Real-Time Water Quality Report

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

Deployment Period
July 25, 2017 to September 5, 2017

Newfoundland Labrador

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

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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.

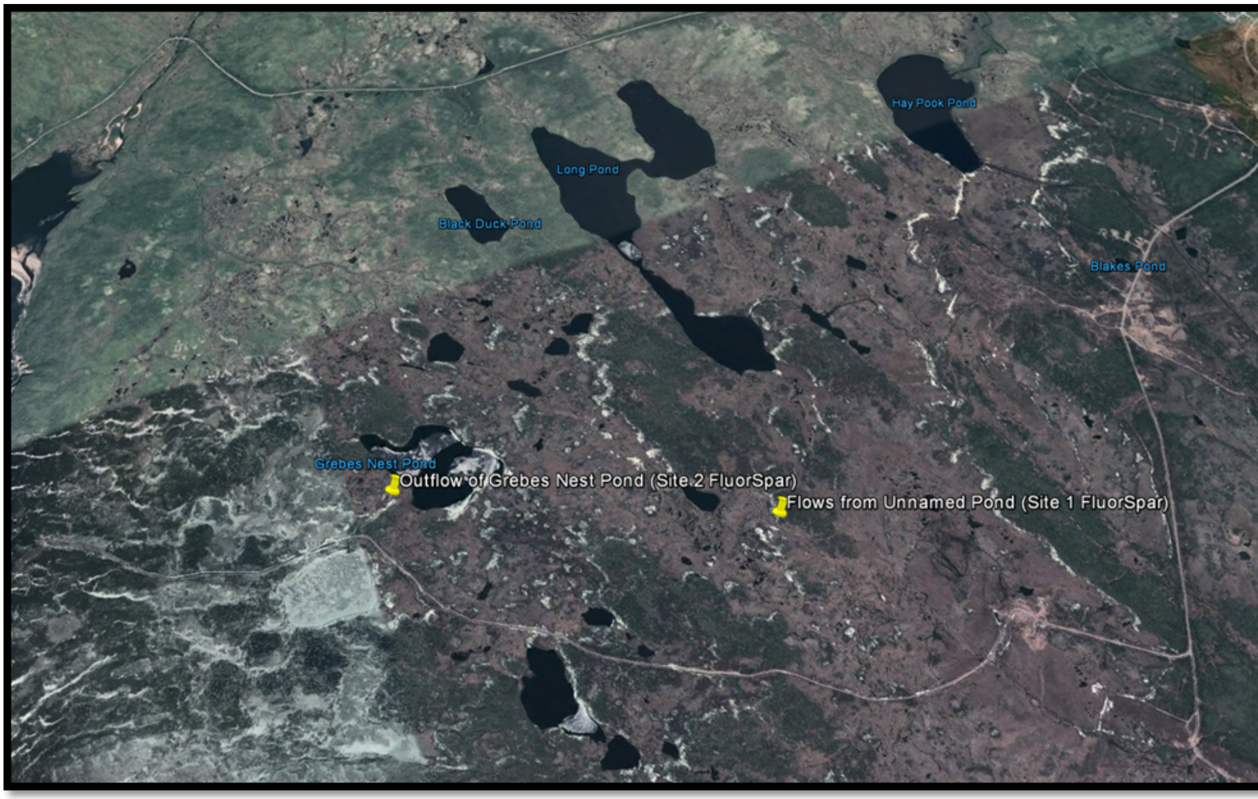

Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

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).

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	July 25	Deployment	Excellent	Fair	Excellent	Excellent	Good
	Sept 5	Removal	Good	Good	Excellent	Excellent	Poor
Unnamed Pond	July 25	Deployment	Marginal	Excellent	Good	Excellent	Fair
	Sept 5	Removal	Excellent	Excellent	Good	Excellent	Poor

At deployment of the field instrument, at Outflow of Grebes Nest Pond site, water temperature, specific conductivity, dissolved oxygen data ranked as 'Excellent' against the QA values that were recorded. pH data was ranked as 'Fair' and turbidity data ranked as 'Good' against the QA values.

During removal of the instrument the ranking for turbidity data was ranked as 'Poor' against the QA data. It is likely that the 'Poor' ranking was a result of fouling occurring on the sensor after some time in the brook. The rankings for the other water quality parameters were acceptable for removal (Table 2).

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, specific conductivity and dissolved oxygen data ranked from 'Good' to 'Excellent'. The turbidity data ranked against the QA sonde as 'Fair'. 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. The ranking for water temperature, pH, dissolved oxygen and specific conductivity where within ' Good' to 'Excellent' in the ranking categories. Turbidity data for the field sonde ranked as ' Poor' against the QA sonde. It was determined during removal that there was a lot of sediment built up around the field sonde's turbidity sensor.

Concerns or Issues during the Deployment Period

Canada Fluorspar is continuing to pump water from the small pond that is upstream from the original Grebes Nest Pond. Grebes Nest Pond has been dewatered for mining purposes and no longer exists.

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 12.90°C to 21.10°C during this deployment period (Figure 4). The water temperature at this station displays diurnal variations of the temperature. The temperatures are consistent, with slight decreases during high stage events, like the one on August 7th, 2017.

High stage events are likely a result from precipitation events. The water temperature responds during these events by decreasing for a short period of time, this is a normal occurrence. This brook has frequent changes in the water supply, which introduces variation in stage and this in turn affects the water temperature (Appendix A).

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.

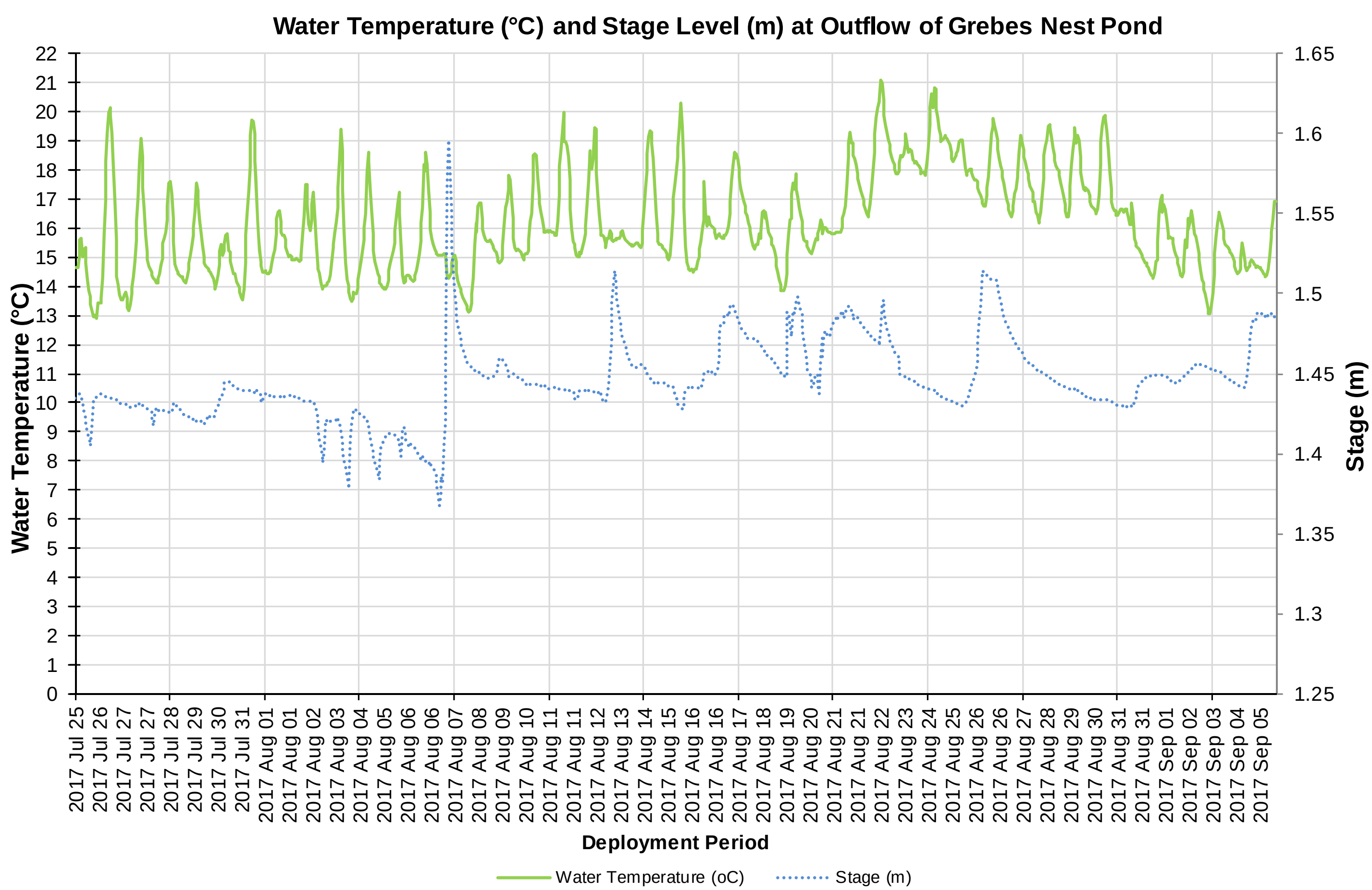

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 5.32 pH units and 6.38 pH units (Figure 5) and are reasonably consistent. The pH data remain 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, as displayed on August 7th, 2017. There was recorded rainfall on this day which may have contributed to material being flushed into the brook. 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.

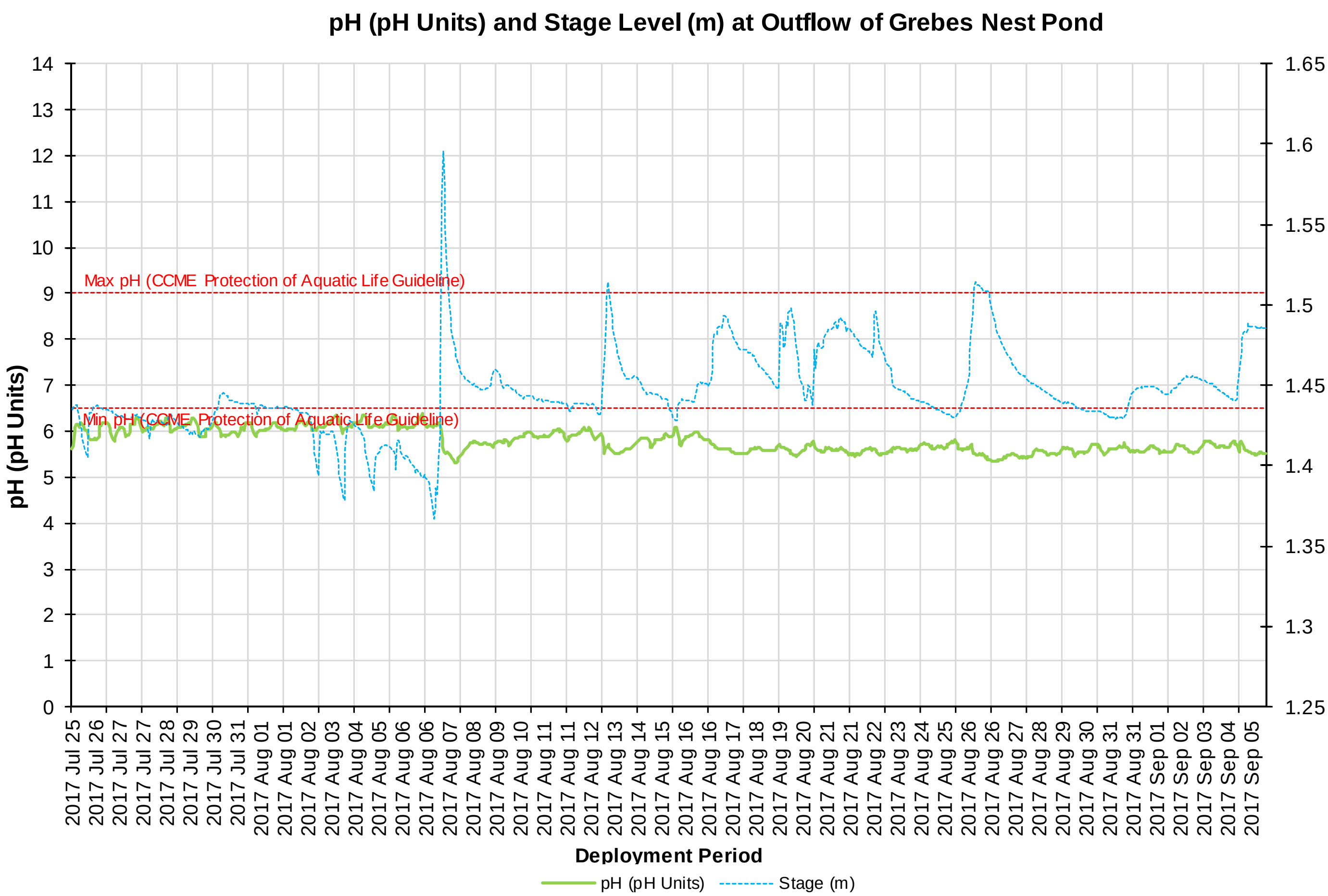

Figure 5: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were within 40.5 µS/cm and 68.8 µS/cm during this deployment period (Figure 6).

The relationship between conductivity and stage level can react in several different ways. During this deployment the specific conductivity levels responded to high stage levels by decreasing initially at the onset of the precipitation amount, however shortly after the dip the conductivity levels increased slightly. This is evident on Figure 6 in several places but most noticeably on August 7th, 2017.

August 7th also had an increase in air temperature and a high rainfall amount (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).

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.

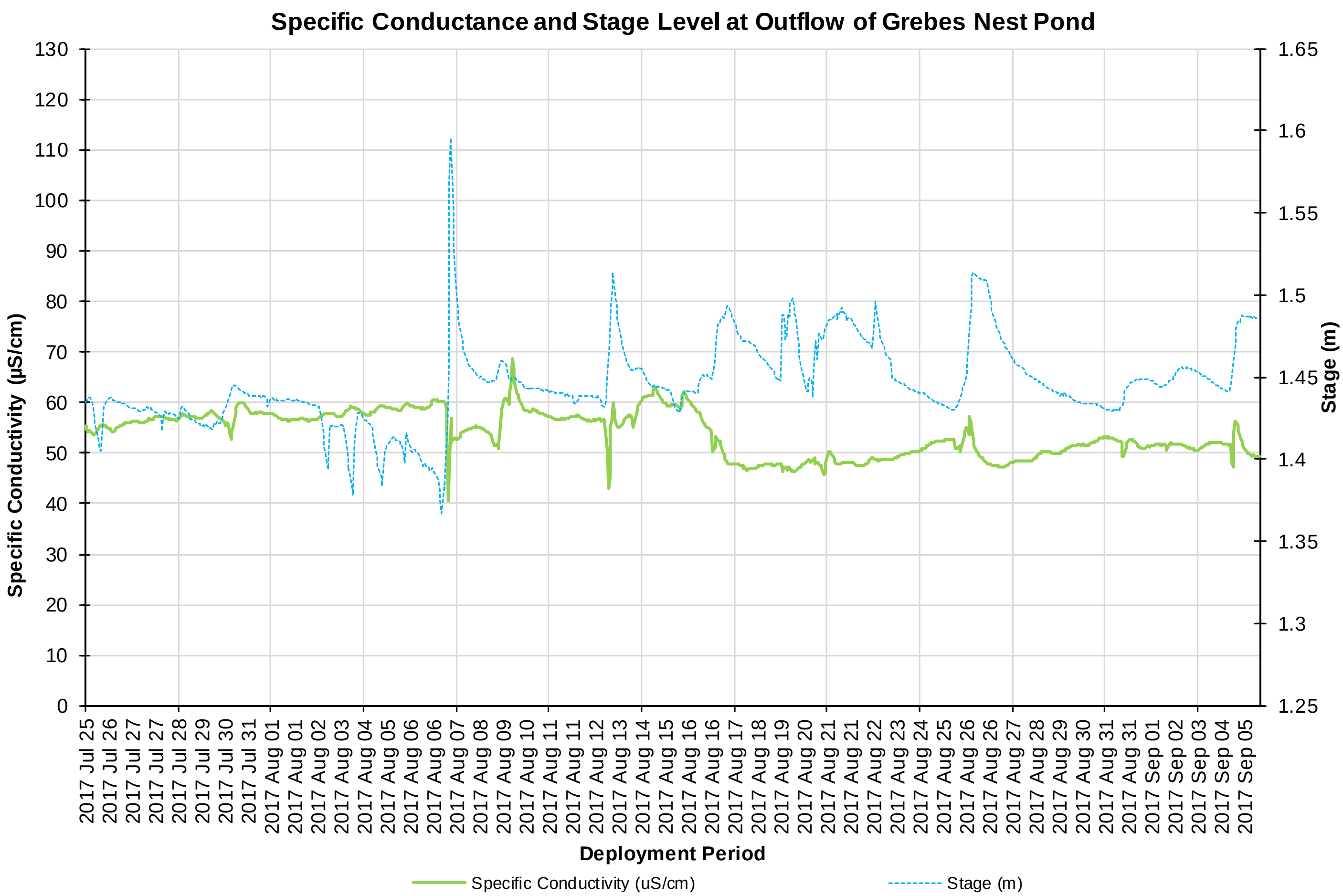

Figure 6: Specific conductivity (µS/cm) and stage (m) values

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 7.06 mg/L to a maximum of 10.29 mg/L. The percent saturation levels for dissolved oxygen ranged within 74.7% Saturation to 107.4% Saturation (Figure 7).

Air and water temperatures will increase as the summer season starts to warm up. There was an increase in water temperature around August 21st to 26th, 2017; this increase influences the level of dissolved oxygen present in the brook. This is a normal reaction in water bodies during the warmer seasons.

The CCME guidelines for the Protection of Aquatic Life provide national 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.

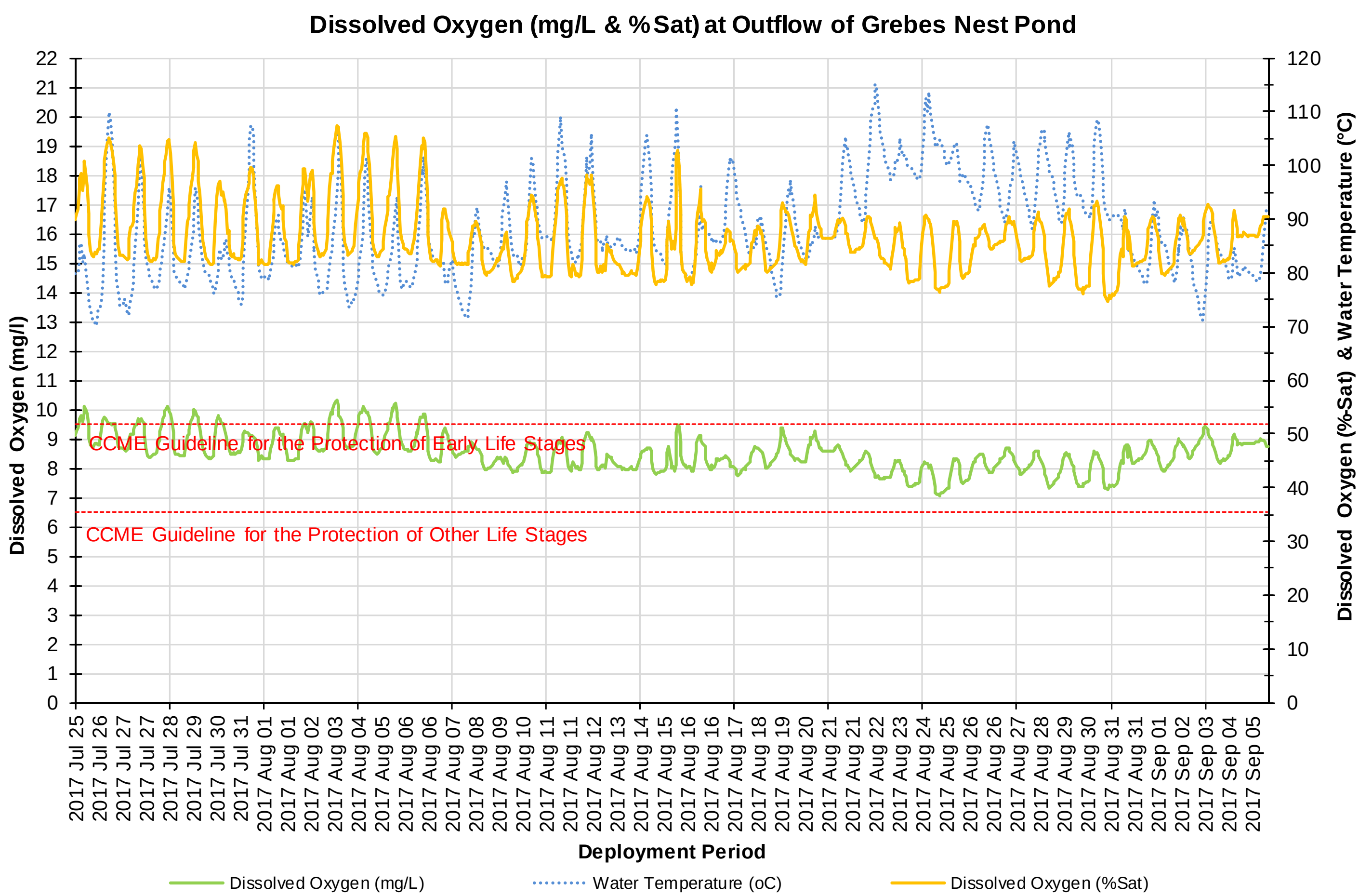

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 5.5 NTU and 778.8 NTU (Figure 8). The deployment data had a median of 17.3 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.

Throughout this deployment the higher turbidity values correlate with precipitation events and subsequently increases in stage (Figure 9). Runoff from surrounding environments can increase the presence of suspended material in water. The turbidity data does return to lower levels after the high peaks.

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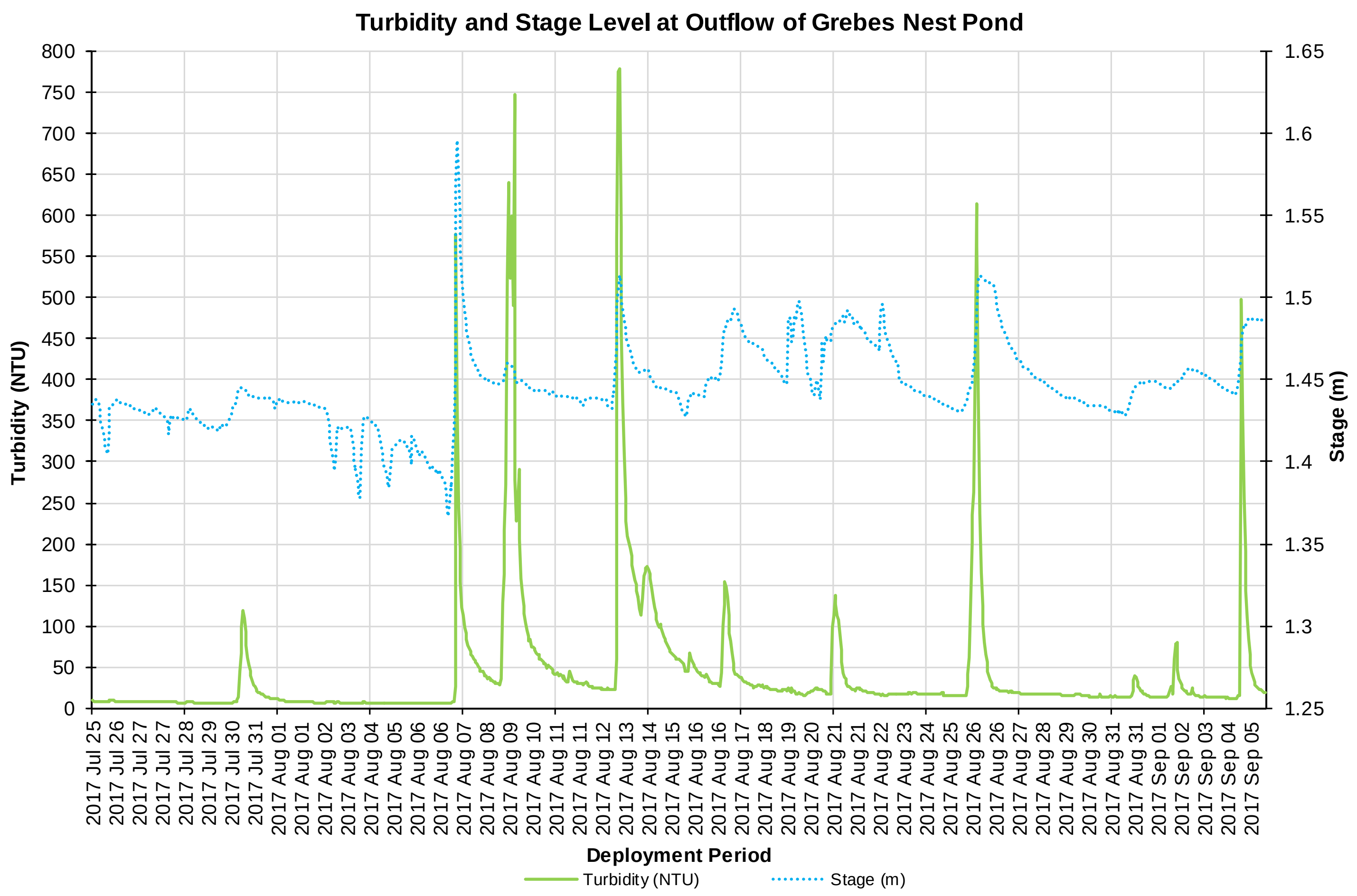

Figure 8: Turbidity (NTU) and stage level (m) values.

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 during any surrounding snow or ice melt as runoff will collect in the brooks. However, direct snowfall will not cause them to rise significantly.

During the deployment period, the stage values ranged from 1.37m to 1.60m. The larger peaks in stage do correspond 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 46 mm on August 7th, 2017.

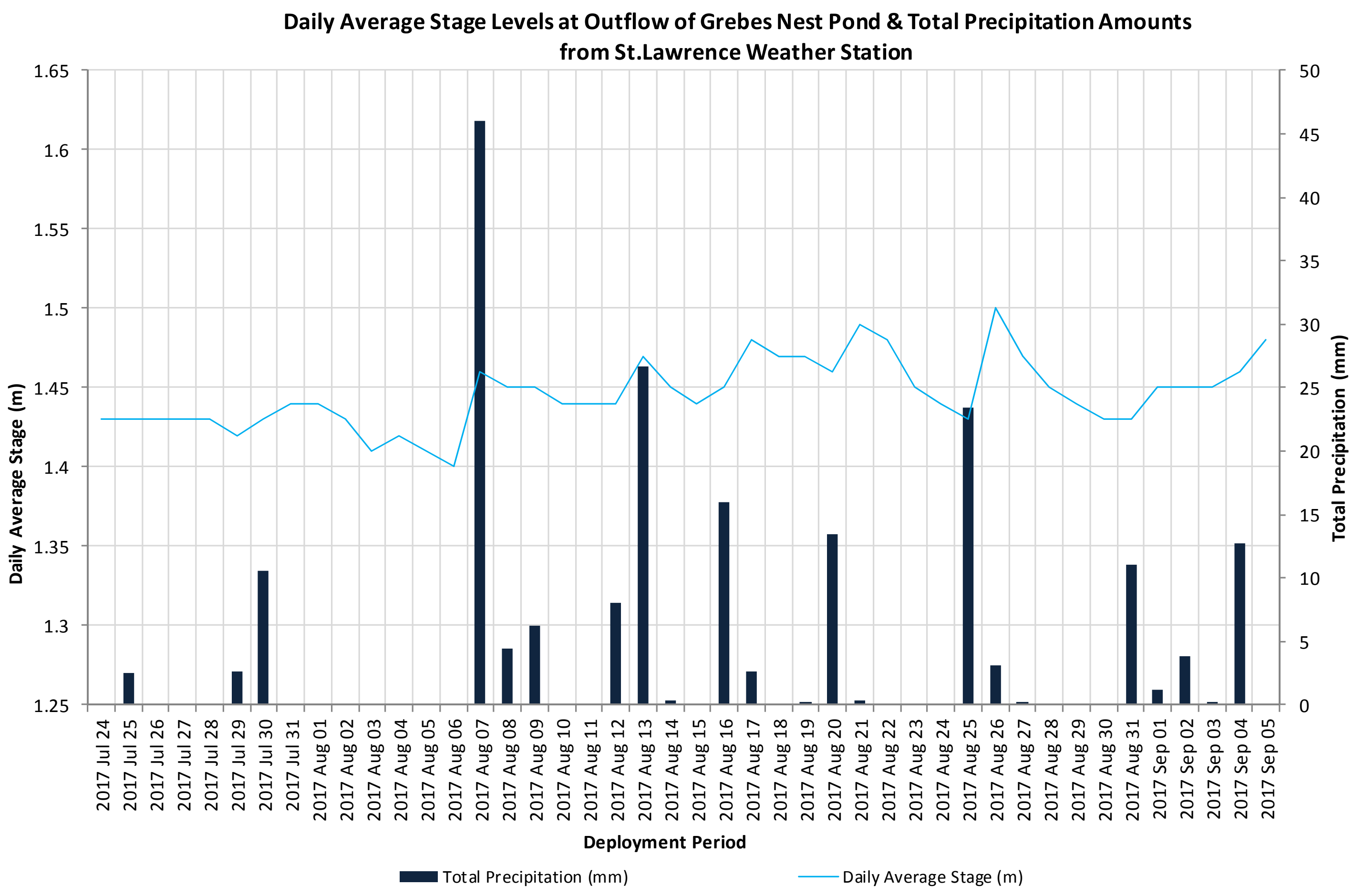

Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond currently flows through a 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 a pond that is located upstream from the old Grebes Nest Pond.

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 and high air temperatures.

When reviewing the graphs as a whole it is evident that the larger precipitation events did cause varying effects with the water quality parameters including pH, conductivity, dissolved oxygen and turbidity. Increases and decreases associated with the rainfall event on August 7th, 2017 were evident on the water temperature, pH, specific conductivity and turbidity graphs. Aside from slight influences in water temperature due to precipitation, the water temperature displayed values that would be expected during this time of year.

The pH values were reasonably consistent, there was a small amount of movement during the higher stage spikes however the pH returned to background or baseline values after each increase. All ambient waterbodies have a unique baseline range for pH levels. The CCME pH guidelines are just a basis by which to gage a water body. Specific conductivity levels responded to high stage levels by decreasing initially at the onset of the precipitation amount, however shortly after the dip the conductivity levels increased slightly. Overall the specific conductivity levels remained consistent throughout the deployment within a range of 40.5 – 68.8 µS/cm. Naturally as the air and water temperatures increase during the summer period the dissolved oxygen levels will decrease. This is a natural reaction. Turbidity values also indicated increases during the higher stage events. These changes in water quality are likely a result of rainfall that occurred throughout this deployment period.

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 11.63°C to 24.86°C during the deployment period (Figure 10). The deployment period displayed a consistent water temperature that represented summer temperatures. There were several dips in the water temperature during the higher stage events. The stage level spikes are likely a result of rainfall (Figure 15), the rainfall can lower the temperature of the water for a short period of time.

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 was evident as the peaks and valleys of the water temperature indicate warmer daytime temperatures and cooler nighttime temperatures. At the end of the deployment, the water temperatures pointed toward a cooler climate as the summer season headed into fall. The brook also indicated a response to the high stage event on August 7th, 2017 along with the Outflow of Grebes Nest Pond station data.

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.

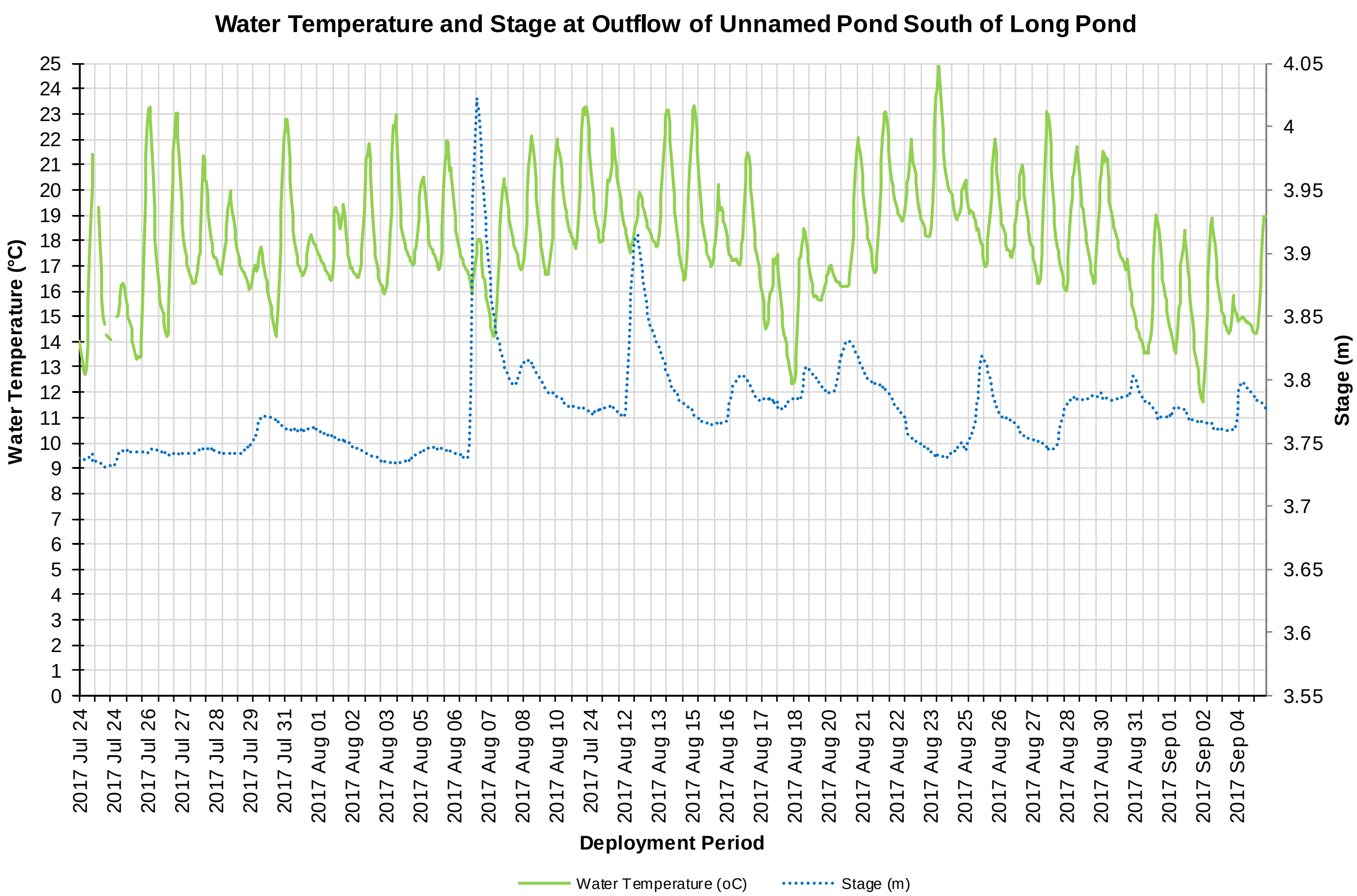

Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout the deployment period, pH values ranged between 6.49 pH units and 7.45 pH units (Figure 11). 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 decreases slightly for short period of time. This is a natural process and can be seen on the graph below on August 7th, August 12th and August 25th, 2017.

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.

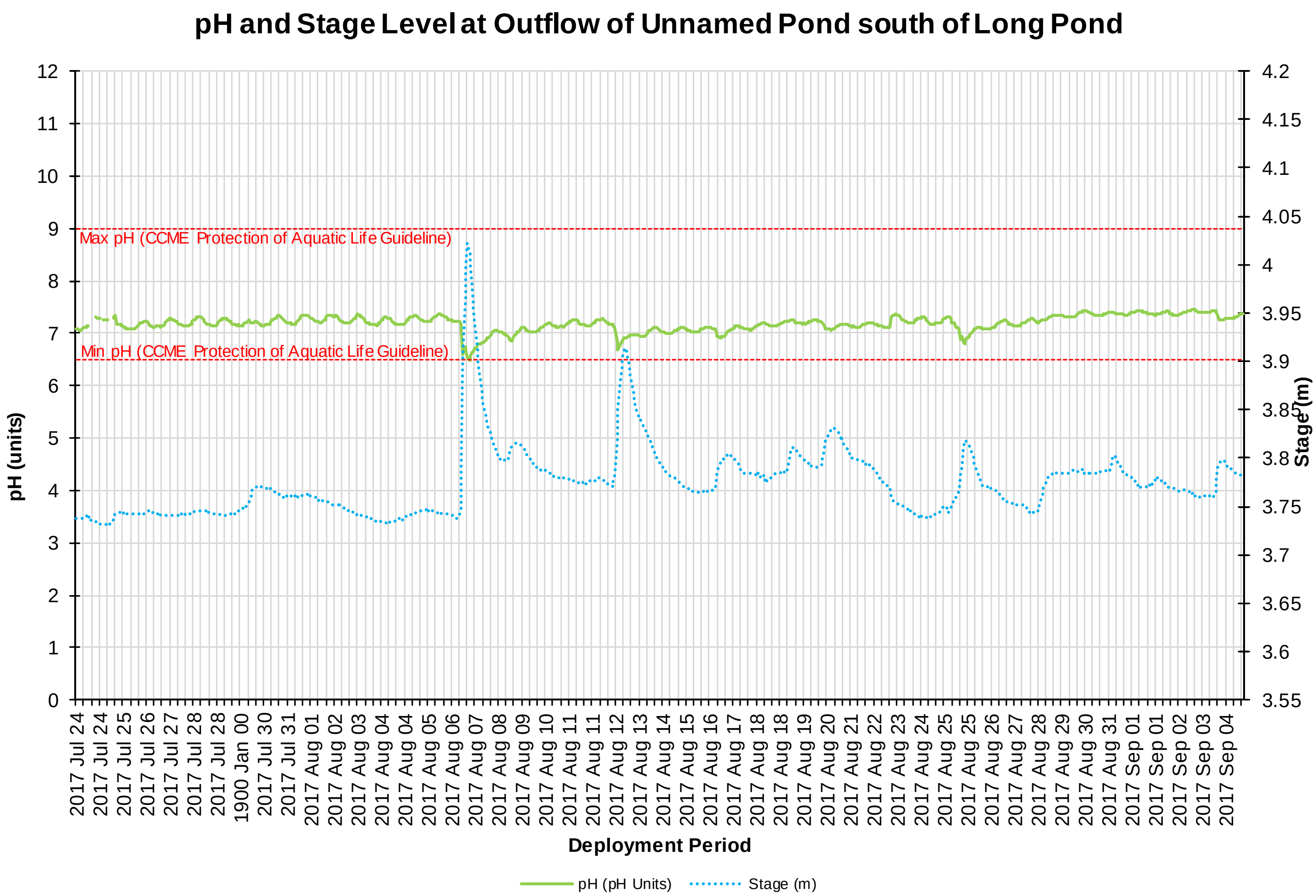

Figure 11: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were between 85.2 µS/cm and 186.1 µS/cm during this deployment period (Figure 12). The median 145.8 µS/cm for the deployment period was higher than the previous deployment of 117.2 µS/cm.

There were several conductivity dips on August 7th, August 12th and again on August 25th 2017 when stage level increased for a short period of time (Figure 12). Stage level was likely influenced by rainfall (Figure 15). When stage levels rise, the specific conductance levels will decrease in response. With the stage level increasing, the increased amount of water in the river dilutes the suspended solids that are present. Over the entire deployment the specific conductivity increases.

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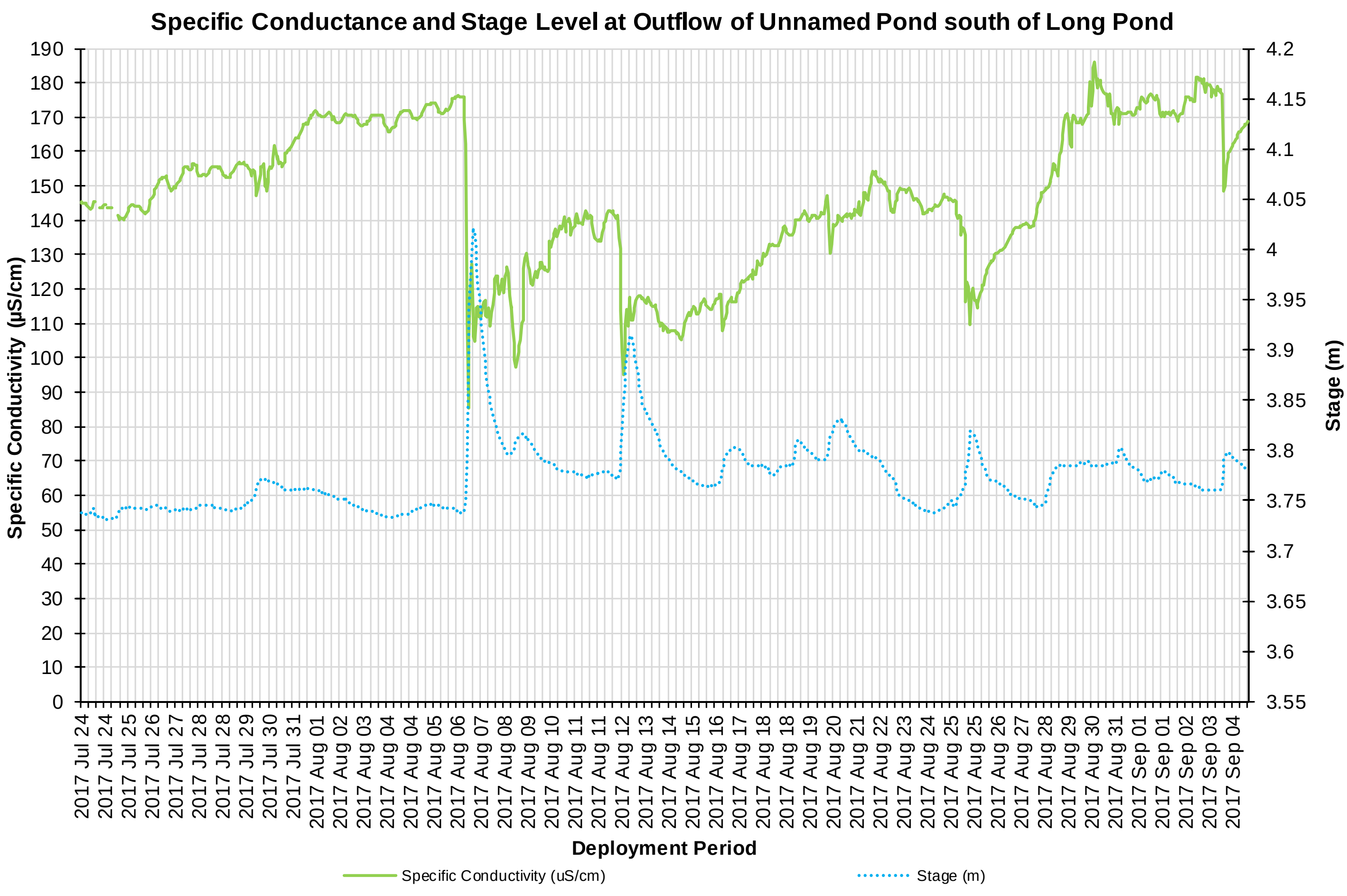

Figure 12: Specific conductivity (µS/cm), and stage (m) values

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 8.39 mg/L to a maximum of 10.60 mg/L. The percent saturation levels for dissolved oxygen ranged within 92.5% Saturation to 105.2% Saturation (Figure 13).

There is a natural diurnal pattern that occurs with dissolved oxygen, as the water temperatures decrease in the evening the dissolved oxygen will increase and as the water temperatures increase during daylight hours the dissolved oxygen will decrease. The spikes in the dissolved oxygen concentration, which are outside of the natural diurnal pattern, are during the colder water temperatures this was displayed on August 7th, August 18th and September 2nd, 2017. This is a result of the normal reaction between water temperature and dissolved oxygen.

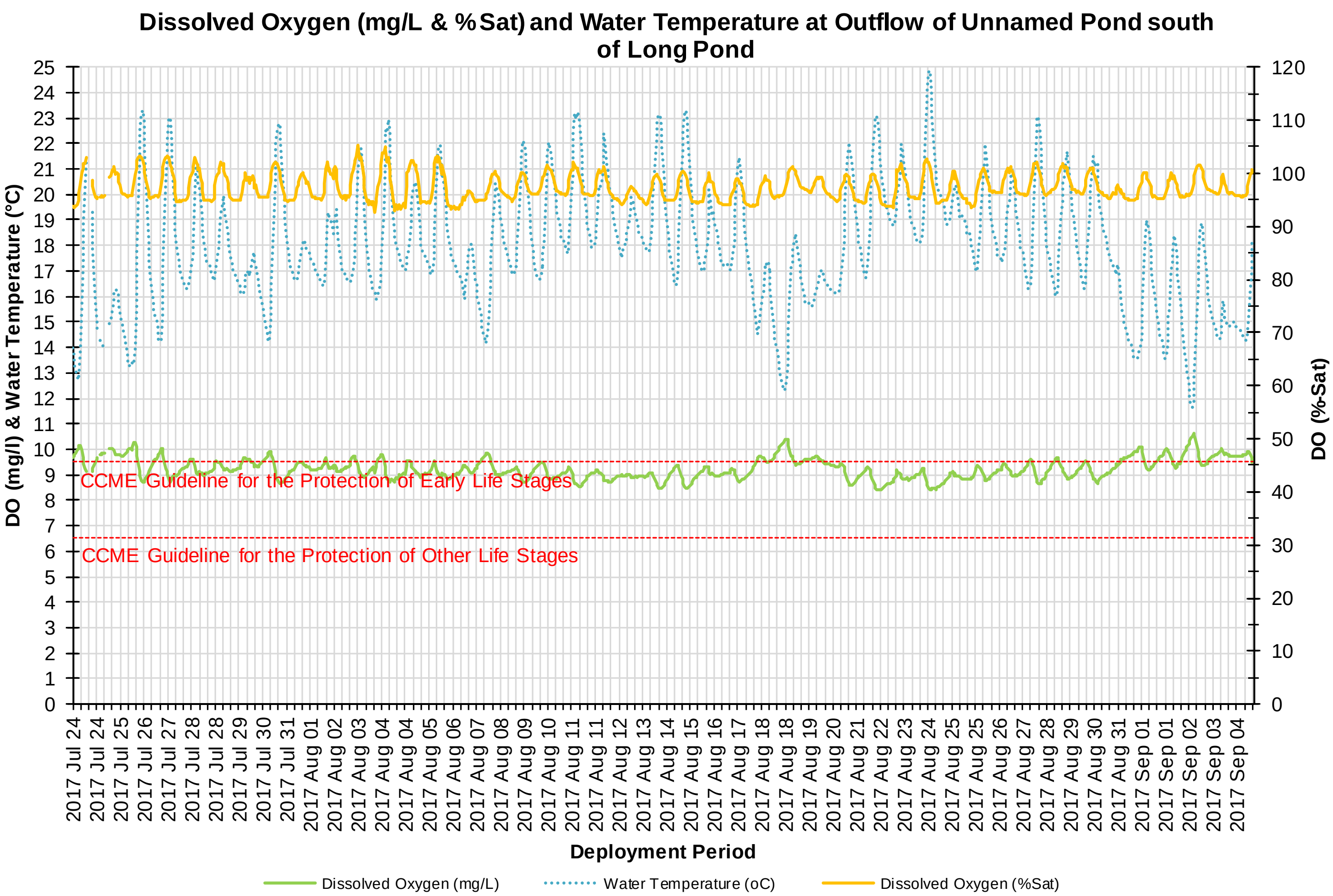

Figure 13: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 4.9 NTU and 15.4 NTU (Figure 14). The deployment data had a median of 5.8 NTU.

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. The highest turbidity event during this deployment was on August 7th, the turbidity increase coincides with changes in other parameters for the same timeframe.

After the precipitation event on August 7th, 2017 the turbidity sensor indicated that it was blocked by debris. Therefore, the data has been removed from August 7th to September 5th, 2017 as it did not represent the brook at this time.

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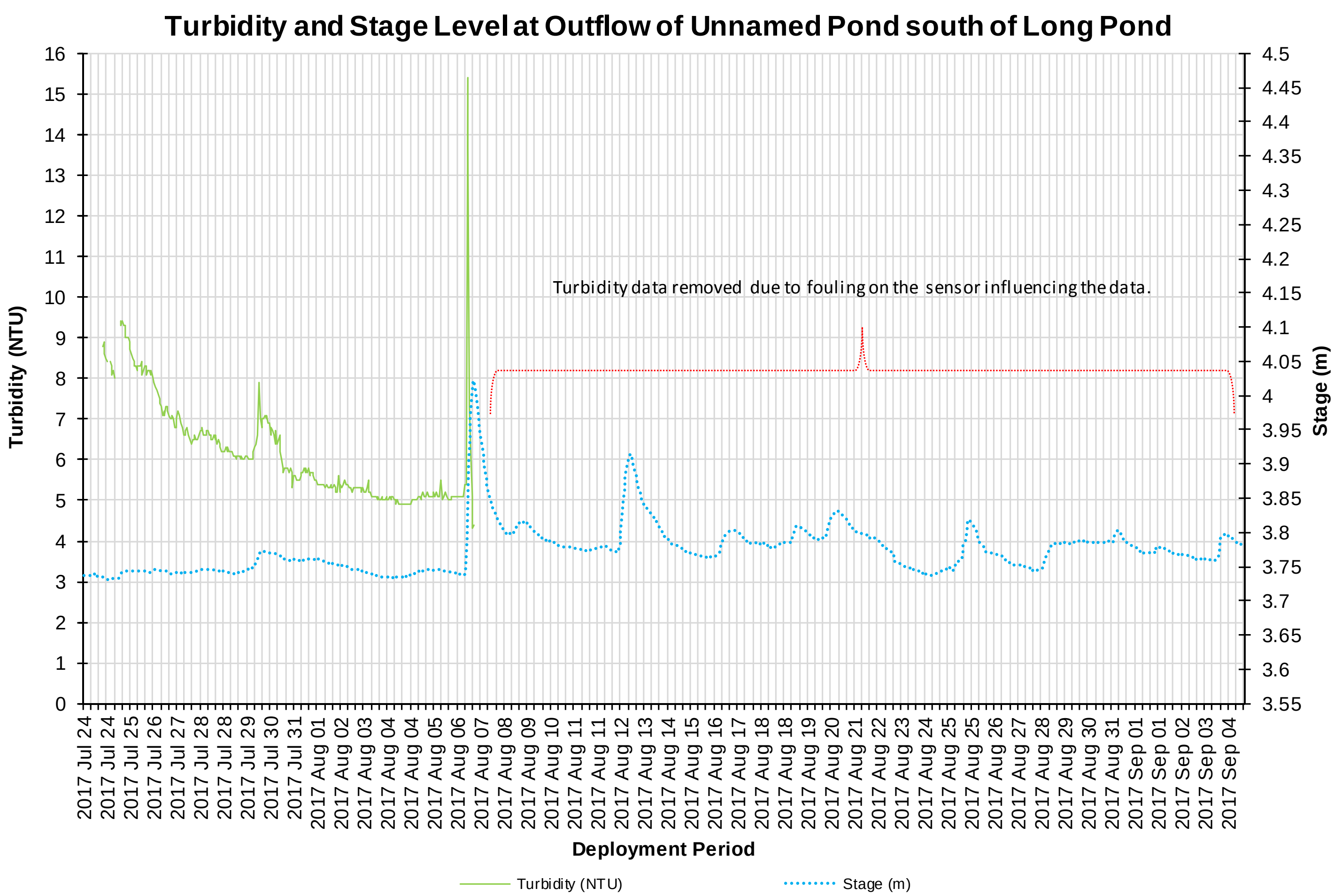

Figure 14: Turbidity (NTU) and stage level (m) values.

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 3.73m to 4.02m. 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 46 mm on August 7th, 2017.

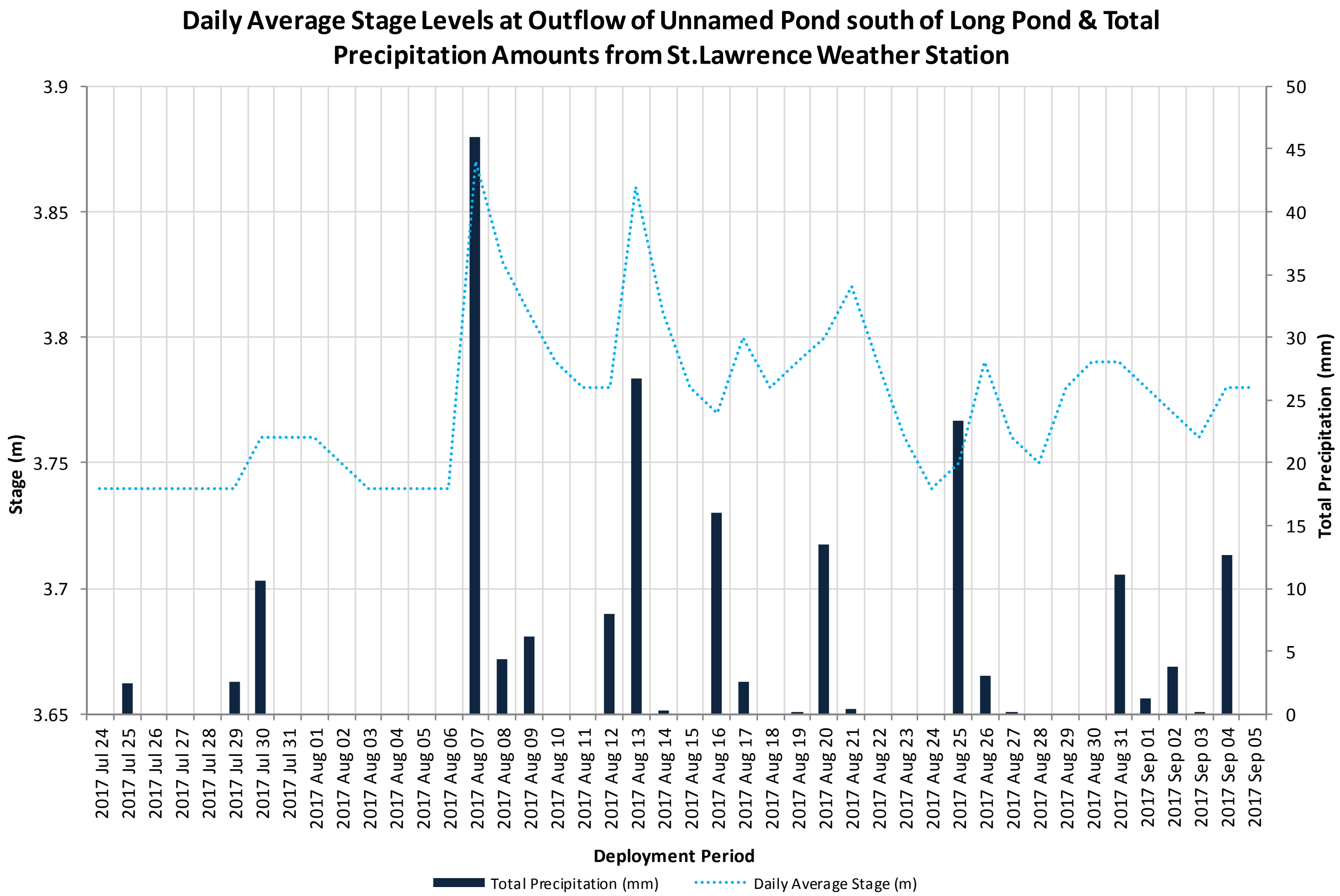

Figure 15: Daily average stage values and daily total precipitation.

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 however the brook skirts along the construction activity that is ongoing. This type of watershed will influence the water quality parameters. This station is the furthest away from the anthropogenic activities that would be occurring on the mine site.

Water temperatures during this deployment were representative of the climate for this time of year. Water temperatures are directly influenced by air temperatures. Seasonal changes in water temperature are evident in the data displayed. These changes will also influence the dissolved oxygen concentration present in the brook. The levels of dissolved oxygen concentration are within natural and expected limits for this brook.

The pH values were consistent for this brook. Any significant change in pH data corresponded with a rise in the stage level. Overall there was a slight increase in the specific conductivity data over the deployment. Majority of the changes in specific conductivity are a result of stage increases.

Due to fouling of the turbidity sensor after a rainfall event, the data was removed from August 7th, 2017 onwards. However, the turbidity data that is collected, indicated a lower median (5.8 NTU) for the deployment than the previous deployment. The rainfall event on August 7th, 2017 influenced all of the water quality parameters reviewed in this report. The changes in each parameter during this time are evident on the graphs provided. Precipitation brings changes to water quality conditions although most of the changes are natural occurrences, precipitation can also influence runoff from surrounding construction areas to flush excess material into waterways.

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

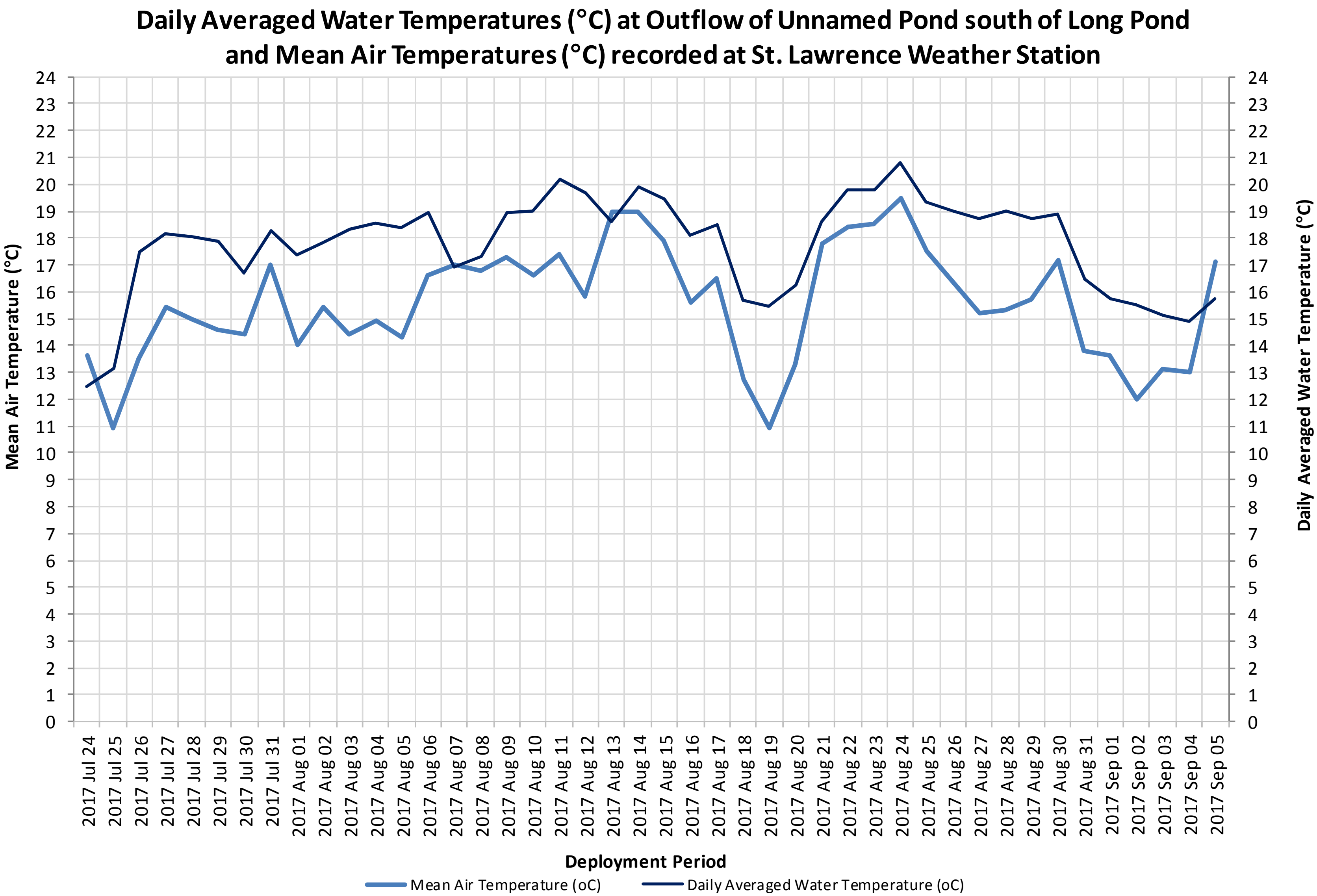

Figure A1: Water Temperatures at Outflow of Unnamed Pond south of Long Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

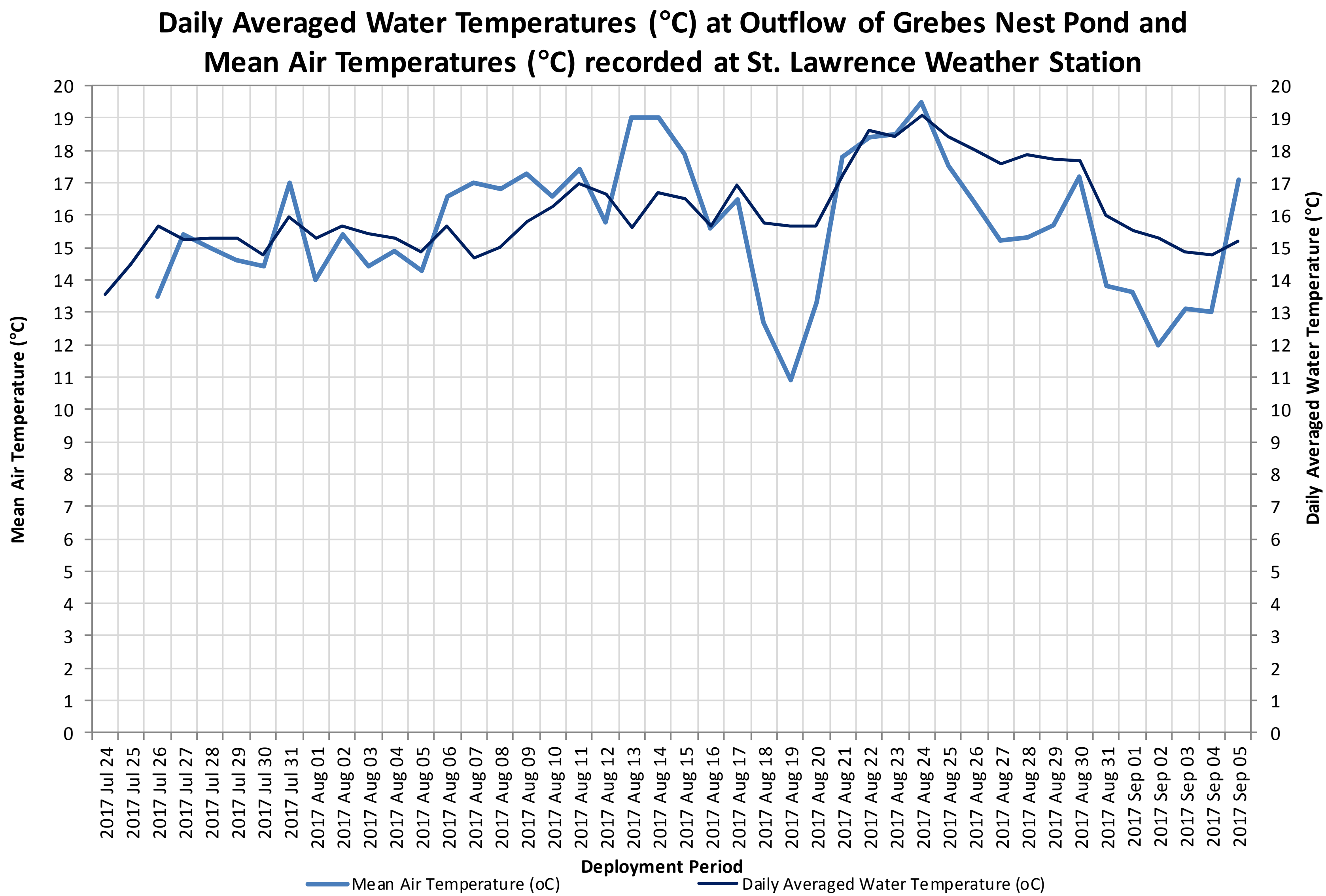

Figure A2: Water Temperatures at Outflow of Grebes Nest Pond and Mean Air Temperatures recorded at St. Lawrence Weather Station

APPENDIX B

COMPARISON GRAPHS OF CANADA FLUORSPAR (NL) INC REAL TIME STATIONS

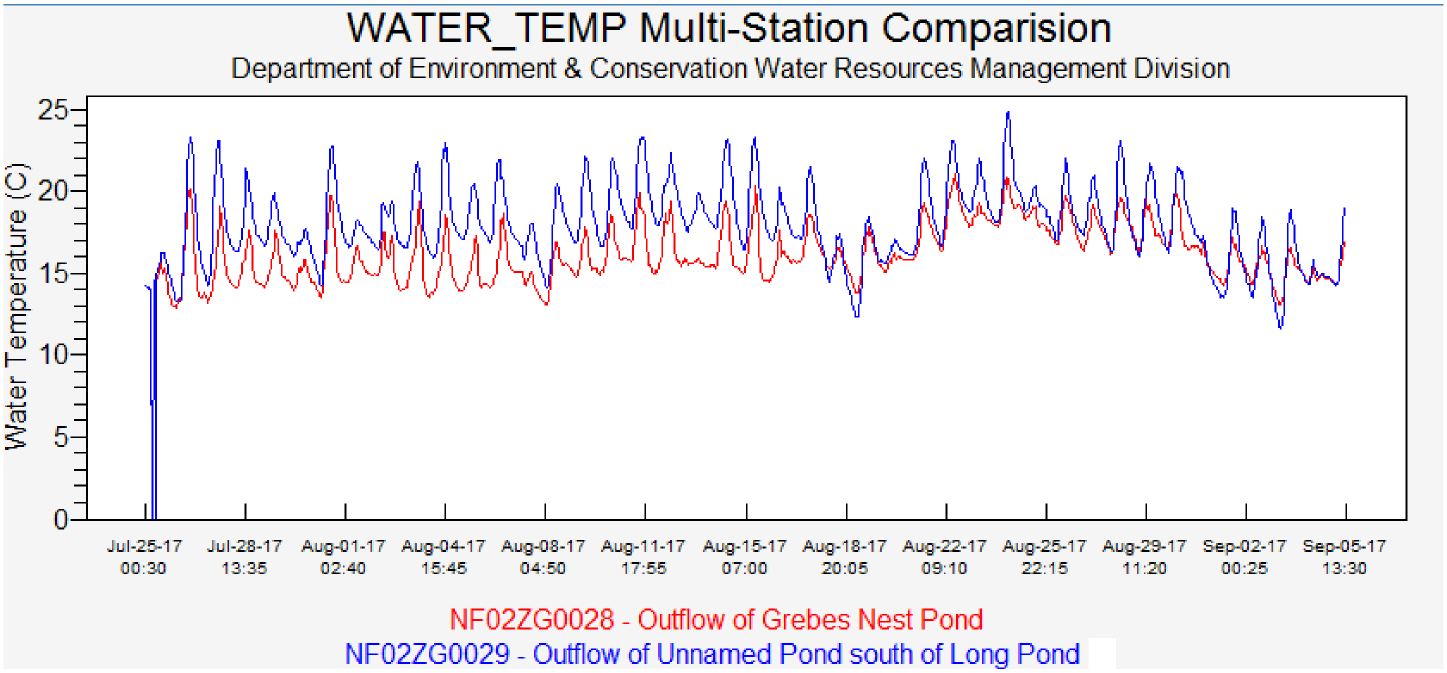

Figure B1: Comparison of Water Temperature at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

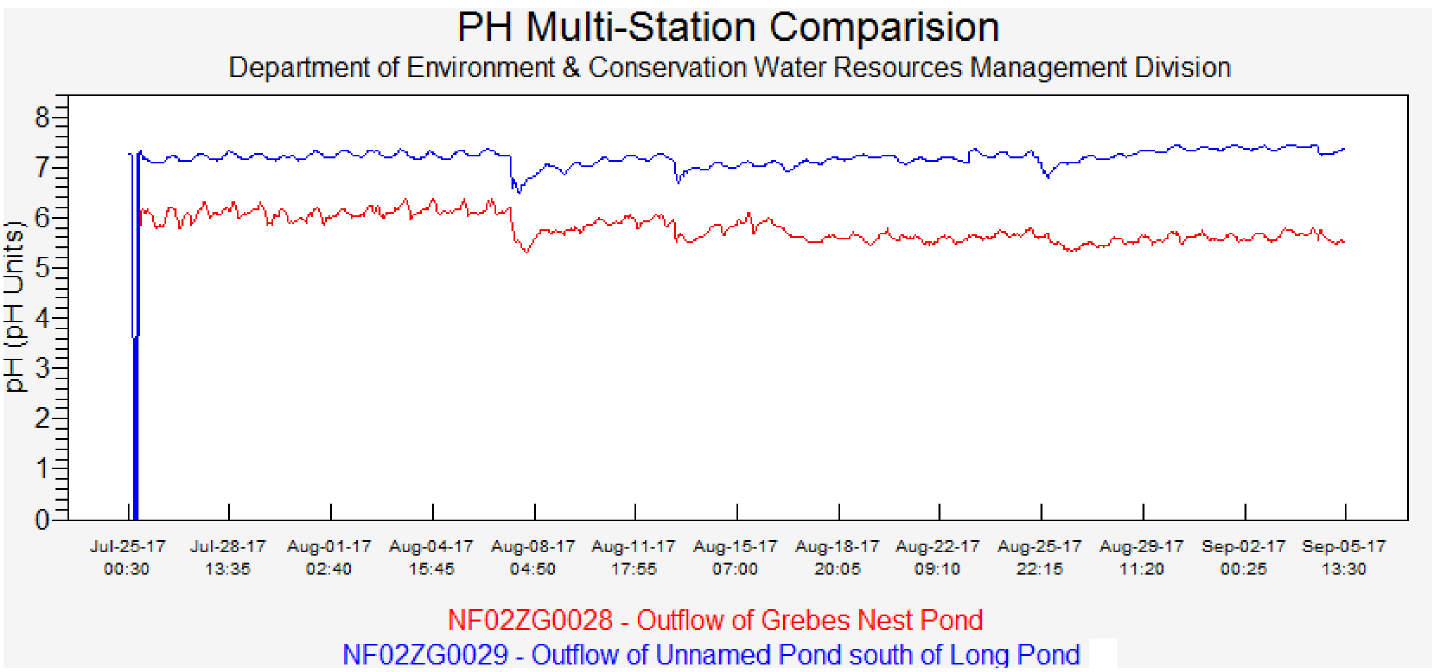

Figure B2: Comparison of pH at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

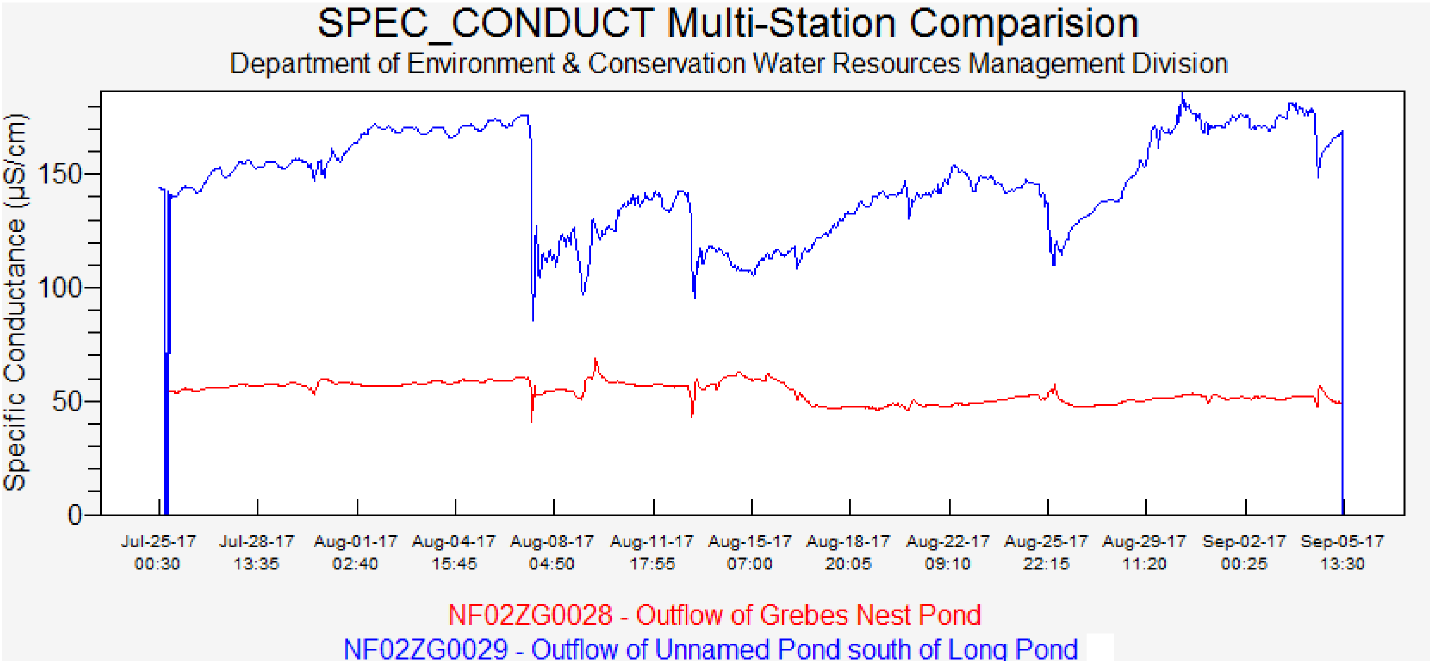

Figure B3: Comparison of Specific Conductivity at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

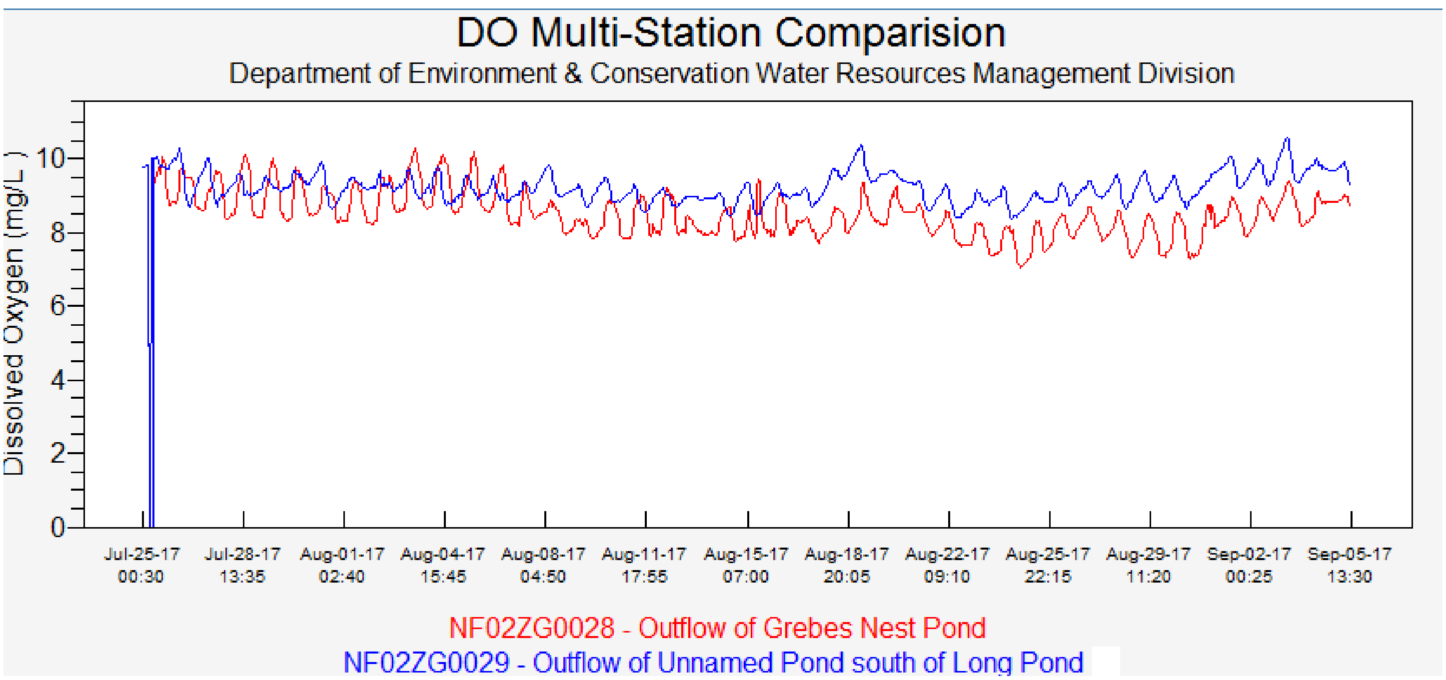

Figure B4: Comparison of Dissolved Oxygen at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

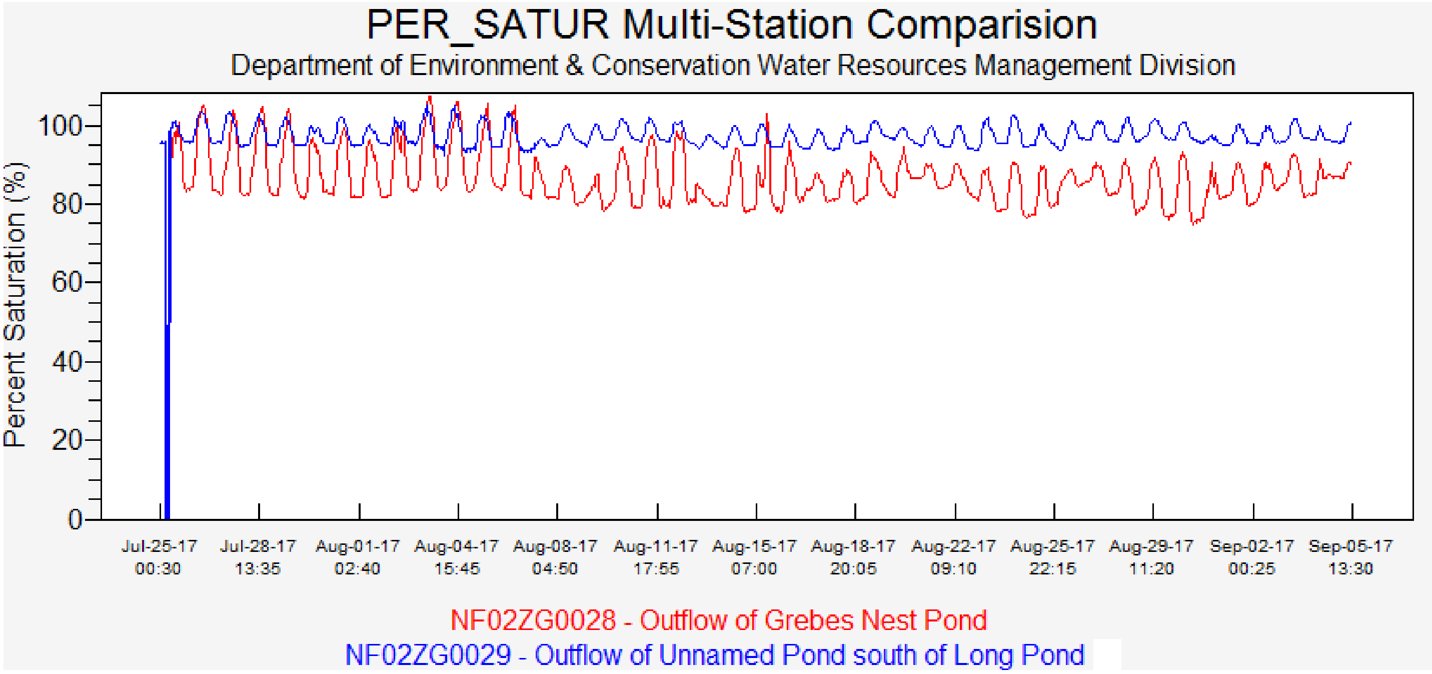

Figure B5: Comparison of Percent Saturation at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.

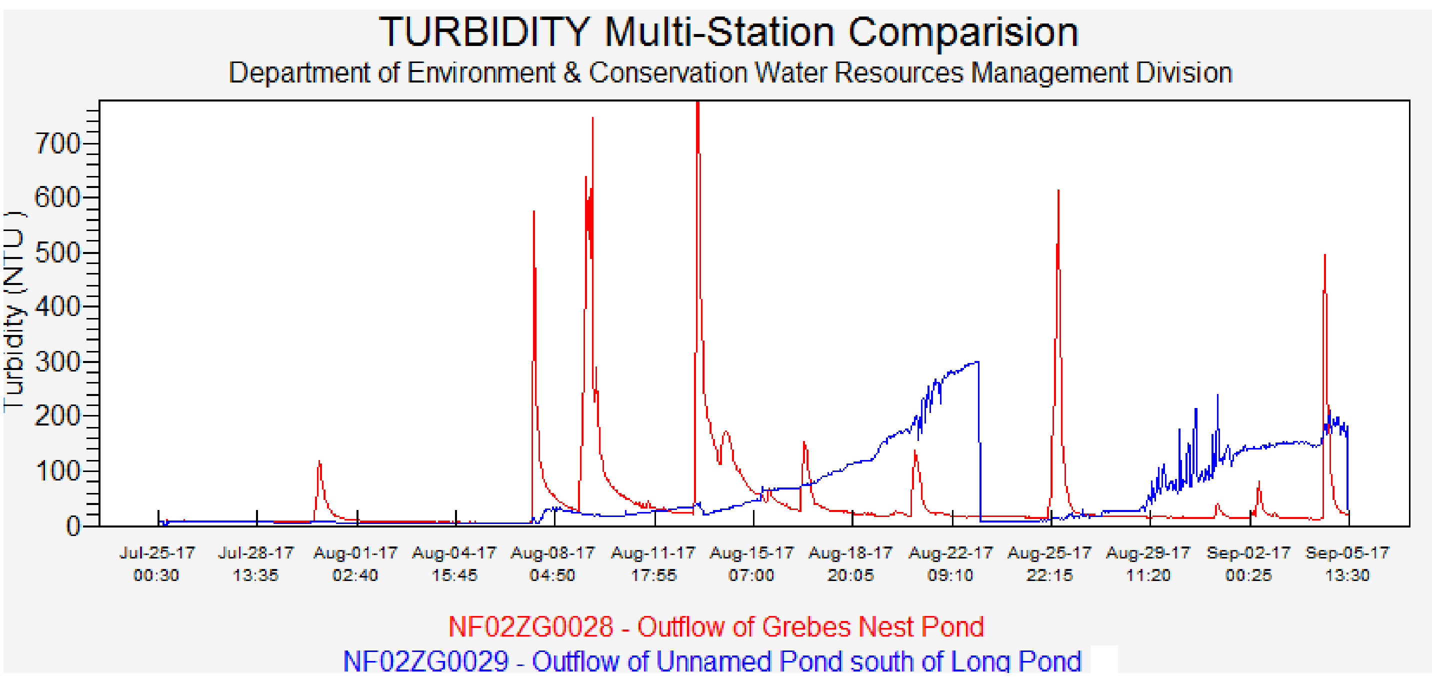

Figure B6: Comparison of Turbidity at the Real-Time Stations at Canada Fluorspar (NL) Inc. Please note the data on this graph, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.