Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period
January 21, 2014 to February 21, 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 32-day period from deployment on January 21, 2014 until removal on February 21, 2014.

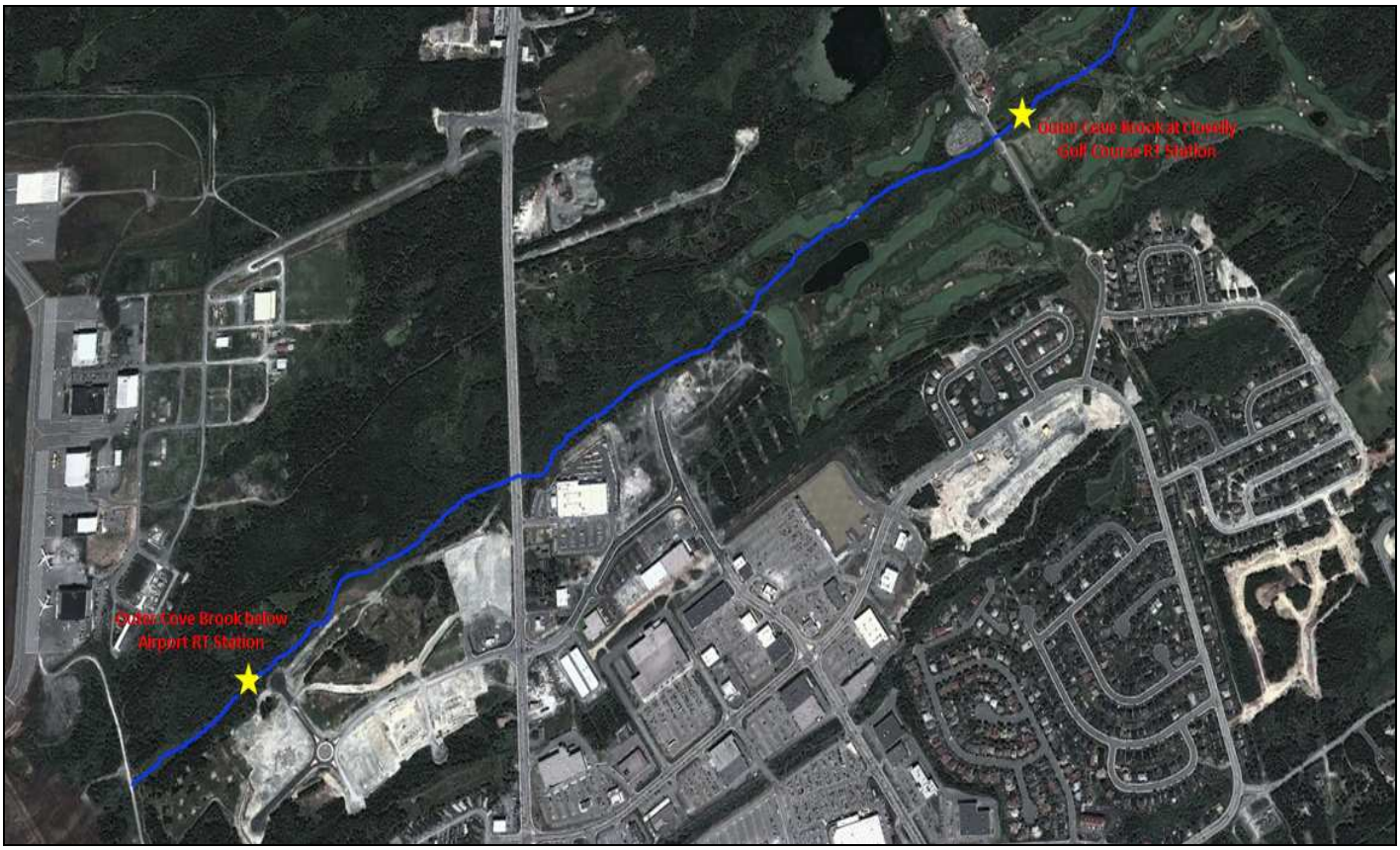


Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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 January 21, 2014 through to February 21, 2014 are summarized in Table 2.

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

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

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

- At removal, the temperature, conductivity and turbidity data all ranked 'excellent', the pH data ranked as 'poor'. The dissolved oxygen data ranked 'marginal'. This could indicate an issue with the dissolved oxygen sensor, as it ranked 'fair' on deployment and then 'marginal' on removal. This will be reviewed during calibration and maintenance.

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

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

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

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

- At removal, temperature, conductivity ranked 'excellent', while dissolved oxygen and turbidity ranked as 'good'. pH data was ranked as 'poor'. This may have been a reflection on the QAQC sonde at this time, as it was identified after that it was having pH issues.

- 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.

Outer Cove Brook, Newfoundland and Labrador

Deployment Notes

- There were several short transmission errors during this deployment period at both stations. Due to the nature of the data transmission it is not uncommon to have the data drop out for period at a time.
- As a result of a transmission error with Water Survey of Canada's data there is a gap in stage data from January 25th, 2014 at 2:15 PM to January 28th, 2014 at 9:15 AM at Outer Cove Brook at Clovelly Golf course only.

Data Interpretation

- The following graphs and discussion illustrate water quality-related events from January 21, 2014 through to February 21, 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 3.60°C during this deployment period (Figure 2).
- Water temperature at 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.
- The water temperature at this station displays diurnal variations; this is typical of shallow streams and ponds which are highly influenced by natural diurnal variations in ambient air temperatures.
- Water temperature is a important parameter and influences the other parameters that are measured by the water quality instrument.

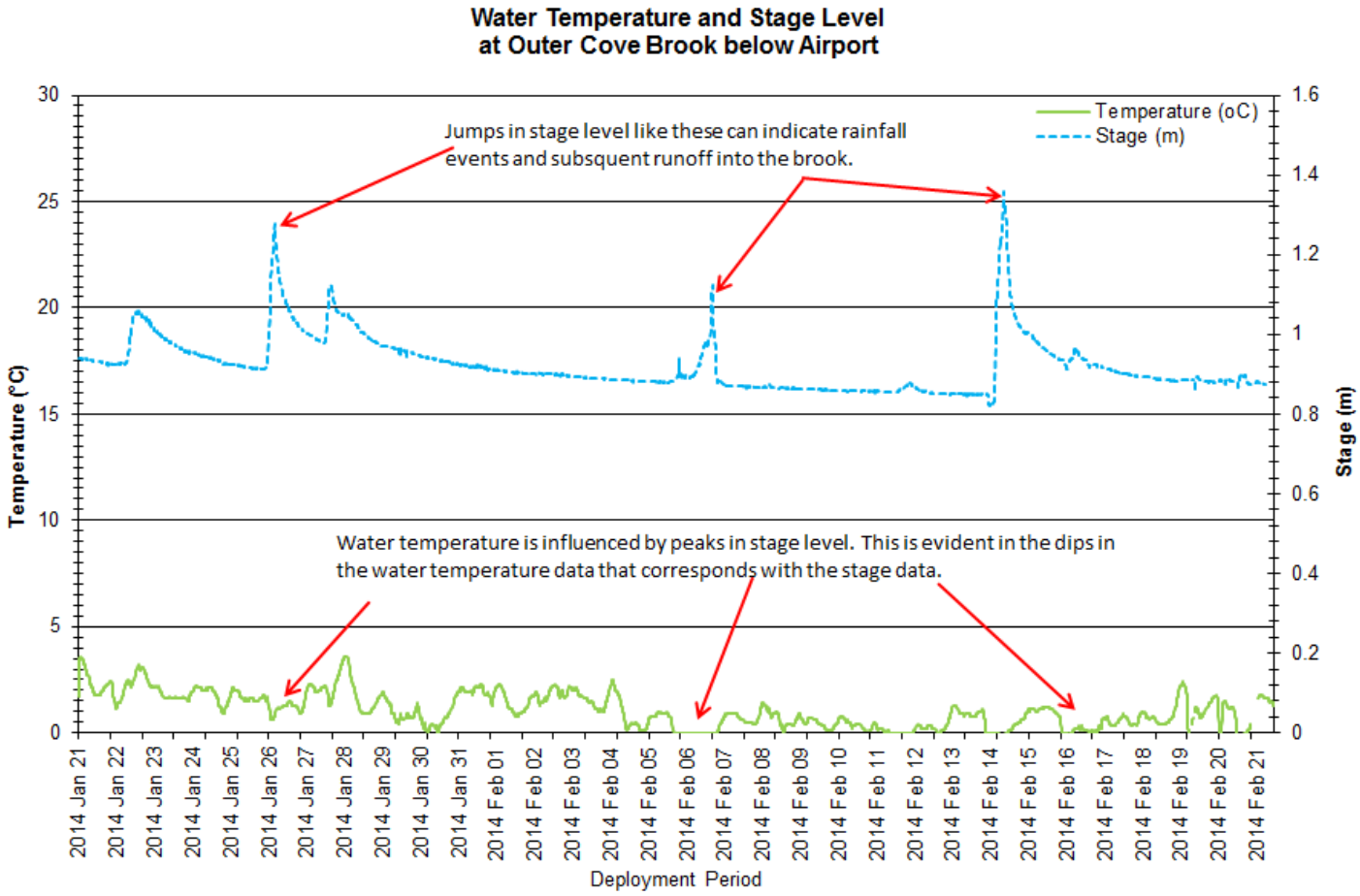


Figure 2: Quarter-hourly water temperature (°C) and stage level (m) values at Outer Cove Brook below Airport for the deployment period January 21, 2014 to February 21, 2014.

pH

- Throughout this deployment period pH values ranged between 6.26 pH units and 6.86 pH units (Figure 3).
- During the deployment, the pH values at this station sit on or just above the minimum CCME Guideline for the Protection of Aquatic Life (between 6.5 and 9 pH units) for the majority of the deployment. During high stage periods the pH values drop slightly lower than the guideline. This is evident on the graph on January 26 to January 27, February 6, and from February 14 to February 18 (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 remained around 6.51 pH units.

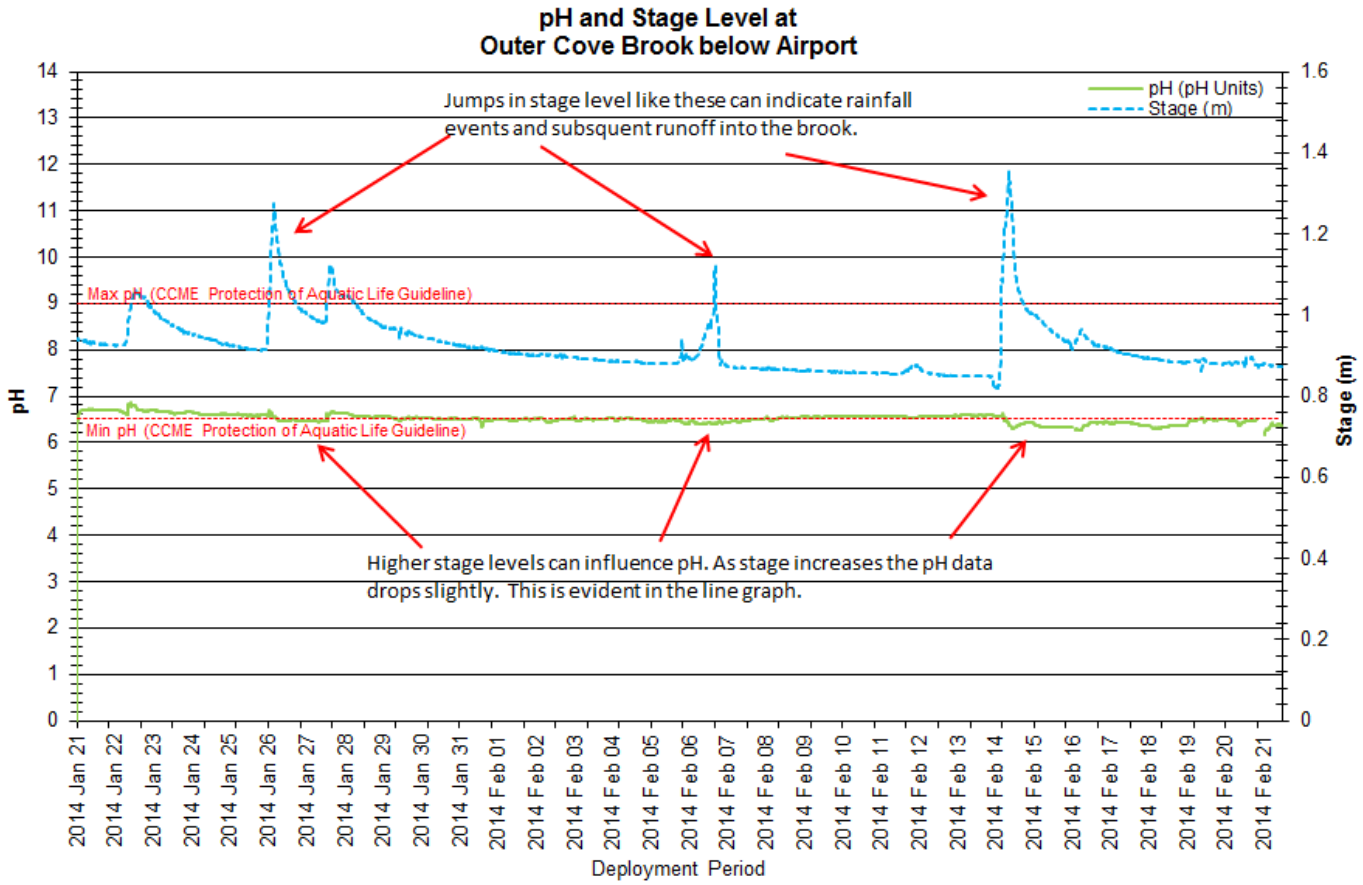


Figure 3: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook below Airport for the deployment period January 21, 2014 to February 21, 2014.

Specific Conductivity & TDS

- The conductivity levels were within 270 µS/cm and 2342.0 µS/cm during this deployment period. TDS ranged from 0.1730 g/L to 1.5000 g/L.
- The peaks in conductivity correspond with the higher stage levels. As stage increases conductivity increases, as road salt and material are washed into the brook. At this time of year during the winter events the roads are salted heavily and as the ice and snow thaws it pushes on into the surrounding urban rivers and brooks.
- The drop in conductivity from February 6 to 7 is due to a rainfall event but apparently there was no sufficient runoff of salt or any material to push the conductivity up.
- 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.

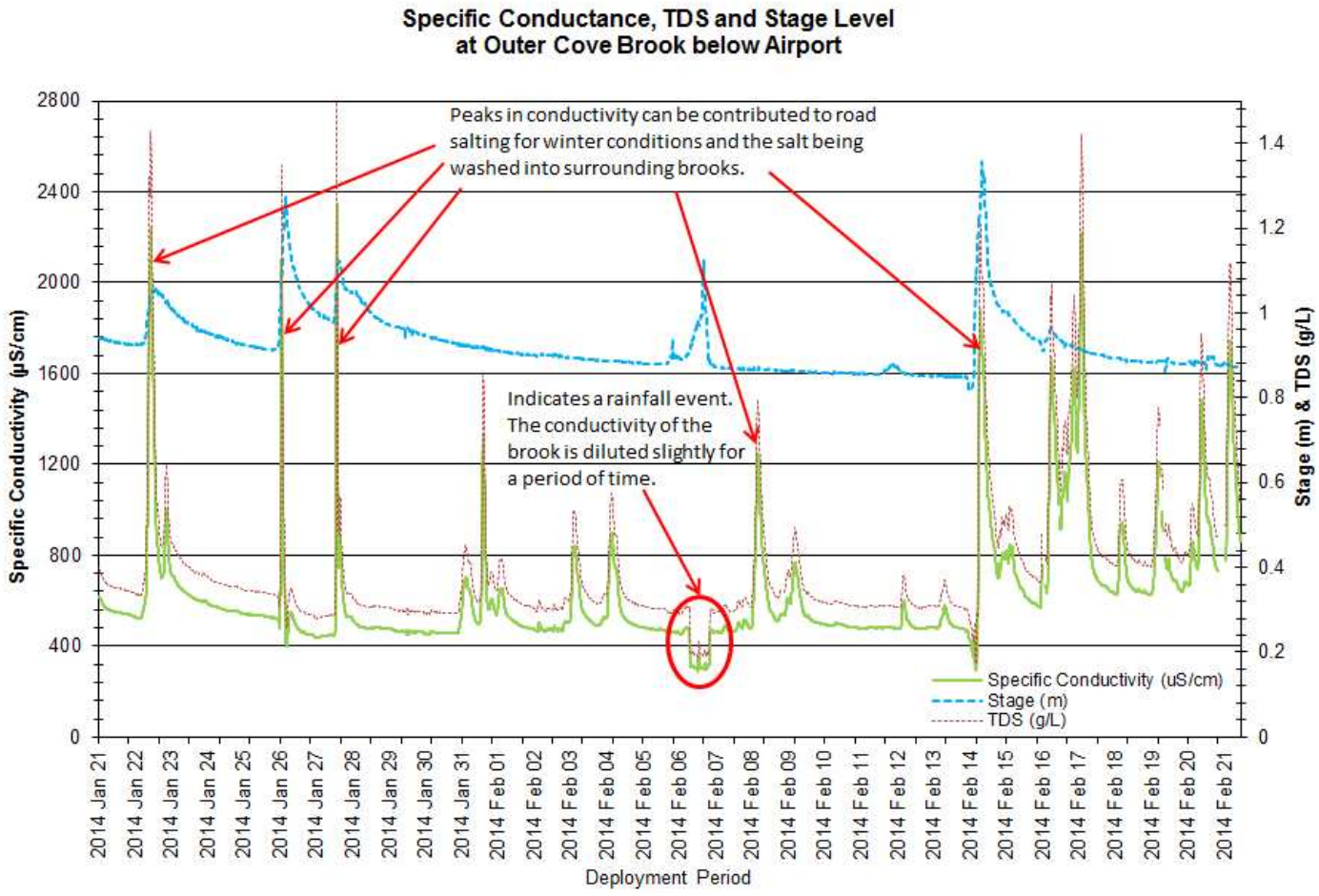


Figure 4: Quarter-hourly specific conductivity (µS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook below Airport for the deployment period January 21, 2014 to February 21, 2014.

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 86.2% Sat and 90.1% Sat. Dissolved Oxygen (mg/L) measured 11.41 mg/L to 11.94 mg/L.
- The DO mg/L values are above the minimum DO CCME guideline for early life stages throughout this deployment period (Figure 5), as the colder water during winter months can hold more oxygen.
- A drop in dissolved oxygen on February 14-16th corresponds with a sharp increase in conductivity at this time. 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.
- 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.

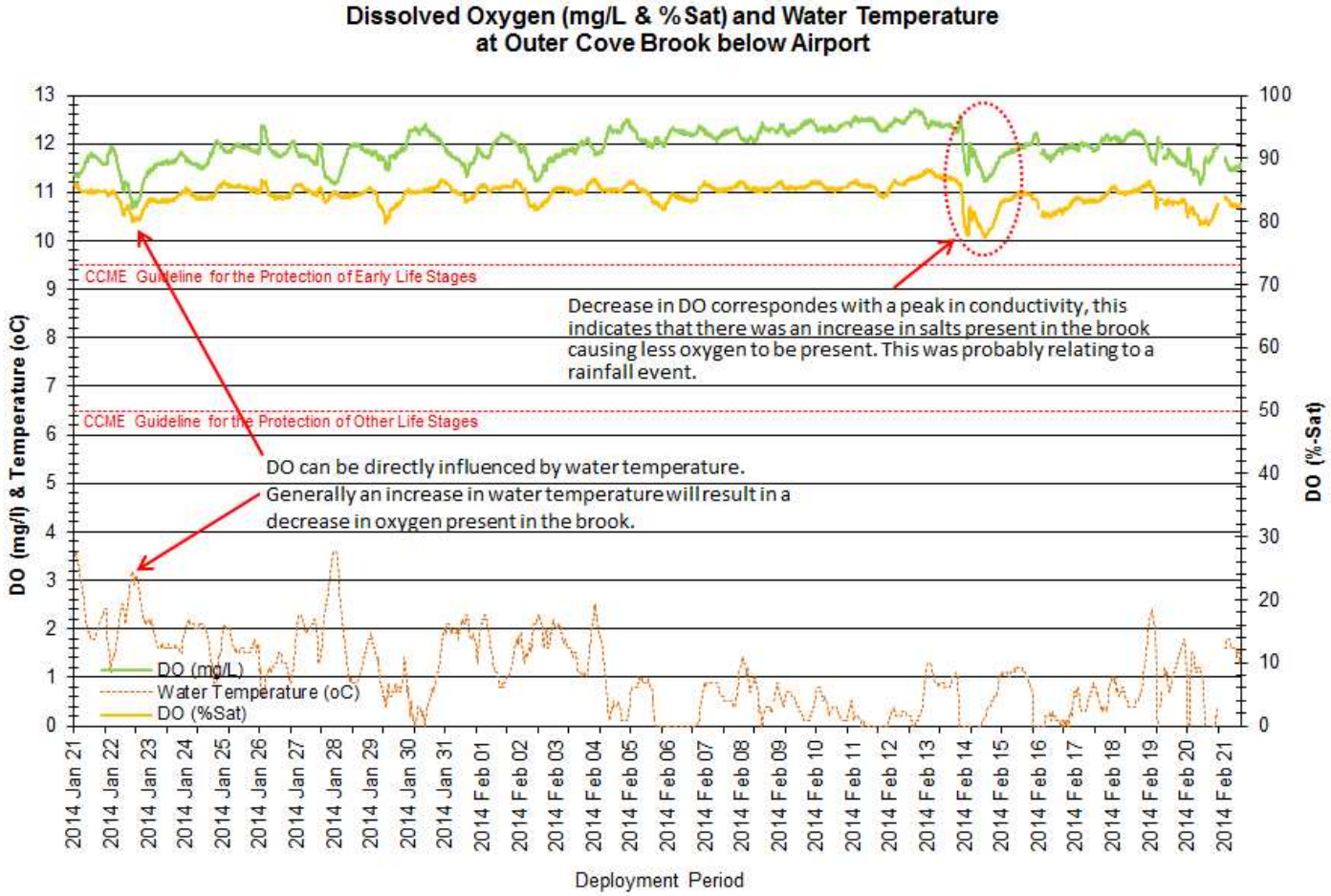


Figure 5: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport for the deployment period January 21, 2014 to February 21, 2014.

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 effect the turbidity value.
- The turbidity sensor records values between 0 NTU and 3000 NTU. However a turbidity reading of 3000NTU 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 640.0 NTU (Figure 6).
- The turbidity events evident on the graph in Figure 6 correspond with the higher stage levels at those times. With rainfall and runoff comes an increase in sediment and material flowing into the brook and this is what is captured by the turbidity sensor.

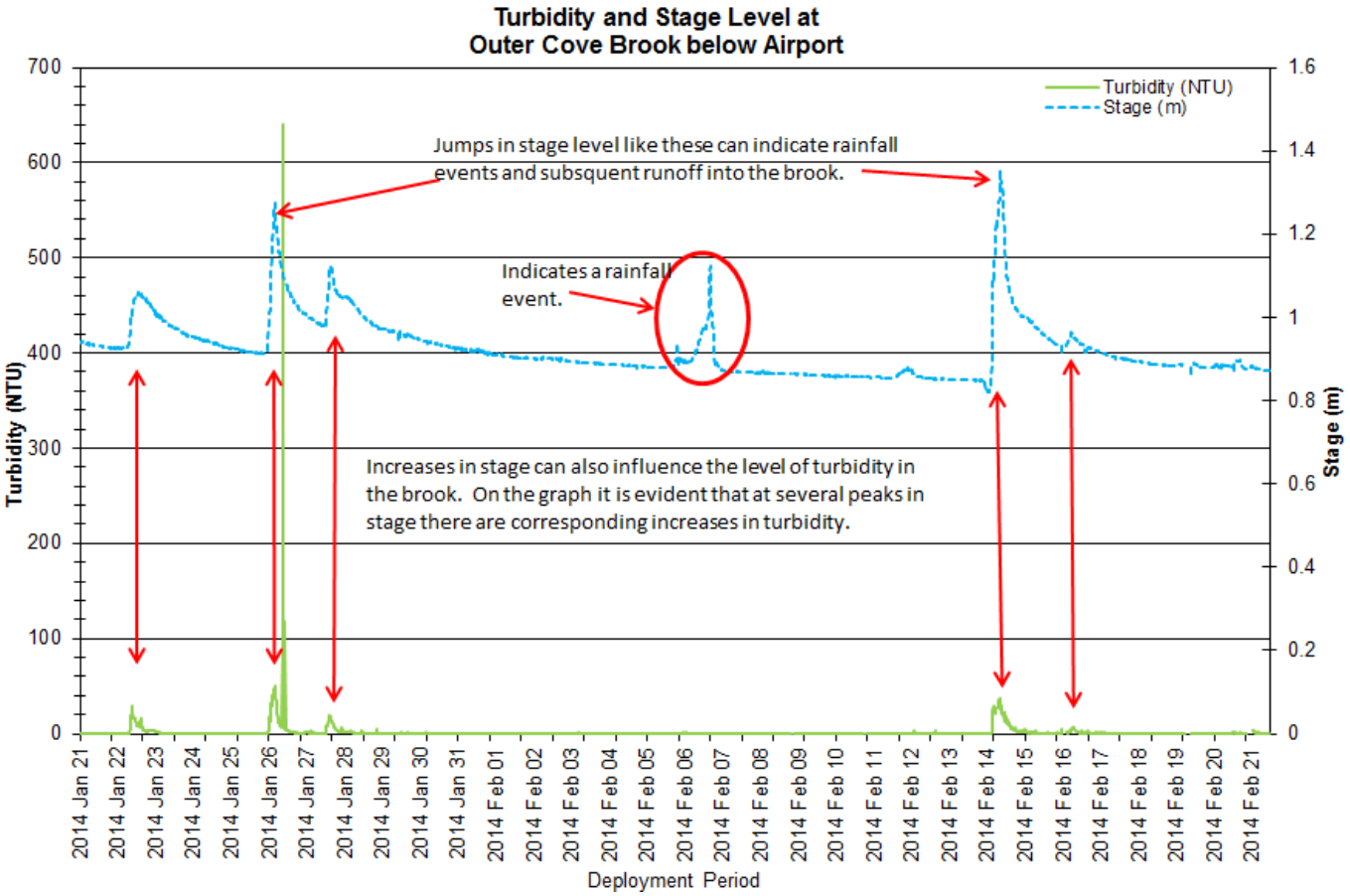


Figure 6: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport for the deployment period January 21, 2014 to February 21, 2014.

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, 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).
- 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 that occurred during this deployment period.

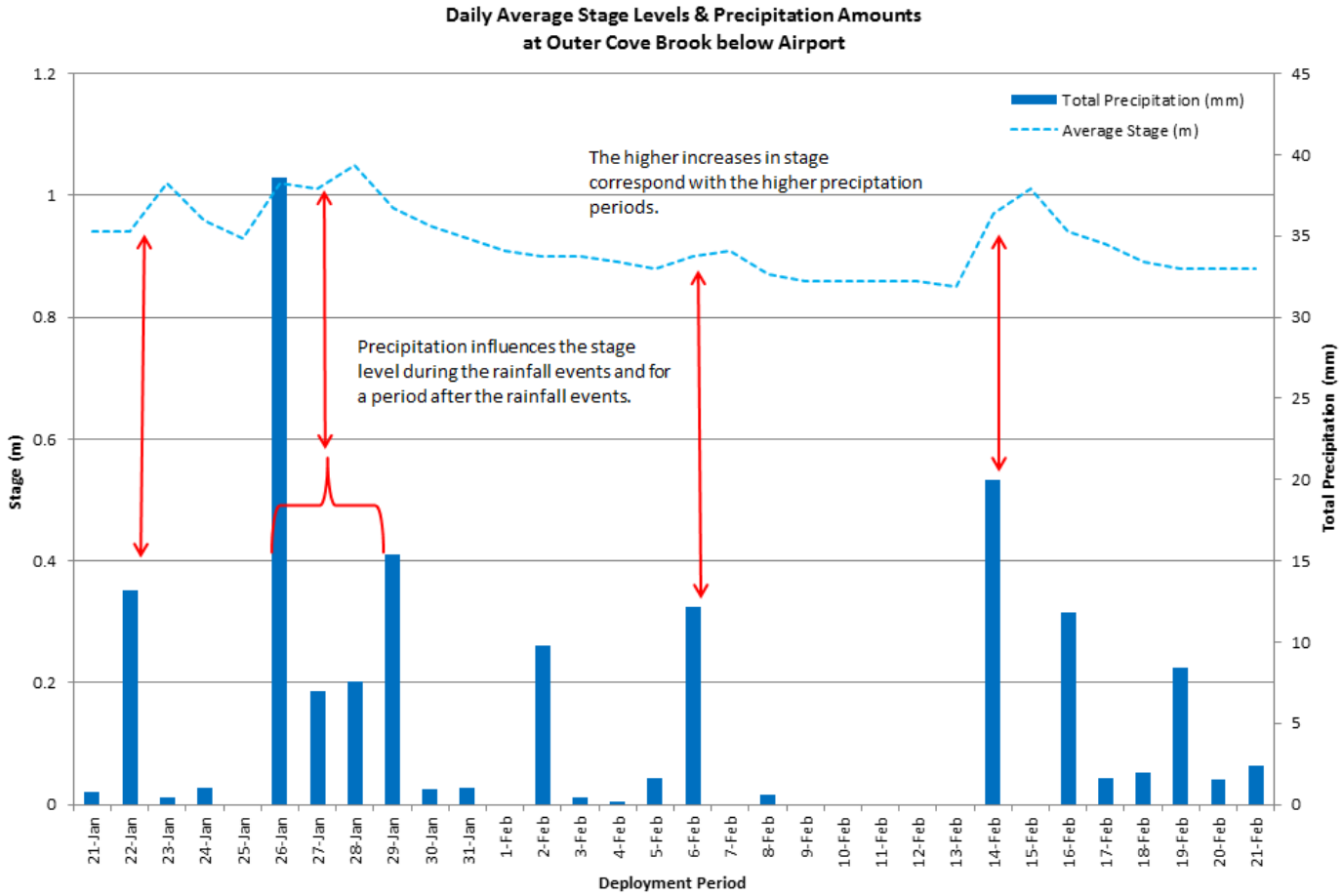


Figure 7: Daily average stage values (m) at Outer Cove Brook below Airport and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period January 21, 2014 to February 21, 2014.

Conclusions

- Generally in natural environments, climate and weather conditions contribute in large part to the variation in water quality parameters. During this deployment it was evident that many of the changes in the parameter data displayed on the graphs, was related to the intermittent precipitation events and small climatic changes of the seasons (i.e. temperature decreases).
- Precipitation events during the deployment period led to related fluctuations in stage, which thus influenced the values of turbidity, pH, specific conductance, and TDS. As ambient air temperatures decreased, there were correspondingly cooler water temperatures, which in turn increased the amount of dissolved oxygen in the water.
- The majority of turbidity events were correlated with increases in stage and thus precipitation events.
- The addition of road salt to roadways during periods of snowfall and low ambient air temperatures led to increases in specific conductance and TDS as the salts were washed into the river system. This indicates that this river is influenced by runoff upstream of the station. These salts can also briefly decrease dissolved oxygen values.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

- Water temperature ranged from -0.06°C to 3.79°C during this deployment period (Figure 8). This is notably cooler than the previous deployment, and is normal during winter months.
- As a result of a transmission error with Water Survey of Canada's data there is a gap in stage data from January 25th, 2014 at 2:15 PM to January 28th, 2014 at 9:15 AM.
- 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 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.

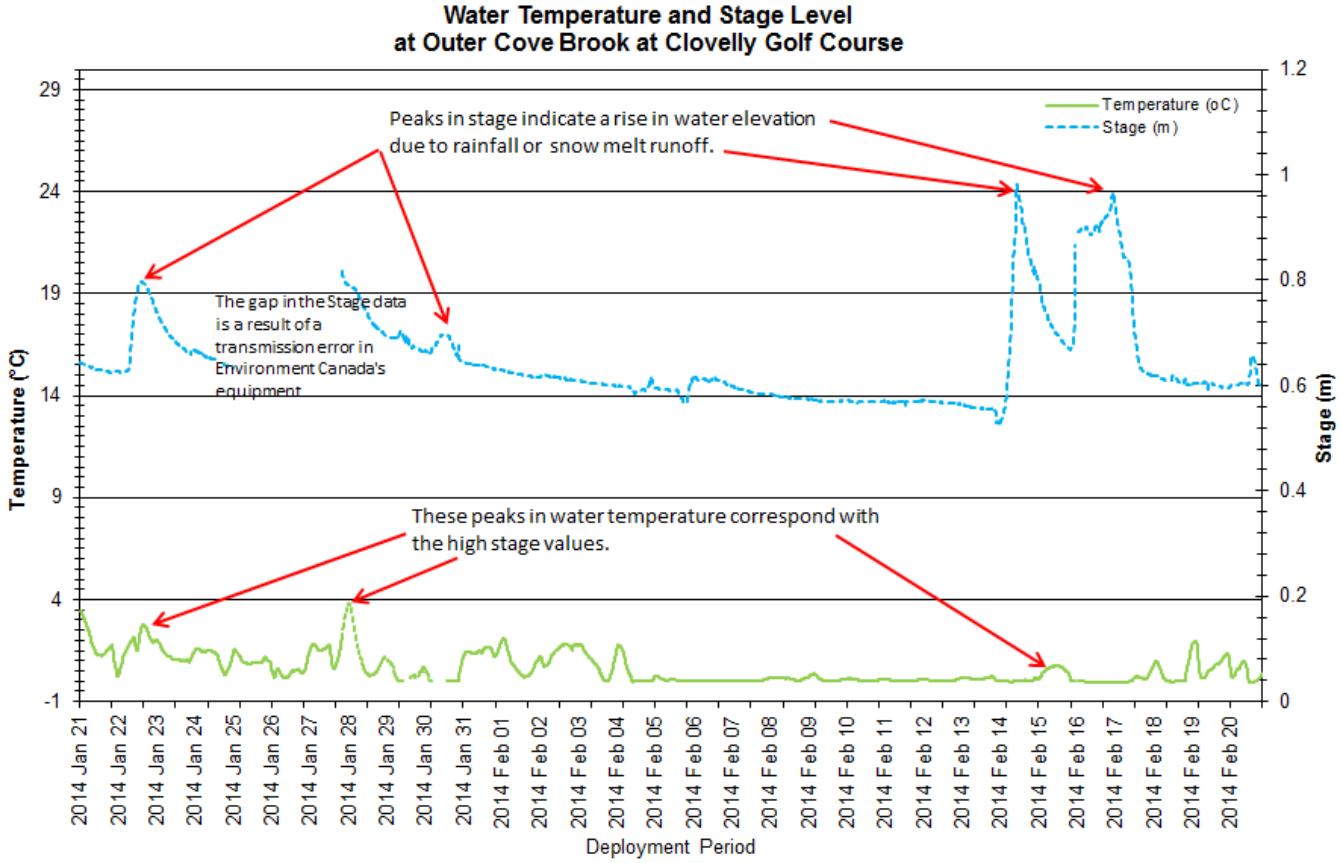


Figure 8: Quarter-hourly water temperature (℃) an d stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period January 21, 2014 to February 21, 2014.

pH

- Throughout this deployment period pH values ranged between 6.19 pH units and 6.63 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), decreasing at times due to precipitation.
- As a result of a transmission error with Water Survey of Canada's data there is a gap in stage data from January 25th, 2014 at 2:15 PM to January 28th, 2014 at 9:15 AM.
- pH levels drop on February 6th to 8th, related to a precipitation event 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 pH level was slightly higher than normal (more acidic than previous deployment months).

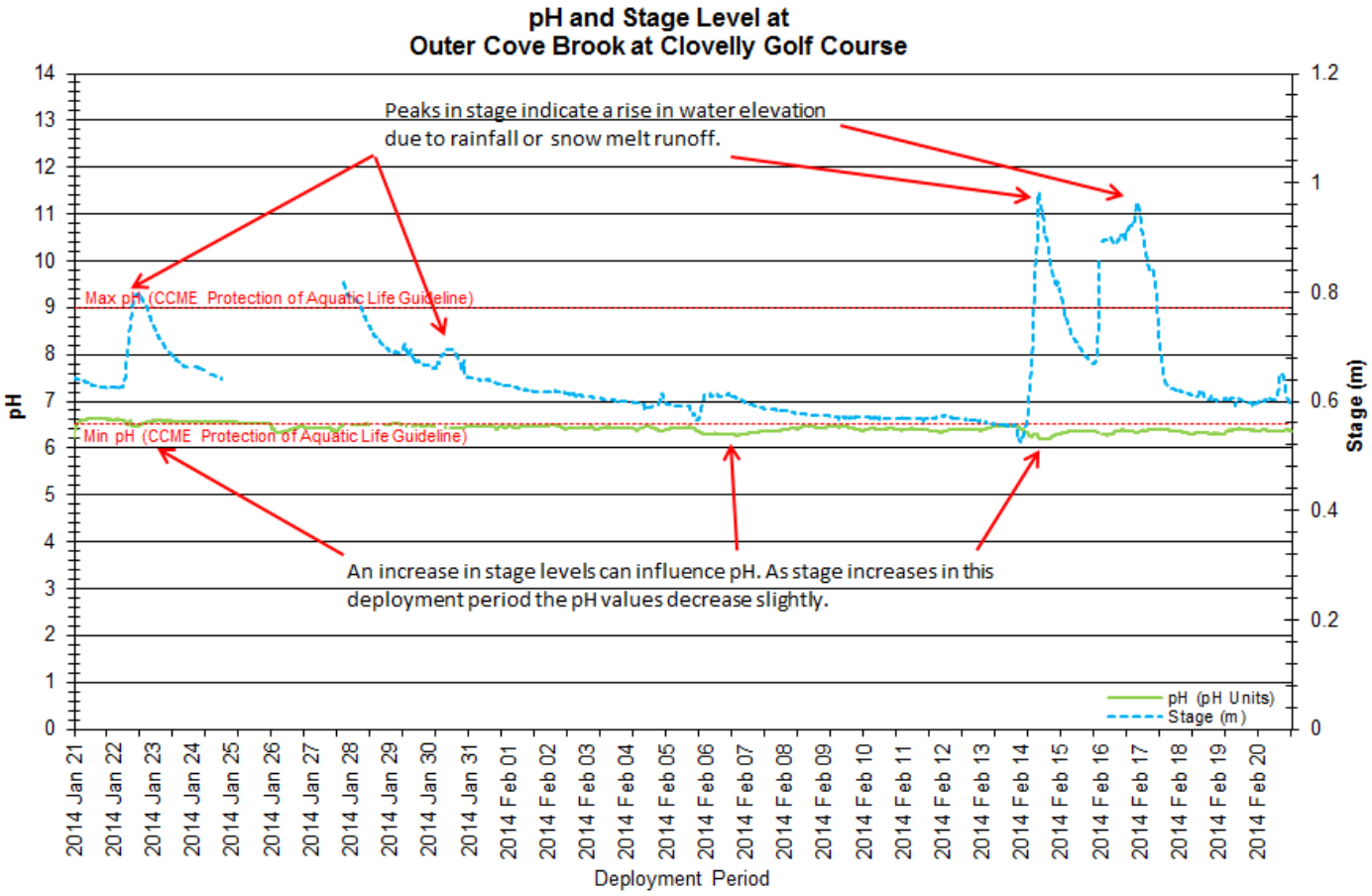


Figure 9: Quarter-hourly pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period January 21, 2014 to February 21, 2014.

Specific Conductivity & TDS

- The conductivity levels were within 468 µS/cm and 2804 µS/cm during this deployment period. TDS ranged from 0.3 g/L to 1.79 g/L. This is lower than the previous deployment period.
- As a result of a transmission error with Water Survey of Canada's data there is a gap in stage data from January 25th, 2014 at 2:15 PM to January 28th, 2014 at 9:15 AM.
- Cold temperatures and snowfall events during winter months can have an effect of increasing conductance levels with the addition of salt on roadways. Salt, flushed into urban streams increases the amount of dissolved substances present hence resulting in the instrument recording higher conductivity values and the peaks in data on the graph (Figure 10).
- Rainfall events, which potentially occurred on January 23rd, 30th and February 14th (see Figure 10), can have the effect of diluting and lowering conductance 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, resulting in decreasing the specific conductivity values.
- 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.

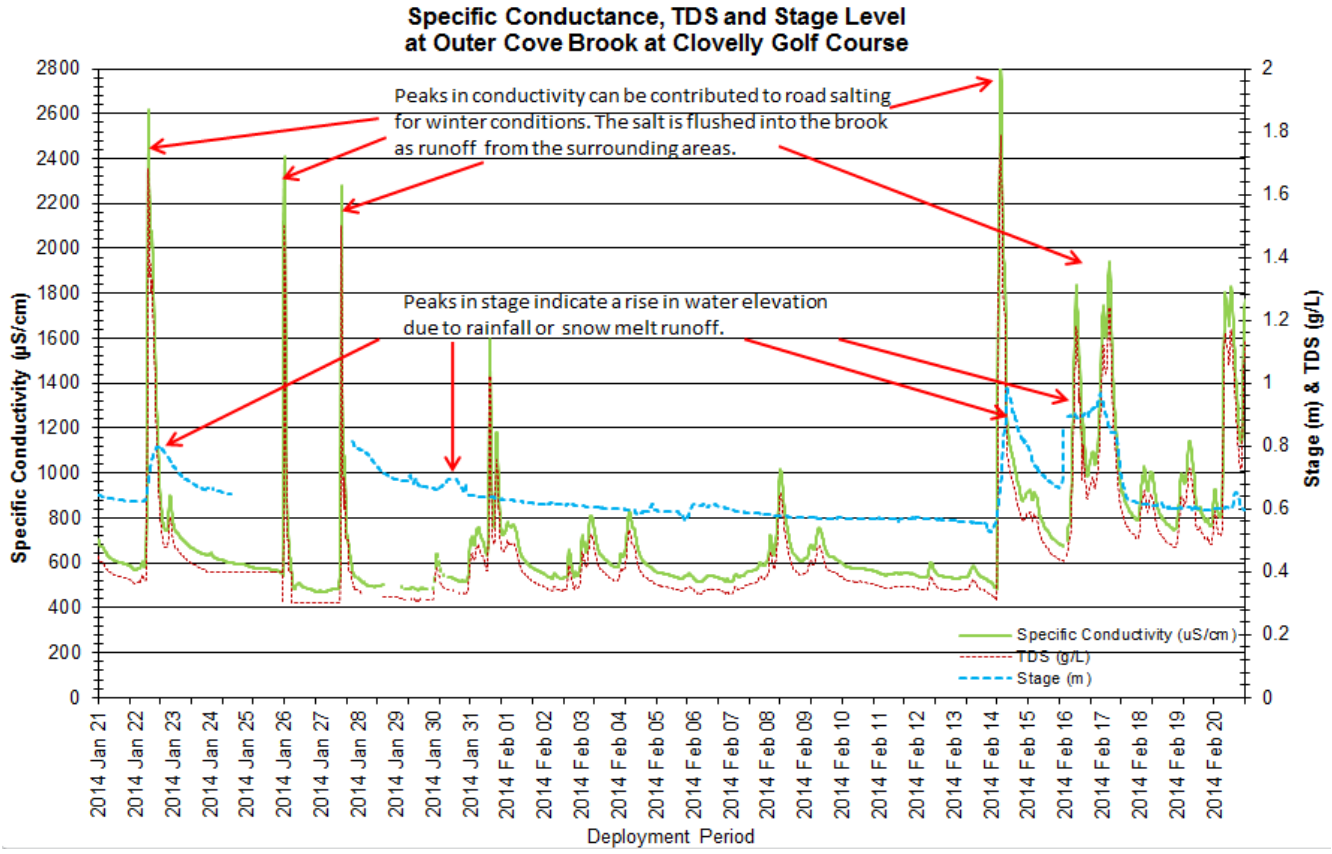


Figure 10: Quarter-hourly specific conductivity (uS/cm), TDS (g/L) and stage (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period January 21, 2014 to February 21, 2014.

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 66.3% Sat–85.1% Sat. Dissolved Oxygen (mg/L) measured 9.66 mg/L to 12.32 mg/L.
- The DO mg/L values are above the minimum DO CCME guideline for early life stages throughout this deployment period (Figure 11).
- The drop in dissolved oxygen on January 22nd and 28th, 2014 correspond to a sharp increase in water temperatures at that time. This was likely a result of rainfall.
- The drops in dissolved oxygen on February 6th, 7th, 14th and 15th, 2014 may have been a result of a large amount of dissolved substances flushed into the brook; generally this is a result of runoff from roadways during the salting periods after snow storms.

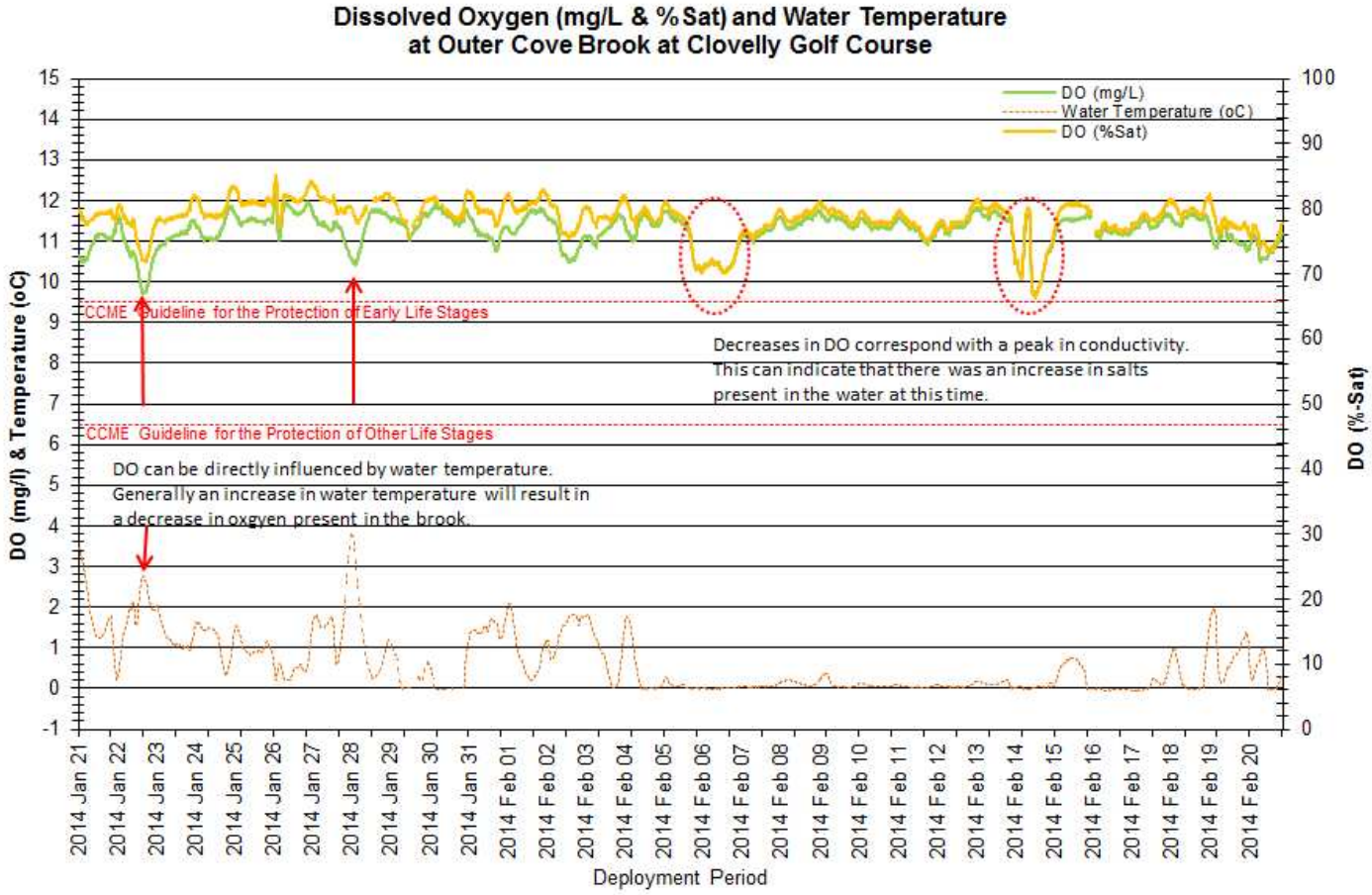


Figure 11: Quarter-hourly dissolved oxygen (mg/L & % sat) and water temperature (℃) values at Outer Cove Brook at Clovelly Golf Course for the deployment period January 21, 2014 to February 21, 2014.

Turbidity

- Turbidity levels during this deployment period ranged within 1.3 NTU and 39.9 NTU (Figure 12).
- As a result of a transmission error with Water Survey of Canada's data there is a gap in stage data from January 25th, 2014 at 2:15 PM to January 28th, 2014 at 9:15 AM.
- 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.

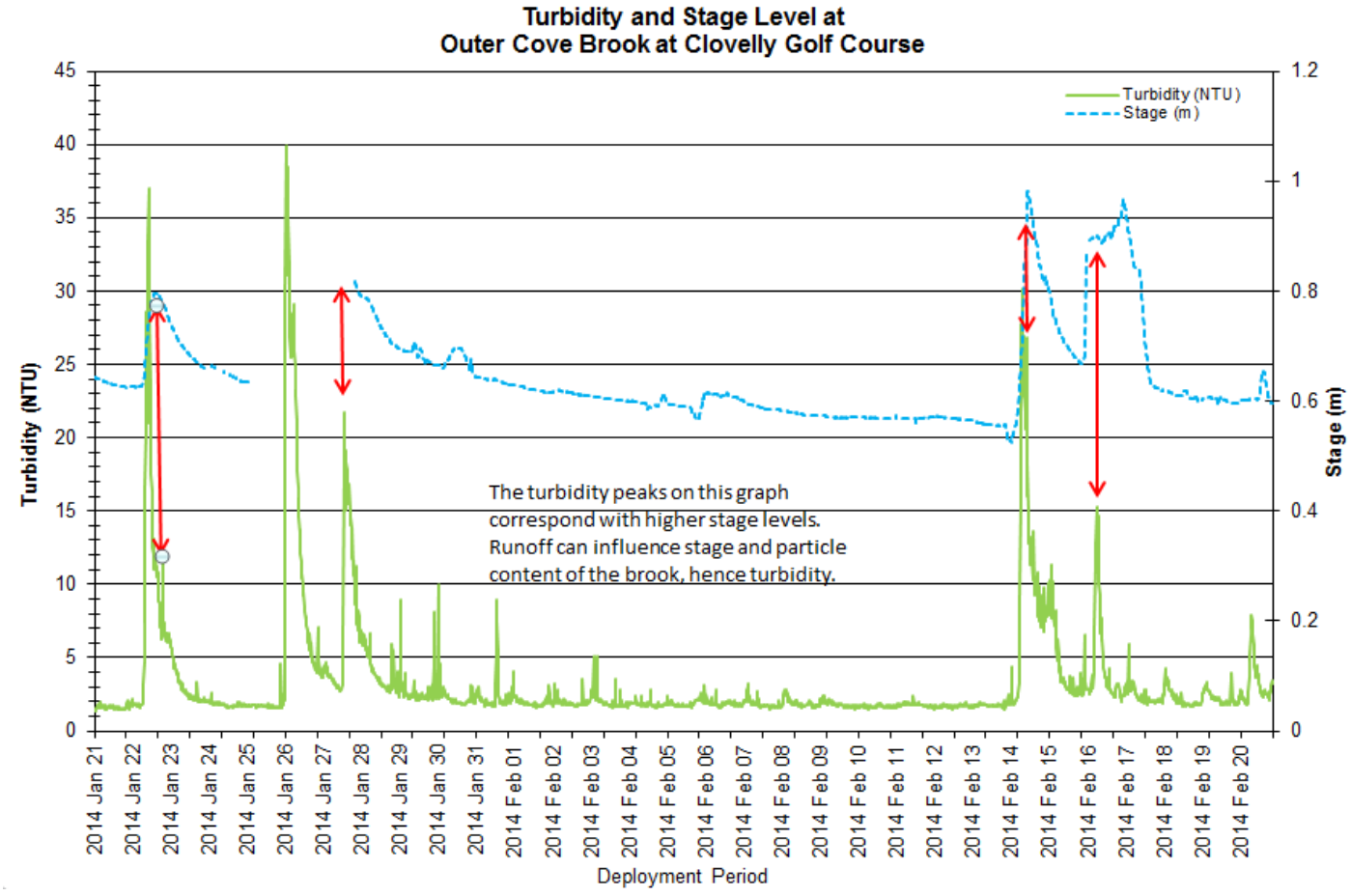


Figure 12: Quarter-hourly turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course for the deployment period January 21, 2014 to February 21, 2014.

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. As a result of a transmission error with Water Survey of Canada's data there is a gap in stage data from January 25th, 2014 at 2:15 PM to January 28th, 2014 at 9:15 AM.
- During the deployment period, the stage values ranged from 0.53m to 0.98m. The larger peaks in stage do correspond with sufficient rainfall events as noted on Figure 13.

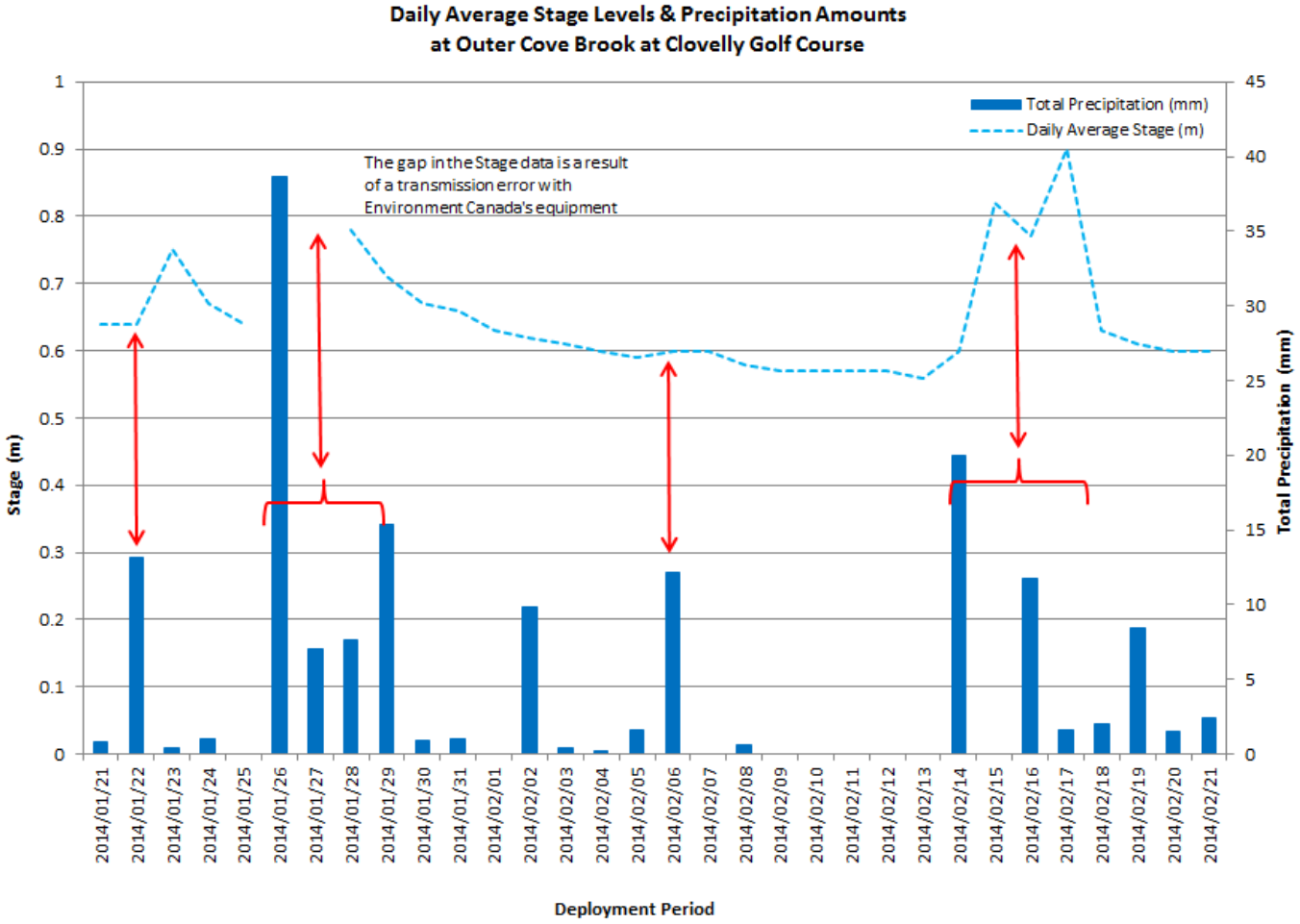


Figure 13: Daily average stage values (m) at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's St. John's Airport Station for the deployment period January 21, 2014 to February 21, 2014.

Conclusion

- As any 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 heavy road ways, which can play a part in 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 mean of 11.26 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 parameters of the brook that flows mainly through residential areas and alongside heavily trafficked roadways.

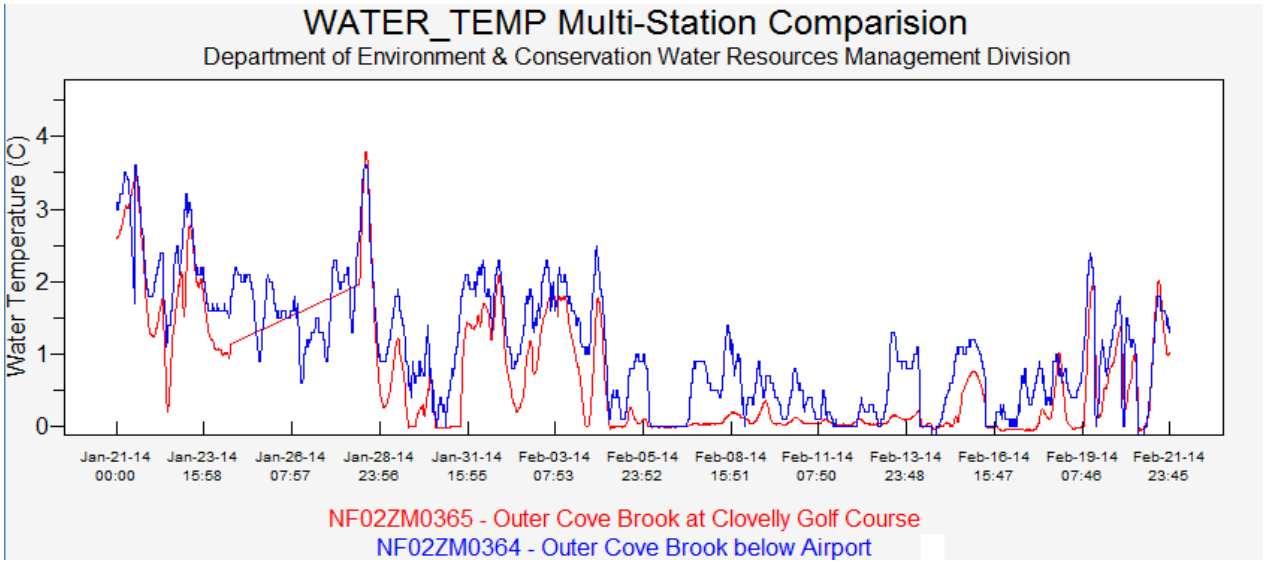
Conclusion

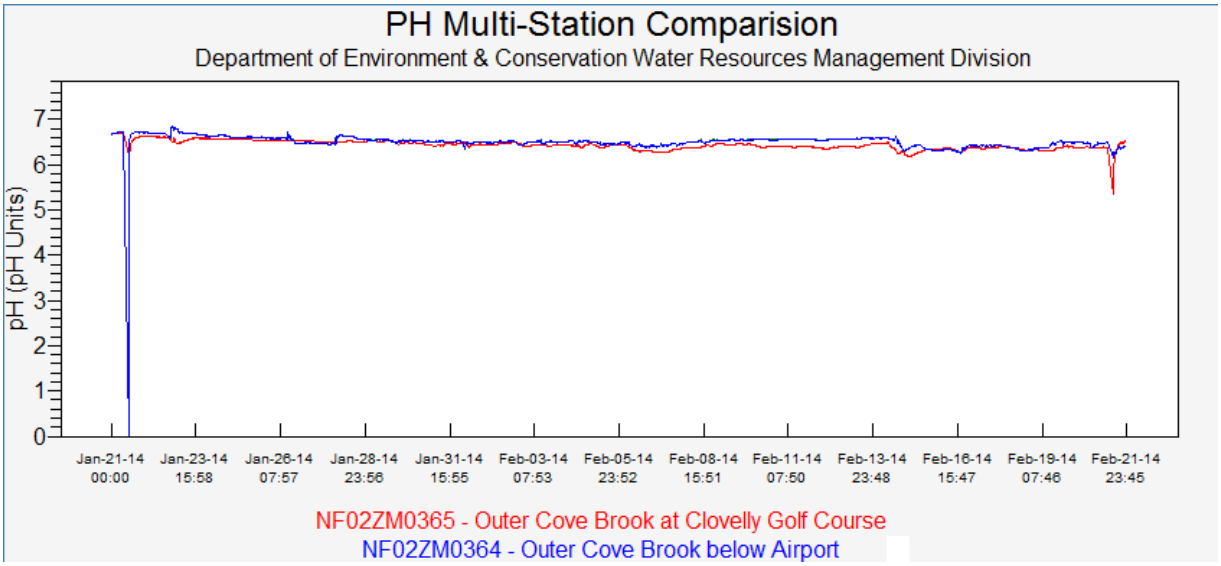
Outer Cove Brook Network

- 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 0.24°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 6.51 and Outer Cove Brook at Clovelly Golf Course reading 6.43. The pH level along the brooks network, for the most part is steady at both stations. However there are several recorded peaks in pH at the Airport station. It is unclear what may be influencing these changes at the present time, WRMD will continue to investigate.
- The Specific Conductivity median at Outer Cove Brook below Airport was 528.0µS/cm with the Outer Cove Brook at Clovelly Golf Course recording a median of 598.0µS/cm. The Specific Conductivity graphs for both stations display several intermittent drops in levels over this deployment period, these drops are linked to corresponding precipitation events.
- Dissolved Oxygen at the upstream station (Outer Cove Brook below Airport) had a median of 84.7%Sat during the deployment period, the downstream station (Outer Cove Brook at Clovelly Golf Course) had a lower median of 79%Sat. Both stations have close DO medians and there is no noticable 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. The small decreases in DO (mg/L and % Sat) can be linked to the increases in water temperature. The large dips in DO (mg/L and %Sat) at both stations correspond with rainfall events at those times.
- 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 2.0NTU. There is not a large difference between the medians, however the turbidity does increase very slightly as the water moves downstream.
- 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

Parameter Station Comparison Graphs





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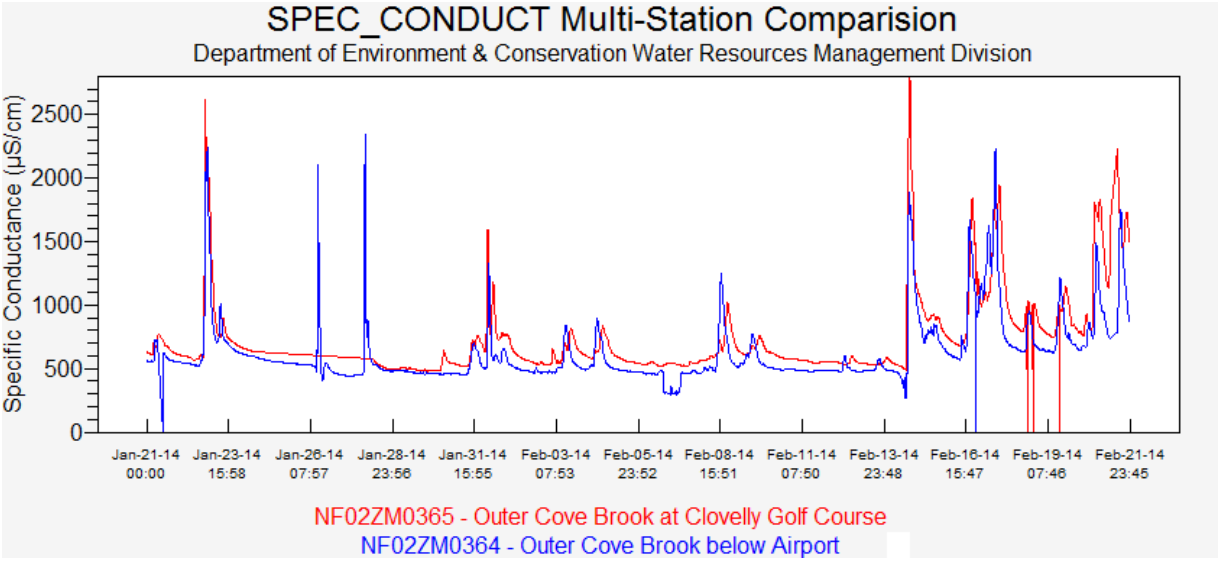

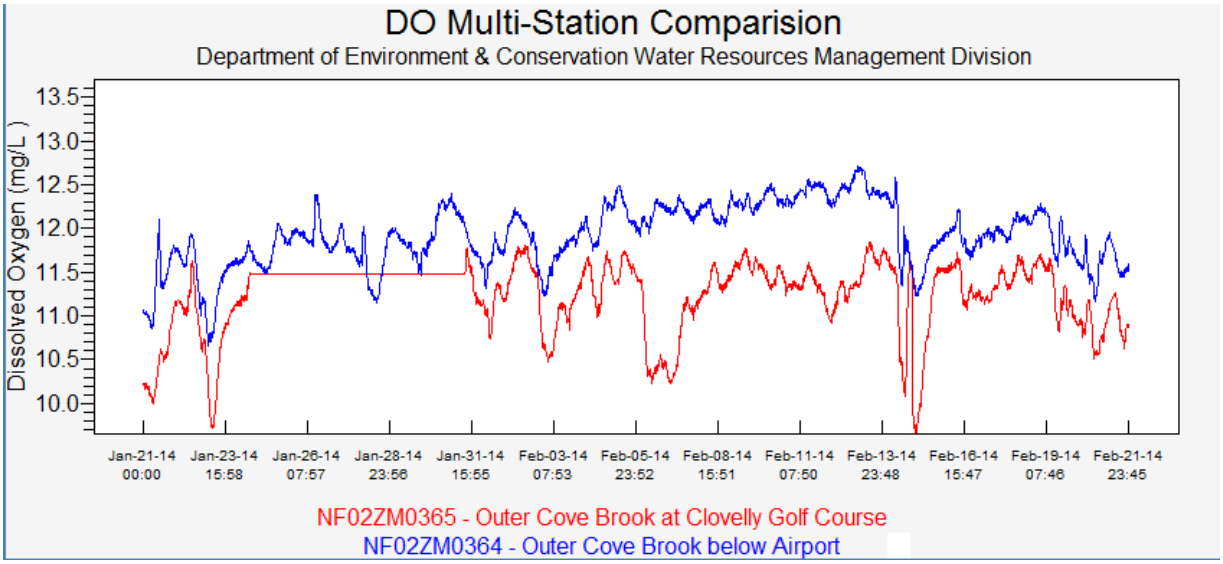

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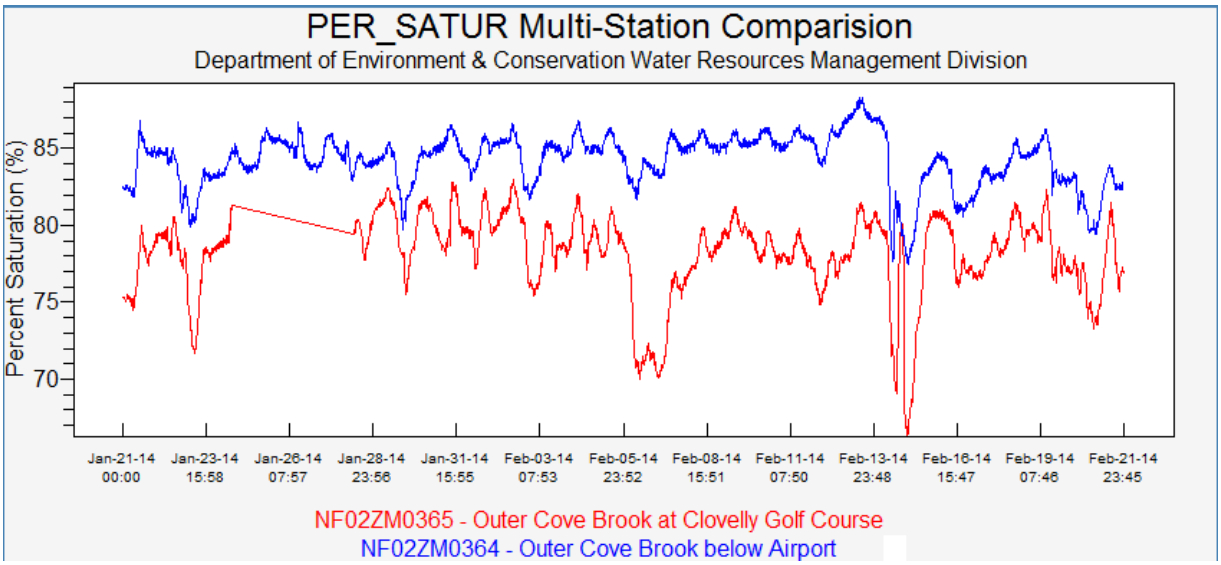

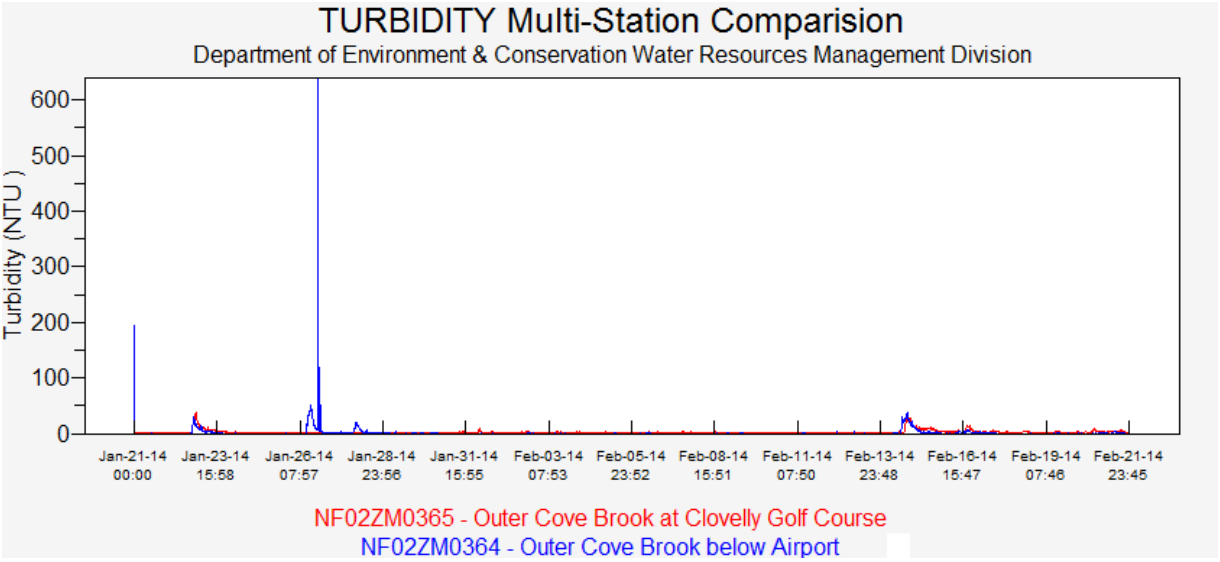

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