Real-Time Water Quality Report

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

Deployment Period
November 27, 2017 to January 8, 2018

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 (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 initiates 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 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, 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, under the management of Howie Wills, 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	**Nov 28**	**Deployment**	Excellent	Excellent	Good	Good	Marginal
	Jan 8	**Removal**	Excellent	Excellent	Excellent	Excellent	Good
Unnamed Pond	**Nov 28**	**Deployment**	Good	Excellent	Good	Poor	Fair
	Jan 8	**Removal**	*No*	*Rank*	*Data*	*Available*	

At deployment of the field instrument at Outflow of Grebes Nest Pond site, the water temperature, pH, specific conductivity and dissolved oxygen data ranked within 'Good' and 'Excellent' against the QA values that were recorded. Turbidity data ranked as 'Marginal' during deployment ranking. This may have been a result of the placement of the two instruments in the brook. There was a small difference of 9.6 NTU between the readings from both sondes.

During removal of the instrument the ranking for water temperature, pH, specific conductivity and turbidity ranked 'Excellent' and 'Good' against the QA data.

At deployment of the field instrument at Outflow of Unnamed Pond south of Long Pond the data ranked as the following; water temperature, pH, specific conductivity and dissolved oxygen ranked as 'Excellent' to 'Good' during deployment. The turbidity values ranked as 'Fair' at deployment of the instrument; there was a small difference between the two readings of 7.6 NTU. All rankings were applicable for deployment of the instrument.

At the end of the deployment the instrument was not transmitting data, therefore there was no ranking available for this time frame.

Concerns or Issues during the Deployment Period

The water supply for Outflow of Grebes Nest Pond station has changed. Currently the water is originating from a sedimentation pond that is upstream of the Real-Time station. A new sedimentation pond was developed to assist in settling out the sediment-laden water that is pumped from the open mine pit. Canada Fluorspar has created a sedimentation pond that naturally overflows down a trough and into a culvert that flows into Outflow of Grebes Nest Pond.

Outflow of Unnamed Pond south of Long Pond station went offline on January 5th 2018; therefore there is no data from January 5th, 2018 to the end of deployment. There were several gaps in stage data during this deployment, December 15th to December 19th, December 26th to December 28th and January 7th and January 8th, 2018. The stage data dropped out of transmission and was not available during these gaps.

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 -0.15°C to 6.52°C during the deployment period (Figure 4). The water temperature at the station does not display obvious diurnal variations of temperature; this may be a result of the variation in stage level during this time. The water levels flowing into this brook will change with the demand on the sedimentation pond.

There is a large dip in water temperature around December 14th and 15th, 2018, there was also an increase in stage level and weather data indicates a precipitation event on December 14th. These factors may have contributed to the drop in water temperature. As the air temperatures start to drop, the water temperature decreased as well. Water temperature can be expected to drop as the seasons change into winter and below 0 °C air temperatures.

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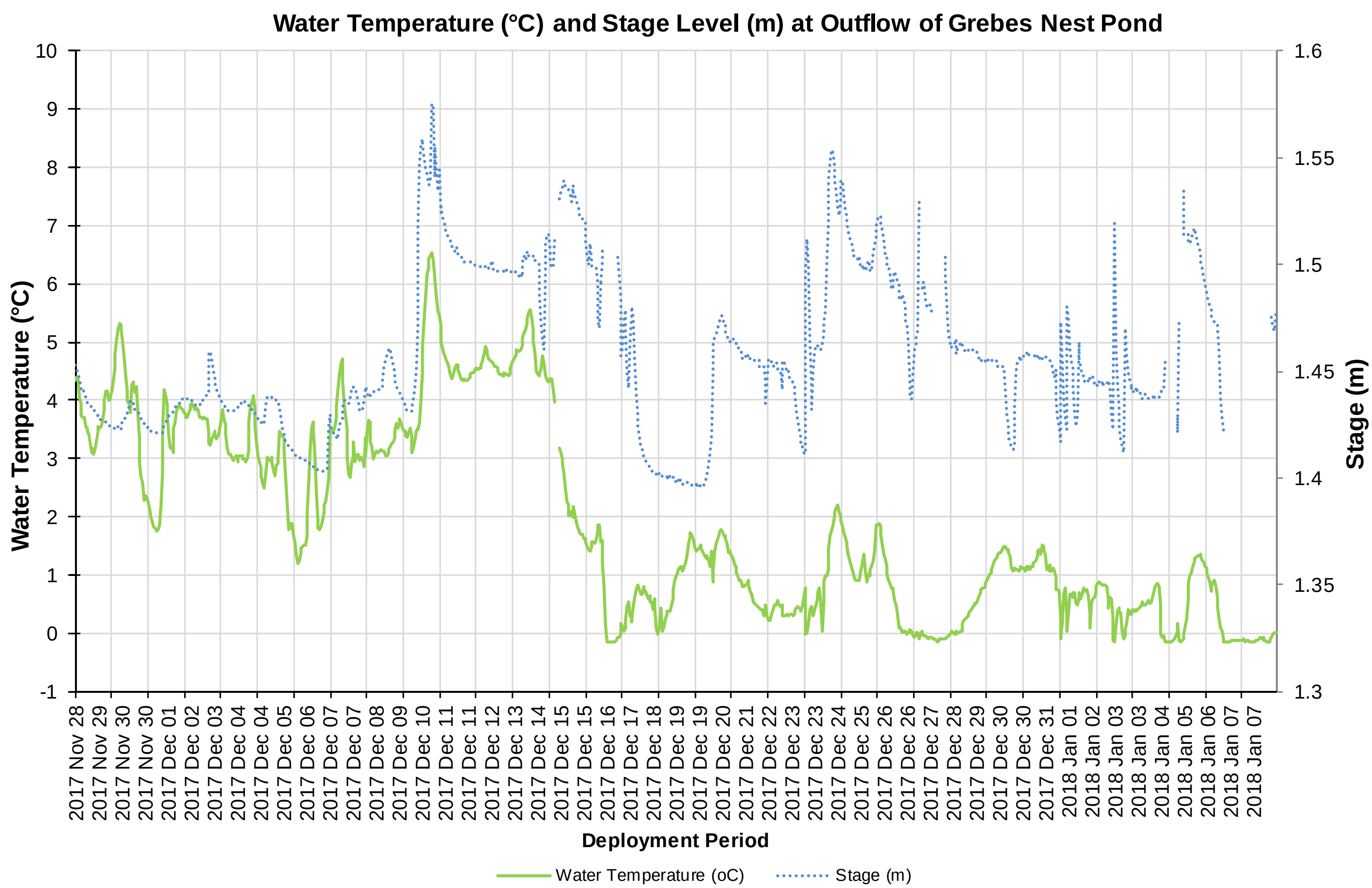

Figure 4: Water temperature (°C) values at Outflow of Grebes Nest Pond

pH

Throughout the deployment period, pH values ranged between 5.86 pH units and 7.41 pH units (Figure 5) and are reasonably consistent. The pH data remain below the minimum Guideline for Protection of Aquatic Life until December 10th, 2018 where the levels increase to about 6.5 pH units.

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 or within the CCME pH guideline.

The pH level increased with stage increases during the high stage events recorded in December. 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.

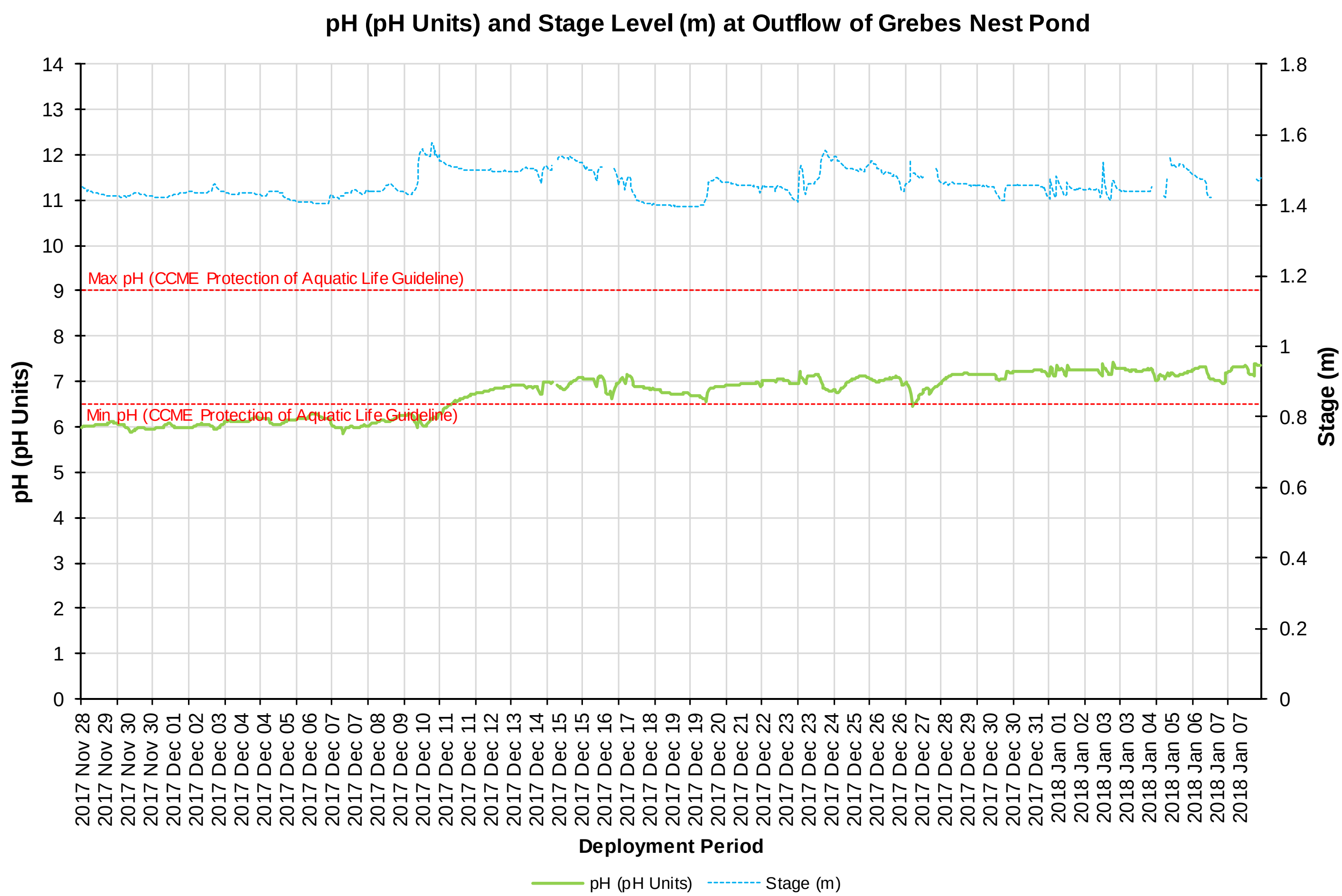

Figure 5: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels were within 74.0 µS/cm and 227.1 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 precipitation; however, shortly after the dip the conductivity levels increased.

Rainfall initially dilutes the brook before organic and inorganic matter is flushed into the water channel, which in turn increases the conductivity (Figure 9, Precipitation graph). This is evident on Figure 6 in several places but most noticeably in December 2017.

Despite several low conductivity dips, the conductivity levels were steadily increasing across deployment.

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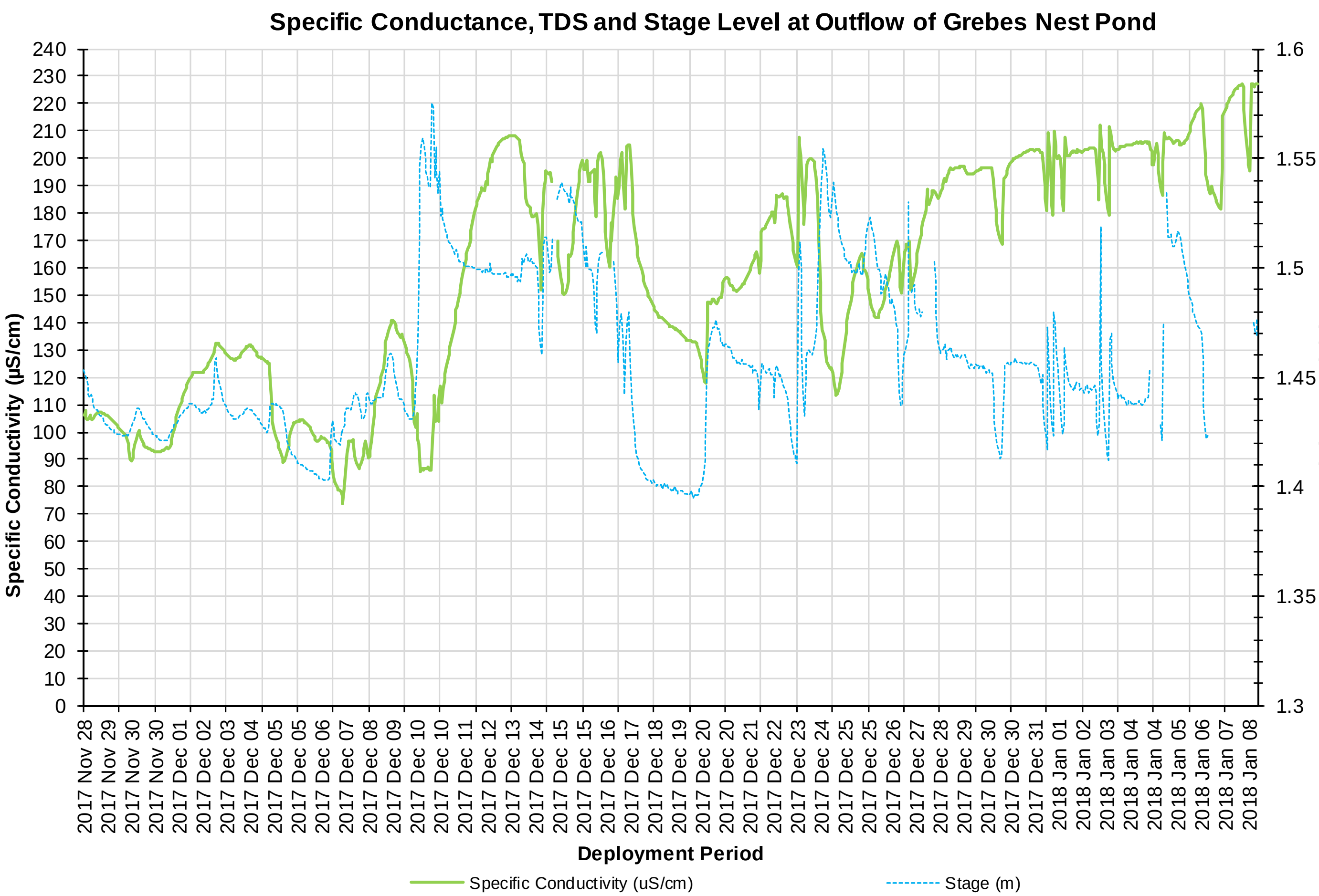

Figure 6: Specific conductivity (µS/cm) and stage (m) values

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 11.45 mg/L to a maximum of 14.34 mg/L. The percent saturation levels for dissolved oxygen ranged within 86.0% Saturation to 103.8% Saturation (Figure 7).

There was a slight increase in the overall dissolved oxygen concentration from December 14th 2017. The precipitation graph (Figure 9) indicates rainfall of on December 13th & 14th, 2017. This is a normal reaction in water bodies as the temperature of the rainfall influences the brook water for a short period of time.

The CCME guidelines for the Protection of Aquatic Life provide national guidance. There are many occasions that natural brook environments move within these guidelines.

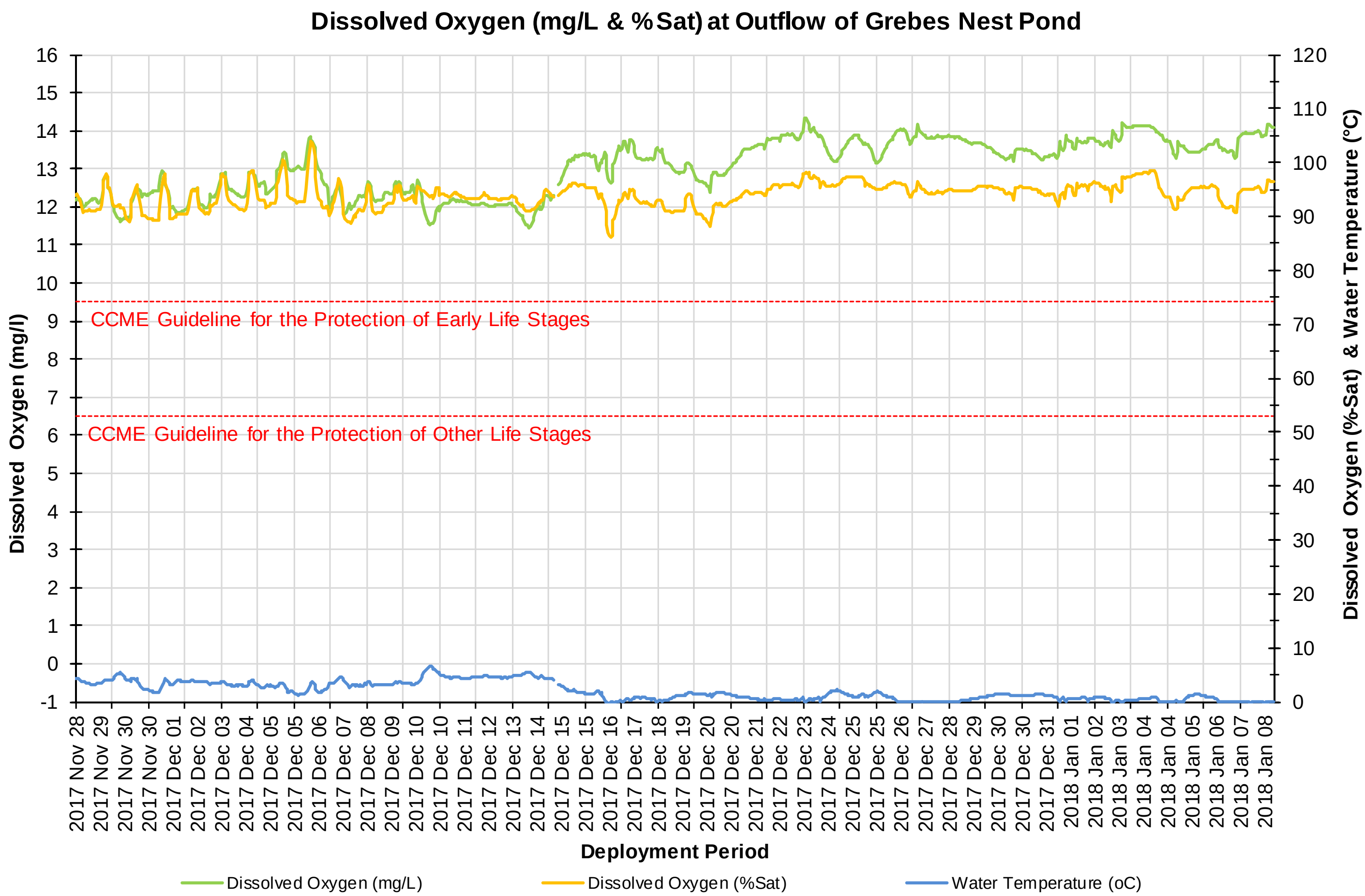

Figure 7: Dissolved Oxygen (mg/L & Percent Saturation) values and Water Temperature (°C)

Turbidity

Turbidity levels during the deployment ranged within 1.6 NTU and 346.8 NTU (Figure 8). The deployment data has a median of 11.7 NTU which is higher than the previous deployment median of 5.9 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 baseline range. Turbidity events with high variability and occurring over a prolonged period of time may warrant concern.

The higher turbidity values in December did correlate with precipitation events (Figure 9). However, Grebes Nest Brook is fed upstream by a sedimentation pond, and it is likely that an increase in flow (due to the rainfall) from the sedimentation pond caused the turbidity increases. Toward the end of the deployment precipitation events decreased and the turbidity spikes recorded were not as high as those in December.

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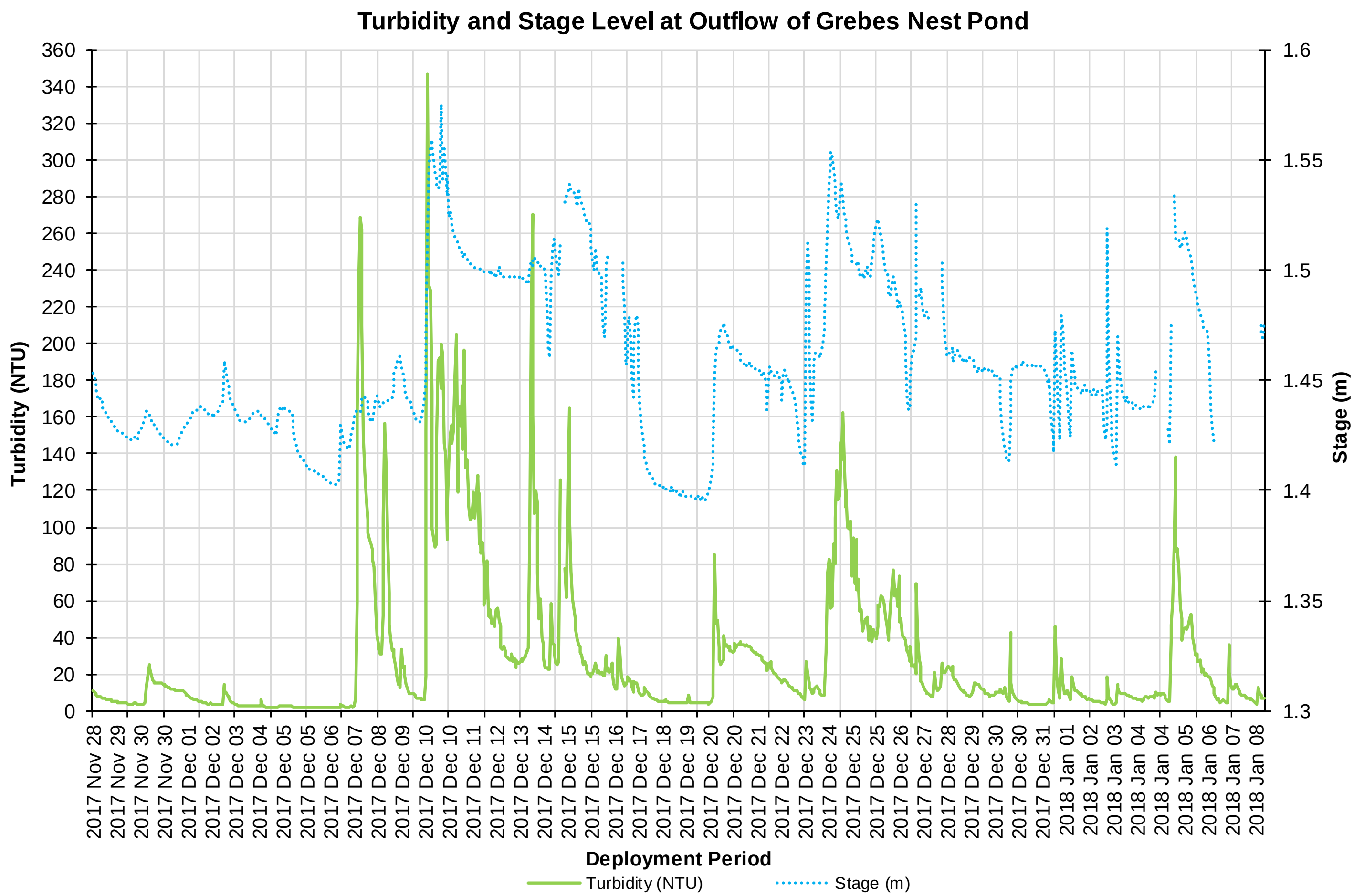

Figure 8: Turbidity (NTU) and stage level (m) values.

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 1.40m to 1.58m. 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 37.7 mm on December 10th, 2017.

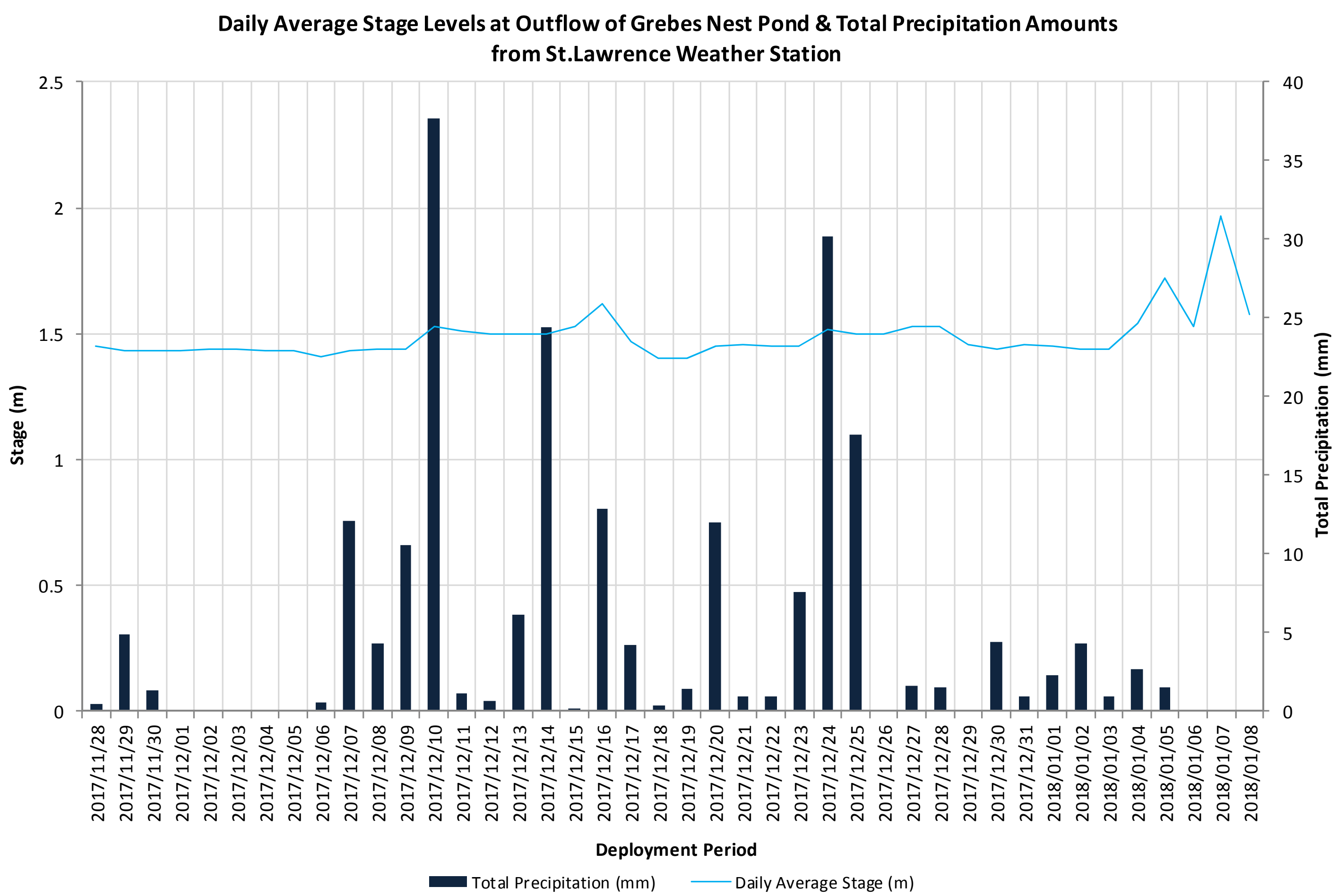

Figure 9: Daily average stage values and daily total precipitation.

Conclusion

Outflow of Grebes Nest Pond currently flows through a developing mine site. At this phase of the project, the natural environment is constantly being disturbed by construction activities. 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.

Currently the water is originating from a sedimentation pond that is upstream of the Real-Time station. A new sedimentation pond was developed to assist in settling out the sediment-laden water that is pumped from the open mine pit. Canada Fluorspar has created a sedimentation pond that naturally overflows down a trough and into a culvert that flows into Outflow of Grebes Nest Pond.

These factors combined can impact the water quality parameters during climatic events such as precipitation and snow melt from high air temperatures. When reviewing the parameter graphs as a whole it is evident that the larger precipitation events did cause varying effects with the water quality parameters pH, conductivity, dissolved oxygen and turbidity. It can be assumed that the increased flow from the sedimentation pond was responsible for the increases in the above mentioned water quality parameters.

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 ranges from -0.02°C to 7.09°C during this deployment period (Figure 10). The graph displays the diurnal pattern that is evident with water temperature and also a decrease of the water temperature as the season changes into winter. There is an evident decrease in the water temperature from December 14th & 15th to the end of the deployment period (Figure 10).

The water temperatures do increase slightly with each stage increase. The stage level increases are likely a result of rainfall (Figure 15), the rainfall can increase the temperature of the water for a short period of time.

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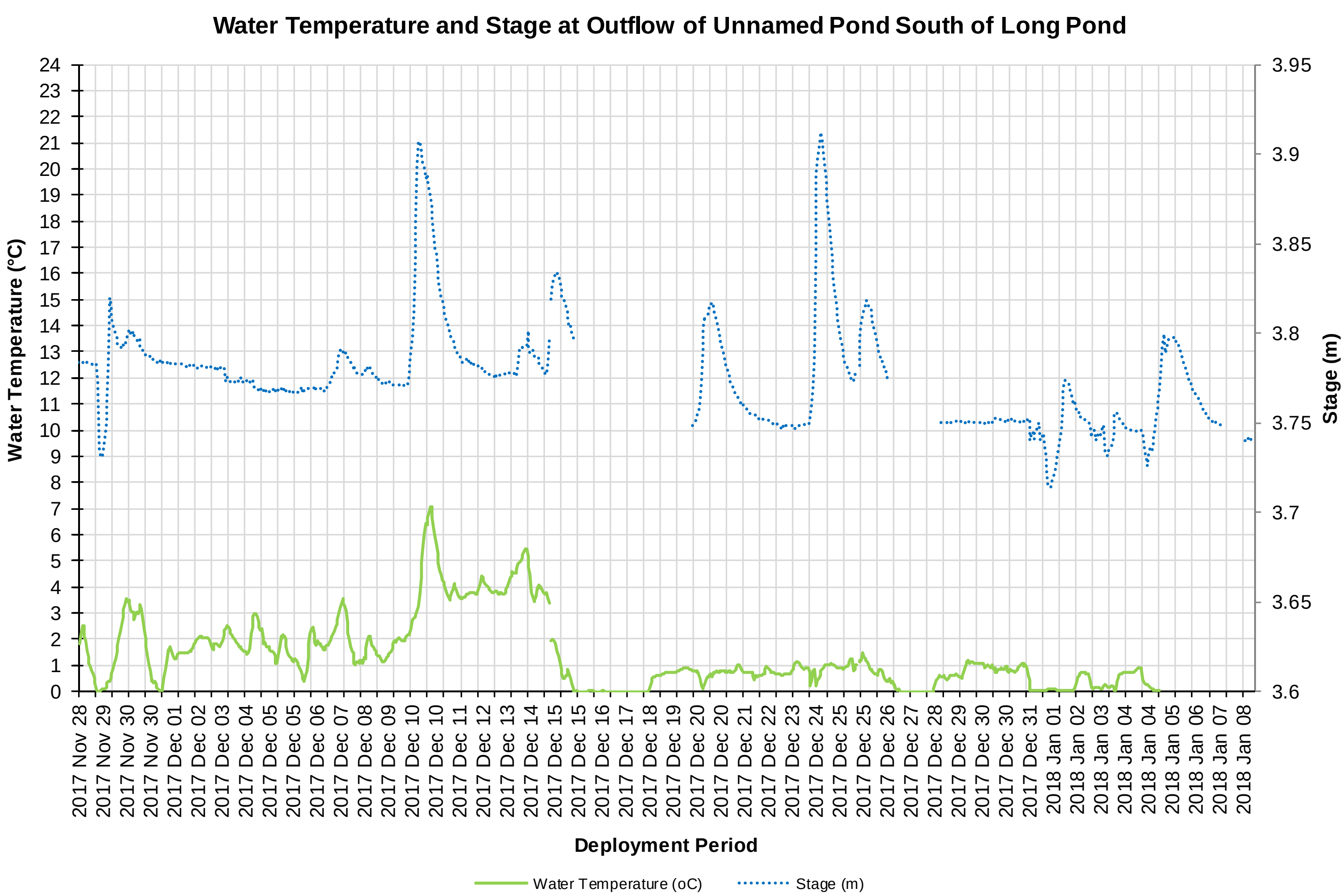

Figure 10: Water temperature (°C) values at Outflow of Unnamed Pond south of Long Pond

pH

Throughout this deployment period, pH values ranged between 6.16 pH units and 7.49 pH units (Figure 11). The Canadian Council of Ministers of the Environment (CCME) guidelines is just a basis by which to compare any significant change in the pH data within a dataset. Every brook is different with its own natural background range. The pH data is consistent across the deployment.

Natural processes such as rainfall and snow melt will alter the pH of a brook for a period of time. This is evident during and after high stage levels, the pH data will increase or decrease for a short period of time. There is a large dip in pH recorded December 15th to December 17th, 2017. The stage data was missing for this timeframe however the weather station in St. Lawrence recorded rainfall from December 14th to December 17th, 2017, it is likely the pH decrease was a result of rainfall.

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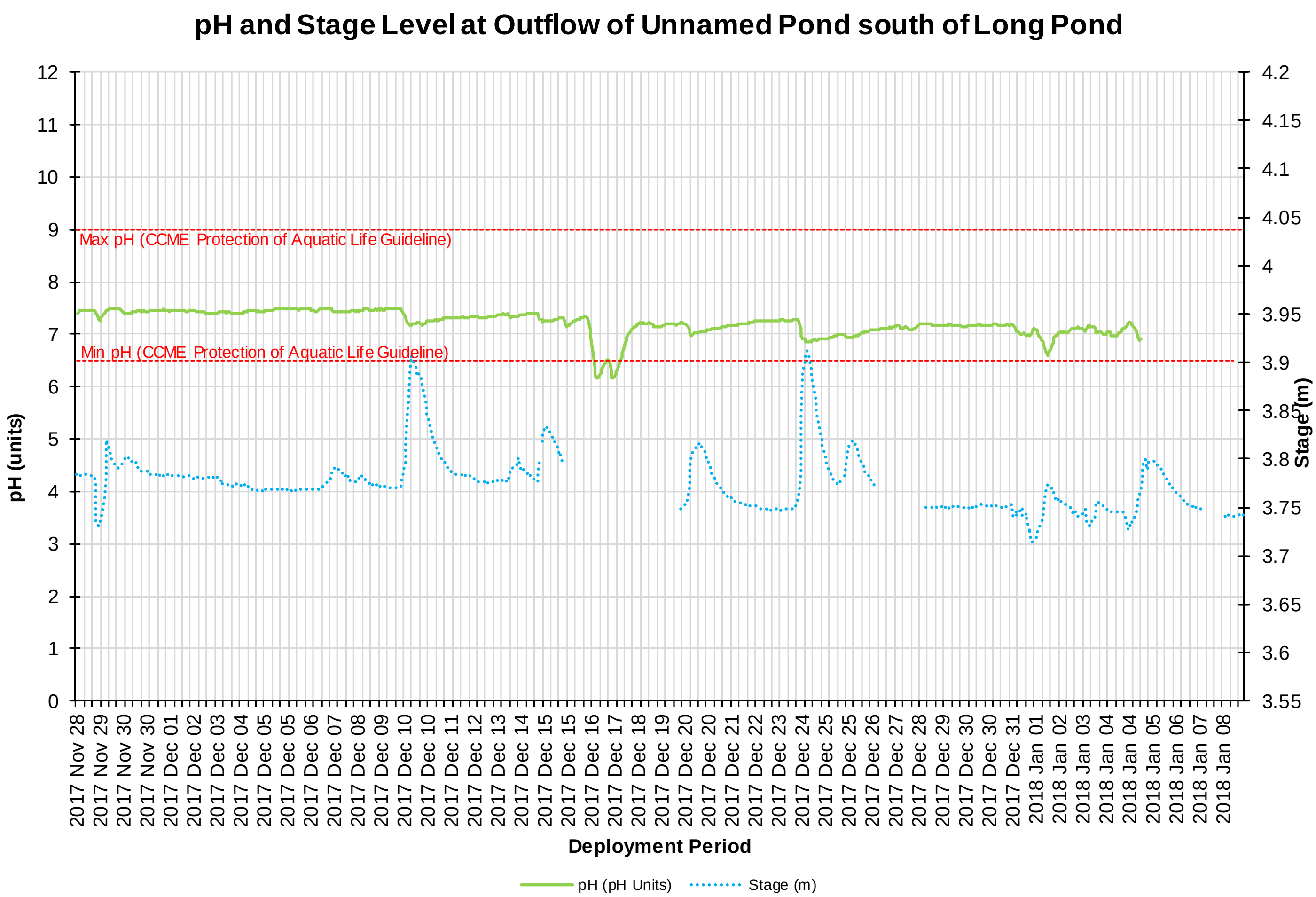

Figure 11: pH (pH units) and stage level (m) values

Specific Conductivity

The conductivity levels ranged between 113.9 µS/cm and 222.1 µS/cm during deployment (Figure 12). This deployment period had a median of 192.5 µS/cm, which was slightly higher than the previous deployment of 186.4 µS/cm.

This station increased in conductivity during high stage events (Figure 12). High stage events can be caused by precipitation. When the stage levels increase, it indicates a larger volume of water present for that time. The extra amount of water in the river dilutes the suspended solids that are present (Figure 12), causing the specific conductivity to dip down. After each dip in conductivity, the brook generally will return to previous levels. The three large dips on Figure 12, correspond with rainfall events from the weather station in St. Lawrence.

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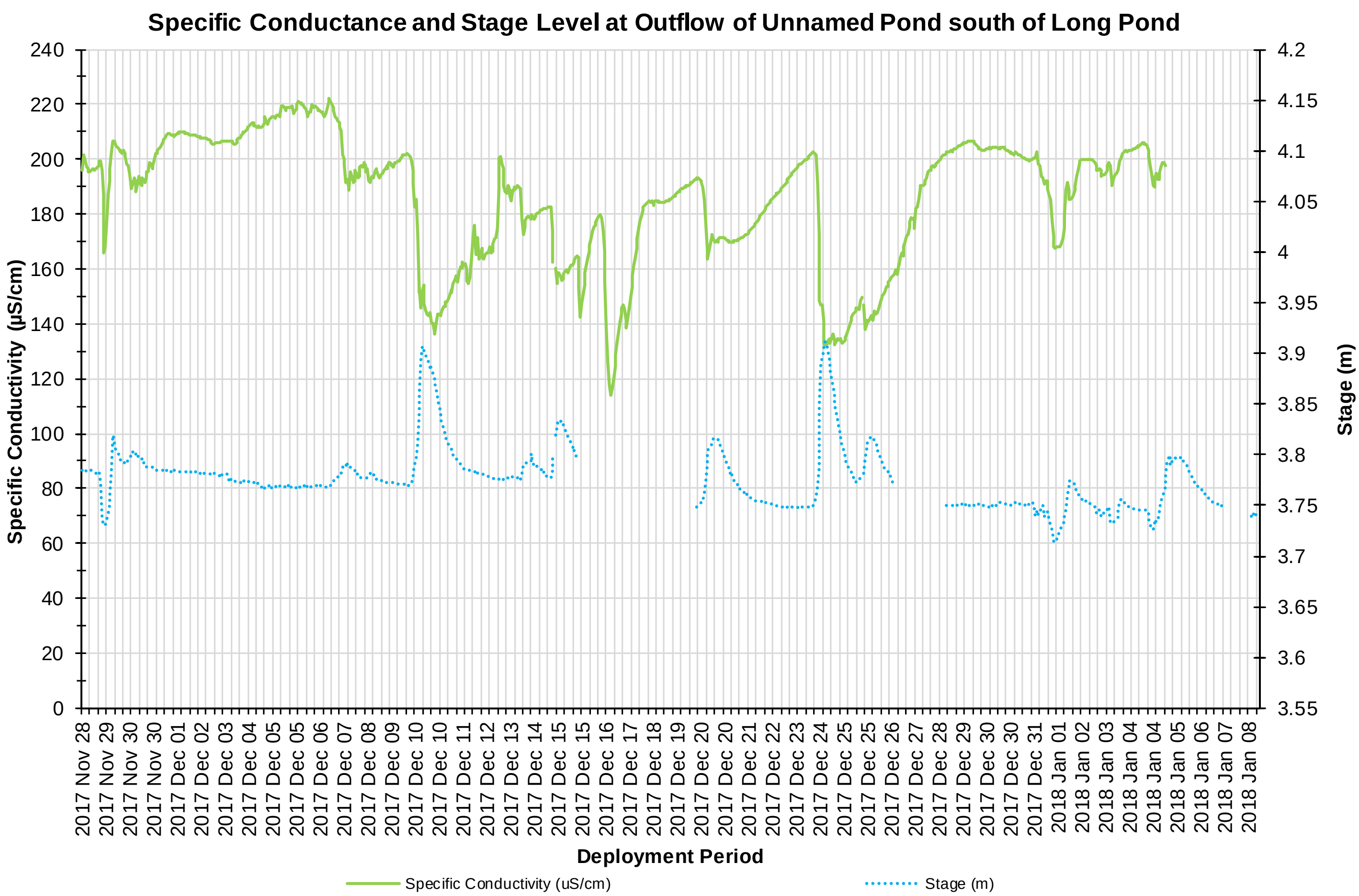

Figure 12: Specific conductivity (µS/cm), and stage (m) values

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 11.62 mg/L to a maximum of 14.24 mg/L. The percent saturation levels for dissolved oxygen ranged within 88.0% Saturation to 99.3% 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 increases in the dissolved oxygen concentration, which are outside of the natural diurnal pattern, are during the colder water temperatures, for example on December 10th and again on December 13th, 2017. This is a result of the normal reaction between water temperature and dissolved oxygen. It is to be expected as the air temperatures decrease for the concentrations of dissolved oxygen to increase in the brook.

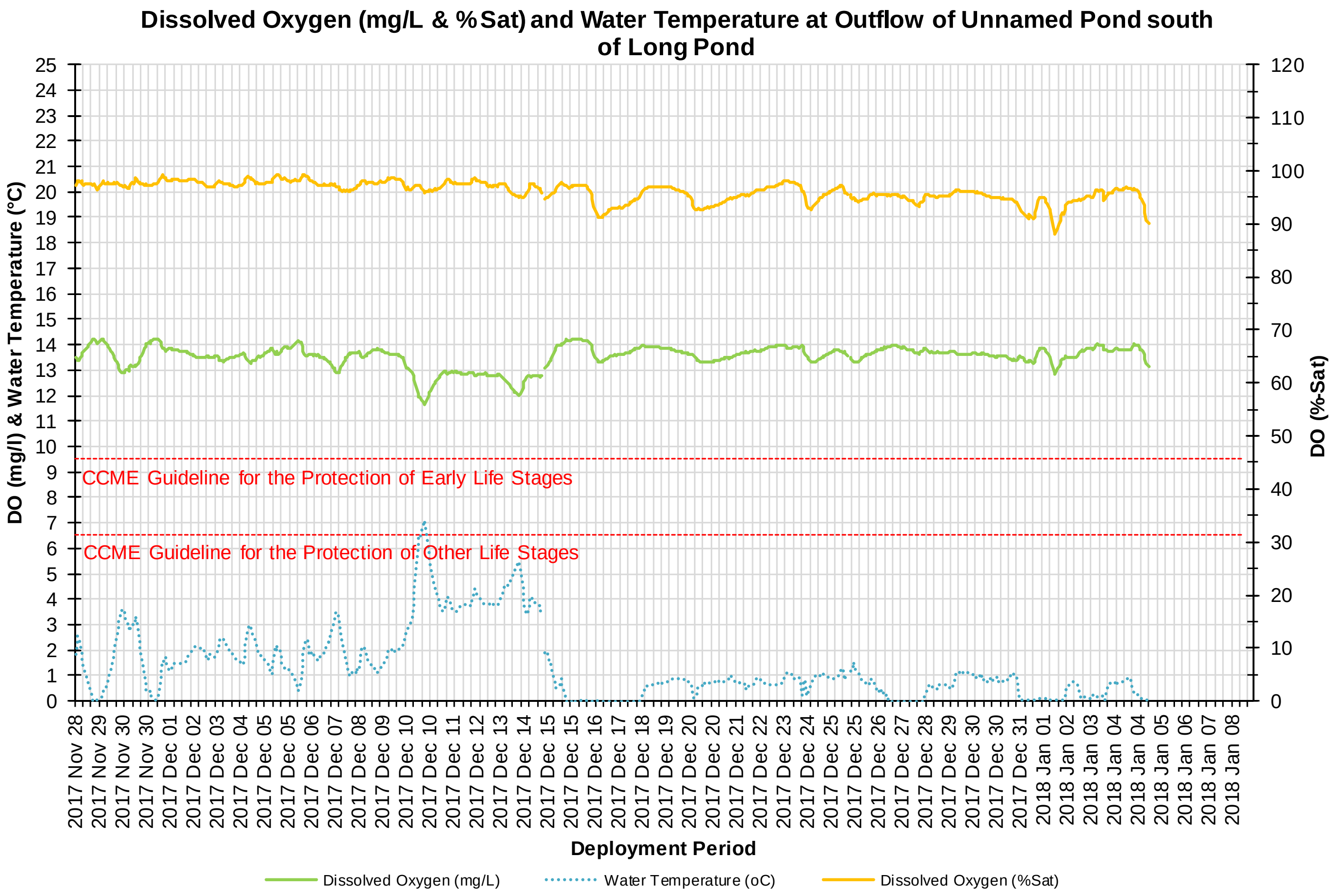

Figure 13: Dissolved Oxygen (mg/L & Percent Saturation) values.

Turbidity

Turbidity levels during the deployment ranged within 6.4 NTU and 28.8 NTU (Figure 14). The deployment data has a median of 15.2 NTU. The median is slightly higher than the previous deployment median of 12.1 NTU.

There are several rainfall events during the deployment (Figure 15) which likely contributed to the turbidity spikes recorded. There are distinct spikes in turbidity and then dips as the turbidity levels settle back down to around 10 NTU.

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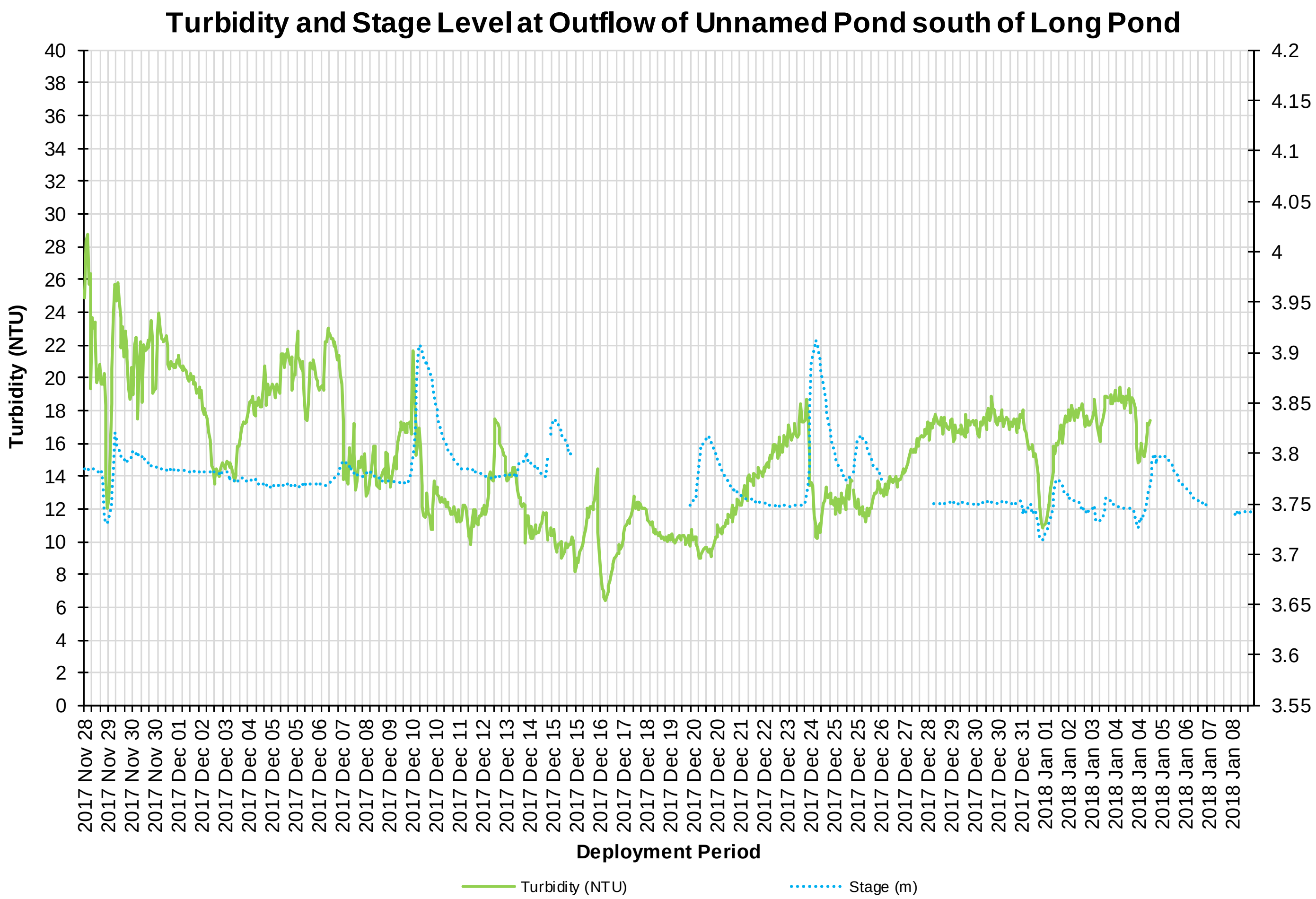

Figure 14: Turbidity (NTU) and stage level (m) values.

Stage and Precipitation

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During the deployment period, the stage values ranged from 3.71m to 3.91m. The larger peaks in stage 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 37.7mm on December 10th, 2017.

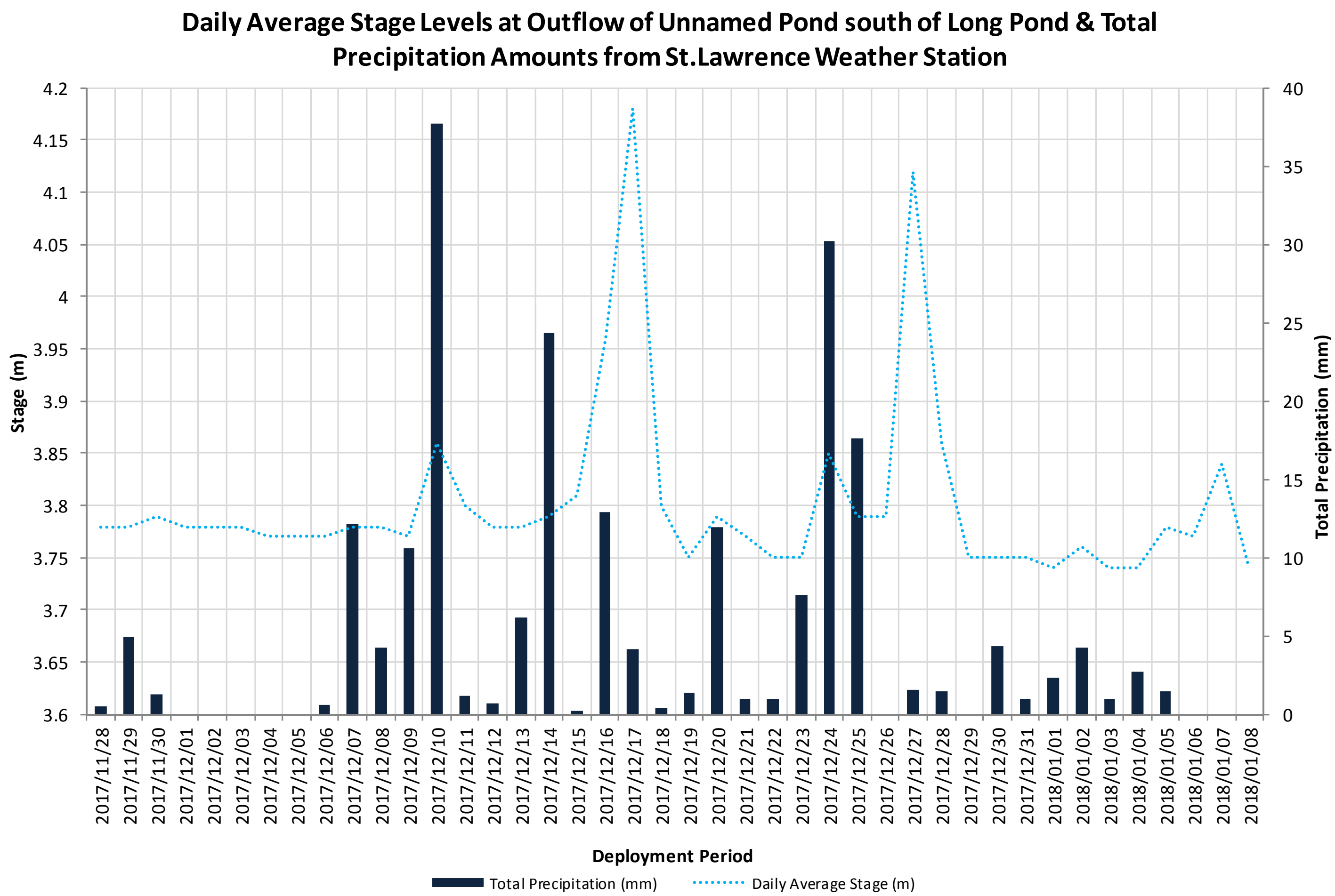

Figure 15: Daily average stage values and daily total precipitation.

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 some undeveloped area that includes natural wetlands and marshlands, however, the brook skirts along the construction activity that is ongoing. There will be influences from these activities on the water quality parameters. This station is the furthest away from the anthropogenic activities that are 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 reasonably consistent for this brook; the large decrease around December 14th to 16th, 2017 was likely a result of rainfall. Any significant change in pH data corresponded with a rise in the stage level.

Turbidity levels remained below 30 NTU over the deployment. There was no especially high turbidity data recorded, however turbidity values would have been expected to drop to a lower level. This month's deployment had a median of 15.2 NTU which was higher than the previous deployment.

Precipitation brings changes to water quality conditions, most of these changes are natural quick adjustments in levels before the data returns to background levels. Precipitation can influence the transfer of runoff from surrounding construction areas by flushing excess material into waterways. The watershed for this brook is impacted by anthropogenic changes as the mining activity continues. The health of a brook can be determined by how quickly it returns to a consistent parameter level after a water quality event.