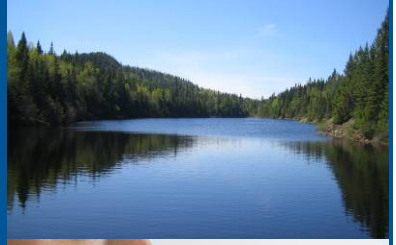







Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
September 4 to October 8, 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 34-day period from deployment on September 4, 2013 until removal on October 8, 2013.

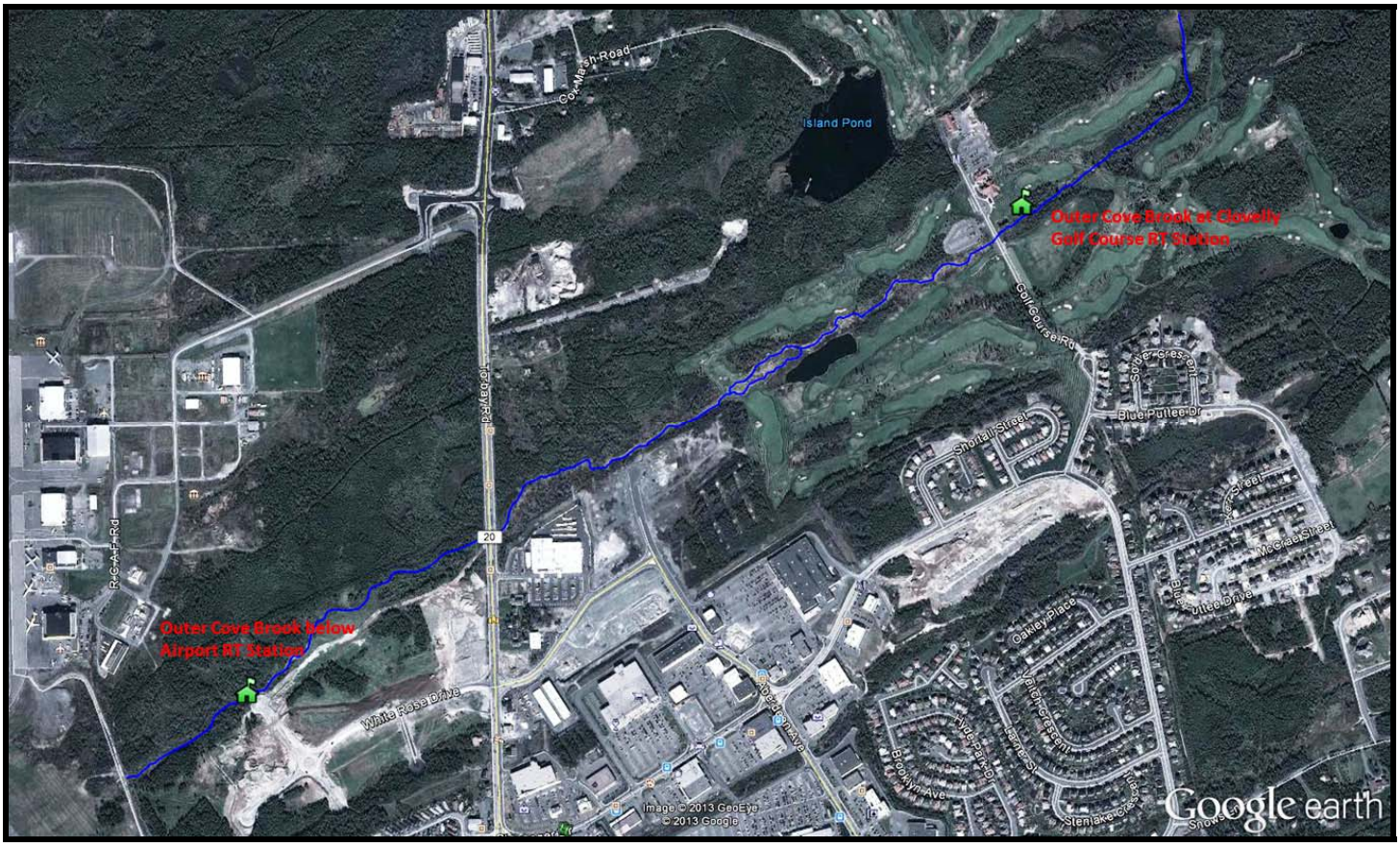


Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 September 4, 2013 through to October 8, 2013 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Sept. 4, 2013 – Oct. 8, 2013

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	Sept 4 2013	Deployment	Good	Excellent	Excellent	Excellent	Excellent
	Oct 8 2013	Removal	Good	Excellent	Excellent	Excellent	Fair

- At the Outer Cove Brook below Airport station at the point of deployment, the dissolved oxygen, conductivity and pH and turbidity sensors ranked 'excellent' while the temperature sensor ranked 'good'.

- At removal, pH, conductivity and dissolved oxygen on the field sonde ranked 'excellent', while temperature ranked 'good' when compared with a freshly calibrated QA/QC sonde. The turbidity sensor ranked 'fair' as the field sonde was reading values slightly higher than the QA/QC sonde, likely due to sensor drift as the values did increase steadily during the last few days of deployment.

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of September 4, 2013 through to October 8, 2013 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Sept. 4, 2013 – Oct. 8, 2013

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Sept 4 2013	Deployment	Excellent	Excellent	Excellent	Good	Excellent
	Oct 8 2013	Removal	Excellent	Excellent	Excellent	Good	Good

- During the Outer Cove Brook Clovelly Golf Course station deployment, temperature, pH, conductivity, and turbidity sensors ranked 'excellent' when compared to the freshly calibrated QA/QC sonde, while the the dissolved oxygen sensor ranked 'good'.

- At removal, temperature, pH and conductivity ranked 'excellent', while dissolved oxygen and turbidity ranked 'good'.

- 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 the below airport station, but none occurred at the Clovelly Golf Course station.
- The river's substrate and surrounding vegetation at the below Airport station no longer appeared red colored, 'slimy', or 'scaly', likely the result of the large amount of flushing the river experienced during this deployment due to numerous precipitation events. The substrate appeared normal, and the water was very clear.
- Significant construction work occurred at the Torbay Road North Development area in September, just downstream of the below Airport station.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from September 4 to October 8, 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 9.20°C to 17.90°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.
- 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.

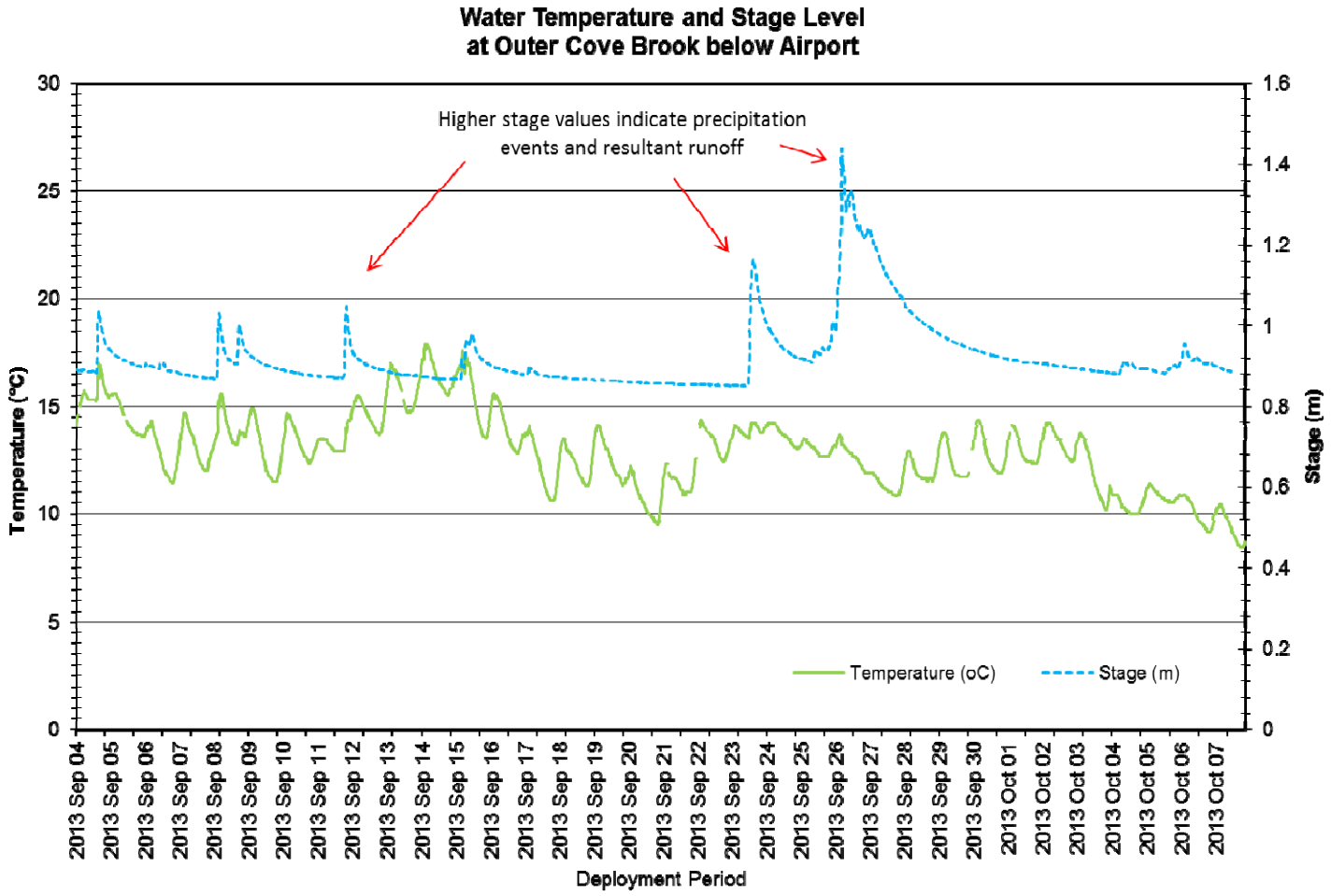


Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period September 4, 2013 to October 8, 2013.

pH

- Throughout this deployment period pH values ranged between 5.87 pH units and 6.51 pH units (Figure 3).
- During the deployment, the pH values at this station hover near the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units), dropping below the guideline after precipitation events such as those on September 24th and 27th (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.

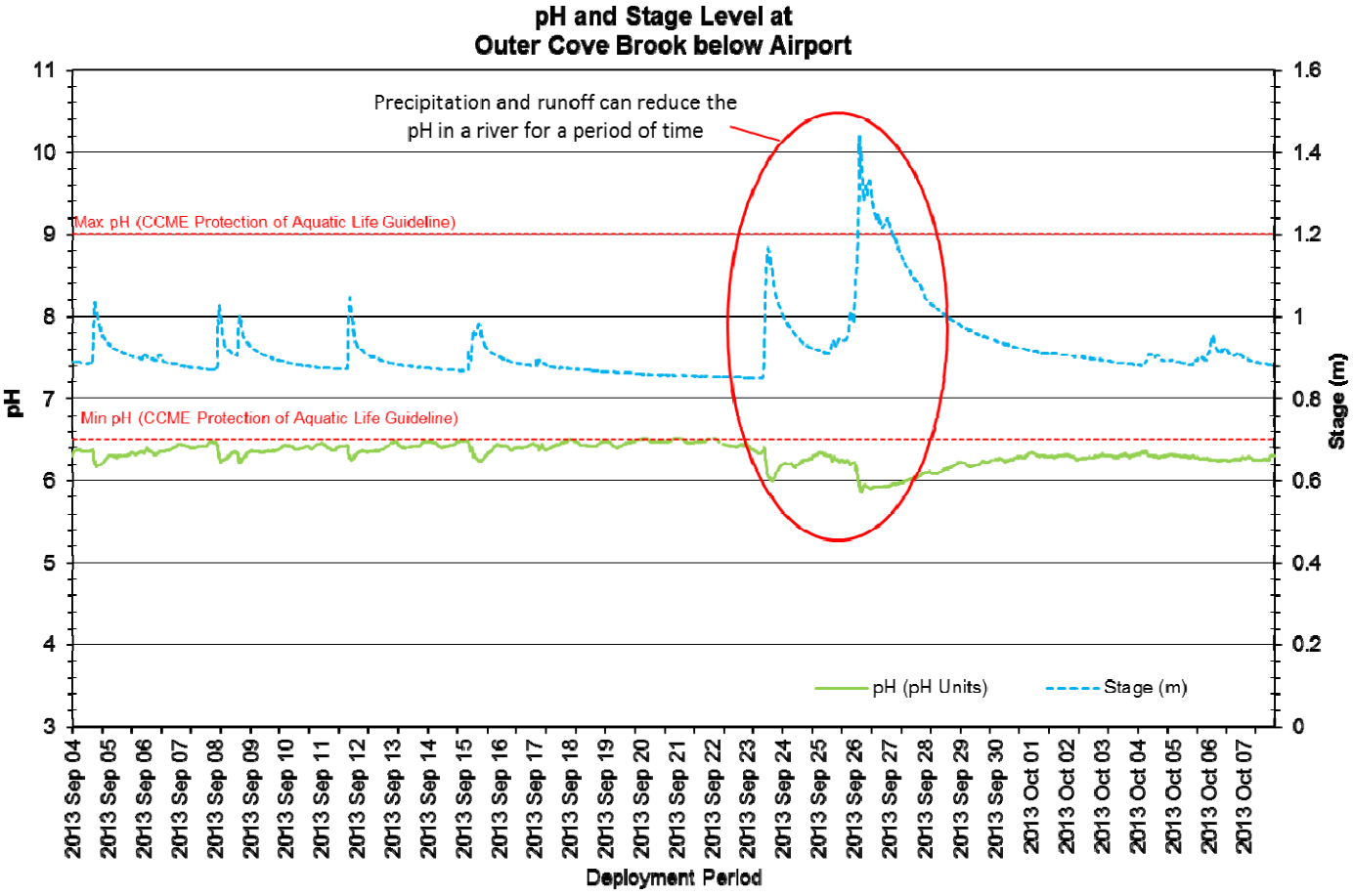


Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period September 4, 2013 to October 8, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 59.6 µS/cm and 412.0 µS/cm during this deployment period. TDS ranged from 0.0381 g/L to 0.2640 g/L.
- Generally, rainfall events, such as that which occurred on September 24th and 27th (see 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.
- 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.

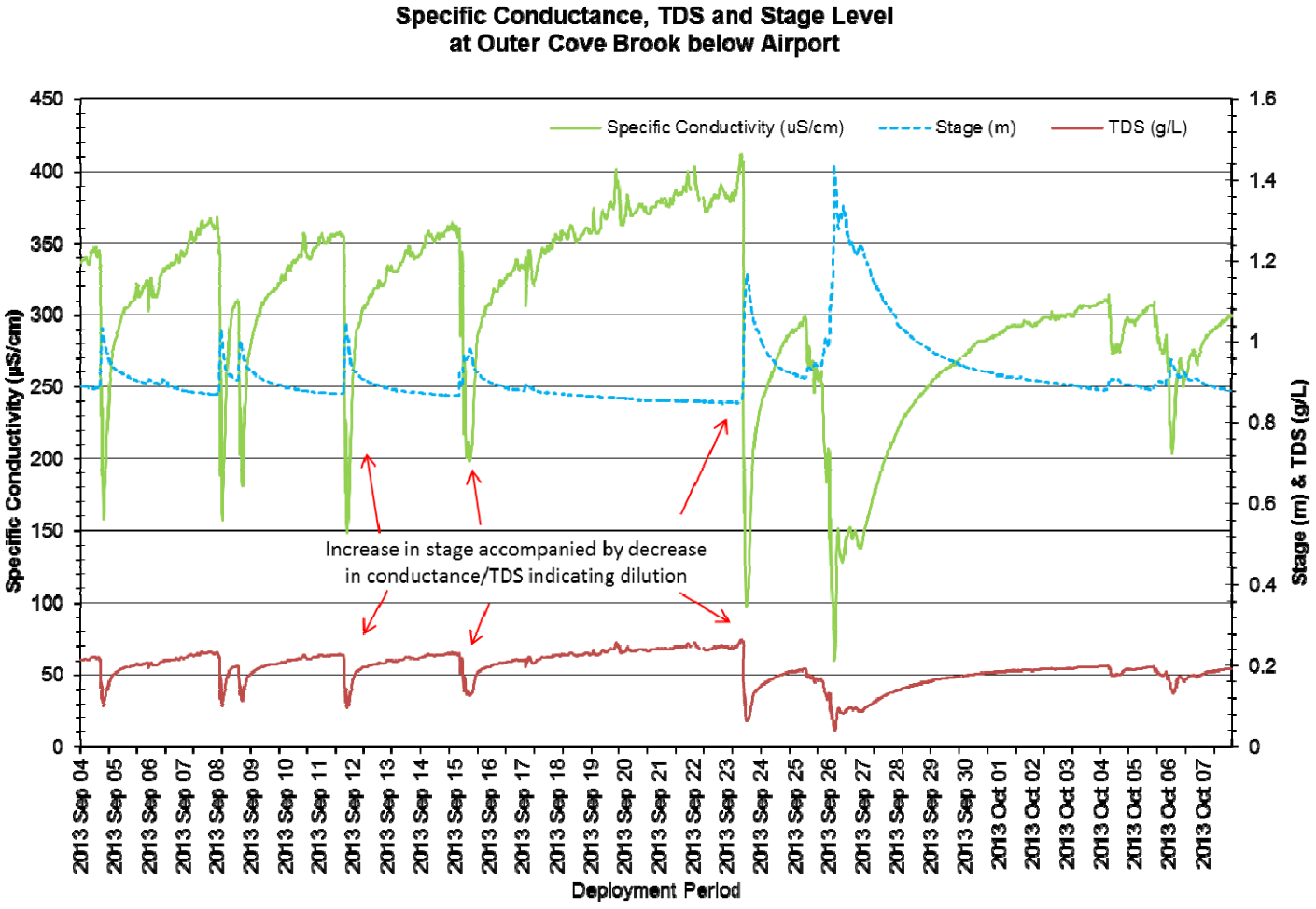


Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period September 4, 2013 to October 8, 2013.

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 84.0% Sat–93.5% Sat. Dissolved Oxygen (mg/L) measured 8.07 mg/L to 10.54 mg/L.
- The DO mg/L values hover around the minimum DO CCME guideline for early life stages, dropping below the guideline when water temperatures increase, and rising again when water temperatures decrease, such as on October 4th (Figure 5). All values are above the CCME guideline for the protection of other life stages.
- 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.

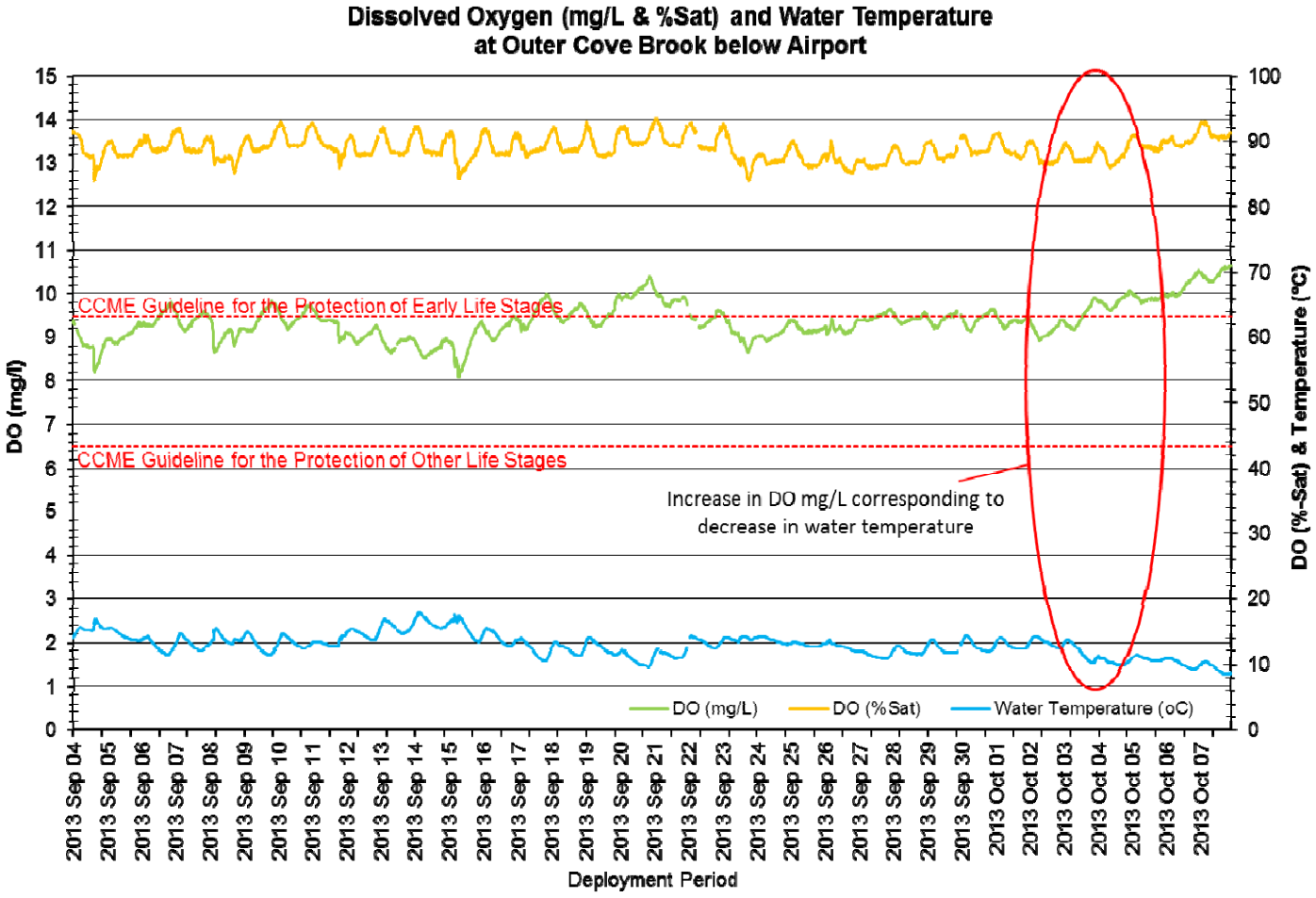


Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period September 4, 2013 to October 8, 2013.

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 256.7 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.

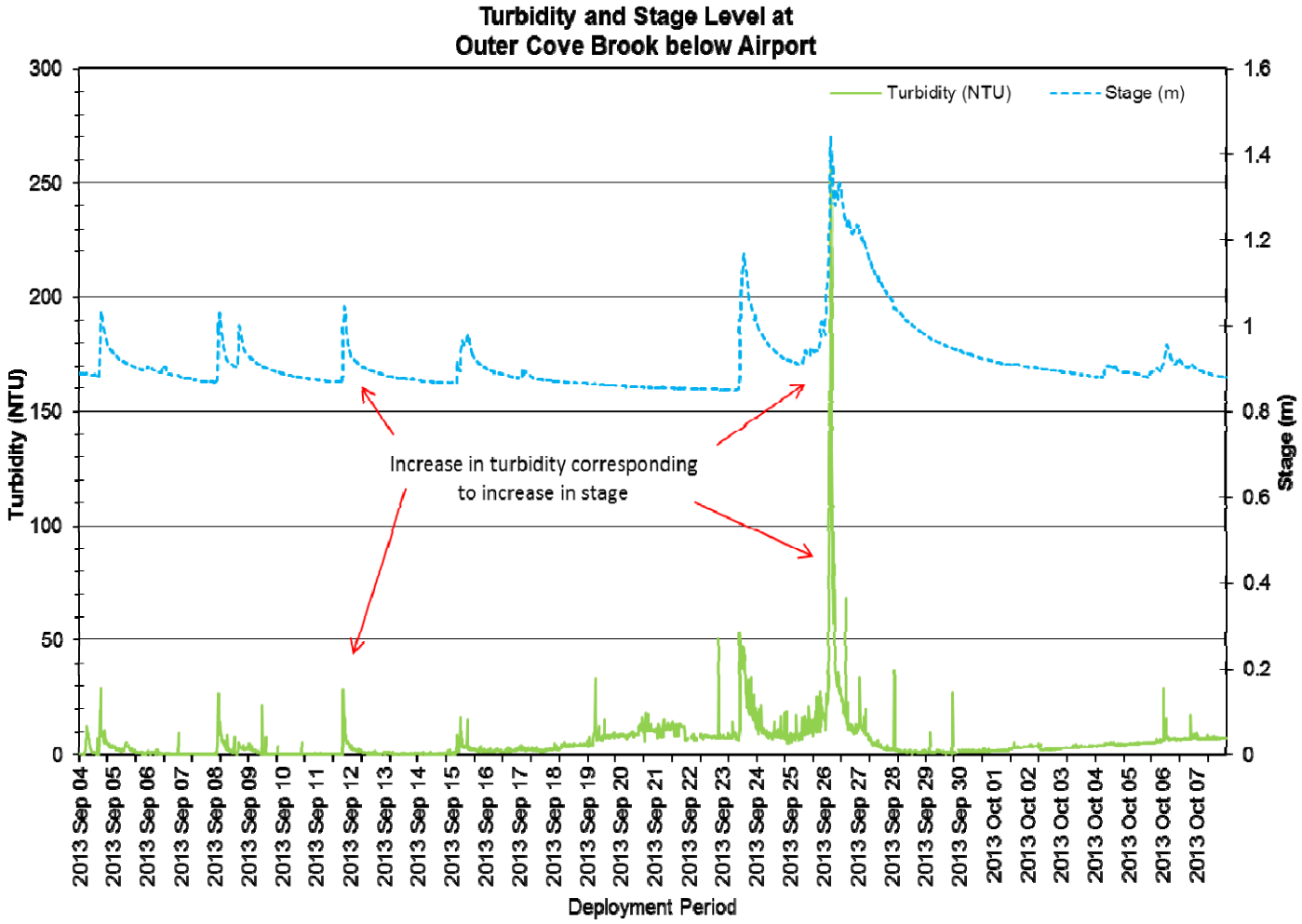


Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period September 4, 2013 to October 8, 2013.

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 1.44m, with the maximum level being reached after a significant rainfall event of 132.2mm over 5 days.

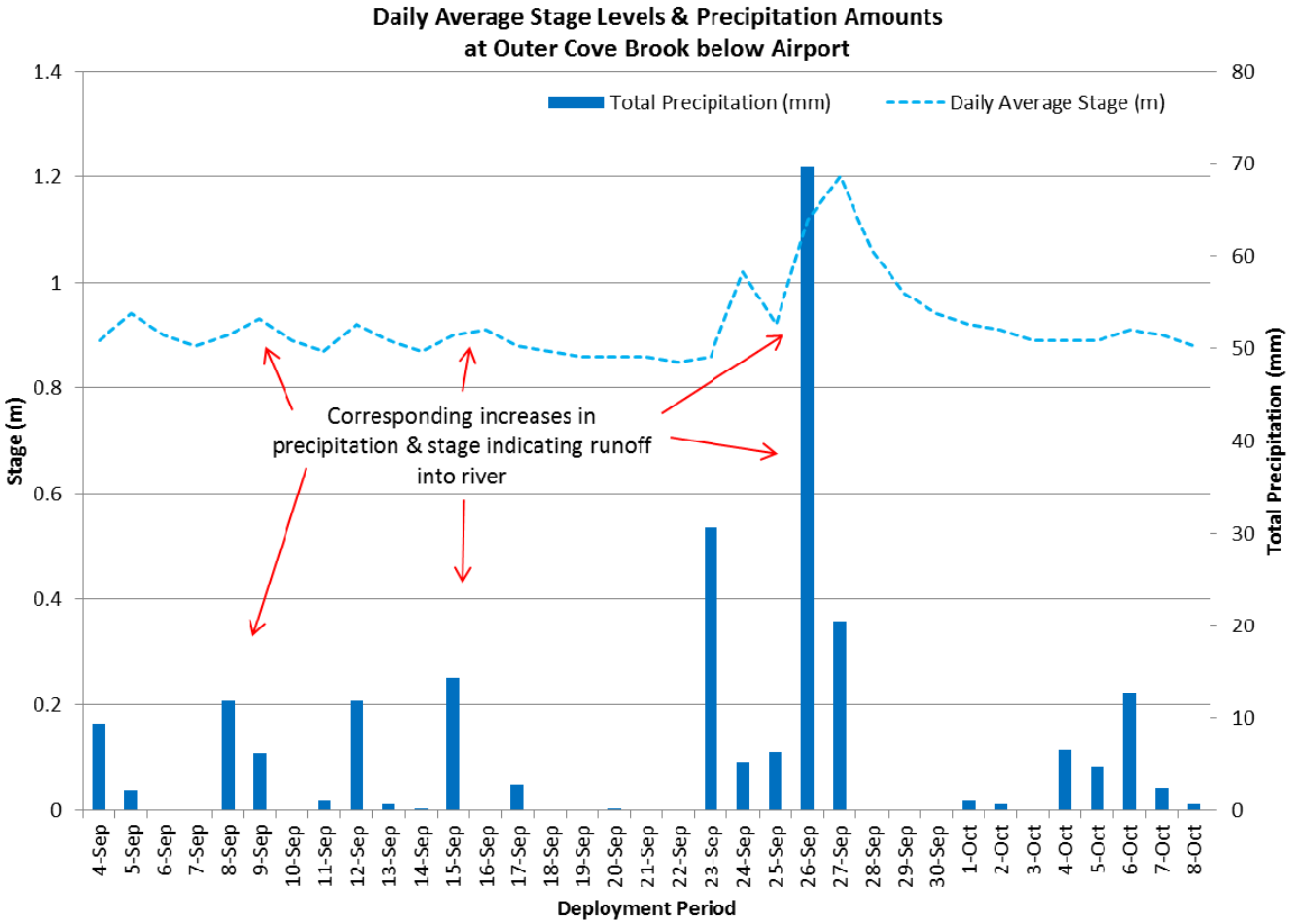


Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period September 4, 2013 to October 8, 2013.

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 increases).
- 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 turbidity sensor began to drift October 3rd. This may be due to a loss of calibration of the sensor due to the large influx of freshwater, or due to biofouling as there is a large amount of leaf debris and grass in the river during the fall season.
- There do not appear to be any issues with conductivity, TDS, dissolved oxygen or pH at this station during this deployment period.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 7.99°C to 18.84°C during this deployment period (Figure 8). This minimum is notably cooler than the previous deployment.
- 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.

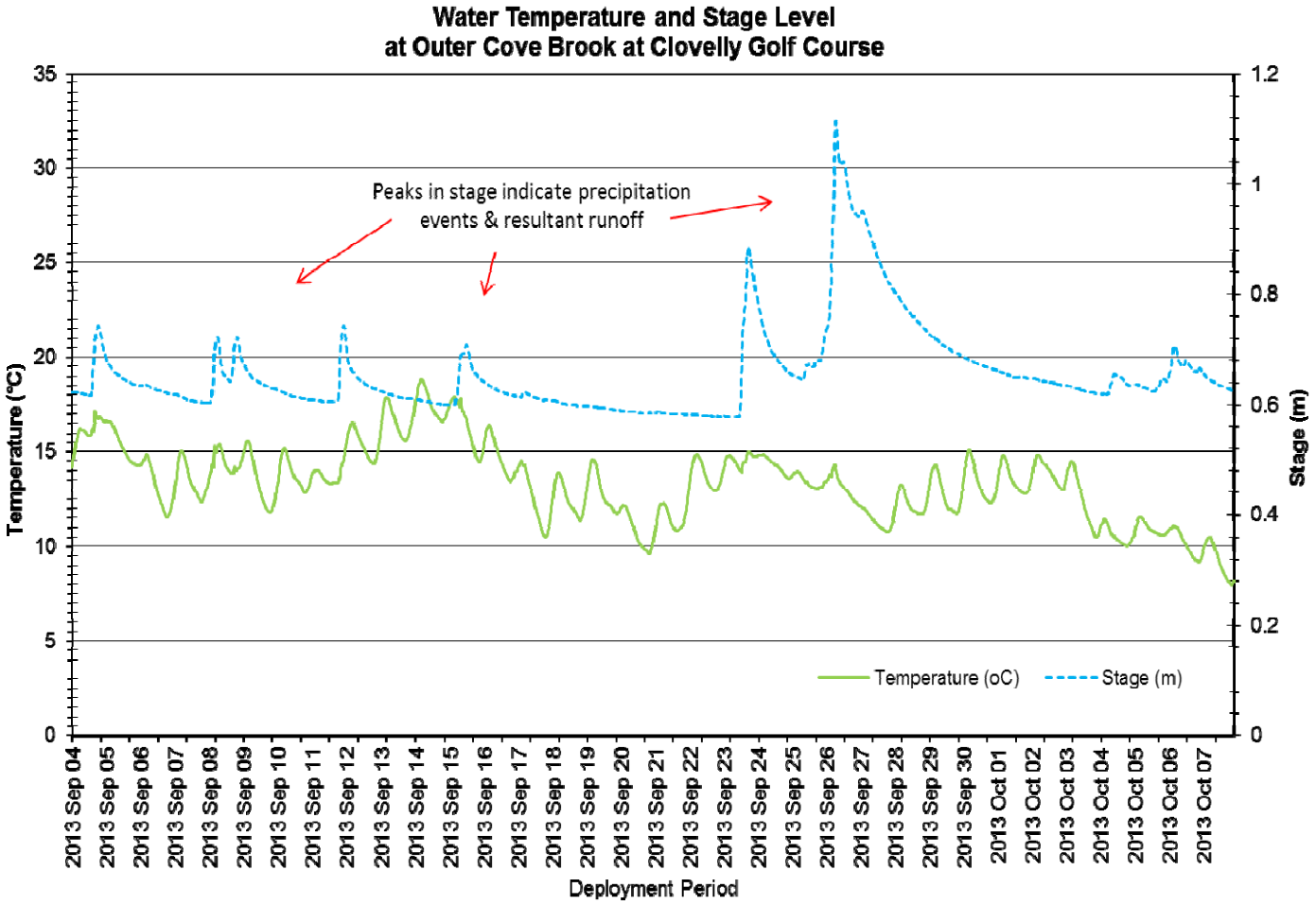


Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period September 4, 2013 to October 8, 2013.

pH

- Throughout this deployment period pH values ranged between 5.81 pH units and 6.26 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 September 24th and 27th, 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.

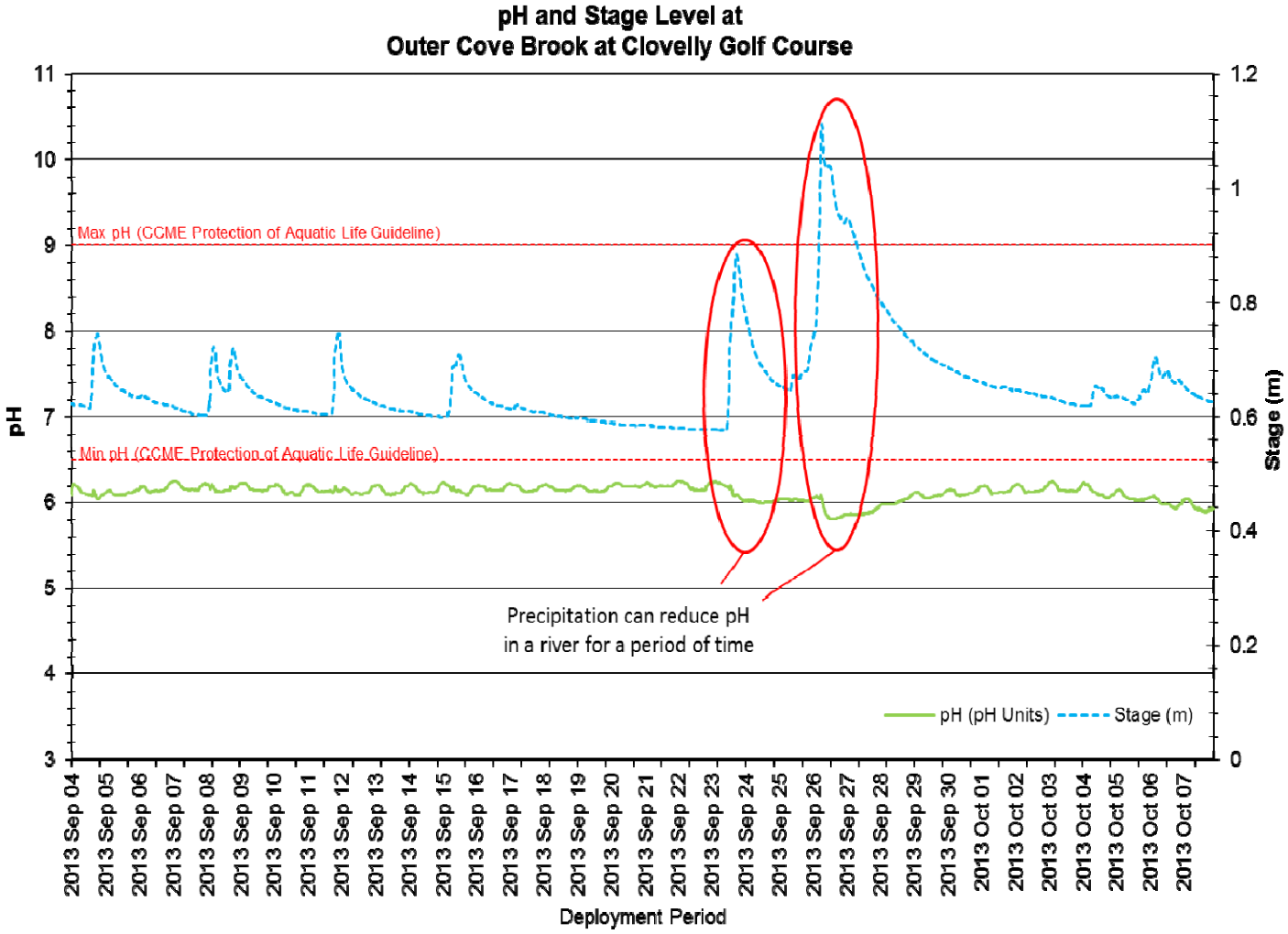


Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period September 4, 2013 to October 8, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 103.2 µS/cm and 374 µS/cm during this deployment period. TDS ranged from 0.0660 g/L to 0.2390 g/L. This is notably lower than in August, likely due to the large input of freshwater from precipitation during September.
- Generally, rainfall events, such as that which occurred on September 27th (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.

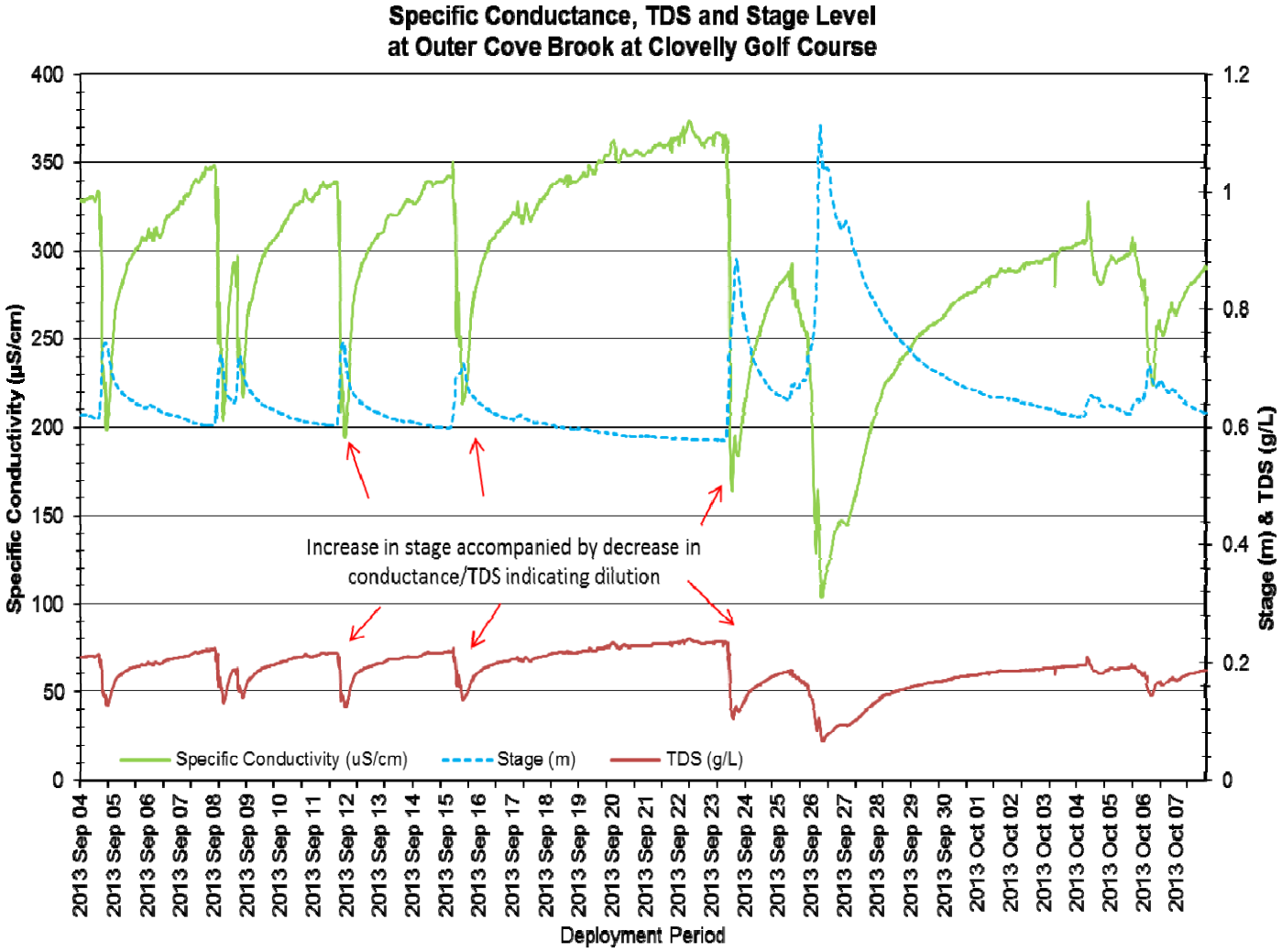


Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period September 4, 2013 to October 8, 2013.

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 70.2% Sat–99.7% Sat. Dissolved Oxygen (mg/L) measured 6.82 mg/L to 10.74 mg/L.
- The DO mg/L values dip below the minimum DO CCME guideline for early life stages for the majority of the deployment due to the warm water temperatures reported over this deployment period. Warm water temperatures September 24th 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.

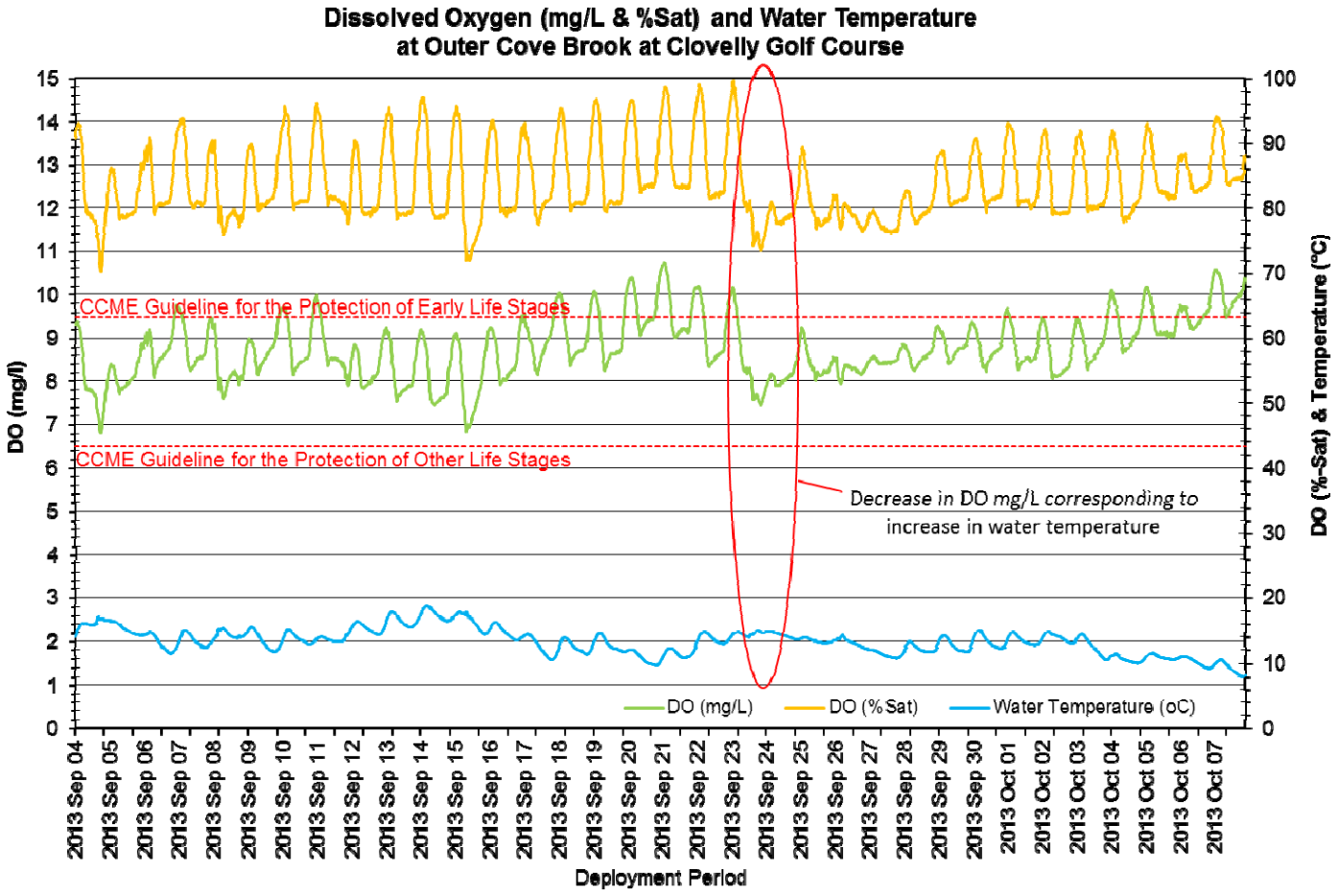


Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period September 4, 2013 to October 8, 2013.

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. Data from October 3rd to 6th was removed from the dataset due to noticeable fouling or sensor error as the values were recorded as 3000 NTU
- The turbidity readings during this deployment ranged within 0.0 NTU to 39.4 NTU (Figure 12). Fluctuations in turbidity values were correlated with increases in stage and thus precipitation events.
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values as sediment and debris were resuspended into the water column.

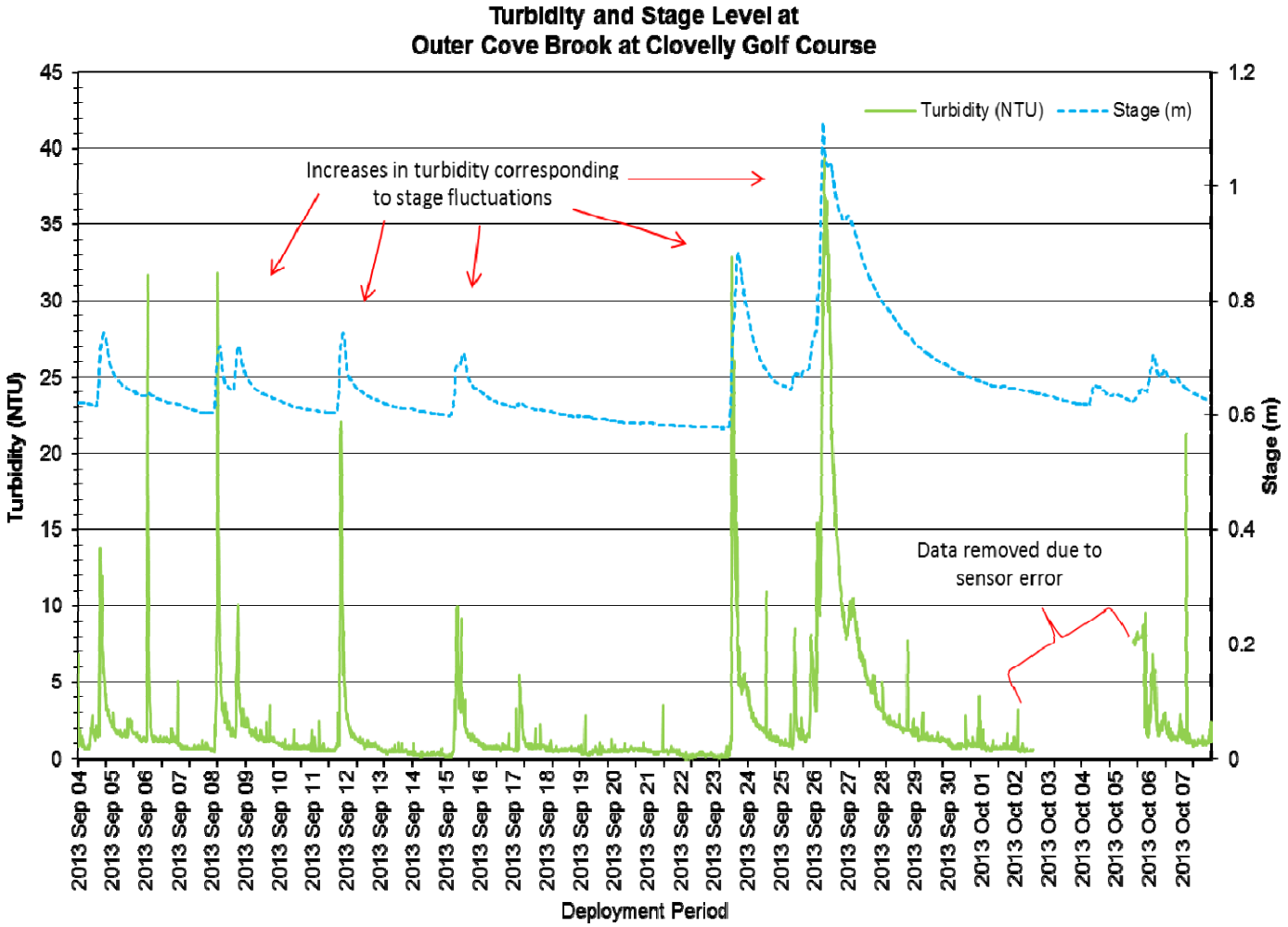


Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period September 4, 2013 to October 8, 2013.

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 0.58m to 1.11m, with the maximum level being reached after a significant rainfall event of 132.2 mm over 5 days. During sonde removal, the flattened shoreline grasses indicated that the banks had recently been inundated by approximately 1.5m, though flow during removal did not exceed the river's banks.

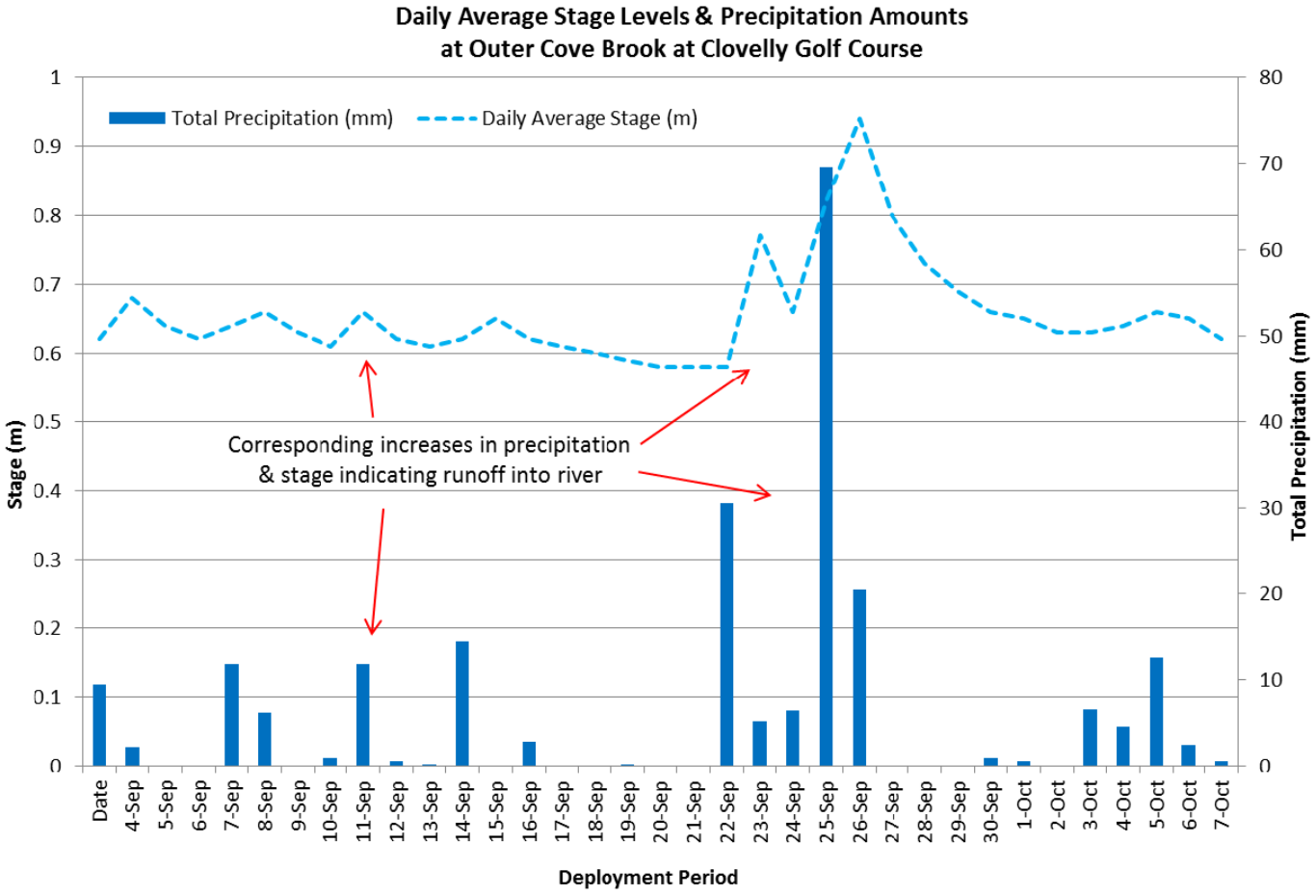


Figure 13: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period September 4, 2013 to October 8, 2013.

Conclusions – Outer Cove Brook at Clovelly Golf Course

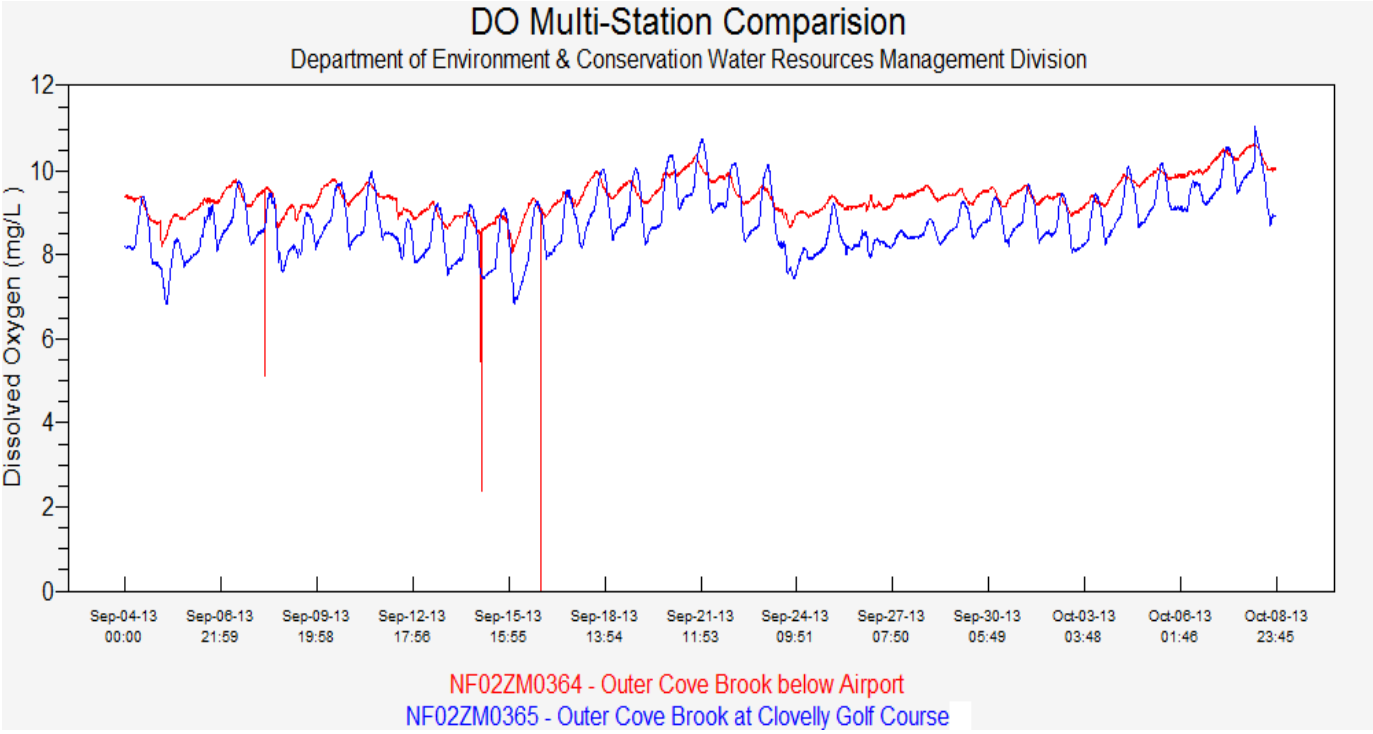
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures decreased, there were correspondingly cooler water temperatures, which in turn increased the amount of dissolved oxygen in the water.
- During this deployment, the turbidity sensor did not suffer from biofouling as it had in previous months, though there was a brief issue with the sensor where it recorded erroneous values. This data was removed from the dataset. Upon removal, the sonde was coated in a layer of black organic material, which may have affected the turbidity sensor.
- 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.
- Generally, dissolved oxygen, pH, conductivity and TDS values are lower while water temperatures are higher at this station than at the below airport station.

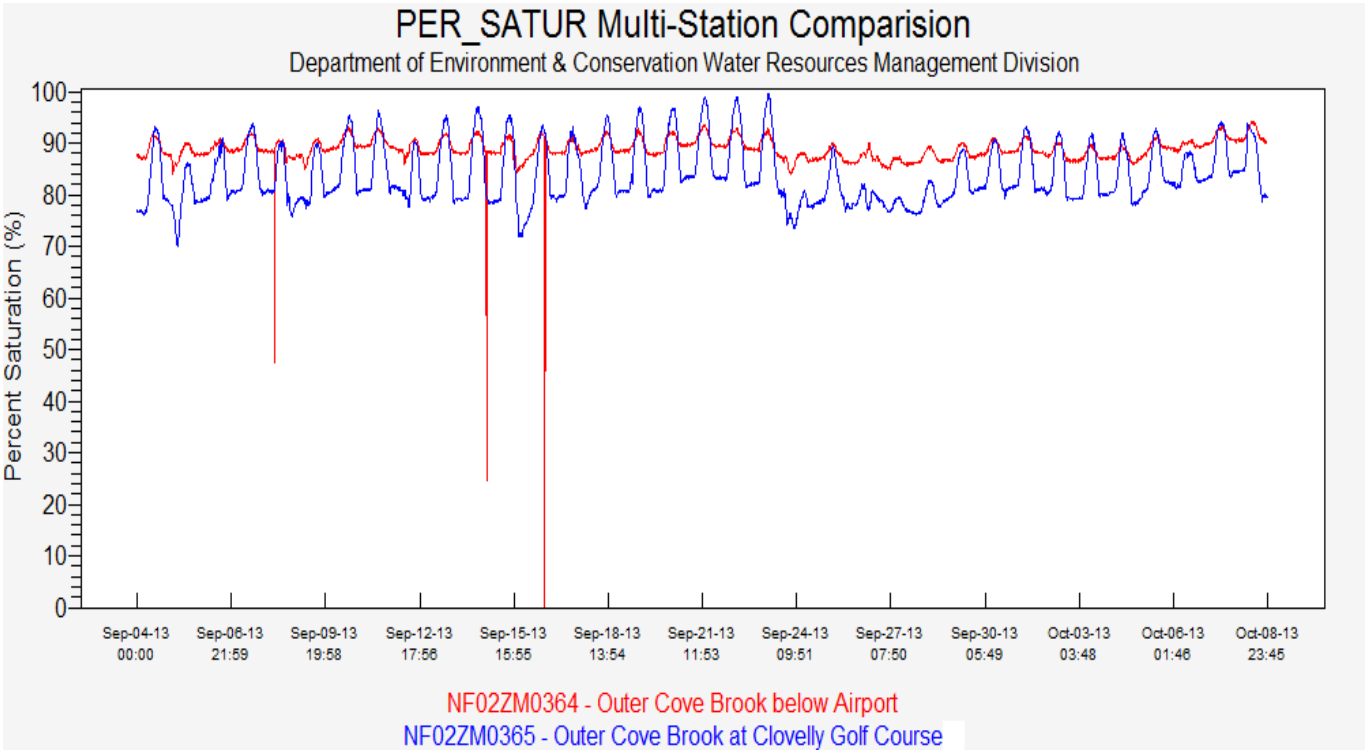
Conclusions – Outer Cove Brook Network

During this deployment period, the median water temperature at the upstream station (below Airport) of 13.00°C was slightly lower than that of the downstream station (at Clovelly Golf Course) of 13.41°C. The median pH value of 6.34 below the Airport is higher than the Clovelly station median of 6.13. A comparison of the two stations pH values over the deployment period indicates that this trend was consistent over this period, and thus there is a noticeable change in pH from the upstream to the downstream station. This will be monitored during the upcoming deployment periods. The specific conductivity medians were similar at both stations with 298 uS/cm reported below the airport and 307 uS/cm reported at the golf course. Dissolved oxygen at the upstream station (below Airport) had a median of 88.7%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 81.8%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 2.7 NTU while at Clovelly Golf Course the median was 0.9 NTU. There does not appear to be any increase in turbidity from the upstream to the downstream station.

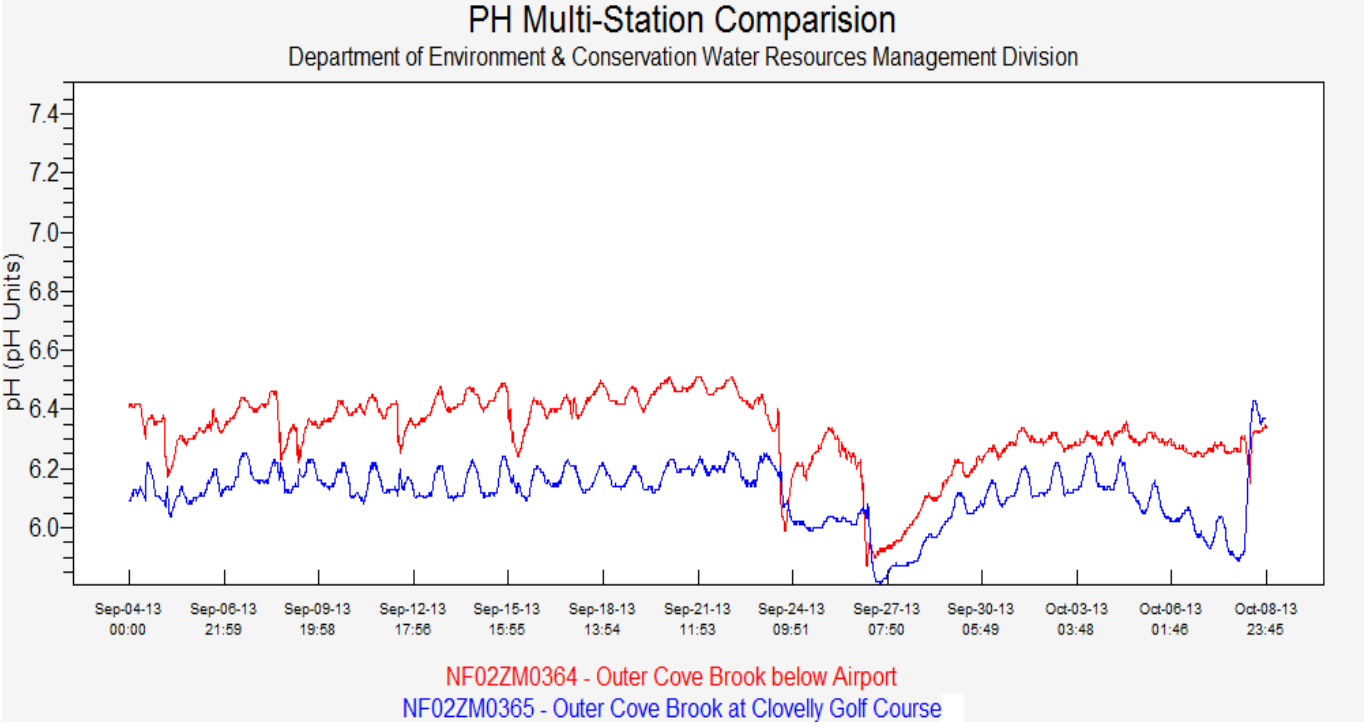
Appendix

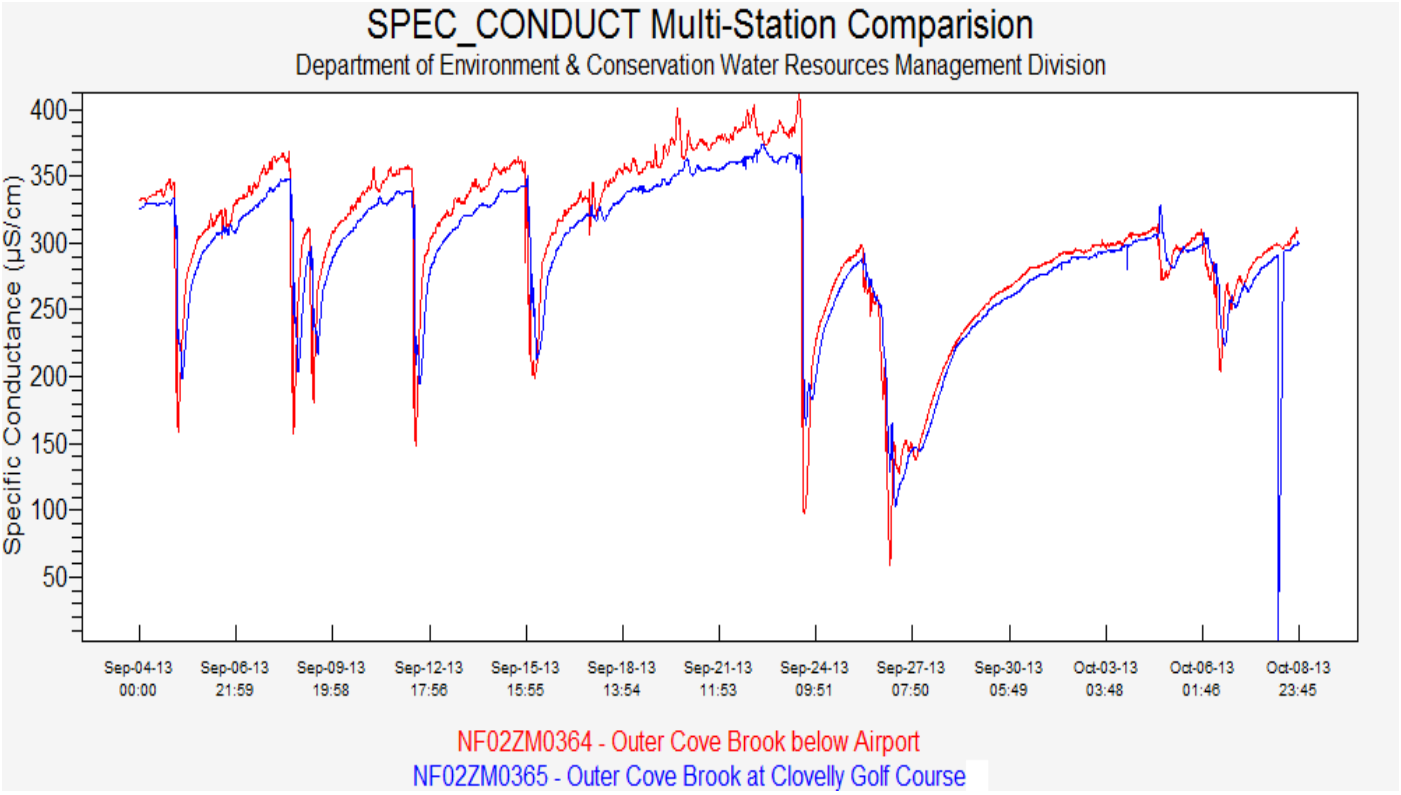
Parameter Station Comparison Graphs



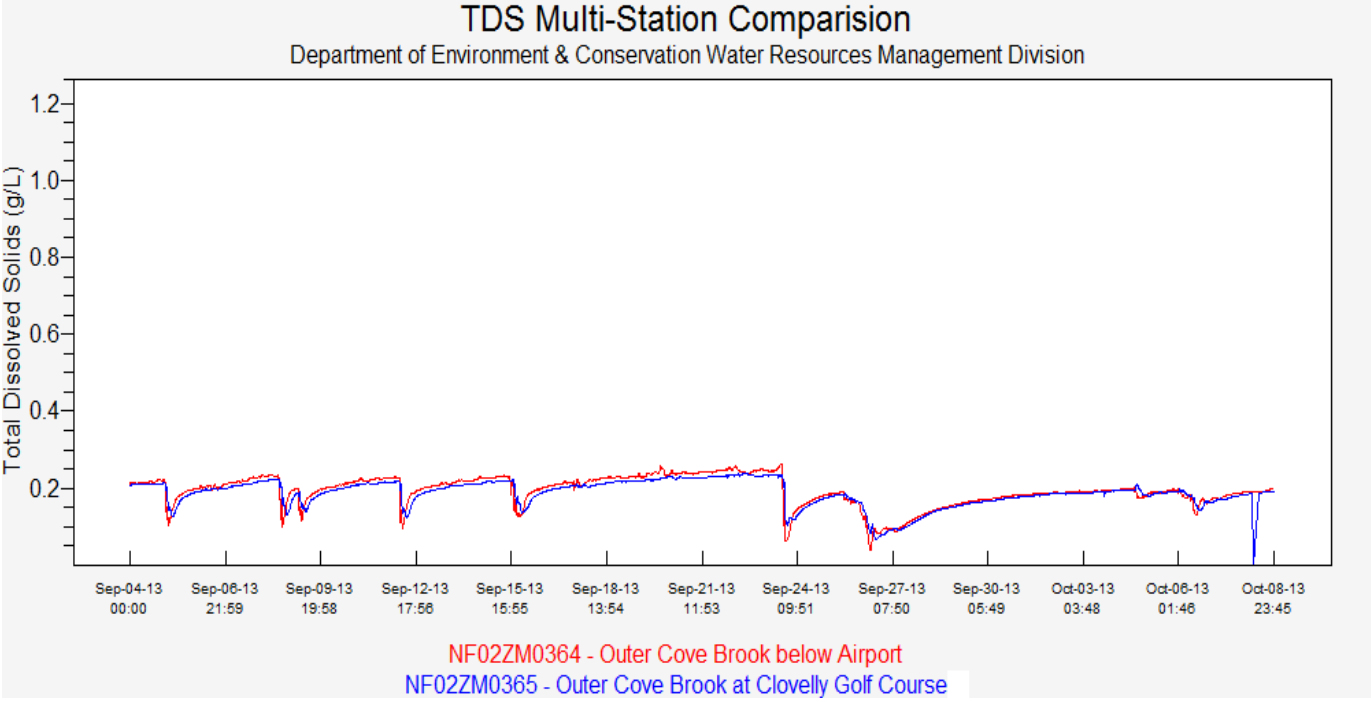


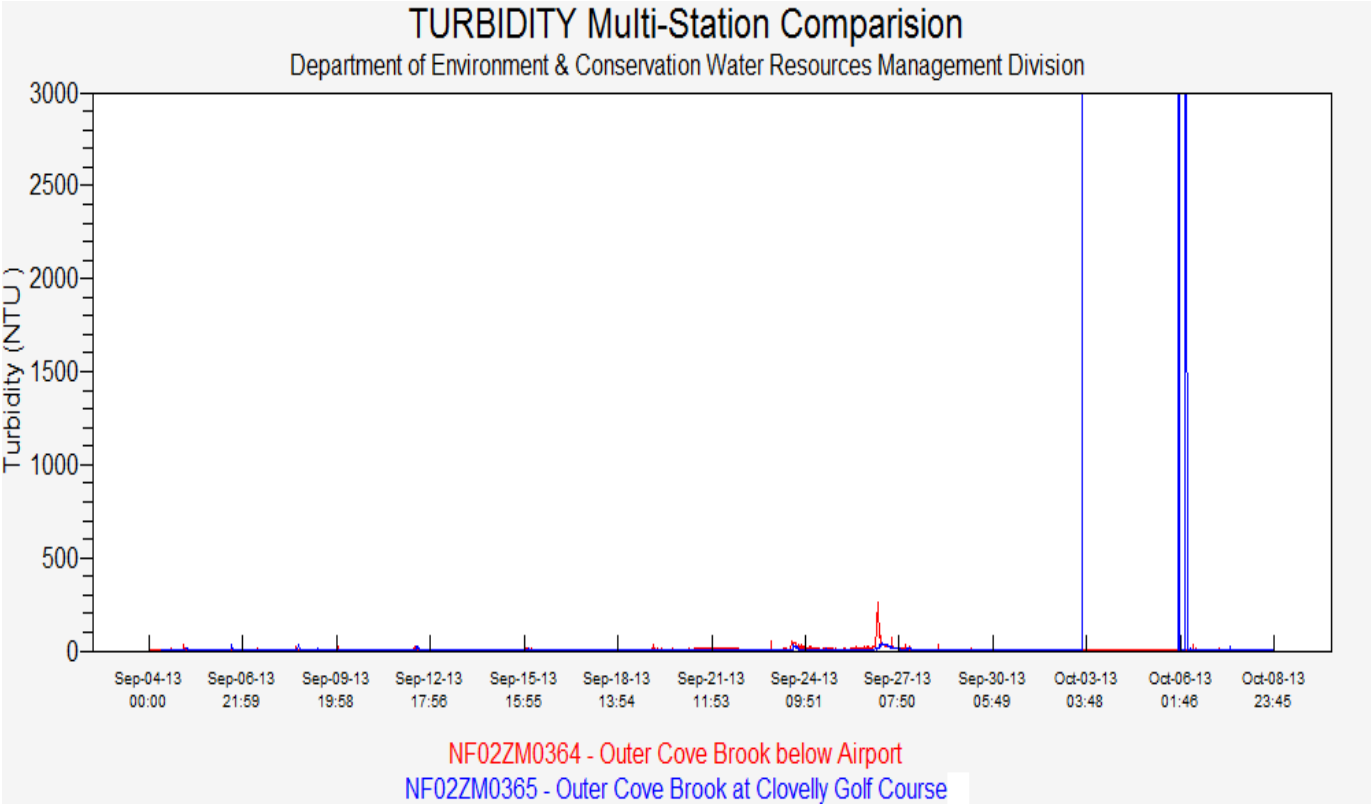
Outer Cove Brook, Newfoundland and Labrador





Outer Cove Brook, Newfoundland and Labrador





Outer Cove Brook, Newfoundland and Labrador