Real-Time Water Quality Report

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

Deployment Period
November 27, 2016 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.

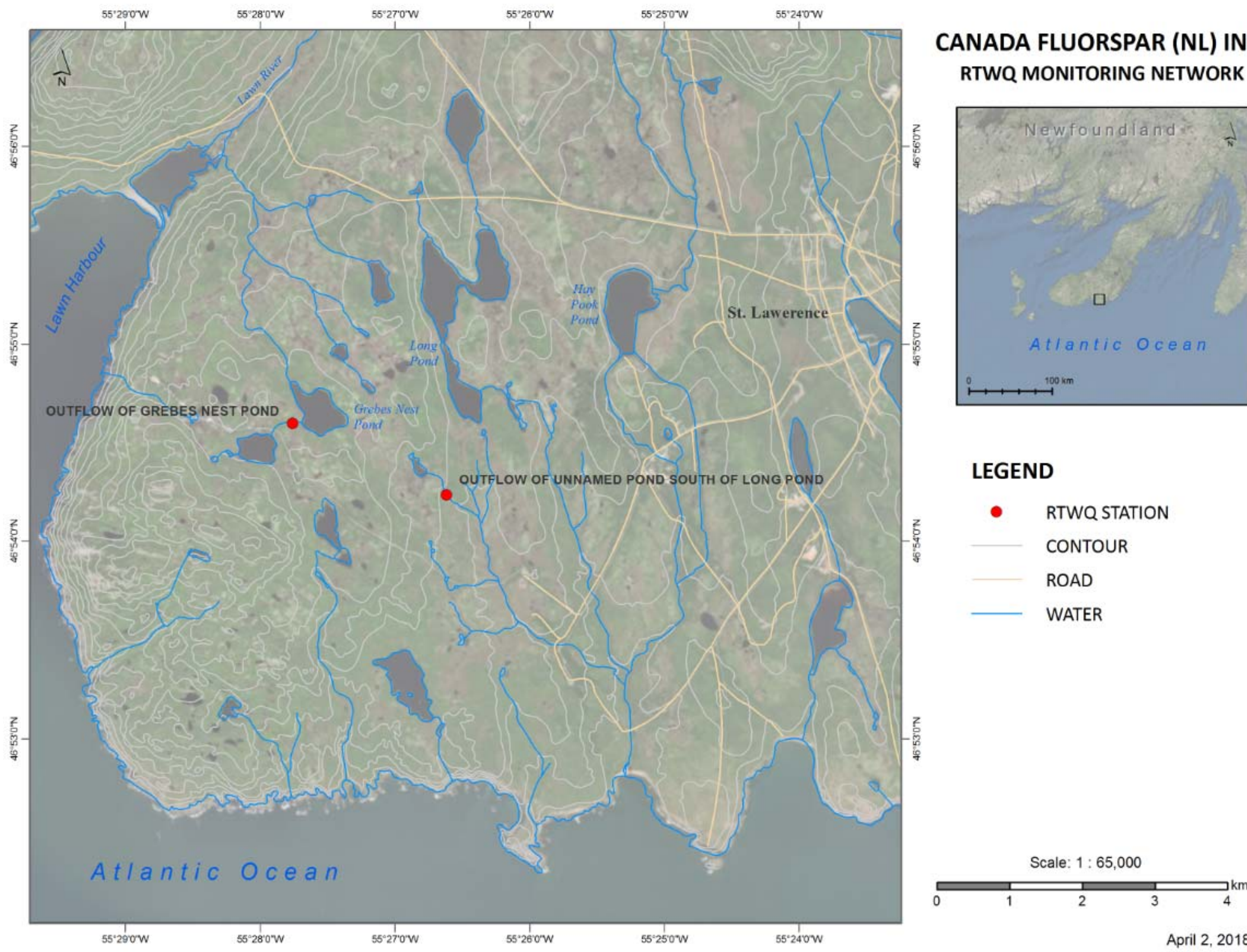


Figure 1: Real-Time Water Quality and Quantity Stations at Canada Fluorspar Inc

Outflow of Grebes Nest Pond

The Outflow of Grebes Nest Pond station is established North West of the pit dewatering effluent outfall 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 3). The pool depth is approximately 0.5 to 1.0 metres. The GPS coordinates for this site are **N46° 54' 35.9" W055° 27' 45.6"**.

The station hut was placed on the North bank approximately 5 metres from the stream (Figure 2). 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.

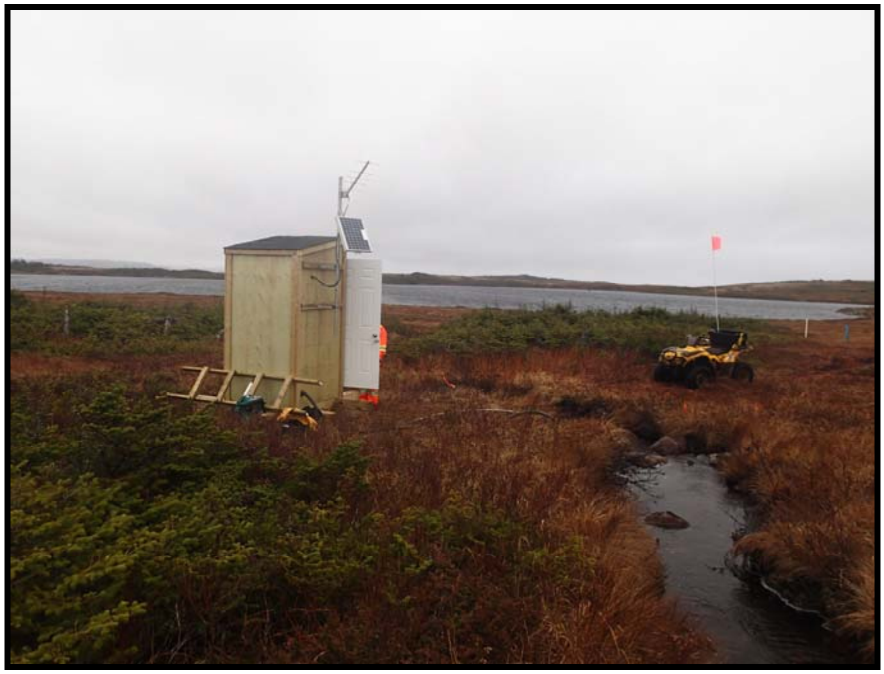


Figure 2: Real-Time Water Quality and Quantity Station at Outflow of Grebes Nest Pond.

Figure 3: Instrument deployed at Outflow of Grebes Nest Pond Real-Time Station

Outflow of Unnamed Pond south of Long Pond

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 5). 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 4).

Figure 4: Real-Time Water Quality and Quantity Station at Outflow of Unnamed Pond south of Long Pond

Figure 5: Instrument deployed at Unnamed Pond south of Long Pond Real-Time Station.

Station Setup

Water quality parameters are measured at each station using a HOSKIN EXO 2 multiprobe instrument (Figure 6).

Figure 6: HOSKIN EXO 2 used for monitoring water quality parameters.

Six water parameters are measured at each station, including five water quality parameters (water temperature, dissolved oxygen, pH, turbidity and specific conductivity), and one water quantity parameter (stage). An additional water quality parameter, total dissolved solids (TDS) is calculated from this specific conductivity and water temperature.

Water quality and quantity data are recorded on an hourly basis (every 60 minutes) at both stations.

The data for both stations is viewable and downloadable online through MAE's Real Time Water Quality Monitoring webpage located here: http://www.mae.gov.nl.ca/waterres/rti/stations.html

Data Interpretation

Performance issues and data records were interpreted for each station during the deployment period for the following parameters:

- Water Temperature (^{o}C)
- pH (pH units)
- Specific Conductivity (uS/cm)
- Total Dissolved Solids (g/L)
- Dissolved Oxygen (mg/L)
- Dissolved Oxygen (%Sat)
- Turbidity (NTU)
- Stage (m)

A description of each parameter is provided in Appendix I.

The following report discusses the water quality parameters over the deployment period from November 26, 2017 to January 8, 2018. These interpretations aim to point out seasonal and overall trends and any major issues affecting the parameters. Any gaps in data are the result of transmission loss, or periods where the instrument was removed from the water.

WSC staff 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 staff visit the site regularly to ensure the data logging and data transmission equipment are working properly. WSC is responsible for handling stage and streamflow issues. The raw water quantity data is transmitted via satellite and published online with the water quality data on the Real-Time Station's website. Water quantity data published online or used in the monthly station report has not been corrected or groomed. WSC is responsible for QA/QC of water quantity data. Corrected stage and streamflow data can be obtained upon request to WSC.

WRMD staff with the Department of Municipal Affairs and Environment (MAE) are 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.

Quality Assurance and Quality Control

To ensure accurate data collection, water quality instruments are subjected to quality assurance procedures, in order to mitigate any errors caused by biofouling and/or sensor drift. Quality assurance procedures include: (i) a thorough cleaning of the instrument, (ii) replacement of any small sensor parts that are damaged or unsuitable for reuse, and (iii) the calibration of the sensors using standard solutions. Quality assurance procedures are carried out every 40-50 days, before the start of a new deployment period. Deployment periods are summarized in Table 1.

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 2). At each deployment and removal the water quality data is ranked and assigned a performance ranking (i.e. poor, marginal, fair, good, excellent) (Appendix II). Appendix II has outlined the rankings for each of the instrument sensors deployed at Canada Fluorspar Inc over the year.

For more detailed analyses of a particular time period, date or deployment period, please refer to the individual deployment reports: http://www.env.gov.nl.ca/env/waterres/rti/rtwq/csdr/index.html

Table 1: Water quality instrument deployment start and end dates for 2017 at Canada Fluorspar (NL) Inc

		Deployment	Removal
Canada Fluorspar Real Time Stations	Outflow of Grebes Nest Pond	November 17, 2016*	January 25, 2017
	Outflow of Unnamed Pond south of Long Pond	December 6, 2016*	January 25, 2017
	Outflow of Grebes Nest Pond	May 10, 2017	June 20, 2017
	Outflow of Unnamed Pond south of Long Pond	May 10, 2017	June 20, 2017
	Outflow of Grebes Nest Pond	June 21, 2017	July 24 2017
	Outflow of Unnamed Pond south of Long Pond	June 21, 2017	July 24, 2017
	Outflow of Grebes Nest Pond	July 25, 2017	September 5, 2017
	Outflow of Unnamed Pond south of Long Pond	July 25, 2017	September 5, 2017
	Outflow of Grebes Nest Pond	September 6, 2017	October 16, 2017
	Outflow of Unnamed Pond south of Long Pond	September 6, 2017	October 16, 2017
	Outflow of Grebes Nest Pond	October 17, 2017	November 27, 2017
	Outflow of Unnamed Pond south of Long Pond	October 17, 2017	November 27, 2017
	Outflow of Grebes Nest Pond	November 27, 2017	January 8, 2018
	Outflow of Unnamed Pond south of Long Pond	November 27, 2017	January 8, 2018

*Please note that Outflow of Grebes Nest Pond station was installed earlier than Outflow of Unnamed Pond south of Long Pond station. Therefore the data will start at different dates during these deployments.

Table 2: 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

Concerns or Issues during the Deployment Period

During this deployment year, the water supply for Outflow of Grebes Nest Pond station some changes. Currently, the water is originating from a sedimentation pond that is upstream of the Real-Time station. This 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 the sedimentation pond to naturally overflow down a trough and into a culvert that supplies Outflow of Grebes Nest Pond. The timeline for the changes to Outflow of Grebes Nest Pond Station are captured in Appendix III.

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

Please note that the precipitation and air temperature data from Environment and Climate Change Canada does not warrant the quality, accuracy, or completeness of any information, data or product from these web pages. It is provided "AS IS" without warranty or condition of any nature.

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

Water Temperature

The water temperature at the two water quality stations ranged from a minimum of -0.15^{o}C recorded at both sites to a maximum of 26.57^{o}C which was recorded at Outflow of Unnamed Pond south of Long Pond (Figure 7).

Both sites displayed evident increases in water temperature as the seasons changed from Spring into Summer temperatures and sharp decreases in water temperature as Summer changed into Fall. Outflow of Unnamed Pond south of Long Pond's median of 7.2^{o}C was higher than that of Outflow to Grebes Nest Pond which was 3.78^{o}C. The graph also displays that the values for water temperature at Unnamed Pond were slightly higher during the warmer season (Figure 7).

Outflow of Unnamed Pond south of Long Pond water temperatures during the summer months were slightly higher than that of Outflow of Grebes Nest Pond. During the summer months Outflow of Grebes Nest Pond was supplemented by water being pumped from John Fitzpatrick Pond, the pond that Grebes Nest actually flows into, therefore it is possible the water was cooler due to coming from a deeper source (Appendix III).

Figure 8 displays the mean air temperature that was recorded at the St. Lawrence weather station during the deployment period for the water quality instruments. It is important to display how air temperatures affect the water temperatures in surface water. There were no air temperatures available toward the end of the deployment period hence the gaps in data on the graph.

Both real-time stations water temperatures mirror the air temperature recorded in St. Lawrence. The water temperature data recorded over the deployment year is what would be expected from a brook in Newfoundland and Labrador.

Table 3. Summary of Water Temperature data at Fluorspar Real-Time Stations

	Water Temperature (oC)	
	Outflow of Grebes	Outflow of Unnamed
Min	-0.15	-0.154
Max	21.1	26.57
Median	3.772	7.201

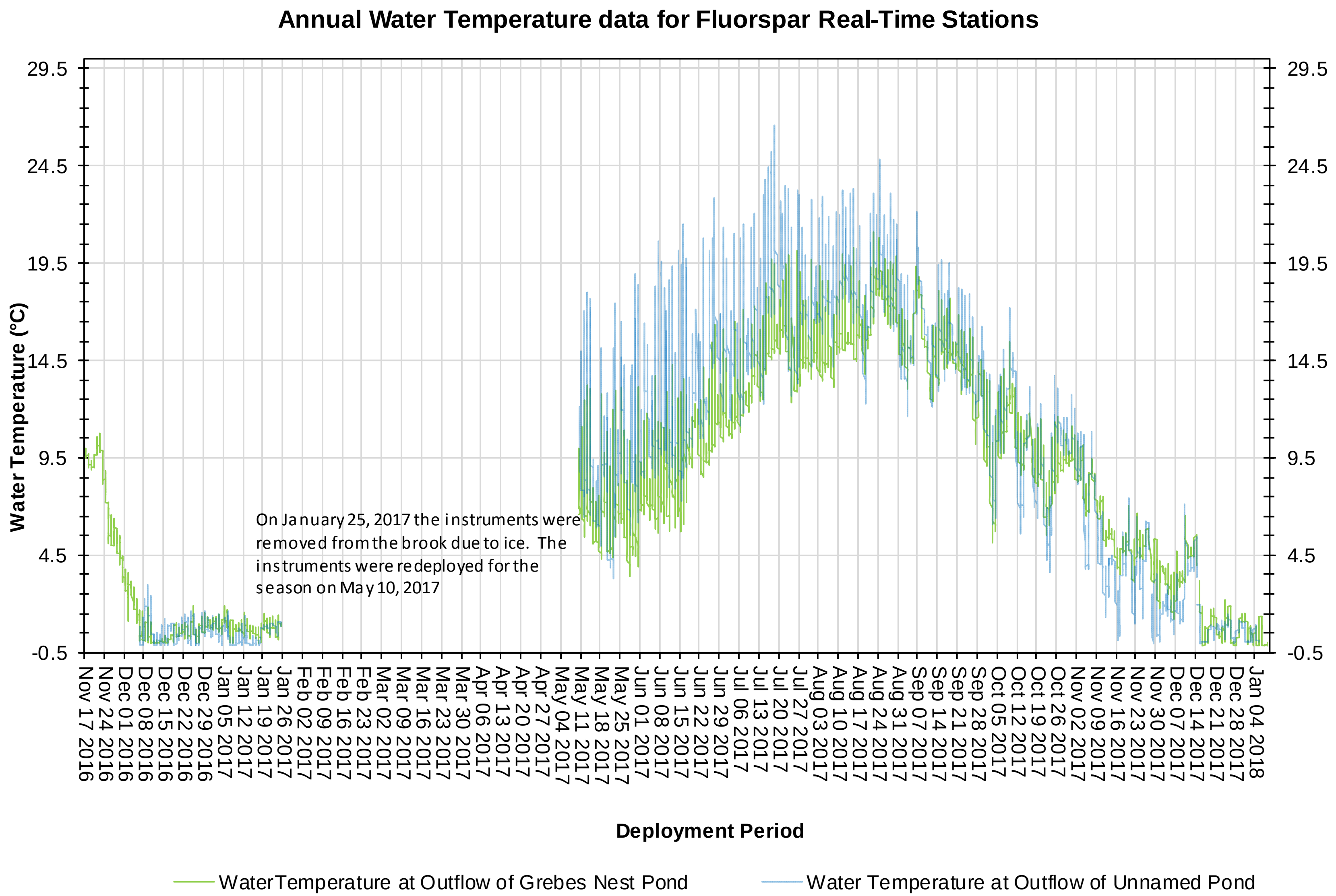


Figure 7: Water temperature (°C) values at the Canada Fluorspar Real-Time Water Quality Stations

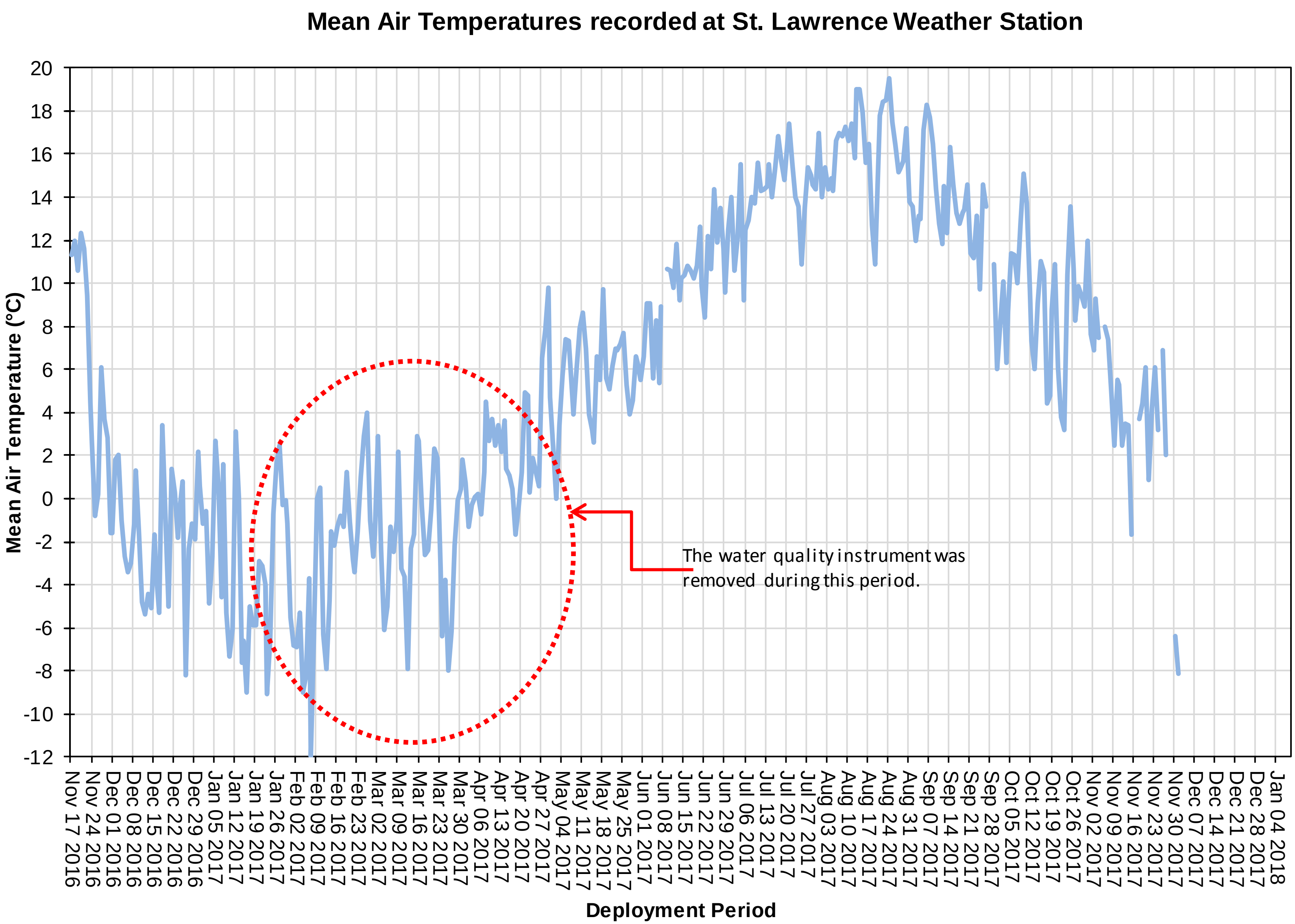


Figure 8: Mean Air Temperatures (°C) recorded at the St. Lawrence Weather Station

pH

The first year of deployment for Canada Fluorspar real-time stations provided pH data that ranged between, a minimum of 4.57 pH units at Outflow of Unnamed Pond south of Long Pond and a maximum of 7.73 pH units also recorded at Outflow of Unnamed Pond south of Long Pond.

For most of the deployment the pH data from Outflow of Grebes Nest Pond remained below the minimum Guideline for Protection of Aquatic Life of 6.5pH units. At the beginning of December 2017 the pH levels were starting to increase. Outflow of Unnamed Pond south of Long Pond pH values were below the CCME guideline until early June 2017, then the values increased and remained higher for the rest of the deployment. 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 (Figure 9).

For the majority of the deployment the pH values at Outflow of Unnamed Pond south of Long Pond were higher than the pH levels at Outflow of Grebes Nest Pond. External factors can influence pH levels, such as precipitation or snow melt run off (Figure 13). Gradual increases in pH levels such as noted for Outflow of Unnamed Pond south of Long Pond can be a result of water level decreasing slightly during the warmer months of the year (Figure 9).

Neither of the sites displayed consistent pH levels during the deployment period. Considering it is the first year of deployment for these stations it will take time to capture the seasonal norms at these Real-Time stations.

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.

Table 4. Summary of pH data at Fluorspar Real-Time Stations

	pH(pH units)	
	Outflow of Grebes	Outflow of Unnamed
Min	5.11	4.57
Max	7.41	7.73
Median	5.82	6.1

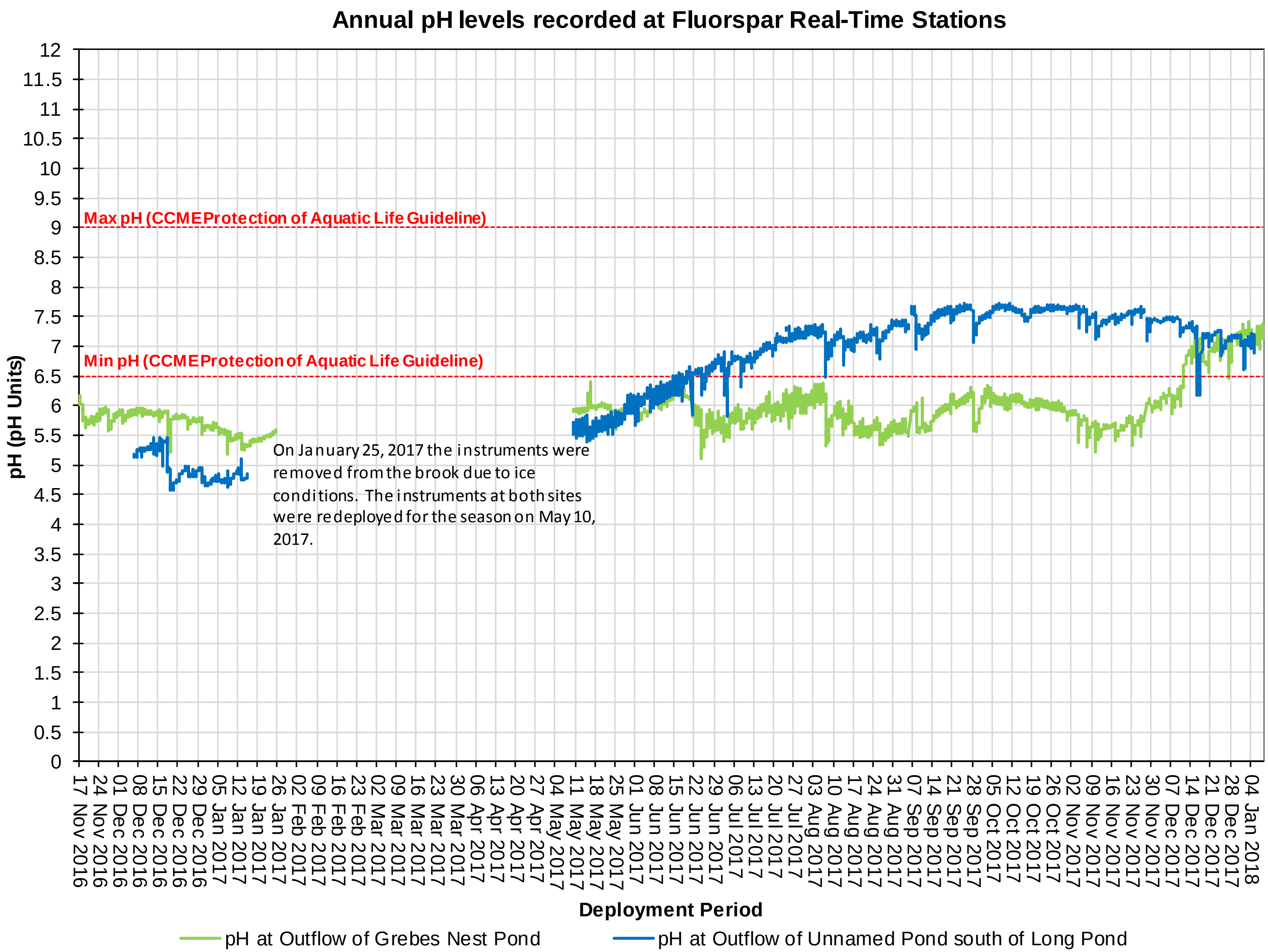


Figure 9: pH (pH units) at the Canada Fluorspar (NL) Inc Real-Time Stations

Specific Conductivity

The conductivity levels over the deployment year recorded a minimum of 29.1 µS/cm at Outflow of Grebes Nest Pond and a maximum of 229.71 µS/cm at Outflow of Unnamed Pond south of Long Pond (Figure 10).

There is a direct relationship between conductivity and stage level. Initially, during higher rainfall events the water column will become diluted lowering the conductivity levels. Then as organic and inorganic materials from surrounding environments are flushed into the brook, conductivity levels will increase for a short period of time (Figure 10).

The conductivity levels at Outflow of Unnamed Pond south of Long Pond steadily increased over the summer months. The sharp dips in the specific conductivity at Outflow of Unnamed station were likely a result of increases in stage from rainfall (Figure 13). The ongoing increase of conductivity at Outflow of Unnamed Pond south of Long Pond indicates that there was another factor influencing the parameter at this station as the conductivity levels continued to climb even without stage or rainfall events. It is likely that the conductivity had increased due to the rise in anthropogenic activities on site upstream from this station (Figure 10).

For the majority of the deployment year, the specific conductivity at Outflow of Grebes Nest Pond was under 100 µS/cm. During early November the conductivity levels started to increase at this station. This was likely a result of the source of water flowing into the brook. The water directed through Outflow of Grebes Nest Pond was coming from the sedimentation pond that filters the water from the open pit mine (Appendix III). Rainfall events will reduce the conductivity for a short period of time. However, with the heavier influences from the sedimentation pond, the conductivity continued to rise until the instrument was removed in January 2018 (Figure 10).

Table 4. Summary of specific conductivity data at Fluorspar Real-Time Stations

	Specific Conductivity (uS/cm)	
	Outflow of Grebes	Outflow of Unnamed
Min	29.1	43.7
Max	227.09	229.71
Median	59.1	87.1

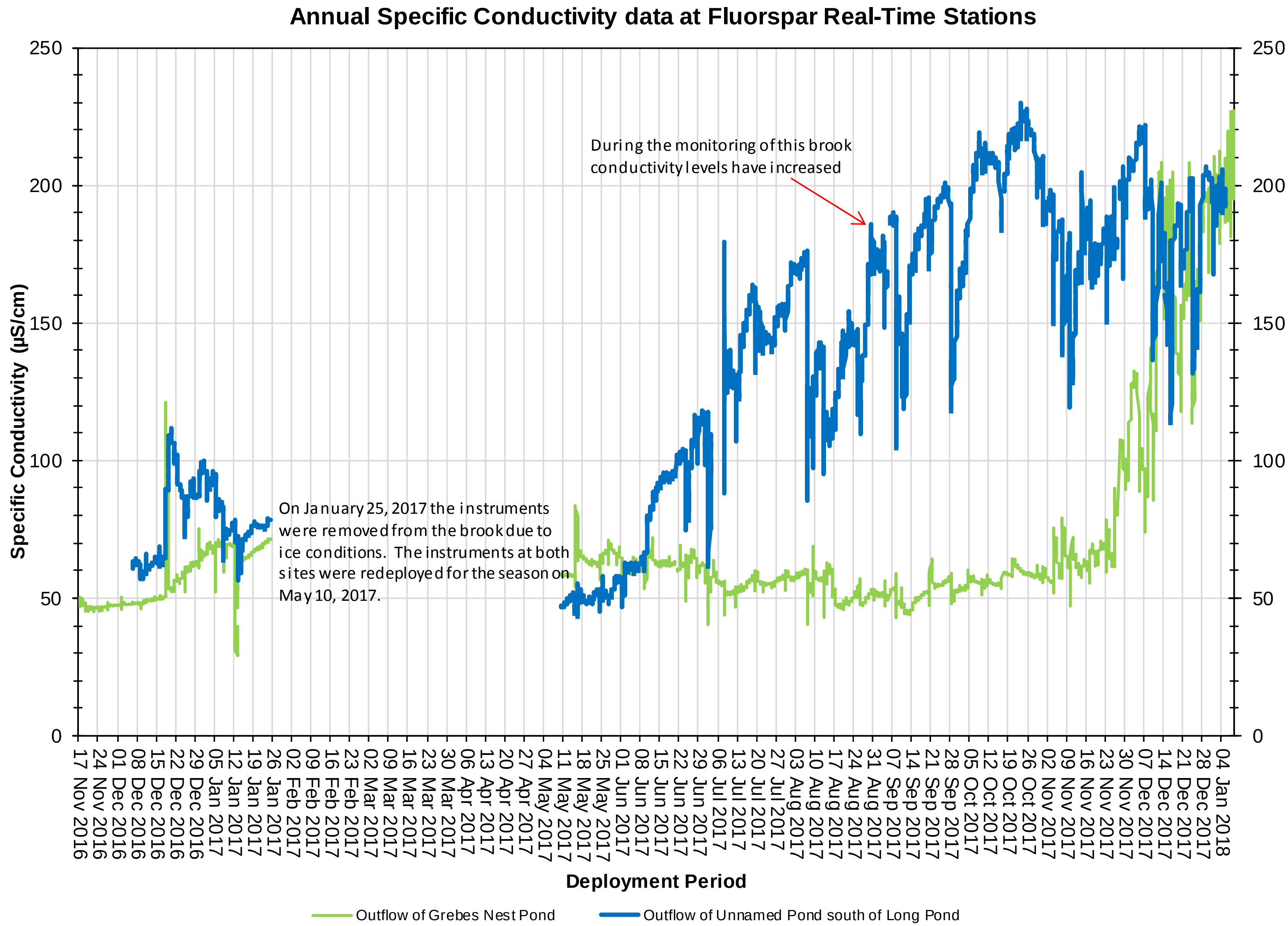


Figure 10: Specific conductivity (µS/cm) at the Canada Fluorspar (NL) Inc Real-Time Stations

Dissolved Oxygen

The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe. The instrument then calculates percent saturation (% Sat) taking into account the water temperature. Both parameters are important and helpful in reading the conditions in an ambient water body.

Over the deployment period the dissolved oxygen concentration ranged from a minimum of 7.06 mg/L recorded at Outflow to Grebes Nest Pond to a maximum of 15.16 mg/L (Table 4) recorded at Outflow to Unnamed Pond south of Long Pond (Table 5). The percent saturation levels for dissolved oxygen ranged from 67.2% Saturation to 115.1% Saturation (Table 4), both values were recorded at Outflow to Grebes Nest Pond.

For the most part, the two real-time stations displayed similar dissolved oxygen trends across the deployment period. Dissolved Oxygen remained above the CCME Guideline for the Protection of Other Life Stages (6.5mg/L).

During the warmer air and water temperatures across the Summer into the early Fall the dissolved oxygen levels dropped to lower concentrations (Figure 7 & 8). Decreases in dissolved oxygen would be expected as warmer water can hold less oxygen.

Toward the end of the deployment, the dissolved oxygen levels started to increase as the air and water temperatures decrease with the change of season into winter. This is a natural process that occurs in every ambient water body throughout the year.

Table 4. Summary of Dissolved oxygen data at Outflow of Grebes Nest Pond

	Grebes: Dissolved Oxygen	
	mg/L	%Sat
Min	7.06	67.2
Max	14.34	115.1
Median	12.35	95

Table 5. Summary of Dissolved oxygen data at Outflow of Unnamed Pond south of Long Pond

	Unnamed Pond: Dissolved Oxygen	
	mg/L	%Sat
Min	8.2	88
Max	15.16	105.6
Median	11.74	98.4

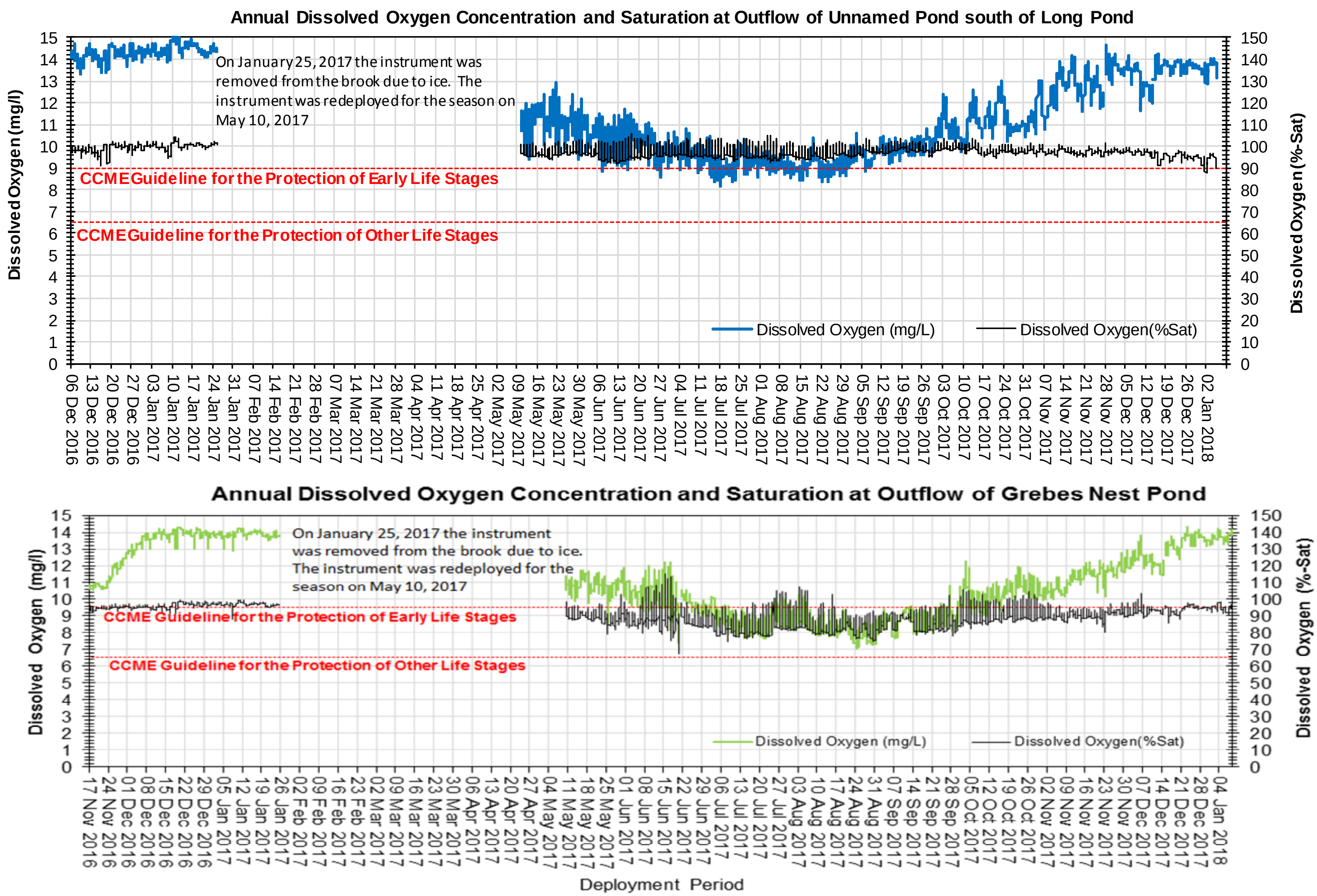


Figure 11: Dissolved Oxygen (mg/L & Percent Saturation) values

Turbidity

Turbidity levels during the deployment ranged from a minimum of 0.16 NTU recorded at Outflow of Unnamed Pond south of Long Pond to a maximum of 1314.4 NTU recorded at Outflow of Grebes Nest Pond (Table 6). The highest median was recorded at Outflow of Unnamed Pond south of Long Pond, 8.8 NTU, indicating that the brook had consistently higher turbidity across the deployment year than Outflow of Grebes Nest Pond (with a median of 1.49 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 events would be of concern.

During the spring thaw there is a higher amount of material present in the brook as the surrounding environment thaws and flushes into the surrounding waterways. Figure 12 displays turbidity spikes on both stations graphs. During the month of May, Outflow of Grebes Nest Pond was having intermediate flow issues and periodically the instrument was sitting in stagnant water. It is likely the higher turbidity values are representative of this environment.

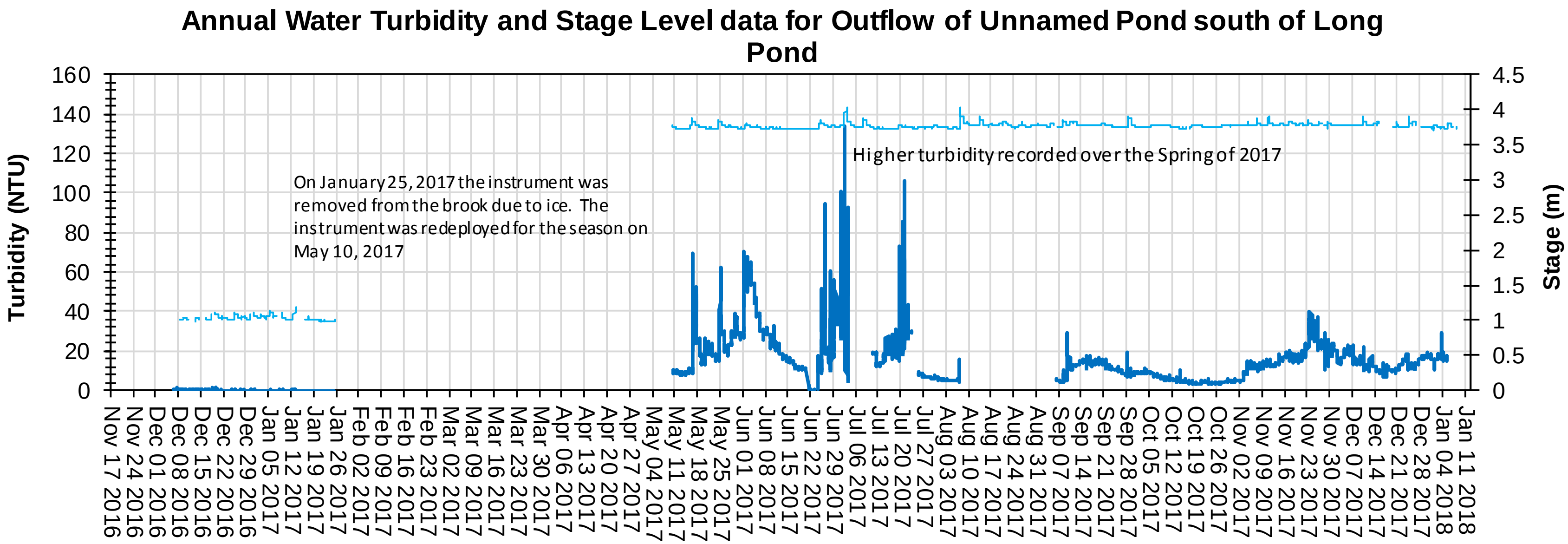
During the summer months it is expected for turbidity levels to decrease as there is less precipitation at this time. The stations at Fluorspar continued to have ongoing turbidity spikes throughout the summer. The turbidity at Outflow of Unnamed Pond south of Long Pond was a likely a result of the activities on site. The testing and use of the tailings management facility and the accompanied action around this site would influence the runoff into the brook. The ongoing turbidity at Outflow of Grebes Nest was likely related to the changes in the water supply into the brook (Appendix III).

Outflow of Unnamed pond south of Long Pond had a turbidity median of 0.1 NTU from November 17, 2016 to January 8, 2017 and a median of 13.7 NTU from November 17, 2017 to January 8, 2018. Outflow of Grebes Nest Pond had a median of 0.7 NTU for December 7, 2016 to January 8, 2017 and then a median of 10.9 NTU from December 7, 2017 to January 8, 2018. The medians for both stations have increased over the deployment year.

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.

Table 6. Summary for Turbidity data at Fluorspar Real-Time stations

	Turbidity (NTU)	
	Outflow of Grebes	Outflow of Unnamed
Min	0.35	0.16
Max	1314.4	133.9
Median	1.49	8.8



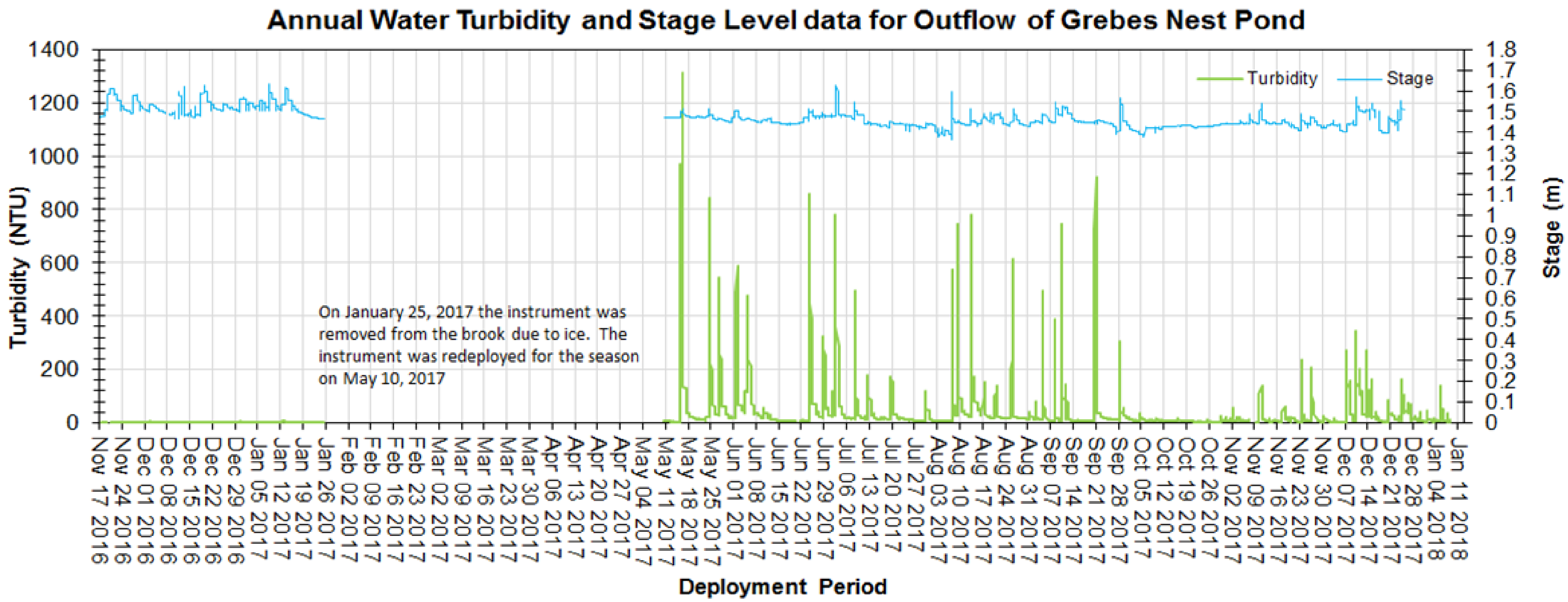


Figure 12: Turbidity (NTU) and stage level (m) values

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 as it provides an estimation of water level at the station and can explain some of the events that are occurring in relation to other parameters (i.e. Specific Conductivity, DO, turbidity). Stage will increase during rainfall events (Figure 13) and during any surrounding snow or ice melt as runoff collects in the brooks. However, direct snowfall will not cause stage to rise significantly.

Outflow of Grebes Nest Pond stage values ranged from 1.37m to 1.64m (Table 7). Despite the changes in the water supply to Outflow of Grebes Nest Pond the stage level did not change significantly over the deployment year. Outflow of Unnamed Pond south of Long Pond recorded stage levels within a minimum of 0.983m to a maximum of 4.024m. Although the stations are not on the same river, both sites had similar peaks in stage during the larger rainfall events.

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 53.9 mm on July 21st, 2017.

Table 7. Summary of for Stage data at Fluorspar Real-Time stations

	Stage (m)	
	Outflow of Grebes	Outflow of Unnamed
Min	1.367	0.983
Max	1.637	4.024
Median	1.485	3.74

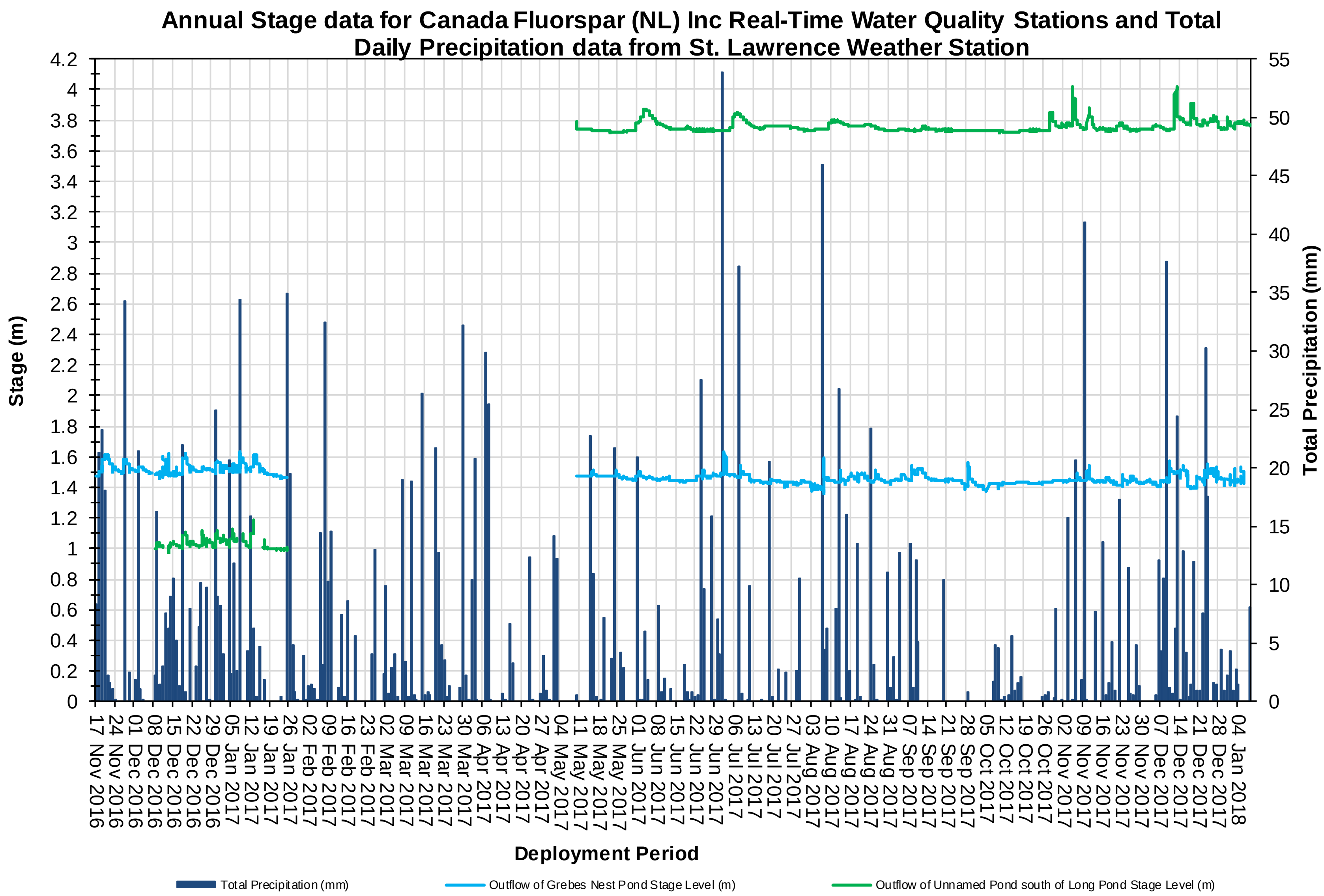


Figure 13: Annual stage values and daily total precipitation.

Conclusion

As with many shallow brooks and streams, precipitation and runoff events play a significant role in influencing the water quality within a water body. The watershed areas for these stations are bordered by marshland, which also has influence on the material present in the water column. The runoff can influence the water quality parameters, especially during climatic events such as precipitation and high air temperatures. Water temperatures during this deployment were representative of the St. Lawrence climate. 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 water column. The levels of dissolved oxygen concentration during the deployment are within natural and expected limits for these two stations.

Outflow to Grebes Nest Pond had varying pH during across the year, likely due to the changes in water source before the sedimentation pond was developed. Outflow of Unnamed Pond south of Long Pond pH increased as the deployment period continued. This was likely linked to disturbances and activities upstream that also influenced the increases in turbidity and specific conductivity at this station. pH levels will adjust with increases and decreases in stage, however, the parameter should return to a consistent level.

Specific Conductivity levels at Outflow to Unnamed Pond south of Long Pond increased steadily from early June to the end of the deployment period. Turbidity levels at this station also spiked during June, and although the values settled out slightly as the deployment continued, the turbidity values did not return to the levels recorded earlier in the year. Stage level at this station was influenced by precipitation events and did increase slightly with other parameter increases, however stage remained within 1.35m to 1.65m across the deployment.

Turbidity levels increased over the deployment for both brooks. From November to January the turbidity at both sites is minimal. During the spring of 2017, the turbidity levels increased significantly and at Outflow of Grebes Nest Pond levels were as high as 1200NTU. Rainfall and runoff can directly affect sediment in waterways, however the sediment should settle out after a period of time.

This was the first year for deployment of the Real-Time water quality stations at Canada Fluorspar (NL) Inc and during this phase of the Canada Fluorspar (NL) Inc project, the natural environment was constantly being disturbed by construction activities as the mine site developed. Grebes Nest Pond was dewatered for mining purposes and over the year the water supply for Outflow of Grebes Nest Pond station did not consistently come from the same source. Currently the Outflow of Grebes Nest Pond station is supplied via a sedimentation pond that was established to settle out the sediment-laden pit water from the open pit mine.

While there were no supply issues with Outflow of Unnamed Pond south of Long Pond, this station also went through changes as the activity on the mine site increased with development of the area. The Outflow of Unnamed Pond south of Long Pond station is downstream from the Tailings Management Facility and ongoing anthropogenic activities on the mine site. There can be influences from these activities on the water quality parameters.

APPENDIX I

DEFINITIONS OF PARAMETERS

Dissolved Oxygen

The amount of Dissolved Oxygen (DO) (mg/l) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).

pH

pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).

Specific conductivity

Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Stage

Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature

Essential to the measurement of most water quality parameters, temperature (^{o}C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids

Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity

Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965).

APPENDIX II

PERFORMANCE RANKING OF INSTRUMENTS

Performance Ranking of Instruments

Station	Date	Action	2017 Deployment Season Comparison Ranking				
			Temperature	pH	Specific Conductivity	Dissolved Oxygen	Turbidity
Outflow of Grebes Nest Pond	Nov 17 2016	Deployment	Good	Good	Excellent	Excellent	Excellent
	Jan 25 2017	Removal	Excellent	Fair	Fair	Excellent	Excellent
Outflow of Unnamed Pond south of Long Pond *different deployment date from Grebes Nest	Dec 6 2016*	Deployment	Good	Good	Good	Excellent	Excellent
	Jan 25 2017	Removal	Good	Poor	Poor	Good	Excellent
Outflow of Grebes Nest Pond	May 10 2017	Deployment	Good	Excellent	Fair	Excellent	Excellent
	June 20 2017	Removal	Fair	Excellent	Good	Fair	Fair
Outflow of Unnamed Pond south of Long Pond	May 10 2017	Deployment	Marginal	Excellent	Good	Excellent	Excellent
	June 20 2017	Removal	Excellent	Good	Excellent	Excellent	Fiar
Outflow of Grebes Nest Pond	June 20 2017	Deployment	Excellent	Excellent	Excellent	Good	Fair
	July 24 2017	Removal	Poor	Excellent	Excellent	Good	Good
Outflow of Unnamed Pond south of Long Pond	June 21 2017	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	July 24 2017	Removal	Fair	Excellent	Excellent	Excellent	Poor
Outflow of Grebes Nest Pond	July 25 2017	Deployment	Excellent	Fair	Excellent	Excellent	Good
	Sept 5 2017	Removal	Good	Good	Excellent	Excellent	Poor
Outflow of Unnamed Pond south of Long Pond	July 24 2017	Deployment	Marginal	Excellent	Good	Excellent	Fair
	Sept 5 2017	Removal	Excellent	Excellent	Good	Excellent	Poor
Outflow of Grebes Nest Pond	Sept 5 2017	Deployment	Fair	Excellent	Good	Excellent	Good
	Oct 16 2017	Removal	Fair	Excellent	Good	Excellent	Good
Outflow of Unnamed Pond south of Long Pond	Sept 6 2017	Deployment	Excellent	Excellent	Fair	Excellent	Fair
	Oct 16 2017	Removal	Excellent	Excellent	Good	Good	Good
Outflow of Grebes Nest Pond	Oct 17 2017	Deployment	Excellent	Good	Good	Good	Excellent
	Nov 27 2017	Removal	Excellent	Fair	Good	Poor	Good
Outflow of Unnamed Pond south of Long Pond	Oct 17 2017	Deployment	Good	Good	Good	Excellent	Good
	Nov 27 2017	Removal	Excellent	Good	Excellent	Good	Good
Outflow of Grebes Nest Pond	Nov 28 2017	Deployment	Excellent	Excellent	Good	Good	Marginal
	Jan 8 2018	Removal	Excellent	Excellent	Excellent	Excellent	Good
Outflow of Unnamed Pond south of Long Pond	Nov 28 2017	Deployment	Good	Excellent	Good	Poor	Fair
	Jan 8 2018	Removal	***No***	***readings***	***available***	***at***	***removal***

*Please note that Outflow of Grebes Nest Pond station was installed earlier than Outflow of Unnamed Pond south of Long Pond station. Therefore the initial start date for the stations is different.

APPENDIX III

TIMELINE OF WATER SUPPLY FOR OUTFLOW OF GREBES NEST POND REAL-TIME STATION

TIMELINE OF WATER SUPPLY FOR OUTFLOW OF GREBES NEST POND REAL-TIME STATION

No.	Date	Water Supply
1	November 17, 2016 to January 2017	Water supplied to brook was the natural outflow from Grebes Nest Pond
2	May 10, 2017 to June 20, 2017	Grebes Nest Pond has been dewatered for mining purposes. Water flow issues this month, instrument is sitting in stagnant water for a portion of this deployment. Unsure of exact timeframe. Brook is dry in places.
3	June 20, 2017 to July 24, 2017	Water is being pumped from another small pond. Smaller pond is upstream from what was the original Grebes Nest Pond.
4	July 25, 2017 to September 5, 2017	Water supply is as noted above for June 20 to July 24, 2017
5	September 5, 2017 to October 16, 2017	John Fitzpatrick pond water is being pumped through a hose to the top of Outflow Grebes Nest Pond brook to provide water to the brook at this time.
6	October 17, 2017 to November 27, 2017	Water is now originating from a sedimentation pond established to catch the high sediment laden water being pumped from the open mine pit.
7	November 28, 2017 to January 8, 2018	Water supply is as noted above.

*There are no exact dates for when the water supply changed. The dates listed above indicate the deployment period that the water changes occurred in.

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