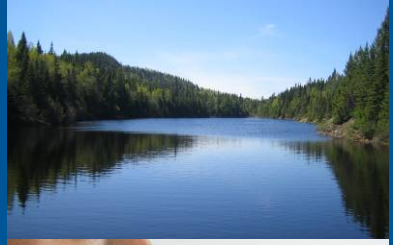





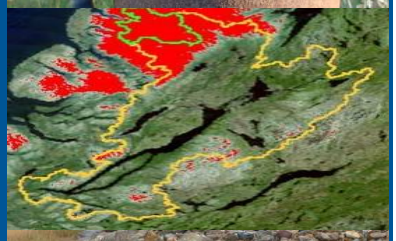

Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
April 9 to May 3, 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 24-day period from deployment on April 9, 2013 until removal on May 3, 2013.

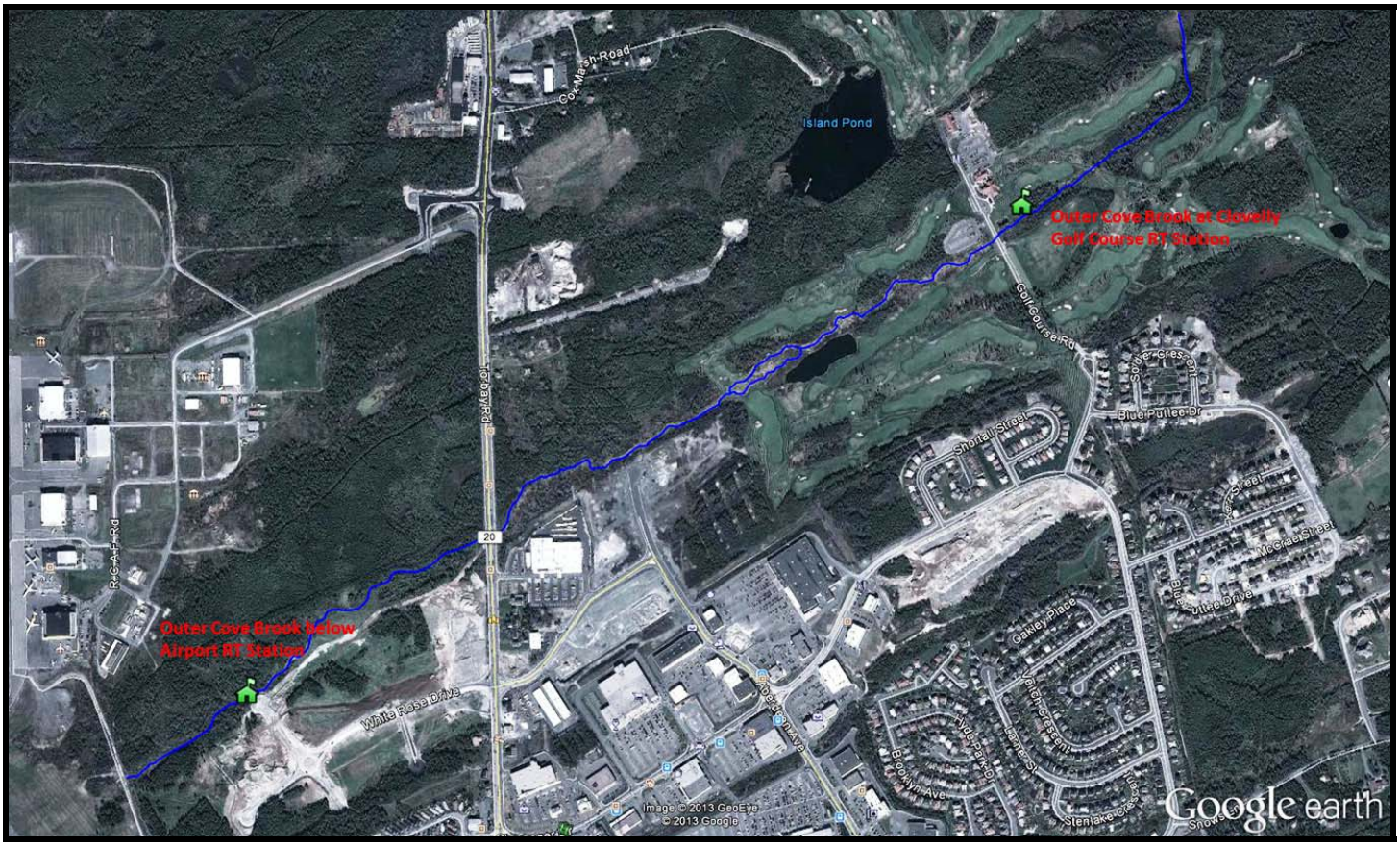


Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 April 9, 2013 through to May 3, 2013 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Apr. 9, 2013 – May. 3, 2013

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	Apr 9 2013	Deployment	Good	Good	Marginal	Good	Excellent
	May 3 2013	Removal	Good	Excellent	Poor	Poor	Poor*

- At the Outer Cove Brook below Airport station at the point of deployment, the turbidity sensor ranked 'excellent' while temperature, pH, and dissolved oxygen ranked 'good'. The conductivity sensor ranked 'marginal', likely due to the QA/QC sonde or field sonde reading being taken before the probe had stabilized.

- At removal, pH ranked as 'excellent' and temperature ranked as 'good'. Conductivity, dissolved oxygen and turbidity ranked as 'poor', as was to be expected after observing a constant rise in turbidity values over the month, reaching the maximum and error value of 3000#, indicative of sensor blockage. The sensor also jumped around frequently between 3000 NTU and 20NTU after April 30th. When the sonde was removed, heavy growth of a 'fur-like' slime substance again coated the sonde casing and the sensors, as in the previous deployment period.

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of April 9, 2013 through to May 3, 2013 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Apr 9, 2013 – May 3, 2013

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Apr 9 2013	Deployment	Good	Good	Good	Excellent	Excellent
	May 3 2013	Removal	Excellent	Good	Fair	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, temperature and dissolved oxygen ranked 'excellent', while pH ranked 'good'. The conductivity sensor ranked as 'fair'. The turbidity sensor ranked as 'poor', despite having been cleaned April 23rd. Analysis of the turbidity data at this site shows that biofouling is an issue. The presence of a brown 'film' was noted on the sensors.

- 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 no transmission errors during this deployment period at either the below airport station or the Clovelly Golf Course station.
- During this deployment period, the stations were visited frequently to determine whether or not the 'slime' substance present on April 9th was still present in the river. The 'slime' was present throughout the deployment period at the airport station, and again coated the sonde probes and casing during removal on May 3rd. It can be expected that this thick coating of 'slime' will affect the probes and thus the data.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from April 9 to May 3, 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 2.10°C to 11.70°C during this deployment period (Figure 2).
- Water temperatures rise from just above freezing to above 10°C, as expected during the spring months, with a further increase in temperatures noted during the last week of the deployment. This is consistent with ambient air temperatures over this time period.
- 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.

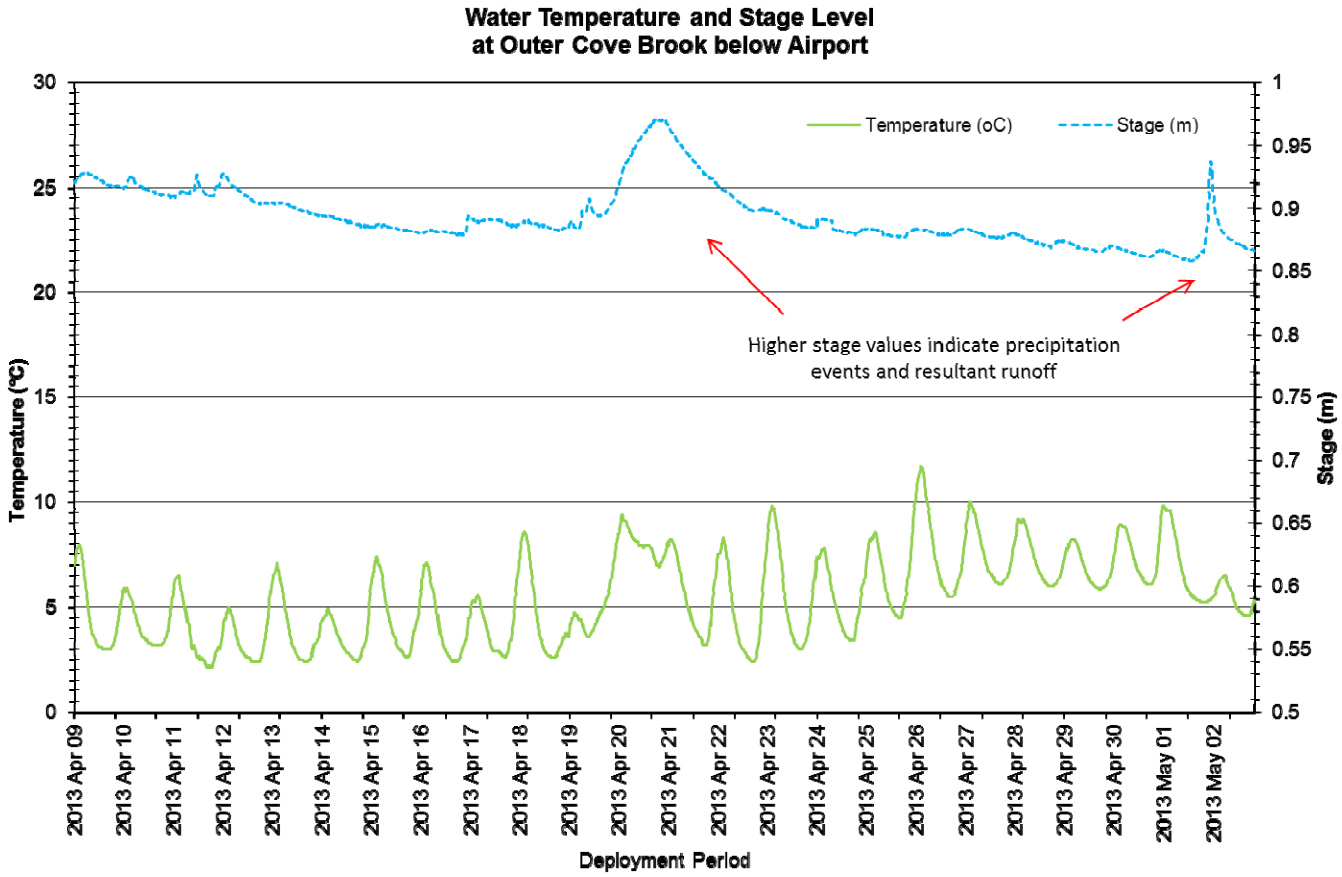


Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period April 9, 2013 to May 3, 2013.

pH

- Throughout this deployment period pH values ranged between 6.49 pH units and 7.02 pH units (Figure 3). The maximum value of 7.02 pH units is higher than the 2012 maximum value at this station of 6.96 pH units.
- During the deployment, the pH values at this station hover just above the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units). There is a notable drop in pH on April 21, related to a precipitation event (Figure 3). This is a natural occurrence between rainfall and pH levels. The pH stays low after this precipitation event, compared to the beginning of the deployment period.
- 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.

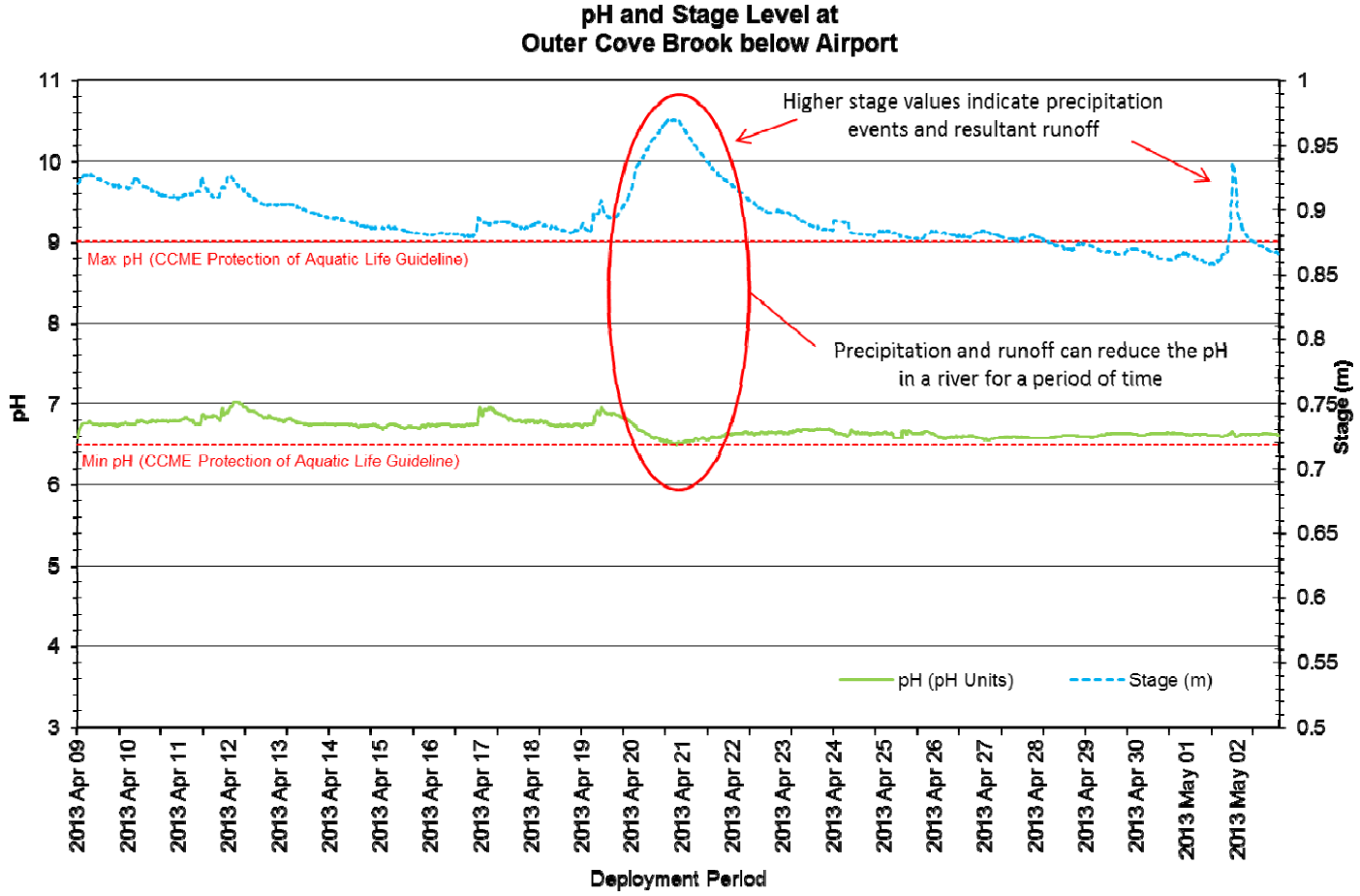


Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period April 9, 2013 to May 3, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 252 µS/cm and 922 µS/cm during this deployment period. TDS ranged from 0.1620 g/L to 0.5900 g/L.
- Generally, rainfall events, such as that which occurred on April 21 (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.
- There is a significant spike in conductivity and TDS on April 17th, accompanied by a small increase in stage. This indicates some input or disturbance in the river at this time which may have led to resuspension of solids and salts. This river has been under investigation by Environment Canada, and this spike may result from disturbance due to sampling upstream or near the station, or due to ATV usage upstream as users frequently drive through the river.
- 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.

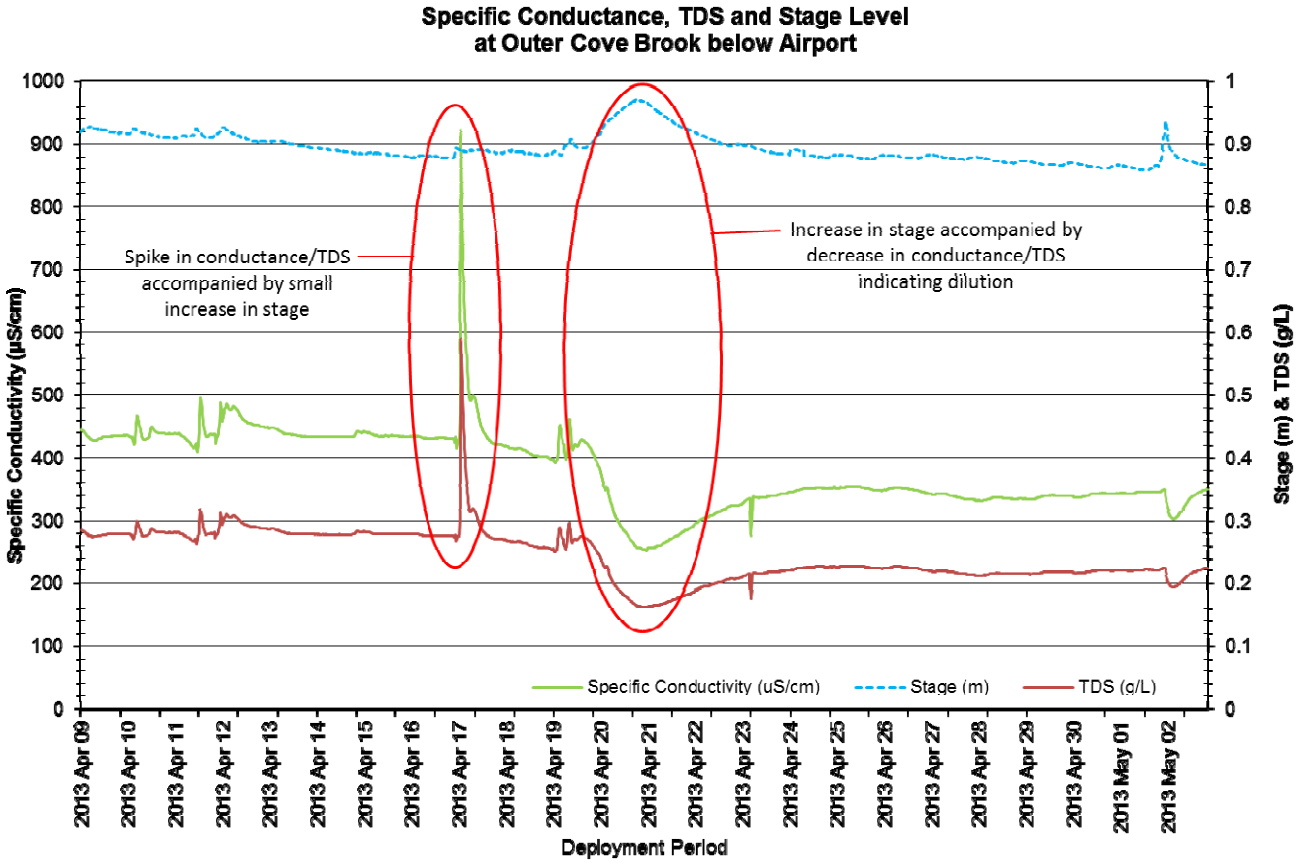


Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period April 9, 2013 to May 3, 2013.

Dissolved Oxygen

- The instrument measures percent saturation directly, then calculates dissolved oxygen (mg/L) using the percent saturation and water temperature values.
- The Dissolved Oxygen % Sat levels within this deployment period were within 15.2% Sat–89.4% Sat. Dissolved Oxygen (mg/L) measured 1.73 mg/L to 11.98 mg/L.
- The DO mg/L values are above the minimum DO CCME guideline for early life stages for the majority of the deployment until April 24th (see Figure 5). After this, the DO readings gradually decline. This is likely due to biofouling of the sensor as there is a large amount of 'furry slime' present in the river and around the probes. The data from April 24-May 3 will be removed from the dataset.
- Dissolved Oxygen percent saturation remains relatively constant throughout the deployment period until April 24th. 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.

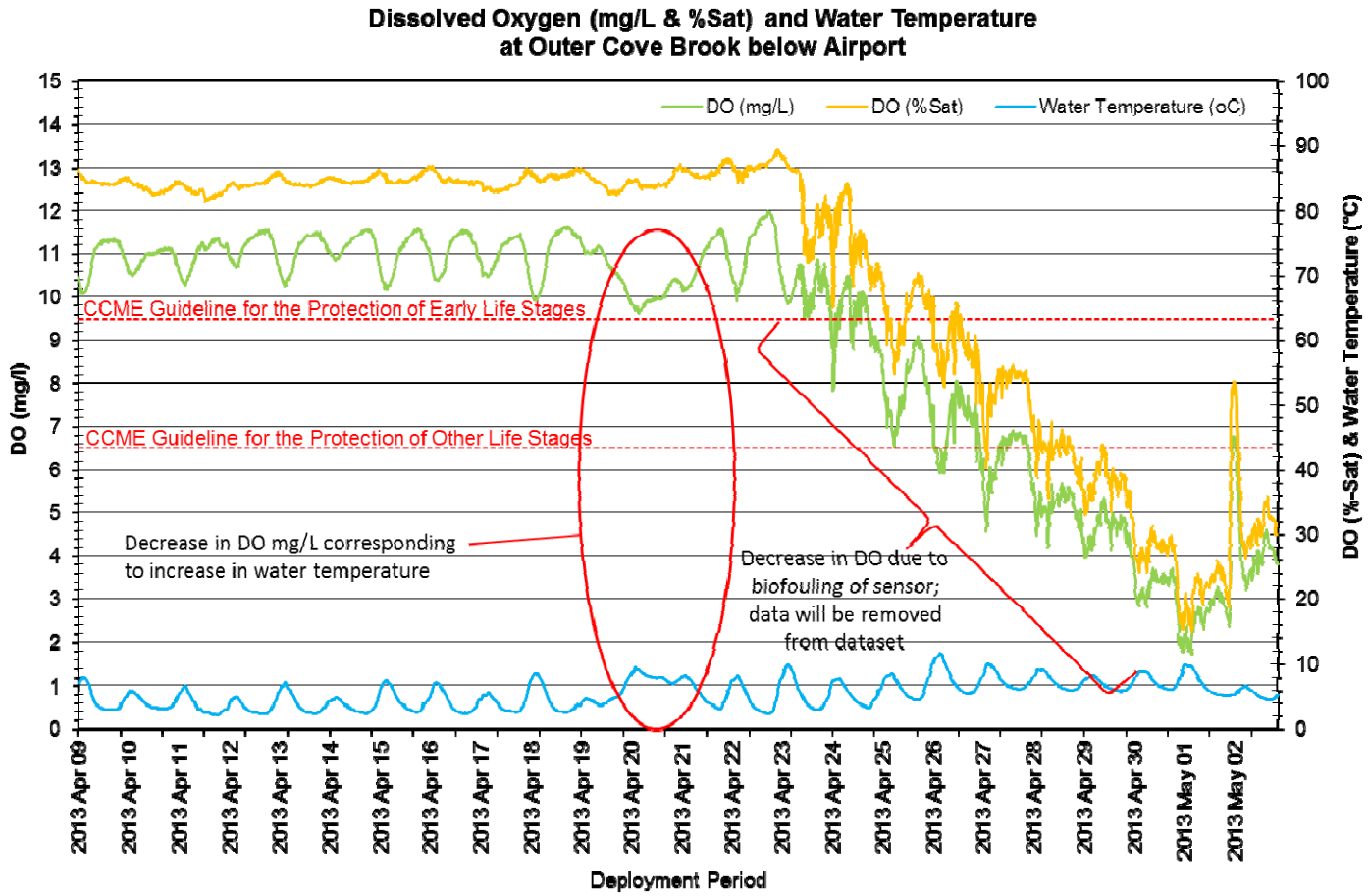


Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period April 9, 2013 to May 3, 2013.

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. From April 23 until the end of deployment, turbidity values increased constantly, maxing out at 3000 NTU, indicating complete blockage of the turbidity sensor or a sensor issue. Values at the end of this deployment period had reached 3000, and thus this data was removed as it was incorrect. Biofouling was evident on the sonde during removal.
- The turbidity readings from April 9 to April 23 ranged within 0.0 NTU to 96.8 NTU. Data from April 23 to removal on May 3 were excluded as there was an issue with the sensor.
- 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 'poor' performance ranking at removal due to the large amount of biofouling occurring around the sensors and on the casing. The substance which fouled the sensors was a thick, whitish-brown 'furry slime', which coated all the equipment in the water as well as the river bed and surrounding vegetation.

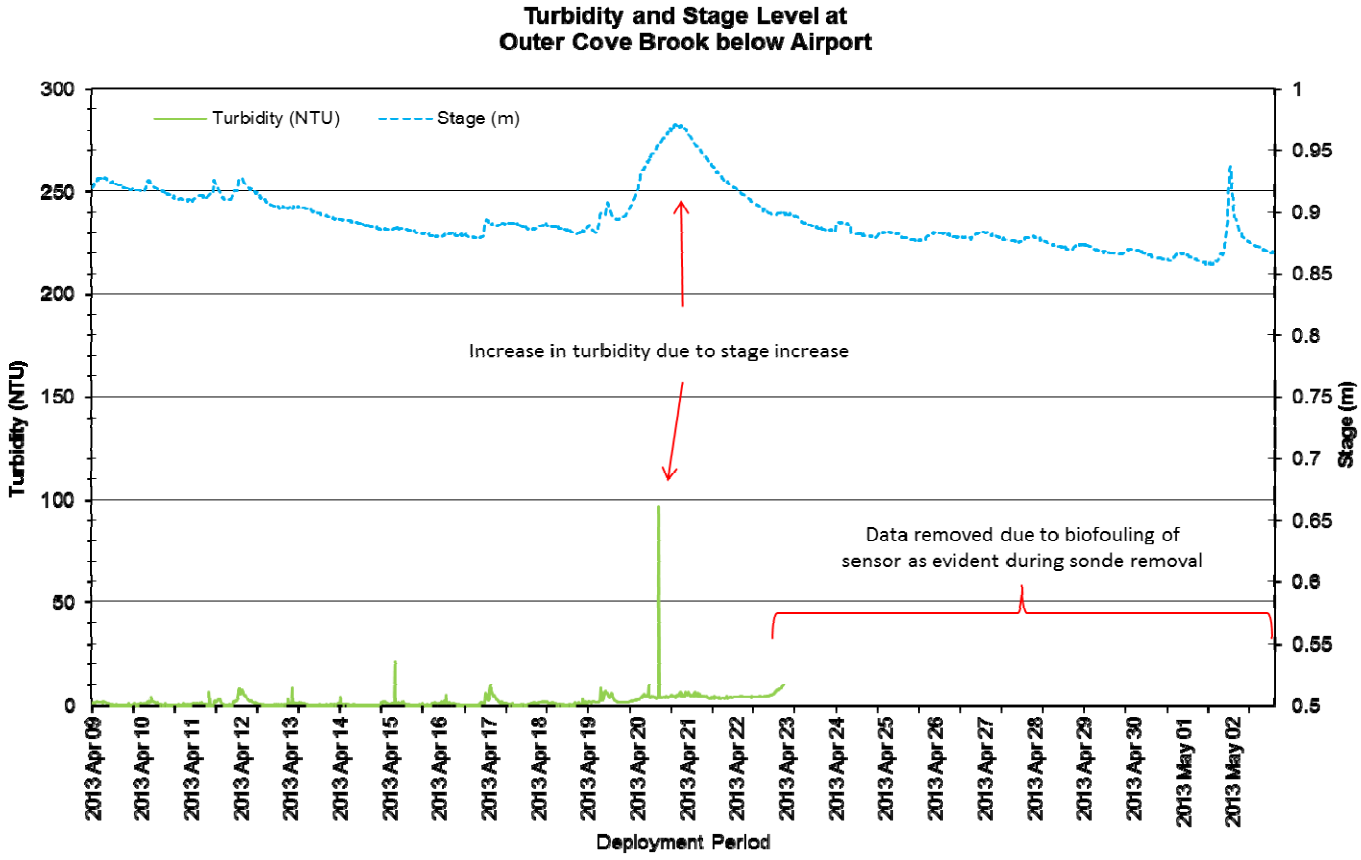


Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period April 9, 2013 to May 3, 2013.

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 0.86m to 0.97m.

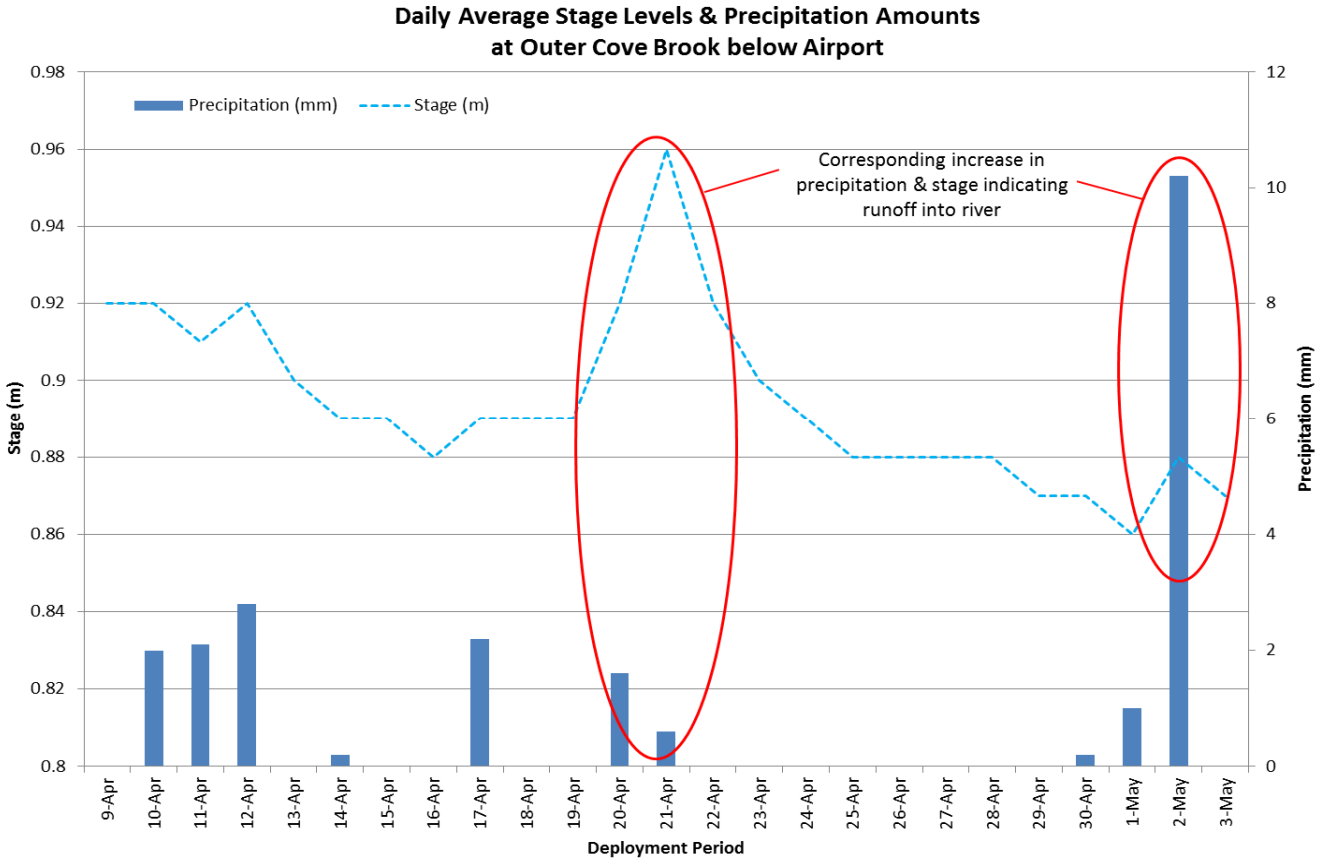


Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period April 9, 2013 to May 3, 2013.

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 began to warm in the spring, 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. High turbidity values at removal and a 'poor' sensor ranking are explained by the presence of a thick slime coating the casing, probe, and all rocks and vegetation in the river.
- An unusual spike in conductivity is due to some input or disturbance upstream of the station. A small spike in turbidity was noted at the same time. This may be due to water sampling occurring upstream as part of the Environment Canada investigation occurring in this river, or due to ATVs running across the river near the airport fence, as evident during a field visit to this location.
- It is evident from the pH, DO and turbidity data that the event or input into the river which occurred in previous months is still influencing the river and producing a slime-like growth in this river. The prolific 'slime' substance coating the river and equipment is further evidence that a definite water quality event took place in this river system.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from 2.01°C to 12.81°C during this deployment period (Figure 8).
- Water temperatures rise from just above freezing to above 10°C, as expected during the spring months, with a further increase in temperatures noted during the last week of the deployment. This is consistent with ambient air temperatures over this time period.
- 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.

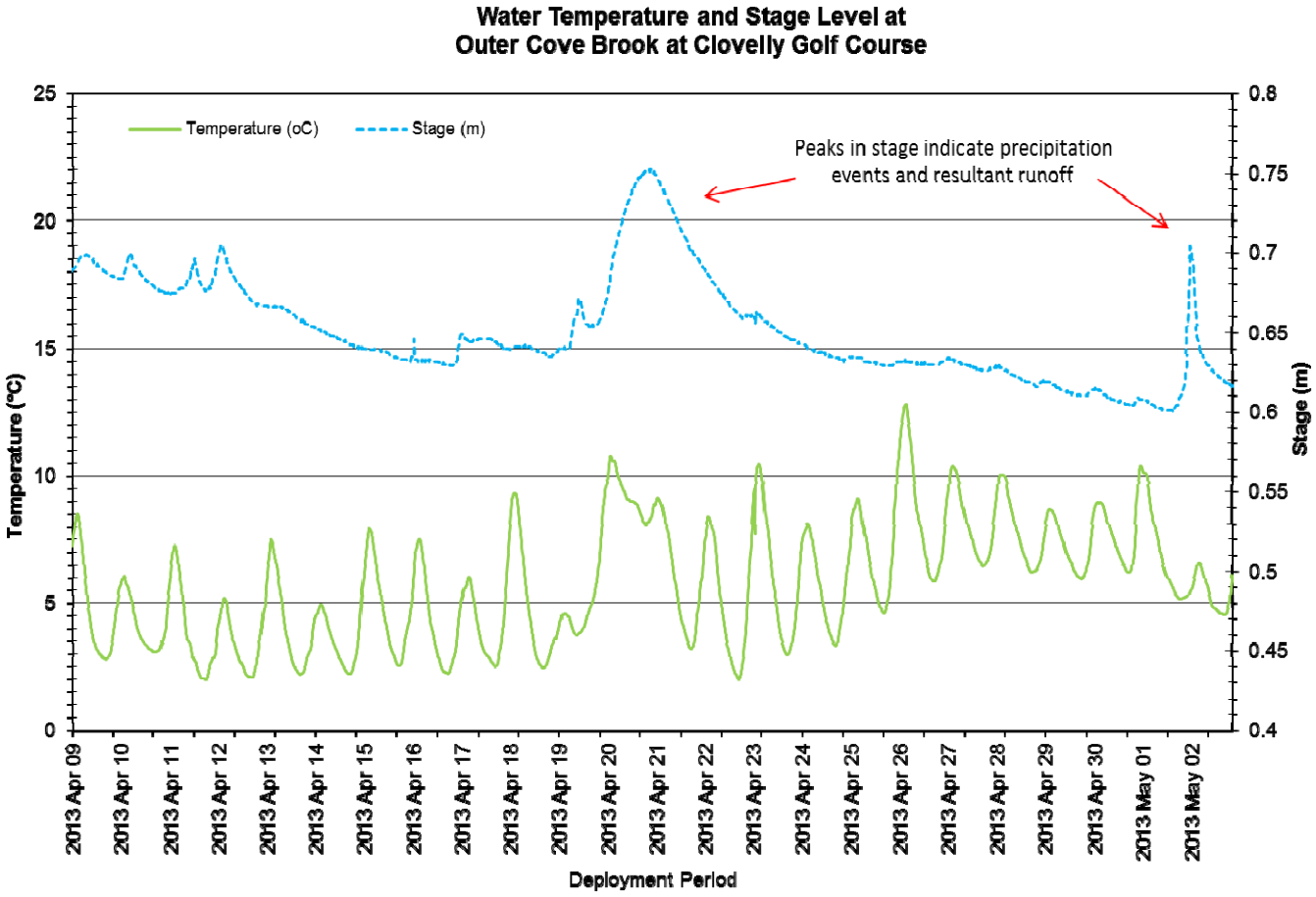


Figure 8: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period April 9, 2013 to May 3, 2013.

pH

- Throughout this deployment period pH values ranged betwen 6.56 pH units and 6.88 pH units (Figure 9).
- 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) but never go below 6.50 pH units.
- There is a notable drop in pH on April 21, related to a precipitation event. 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.

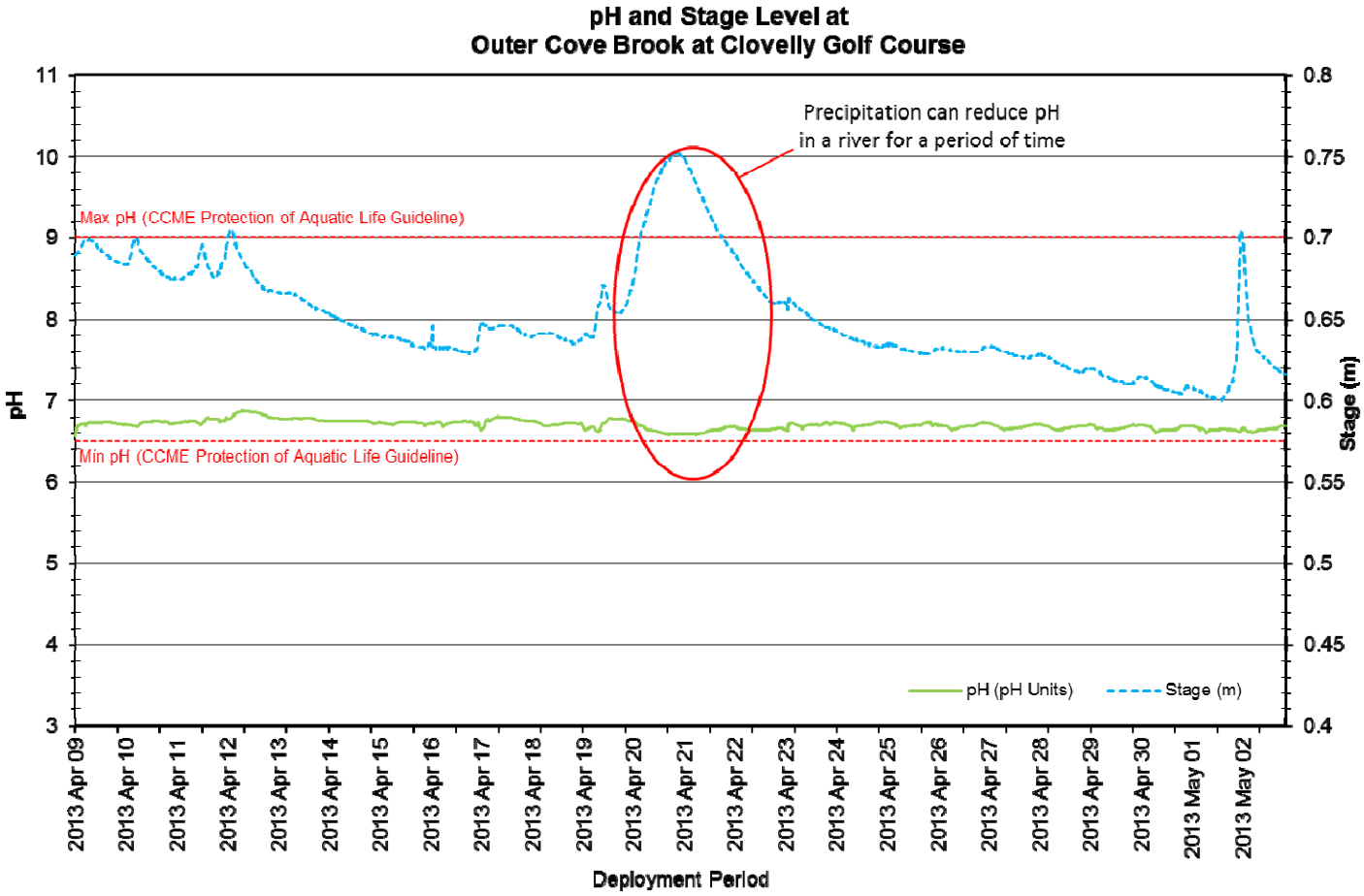


Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period April 9, 2013 to May 3, 2013.

Specific Conductivity & TDS

- The conductivity levels were within 284 µS/cm and 898 µS/cm during this deployment period. TDS ranged from 0.1820 g/L to 0.5740 g/L. These values are notably lower than those of the previous deployment period.
- Generally, rainfall events, such as that which occurred on April 21 (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.
- There is a significant spike in conductivity and TDS on April 17th, accompanied by a small increase in stage. This increase was also evident at this time at the below airport station. This indicates some input or disturbance in the river at this time which may have led to resuspension of solids and salts. This river has been under investigation by Environment Canada, and this spike may result from disturbance due to sampling upstream or near the station. Other possible causes of the river disturbance include construction occurring upstream and ATV usage cutting through the river.
- 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.

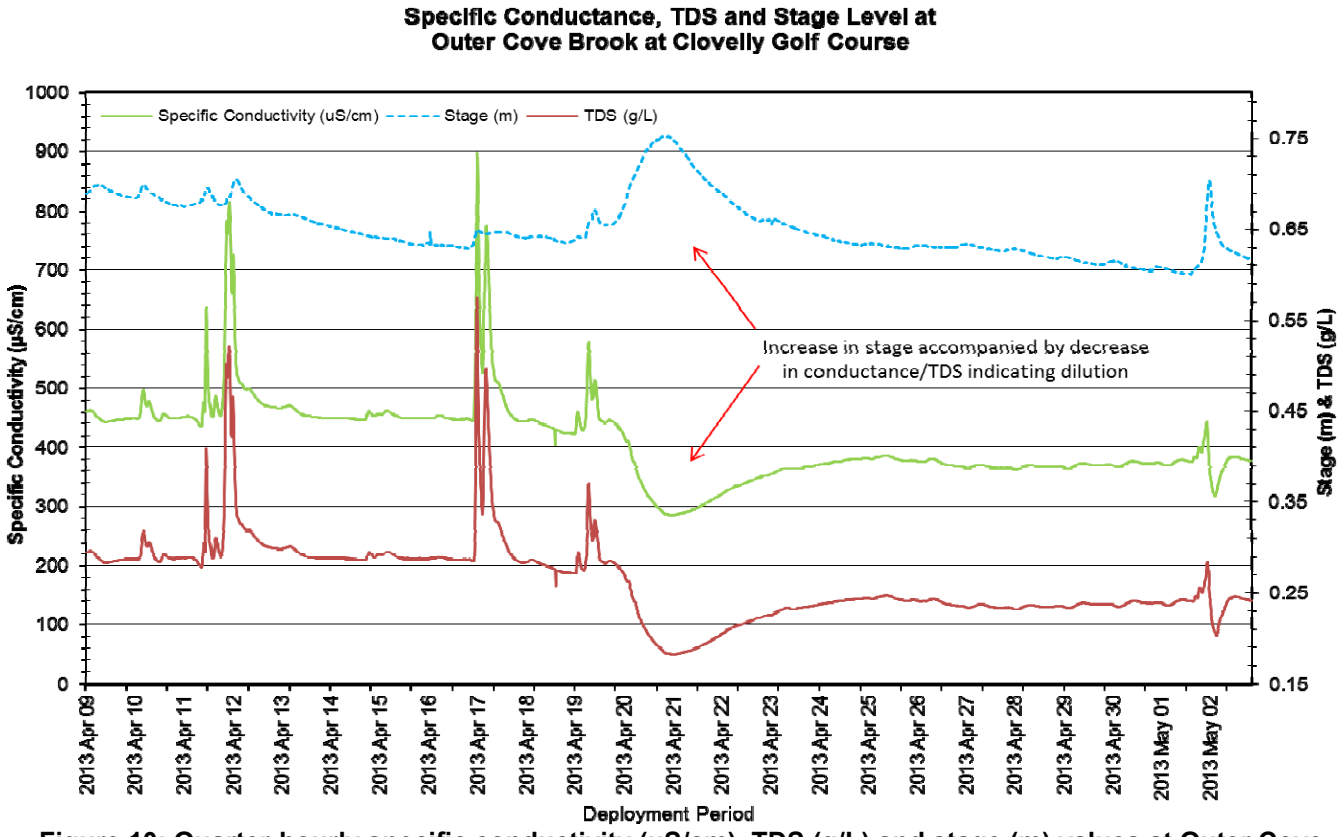


Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period April 9, 2013 to May 3, 2013.

Dissolved Oxygen

- The instrument measures percent saturation directly, then calculates dissolved oxygen (mg/L) using the percent saturation and water temperature values.
- The Dissolved Oxygen % Sat levels within this deployment period were within 68.6% Sat–87.6% Sat. Dissolved Oxygen (mg/L) measured 7.79 mg/L to 11.47 mg/L. The DO mg/L values are above the minimum DO CCME guideline for early life stages for the majority of the deployment, but dip below this threshold on several occasions, notably April 20th and 26th (see Figure 11). This coincides with peaks in water temperatures during this period.
- 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.

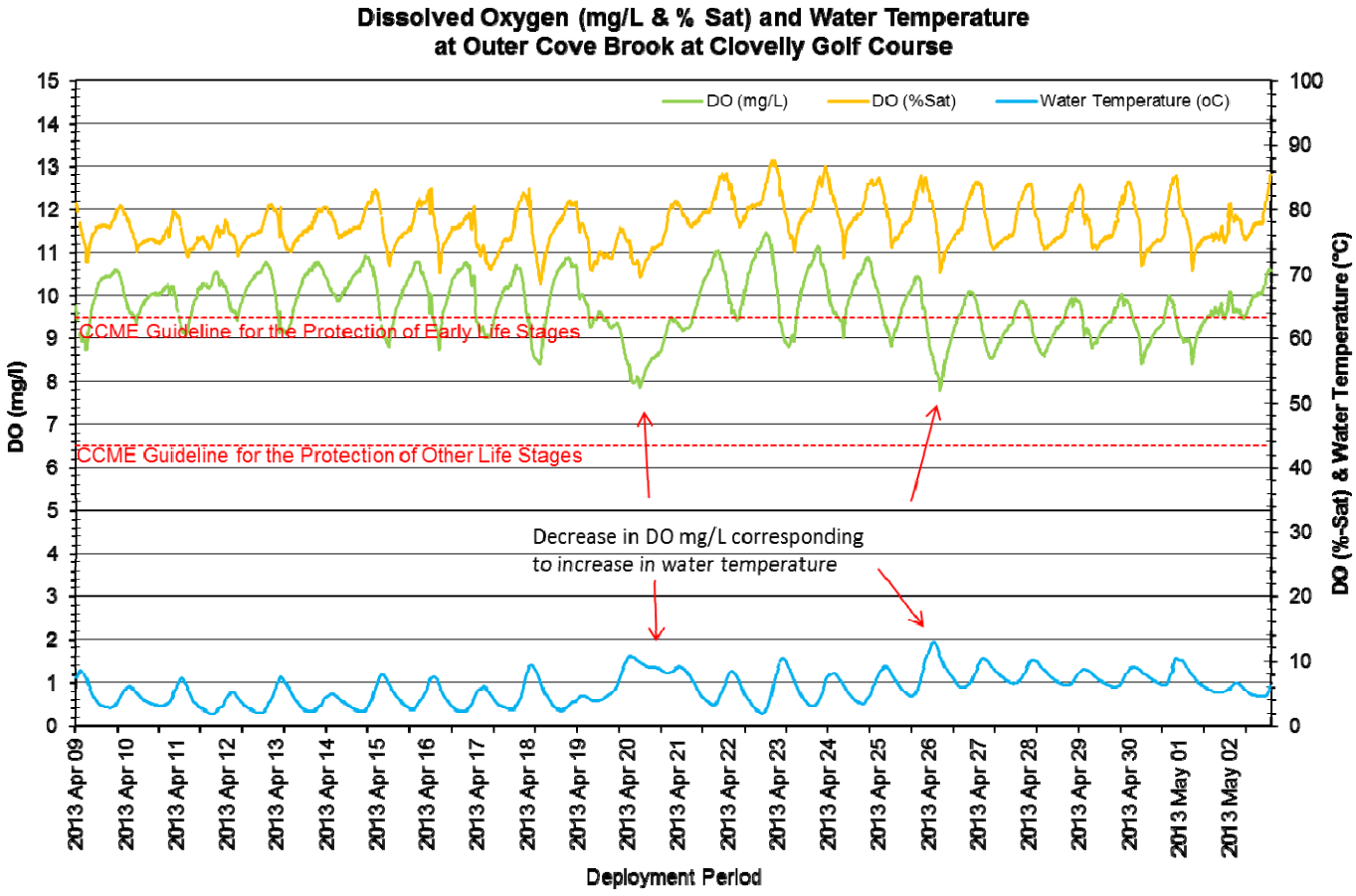


Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course for the deployment period April 9, 2013 to May 3, 2013.

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, this is not a valid turbidity reading.
- The turbidity readings during this deployment, for data that was not removed due to biofouling ranged within 2.5 NTU to 47.7 NTU (Figure 12).
- This sensor was cleaned on April 23 when a constant climb in turbidity indicated biofouling of the sensor. Once the thin layer of brown slime was cleaned from the sensor, turbidity dropped down, indicating the sensor had been fouled. The 'poor' sensor reading at removal indicates that biofouling is an interfering factor at this location.
- Several precipitation events and corresponding stage increases led to fluctuating turbidity values as sediment and debris were resuspended into the water column.

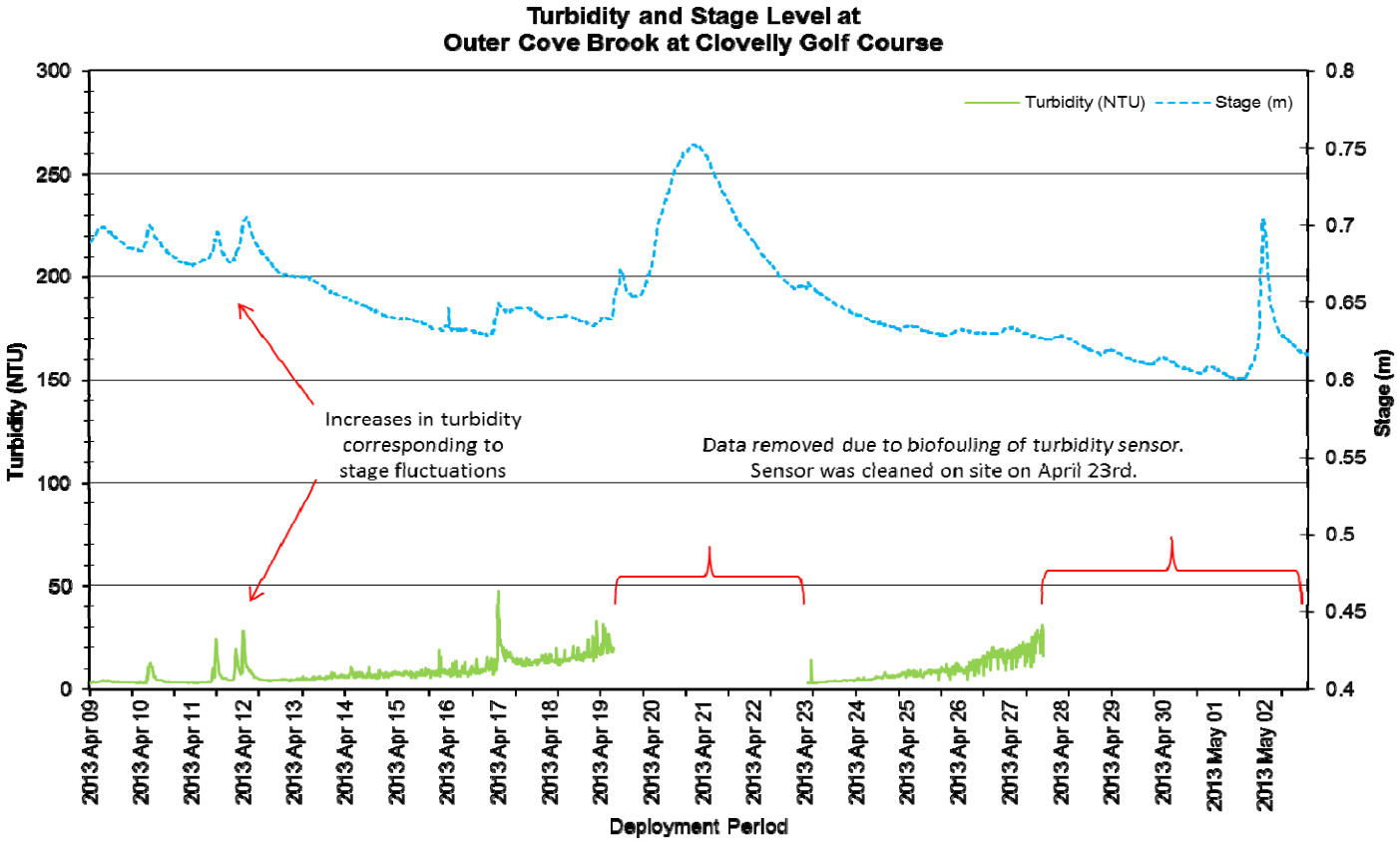


Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period April 9, 2013 to May 3, 2013.

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 0.60m to 0.75m.

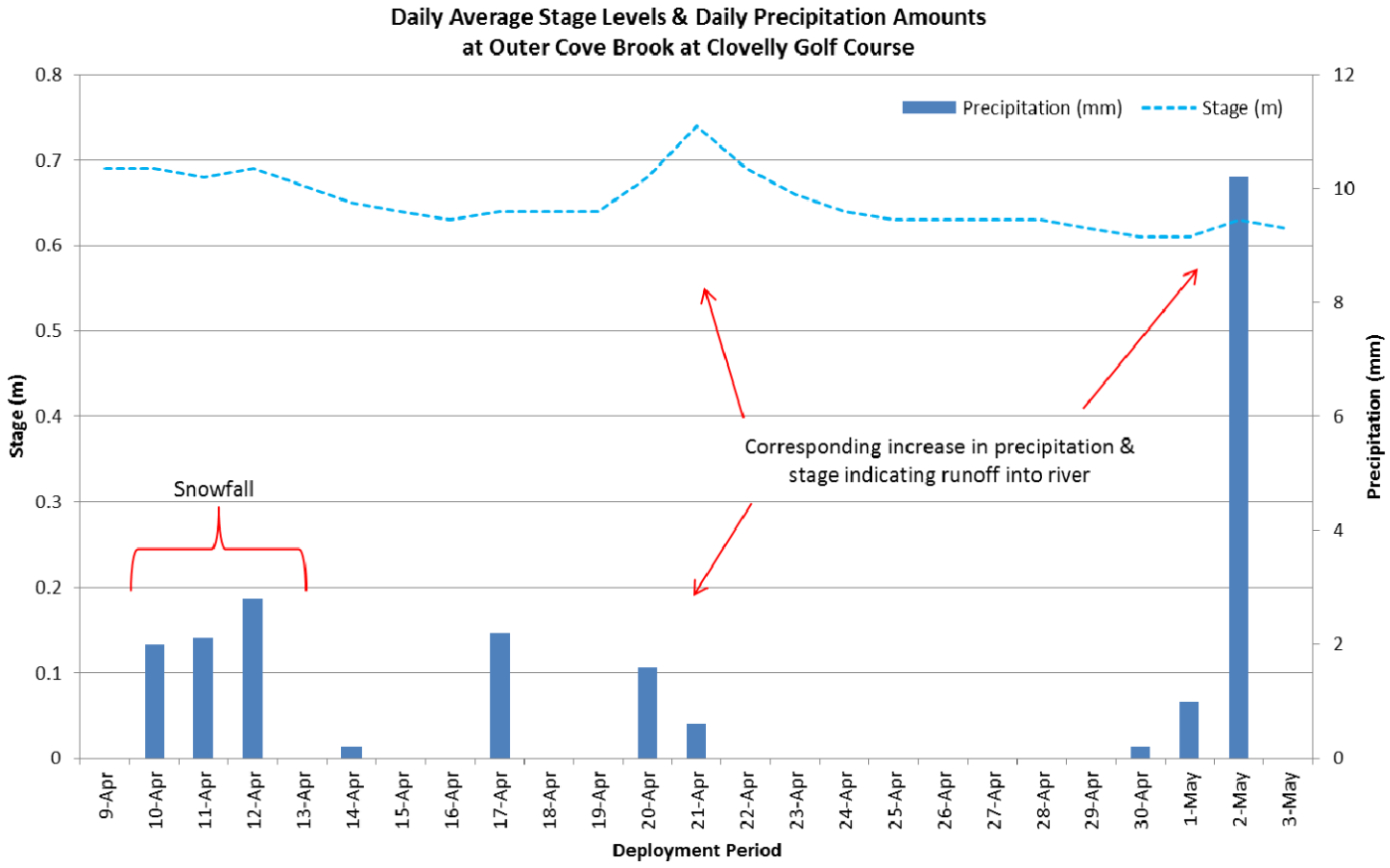


Figure 13: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period March 6 to April 9, 2013.

Conclusions – Outer Cove Brook at Clovelly Golf Course

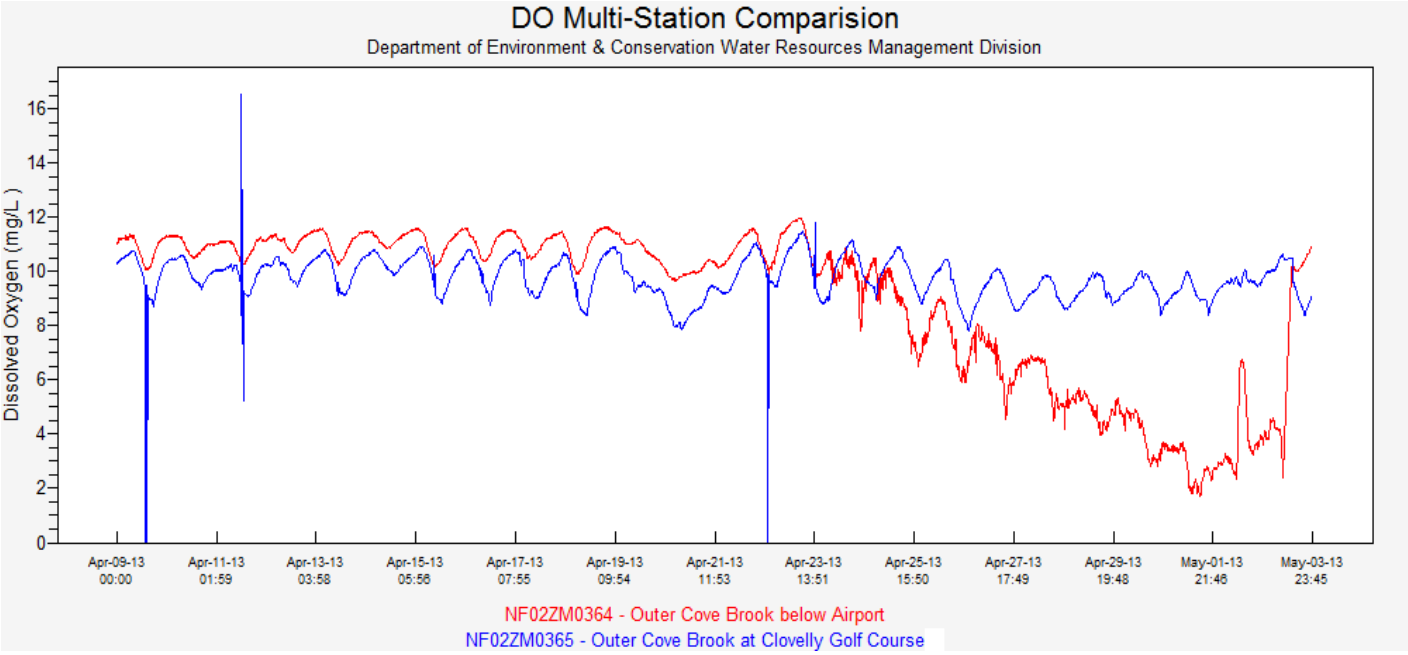
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures began to warm in the spring, there were correspondingly warmer water temperatures, which in turn decreased the amount of dissolved oxygen in the water.
- High turbidity values at removal and a 'poor' sensor ranking are explained by the presence of a thin layer of brownish slime coating the sensors. To prove the presence of biofouling at this site, the sensor was cleaned on April 23rd after a steady climb in turbidity values, and resulted in a drop in turbidity values, before biofouling again built up on the probes.
- It is evident from the conductivity data (Figure 10) that there is an influence upstream of this station which is causing spikes in TDS and conductance values. This may be related to construction upstream of this station near Torbay Road, or some other disturbance of the river causing resuspension of solids present in the water.

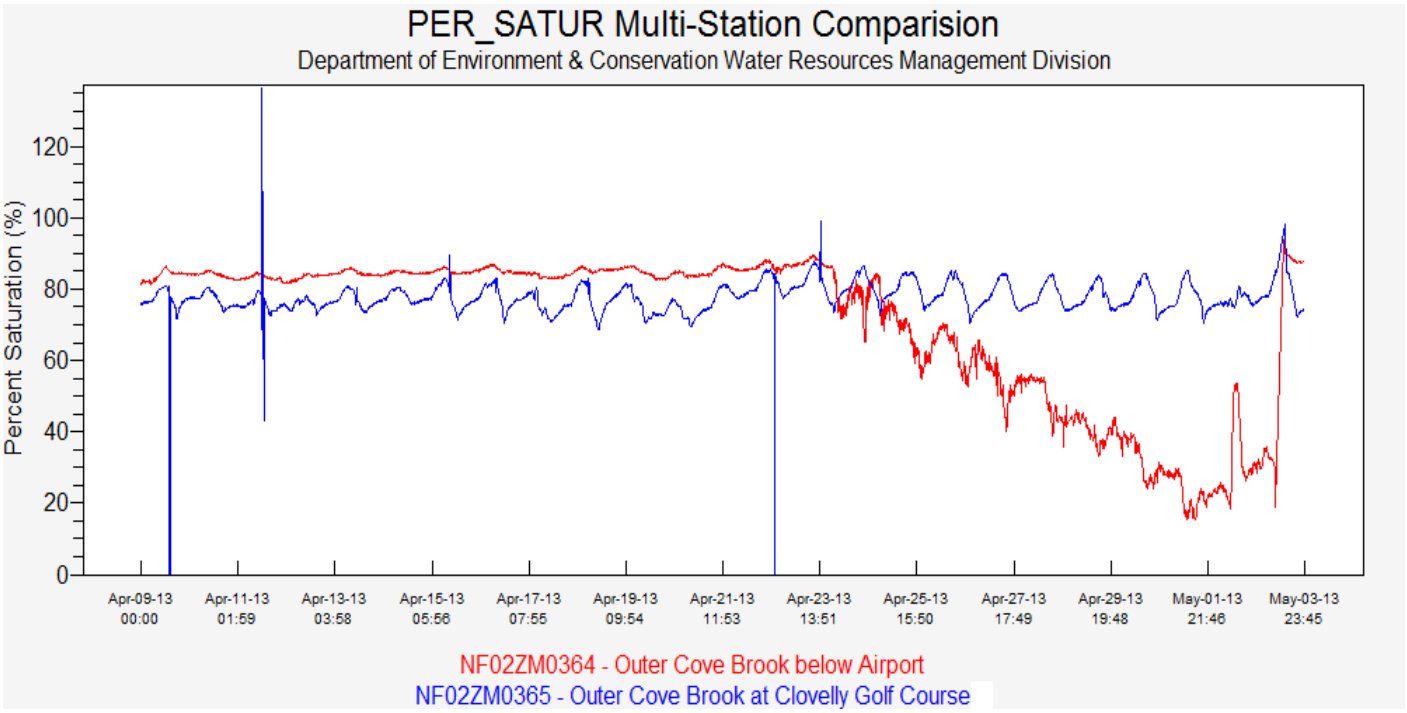
Conclusions – Outer Cove Brook Network

During this deployment period, the median water temperature at the upstream station (below Airport) of 5.35°C was very similar to that of the downstream station (at Clovelly Golf Course) of 5.60°C. The median pH values for both were also comparable with below Airport's median at 6.67 and Clovelly Golf Course reading 6.70, and thus no significant change in pH from the upstream to the downstream station. The specific conductivity medians were similar at both stations with 353 uS/cm reported below the airport and 382.5 uS/cm reported at the golf course. These values are approximately 200 uS/cm lower than during the previous deployment period. It should be noted that when conductance and TDS data from both stations are analyzed together, there are spikes in both parameters on April 12th, 19th and May 1st at Clovelly that do not occur at the airport station. This indicates some influence is increasing these parameters between the airport and golf course. This may be an influence of ongoing construction near Torbay Road. Dissolved oxygen at the upstream station (below Airport) had a median of 83.6%Sat during the deployment period, while the downstream station (Clovelly Golf Course) had a lower median of 77.2%Sat. This lower oxygen content at the downstream station may be due the presence of more salts in water at this station, as indicated by specific conductance values, which lowers the amount of oxygen the water can hold. A comparison of turbidity cannot be made between stations as both stations had significant biofouling or sensor issues.

Appendix

Parameter Station Comparison Graphs





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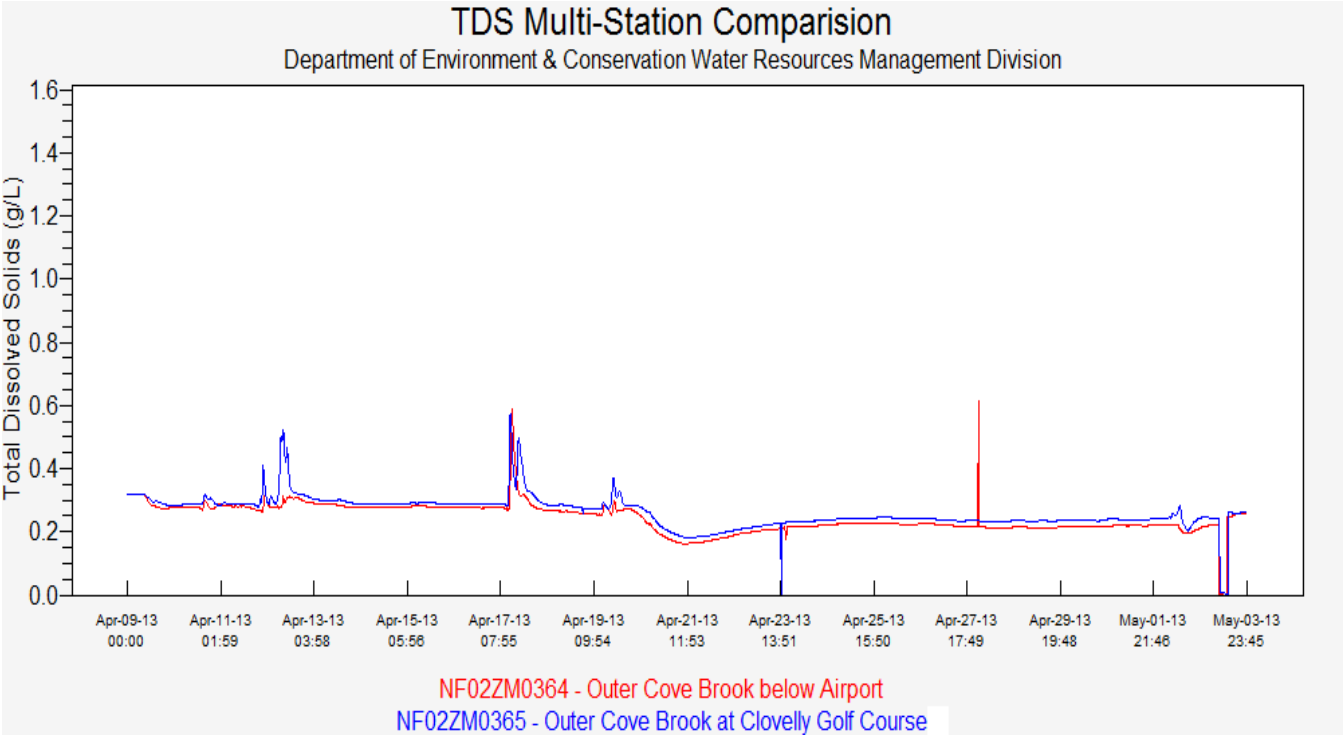

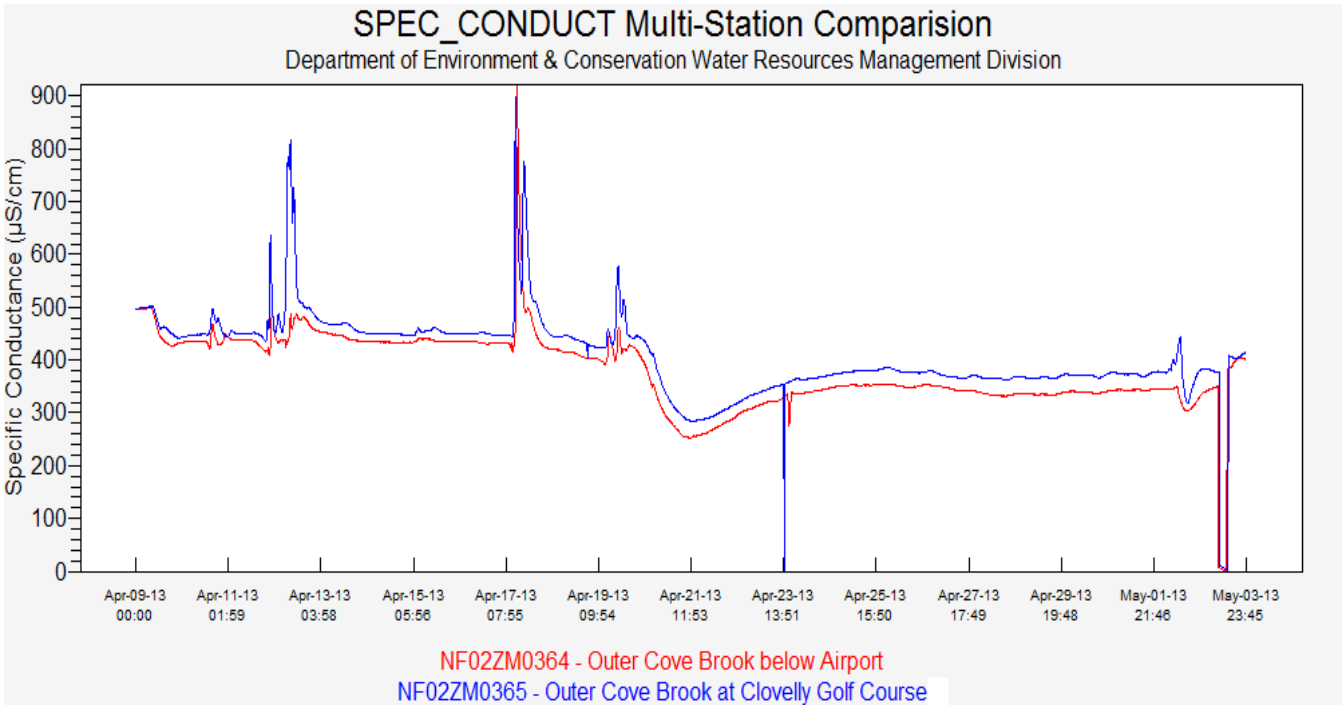

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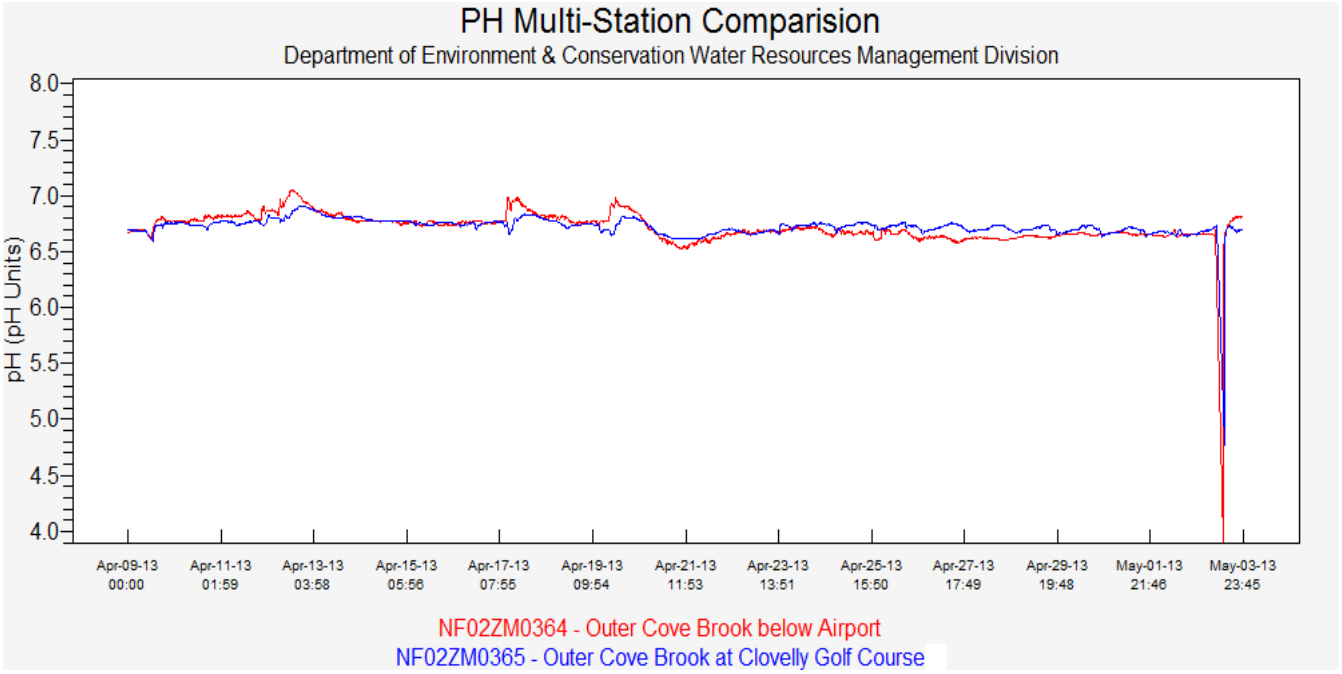

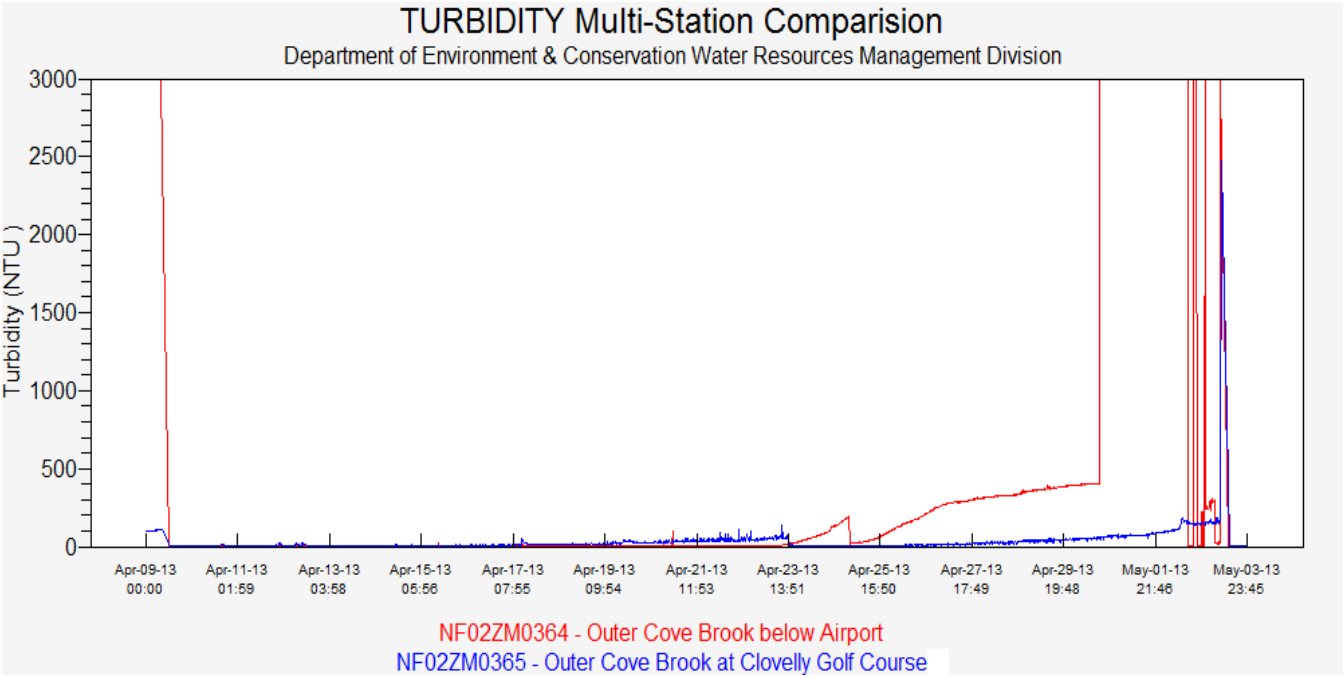

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