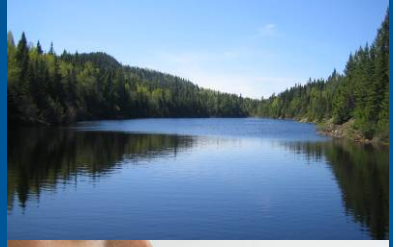
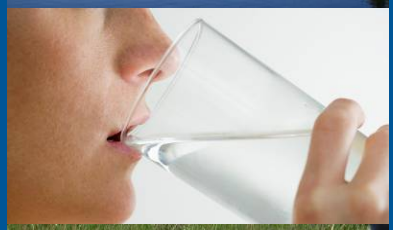






Real-Time Water Quality Report

Outer Cove Brook Network

Deployment Period includes:

Outer Cove Brook below Airport
July 22, 2015 to August 28, 2015

Outer Cove Brook at Clovelly Golf Course
July 22, 2015 to September 2, 2015

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 mitigated measures can be taken.

The purpose of these real-time stations is to monitor, process and publish 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 deployment period of July 22, 2015 to August 28, 2015 for the Outer Cove Brook below Airport station and the deployment period of July 22, 2015 to September 2, 2015 for Outer Cove Brook at Clovelly Golf Course station. Due to weather conditions and time constraints the scheduled field visits for removal of the instruments had to be separate.

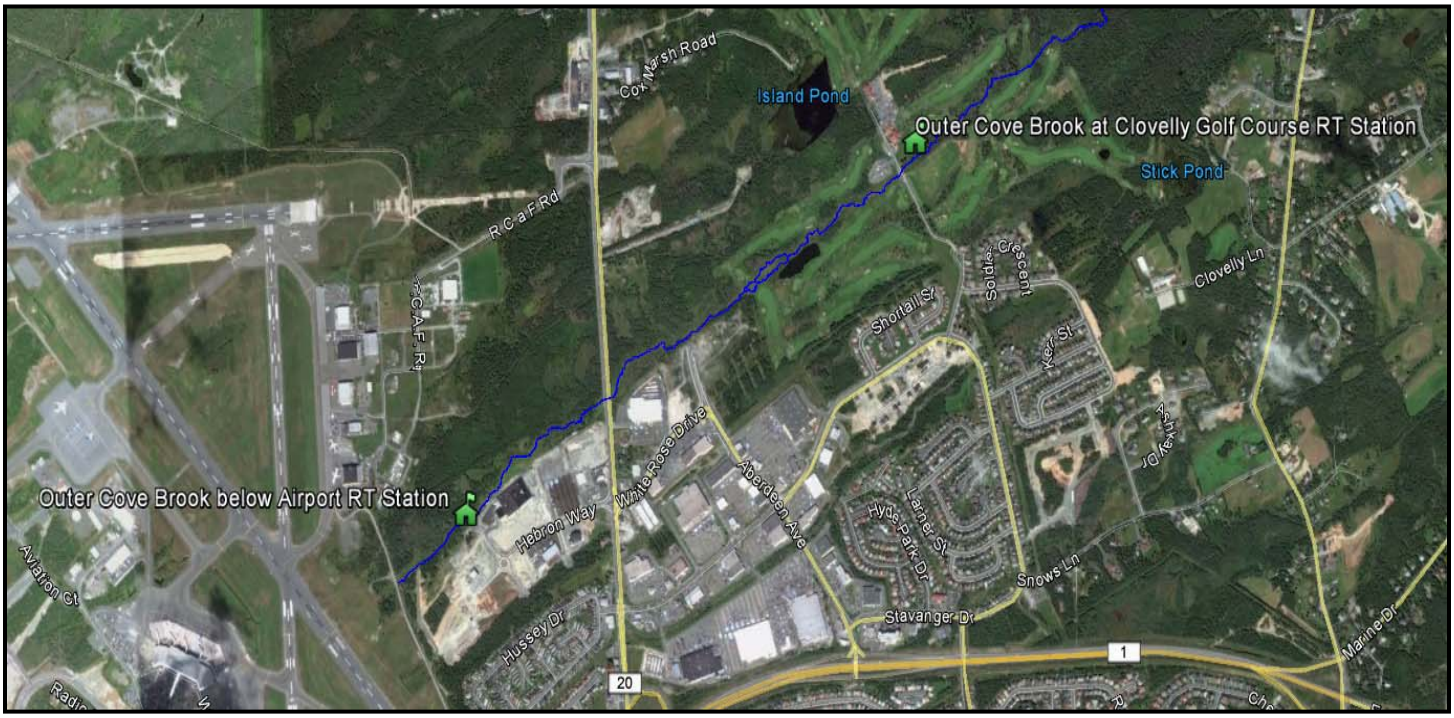

Figure 1: Outer Cove Brook Real-Time Water Quality and Quantity Stations.

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).

Water Resources Management Division (WRMD) staff (Environment and Conservation (ENVC)) is responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Tara Clinton, under the supervision of Renee Paterson, is ENVC's main contact for the real-time water quality monitoring operations at Outer Cove Brook, and is responsible for maintaining and calibrating water quality instruments, as well as grooming, analyzing and reporting on water quality data recorded at the stations during the deployment year.

Water Survey of Canada (WSC) staff (Environment Canada (EC)) under the management of Howie Wills, play an essential role in the data logging/communication aspect of the network and the maintenance of the water quantity monitoring equipment. EC-WSC staff visit the sites regularly to ensure the data logging and data transmitting equipment are working properly. WSC is responsible for handling stage and streamflow issues. The quantity data is raw data that is transmitted via satellite and published online with the quality data on the Real-Time Stations website. Quantity data has not been corrected or groomed when published online or used in the monthly reports for the stations. WSC is responsible for QA/QC of water quantity data. Corrected stage and streamflow data can be obtained upon request to WSC.

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.

Concerns or Issues during the deployment period

There were no outstanding issues or problems at these stations during deployment.

Deployment and removal instrument performance rankings for **Outer Cove Brook below Airport** are summarized in Table 2.

Table 2: Instrument performance rankings for Outer Cove Brook below Airport

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Below Airport	July 22	Deployment	Excellent	Excellent	Excellent	Fair	Excellent
	August 28	Removal	Excellent	Fair	Excellent	Poor	Fair

During the Outer Cove Brook below Airport station deployment, the water quality parameter data ranked as 'Excellent' for water temperature, pH, conductivity and turbidity. The dissolved oxygen data ranked as 'Fair' when compared to the QAQC sonde.

During the Outer Cove Brook below Airport station removal, the data collected displayed that the water quality parameters for water temperature and conductivity ranked as 'Excellent', while pH and turbidity comparisons ranked as 'Fair'. The dissolved oxygen data ranked as 'Poor' when compared against the QAQC sonde.

Deployment and removal instrument performance rankings for **Outer Cove Brook at Clovelly Golf Course** are summarized in Table 3.

Table 3: Instrument performance rankings for Outer Cove Brook at Clovelly Golf Course

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Clovelly Golf Course	July 22	Deployment	Excellent	Fair	Excellent	Excellent	Excellent
	September 2	Removal	Excellent	Good	Excellent	Excellent	Good

Comparison of the field sonde and QAQC sonde data during the deployment at Outer Cove Brook Clovelly Golf Course indicated the following: water temperature, conductivity, dissolved oxygen and turbidity comparison data all ranked as 'Excellent'. pH values ranked as 'Fair' during deployment. The pH sensor can take some time to stabilize and it is likely that enough time wasn't provided to allow the sensor to stabilize.

At removal the comparison between the field sonde and QAQC sonde indicated that, water temperature, conductivity and dissolved oxygen ranked as 'Excellent', while the data for pH and turbidity ranked as 'Good' The QAQC sonde had a low pH reading for this brook at comparison.

Outer Cove Brook below Airport

Water Temperature

Water temperature ranged from 9.20°C to 19.80°C during this deployment period (Figure 2). There were noticeable increases and decreases in the water temperature. This is consistent with ambient air temperatures over this time period, generally increasing during daylight hours and cooling overnight.

As the deployment period came to an end, the water temperature starts to increase with the warmer air temperatures. The water temperatures at this station do display diurnal variations. Shallow streams and ponds are highly influenced by natural diurnal variations in the surrounding air temperatures (Appendix I) and the precipitation events that may occur.

Please note the stage data is raw data that is published on our web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

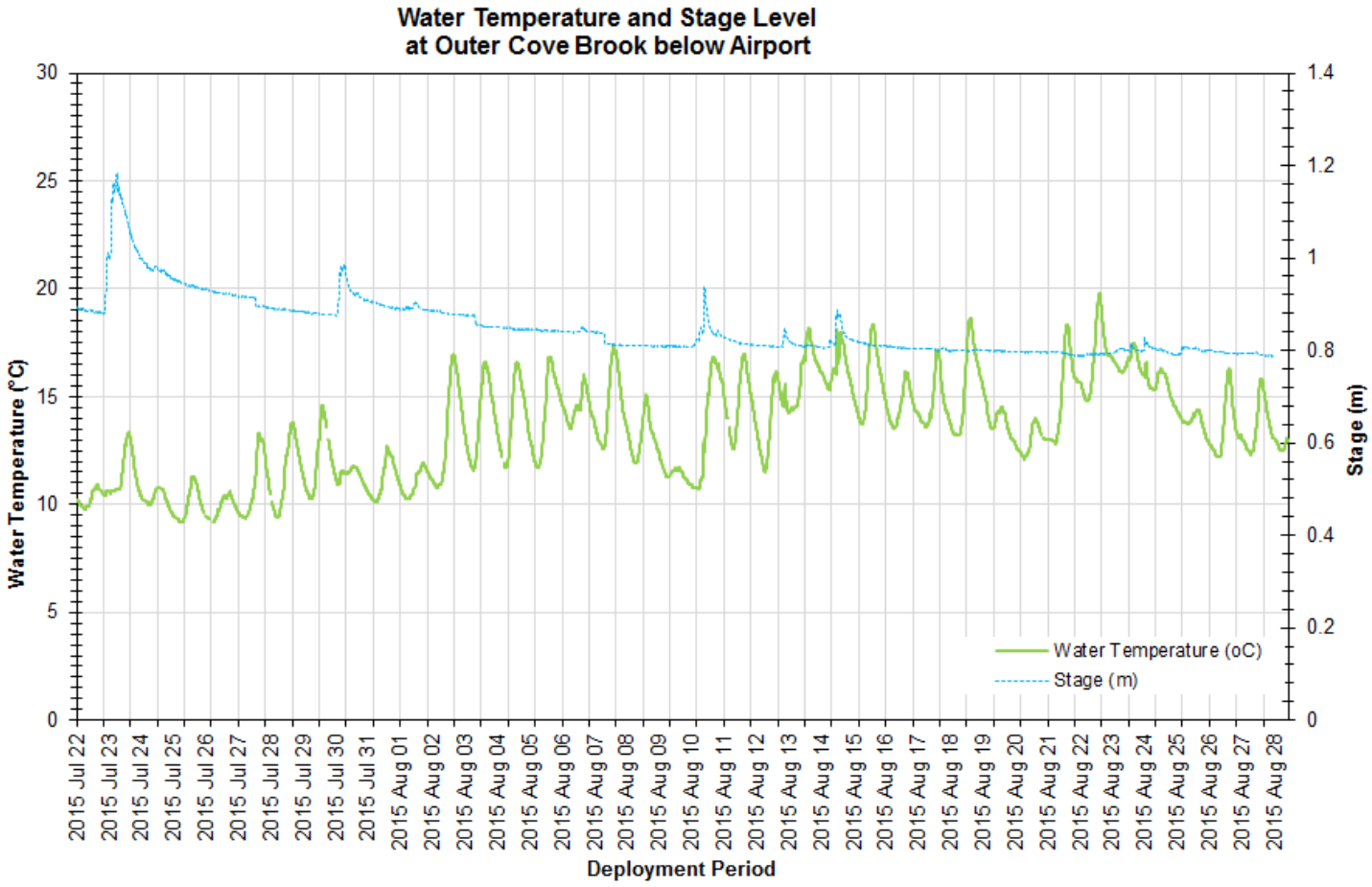

Figure 2: Water temperature (°C) and Stage (m) values at Outer Cove Brook below Airport

pH

Throughout the deployment period, pH values ranged between 5.83 pH units and 6.82 pH units (Figure 3).

During this deployment, the pH values dipped below the minimum CCME Guidelines for the Protection of Aquatic Life (6.5 pH units) on several occasions. The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different.

The graph indicates that as the stage level increases the pH data decreases for a short period of time. During the deployment period the median pH level was 6.60 pH units. The pH data decreases gradually over the deployment period. This could be due to the decrease in stage level as the summer months start to warm.

Please note the stage data is raw data that is published on our web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

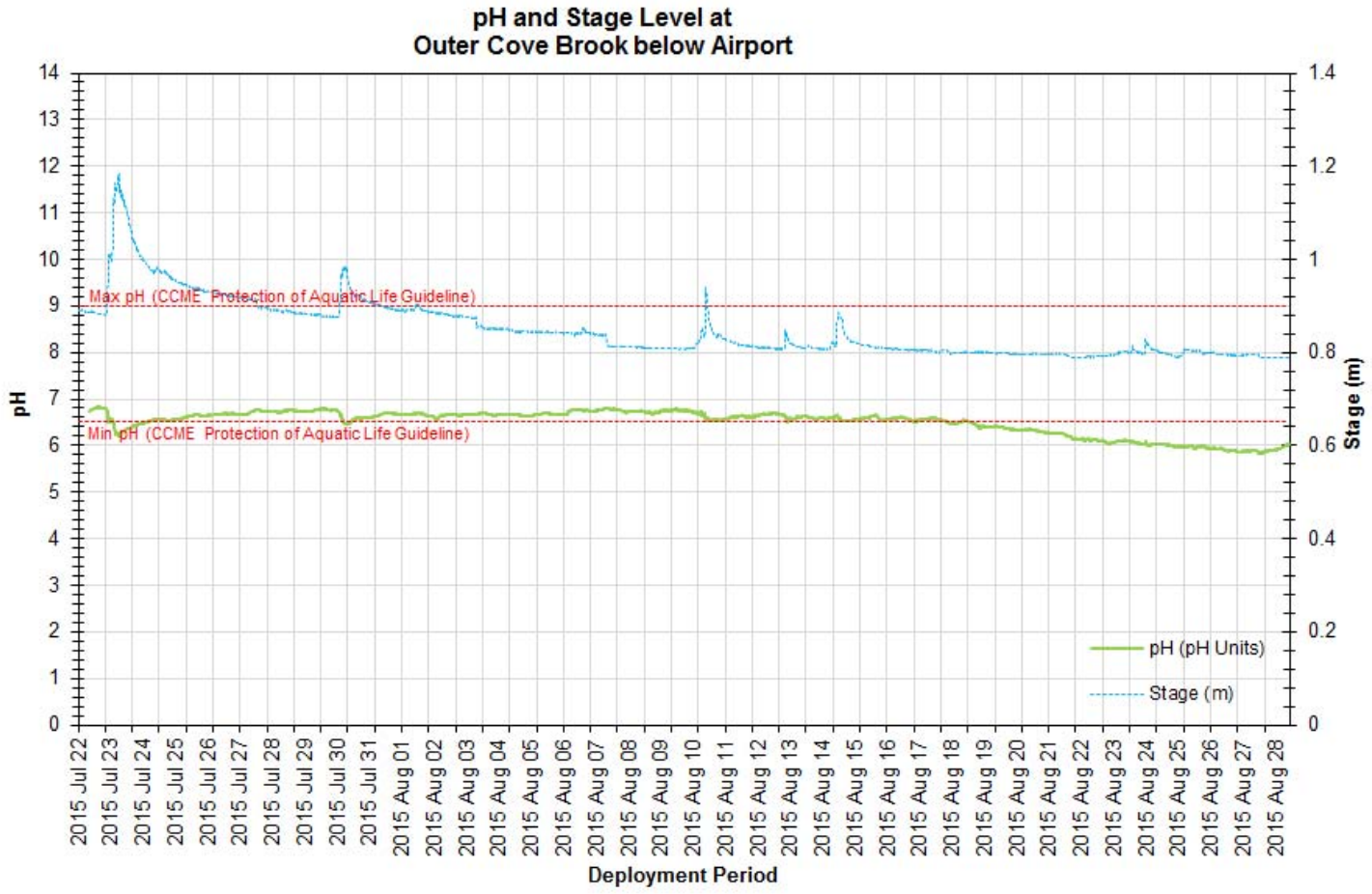

Figure 3: pH (pH units) and stage level (m) values at Outer Cove Brook below Airport

Specific Conductivity

The conductivity levels were within 120.1 µS/cm and 650.0 µS/cm during this deployment period.

Figure 4 displays the inverse relationship between conductivity and stage level. When stage levels rise, the specific conductance levels drop in response as the increased amount of water in the river system dilutes the solids that are present.

The dips in conductivity data after increases in stage indicate that the brook is being flushed naturally; the suspended matter and dissolved substances in the brook are flushed for a short period of time with the higher flow. This is evident on several occasions during this deployment.

Please note the stage data is raw data that is published on our web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

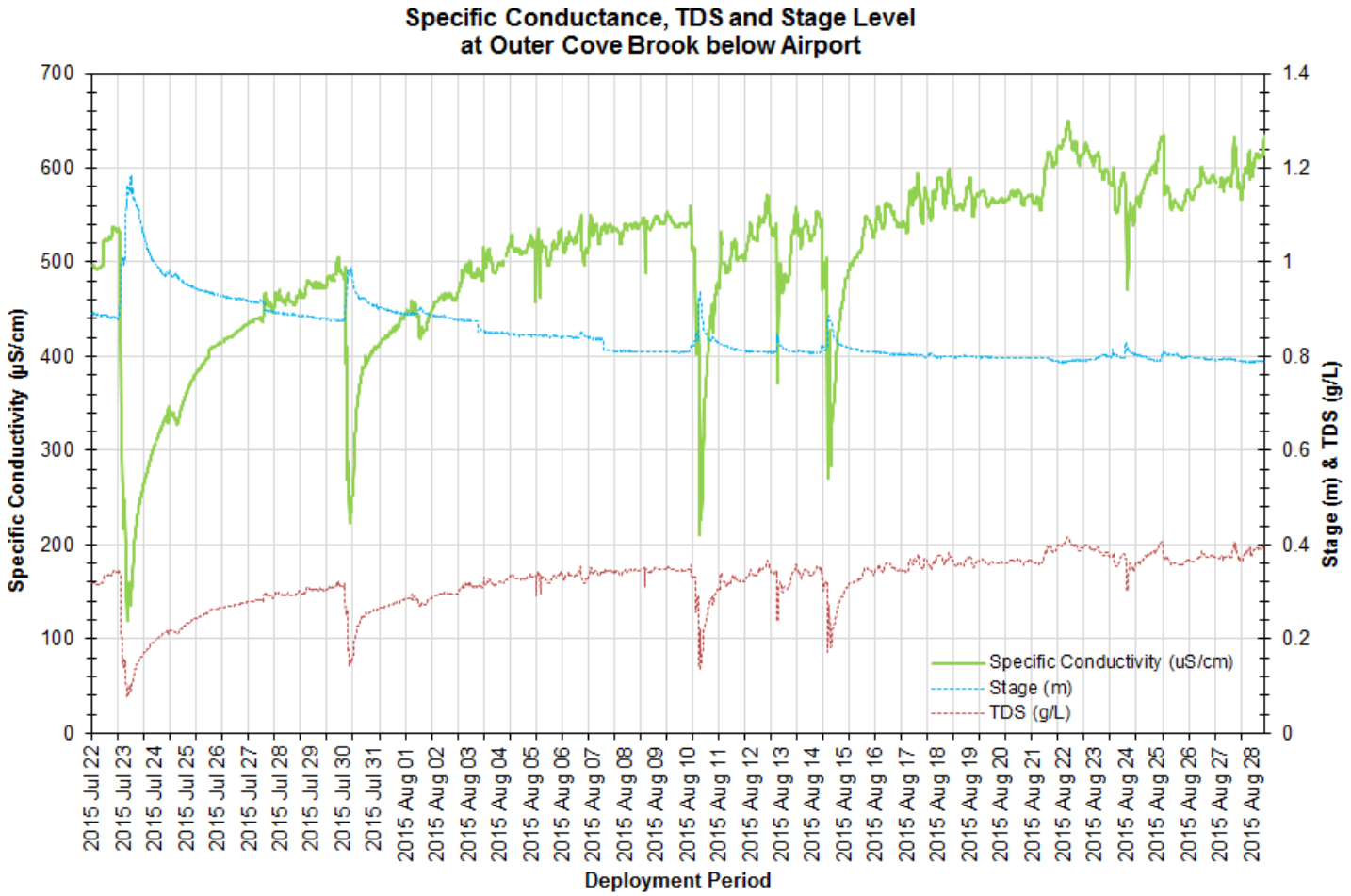

Figure 4: Specific conductivity (µS/cm) and stage (m) values at Outer Cove Brook below Airport.

Dissolved Oxygen

The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe and then the instrument calculates percent saturation (% Sat) with water temperature.

The Dissolved Oxygen % Sat levels were within 83.1 %Sat to 95.1 %Sat. Dissolved Oxygen (mg/L) measured 8.10 mg/L to 10.57 mg/L (Figure 5).

The dissolved oxygen levels decreased slightly as the deployment period continued. The warmer water temperatures utilized more dissolved oxygen in the water body during the summer months. This is a normal occurrence in water bodies.

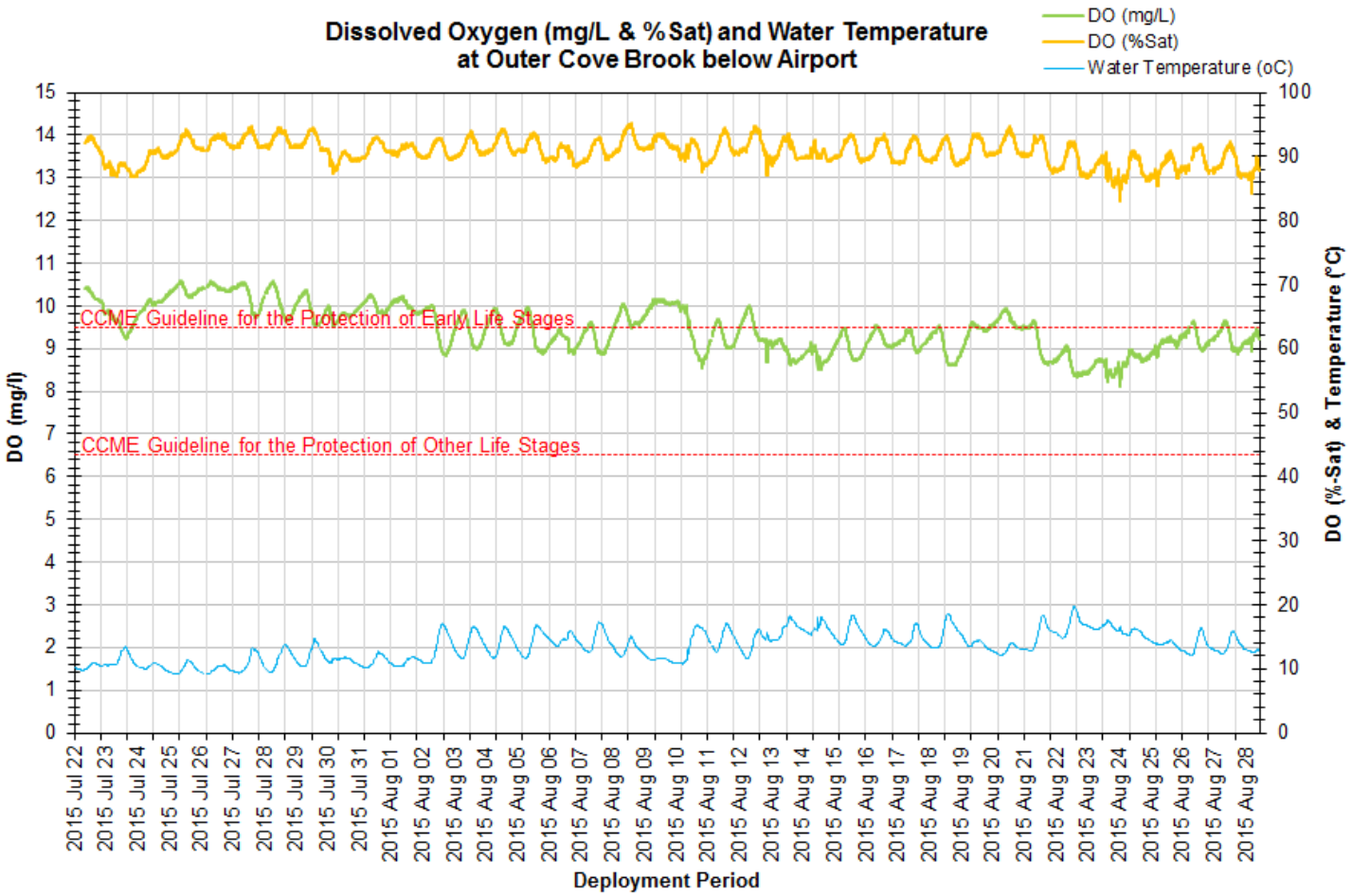

Figure 5: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook below Airport.

Turbidity

Turbidity levels during the deployment ranged between 0.0 NTU and 86.2 NTU (Figure 6). The deployment data had a median of 0.0 NTU which was lower than the previous month.

Most of the turbidity events in the deployment period correlate with increases in stage potentially from precipitation (Figure 6). Precipitation can increase the presence of suspended material in water.

It was determined that the data from August 4th, 2015 onwards was not representative of the Outer Cove Brook at that time. All the data was removed from August 4th to the end of deployment.

Please note the stage data is raw data that is published on our web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

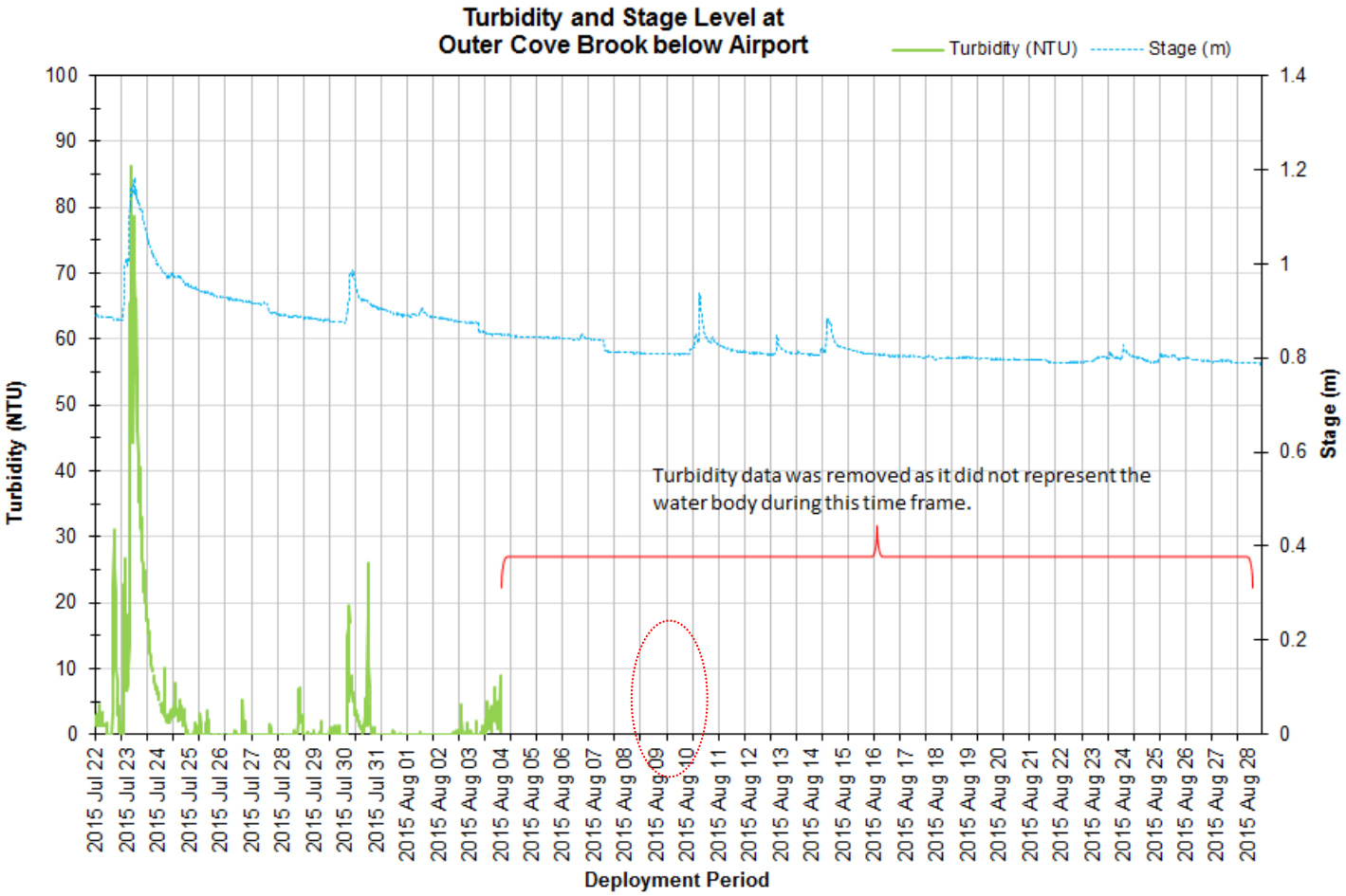

Figure 6: Turbidity (NTU) and stage level (m) values at Outer Cove Brook below Airport.

Stage, Stream Flow & Precipitation

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).

During the deployment period, the daily averaged stage data ranged from 0.79m to 1.18m. Stream flow data ranged within 0.03 m^3/s to 2.34 m^3/s. The larger peaks in stage correspond with substantial rainfall events as noted on Figure 7.

Precipitation data was obtained from Environment Canada's St. John's Airport weather station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 26.1 mm on July 22nd which increased both stage and stream flow on July 23rd, 2015.

Please note the stage and stream flow data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

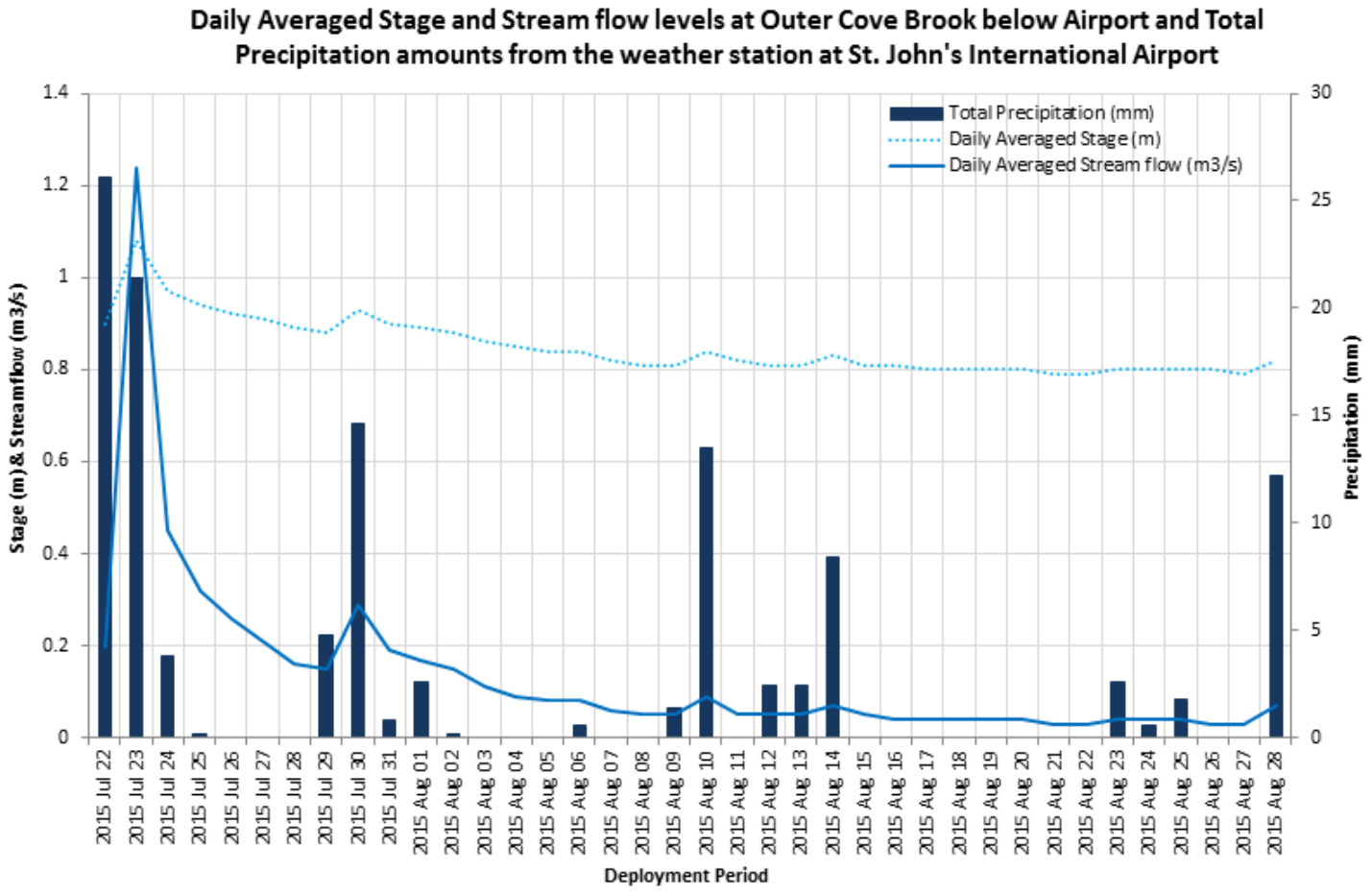

Figure 7: Daily average stage & stream flow values at Outer Cove Brook below Airport and daily total precipitation values from Environment Canada's St. John's Airport Station.

Conclusion

As with many shallow brooks and streams, precipitation events play a role in influencing the parameters within the water body. Outer Cove Brook at Airport flows through significant developed areas, including residential zones and within the boundaries of heavily used road ways, which can influence the parameter levels that are recorded.

Rainfall events decreased conductivity for short periods of time flushing the dissolved material through the brook. High stage levels reflecting rainfall, also contributed to bursts in turbidity readings for short periods of time. During the deployment there were inaccuracies with the turbidity data from August 4th onwards, this data was removed to ensure it was not used in any statistical analysis.

The warmer ambient air temperatures (Appendix I) resulted in a slight increase in water temperature over this deployment period. In turn, water temperature directly affects the amount of dissolved oxygen present in the brook and it is common to see mirroring trends in dissolved oxygen.

Outer Cove Brook at Clovelly Golf Course

Water Temperature

Water temperature ranged from 9.34°C to 20.16°C during this deployment period (Figure 8).

During this deployment period the water temperature remains reasonably consistent. Water temperatures increased slighting toward the end of the deployment (Figure 8). There are minor dips in water temperature during the higher stage events, this can be noted on July 30th and August 9th.

Water temperature on these water quality instruments is a very important parameter and it has the ability to influence other parameters.

Please note the stage data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

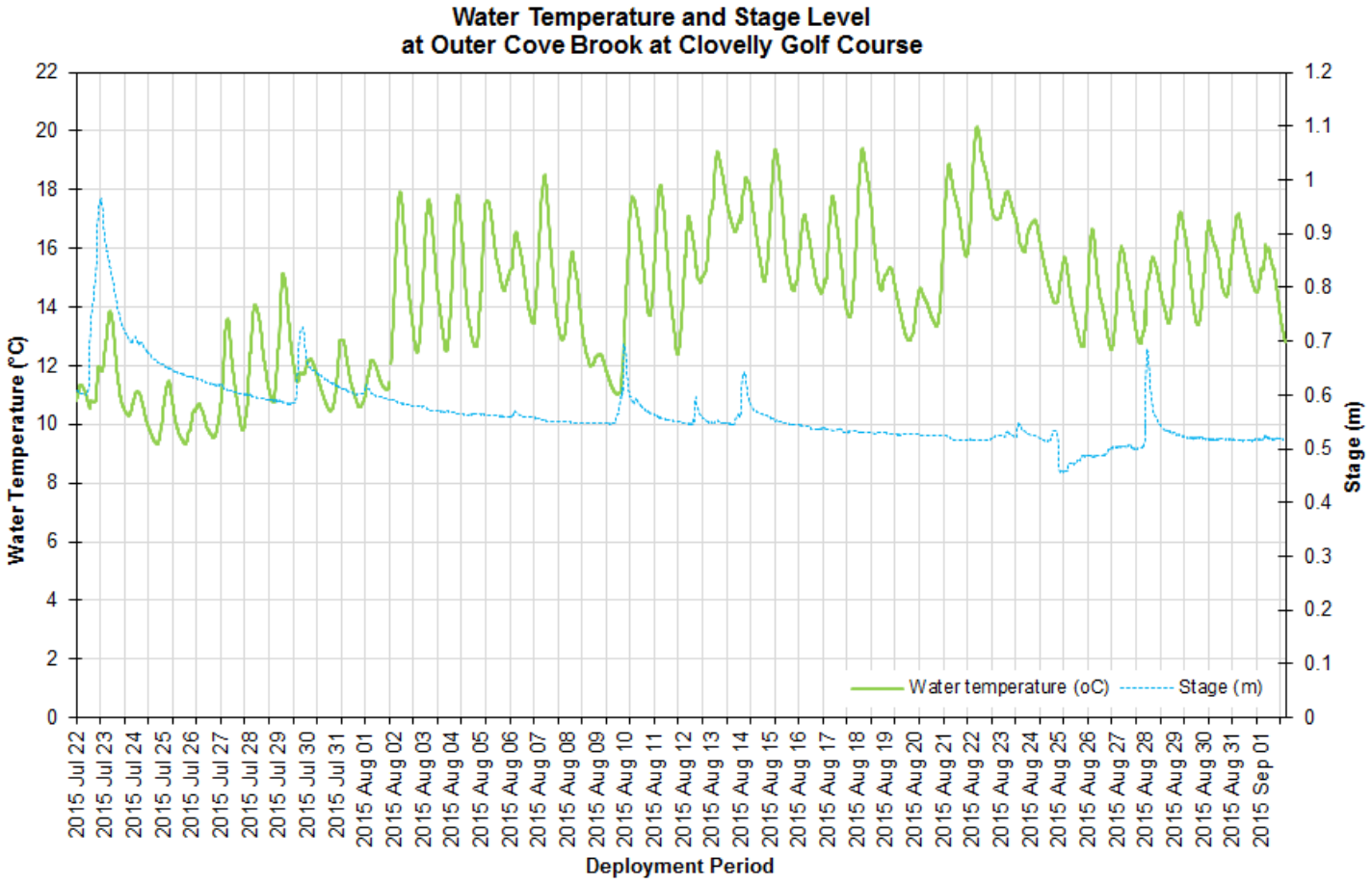

Figure 8: Water temperature (°C) and Stage (m) levels at Outer Cove Brook at Clovelly Golf Course.

pH

Throughout this deployment period pH values ranged between 5.92 pH units and 6.46 pH units (Figure 9).

The pH data did dip below the minimum CCME guideline for the Protection of Aquatic Life. There are very slight decreases in pH during higher stage events (for example July 23rd, 2015).

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 6.13 units (a lower pH median from last deployment of 6.40 pH units).

Please note the stage data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

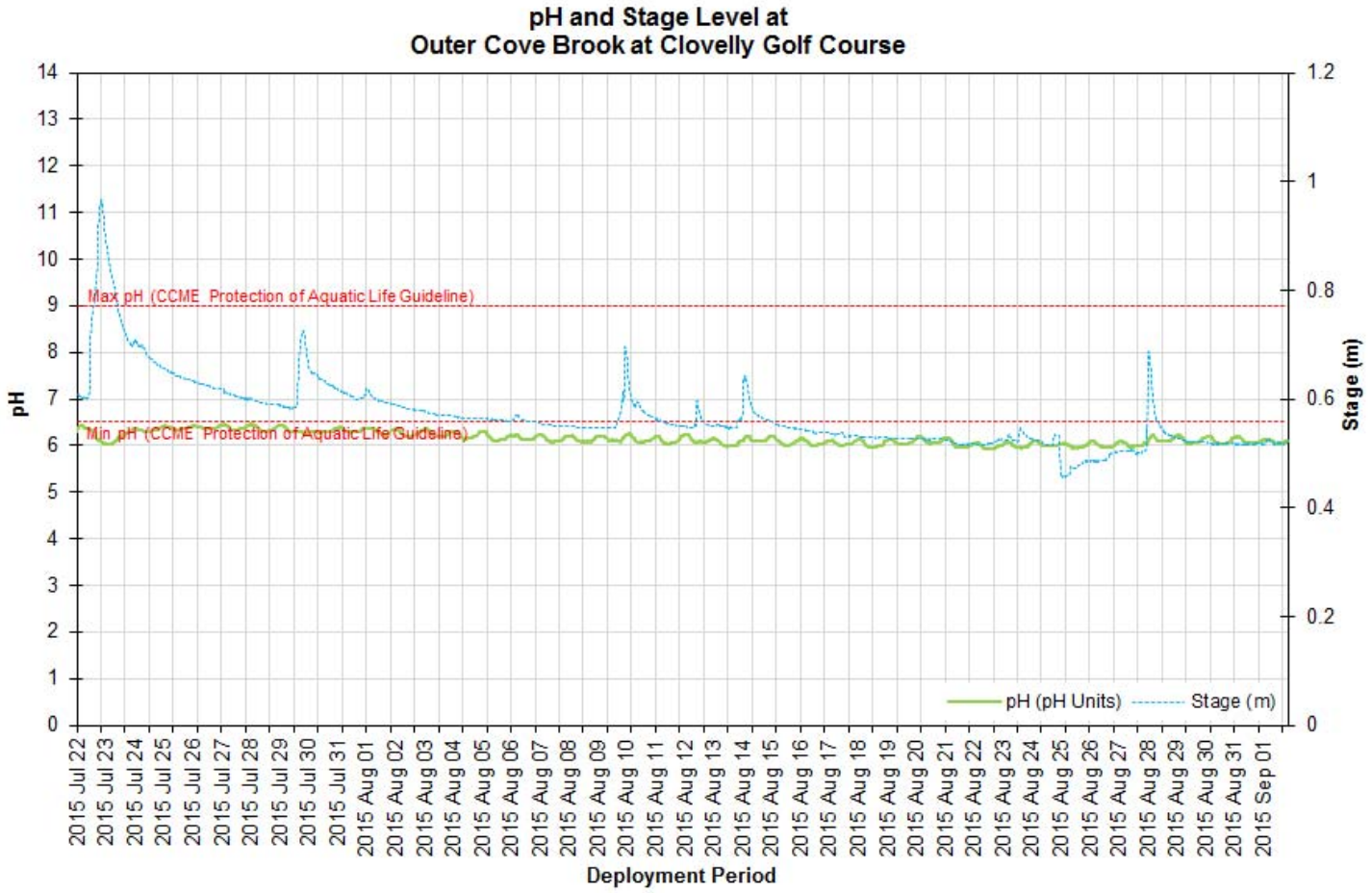

Figure 9: pH (pH units) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Specific Conductivity & TDS

The conductivity levels were within 148.8µS/cm and 647.0µS/cm during this deployment period. TDS ranged from 0.0952g/L to 0.4140g/L (Figure 10). The conductivity probe measures the dissolved particles present in the water body.

Normally rainfall saturates the brook and flushes the dissolved particles from the water column diluting the conductivity levels for a short period of time. This is evident on Figure 10, as the stage increases in the brook the conductivity levels dip for short periods of time.

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.

Please note the stage data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC

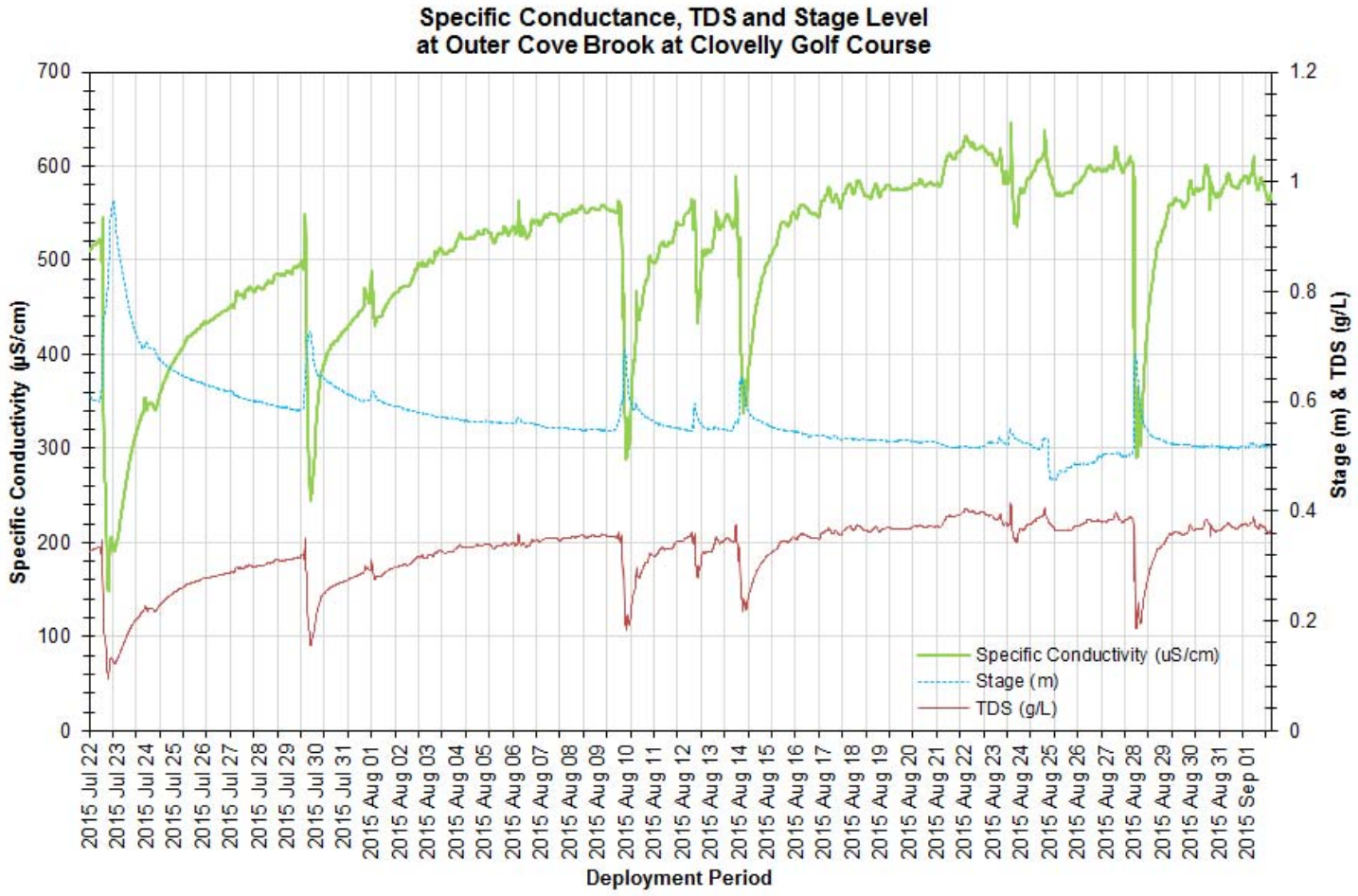

Figure 10: Specific conductivity (uS/cm) and stage (m) values at Outer Cove Brook at Clovelly Golf Course.

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 63.4 %Sat to 94.7 %Sat. Dissolved Oxygen (mg/L) measured 5.97 mg/L to 10.03 mg/L (Figure 11).

The majority of dissolved oxygen (mg/L) levels remained above the CCME Guideline for the Protection of Other Life Stages. The dissolved oxygen levels start to dip below the guideline on August 12th and August 13th, 2015 and again on August 23rd, 2015. As expected, when compared to the mean air temperatures (Appendix I) for St. John's, it is during some of the warmest periods of this deployment.

It should be noted that the warmer water temperatures decrease the amount of dissolved oxygen a water body can hold. As water temperatures increase (most likely during the day) the dissolved oxygen levels in the water decrease with consumption from the aquatic organisms and vegetation present in the brook.

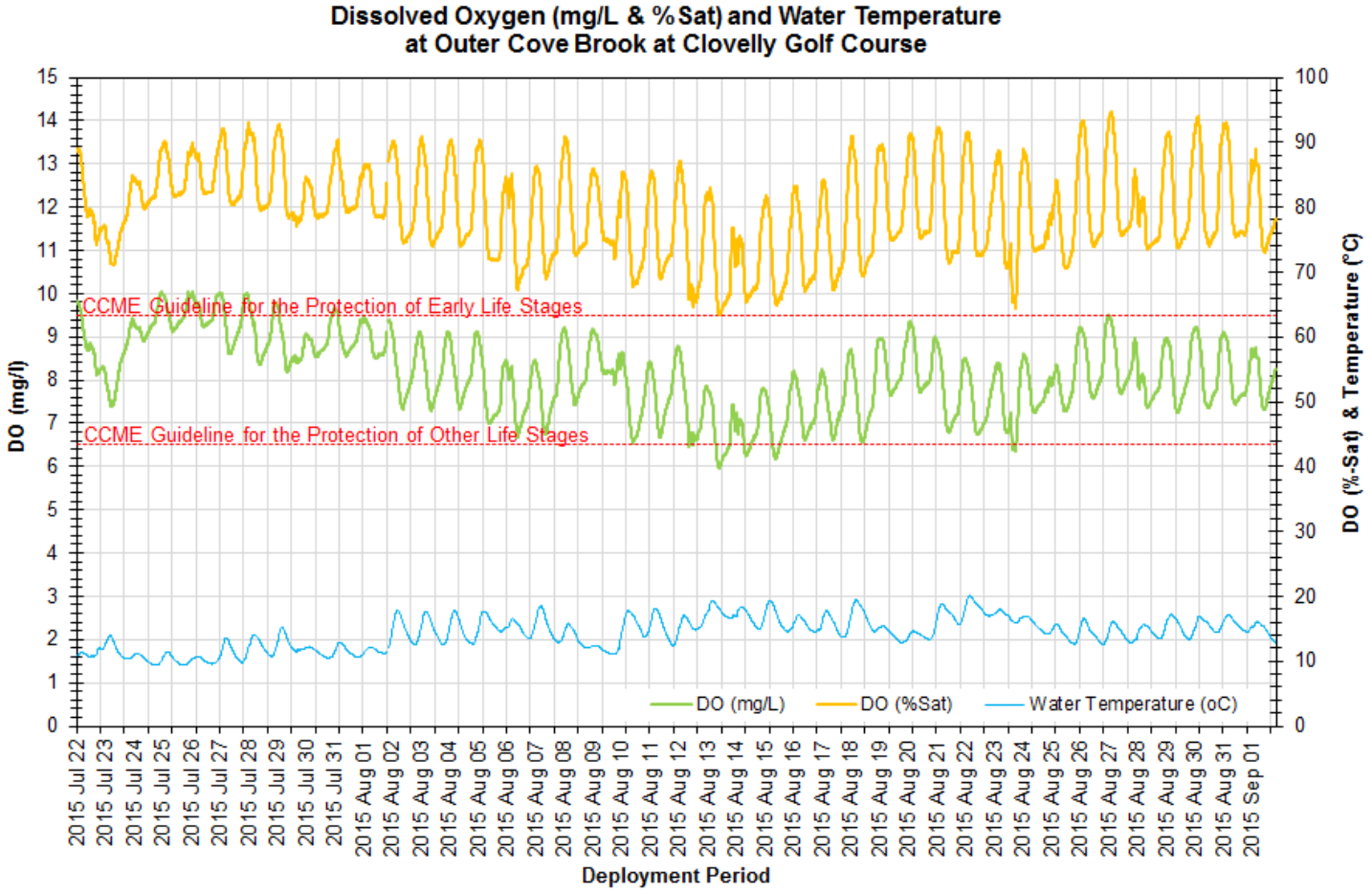

Figure 11: Dissolved oxygen (mg/L & % sat) and water temperature (°C) values at Outer Cove Brook at Clovelly Golf Course.

Turbidity

Turbidity levels during the deployment period ranged from 0.8 NTU to 104.9 NTU (Figure 12), with a median of 6.0 NTU.

As depicted on the graph there were several turbidity spikes during this deployment. The majority of turbidity increases on the turbidity graph correspond with stage increases at the same time. The largest turbidity event was recorded on August 24th 2015. The total precipitation data indicates that there was two days of rainfall from August 23rd to August 24th, 2015 which likely contributed to the turbidity.

The turbidity data from July 31st to August 20th, 2015 was removed due to the fact that it not representing the water body's actual turbidity at the time. The data indicated that the sensor was blocked which inhibited it from being able to stabilize.

Please note the stage data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC

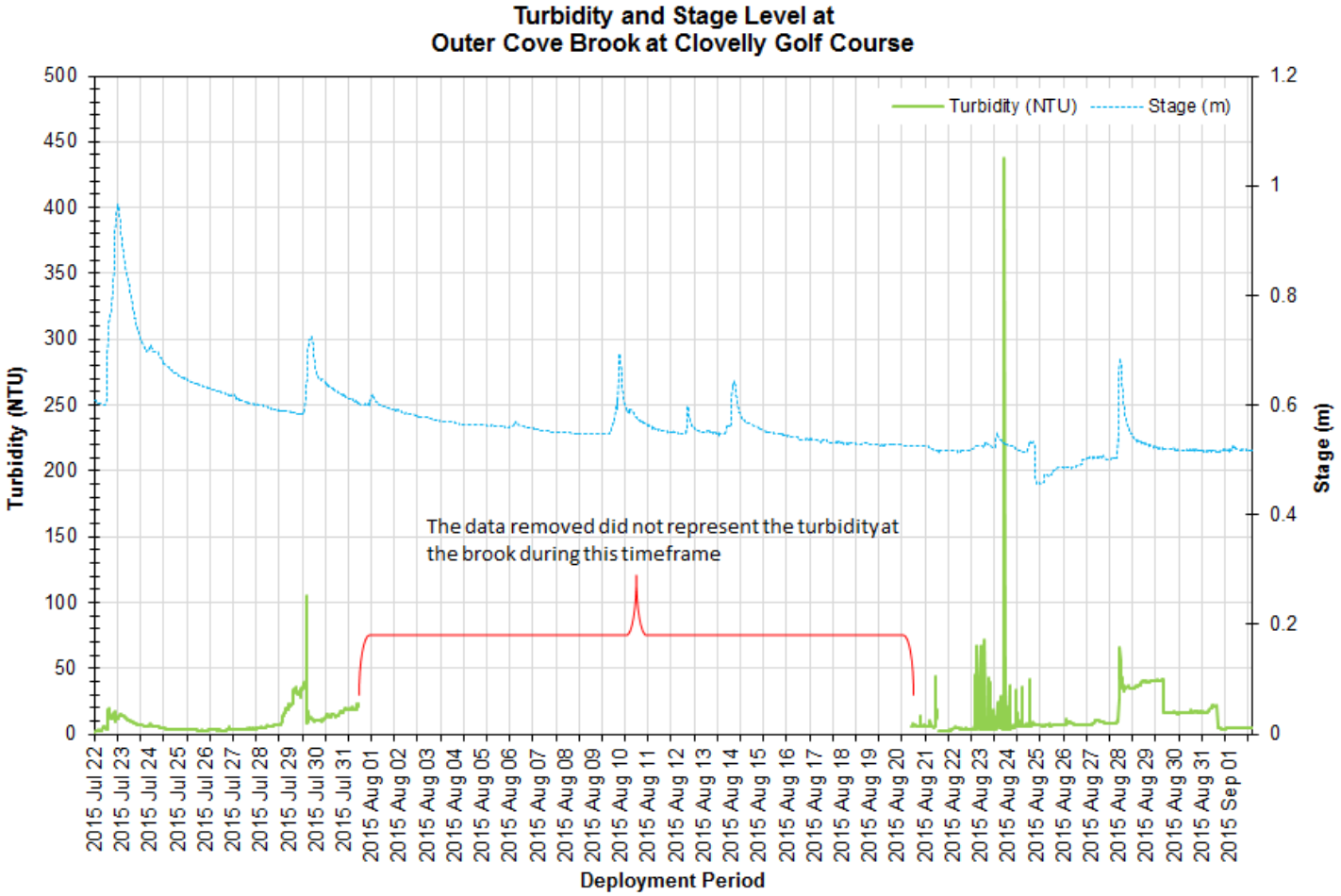

Figure 12: Turbidity (NTU) and stage level (m) values at Outer Cove Brook at Clovelly Golf Course.

Stage, Stream Flow and Total Precipitation

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).

Stage levels during this deployment ranged from a minimum of 0.46m to a maximum of 0.97m. Stream flow levels ranged from a minimum of 0.01m^3/s to a maximum of 1.31m^3/s. The precipitation ranged from a minimum of 0.0 mm a day to a maximum of 26.1mm which was on July 22nd, 2015. This rainfall event increased stage and stream flow at Outer Cove Brook at Clovelly Golf Course for a short period of time (Figure 13).

Precipitation data was obtained from Environment Canada's St. John's Airport weather station. Please note the stage and stream flow data graphed below is raw data that is published on WRMD web page. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

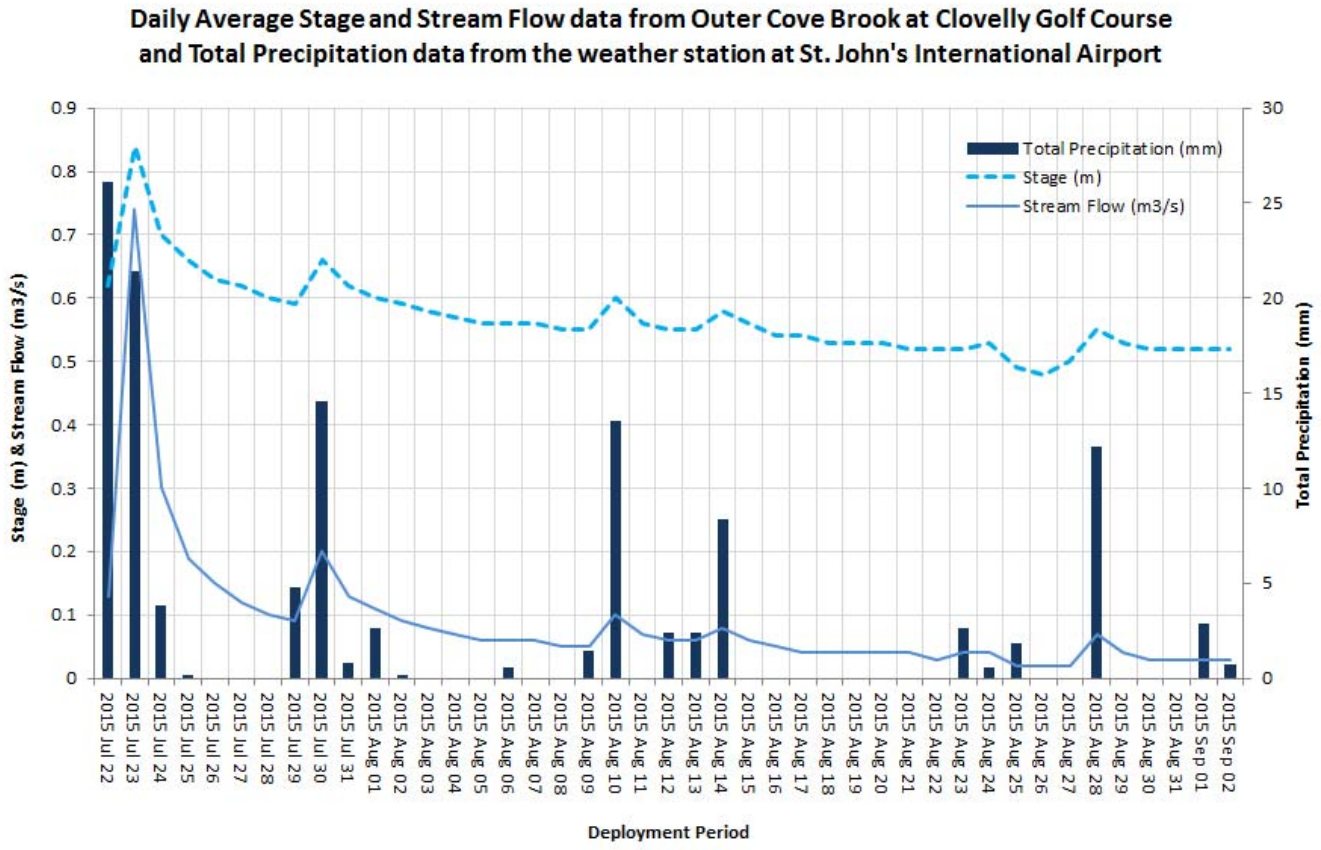

Figure 13: Daily average stage & stream flow values at Outer Cove Brook at Clovelly Golf Course and daily total precipitation values (mm) from Environment Canada's Weather Station at St. John's International Airport.

Conclusion

This brook flows through significant developed areas, including residential zones, golf courses and within the boundaries of heavily used road ways, which can influence the water quality parameters in the areas of turbidity increases or conductivity increases when runoff from residential areas is a factor.

Water temperature displayed data representative of an urban brook, with examples of small increases in water temperature during higher stage events. pH data indicated an influence from the higher stage event on July 23rd, 2015. During the increases in stage the conductivity levels also adjusted by decreasing as the suspended minerals are flushed from the brook for a short period of time.

Dissolved oxygen levels remained relatively constant. The concentration levels of dissolved oxygen had a median of 8.12mg/L during deployment. The dissolved oxygen levels did drop below the CCME guideline for the Protection of Other Life Stages during periods of warmer air temperatures in August.

Turbidity levels fluctuated during deployment, with the majority of the higher turbidity values linked with high stage levels. Due to the sensor becoming blocked the data was removed from July 31st through to August 20th, 2015 as it should not be included in any statistical analysis.

APPENDIX I

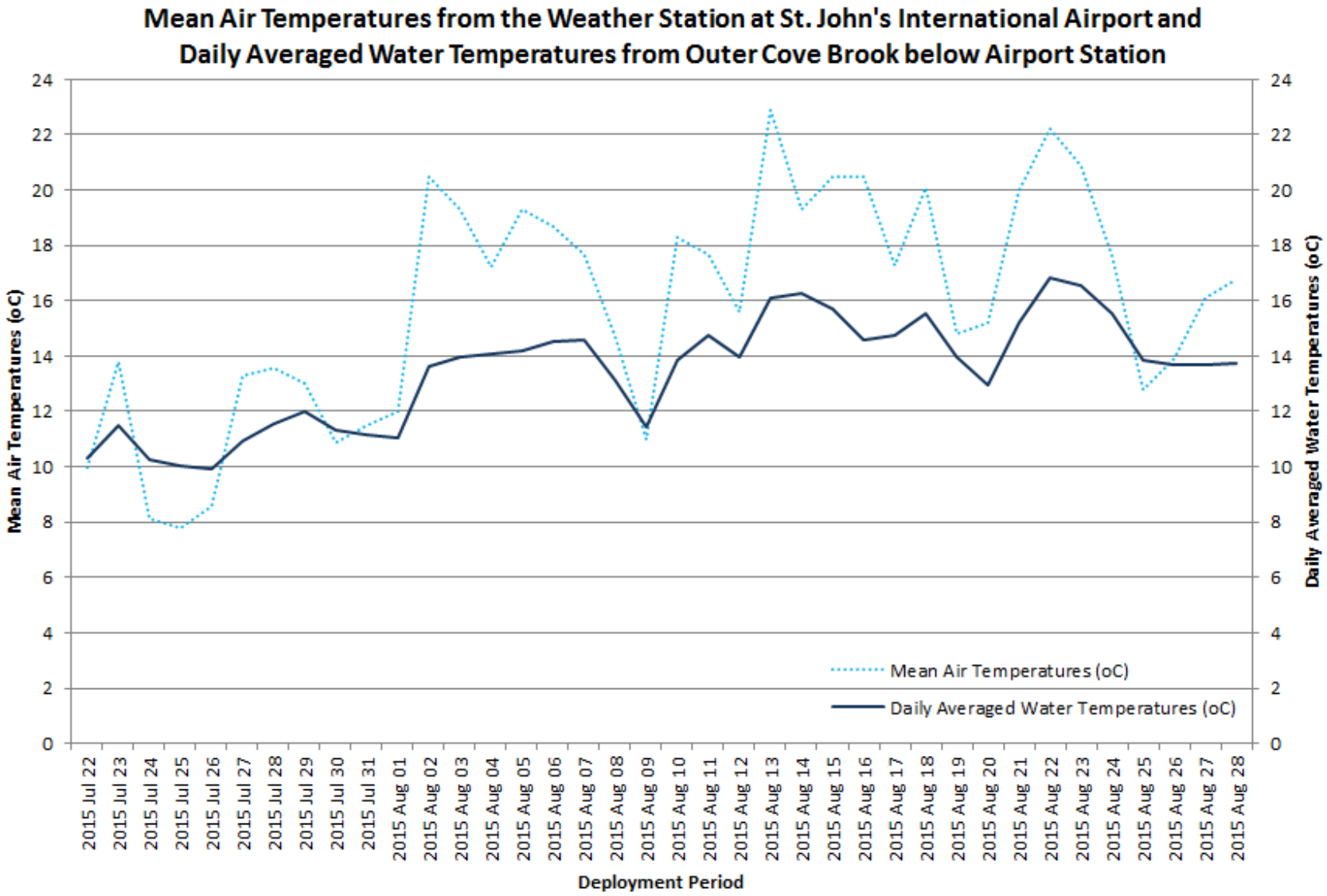

Figure 14: Daily average water temperature values from Outer Cove Brook below Airport and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

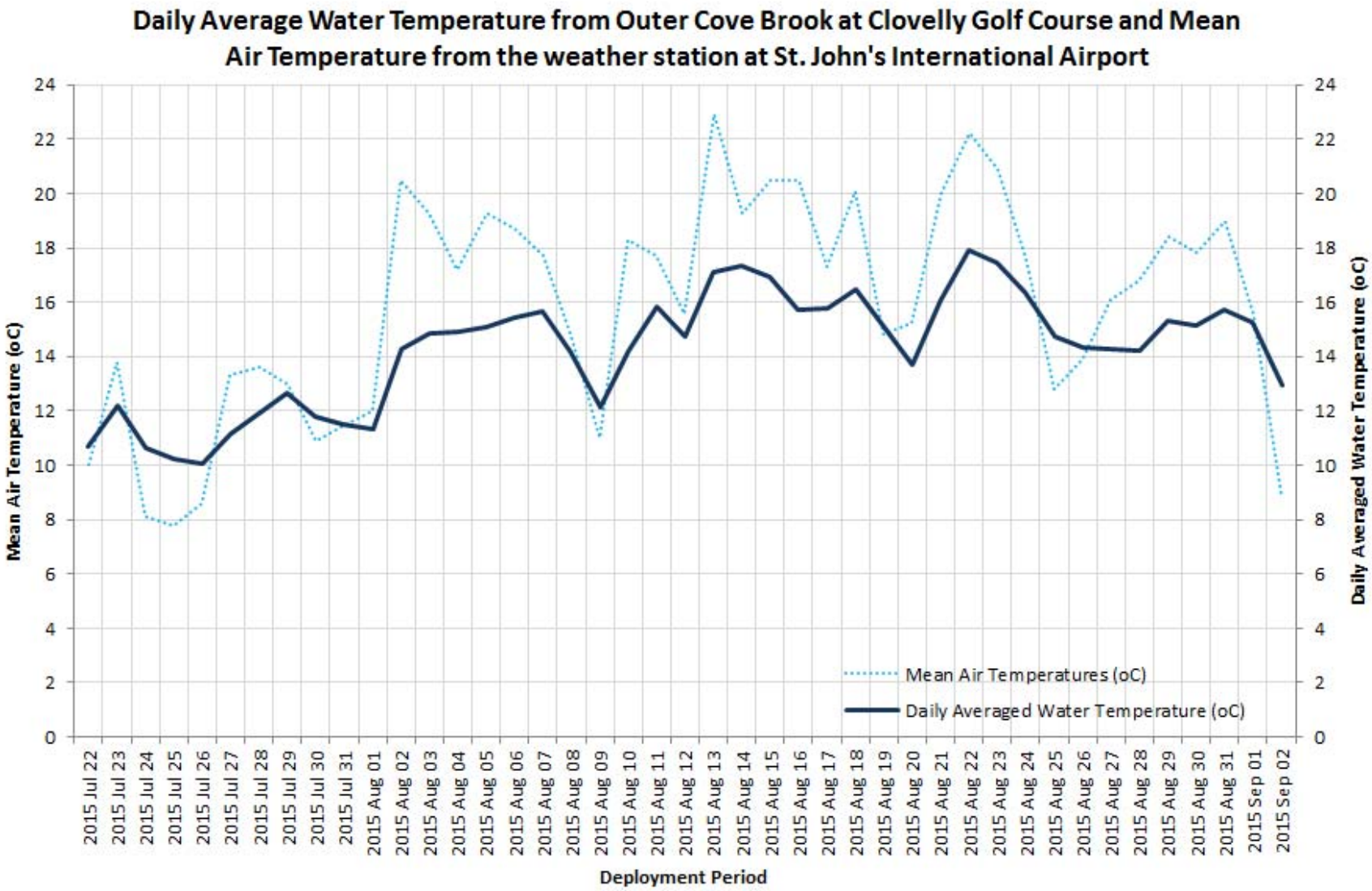

Figure 15: Daily average water temperature values from Outer Cove Brook at Clovelly Golf Course and air temperature values from Environment Canada's Weather Station at St. John's International Airport.

Outer Cove Brook, Newfoundland and Labrador