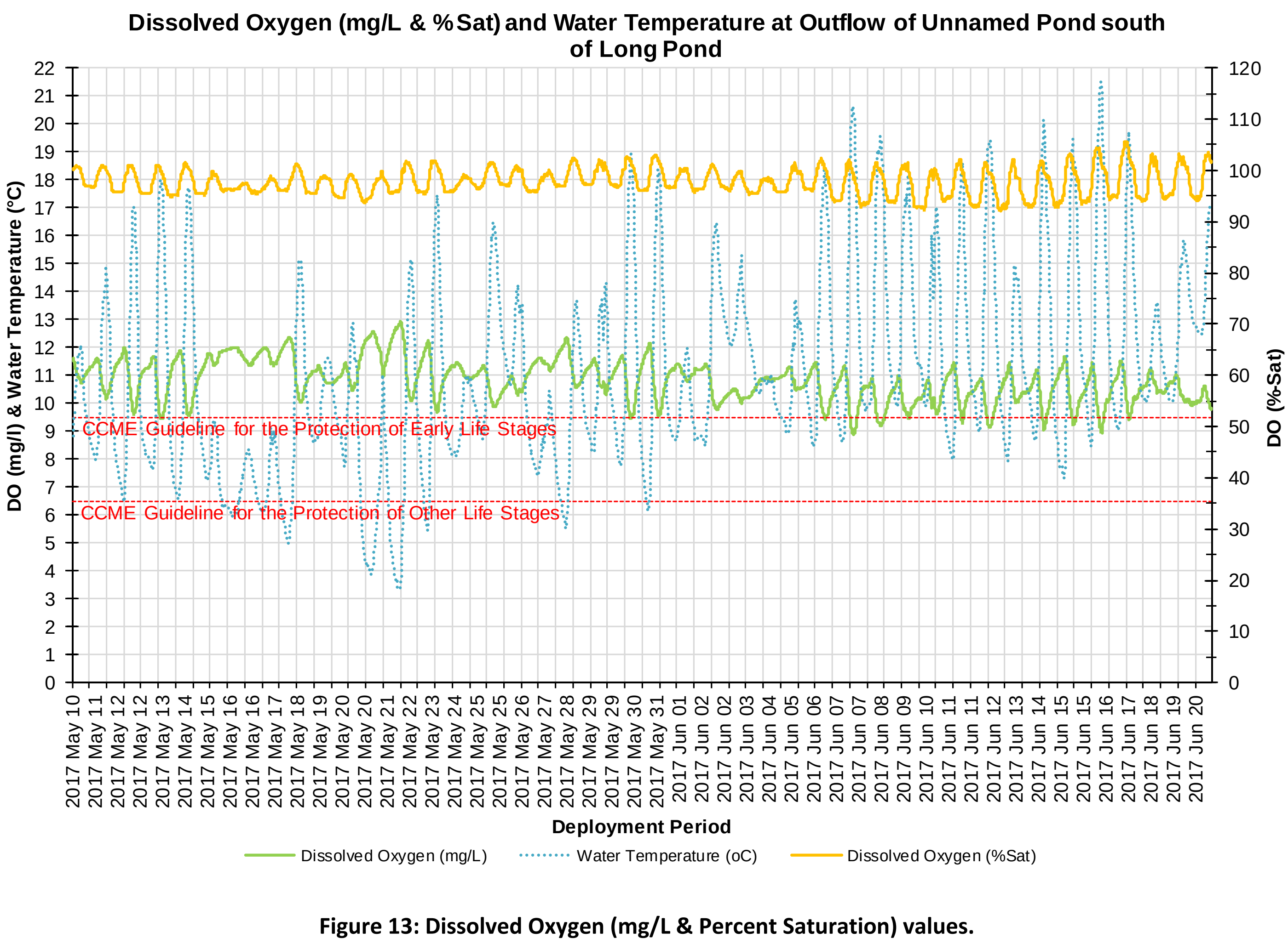

Figure 13: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 7.9 NTU and 69.9 NTU (Figure 14). The deployment data had a median of 21.0 NTU. The median was higher than previous deployments turbidity levels during the deployment. There was more construction and activities occurring within the catchment of this brook at this time.

At this station the large turbidity events correlate with increases in stage level. The stage levels occurred during the precipitation events that were recorded in St. Lawrence. Rainfall and subsequent runoff can increase the presence of suspended material in water.

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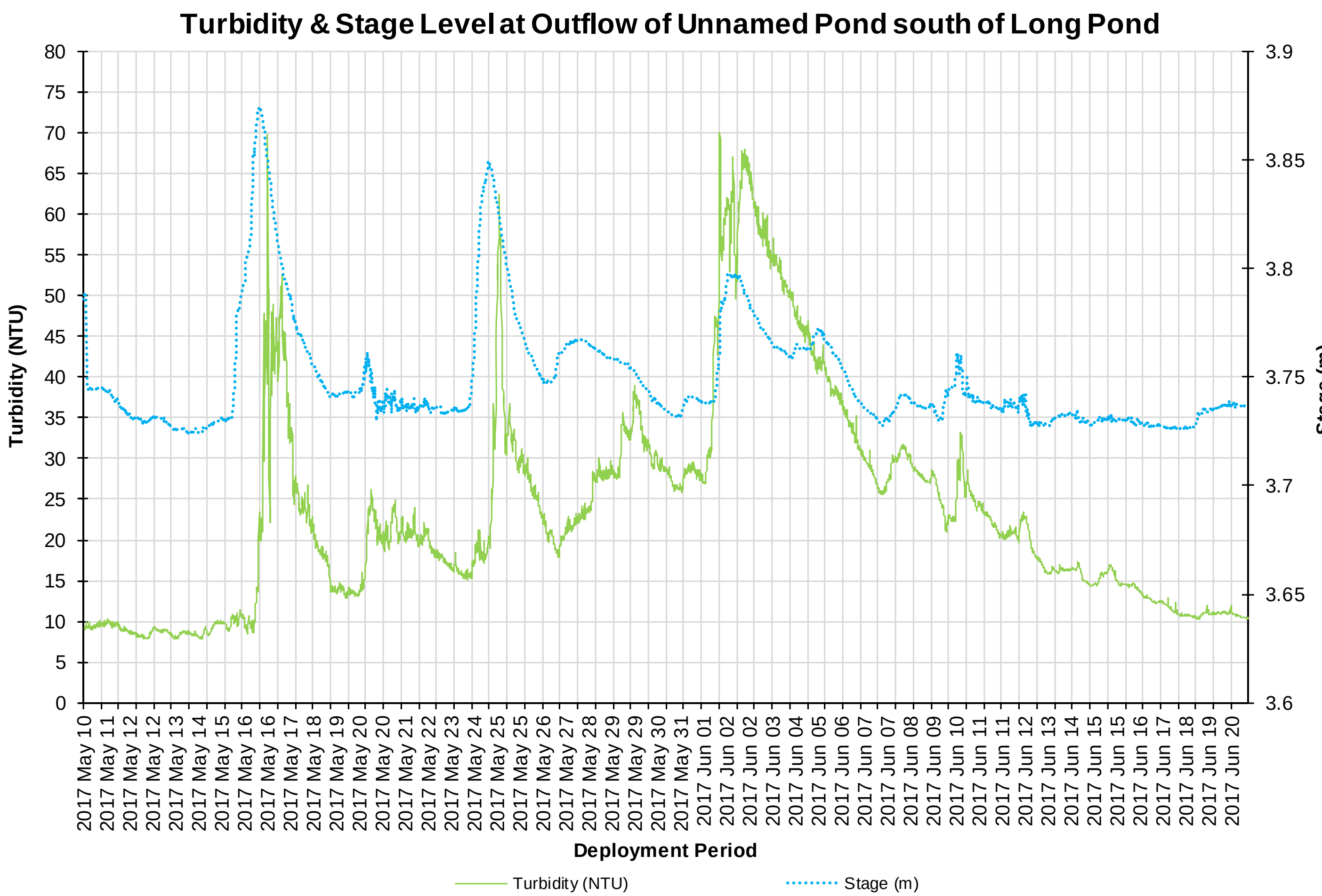

Figure 14: Turbidity (NTU) and stage level (m) values.

Stage and Precipitation

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Stage is important to display as it provides an estimation of water level at the station and can explain some of the events that are 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.

During the deployment period, the stage values ranged from 3.72m to 3.87m. The larger peaks in stage do correspond with substantial rainfall events as noted on Figure 15. Precipitation data was obtained from Environment Canada's St. Lawrence weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 22.8 mm on May 15th 2017.

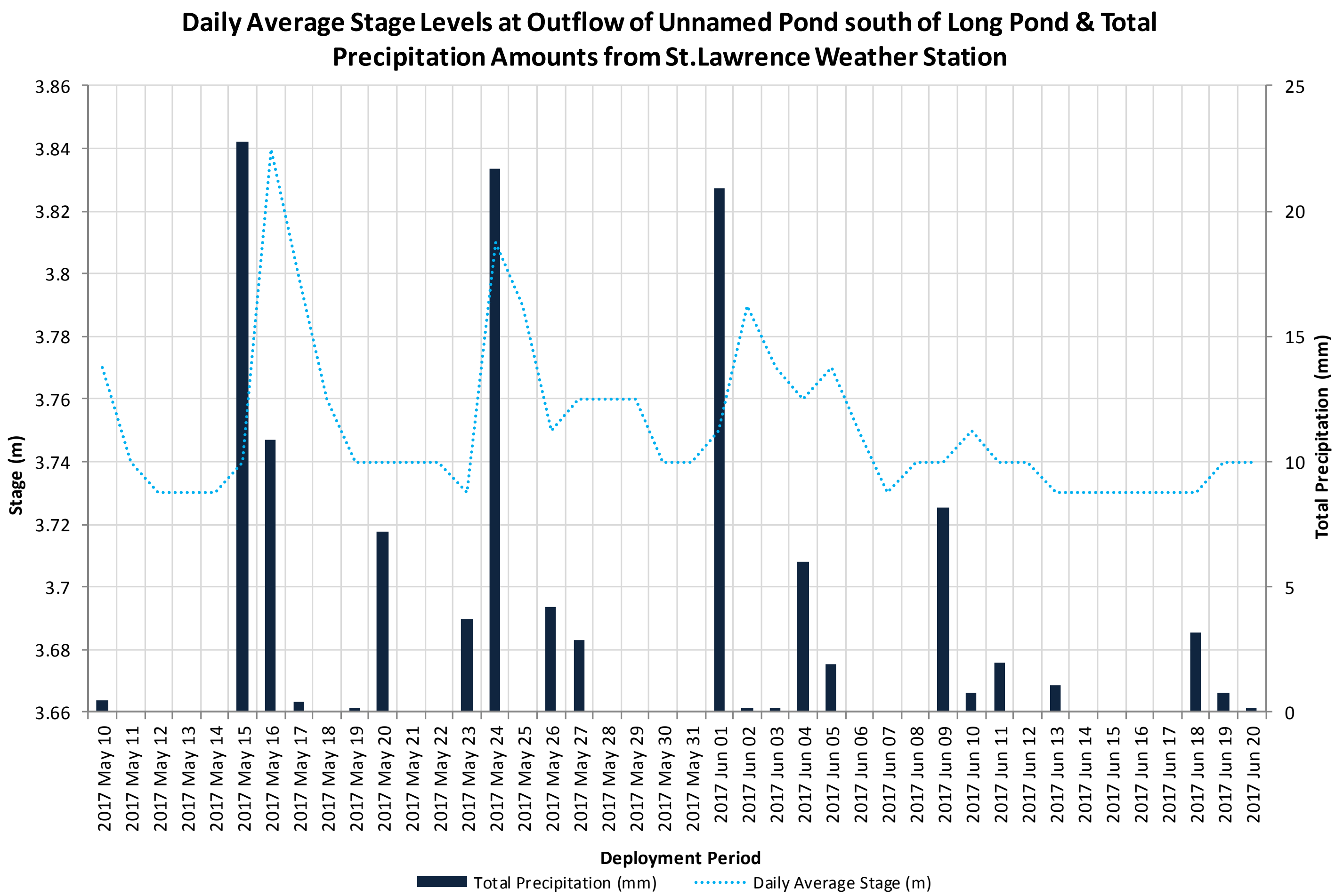

Figure 15: Daily average stage values and daily total precipitation.

Conclusion

As with many shallower brooks and streams, precipitation and runoff events play a significant role in influencing the water quality within the water body. The Outflow of Unnamed Pond south of Long Pond runs through undeveloped areas that include natural wetlands and marshlands, the brook skirts along the construction activity that is ongoing. This type of watershed background will influence the water quality parameters. This station is the furthest away from the anthropogenic activities that would be occurring on the mine site.

It is evident that the larger precipitation events did influence varying effects with the water quality parameters including pH, conductivity, dissolved oxygen and turbidity. Water temperatures are directly influenced by air temperatures and then water temperatures, in turn, will influence the dissolved oxygen concentration in the brook. Water temperatures during the deployment were representative of the climate for this time of year.

For most of the deployment period the pH values were reasonably consistent. Any change in pH data corresponded with a rise or dip in the stage level during the same timeframe. The specific conductivity dips were a result of high stage levels and rainfall events. The increase in conductivity at the end of deployment was during a decrease in stage. It is possible that as the stage dipped, the conductivity became more concentrated for a short period of time. There was significant movement in the turbidity data during this deployment; the median for the deployment was 21.4 NTU. There was more activity occurring on the mine site at this time, and the higher turbidity was likely a result of runoff from earth moving activities.

The watershed for this brook will undergo anthropogenic changes as the mining activities increase. The health of a brook can be determined by how quickly it returns to a consistent parameter level after a water quality event.

APPENDIX A

WATER TEMPERATURE AND AIR TEMPERATURE COMPARISON

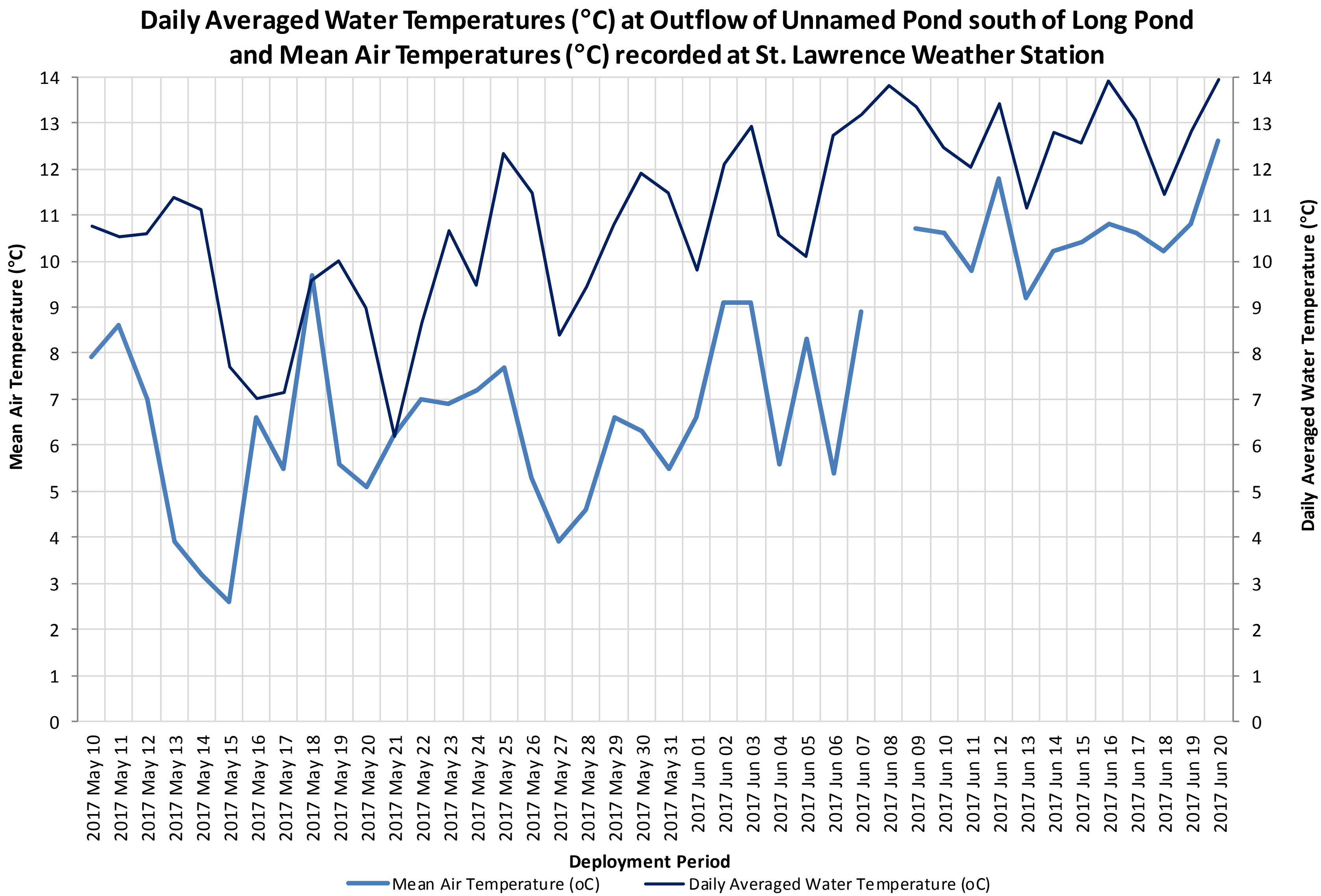

Figure A1: Water Temperatures at Outflow of Unnamed Pond south of Long Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

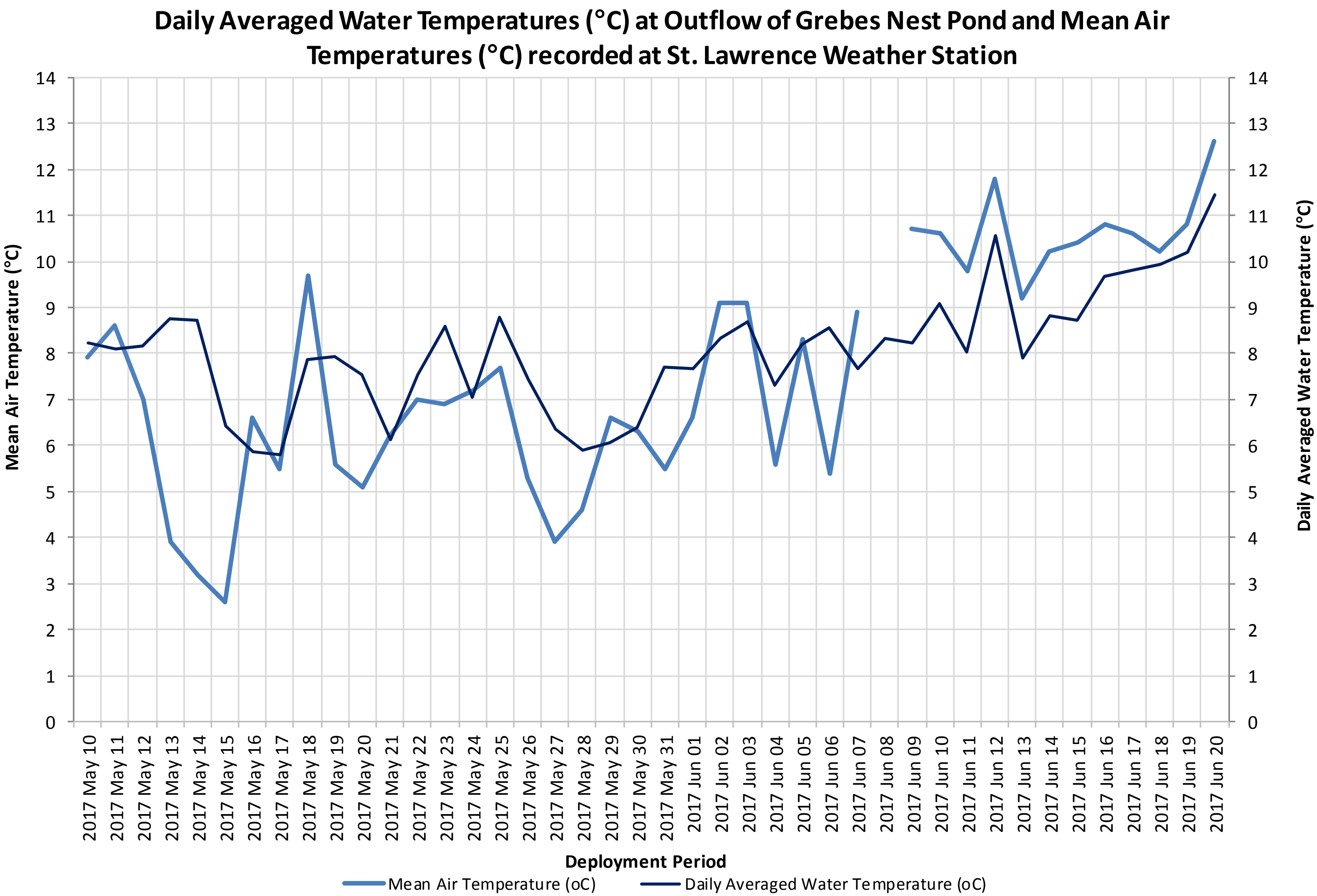

Figure A2: Water Temperatures at Outflow of Grebes Nest Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

Canada Fluorspar (NL) Inc, Newfoundland and Labrador