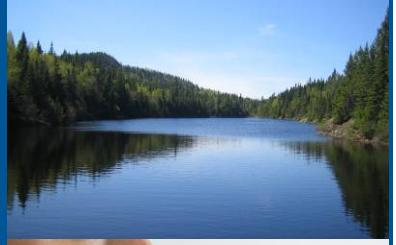







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
November 6 to December 17, 2013

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division

Outer Cove Brook, Newfoundland and Labrador

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General

- The Water Resources Management Division (WRMD), in partnership with the City of St. John's and Environment Canada, maintain two real-time water quality and water quantity monitoring stations along Outer Cove Brook.
- This deployment report discusses water quality related events occurring at the stations: Outer Cove Brook below Airport and Outer Cove Brook at Clovelly Golf Course in St. John's.
- WRMD staff monitors the real-time web pages regularly. The City of St. John's will be notified of any water quality issues that arise so mitigative measures can be taken.
- The purpose of these real-time stations is to monitor, process and publish hydrometric (water quantity) and real-time water quality data at the real-time stations. Outer Cove Brook is in the vicinity of the Torbay Road North Commercial Development Area and the real-time stations allow for assessment and management of the water body.
- This report covers the 41-day period from deployment on November 6, 2013 until removal on December 17, 2013.

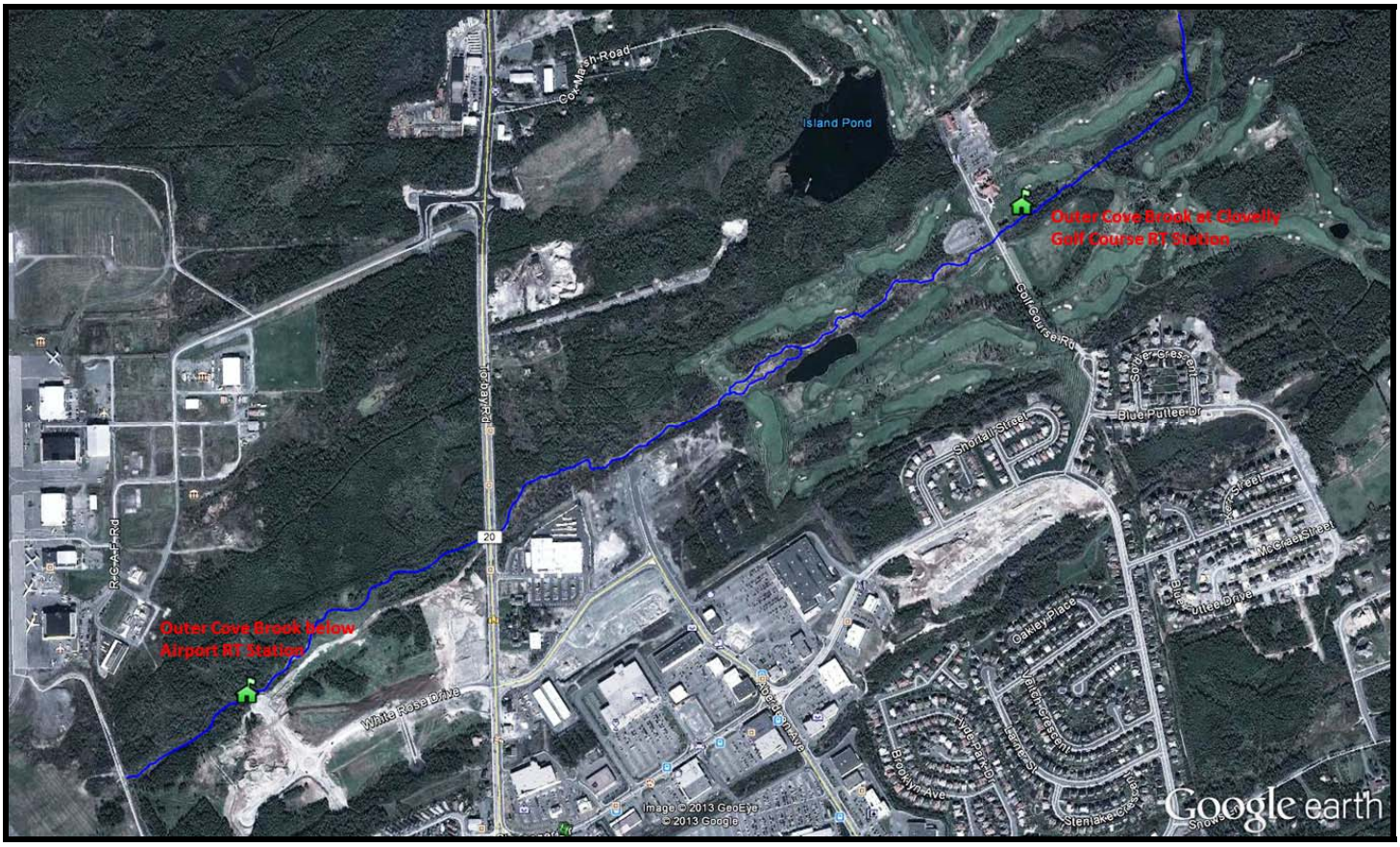


Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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).

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.
- Deployment and removal instrument performance rankings for **Outer Cove Brook below Airport** for the period of November 6, 2013 through to December 17, 2013 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Nov 6, 2013 – Dec 17, 2013

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	Nov 6 2013	Deployment	Poor	Excellent	Good	Good	Good
	Dec 17 2013	Removal	Good	Fair	Excellent	Marginal	Good

- At the Outer Cove Brook below Airport station at the point of deployment, the pH sensor ranked 'excellent' while the conductivity, dissolved oxygen and turbidity sensors ranked 'good'. The temperature sensor on deployment ranked 'poor', which was due to a faulty thermometer on the QA/QC sonde used during deployment.

- At removal, conductivity on the field sonde ranked 'excellent', while temperature and turbidity ranked 'good' when compared with a freshly calibrated QA/QC sonde. The pH sensor ranked 'fair' and the dissolved oxygen sensor ranked 'marginal'. Sensor drift may have been an issue as this was a longer than normal deployment period (41 days).

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of November 6, 2013 through to December 17, 2013 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Nov 6, 2013 – Dec 17, 2013

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Nov 6 2013	Deployment	Poor	Good	Good	Good	Excellent
	Dec 17 2013	Removal	Good	Good	Marginal	Fair	Excellent

- During the Outer Cove Brook Clovelly Golf Course station deployment, the turbidity sensor ranked 'excellent' while the pH, conductivity and dissolved oxygen sensors ranked 'good' when compared to the freshly calibrated QA/QC sonde. The temperature sensor ranked 'poor', due to a faulty thermometer on the sonde used for QA/QC during deployment.

- At removal, turbidity ranked 'excellent', while temperature and pH ranked 'good'. The dissolved oxygen sensor ranked 'fair' while the conductivity sensor ranked 'marginal'. Sensor drift may have been an issue as this was a longer than normal deployment period (41 days).

- Outer Cove Brook has a large amount of algae growing and it was very hard to select a location for the sonde where the probes wouldn't be influenced by the long hair-like algae. The algae may cause issues periodically if it becomes tangled around the turbidity sensor or block the sensors on the conductivity probe.

Deployment Notes

- There were several short transmission errors during this deployment period at both stations. Transmission loss gaps generally occurred for an hour at a time.
- There was very low flow observed at Outer Cove Brook during sonde removal at the end of the deployment period. Shore fast ice was noted at both locations in the vicinity of the sondes, though they were not encased in or covered by the ice during removal.
- Significant construction work occurred at the Torbay Road North Development area in November, just downstream of the below Airport station.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from November 6, 2013 to December 17, 2013 at the Outer Cove Brook Stations.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request from Water Survey of Canada.
- Precipitation data from the deployment period was retrieved from Environment Canada's weather station at St. John's Airport and supplemented with information from 'The Weather Network' when EC data was not available.

Outer Cove Brook below Airport

Water Temperature

- Water temperature ranged from 0°C to 11.90°C during this deployment period (Figure 2).
- There are noticeable increases and decreases in the water temperature during the deployment period. This is consistent with ambient air temperatures over this time period, generally increasing during daylight hours and cooling overnight. Overall, temperature is decreasing as winter approaches.
- Water temperatures display diurnal variations, typical of shallow streams and ponds which are highly influenced by natural diurnal variations in ambient air temperatures.
- Water temperature is a very important parameter and it has the ability to influence other parameters that are measured by the water quality instrument.

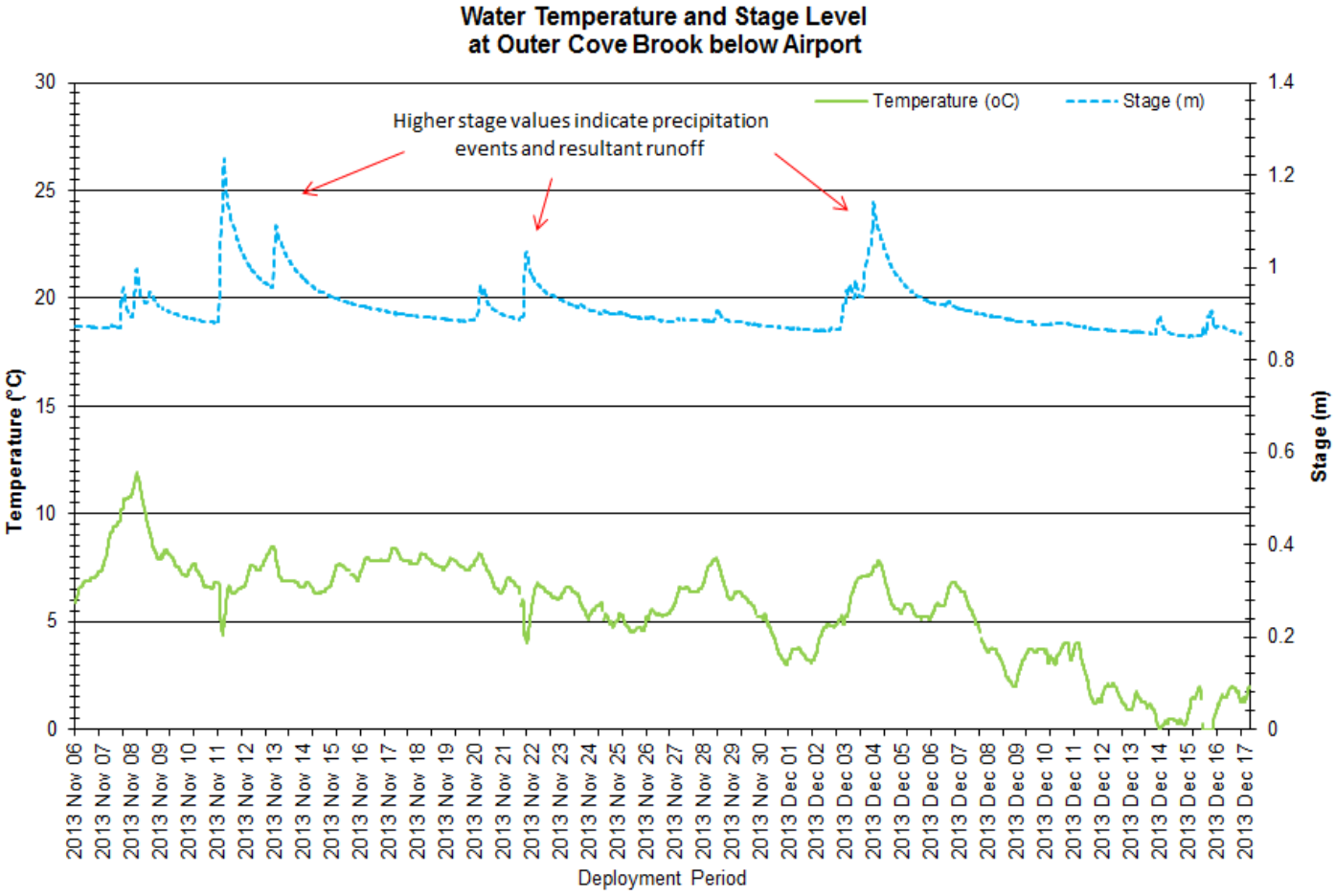


Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period November 6, 2013 to December 17, 2013.

pH

- Throughout this deployment period pH values ranged between 6.17 pH units and 7.02 pH units (Figure 3). These values are notably higher than during the previous deployment.
- During the deployment, the pH values at this station hover above the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units) for the majority of the deployment, dropping below the guideline after precipitation events such as those on November 22nd and December 4th (Figure 3). This is a natural occurrence between rainfall and pH levels.
- The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. In the case of Outer Cove Brook below Airport, pH is within the normal range for stream water in St. John's.

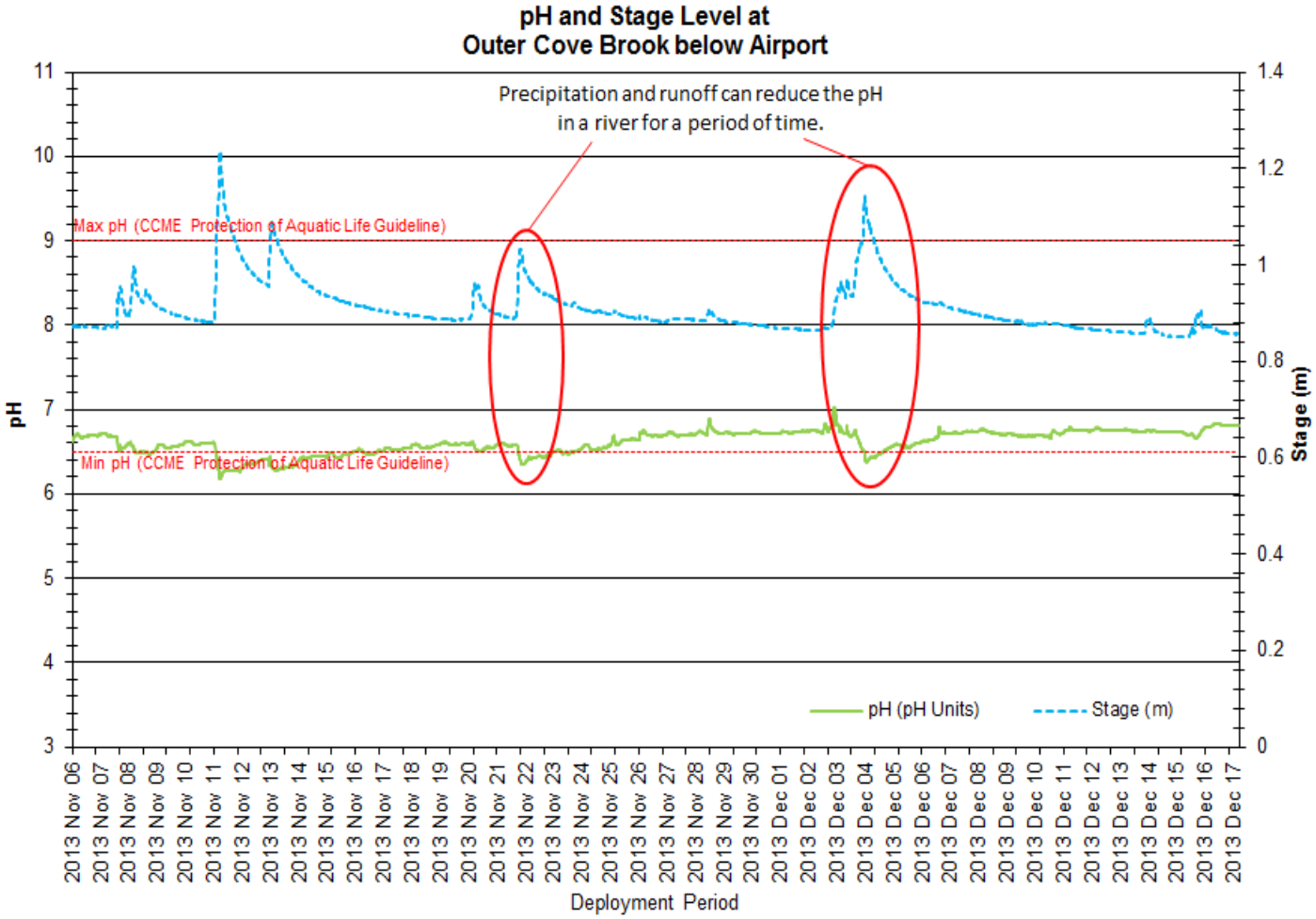


Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period November 6, 2013 to December 17, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 106.7 µS/cm and 1470.0 µS/cm during this deployment period. TDS ranged from 0.0683 g/L to 0.9410 g/L. These values are notably higher than those of the previous deployment period.
- Generally, rainfall events, such as that which occurred on November 8th and 11th (Figure 4), can have the effect of diluting and lowering conductance levels. When stage levels rise, the specific conductance levels drop in correlation as the increased amount of water in the river system dilutes the solids present there, thus generally decreasing the specific conductivity readings.
- Cold temperatures and snowfall events during winter months can have the effect of increasing conductance levels due to the addition of salt to roadways. Through wind, snowmelt and rainfall, these salts are carried into the water system, increasing the specific conductance. The increases on November 25th and December 3rd are in response to cold winter temperatures.
- Total Dissolved Solids (TDS), is a parameter that the instrument calculates by an algothrim that utilizes the data from specific conductivity and water temperature to produce a TDS value and generally always mirrors specific conductivity.

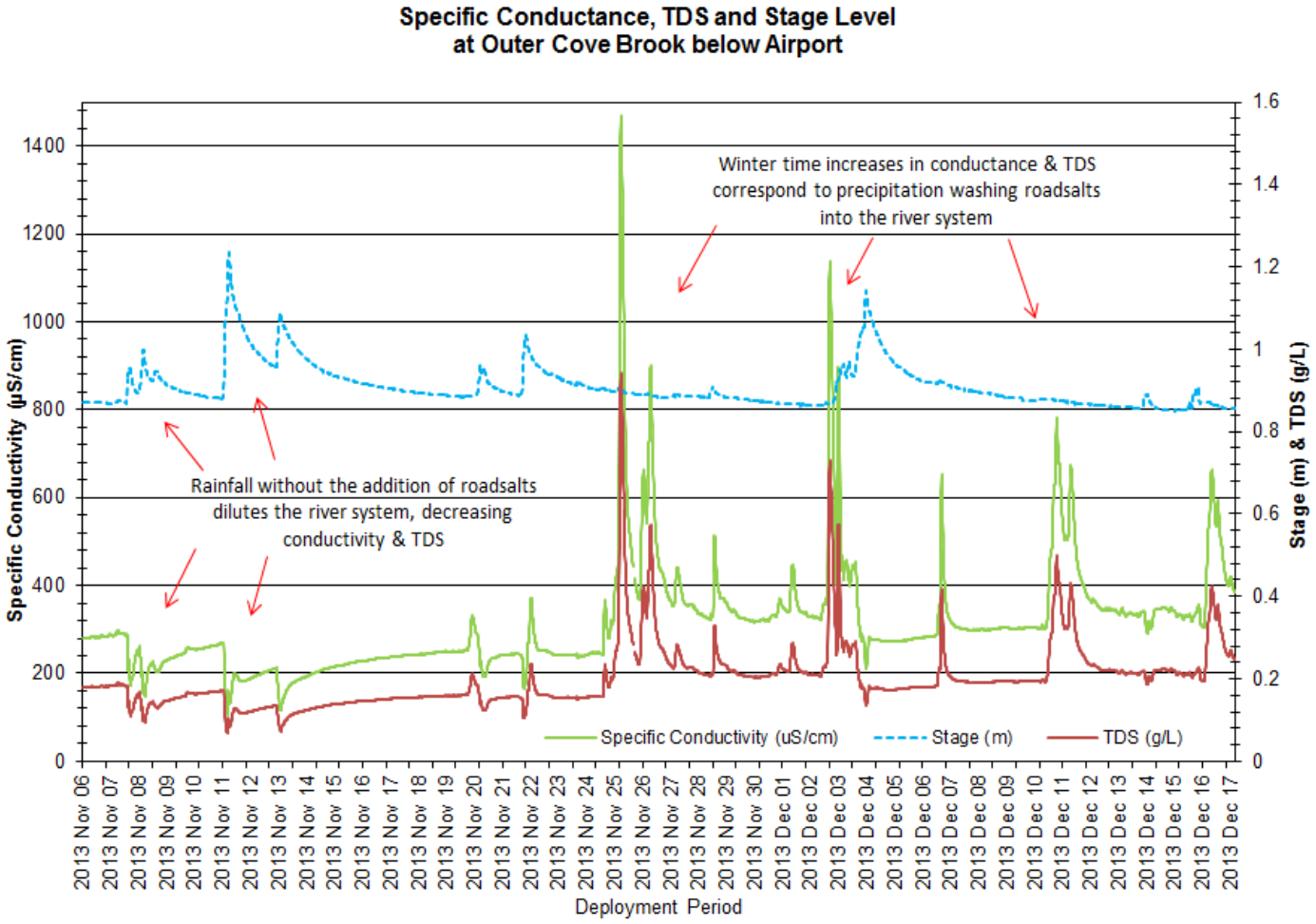


Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period November 6, 2013 to December 17, 2013.

Dissolved Oxygen

- The instrument measures dissolved oxygen (mg/L) directly then calculates percent saturation (% Sat.).
- The Dissolved Oxygen % Sat levels within this deployment period were within 80.4% Sat–91.8% Sat. Dissolved Oxygen (mg/L) measured 9.26 mg/L to 12.77 mg/L. Water temperatures were cooler during this deployment period, resulting in higher oxygen levels.
- The DO mg/L values are generally above the minimum DO CCME guideline for early life stages, dropping below the guideline when water temperatures increased on November 8th (Figure 5), and rising again when water temperatures decrease.
- Dissolved Oxygen percent saturation remains relatively constant throughout the deployment period. Dissolved oxygen mg/L content fluctuates with the water temperature changes. Small decreases in dissolved oxygen values are inversely related to increases in water temperature as warmer water can hold less oxygen.

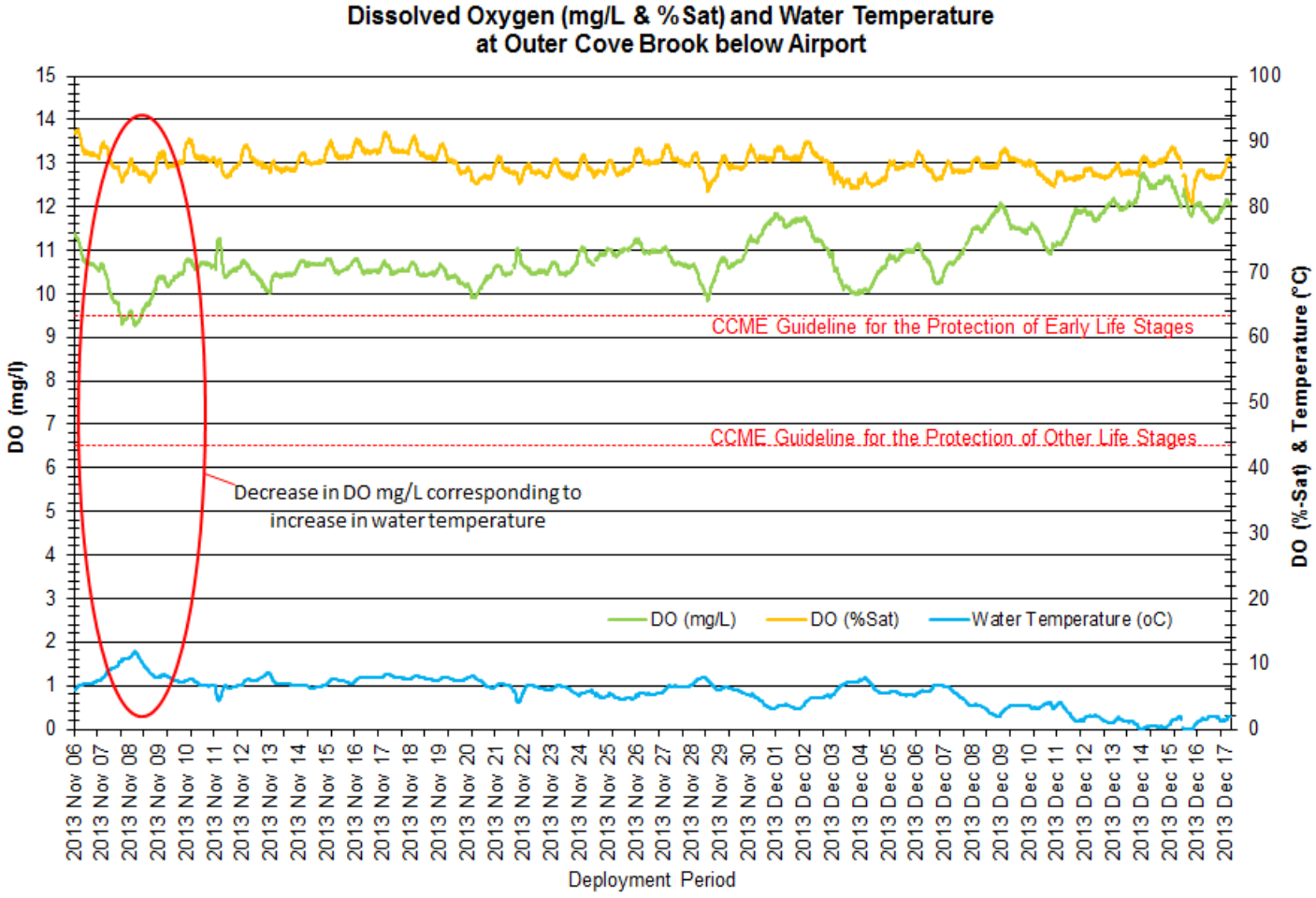


Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period November 6, 2013 to December 17, 2013.

Turbidity

- Outer Cove Brook below Airport contains a significant amount of algae. High algal growth, biofouling, or leaf and grass debris can interfere with turbidity measurements as they block the sensor.
- The turbidity sensor can read a turbidity value between 0 NTU and 3000 NTU. If a reading hits 3000NTU it is identified as an error reading and thus is not a true turbidity value.
- The turbidity readings during this deployment ranged within 0.0 NTU to 48.2 NTU (Figure 6).
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values (see Figure 6) as sediment and debris were resuspended into the water column. Sudden increases in turbidity for single readings may indicate debris is blocking the turbidity sensor.

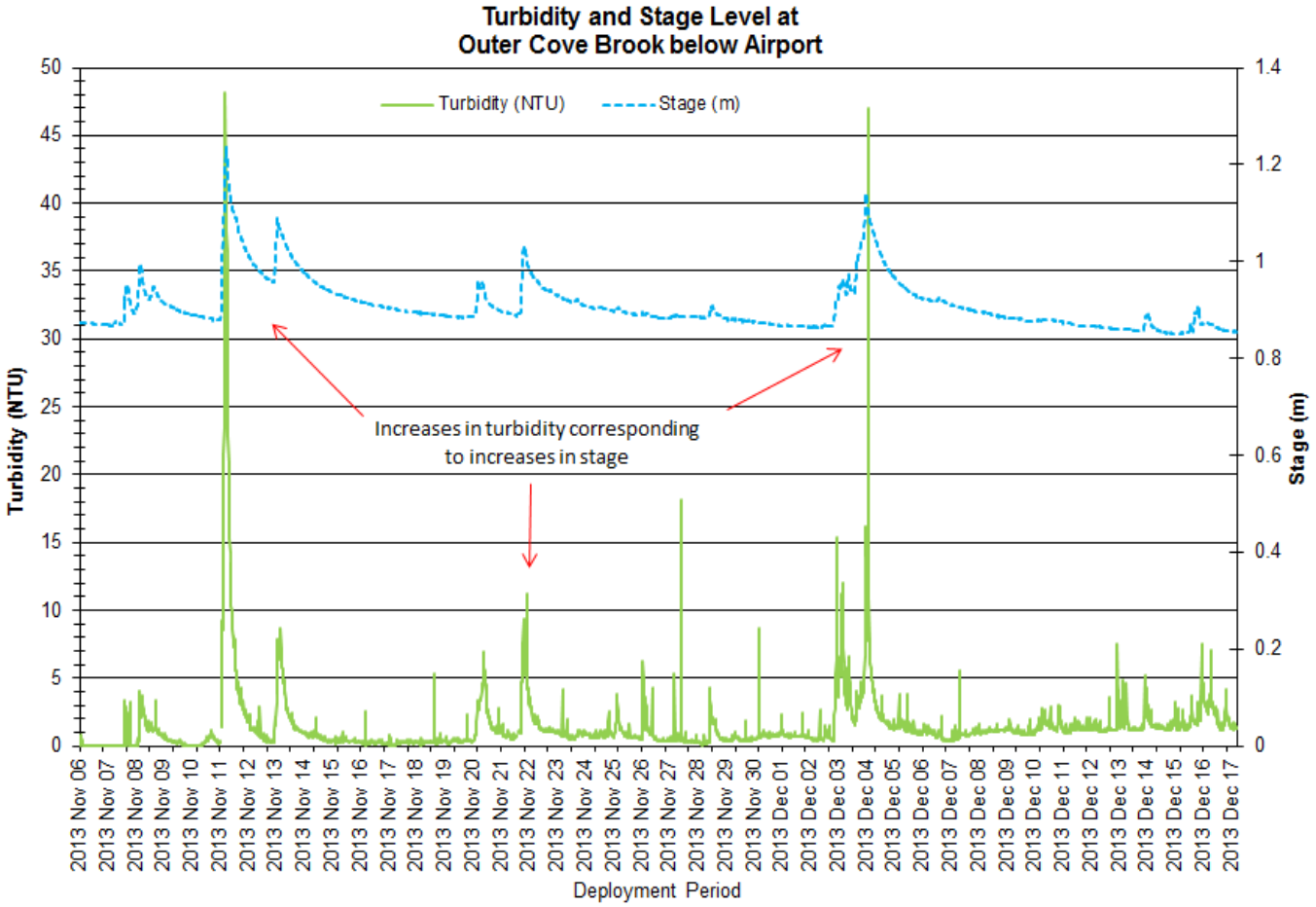


Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period November 6, 2013 to December 17, 2013.

Stage

- Stage values are based on a vertical reference that is unique to each station. As a result, absolute values of stage are not comparable between stations, but relative changes in stage are.
- Stage provides an estimation of water level at the station and can explain some of the changes that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Stage increases during precipitation events (Figure 7) due to increased runoff from the surrounding area.
- Precipitation data was obtained from Environment Canada's St. John's Airport weather station and supplemented with data from 'The Weather Network' when EC data was unavailable.
- During the deployment period, the stage ranged from 0.85m to 1.24m.

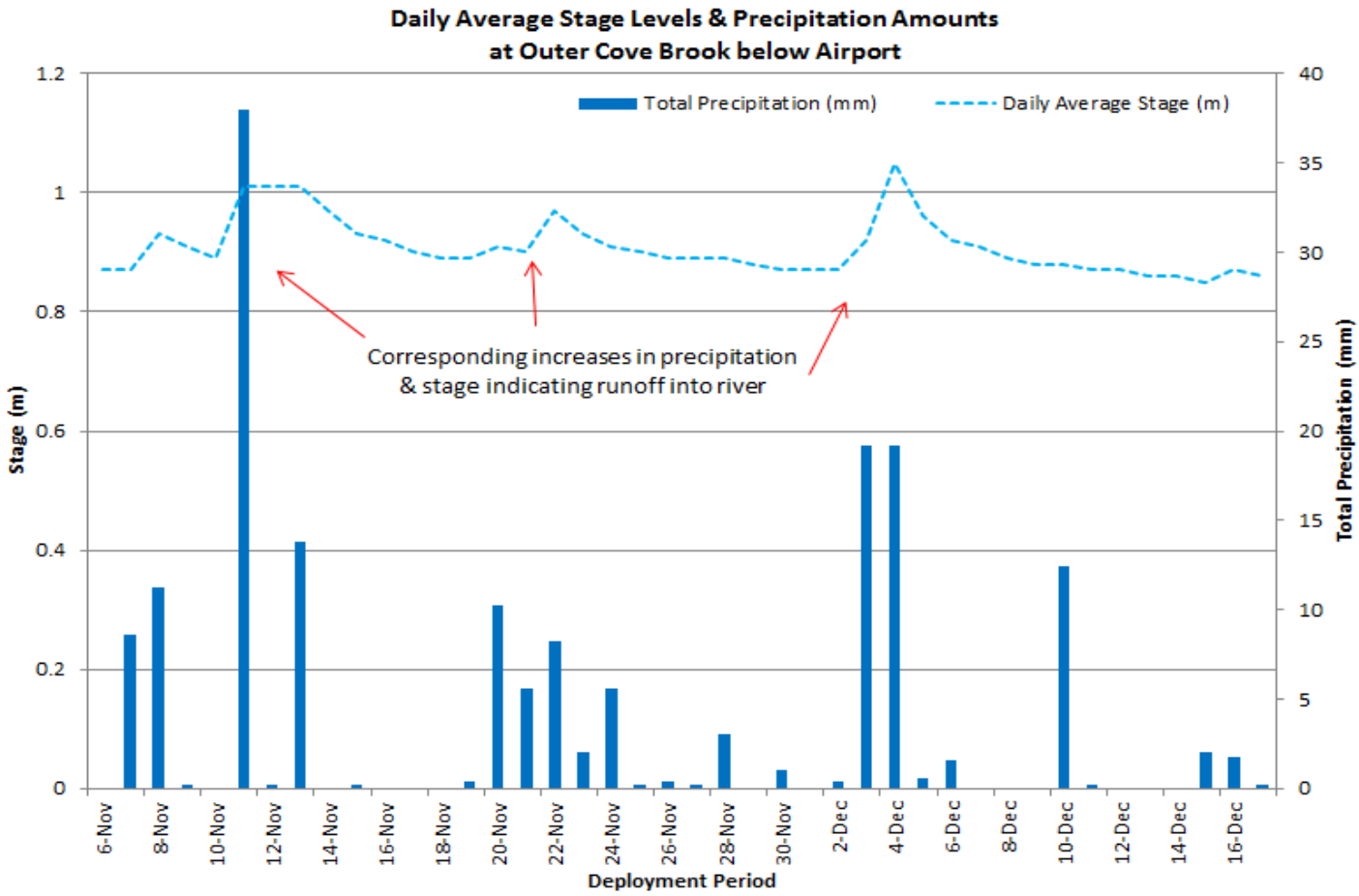


Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period November 6, 2013 to December 17, 2013.

Conclusions

- Generally in natural environments, climate and weather conditions contribute in large part to the variation in water quality parameters. During this deployment it was evident that many of the changes in the parameter data displayed on the graphs, was related to the intermittent precipitation events and small climatic changes of the seasons (i.e. temperature decreases).
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures decreased, there were correspondingly cooler water temperatures, which in turn increased the amount of dissolved oxygen in the water.
- The majority of turbidity events were correlated with increases in stage and thus precipitation events.
- The addition of road salt to roadways and runways during periods of snowfall and low ambient air temperatures led to increases in specific conductance and TDS as the salts were washed into the river system. This indicates that this river is influenced by runoff upstream of the station.
- The pH observed during this deployment is higher than normal for this waterbody. This may indicate an influence of some sort on the brook upstream of the real-time station. It should be noted that a similar increase in pH was noted during Spring of 2013 when an input into the stream led to increased ammonia and nitrate levels in the brook.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 0.0°C to 11.94°C during this deployment period (Figure 8). This is notably cooler than the previous deployment, and is normal during winter months.
- There are noticeable increases and decreases in the water temperature during the deployment period. This is consistent with ambient air temperatures over this time period, generally increasing during daylight hours and cooling overnight.
- Water temperatures display diurnal variations, typical of shallow streams and ponds which are highly influenced by natural diurnal variations in ambient air temperatures.
- Water temperature is a very important parameter and it has the ability to influence other parameters that are measured by the water quality instrument.

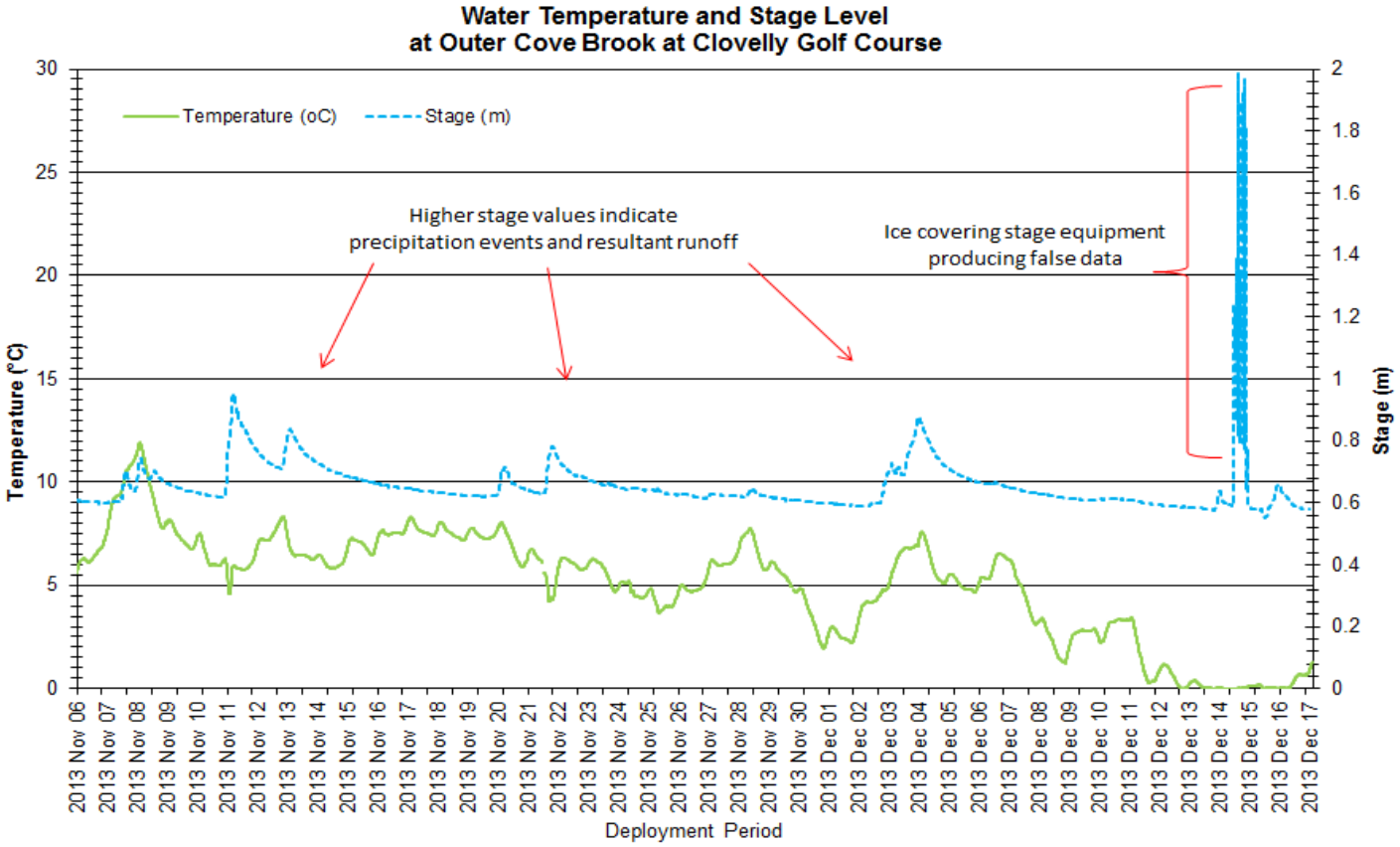


Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 6, 2013 to December 17, 2013.

pH

- Throughout this deployment period pH values ranged between 5.92 pH units and 6.51 pH units (Figure 9).
- During the deployment, the pH values at this station are below the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units) decreasing further at times due to the addition of precipitation. There are notable drops on November 11th and December 4th, related to precipitation events. This is a natural occurrence between rainfall and pH levels.
- The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. In the case of Outer Cove Brook at Clovelly Golf Course, pH is within the normal range for stream water in St. John's.

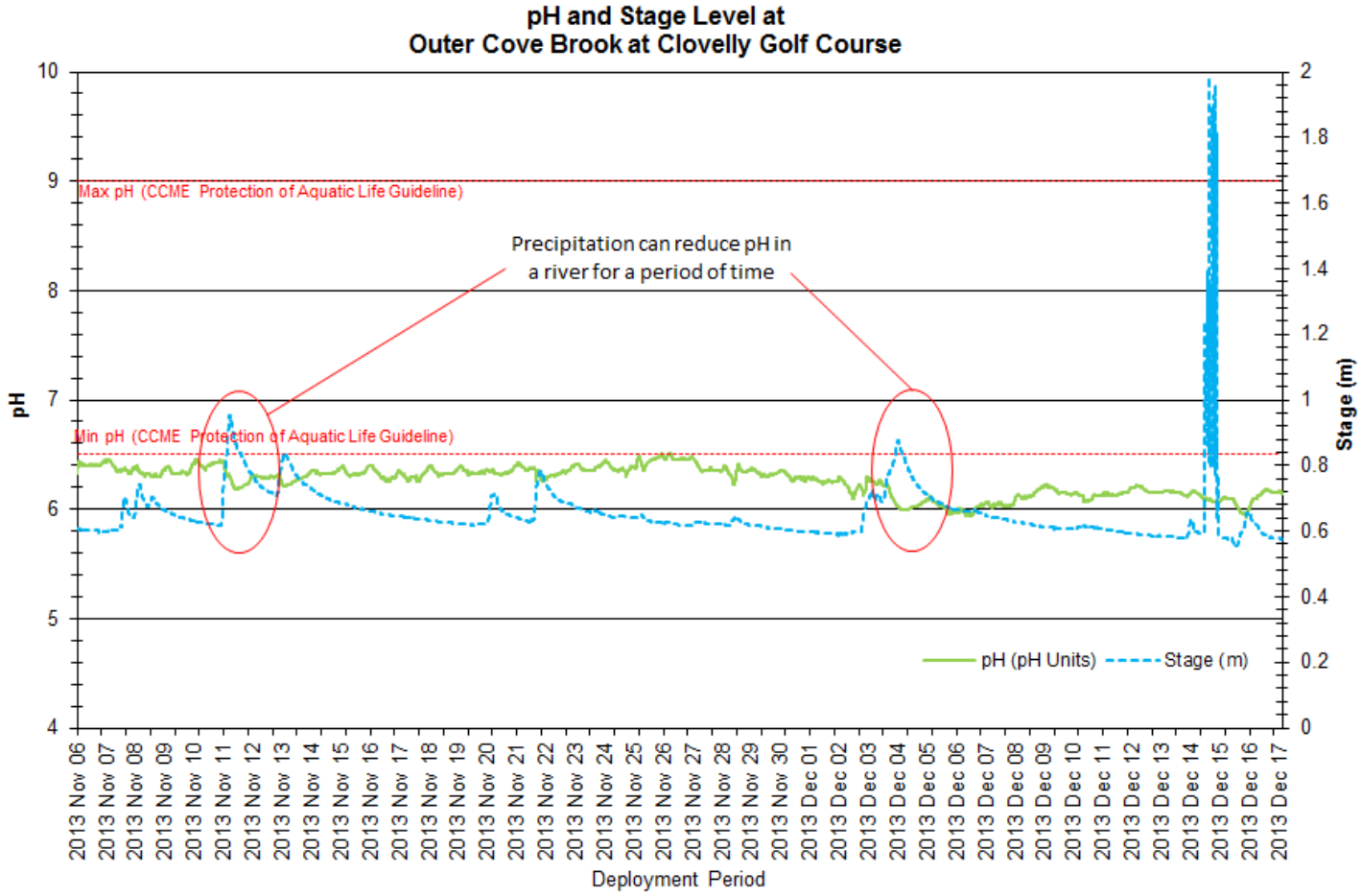


Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 6, 2013 to December 17, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 121.5 µS/cm and 2002.0 µS/cm during this deployment period. TDS ranged from 0.0778 g/L to 1.2800 g/L. This is notably higher than during the previous deployment.
- Cold temperatures and snowfall events during winter months can have the effect of increasing conductance levels due to the addition of salt to roadways. Through wind, snowmelt and rainfall, these salts are carried into the water system, increasing the specific conductance. The increases on November 25th and December 3rd are in response to winter temperatures and road salt application.
- Generally, rainfall events, such as that which occurred on November 8th and 11th (see Figure 10), can have the effect of diluting and lowering conductance levels. When stage levels rise, the specific conductance levels drop in correlation as the increased amount of water in the river system dilutes the solids present there, thus generally decreasing the specific conductivity readings.
- Total Dissolved Solids (TDS), is a parameter that the instrument calculates by an algothrim that utilizes the data from specific conductivity and water temperature to produce a TDS value and generally always mirrors specific conductivity.

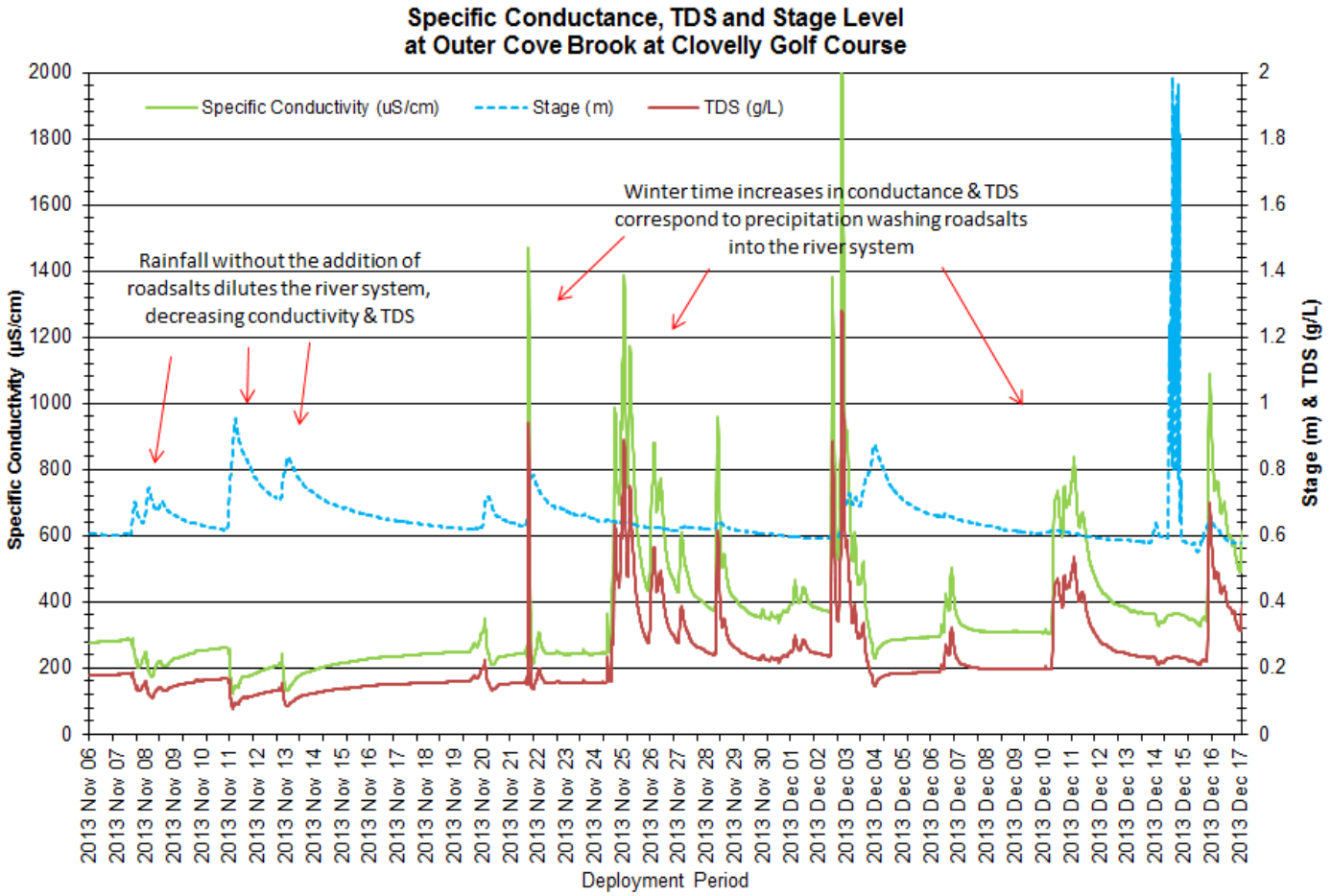


Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 6, 2013 to December 17, 2013.

Dissolved Oxygen

- The instrument measures dissolved oxygen (mg/L) then calculates percent saturation (% Sat).
- The Dissolved Oxygen % Sat levels within this deployment period were within 71.6% Sat–90.0% Sat. Dissolved Oxygen (mg/L) measured 8.31 mg/L to 12.35 mg/L. Water temperatures were cooler during this deployment period, resulting in higher oxygen levels.
- The DO mg/L values dip below the minimum DO CCME guideline for early life stages during warm periods during the deployment. Warm water temperatures November 8th and 28th led to lower oxygen (mg/L) levels in the water at this time (Figure 11).
- Dissolved Oxygen percent saturation remains relatively constant throughout the deployment period, with diurnal fluctuations. Dissolved oxygen mg/L content fluctuates with the water temperature changes. Decreases in dissolved oxygen values are inversely related to increases in water temperature as warmer water can hold less oxygen.

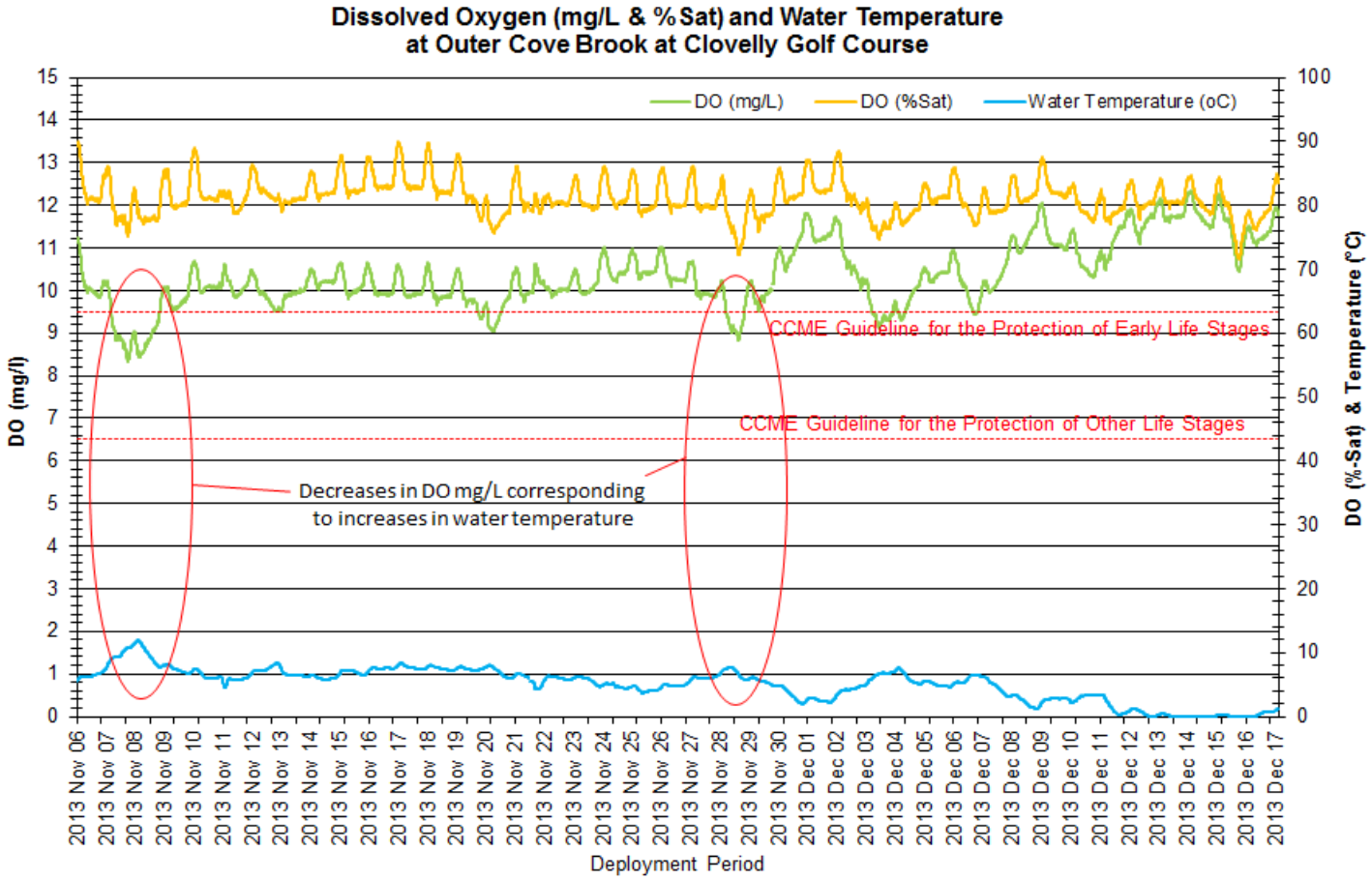


Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 6, 2013 to December 17, 2013.

Turbidity

- Outer Cove Brook contains a significant amount of algae. High algal growth in the summer or leaf debris during all seasons can interfere with turbidity measurements as they block the sensor.
- The turbidity sensor can read turbidity values between 0 NTU and 3000 NTU. If a turbidity reading hits 3000NTU it is always identified as an error reading and thus is not a valid turbidity reading.
- The turbidity readings during this deployment ranged within 1.0 NTU to 141.4 NTU (Figure 12). Fluctuations in turbidity values were correlated with increases in stage and thus precipitation events. Biofouling does not appear to have been an issue during this deployment, even though the sonde was coated in fine organic material during removal.
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values as sediment and debris were resuspended into the water column.

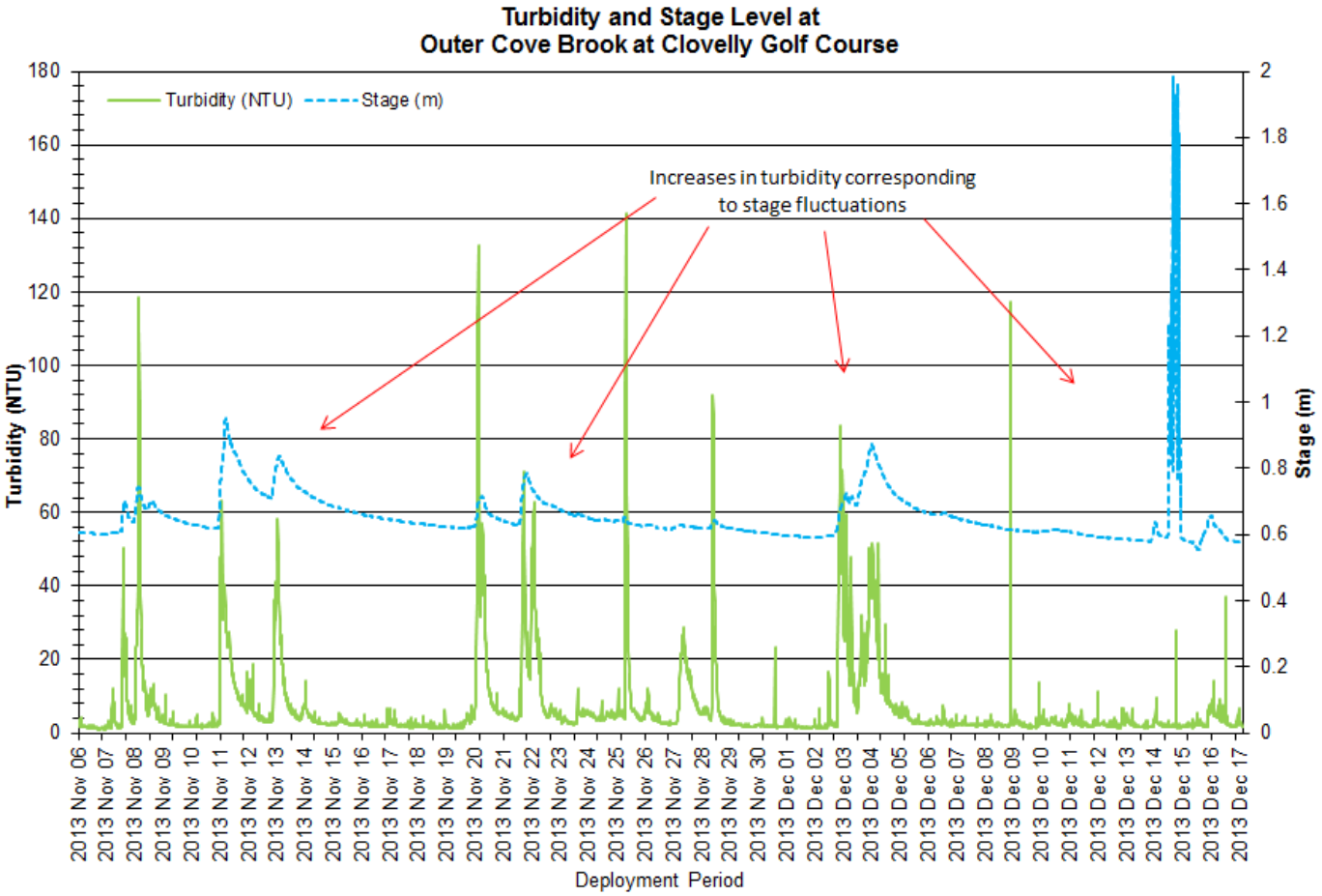


Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period November 6, 2013 to December 17, 2013.

Stage

- Stage values are based on a vertical reference that is unique to each station. As a result, absolute values of stage are not comparable between stations, but relative changes in stage are.
- Stage 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 increases during precipitation events due to increased runoff from the surrounding area (see Figure 13).
- Precipitation data was obtained from Environment Canada's St. John's Airport weather station and supplemented with data from 'The Weather Network' when EC data was unavailable.
- During the deployment period, the stage values ranged from 0.55m to 1.99m. However, the maximum value is inaccurate as this value was recorded due to interference from ice covering the equipment in the river on December 15th.

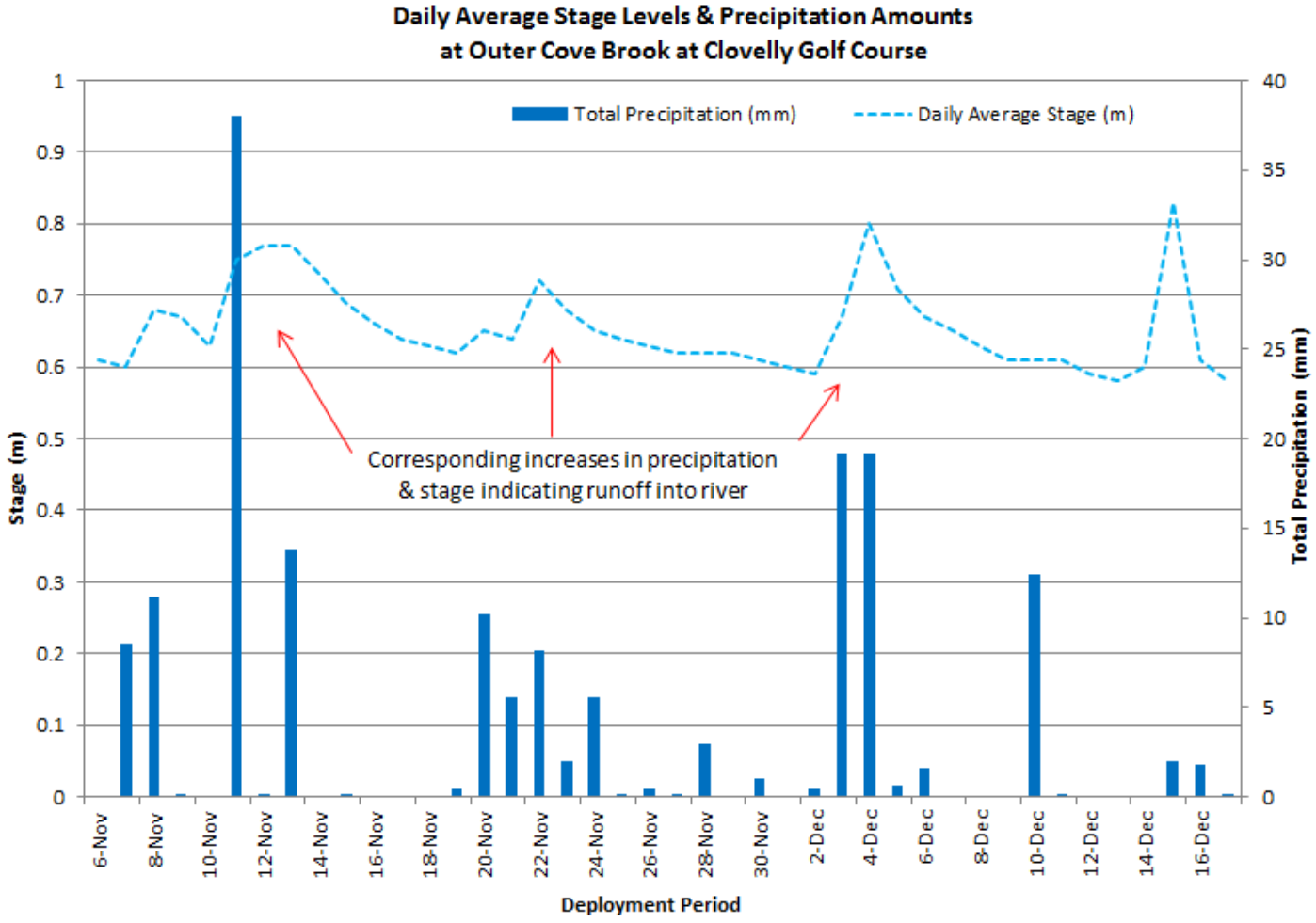


Figure 13: Daily average stage values (m) at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period November 6, 2013 to December 17, 2013.

Conclusions – Outer Cove Brook at Clovelly Golf Course

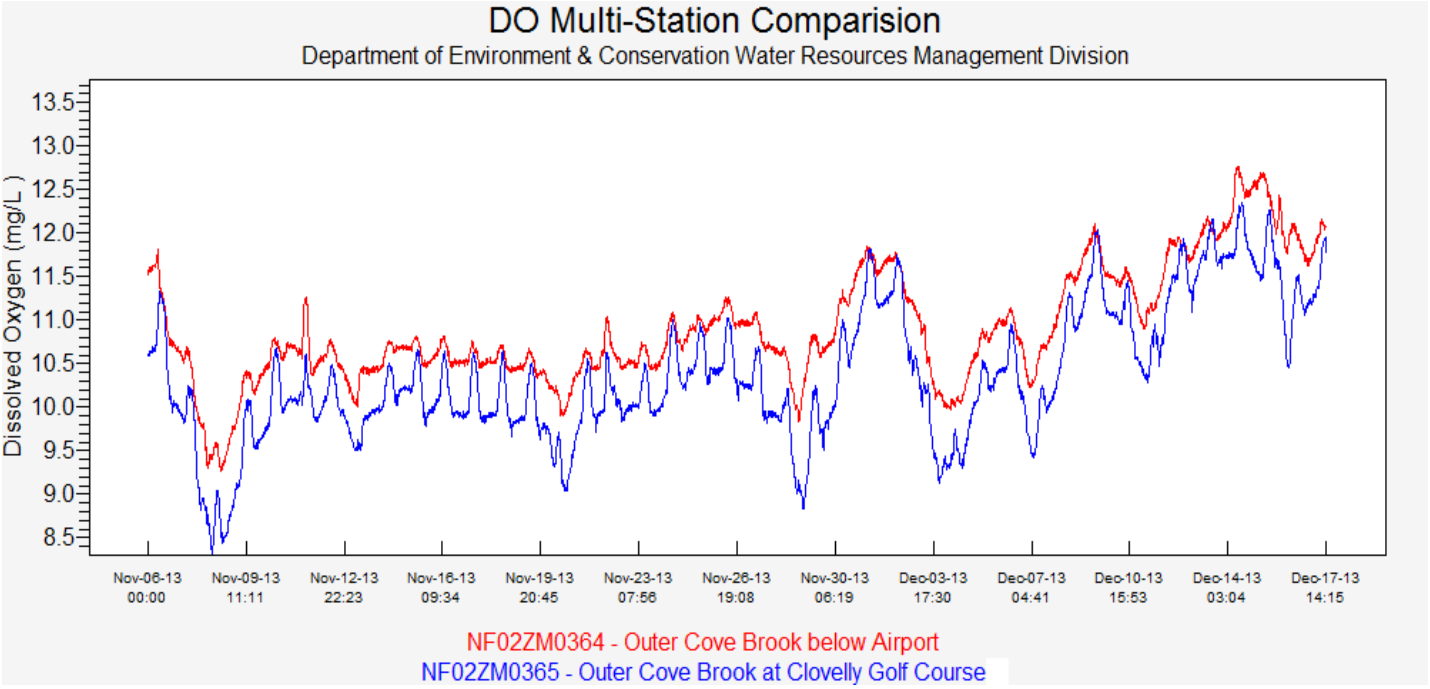
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures decreased, there were correspondingly cooler water temperatures, which in turn increased the amount of dissolved oxygen in the water.
- Dissolved oxygen values at this site fluctuate diurnally, increasing values during the day and decreasing values into the night, indicating a relationship between the oxygen levels and sunlight.
- Specific conductivity and TDS are notably higher at this station than at the below airport station. Numerous increases in these parameters during deployment indicate the addition of salts to the roadways upstream of this station. Increases did occur at the below airport station but were smaller in magnitude, indicating possible inputs having occurred between the two stations.
- Generally, dissolved oxygen, pH and water temperatures are lower while turbidity, conductivity and TDS values are higher at this station than at the below airport station.

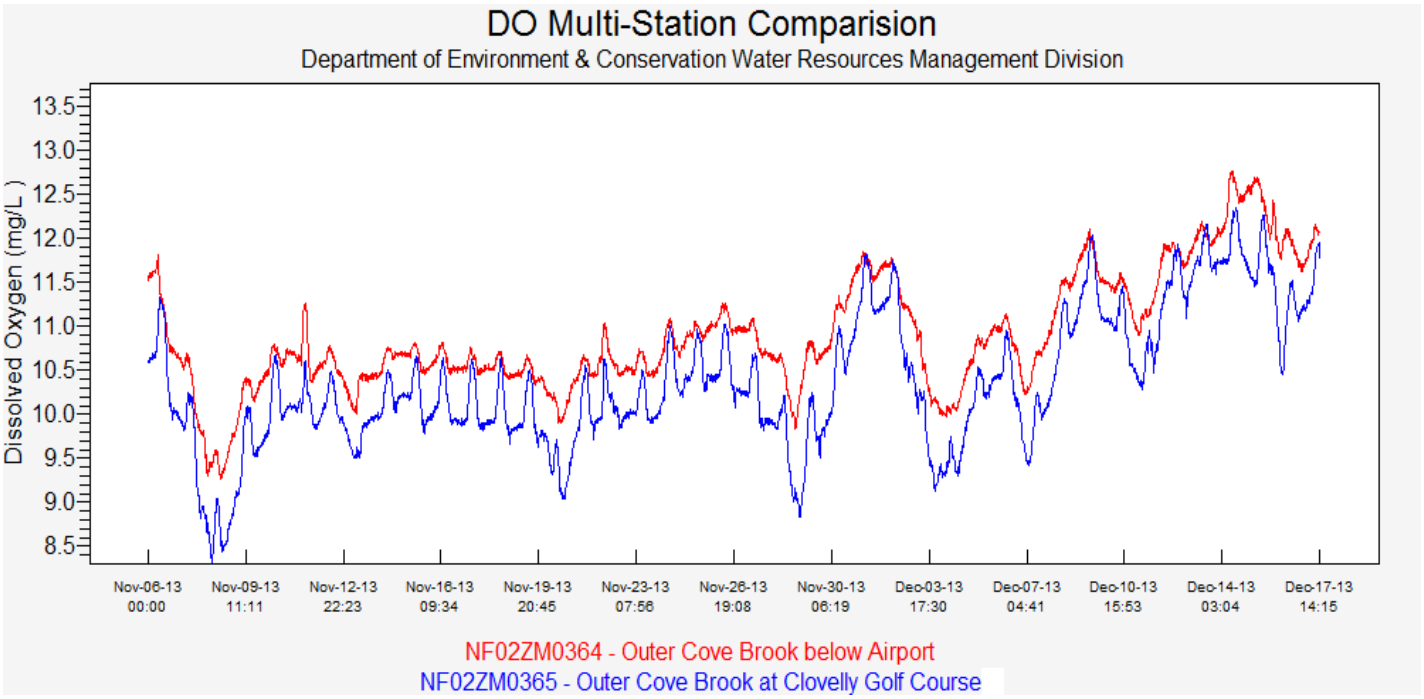
Conclusions – Outer Cove Brook Network

During this deployment period, the median water temperature at the upstream station (below Airport) of 6.30°C was slightly higher than that of the downstream station (at Clovelly Golf Course) of 5.81°C. The median pH value of 6.63 below the Airport is higher than the Clovelly station median of 6.30. This values are higher than those of the previous deployment. The specific conductivity medians were similar at both stations with 287 uS/cm reported below the airport and 295 uS/cm reported at the golf course. Dissolved oxygen at the upstream station (below Airport) had a median of 86.4%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 80.9%Sat. The lower oxygen levels at the downstream Clovelly station occur at night, indicating an interaction with the prolific aquatic grass growth which cannot synthesize oxygen and replenish the dissolved oxygen in the water at night. The median turbidity value below the airport was 0.9 NTU while at Clovelly Golf Course the median was 2.8 NTU. Turbidity spikes related to stage increases reach a higher magnitude at the Clovelly station.

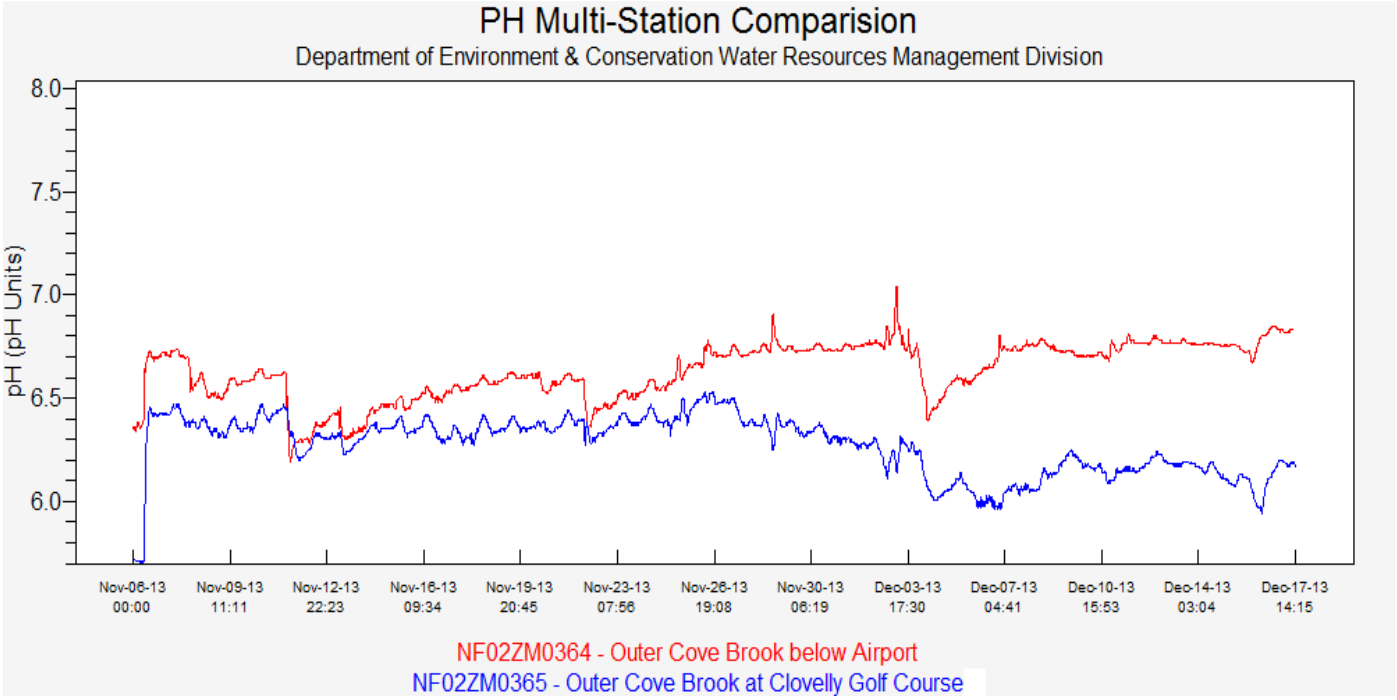
Appendix

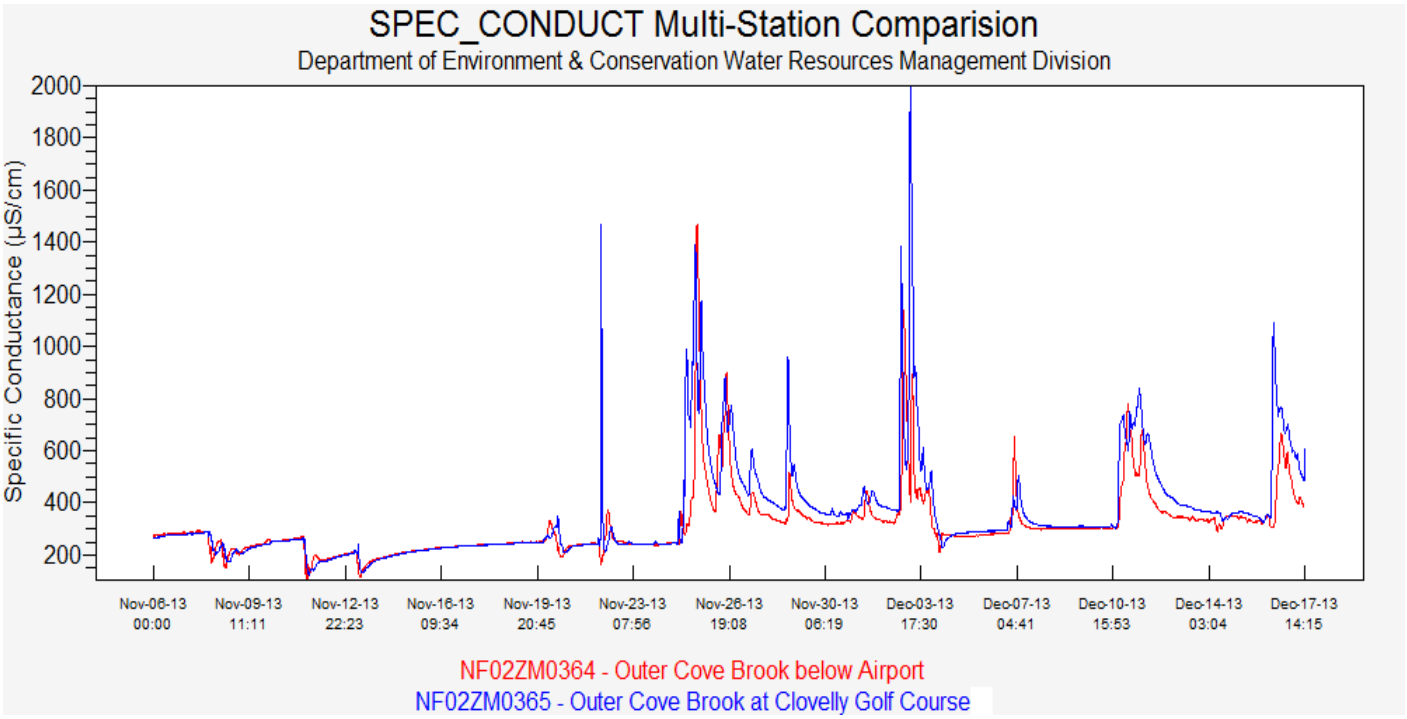
Parameter Station Comparison Graphs



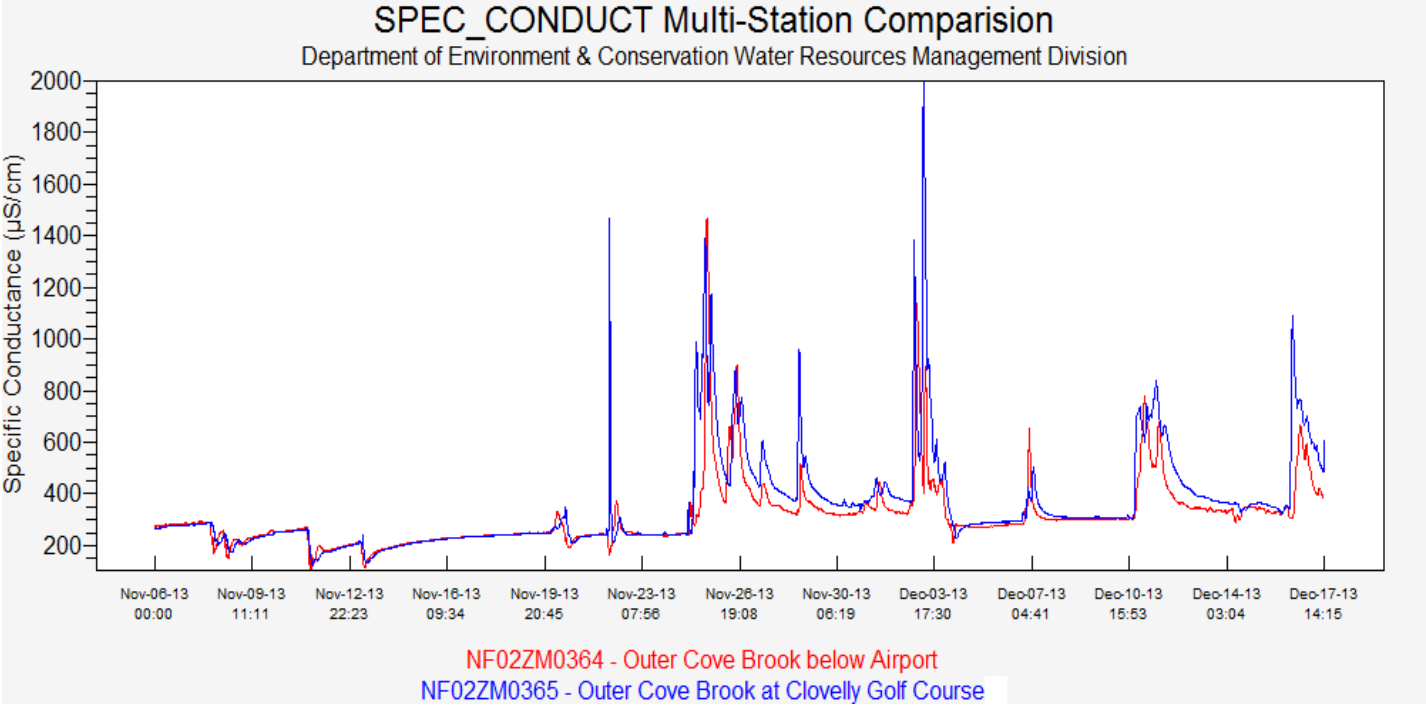


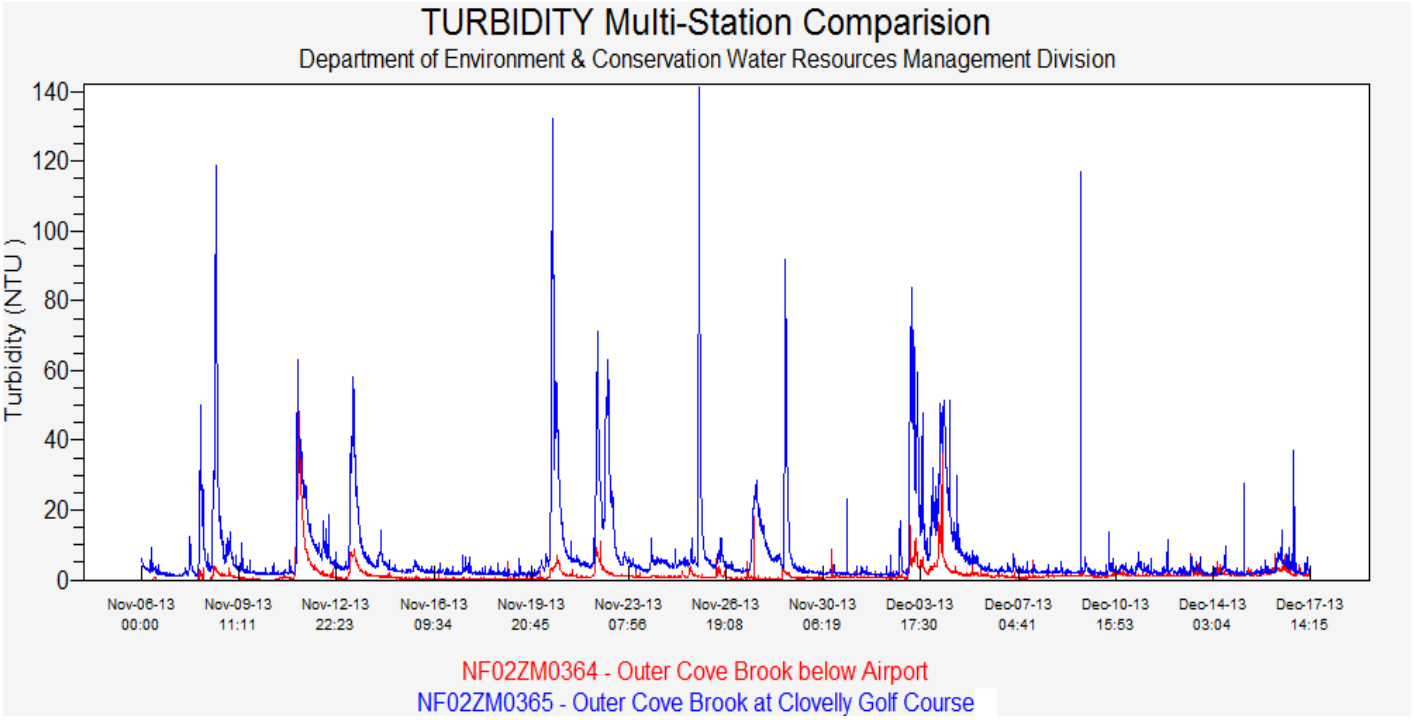
Outer Cove Brook, Newfoundland and Labrador





Outer Cove Brook, Newfoundland and Labrador





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