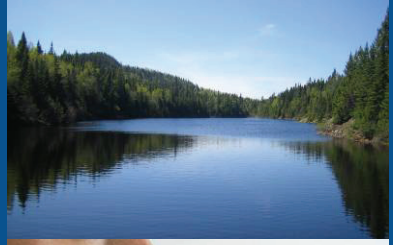
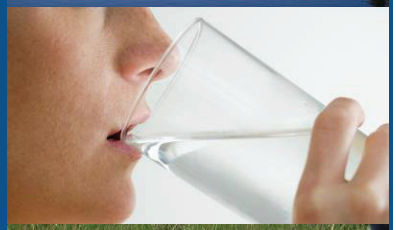




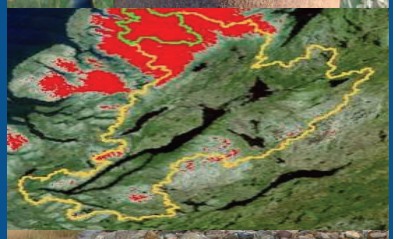

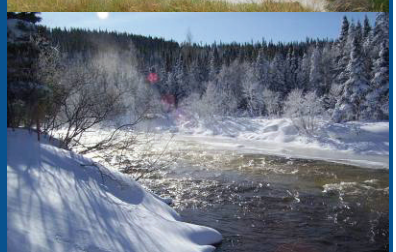

Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
July 3 to August 6, 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 33-day period from deployment on July 3, 2013 until removal on August 6, 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 July 3, 2013 through to August 6, 2013 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport July 3, 2013 – Aug. 6, 2013

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	July 3 2013	Deployment	Fair	Excellent	Excellent	Excellent	Fair
	Aug. 6 2013	Removal	Excellent	Good	Good	Excellent	Fair

- At the Outer Cove Brook below Airport station at the point of deployment, the dissolved oxygen, conductivity and pH sensors ranked 'excellent' while the temperature and turbidity sensors ranked 'fair'. Debris stirred up during deployment may have affected the QA/QC reading of turbidity, and the temperature sensor may have not stabilized before the value was recorded, leading to 'fair' rankings for both these sensors.

- At removal, temperature and dissolved oxygen ranked as 'excellent' while pH and conductivity ranked as 'good'. Turbidity again ranked as 'fair', indicating that there may be some biofouling affecting this sonde at this location.

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

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course July 3, 2013 – Aug. 6, 2013

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	July 3 2013	Deployment	Good	Excellent	Good	Excellent	Excellent
	Aug. 6 2013	Removal	Good	Excellent	Excellent	Excellent	Poor

- During the Outer Cove Brook Clovelly Golf Course station deployment, all sensors ranked 'excellent' or 'good' when compared to the freshly calibrated QA/QC sonde.

- At removal, pH, conductivity and dissolved oxygen ranked 'excellent', while temperature ranked 'good'. The turbidity sensor ranked 'poor'. This is expected as data transmitted from the sensor reached a value of 3000NTU numerous times during deployment, indicating an issue with the sensor.

- 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. A significant transmission loss occurred at the below airport station from July 4th, 1:45am to July 8th, 2:15pm, resulting in a data gap in the online graphs. For this period, the water quality data was pulled from the internal sonde memory and used to fill the data gap. Stage information for this data gap is unavailable due to the lost transmission.
- There were issues with the dissolved oxygen and turbidity values being transmitted from July 8th at 2:30pm until July 9th at 10:30am at the below airport station. The values reported during this time were erroneous and thus have been removed from the dataset.
- There was no 'slime' present in the river at this time. The substrate in the river at the below airport station is red in color, and rock surfaces are still coated in places by a red-colored 'scaling' substance. There was a lot of black/brown organic material in the river during sonde removal at both stations.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from July 3 to August 6, 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 10.20°C to 21.80°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.

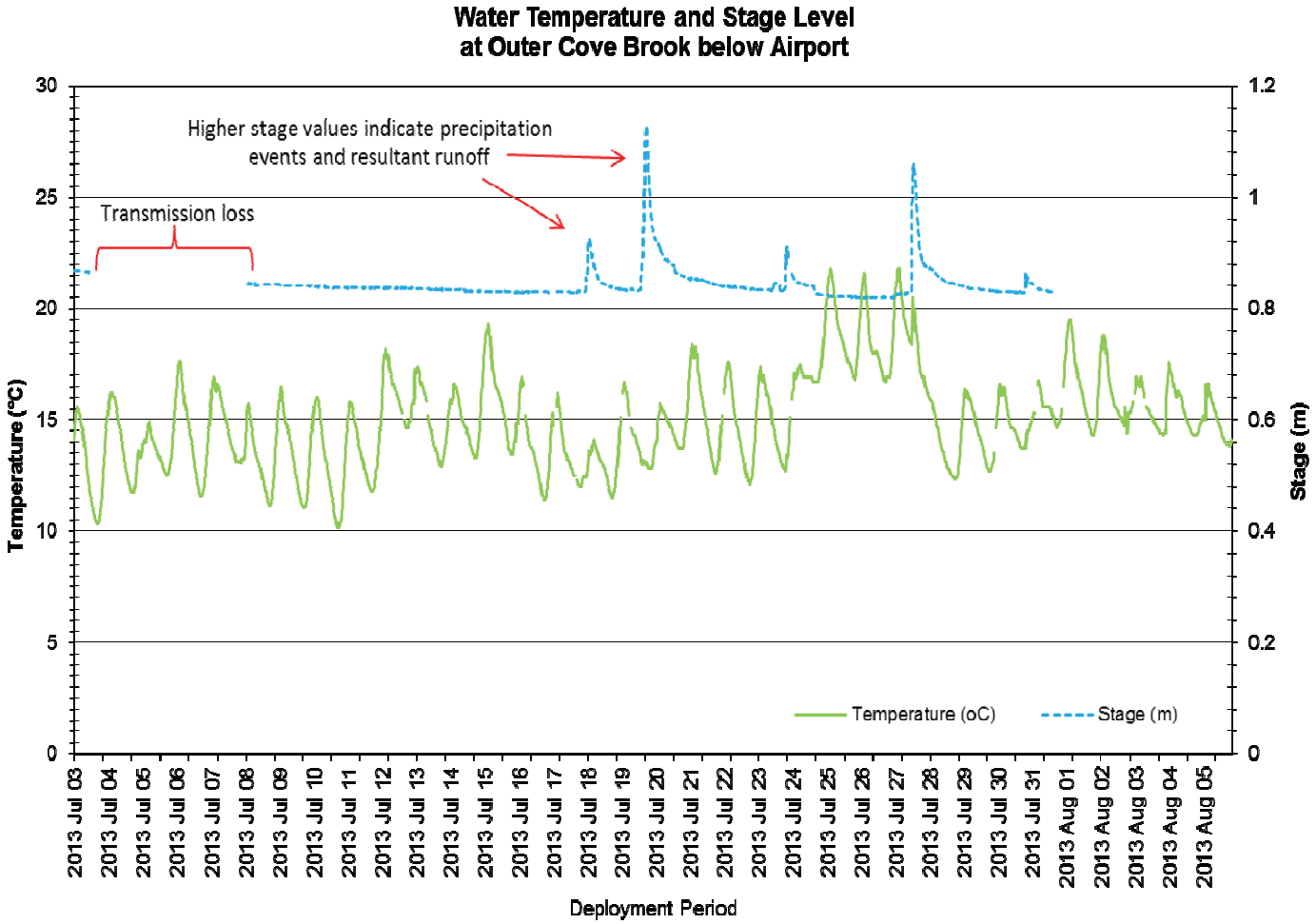


Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period July 3, 2013 to August 6, 2013.

pH

- Throughout this deployment period pH values ranged between 6.06 pH units and 6.78 pH units (Figure 3).
- During the deployment, the pH values at this station hover around the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). There are notable drops in pH on July 19th and 27th, related to precipitation events (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.

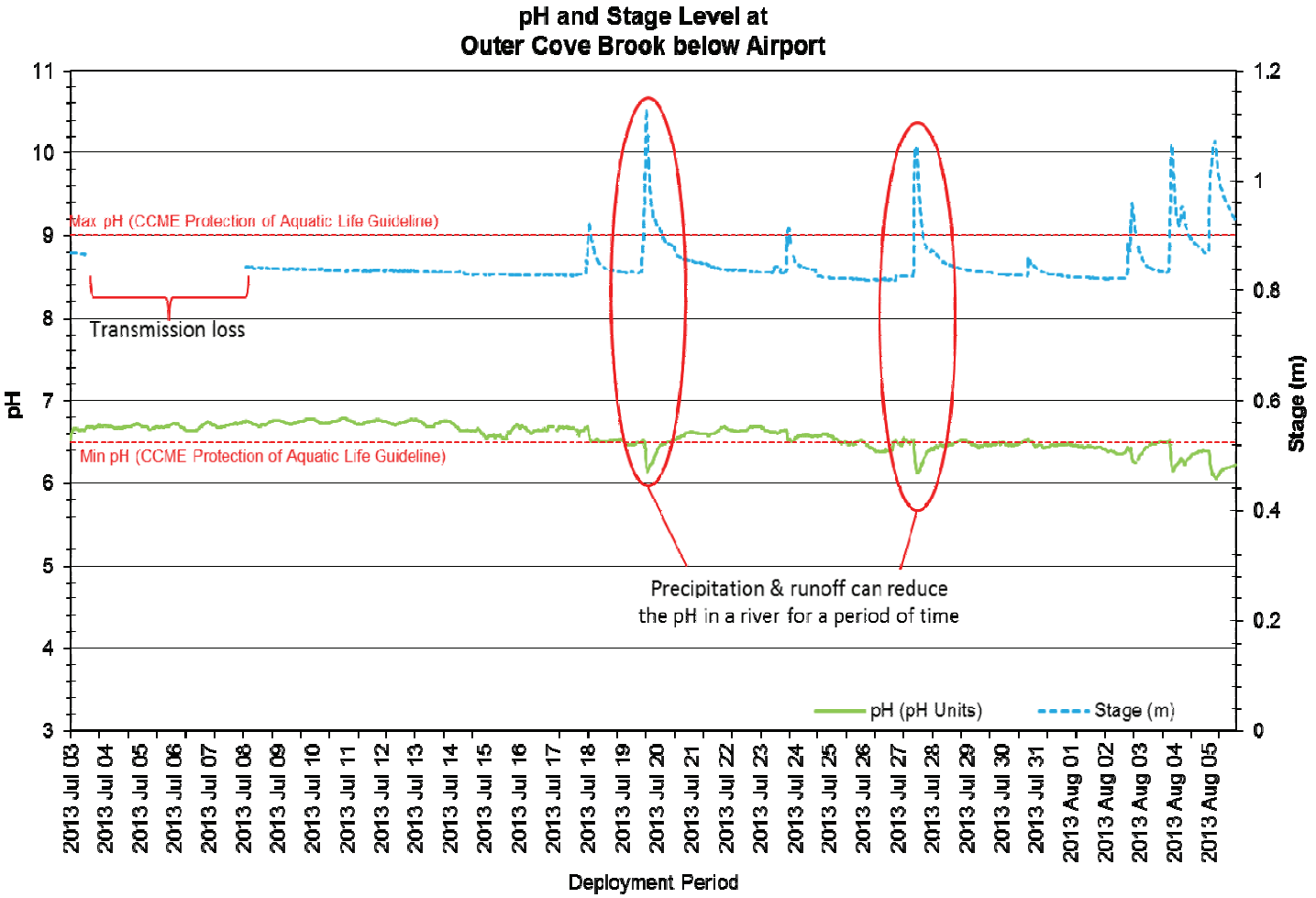


Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period July 3, 2013 to August 6, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 114.7 µS/cm and 507 µS/cm during this deployment period. TDS ranged from 0.0734 g/L to 0.3240 g/L.
- There are small spikes in conductivity and TDS on July 26th and 27th. This indicates some input or disturbance in the river at this time which may have led to resuspension of solids and salts.
- Generally, rainfall events, such as that which occurred on July 19th 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.

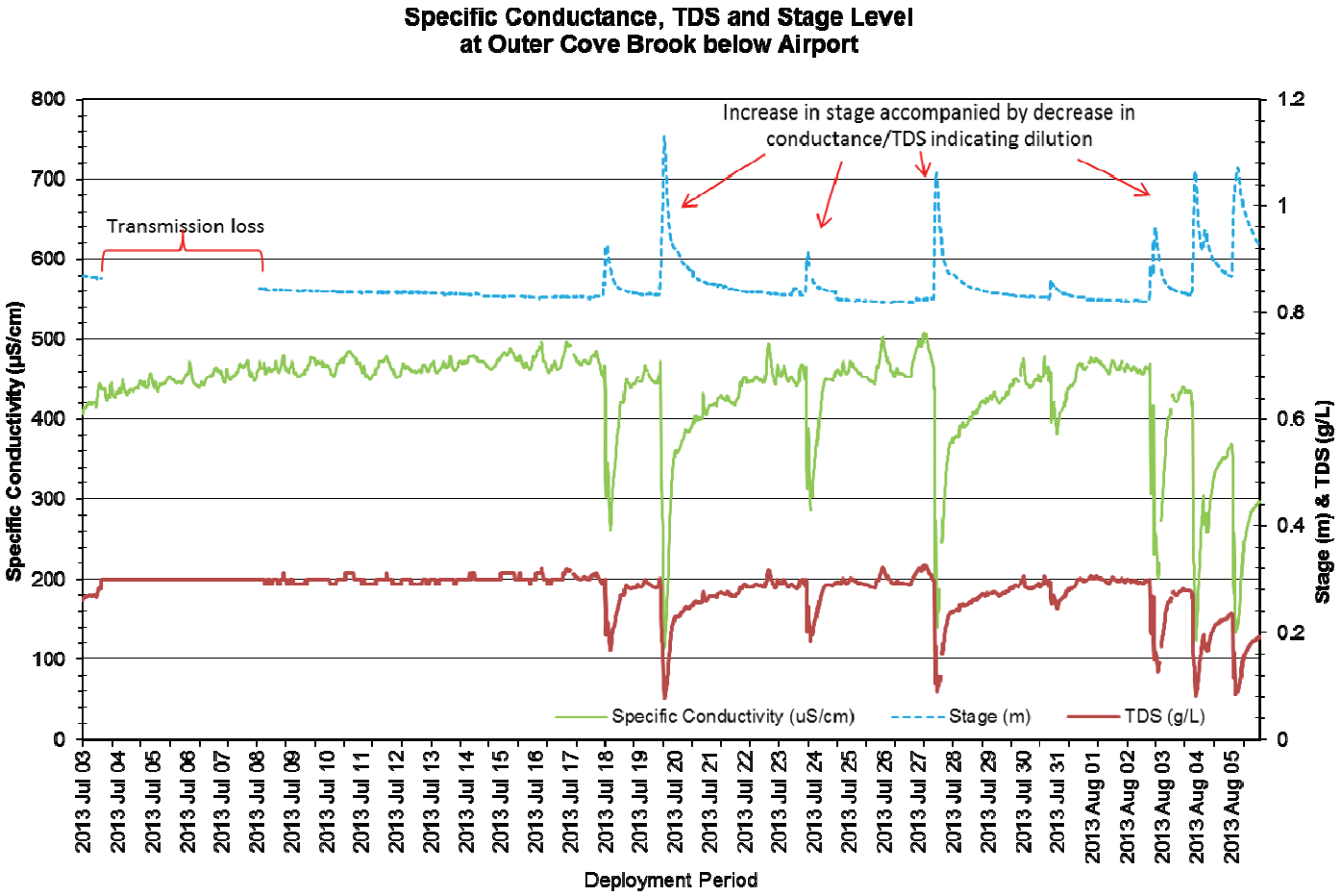


Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period July 3, 2013 to August 6, 2013.

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 82.3% Sat–92.6% Sat. Dissolved Oxygen (mg/L) measured 7.57 mg/L to 10.01 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 (Figure 5).
- 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.

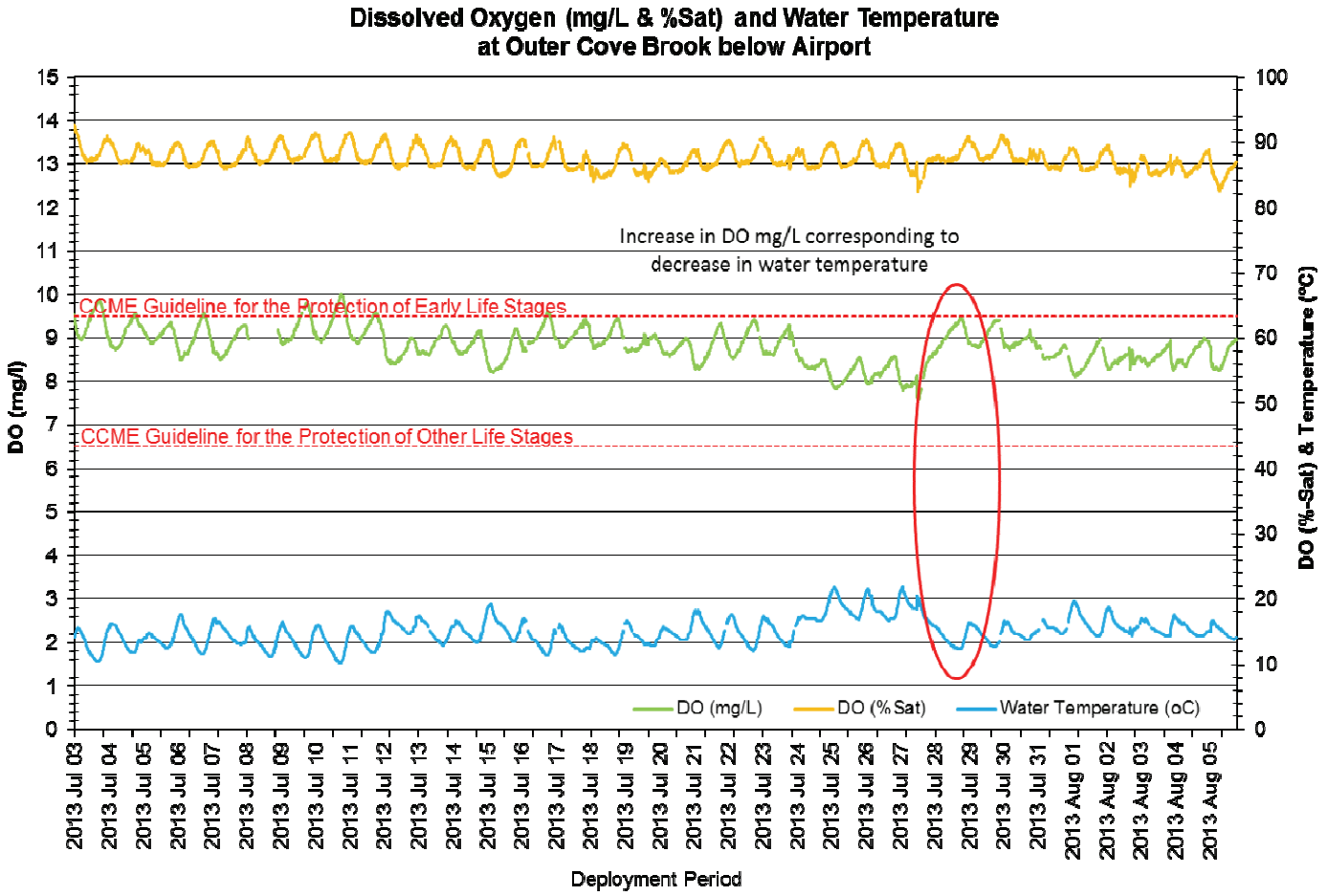


Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period July 3, 2013 to August 6, 2013.

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 deployment ranged within 0.0 NTU to 837 NTU.
- 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.
- This sensor received a 'fair' performance ranking at deployment and removal, likely due to the large amount of organic debris accumulated in the river which is easily resusupeneded or attached to the sonde, and can interfere with field sonde or QA/QC sonde readings.
- Biofouling is a known issue at this location, and likely caused several of the higher turbidity values during deployment as there is a large amount of debris in this river. The numerous precipitation events lead to 'flushing' of the river system, allowing debris to wash away from the sonde after a period of time. Erroneous data due to biofouling (July 14th to July 18th) will be removed from the dataset.

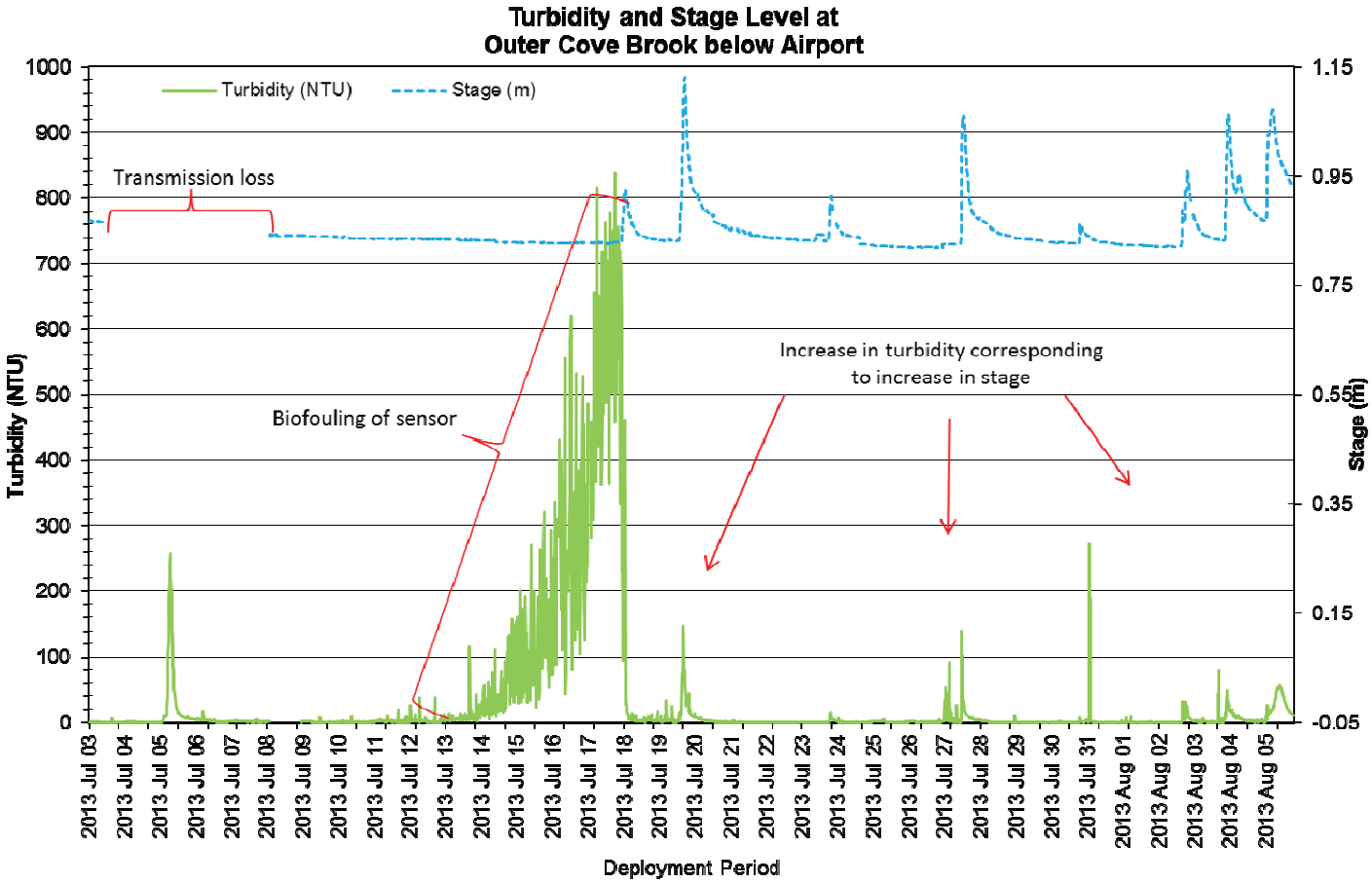


Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period July 3, 2013 to August 6, 2013.

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 0.82m to 1.13m, consistent with the previous month's deployment.

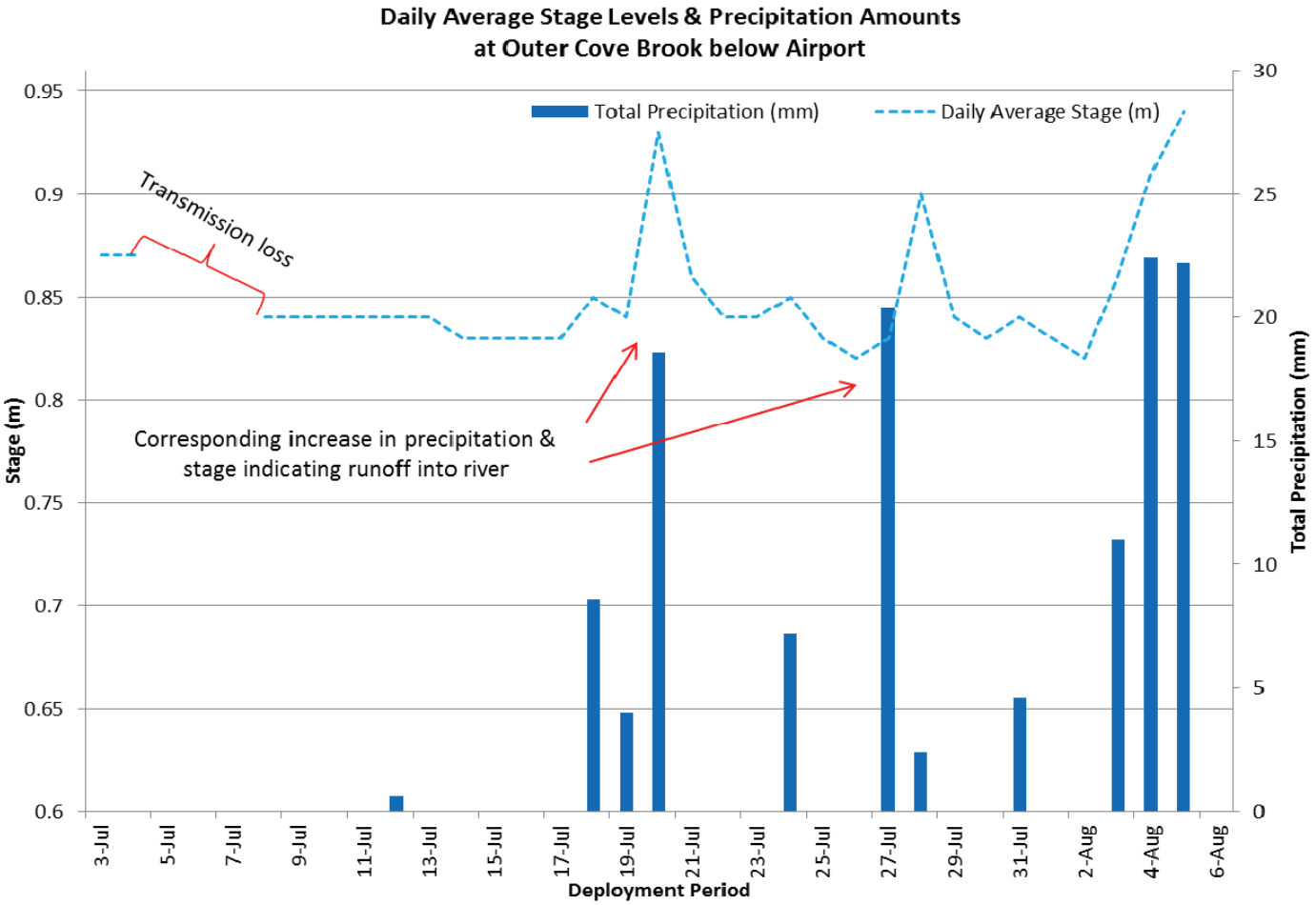


Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period July 3, 2013 to August 6, 2013.

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 rose, there were correspondingly warmer water temperatures, which in turn decreased the amount of dissolved oxygen in the water.
- The majority of turbidity events were correlated with increases in stage and thus precipitation events. Biofouling is still a factor contributing to the high turbidity values as a 'fair' sensor ranking was noted on sonde deployment and removal. Turbidity values fluctuated with stage increases and returned to zero after a prolonged period of higher than normal values were recorded, indicating that the increased stage level was allowing the river system to be flushed, freeing the sonde of the biofouling which accumulated and contributed to the increased turbidity values during deployment.
- Minor spikes in conductivity and TDS on July 26th and 27th are due to some input or disturbance upstream of the station. A spike in turbidity was also noted on July 27th.
- It was noted that the upper surfaces of the substrate at this location have turned to a red-orange color, but when the substrate is disturbed or turned over the rocks are their normal greyish-blue hue. This appears to be a remnant of the previous slime/scaling growth at this location. A high content of black organic debris was also noted at this location during sonde removal.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 11.10°C to 22.73°C during this deployment period (Figure 8).
- 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.

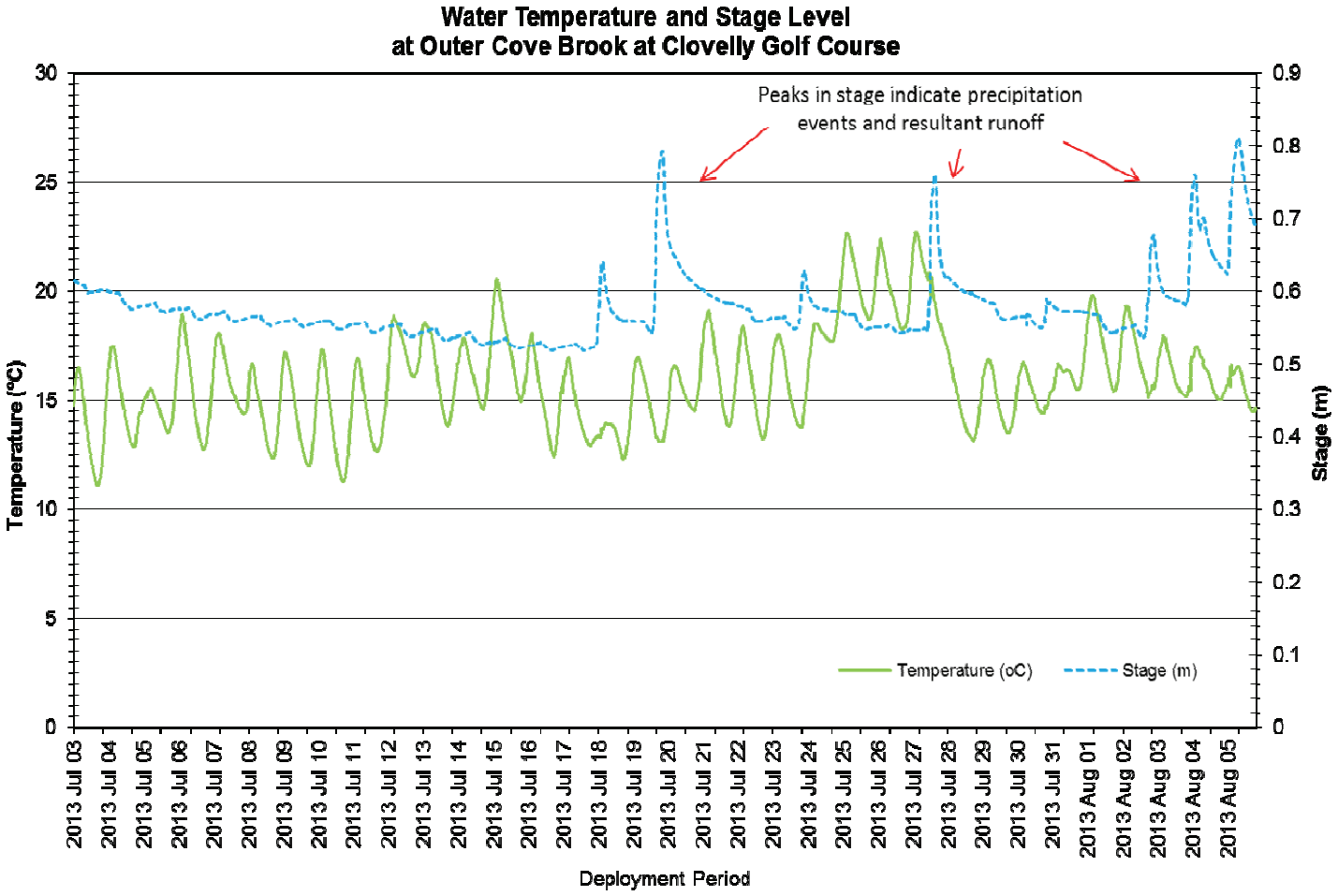


Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period July 3, 2013 to August 6, 2013.

pH

- Throughout this deployment period pH values ranged between 5.52 pH units and 6.58 pH units (Figure 9).
- During the deployment, the pH values at this station hover just below the 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 July 20th 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.

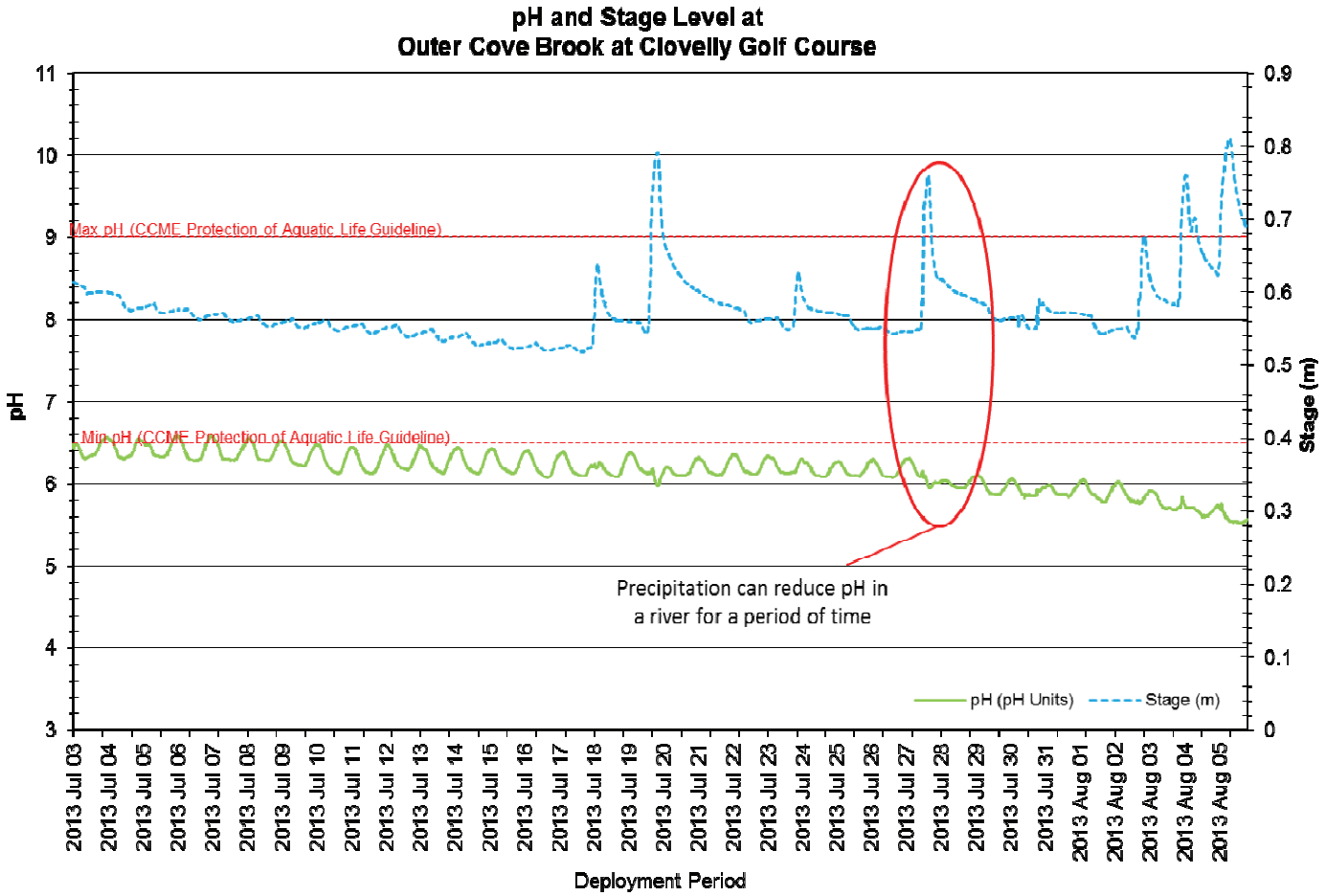


Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period July 3, 2013 to August 6, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 181.1 µS/cm and 487 µS/cm during this deployment period. TDS ranged from 0.1159 g/L to 0.3120 g/L. These values are very similar to those of the previous deployment period.
- Generally, rainfall events, such as that which occurred on July 20th (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.
- The spikes in conductivity and TDS noted at the below airport station July 26th and 27th are also noted at the Clovelly station, though there is a time lag when both sets of data are compared.
- 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.

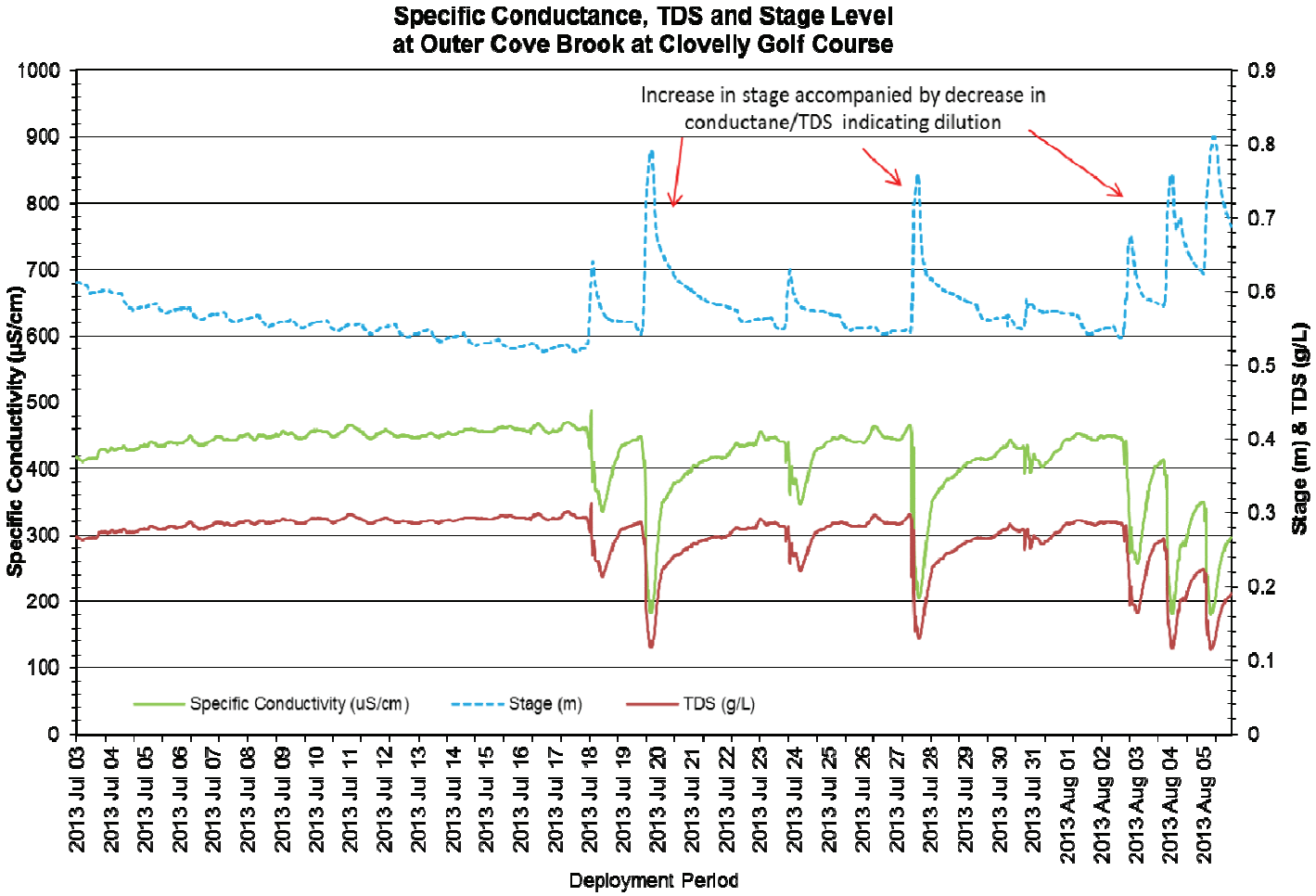


Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period July 3, 2013 to August 6, 2013.

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 58.1% Sat–104.9% Sat. Dissolved Oxygen (mg/L) measured 5.33 mg/L to 10.14 mg/L. These values are lower than during the previous deployment, as was expected due to the higher ambient air temperatures.
- The DO mg/L values dip below the minimum DO CCME guideline for early life stages for the majority of the deployment, coinciding with the high water temperatures reported over this deployment period. High water temperatures July 25th to 27th lead to low oxygen 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.

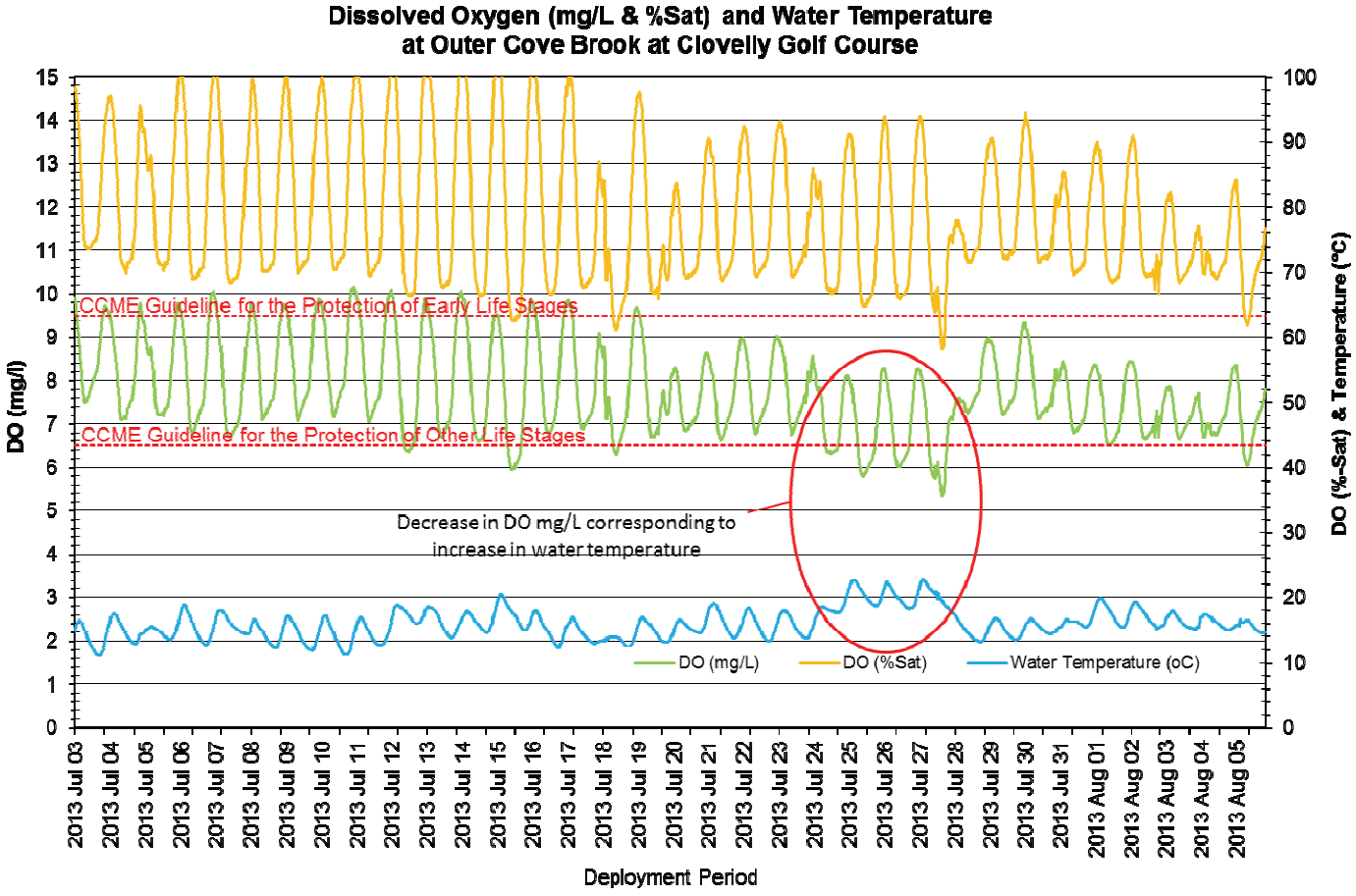


Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period July 3, 2013 to August 6, 2013.

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. Sharp peaks in turbidity to 3000 were noted during this deployment. Erroneous values have been removed from the dataset.
- After the removal of erroneous 3000NTU data, the turbidity readings during this deployment ranged within 0.0 NTU to 185.2 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.

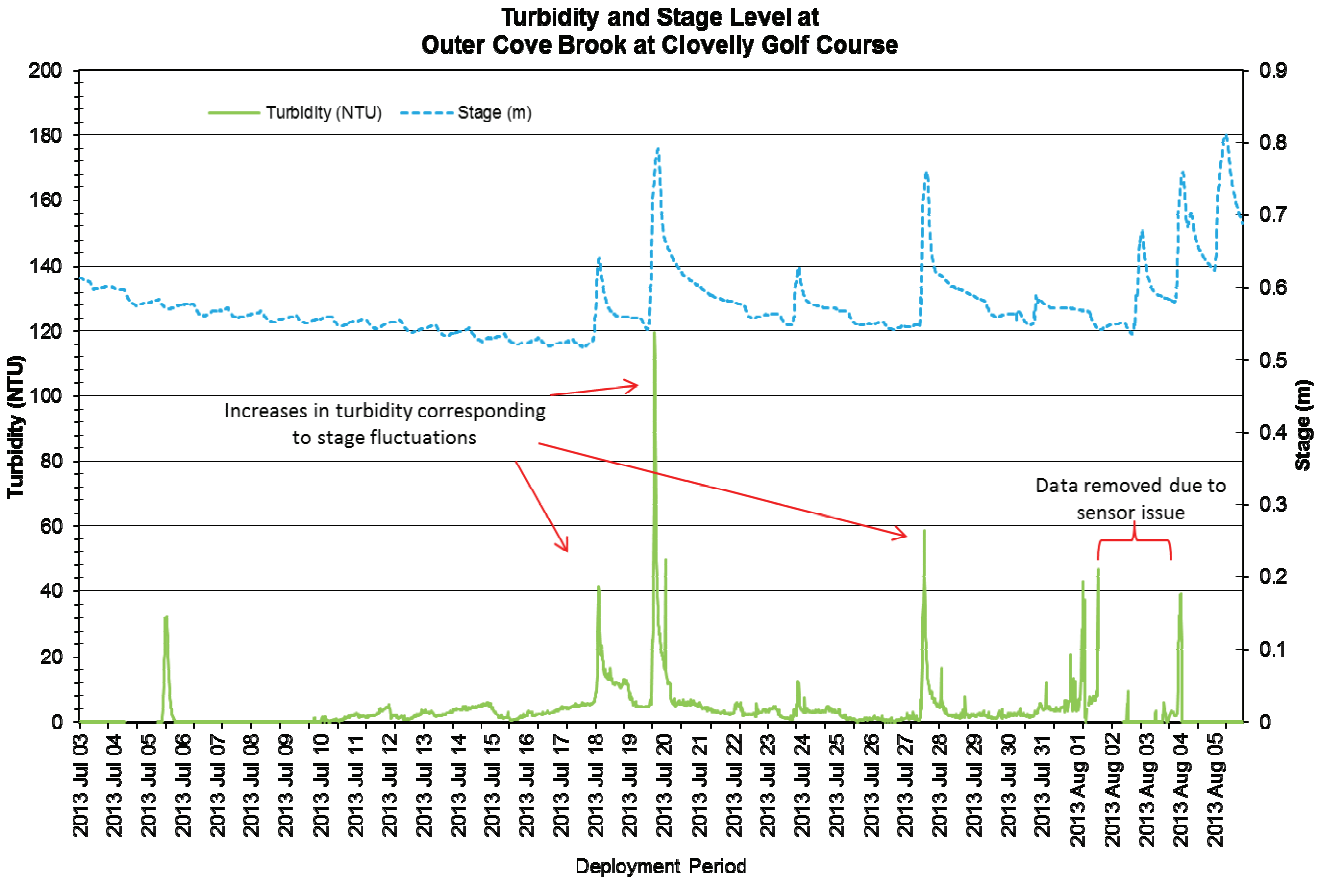


Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period July 3, 2013 to August 6, 2013.

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 0.52m to 0.81m.

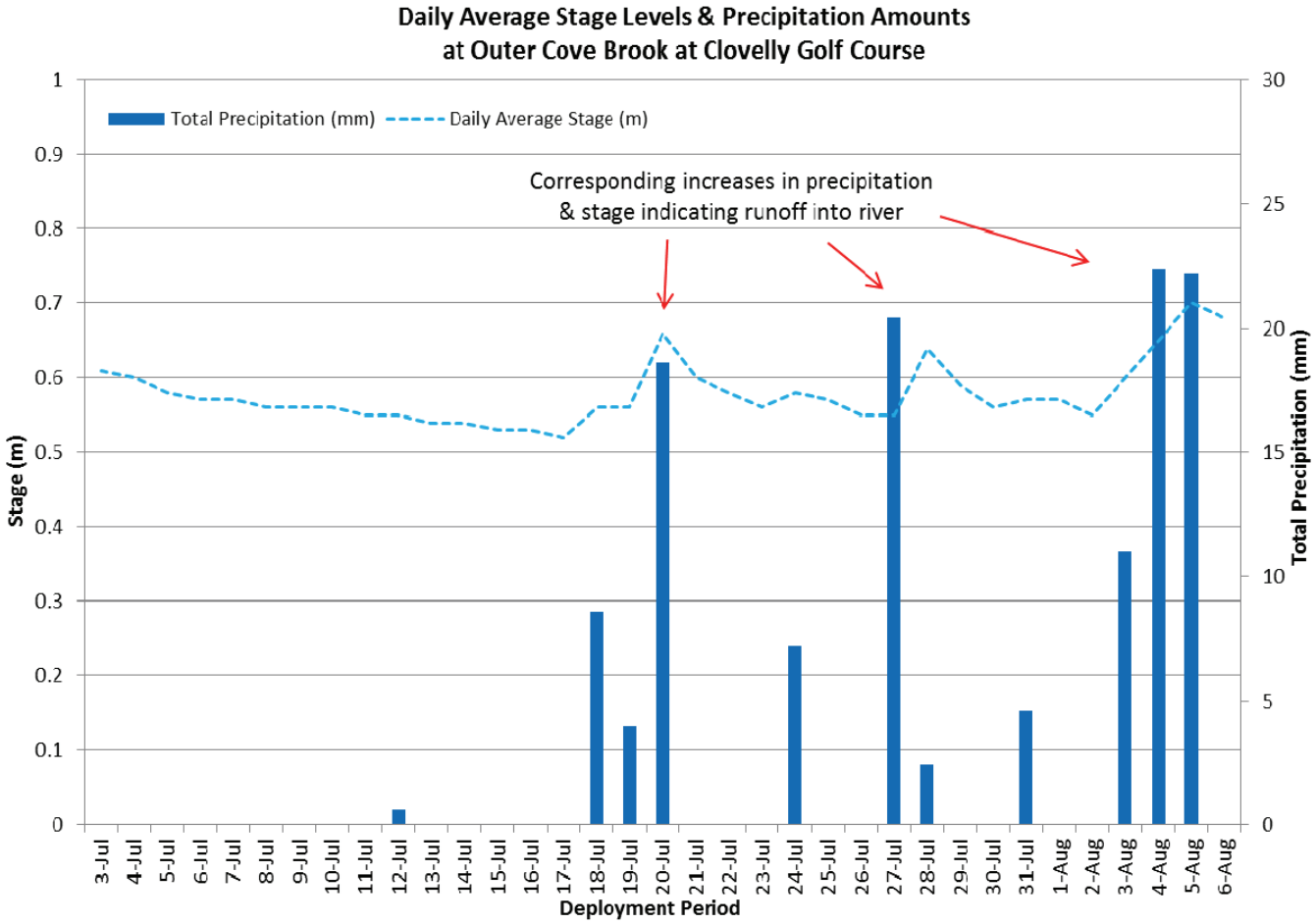


Figure 13: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period July 3, 2013 to August 6, 2013.

Conclusions – Outer Cove Brook at Clovelly Golf Course

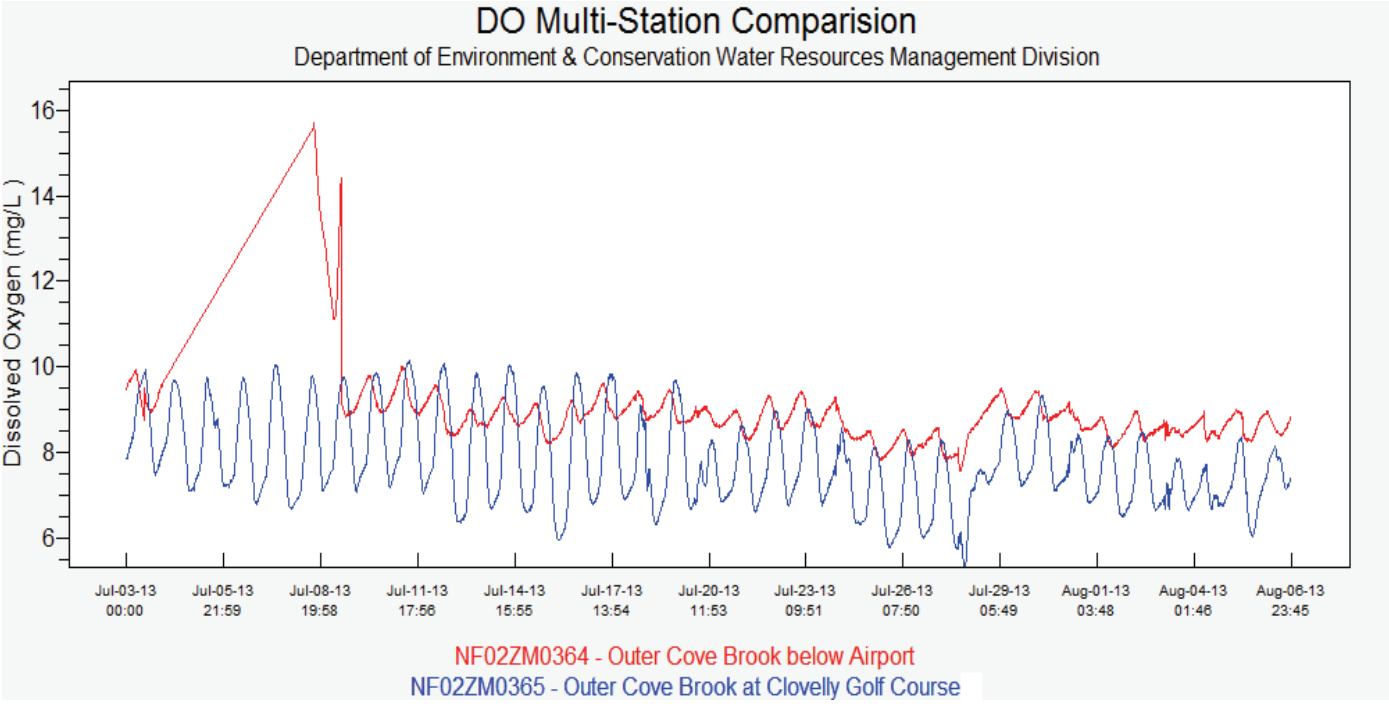
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures rose, there were correspondingly warmer water temperatures, which in turn decreased the amount of dissolved oxygen in the water.
- During this deployment, the turbidity sensor did not suffer from biofouling as it had in previous months. However, sudden peaks in turbidity to 3000 NTU indicate an issue with the sensor. A replacement sonde will be utilized for the next deployment so that this sensor issue can be investigated further in the lab.
- Spikes in TDS/conductance noted previous at the below airport station on July 26th and 27th, also occurred at the Clovelly station, though there was a time lag. On July 26th, conductivity peaked to a value of 502 uS/cm at the airport station at 11:45am, before peaking to 463 at 9:00pm at the downstream Clovelly station. There may therefore be an influence upstream of both stations which is causing spikes in TDS and conductance values.
- Generally, conductivity and TDS values are lower and water temperatures are higher at this station than at the below airport station.

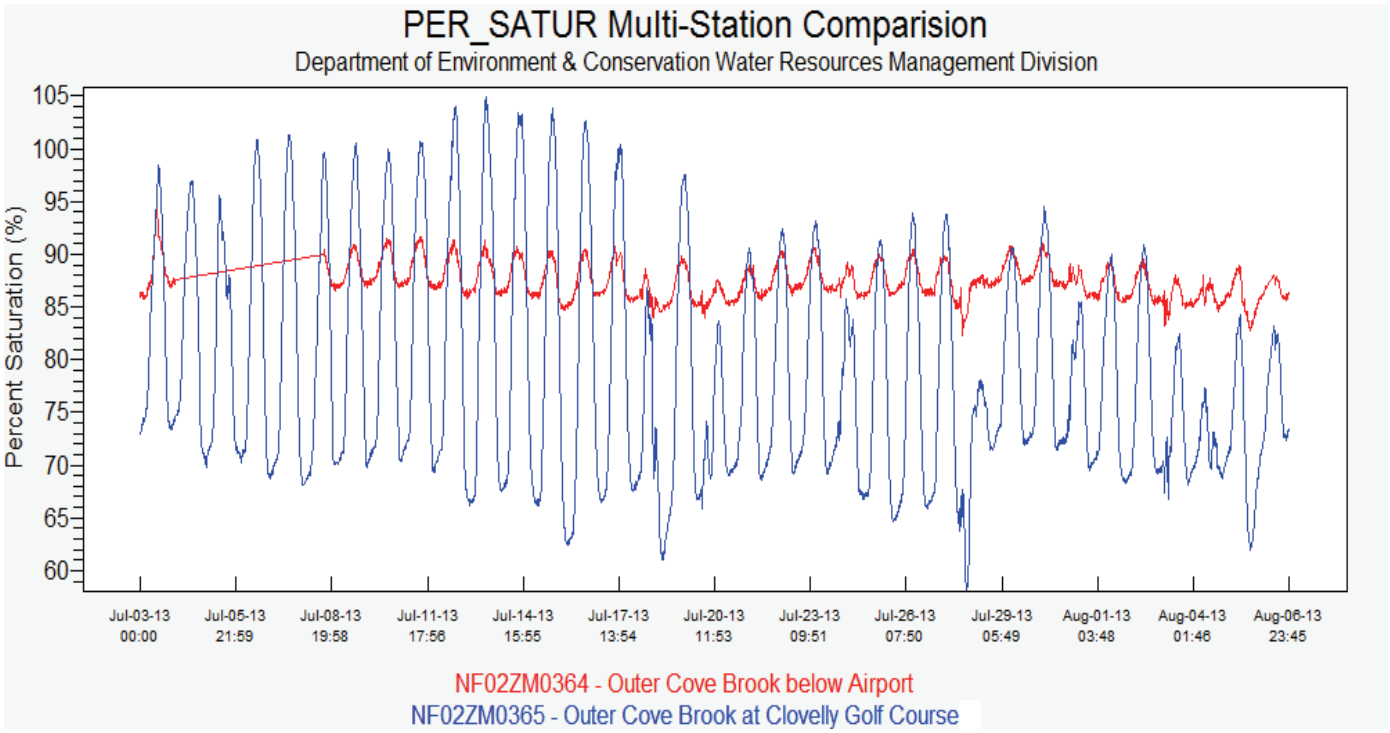
Conclusions – Outer Cove Brook Network

During this deployment period, the median water temperature at the upstream station (below Airport) of 14.80°C was slightly lower than that of the downstream station (at Clovelly Golf Course) of 15.81°C. The median pH value of 6.61 below the Airport is almost a half pH unit higher than the Clovelly station median of 6.17. 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. The specific conductivity medians were similar at both stations with 454 uS/cm reported below the airport and 440 uS/cm reported at the golf course, values which are nearly identical to the previous deployment. Spikes in TDS and conductance on July 26th and 27th at both stations indicate a disturbance may have influenced this stream at this time upstream of both stations. Dissolved oxygen at the upstream station (below Airport) had a median of 87.3%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 75.2%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 1.3 NTU while at Clovelly Golf Course the median was 2.1 NTU. However, there were issues with the turbidity sensor at Clovelly near the end of deployment resulting in erroneous data being removed from the dataset.

Appendix

Parameter Station Comparison Graphs





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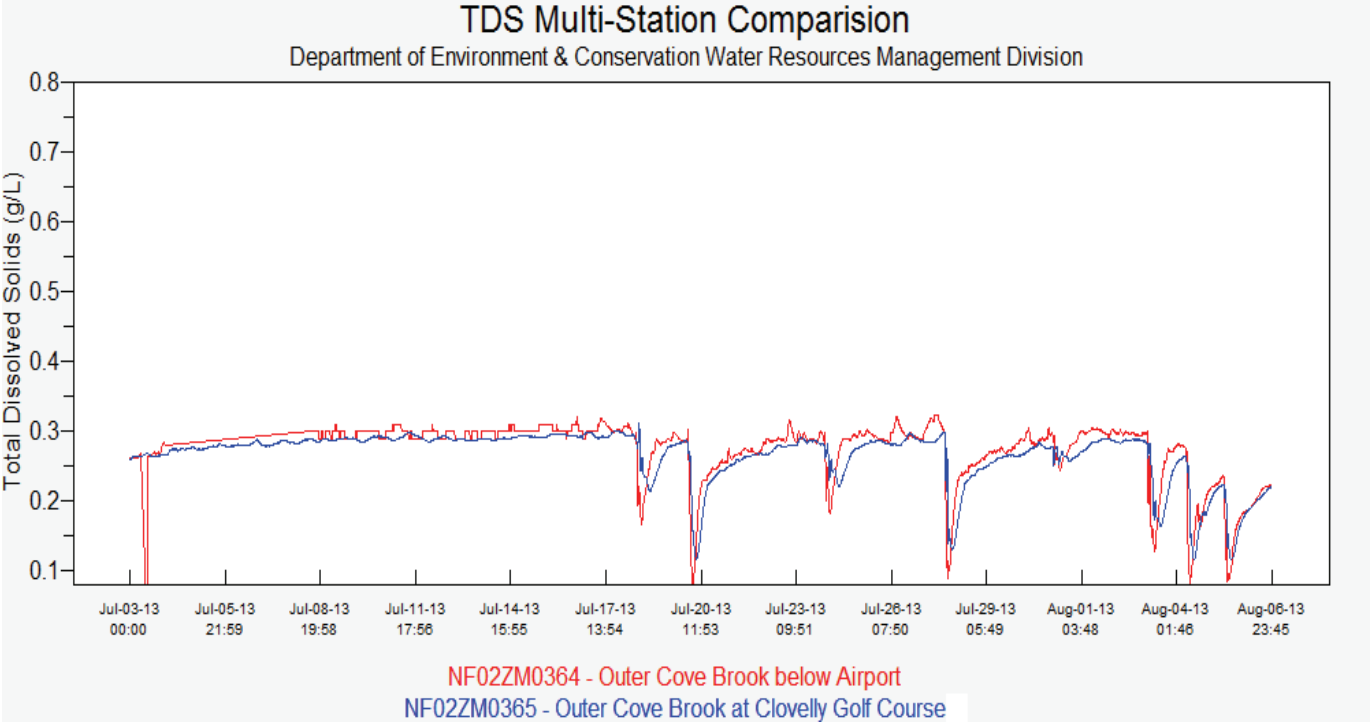

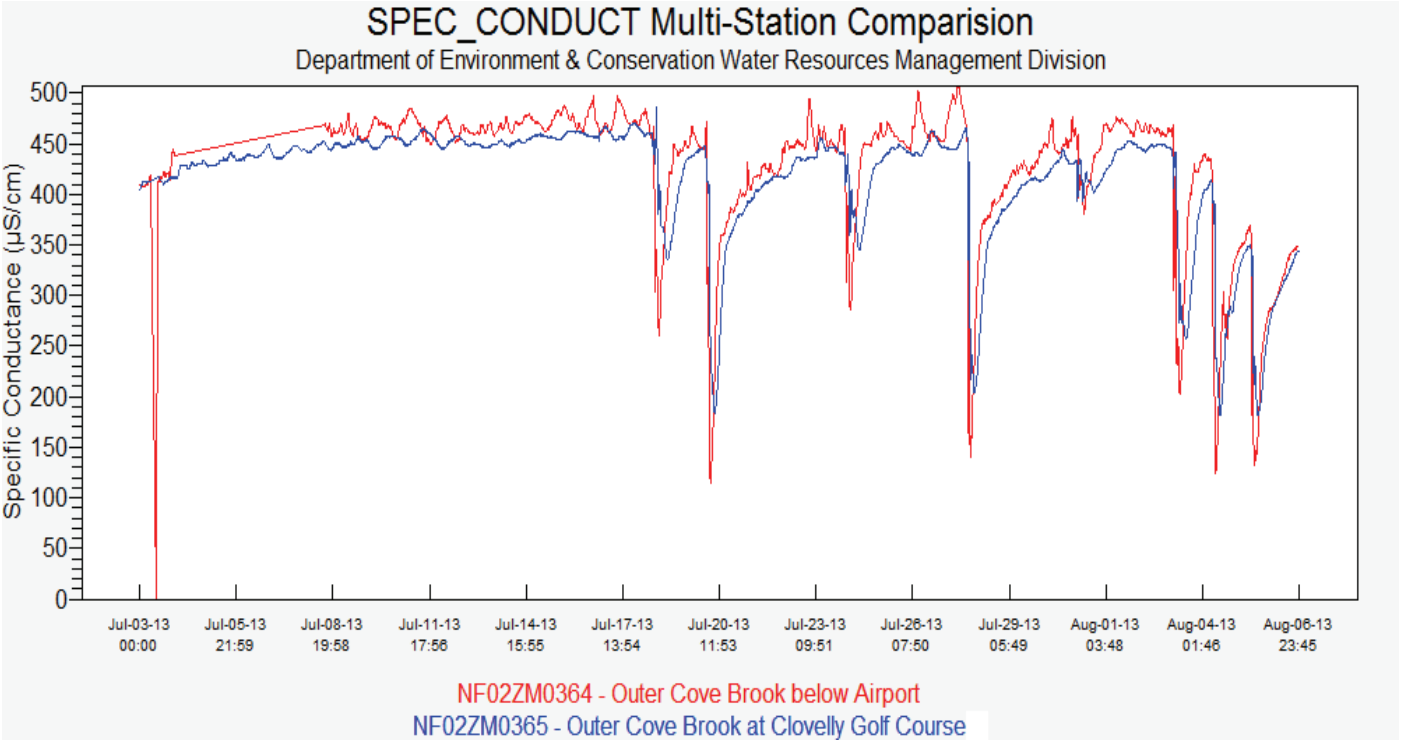

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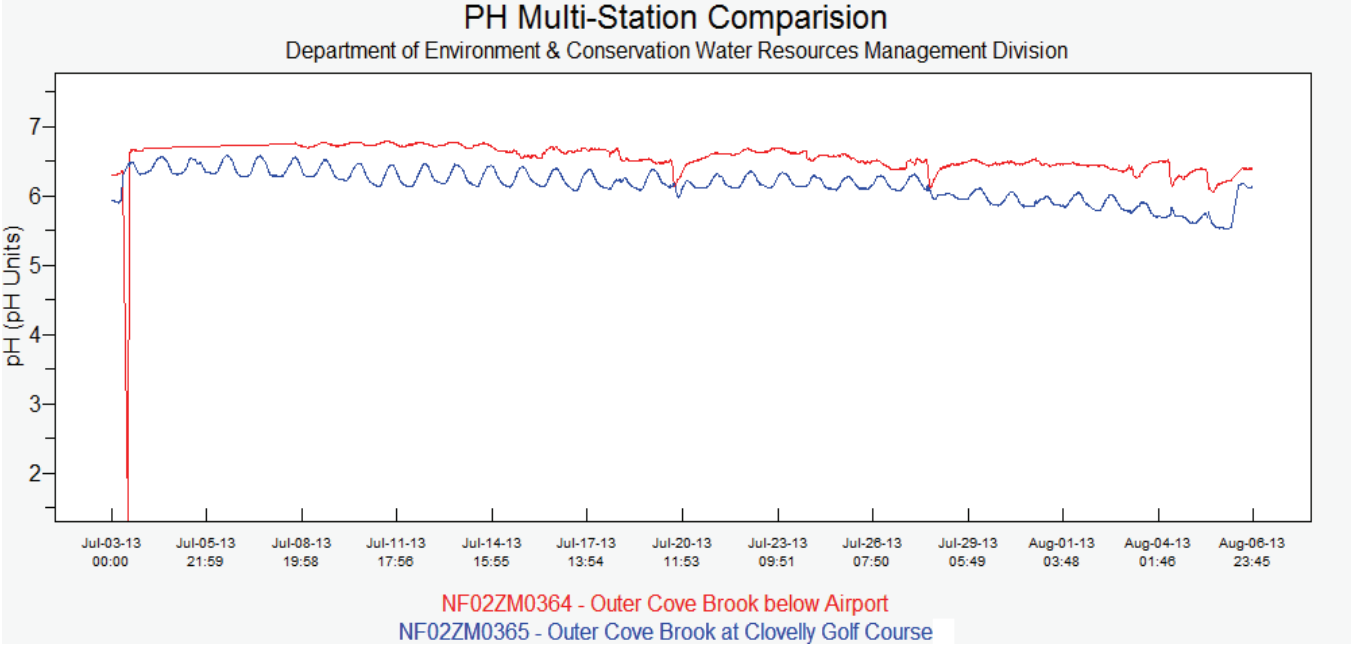

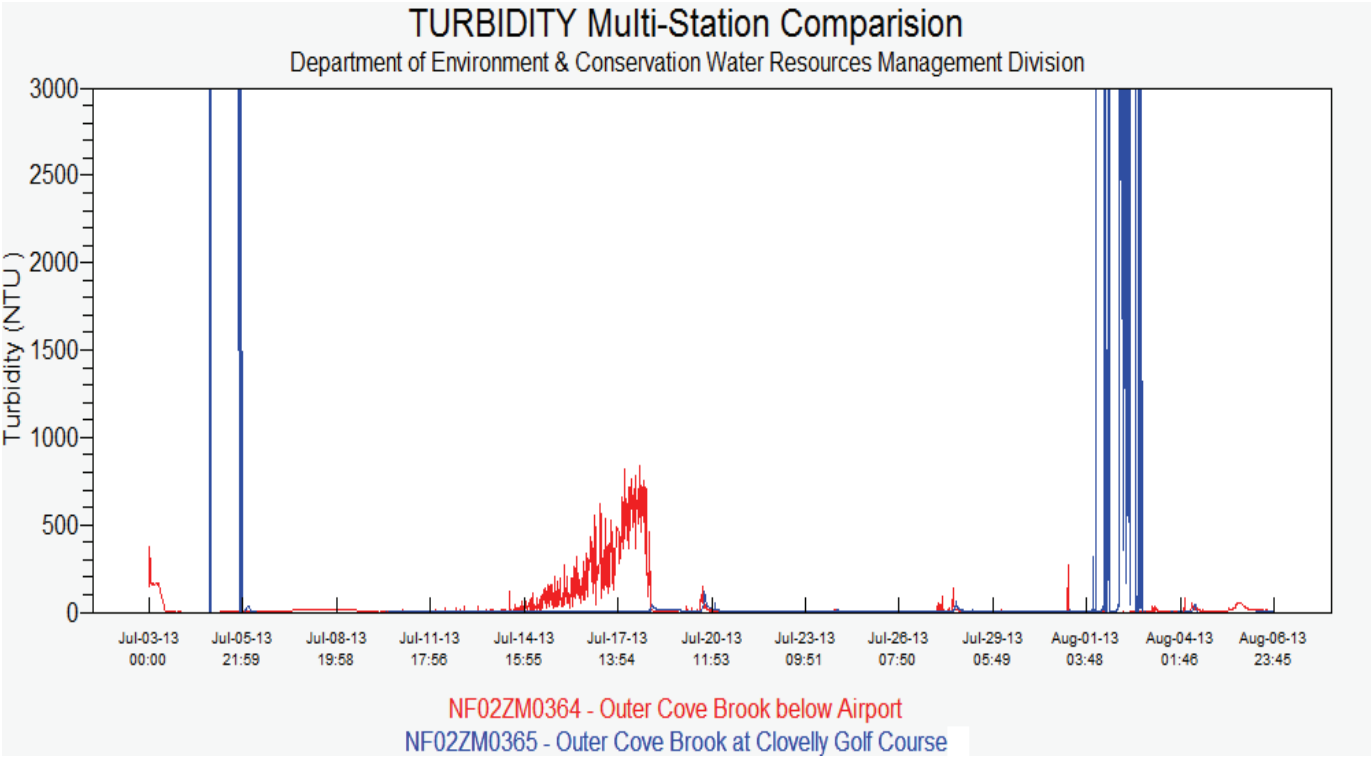

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