Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
February 21, 2014 to April 8, 2014

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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Outer Cove Brook, Newfoundland and Labrador

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 47-day period from deployment on February 21, 2014 until removal on April 8, 2014.

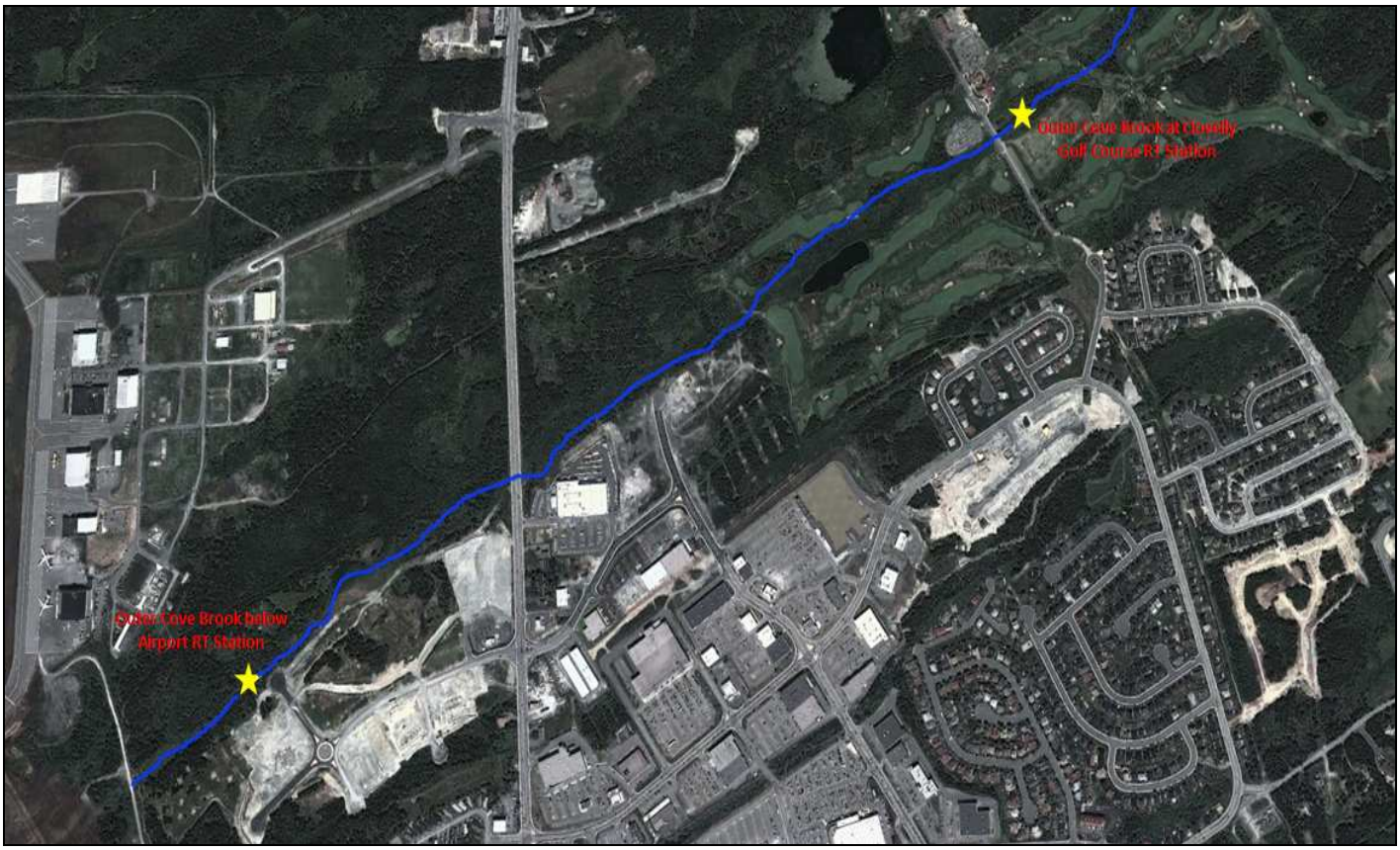

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 February 21, 2014 to April 8, 2014 are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport Feb 21, 2014 – April 8, 2014

Station	**Date**	**Action**	**Comparison Ranking**				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Below Airport	**Feb 21 2014**	**Deployment**	Excellent	Good	Excellent	Fair	Excellent
	April 8 2014	**Removal**	Excellent	Marginal	Excellent	Poor	Excellent

- At the Outer Cove Brook below Airport station at the point of deployment, the water temperature, pH, conductivity and turbidity sensor ranked as 'excellent' & 'good' while the dissolved oxygen data ranked 'fair'. The 'fair' ranking may be due to the sonde potentially needing more time to stabilize before the dissolved oxygen values were recorded.

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- At removal, the temperature, conductivity and turbidity data all ranked 'excellent', the pH data ranked as 'marginal'. The dissolved oxygen data ranked 'poor'. At the time of removal there was a lot of biofouling on the sensors. This type of fouling can inhibit the sensors ability to read correctly.

- Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** for the period of February 21, 2014 to April 8, 2014 are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course Feb 21, 2014 – April 8, 2014.

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	Feb 21 2014	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	April 8 2014	Removal	Excellent	Good	Excellent	Good	Excellent

- During the Outer Cove Brook Clovelly Golf Course station deployment, temperature, conductivity, dissolved oxygen and turbidity data all ranked as 'excellent' and pH ranked as 'good'.

  At removal, temperature, conductivity and turbidity ranked 'excellent', while pH and dissolved oxygen ranked as 'good'. These ranks are reasonably good for an instrument that has spent 47 days in the water.

- 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.

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Deployment Notes

There were several short transmission errors during this deployment period at the Outer Cove Brook below Airport stations. Due to the nature of the data transmission it is not uncommon to have the data drop out for period at a time. This station sits right among a large cover of trees, which may interfere with transmission as well.

The larger of the data gaps was between March 5, 2014 at 5:45pm through to March 7, 2014 at 12:45pm; this is evident by the gap in data on the parameter graphs for Outer Cove Brook below Airport.

Data Interpretation

The following graphs and discussion illustrate water quality-related events from February 21, 2014 through to April 8, 2014 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.

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from -0.1°C to 3.90°C during this deployment period (Figure 2).

Water temperature in this brook displays a typical variation in pattern over the deployment period. Water temperature is influenced by air temperature. Over the course of the deployment period the water temperature drops to 0°C or below several times.

On March 1st, March 25th and April 1st 2014 there is a dip in water temperature which also corresponds with increases in stage level. It can be assumed snow melt and ice melt are flushed into the brook creating a cooler water temperature at these times.

The water temperatures at this station still display diurnal variations even in the cooler months. Shallow streams and ponds are highly influenced by natural diurnal variations in the surrounding air temperatures.

Water temperature is an important parameter for this instrument. It influences the other parameters that are being measured by the water quality instrument.

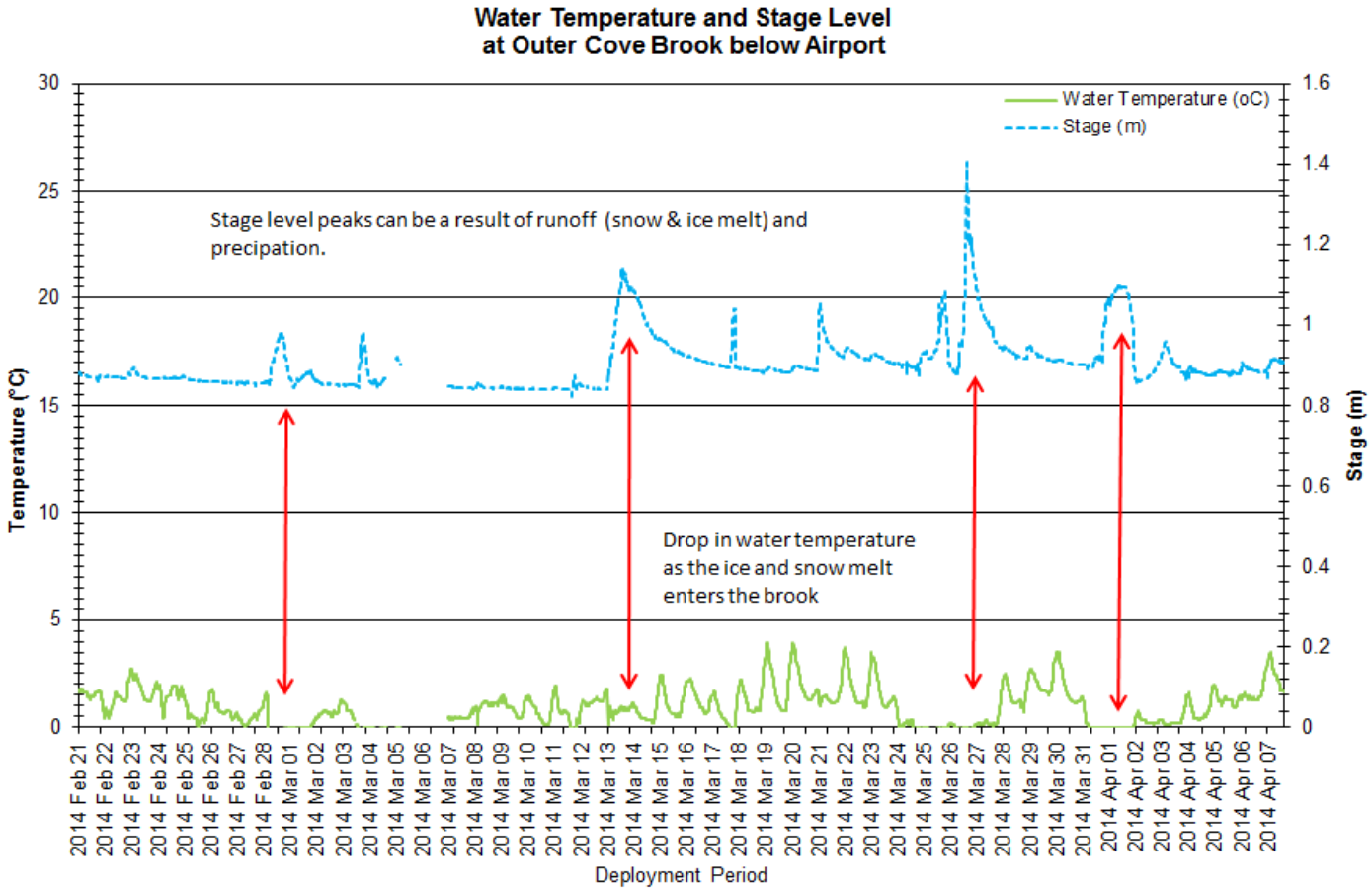

Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport.

pH

Throughout this deployment period pH values ranged between 5.84 pH units and 7.51 pH units (Figure 3).

During the deployment, the pH values at this station along the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units).

During high stage periods the pH values drop slightly lower than the minimum pH guideline. This is evident on the graph on March 1st, March 5th, March 13th, March 26th and April 3rd (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 during this deployment maintained a median of 6.57 pH units.

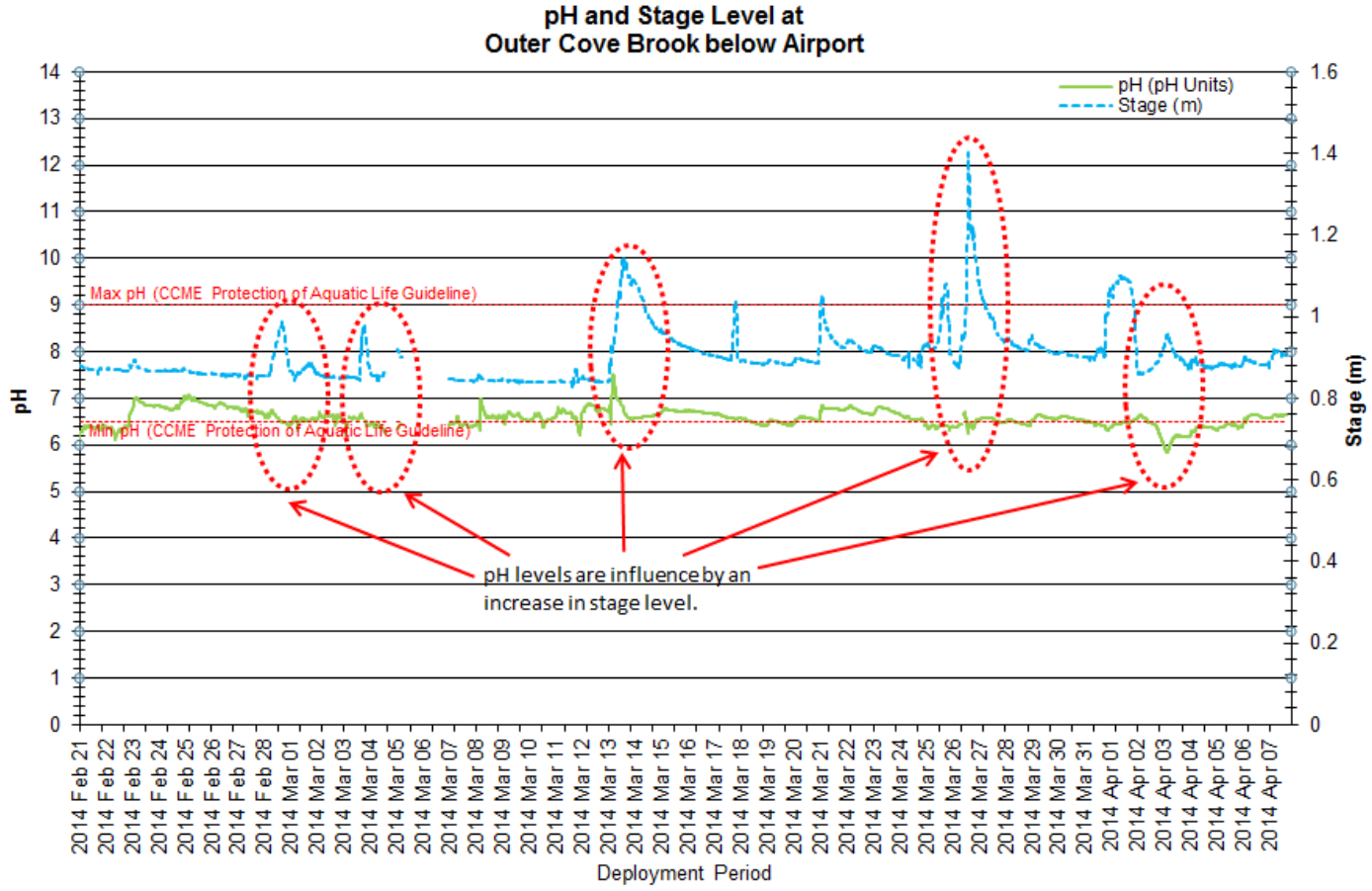

Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity & TDS

The conductivity levels were within 397.0 µS/cm and 2912.0 µS/cm during this deployment period. TDS ranged from 0.2540 g/L to 1.8600 g/L.

The peaks in conductivity on February 28th, March 13th, March 21st and March 26th, correspond with the higher stage levels. The presence of inorganic dissolved solids such as road salt and material are washed into the brook and increase the 'normal' levels of conductivity.

During the colder winter months of the year, the city roads are salted heavily. As the ice and snow thaws the residual salts are flushed into surrounding rivers and brooks.

Total Dissolved Solids (TDS), is a parameter that the instrument calculates. TDS is achieved through an algothrim that utilizes data from specific conductivity and water temperature which produces the TDS value. This value generally always mirrors specific conductivity.

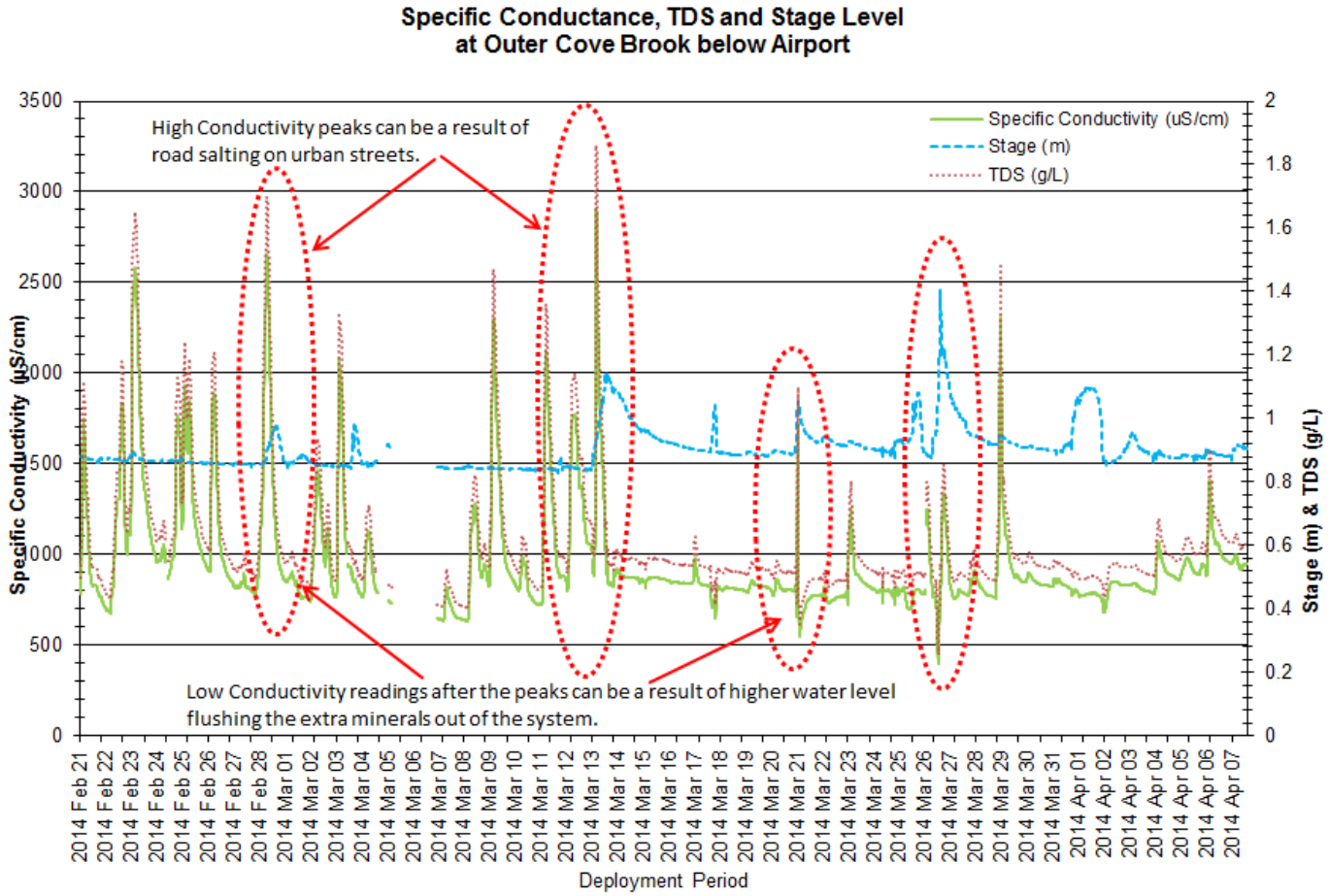

Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport.

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 59.7% Sat and 83.9% Sat. Dissolved Oxygen (mg/L) measured 8.71 mg/L to 11.93 mg/L.

The DO mg/L values are above the minimum DO CCME guideline for early life stages for the majority of this deployment period (Figure 5).

A drop in dissolved oxygen on March 24th corresponds with a sharp increase in conductivity, stage level and a drop in water temperature. The decrease is likely due to the large amount of salts present in the brook, this can lower the amount of oxygen the water can hold.

The display of DO data from March 31st through to April 7th indicates fouling on the sensor (see Appendix B for pictures of the fouling).

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.

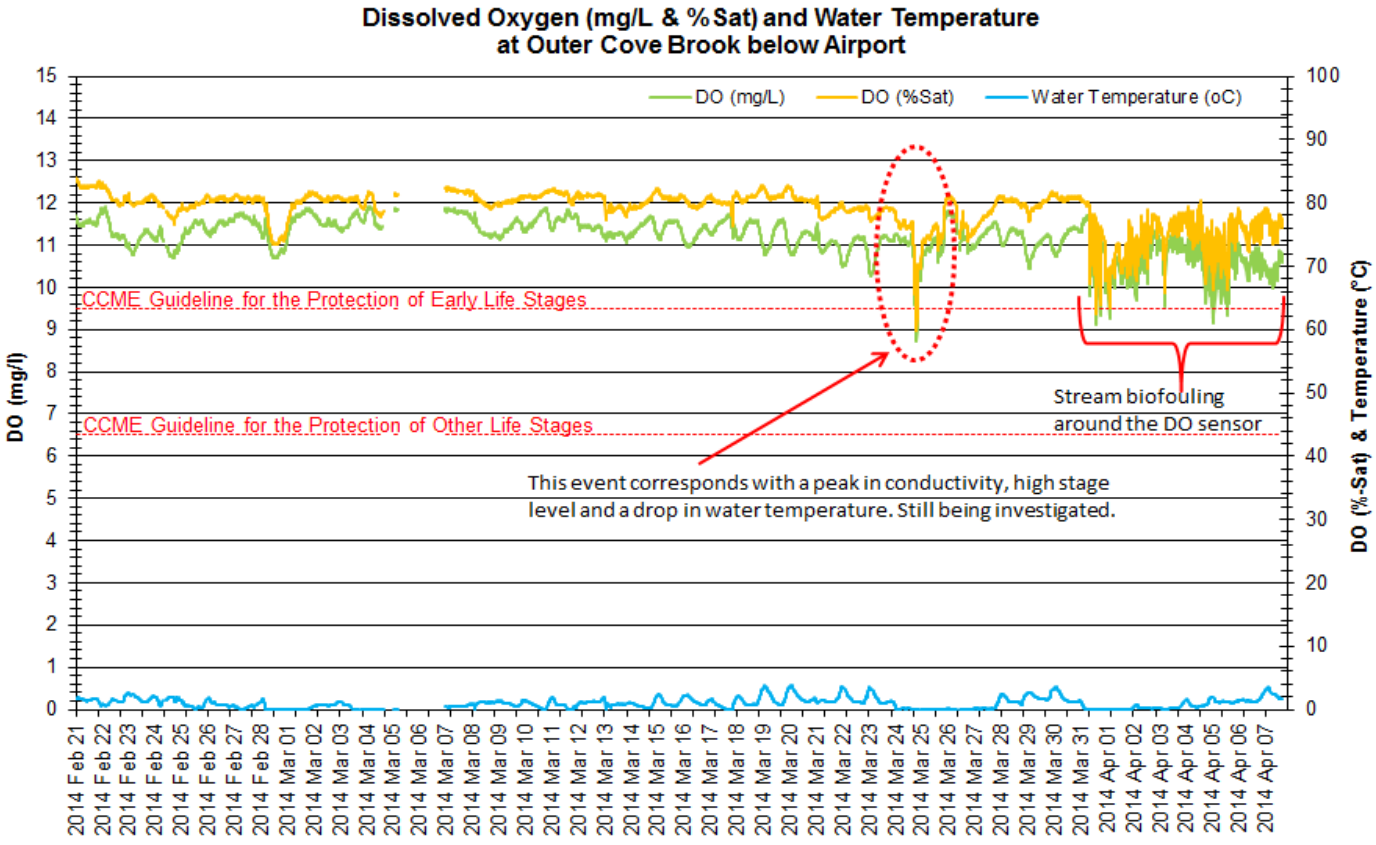

Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

At particular times in the year Outer Cove Brook below Airport can contain significant amounts of algae. High algal growth, biofouling, or leaf and grass debris can interfere with a turbidity sensor as the particles can block the sensor and affect the turbidity value.

The turbidity sensor records values between 0 NTU and 3000 NTU. However a turbidity reading of 3000 NTU is identified as an error and is not a true turbidity value. Readings of 3000 NTU should not be included in any statistical analysis.

The turbidity readings during this deployment ranged within 0.0 NTU to 573.0 NTU (Figure 6).

The turbidity events evident on March 13-14th and March 27th correspond with the higher stage levels. With increase in rainfall and runoff comes an increase in sediment and material flowing into the brook and this is what is captured by the turbidity sensor.

The display of turbidity data from April 3rd through to April 7th indicates fouling on the sensor (see Appendix B for pictures of the fouling).

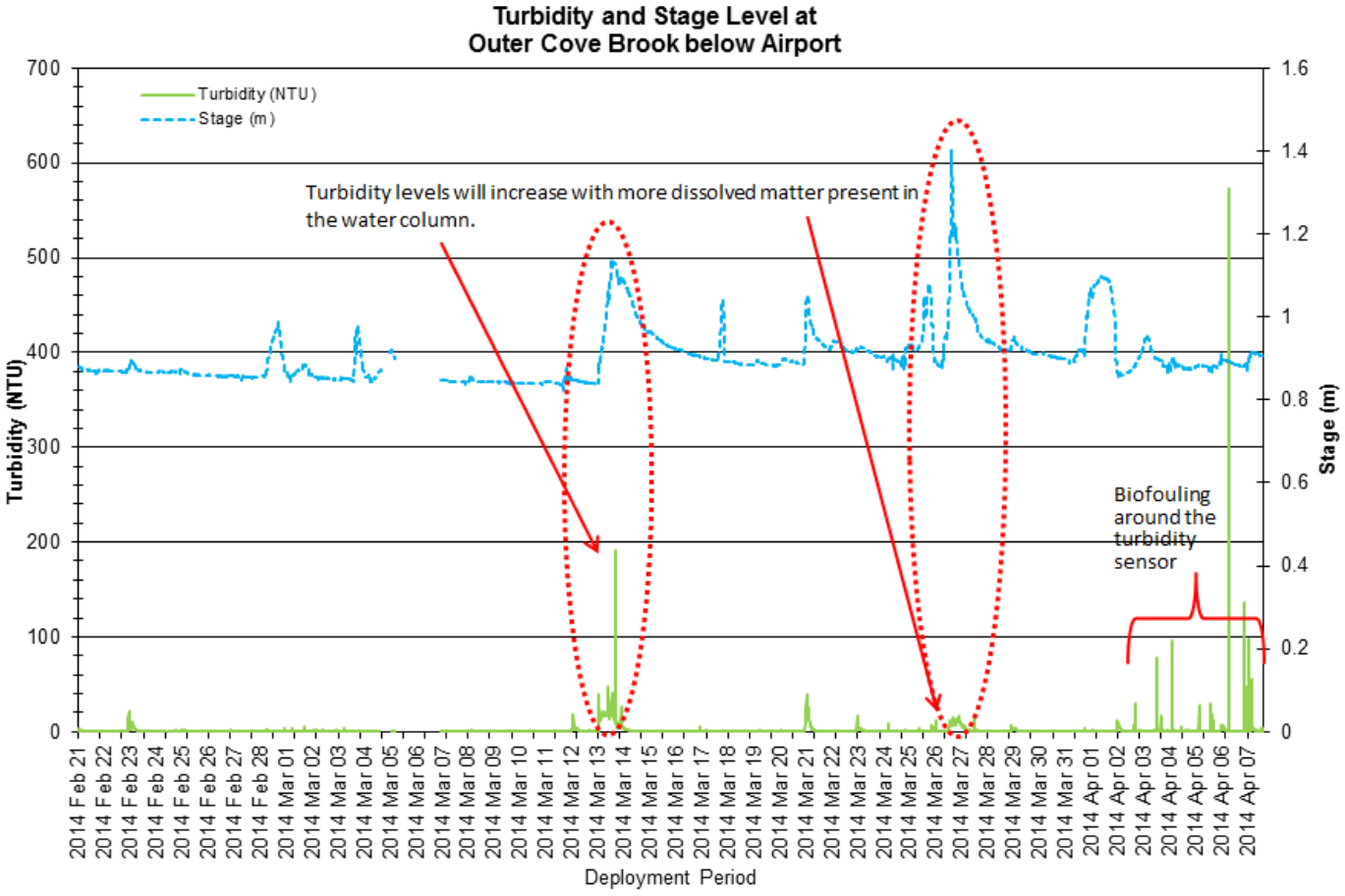

Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

Stage

The below graph includes precipitation data from St. John's International Airport weather station.

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gauge level)**.** Stage is important to display as it 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).

It is not unusual to see Stage vary throughout the deployment period (Figure 7). Stage is directly influenced by rainfall and subsequent runoff from the surrounding environment.

The peaks in Stage in Figure 7 were a response to the rainfall events or snowmelt events that occurred during this deployment period. Stage levels during this deployment ranged within a minimum of 0.83m and a maximum of 1.40m.

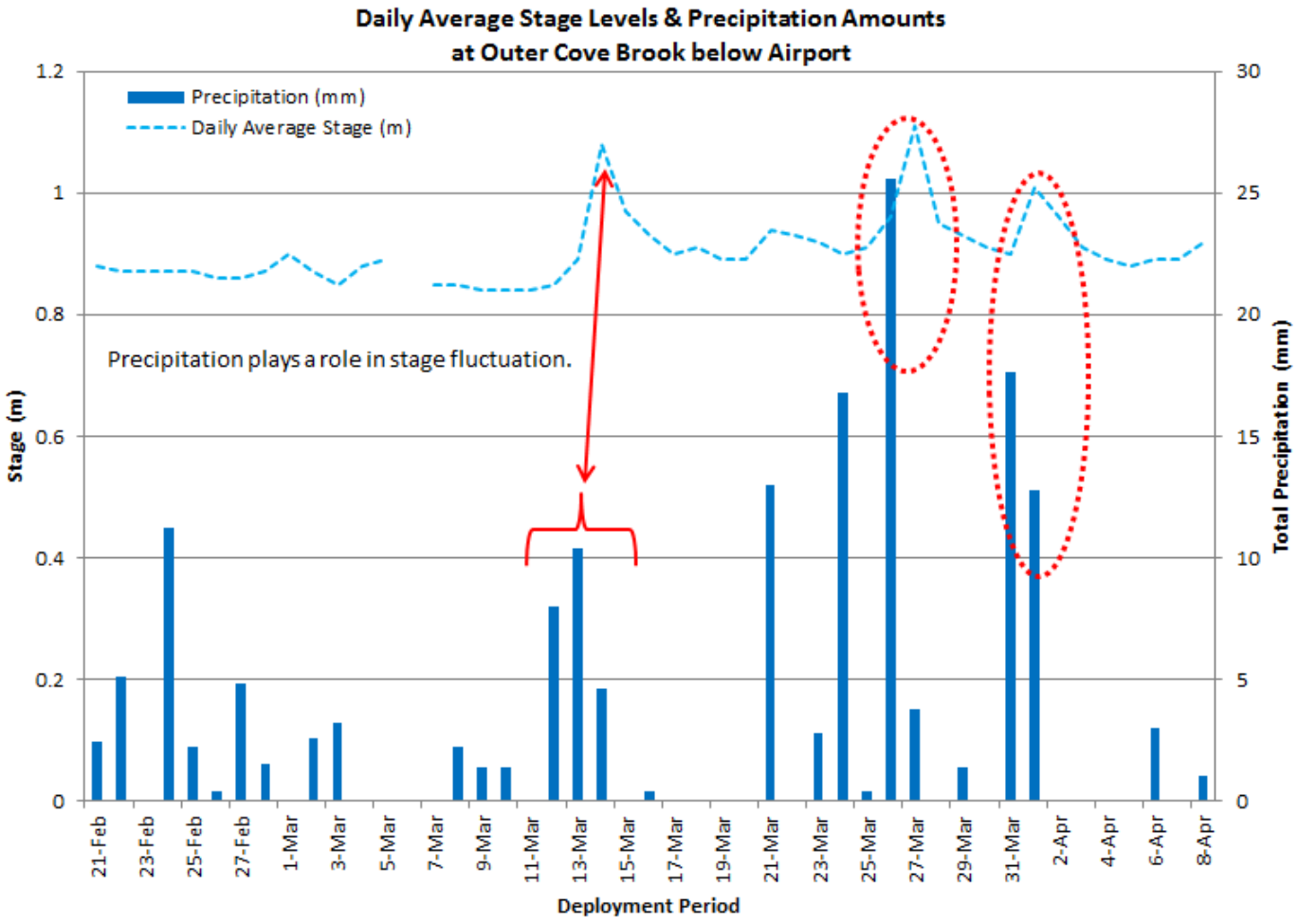

Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station.

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 and snow melt 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. During the last part of the deployment period there was disturbance to the turbidity data from fouling on the sensor.

The addition of road salt to roadways 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. These salts can also briefly decrease dissolved oxygen values.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from -0.10°C to 5.31°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. This is typical of shallow streams which are highly influenced by natural diurnal variations in ambient air temperatures.

The higher water temperatures indicated on the graph also correspond with increases in stage. This can indicate that there was a rainfall or snow melt event during those particular times.

Water temperature is a very important parameter and it has the ability to influence other parameters that are measured by the water quality instrument.

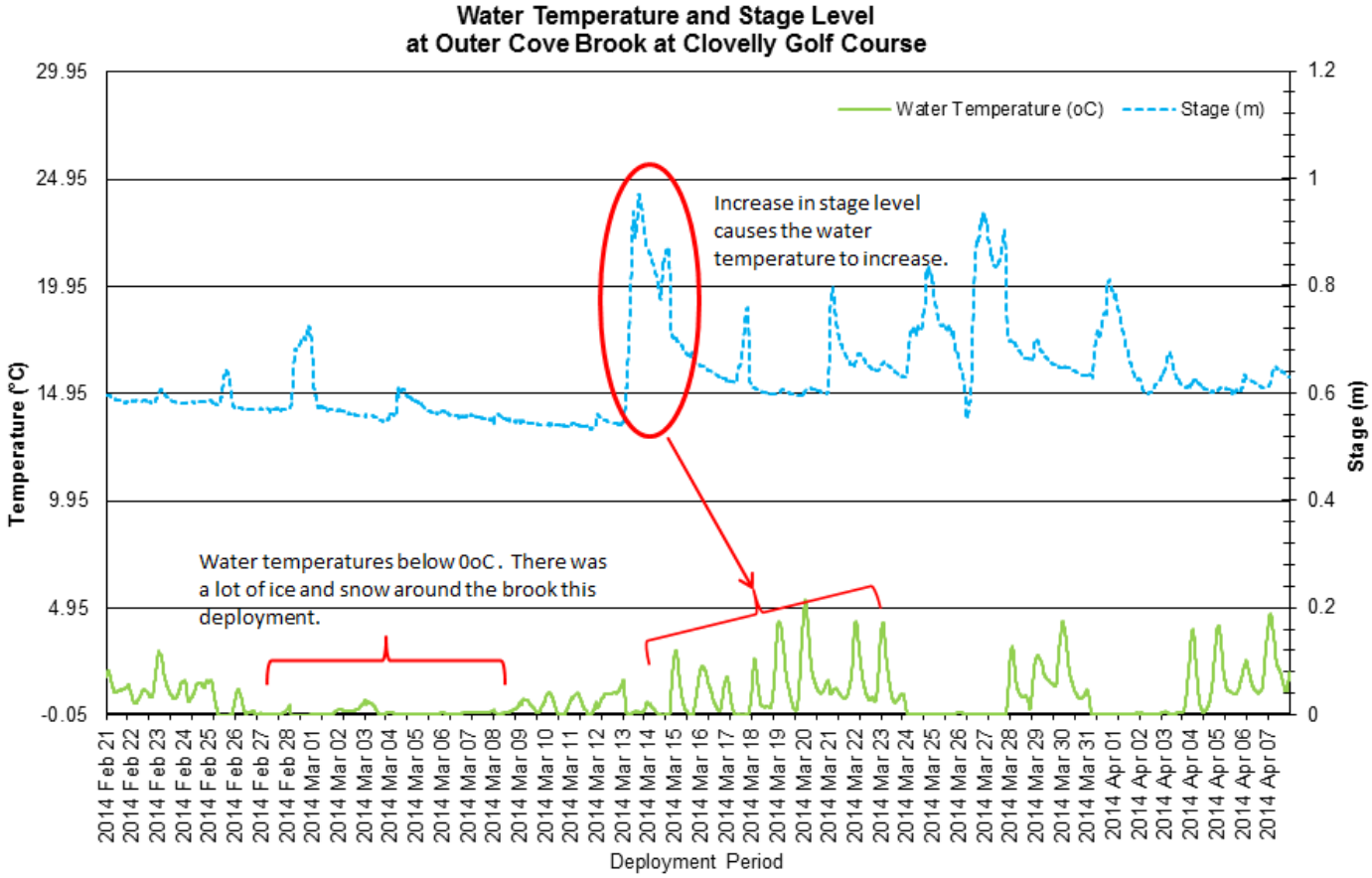

Figure 8: Quarter-hourly water temperature (℃) an d stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 5.34 pH units and 6.92 pH units (Figure 9).

During the deployment, the pH values at this station sit along the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units), dropping at times due to precipitation.

pH levels dip below the CCME minimum guideline on February 28th, March 14th and April 3rd. These dips correspond with precipitation events on the same dates. 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. During this deployment period the median pH level was 6.60 units, which was slightly higher than last month (more alkaline than previous deployment months).

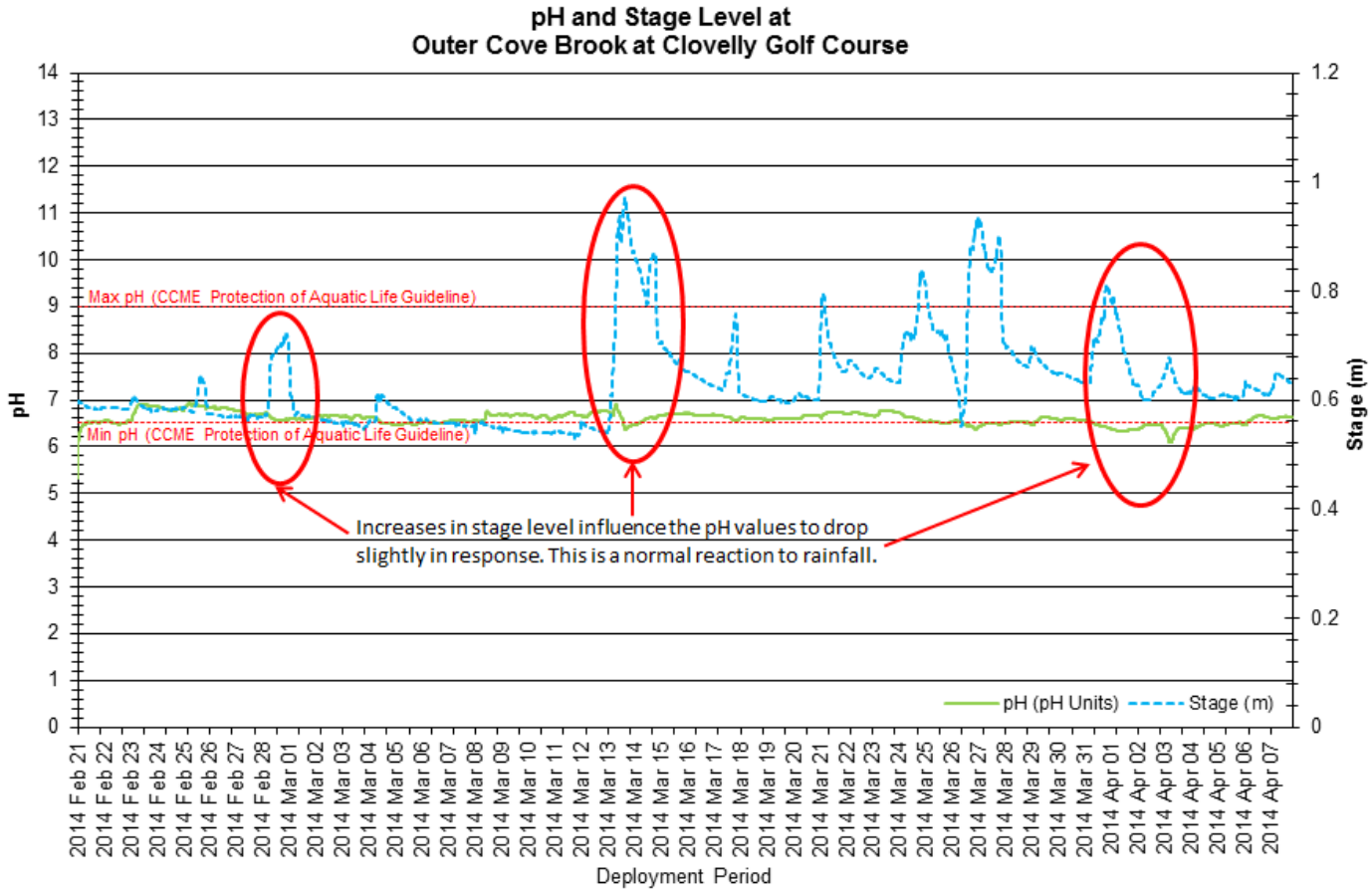

Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 670 µS/cm and 4541.0 µS/cm during this deployment period. TDS ranged from 0.4290 g/L to 2.9100 g/L.

Road salting for safety during winter months can increase conductance levels in nearby streams, as displayed on February 23rd to February 26th and March 10th. Salt, flushed into urban streams increases the amount of dissolved substances present causing high peaks in conductivity values (Figure 10).

Higher stage level can flush the salts into the brook leading to higher conductivity levels. Data on February 28th, March 13th and March 21st (see Figure 10) display the initial peak of conductivity and then the lower levels. When stage levels rise, the specific conductance levels drop in response as the increased amount of water in the river system dilutes the solids present.

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.

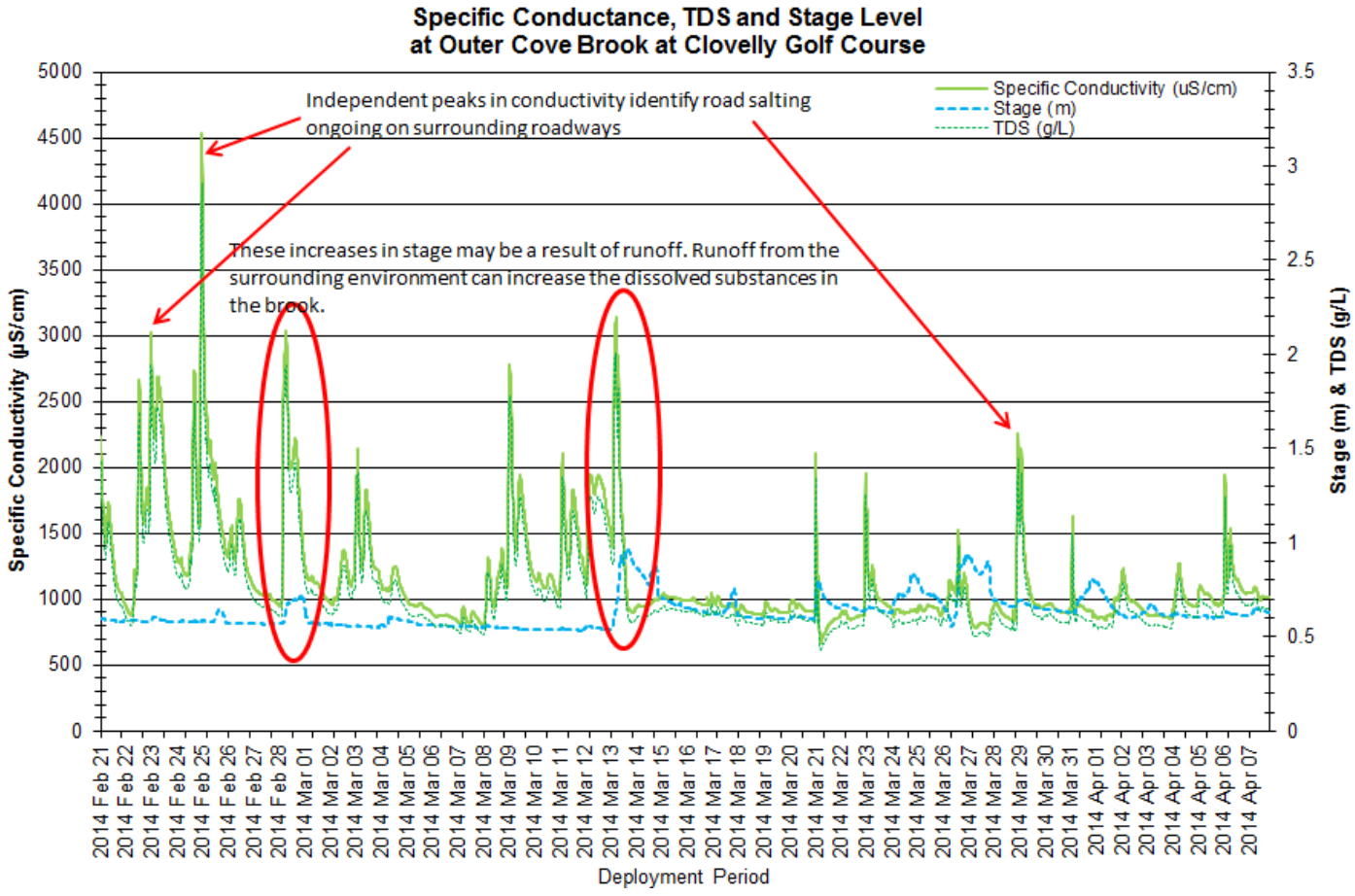

Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 57.1 % Sat–83.2 % Sat. Dissolved Oxygen (mg/L) measured 8.32 mg/L to 11.77 mg/L.

For the majority of the deployment period, the DO mg/L values remain above the minimum DO CCME guideline for early life stages (Figure 11).

It is expected when water temperature drop that DO levels increase. Dissolved oxygen in water is sufficiently influenced by water temperature. Colder water holds more oxygen than warm water. Therefore it is unclear what would cause the DO to drop so significantly during February 28th, March 25th and 27th, and April 1st , when the water temperature at those times is also low. These events are still being investigated.

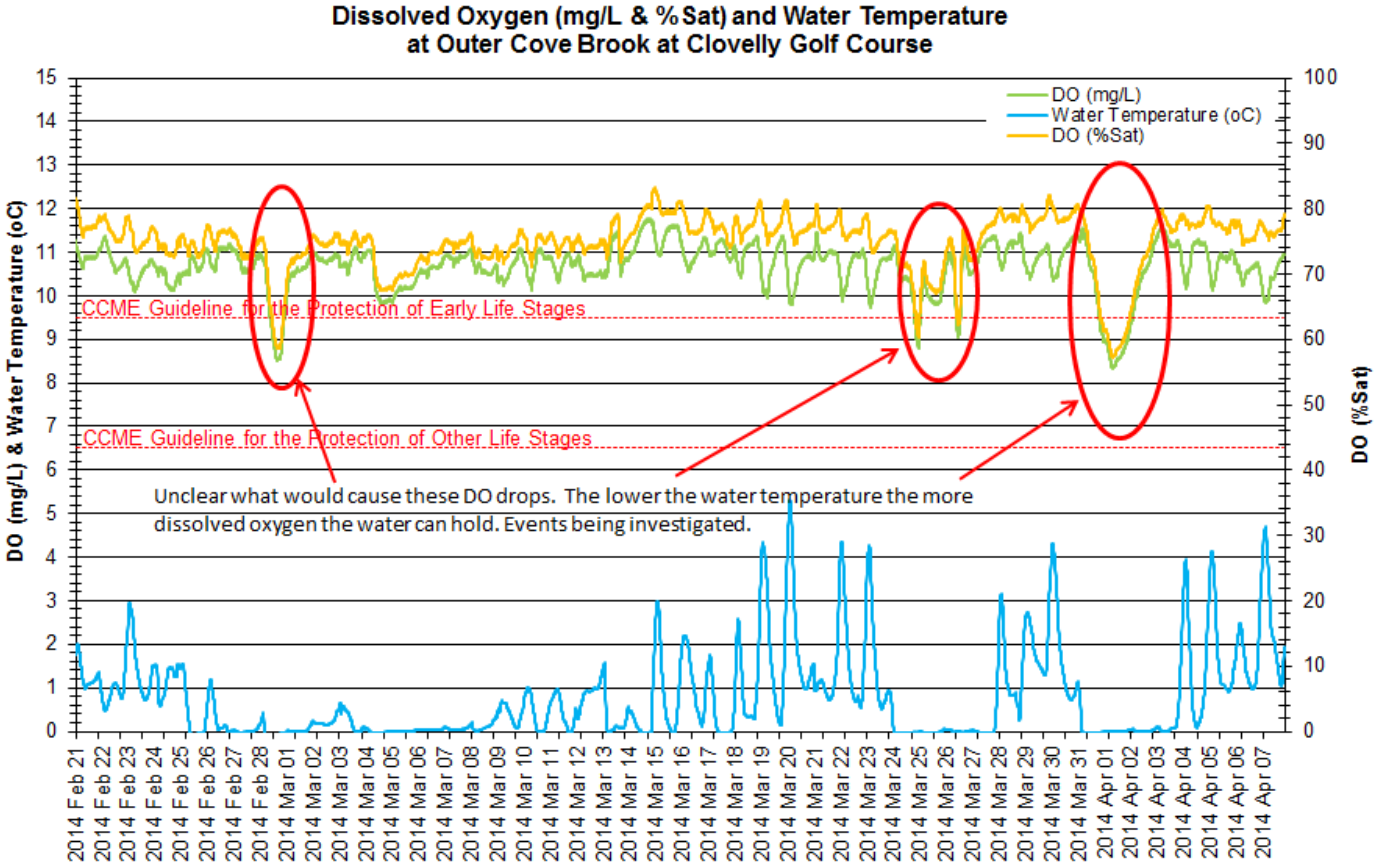

Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (℃) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during this deployment period ranged within 0.8 NTU and 177.8 NTU (Figure 12).

The turbidity sensor on this instrument can read turbidity values between 0 NTU and 3000 NTU. However a turbidity reading of 3000 NTU is always identified as an error reading and should not be used as a valid reading or included in any statistical analysis.

This brook naturally contains a large amount of algal growth. There is aquatic vegetation present during the winter months but for the most part the higher algal growth is during the warmer seasons. It is during those times that it sometimes becomes a hindrance for the water quality instrument.

The turbidity events noted during this deployment period, correlated with increases in stage and in turn precipitation events. Jointly rainfall and precipitation can have the ability of increasing the presence of suspended material in water.

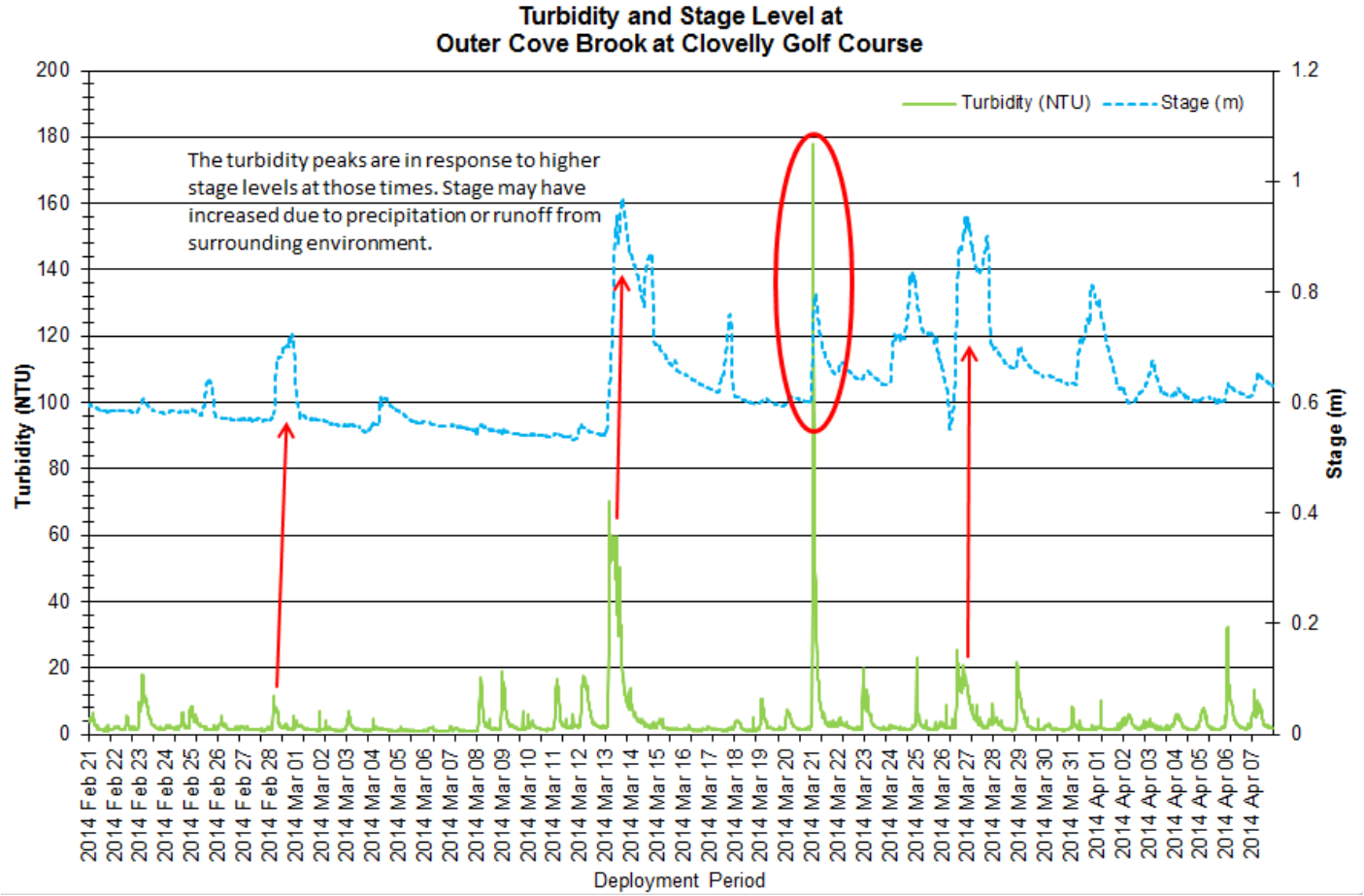

Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Stage

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level)**.** Stage is important to display as it 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 will increase during rainfall events (Figure 13) and during any surrounding snow or ice melt as runoff will collect in the brooks. However, direct snowfall will not cause stage to rise significantly.

Precipitation data was obtained from Environment Canada's St. John's Airport weather station.

During the deployment period, the stage values ranged from 0.53m to 0.97m. The larger peaks in stage do correspond with sufficient rainfall events as noted on Figure 13.

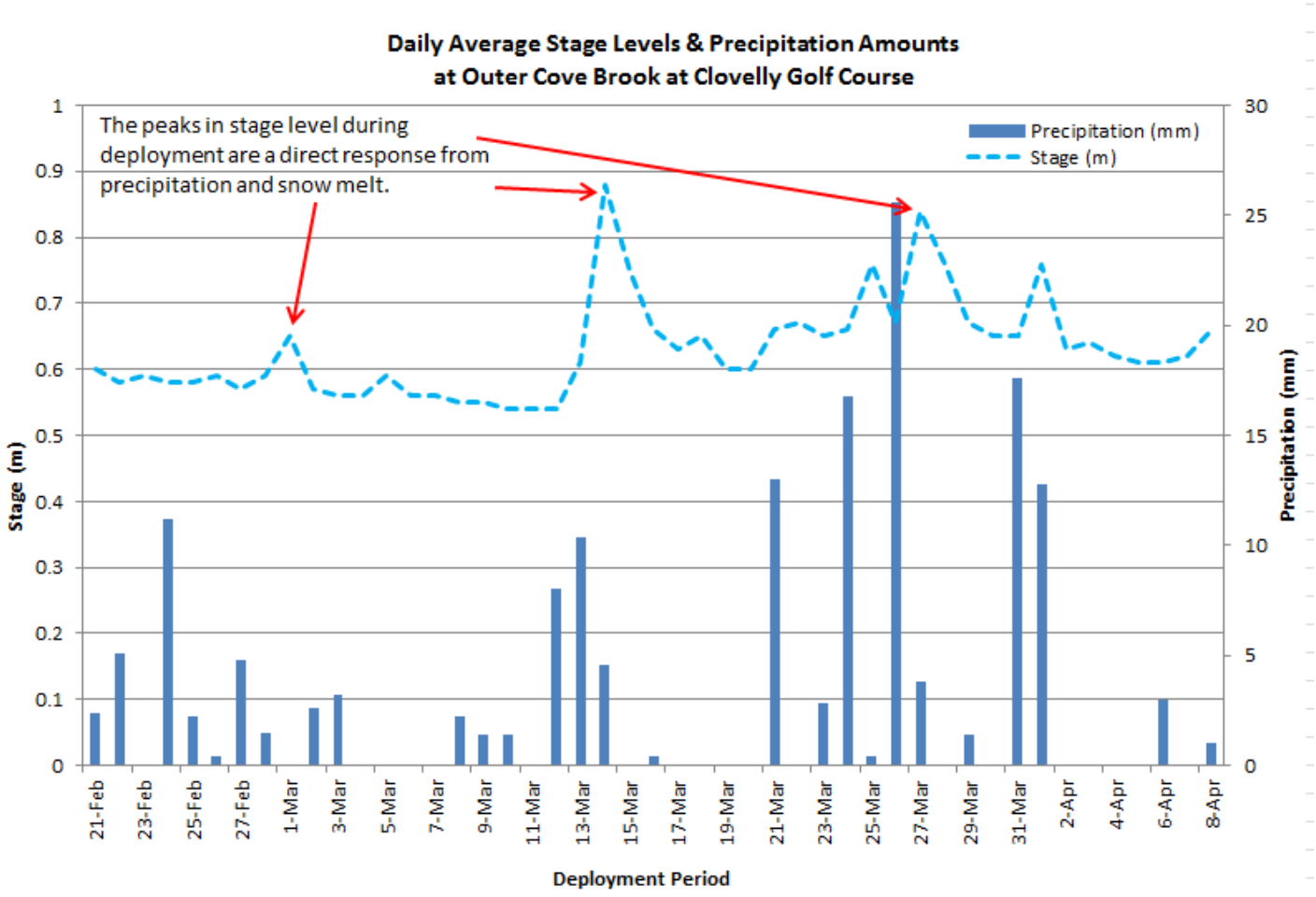

Figure 13: Daily average stage values (m) at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station.

Conclusion

- As with many shallow brooks and streams, precipitation events play a role in influencing the parameters within the water body. This brook also flows through significant developed areas, including residential zones, golf courses and within the boundaries of heavily trafficked road ways, which can influence the parameter levels that are recorded.

- It is evident by the parameter data recorded that precipitation events during this deployment period have influenced fluctuations in stage. Precipitation can also impact the turbidity, pH, specific conductivity, and TDS in the brook. An influx of rainfall will dilute conductivity and TDS, and increase turbidity. pH values dropped (acidity increases) potentially with an increase in runoff from the surrounding environment with higher dissolved substances present.

- As ambient air temperatures decreased it caused the water temperature to drop. Temperature directly affects the amount of dissolved oxygen present in the brook during those times. As noted in Figure 11 with a median of 10.76 mg/L of DO during the deployment period.

- Specific conductivity is slightly higher at this station than the below airport station. This brook has the potential for a larger influence of salt runoff; this station captures the runoff from residential areas and alongside heavily trafficked roadways.

Conclusion

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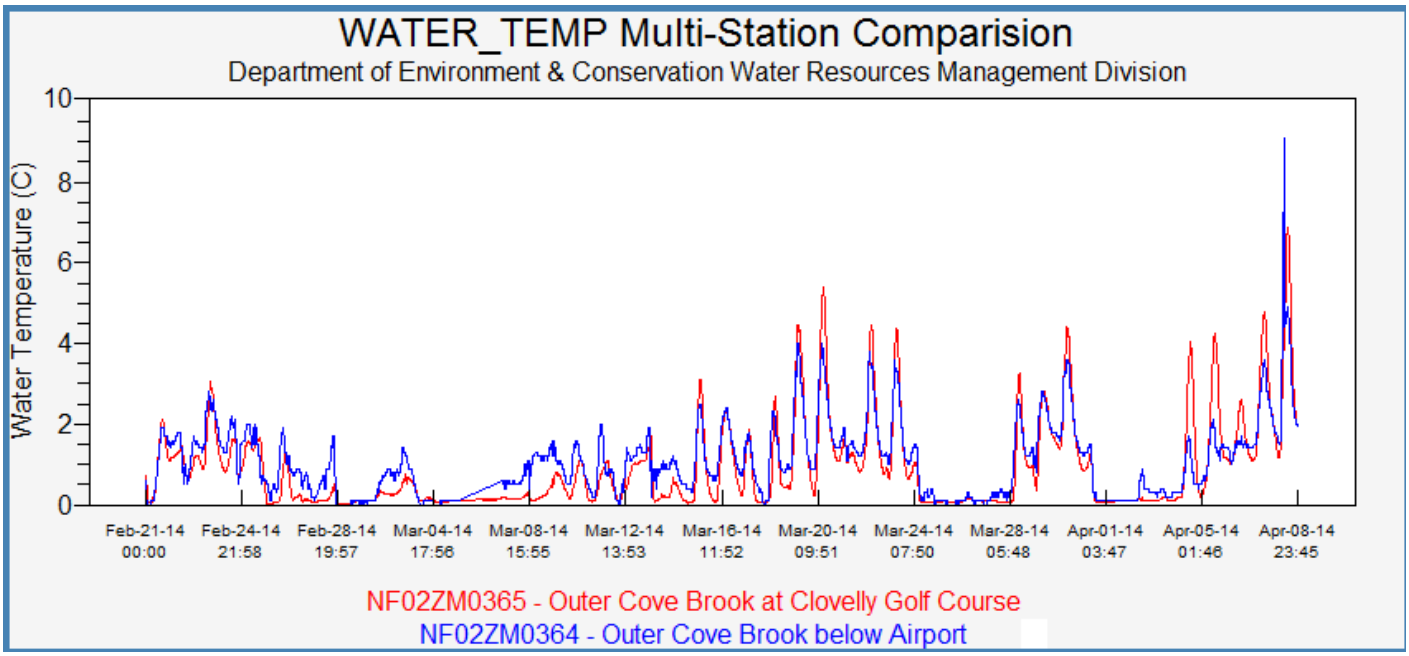
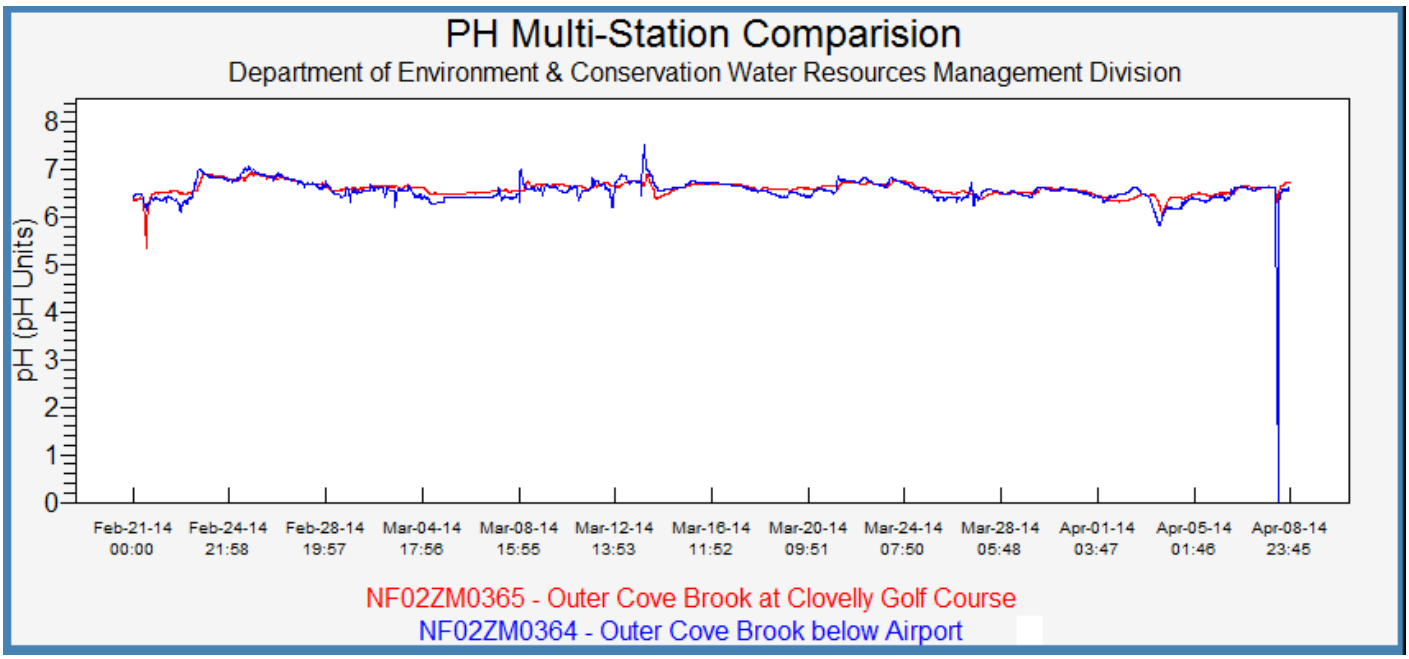
- During this deployment it can be assumed that many of the events that occurred were related to the intermittent precipitation events. Generally in natural environments, climate and weather conditions can be responsible for influencing the variation in water quality parameters.
- During this deployment period the median water temperature at the upstream station (Outer Cove Brook below Airport) of 0.9°C was slightly higher to that of the downstream station (Outer Cove Brook at Clovelly Golf Course) of 0.33°C. Water Temperature continues to fluctuate and is influenced by the surrounding winter air temperatures; this is to be expected with the colder temperatures at night and slightly warmer temperatures during the day. It should also be noted that there is considerably more aquatic growth present in the downstream station which can also create warmer water temperatures during the daylight hours.
- The median pH values for both was also comparable with, Outer Cove Brook below Airport's median at 6.57 and Outer Cove Brook at Clovelly Golf Course reading 6.60. The pH level along the brooks network, for the most part is steady at both stations.
- The Specific Conductivity median at Outer Cove Brook below Airport was 851.0µS/cm with the Outer Cove Brook at Clovelly Golf Course recording a median of 1000.0µS/cm. The Specific Conductivity graphs for both stations display several intermittent peaks in levels over this deployment period, these peaks are linked to road salting events during or after winter storms.
- Dissolved Oxygen at the upstream station (Outer Cove Brook below Airport) had a median of 80 %Sat during the deployment period, the downstream station (Outer Cove Brook at Clovelly Golf Course) had a lower median of 75.5 %Sat. Both stations have close DO medians and there is no noticeable difference between them, however the downstream station does have considerably more aquatic growth in the stream which can increase the use of oxygen present in the water. There were several drops in DO at Outer Cove Brook at Clovelly Golf Course that are unexplained; these events are still being investigated.
- The turbidity median values between the downstream and upstream stations are slightly different. The upstream station (Outer Cove Brook below Airport) has a turbidity median of 0.0NTU with the downstream station (Outer Cove Brook at Clovelly Golf Course) holding a median of 1.9NTU. There is not a large difference between the medians, however the turbidity does increase very slightly as the water moves downstream. Outer Cove Brook below Airport also had some fouling on the turbidity sensor towards the end of the deployment.
- Increases in stage level can explain the peaks in the turbidity values during the deployment period. As organic matter and natural minerals are washed into the brook, the suspended matter in the water column will increase and the turbidity sensor and the specific conductivity sensor will pick up these additional changes in the water body.

Appendix A

Parameter Station Comparison Graphs





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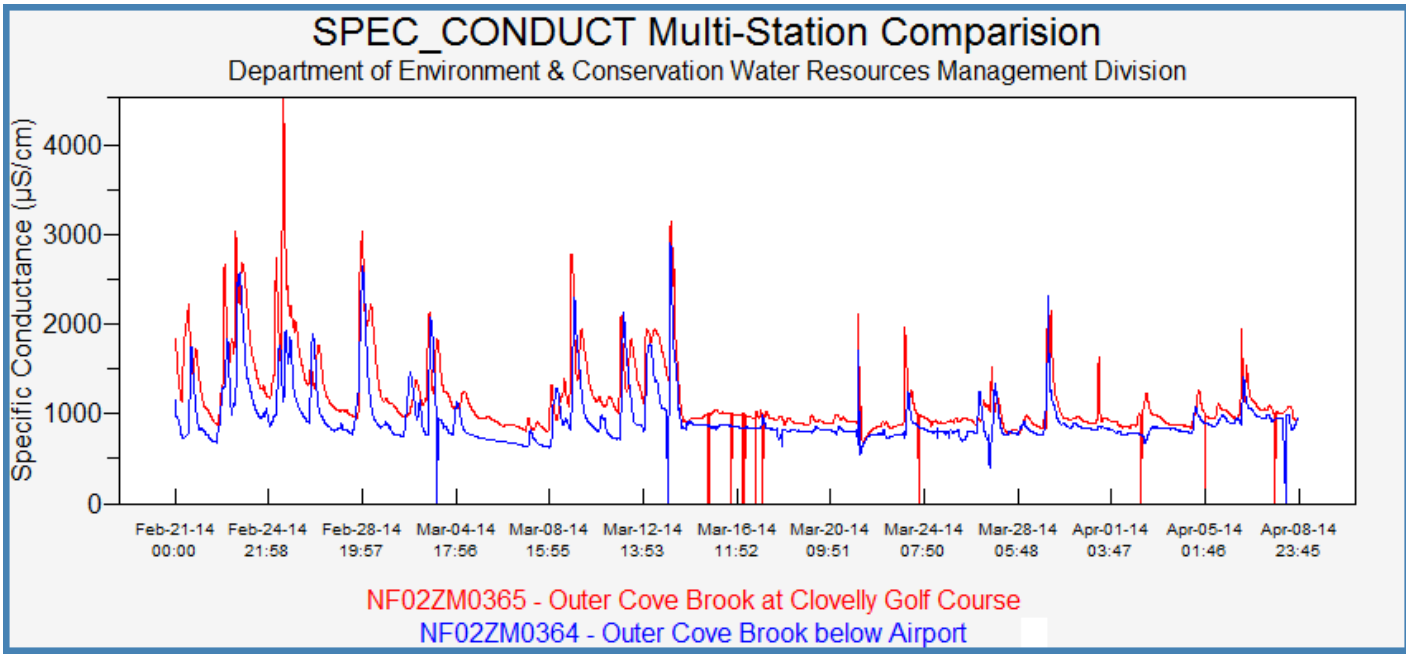

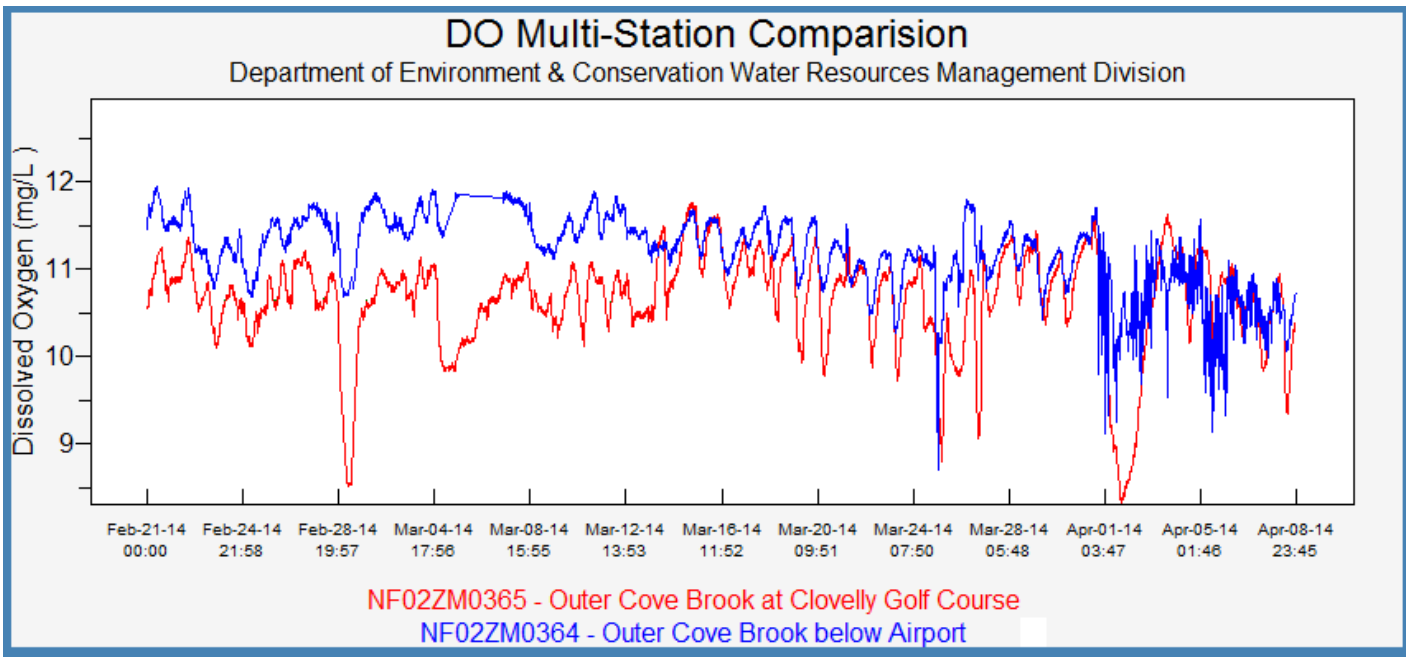

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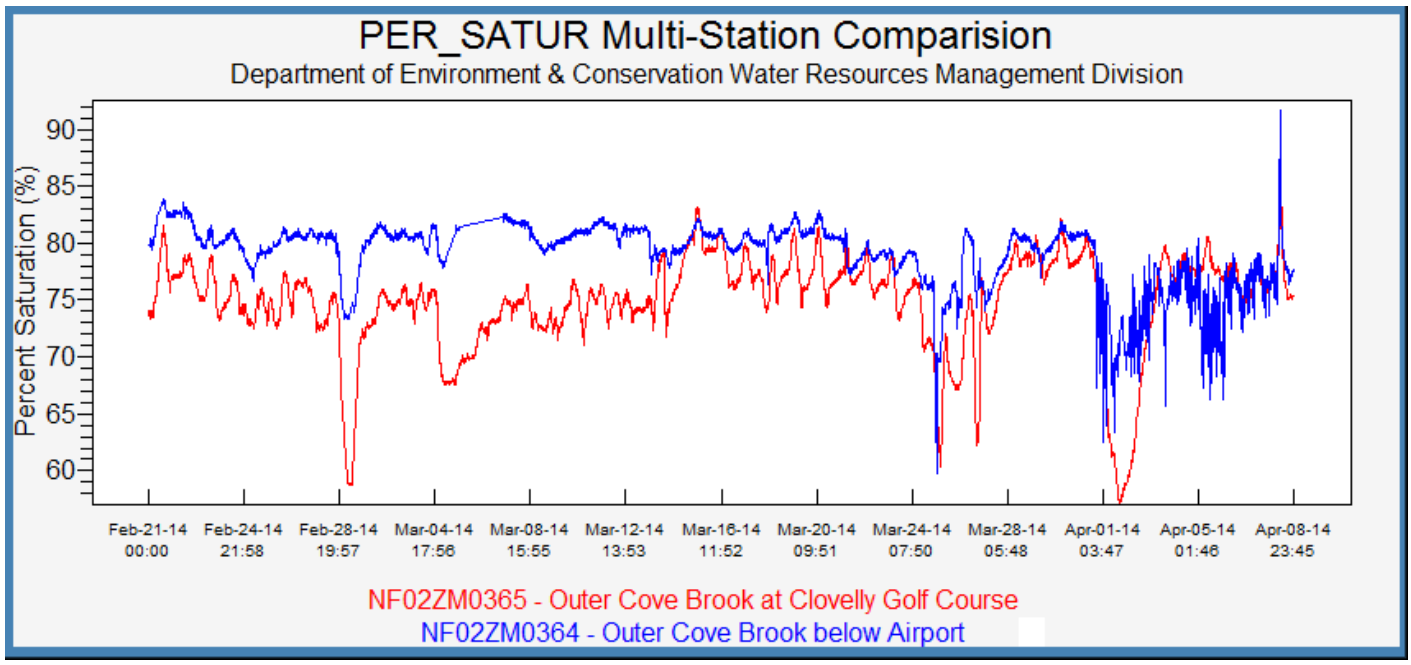

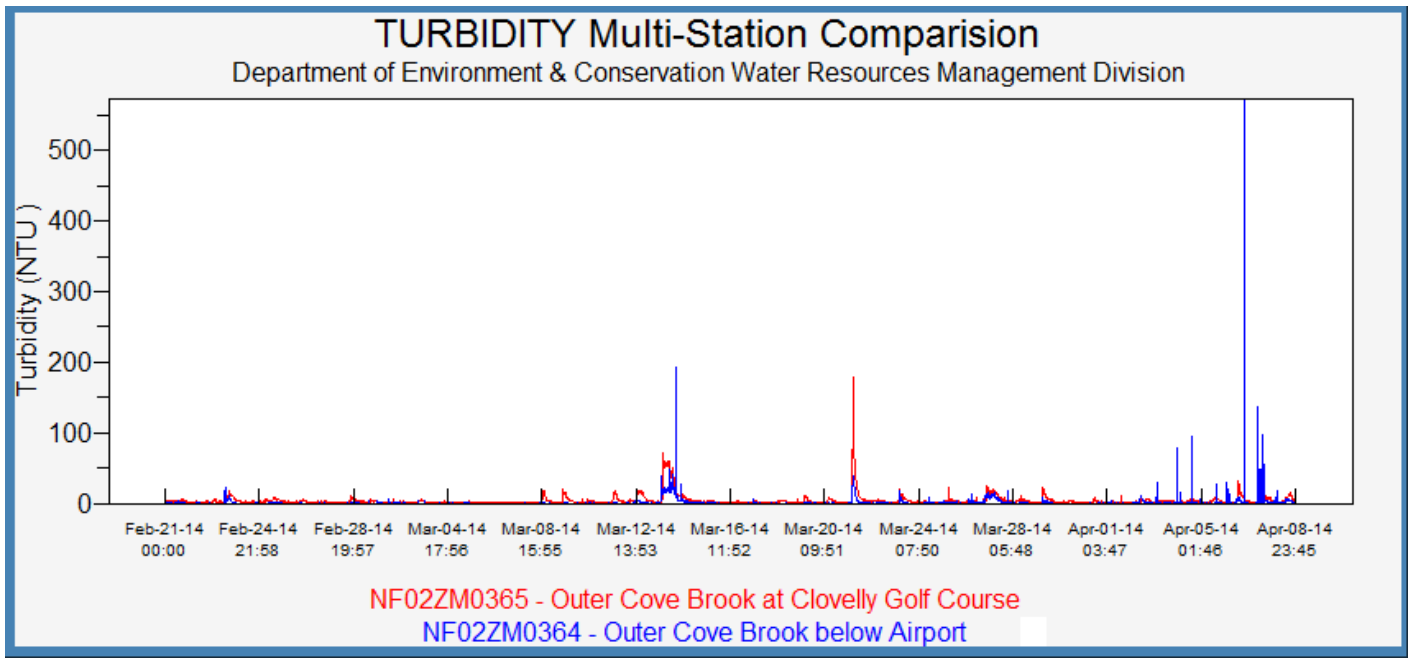

Appendix B

Pictures of biofouling on Outer Cove Brook at Airport Station instrument

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