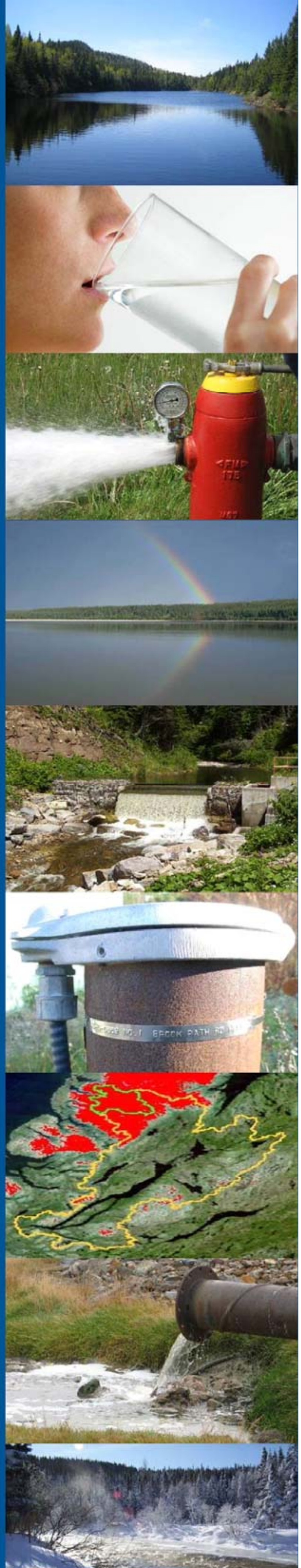

Real Time Water Quality Report

City of St. John's
Outer Cove Brook Network

Annual Deployment Report 2013

January 1 to December 31, 2013

Newfoundland Labrador

Government of Newfoundland and Labrador
Department of Environment and Conservation
Water Resources Management Division

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Acknowledgements

The Real-Time Water Quality monitoring network at Outer Cove Brook in St. John's NL, is fully funded by the City of St. John's. The network's success is dependent on a joint partnership between the City of St. John's, Environment Canada (EC), and the Newfoundland and Labrador Department of Environment and Conservation (ENVC). Managers and program leads from each organization, namely Renee Paterson (ENVC), Howie Wills (EC), and David Wadden (City of St. John's), are committed to the operation of this network and ensuring it continually provides meaningful and accurate water quality and quantity data.

Staff of Environment Canada (Water Survey Canada) under the management of Howie Wills, play an essential role in the data logging/communication aspect of the network and maintains all water quantity monitoring equipment. EC-WSC staff visit the sites regularly to ensure the data logging and data transmitting equipment are working properly. Environment Canada also plays the lead role in dealing with stage and flow issues.

ENVC is responsible for maintenance of the real-time water quality monitoring equipment, as well as recording and managing the water quality data. Kyla Brake, under the supervision of Renee Paterson, is ENVC's main contact for the real-time water quality monitoring operations at Outer Cove Brook, and was responsible for maintaining and calibrating water quality instruments, as well as grooming, analyzing and reporting on water quality data recorded at the stations during 2013.

All individuals from each agency are committed to maintaining and improving the Outer Cove Brook real-time monitoring network, and ensuring that it continues to provide meaningful, reliable and accurate water quality and quantity data.

Introduction

The Newfoundland and Labrador Department of Environment and Conservation (ENVC), in partnership with the City of St. John's and Environment Canada (EC), established two real-time water quality and quantity monitoring stations in April 2012 at Outer Cove Brook in the east end of St. John's, NL.

The official names of each of the stations are Outer Cove Brook below Airport (NF02ZM0364) and Outer Cove Brook at Clovelly Golf Course (NF02ZM0365). Their locations in relation to each other and surrounding land uses are shown in Figure 1.

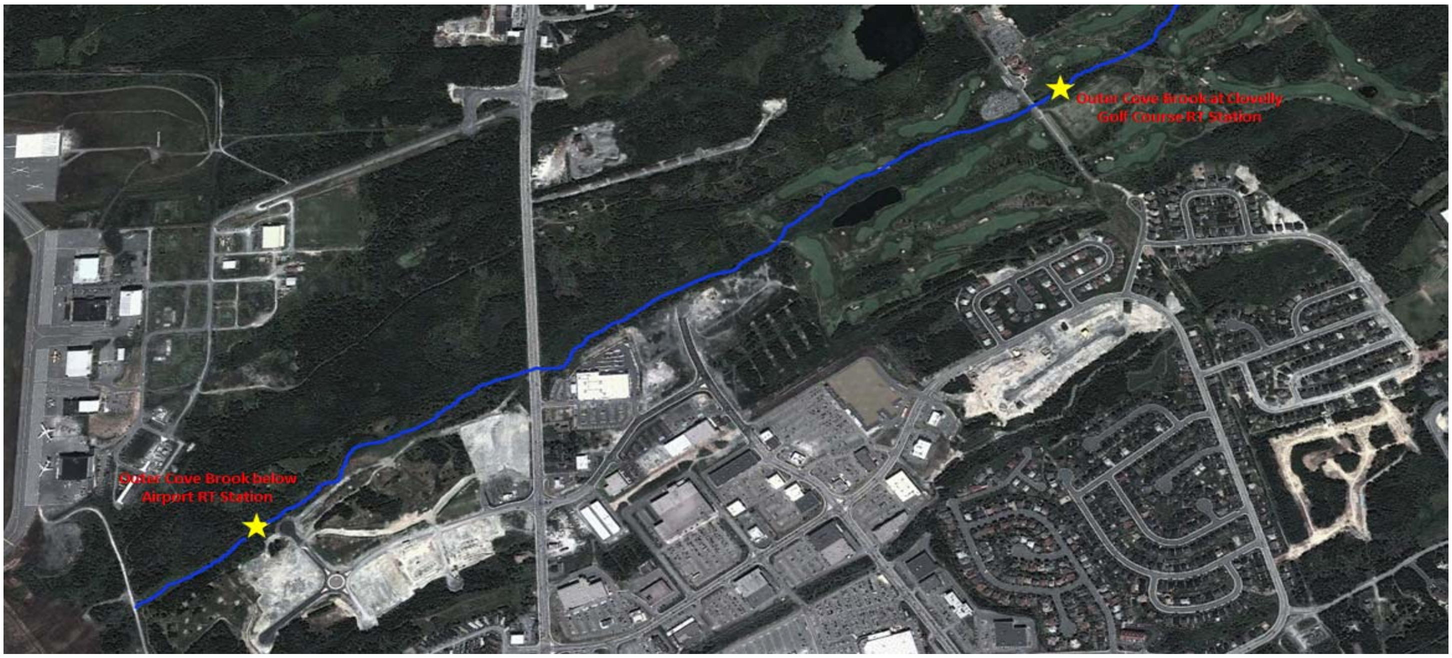

Figure 1: Locations of Outer Cove Brook Real-Time Water Quality and Quantity Monitoring Stations.

The Outer Cove Brook network was established in response to increased commercial development in the Torbay Road North Commercial Development Area. A significant portion of the land surrounding Outer Cove Brook is currently being developed into commercial establishments. One station is located upstream of the developments, while the other station is downstream.

An agreement was signed between the City of St. John's and the ENVC for the establishment of a real-time monitoring network for Outer Cove Brook. Under this agreement, the City of St. John's is responsible for providing funding for the installation of two real-time water quality and quantity monitoring stations, including associated maintenance and equipment costs.

ENVC is responsible for the maintenance and calibration of water quality monitoring instruments, including initial setup of the station, and will continually retrieve, groom, analyze and report on the water quality data recorded at each of the stations. Real-time graphs of the water quality data will be published online, and will be monitored daily. The City of St. John's staff will be notified of any issues so that mitigative measures can be taken.

Environment Canada is responsible for the maintenance of the station's water quantity monitoring, datalogging and communications equipment. They are to ensure that the equipment is operating properly and transmitting the data efficiently. Environment Canada also plays the lead role in addressing all issues with stage and flow.

Site Descriptions

The headwaters of Outer Cove Brook originate in a boggy area of Airport Heights, just east of Windsor Lake (Figure 2). The brook flows beneath Portugal Cove Road, north toward St. John's International Airport, where it is partially channeled beneath the runways before emerging in a forested area on the eastern perimeter of the airport. The Outer Cove Brook below Airport station is approximately 400m downstream of the airport's perimeter. At this station, the river is surrounded by tall grasses and marshland, with mature conifer forests (see Figure 3a). The sonde is located in a deep section of the well-defined channel.

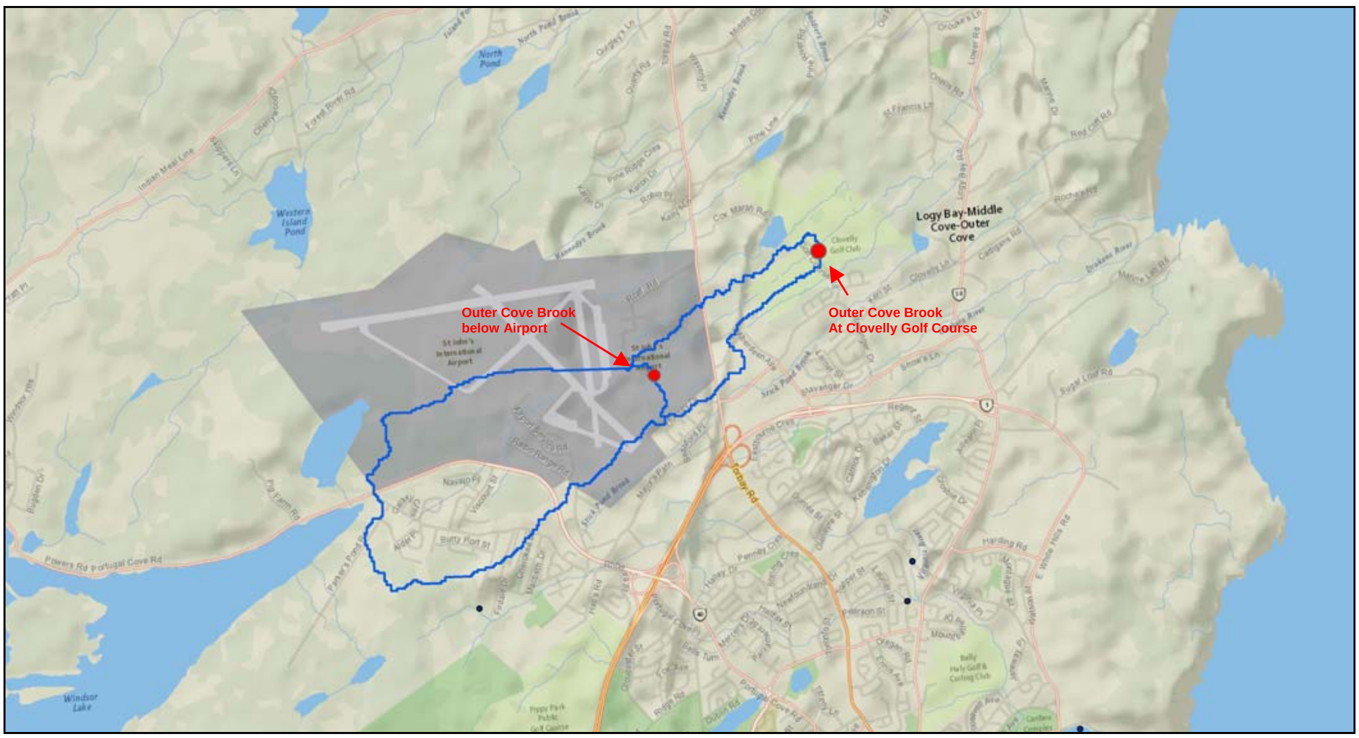

Figure 2: Map of the Outer Cove Brook Real-Time Water Quality/Quantity Monitoring Stations Watersheds

Outer Cove Brook then flows through the new Torbay Road North Commercial Development Area before passing beneath Torbay Road. The brook continues flowing north-east through marshlands surrounded by forest, bordering along the Abderdeen Extension development area, before entering and flowing through a buffer zone within Clovelly Golf Course. The second real-time station, Outer Cove Brook at Clovelly Golf Course, is located in a patch of trees on the eastern side of Golf Course Road adjacent to the clubhouse. The station sits in a marshy area which is heavily saturated during high flows and surrounded by tall grasses and some conifers (Figure 3b). The sonde typically sits in a deep, defined channel upstream of the braided portion of the river.

Downstream of the real-time stations, Outer Cove Brook meanders through the buffer zone in Clovelly Golf Course before entering a heavily forested area, where it continues northeastward to Savage Creek and is joined by Stick Pond Brook before crossing Outer Cove Road and flowing through the valley to its outlet in the Atlantic Ocean at Outer Cove Beach.

Figure 3: (a) Outer Cove Brook below Airport (b) Outer Cove Brook at Clovelly Golf Course

Station Setup

- Water quality parameters are measured at each station using a Hydrolab DataSonde instrument (Figure 4).

Model DS5 © 2005 Hach Company

Figure 4: Hydrolab DataSonde used for monitoring water quality parameters.

- Six water parameters are measured at each station, including five water quality parameters (water temperature, dissolved oxygen, pH, turbidity and specific conductivity), and one water quantity parameter (stage). An additional water quality parameter, total dissolved solids (TDS) is calculated from this specific conductivity and water temperature.

- Water quality and quantity data are recorded on a quarter-hourly basis (every 15 minutes) at both stations.
- All data is viewable and downloadable online through ENVC's Automatic Data Retrieval System (ADRS) located here: http://www.env.gov.nl.ca/wrmd/ADRS/v6/Graphs_List.asp

Quality Assurance and Quality Control

- To ensure accurate data collection, water quality instruments are subjected to quality assurance procedures, in order to mitigate any errors caused by biofouling and/or sensor drift.
- Quality assurance procedures include: (i) a thorough cleaning of the instrument, (ii) replacement of any small sensor parts that are damaged or unsuitable for reuse, and (iii) the calibration of the sensors using standard solutions.
- Quality assurance procedures are carried out every 30-40 days, before the start of a new deployment period.
- Deployment periods for 2013 are summarized in Table 1.

Table 1: Water quality instrument deployment start and end dates for 2013 at Outer Cove Brook Stations

Deployment	Removal	Days Deployed
Dec 7 (2012)	Jan-08	32
Jan-08	Feb-05	Not deployed/ice
Feb-05	Mar-06	31
Mar-06	Apr-09	33
Apr-09	May-03	24
May-03	Jun-04	31
Jun-05	Jul-03	28
Jul-03	Aug-06	33
Aug-06	Sep-04	28
Sep-04	Oct-08	34
Oct-08	Nov-06	28
Nov-06	Dec-17	41
Dec-17	Jan (2014)	n/a

- As part of the quality control procedures, instrument performance is tested at the start and end of its deployment period. The process is outlined in Appendix A.

- Instruments are assigned a performance ranking (i.e. poor, marginal, fair, good, excellent) for each water quality parameter measured.

- Appendix B details the instrument performance rankings of each of the instrument sensors deployed at Outer Cove Brook.

- The main issues which led to poor or marginal performance rankings were the presence of algae or biofouling on the field sonde at removal, and calibration issues with the QA/QC sonde, as indicated by QA/QC measurements being off by identical increments at both stations.

- For more detailed analyses of a particular time period, date or deployment period, please refer to the individual deployment reports : http://www.env.gov.nl.ca/env/waterres/rti/rtwq/csdr/index.html

Data Interpretation

- Performance issues and data records were interpreted for each station during the deployment period for the following parameters:
  (i) Stage (m)
  (ii) Temperature (°C)
  (iii) pH
  (iv) Specific conductivity (μS/cm)
  (v) Total dissolved solids (g/L)
  (vi) Dissolved oxygen (mg/L)
  (vii) Turbidity (NTU)

- A description of each parameter is provided in Appendix C.

- The following parameter analyses cover the entire deployment period from January 1 to December 31, 2013. These interpretations aim to point out seasonal and overall trends and major issues affecting the parameters.
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- Any gaps in data are the result of transmission loss, or periods where the instrument was removed from the water.

- Both sondes were removed from January 8 to February 5 due to extreme ice conditions which could have damaged the sondes.

- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to the 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.

Outer Cove Brook below Airport

Stage

- Stage values are based on a vertical reference that is unique to each station, thus absolute values of stage are not comparable between stations, but relative changes in stage are.
- Figure 5 displays stage values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013. These values are provisional. Quality assured and quality controlled stage values are available through EC (http://www.ec.gc.ca/rhc-wsc/default.asp).
- Stage values ranged from 0.793 m to 1.44 m. The highest stage value was recorded on September 26, corresponding to the largest rain event of 2013 (69.4mm).
- Fluctuations in stage correspond to precipitation events as increased runoff into the river increases the river's volume, raising the stage level.
- The decrease in stage levels from April to June is indicative of the end of the spring thaw period. Stage levels were lower during the summer months, with precipitation events in the fall leading to an overall increase in stage as winter approaches.

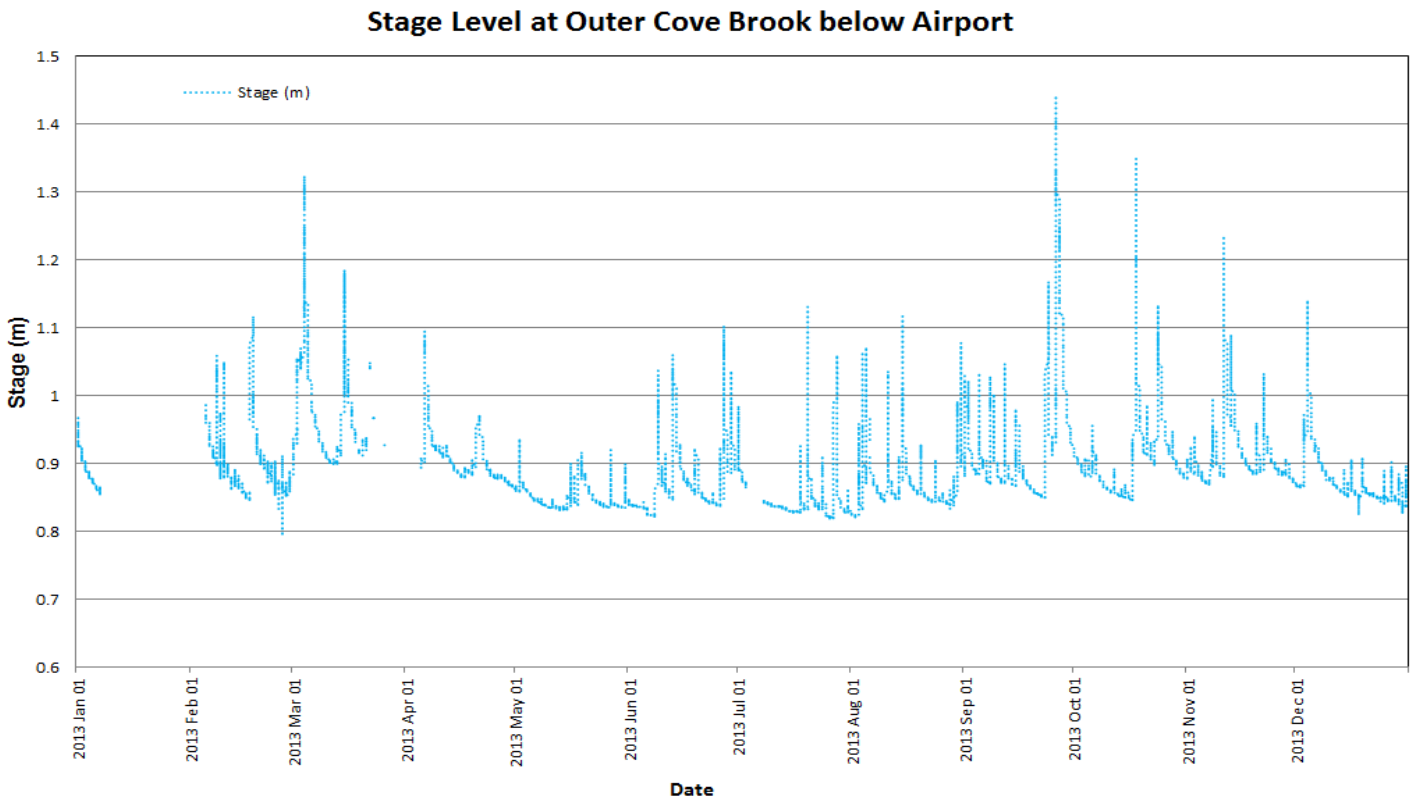

Figure 5: Quarter-hourly stage (m) values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013.

Temperature

- Water temperature at this station displays large diurnal variations, shown in Figure 6, typical of shallow water streams and ponds as they are highly influenced by diurnal variations in ambient air temperatures. The largest daily fluctuations are noticeable during July and August.
- Water temperatures ranged from -0.1°C to 21.8 °C, with a median of 8.3 °C.
- Seasonal temperature trends are obvious in Figure 6 as temperatures increase throughout spring and into the summer months, peaking in August, before gradually decreasing again throughout fall as winter approaches.
- One anomaly in this trend is the temperature data for May 12 to 21, where a drop in air temperatures for a few days resulted in a corresponding drop in water temperatures during this time period.

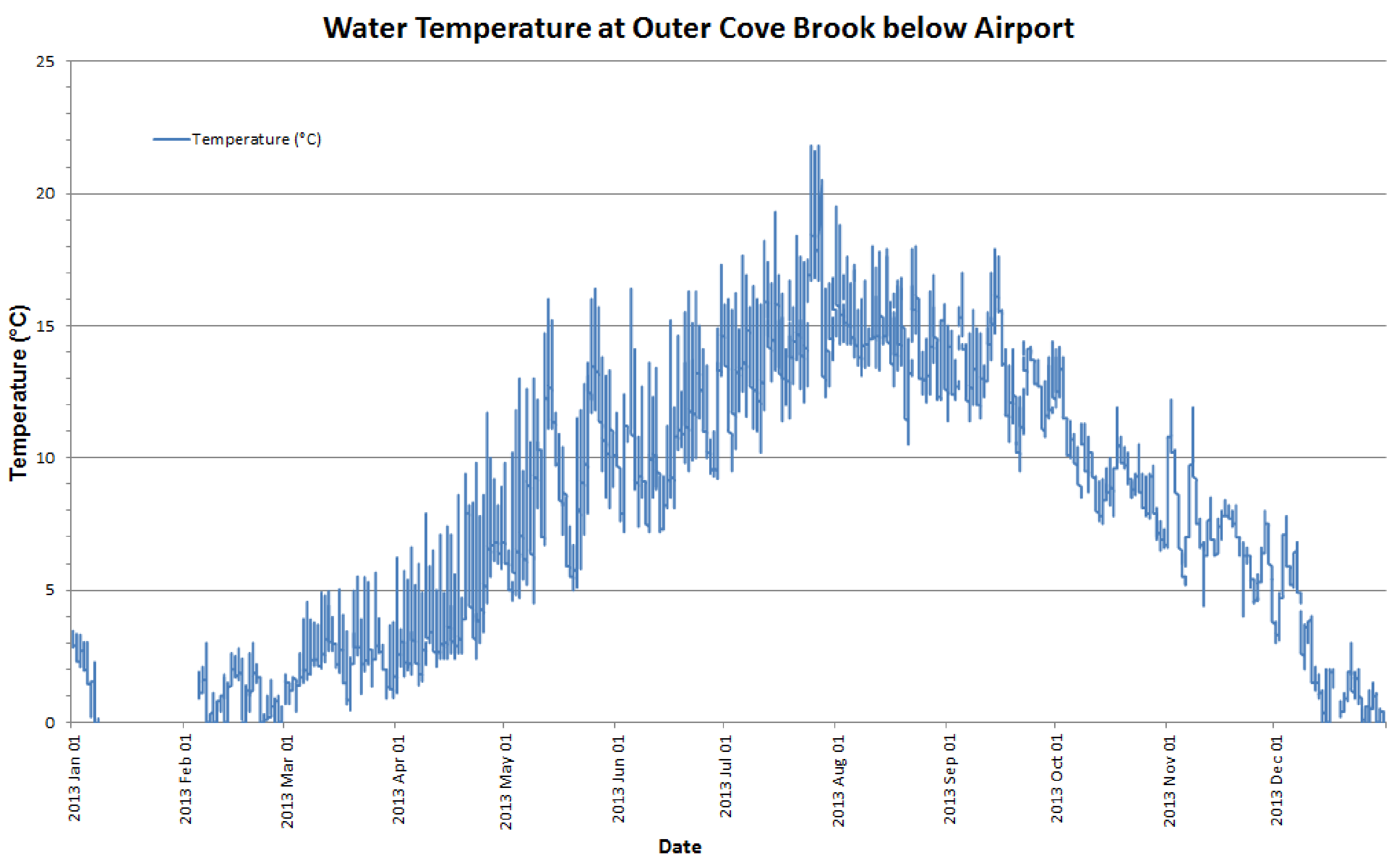

Figure 6: Quarter-hourly temperature (°C) values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013.

pH

- pH values ranged between 5.79 and 7.34 pH units, with a median of 6.54 pH units.
- The CCME guidelines for the protection of freshwater aquatic life provide a basis by which to judge the overall health of a river system. At this station, pH values hover around the minimum guideline of 6.5, as shown in Figure 7. 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.
- There are visible drops in pH values throughout the year, corresponding to precipitation events. This is a natural occurrence between precipitation and pH levels.
- During winter and spring thaw months (November, December, March, April), there is a periodic notable increase in pH, reaching values above 7.00, and indicating that there is an input into this stream during these periods which is affecting the water quality by creating a more alkaline environment.
- Visible jumps in the data after data gaps are the result of removal and recalibration of the instrument. This is noted in Figure 7 (circled).

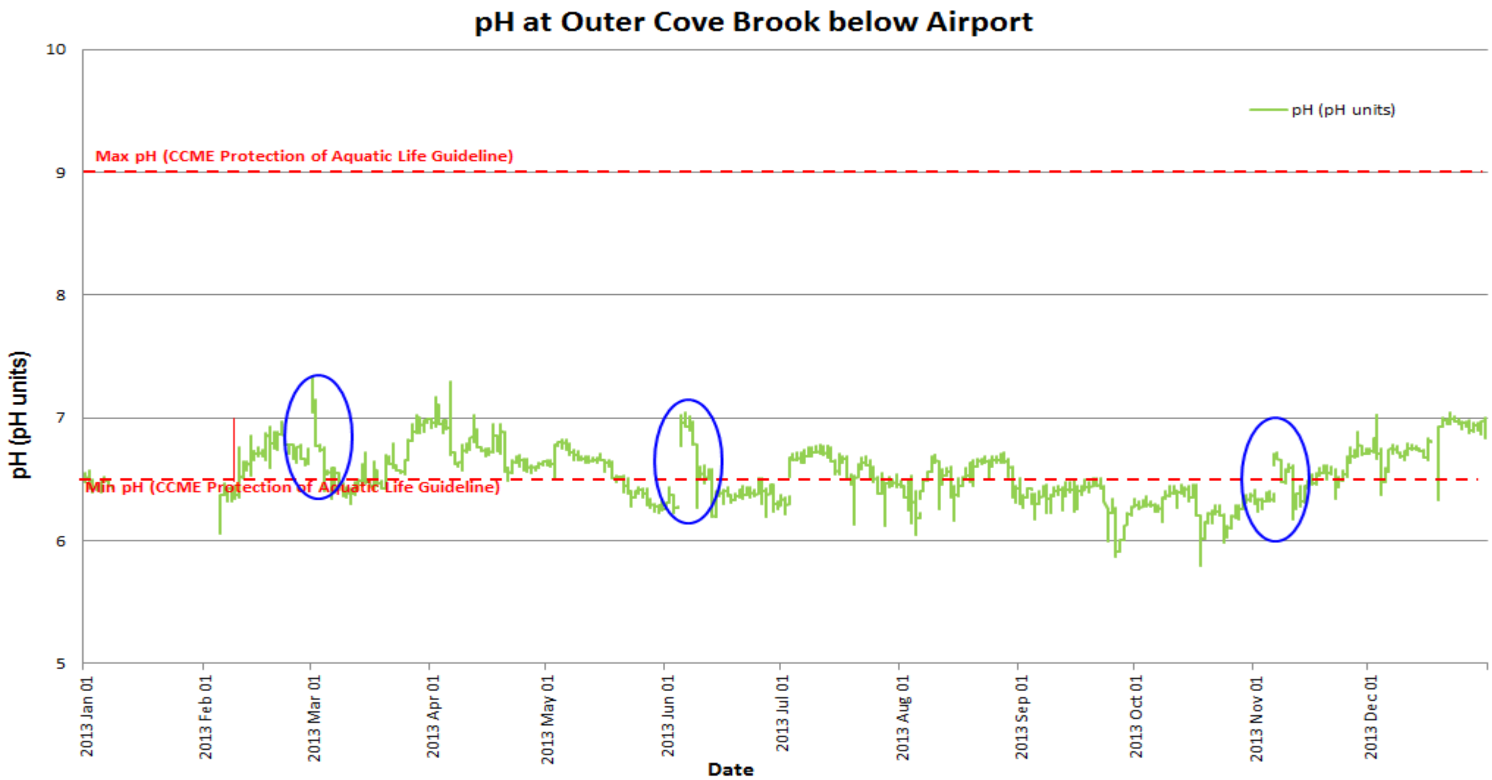

Figure 7: Quarter-hourly pH (pH units) values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013.

Specific Conductance and Total Dissolved Solids (TDS)

- Specific conductivity ranged from 58.6 to 2141 µS/cm, with a median value of 414 µS/cm. Total dissolved solids (TDS) ranged between 0.0375 and 1.3700 g/L, with a median value of 0.2660 g/L.

- The maximum values for both parameters were reached on March 1. Cold temperatures and snow throughout February was followed by rainfall on March 1, which washed roadsalts into the river system, leading to large increases in both parameters.

- A seasonal trend in relation to stage is evident for specific conductivity and TDS in Figure 8. Cold, snowy winter months (noted in Figure 8) are marked by spikes in conductivity and TDS with stage increases as salts used on roadways and runways are washed, carried or blown in the brook during winter storms. Spring, summer and fall rainfalls cause increases in stage with drops in TDS and conductivity due to dilution of solids in the brook from the added freshwater.

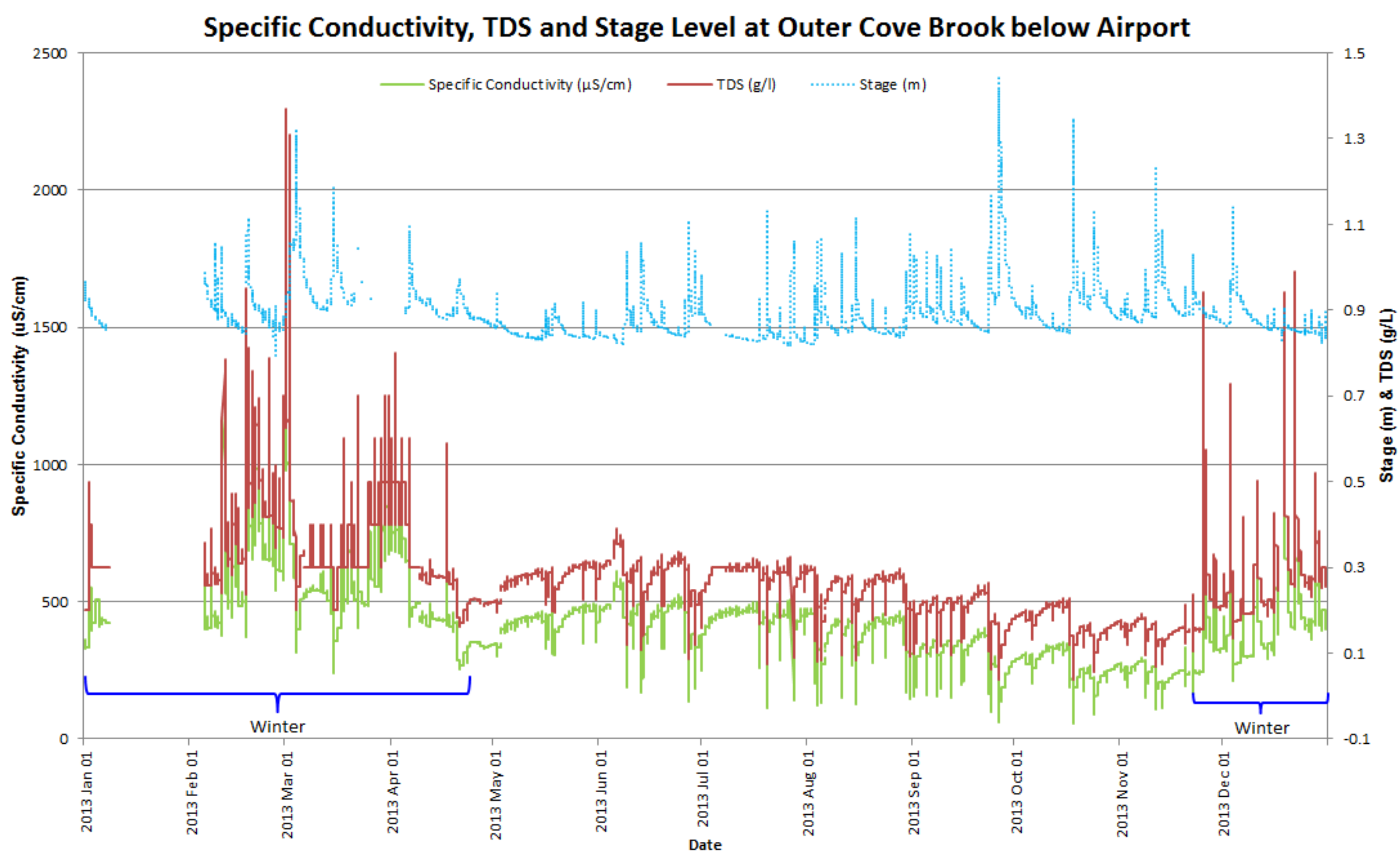

Figure 8: Quarter-hourly specific conductivity (µS/cm), total dissolved solids (g/L) and stage level (m) values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013.

Turbidity

- Turbidity values ranged from 0 NTU to 2373 NTU, with a median of 1.7 NTU. The maximum value of 2373 NTU was recorded with a rise in stage level on June 27, corresponding to a 30mm rainfall event occurring at this time.

- Generally, turbidity events coincide with rises in stage, as shown in Figure 9, which correspond to precipitation events.

- Short-term turbidity sensor interference events were recorded throughout the year. This interference is due to biofouling, leaf debris, and strands of algae which are abundant in Outer Cove Brook. For these reasons, data was removed for several time periods as this data is inaccurate and should not be used for statistical analysis.

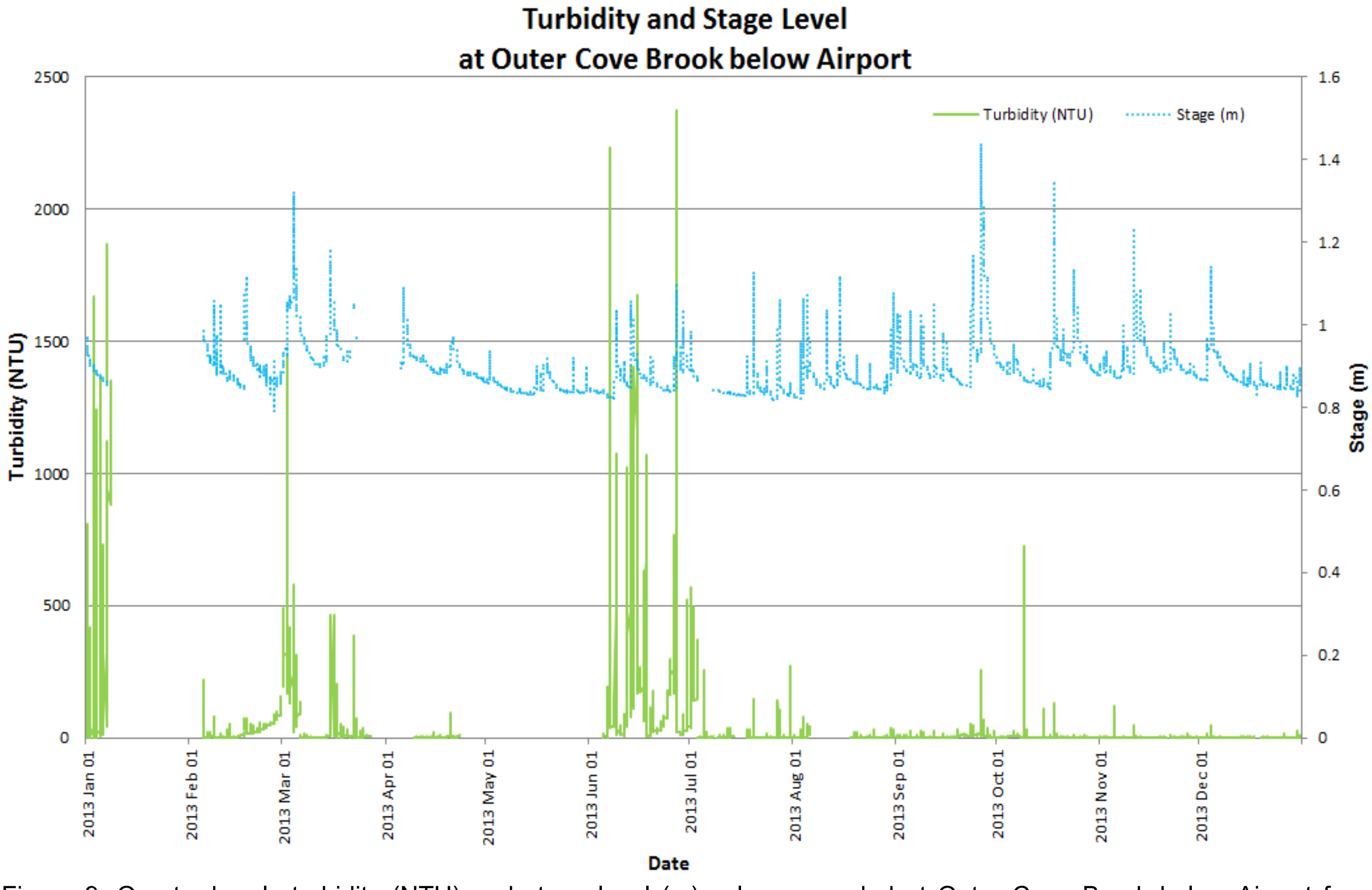

Figure 9: Quarter-hourly turbidity (NTU) and stage level (m) values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013.

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 values ranged from 9.8 to 94.8 %sat, with a median of 86.7 %sat. Dissolved Oxygen (mg/L) measured 1.36 to 13.42 mg/L, with a median of 10.29 mg/L. The DO mg/L values are above the minimum DO guideline for the protection of early life stages for most of the year, but dip below the guideline during summer months when the water is warmer and can hold less oxygen.

- Dissolved oxygen (% sat) remained relatively constant throughout the seasons. Figure 10 demonstrates the natural inverse relationship that exists between dissolved oxygen (mg/L) and water temperature. As water temperatures increase, DO (mg/L) decreases as warmer water can hold less oxygen.

- Two notable events in April/May show sharp declines in water oxygen levels. During this time, a prolific 'slime' substance was present in the brook, coating all vegetation and surfaces, and leading to low oxygen levels as well as biofouling of the sonde. Oxygen data for the month of May was excluded from the dataset as it was affected by the layer of 'slime' growing on the sonde and was thus inaccurate.

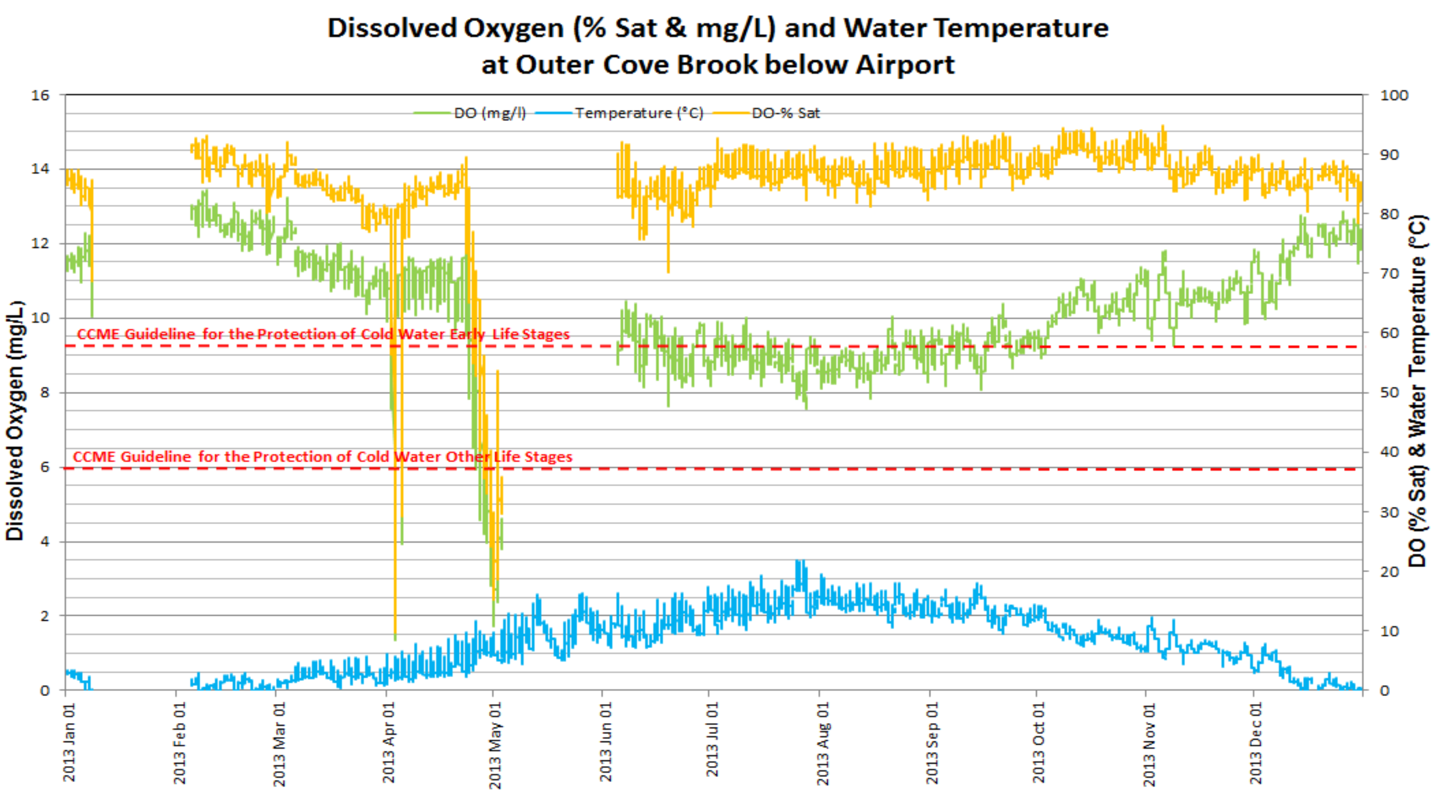

Figure 10: Quarter-hourly dissolved oxygen (% Sat & mg/L) and water temperature (°C) values recorded at Outer Cove Brook below Airport from January 1 to December 31, 2013.

Conclusions

- Outer Cove Brook below Airport displays characteristics typical of other St. John's area streams:
    - Stage levels are influenced by precipitation
    - Water temperatures are diurnal and influenced by air temperatures
    - Slightly acidic overall pH values
    - Specific conductivity decreases with increased rainfall; increases in winter due to road salt inputs
    - Dissolved oxygen (mg/L) varies inversely with water temperature
    - Turbidity increases correspond to precipitation events suspending sediments into the water column or debris blocking the sensor
    - Algae and biofouling are natural occurrences in this water body which affect turbidity readings

Outer Cove Brook at Clovelly Golf Course

Stage

- Stage values are based on a vertical reference that is unique to each station, thus absolute values of stage are not comparable between stations, but relative changes in stage are.

- Figure 11 displays stage values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013. These values are provisional. Quality assured and quality controlled stage values are available through EC (http://www.ec.gc.ca/rhc-wsc/default.asp).

- Stage values ranged from 0.506 m to 1.113 m. The highest stage value was recorded on September 26, corresponding to the largest rainfall event of 2013. This was also the event which caused the highest stage level value at the below Airport station.

- Fluctuations in stage correspond to precipitation events as increased runoff into the river increases the river's volume, raising the stage level.

- The decrease in stage levels from April to June is indicative of the end of the spring thaw period. Stage levels were lower during the summer months, with precipitation events in the fall leading to an overall increase in stage as winter approaches.

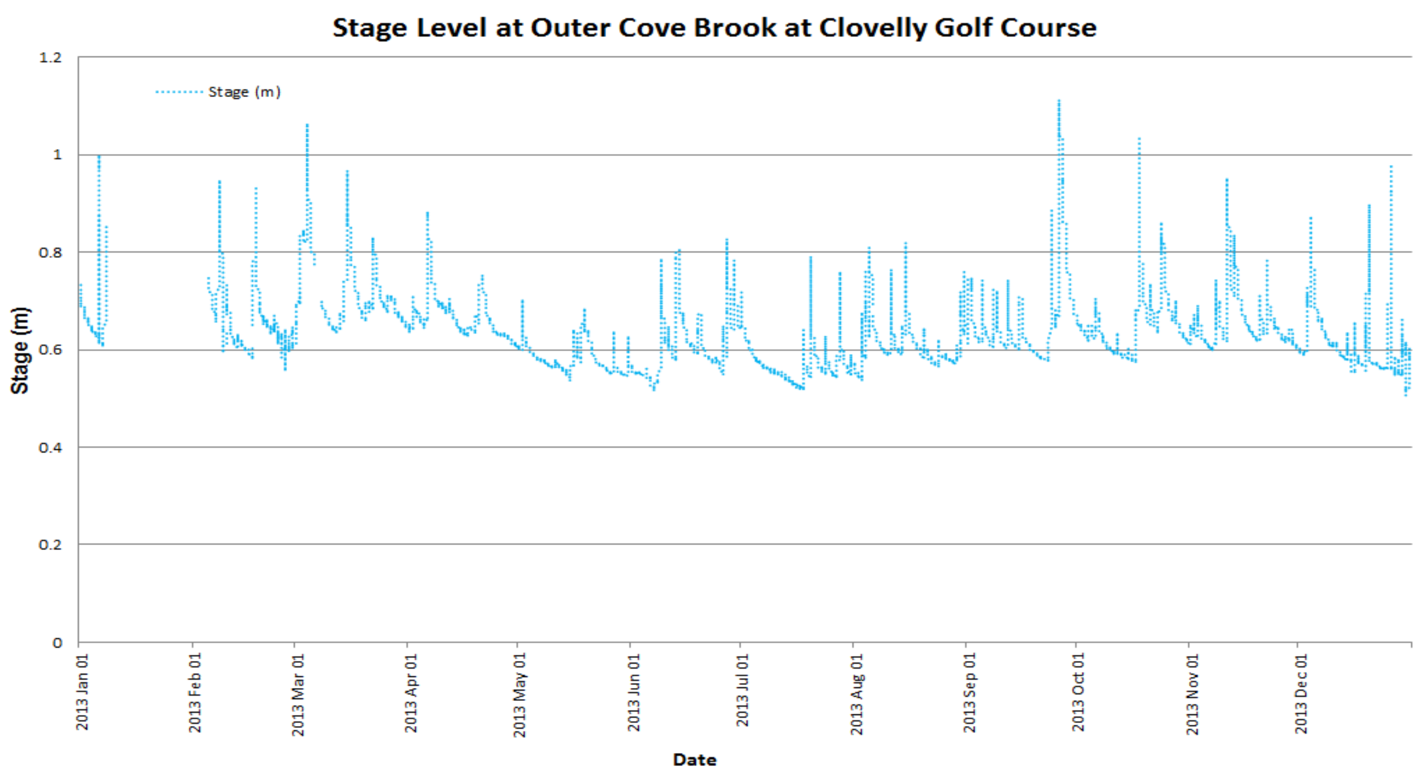

Figure 11: Quarter-hourly stage (m) values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013.

Temperature

- Water temperature at this station displays large diurnal variations, shown in Figure 12, typical of shallow water streams and ponds as they are highly influenced by diurnal variations in ambient air temperatures. The largest daily fluctuations are noticeable during July and August.

- Water temperatures ranged from -0.06 to 22.73 °C, with a median of 8.6 °C.

- Seasonal temperature trends are obvious in Figure 12 as temperatures increase throughout spring and into the summer months, peaking in August, before gradually decreasing again throughout fall as winter approaches.

- One anomaly in this trend is the temperature data for May 12 to 21, where a drop in air temperatures for a few days resulted in a corresponding drop in water temperatures during this time period.

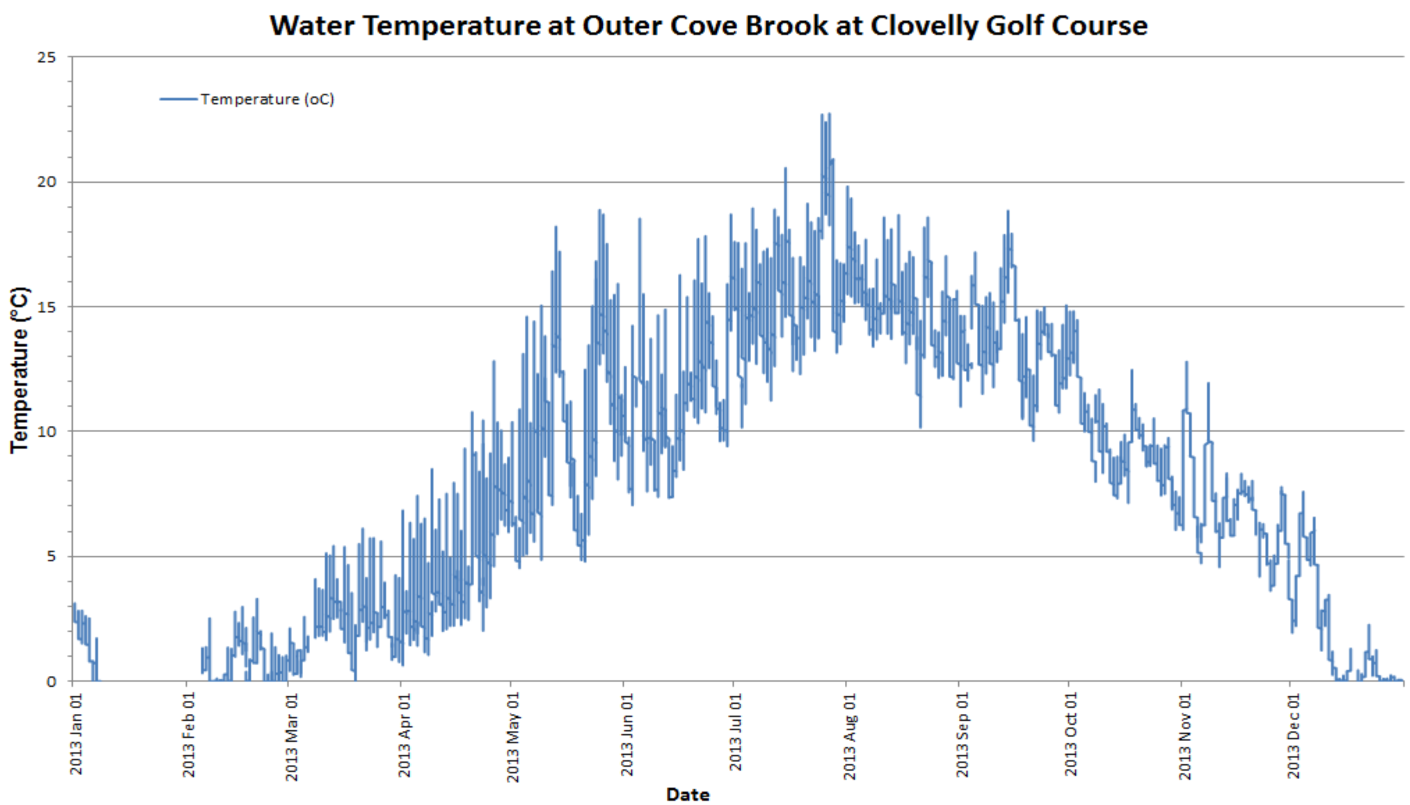

Figure 12: Quarter-hourly temperature (°C) values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013.

pH

- pH values ranged between 5.52 and 7.22 pH units, with a median of 6.39 pH units. The maximum value was reached at the same time the maximum value of 7.34 was reached at the before Airport Station, indicating an input into the brook upstream of both stations affecting the water quality.

- The CCME guidelines for the protection of freshwater aquatic life provide a basis by which to judge the overall health of a river system. At this station, pH values hover around the minimum guideline of 6.5, as shown in Figure 13. Naturally, all streams and brooks are different. In the case of Outer Cove Brook at Clovelly Golf Course, pH is generally within the normal range for stream water in St. John's.

- There are visible drops in pH values throughout the year, corresponding to precipitation events. This is a natural occurrence between precipitation and pH levels.

- pH values reach notable high values in February, March and December, suggesting that the high values are related to winter temperatures and inputs into this brook during these months.

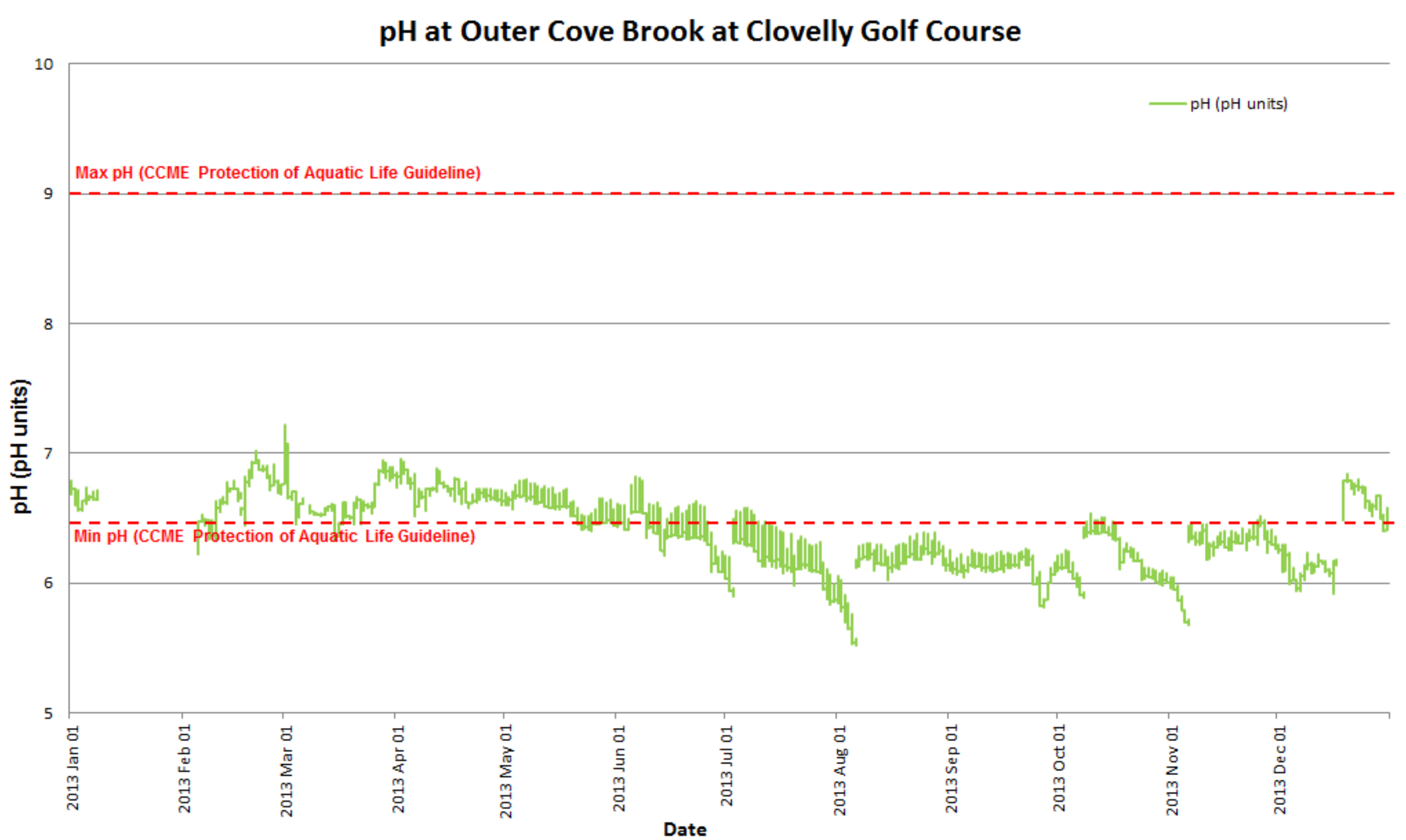

Figure 13: Quarter-hourly pH (pH units) values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013.

Specific Conductance and TDS

- Specific conductivity ranged from 100.2 to 3896 uS/cm, with a median of 415 uS/cm. Total dissolved solids (TDS) ranged between 0.0641 and 2.4900 g/L, with a median of 0.2660 g/L.
- The maximum values for both parameters were reached on February 17. Cold temperatures and snow throughout February was followed by rainfall on February 17, which washed salts used on roadways during freezing temperatures and snow conditions into the river system, leading to large increases in both parameters.
- A seasonal trend in relation to stage is evident for specific conductivity and TDS in Figure 14. Cold, snowy winter months are marked by spikes in conductivity and TDS with stage increases as salts used on roadways and runways are washed, carried or blown in the brook during winter storms. Spring, summer and fall rainfalls cause increases in stage with drops in TDS and conductivity due to dilution of solids in the brook from the added freshwater.

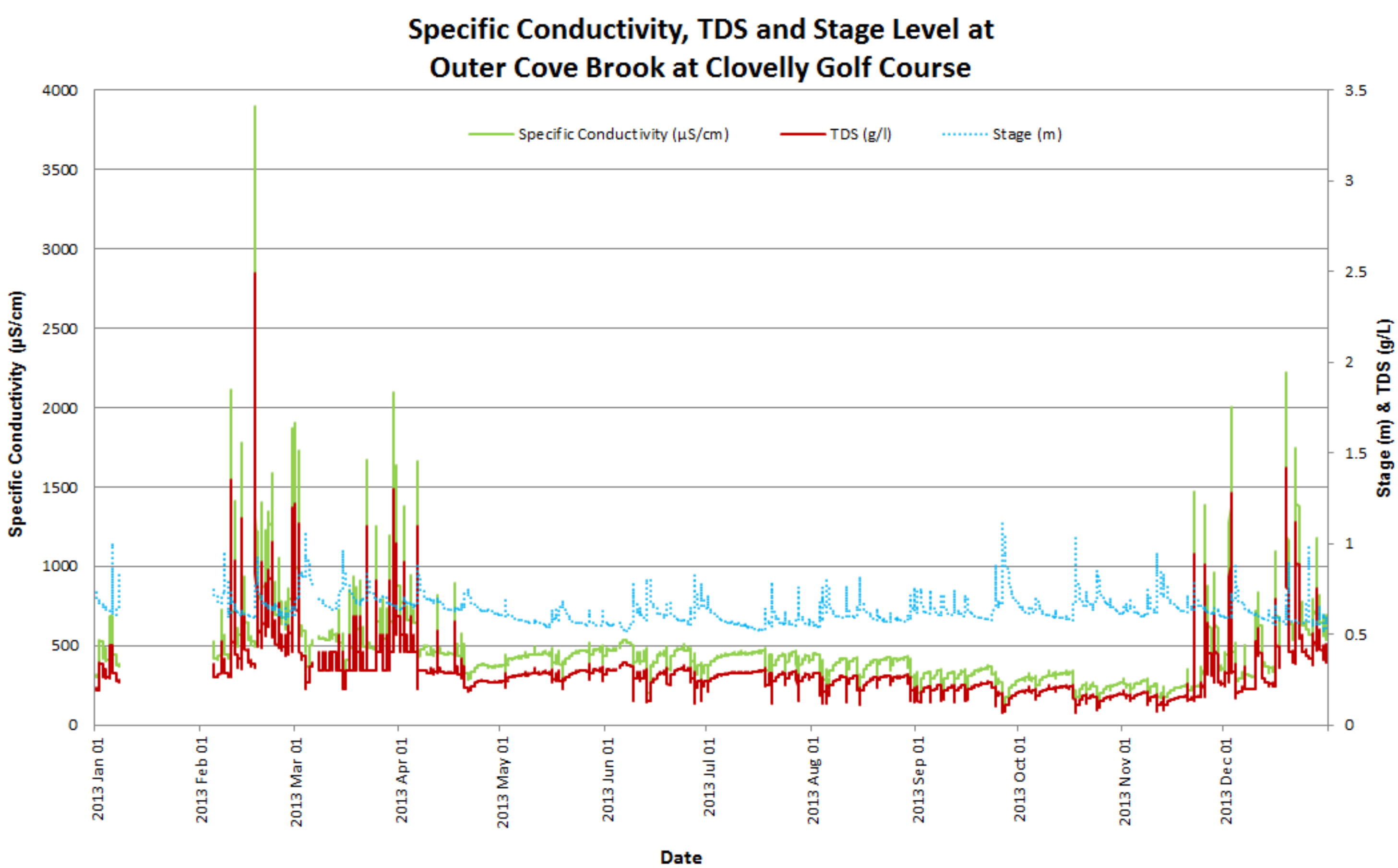

Figure 14: Quarter-hourly specific conductivity (µS/cm), total dissolved solids (g/L) and stage level (m) values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013.

Turbidity

- Turbidity values ranged from 0 NTU to 327.5 NTU, with a median of 2.7 NTU. The maximum value of 327.5 NTU was recorded on April 6, at the same time as an increase in stage, and thus is the result of a precipitation event.

- Generally, turbidity events coincide with rises in stage, as shown in Figure 15, which correspond to precipitation events.

- Short-term turbidity sensor interference events were recorded throughout the year. This interference is due to biofouling, leaf debris, and strands of algae which are abundant in Outer Cove Brook. For these reasons, data was removed for several time periods as this data is inaccurate and should not be used for statistical analysis.

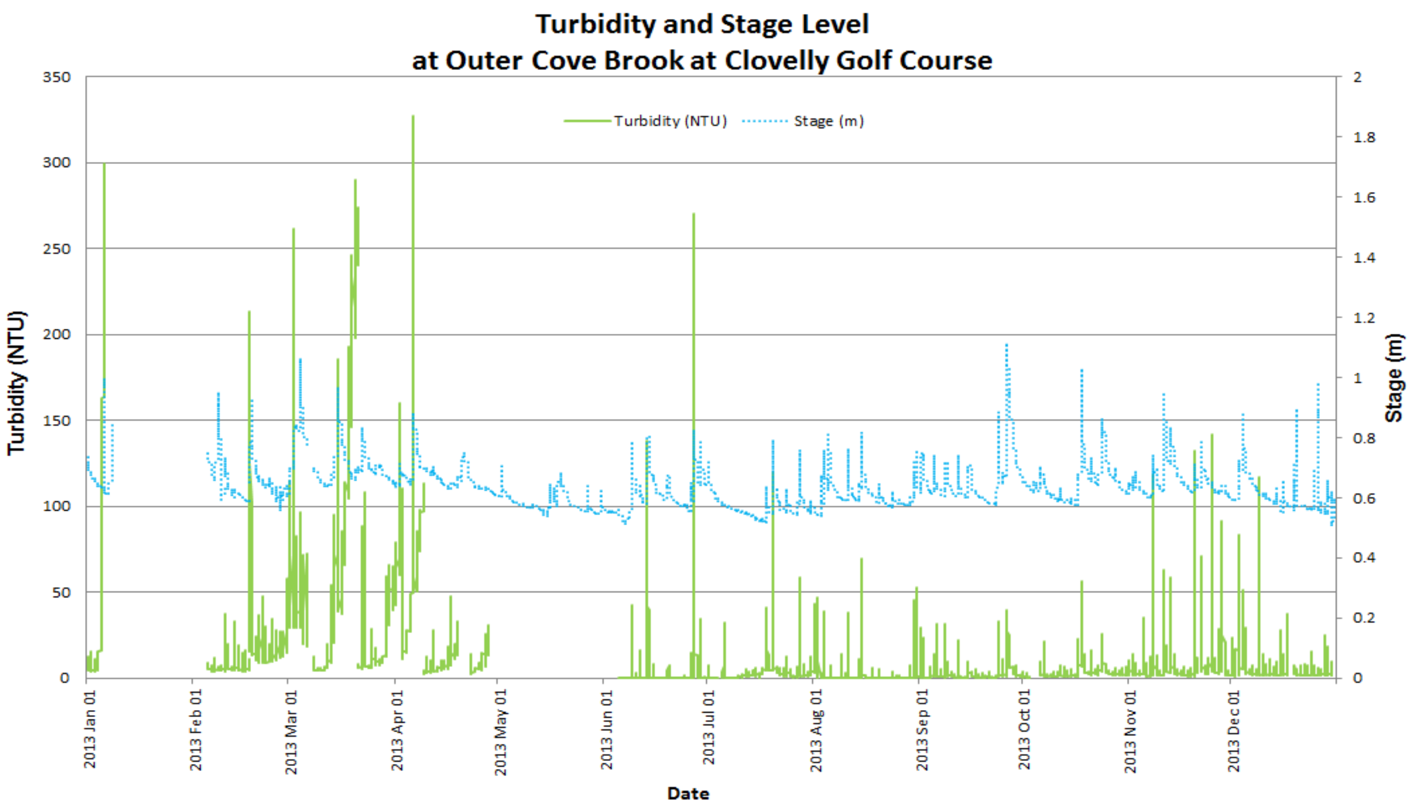

Figure 15: Quarter-hourly turbidity (NTU) and stage level (m) values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013.

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 values ranged from 57.4 to 104.9 %sat, with a median of 79.9 %sat. Dissolved Oxygen (mg/L) measured 5.33 to 12.69 mg/L, with a median of 9.56 mg/L. The DO mg/L values are above the minimum DO guideline for the protection of early life stages during winter, spring and fall months, but dip below this minimum value during the warmer summer months.

- Dissolved oxygen (% sat) remained relatively constant throughout the seasons. Figure 16 demonstrates the natural inverse relationship that exists between dissolved oxygen (mg/L) and water temperature.

- The large fluctuations in DO during summer are due to the presence of large amounts of algae and vegetation around this station. During the day, the plants are photosynthesizing, producing oxygen, but cease this process as night due to the absence of sunlight, causing the depletion of oxygen in the water at night.

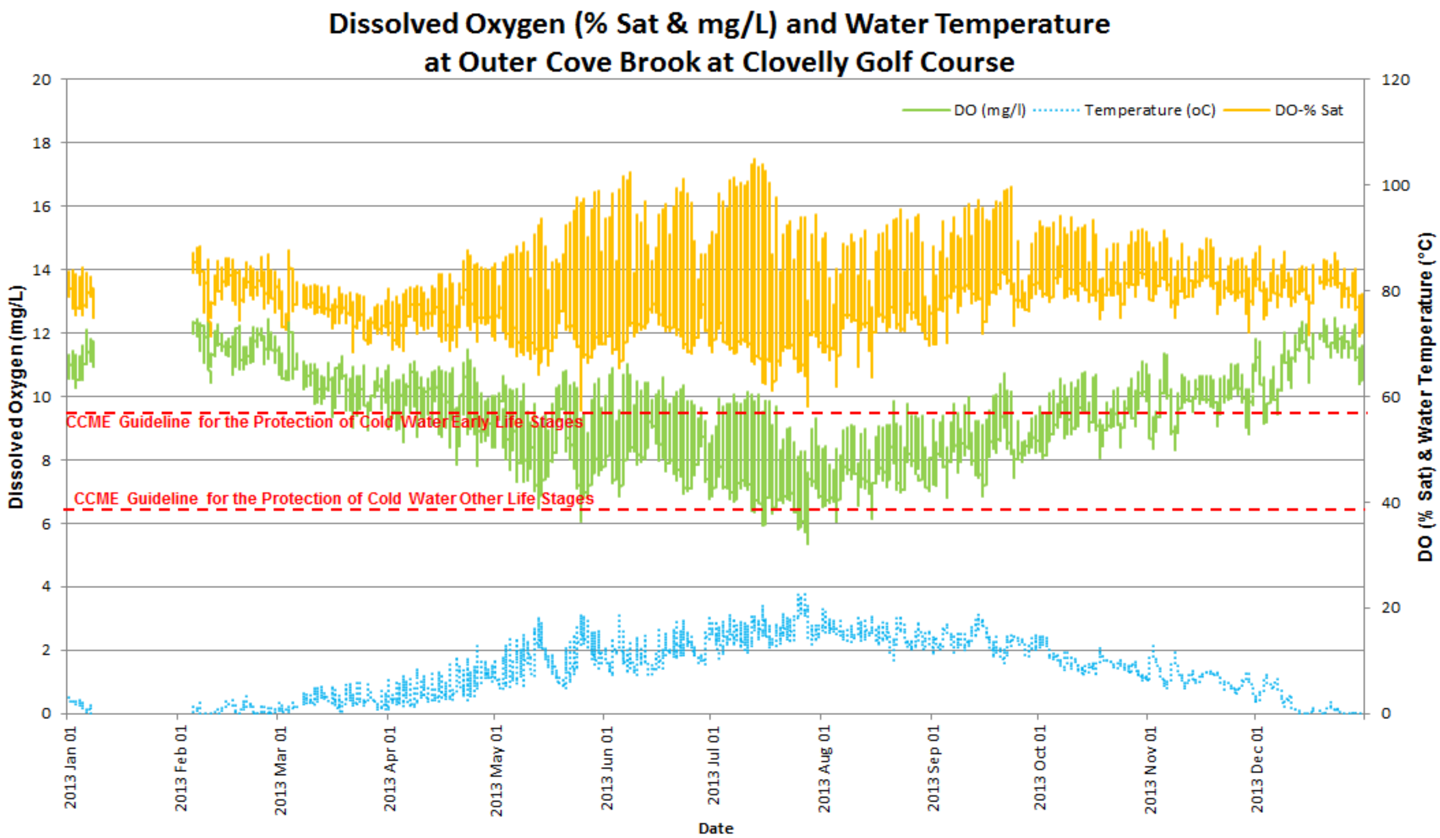

Figure 16: Quarter-hourly dissolved oxygen (% Sat & mg/L) and water temperature (°C) values recorded at Outer Cove Brook at Clovelly Golf Course from January 1 to December 31, 2013.

Conclusions

- Outer Cove Brook at Clovelly Golf Course displays characteristics typical of other St. John's area streams:
    - Stage levels are influenced by precipitation
    - Water temperatures are diurnal and influenced by air temperatures
    - Slightly acidic overall pH values
    - Specific conductivity decreases with increased rainfall; increases in winter due to road salt inputs
    - Dissolved oxygen (mg/L) varies inversely with water temperature. The large amount of vegetation surrounding this station, including abundant algae, caused large fluctuations in DO values during summer months.
    - Turbidity increases correspond to precipitation events suspending sediments into the water column or debris blocking the sensor
    - Algae and biofouling are natural occurrences in this water body which affect turbidity and DO readings

Conclusions - Outer Cove Brook Network

- Summary data for the water quality parameters measured at both Outer Cove Brook stations is shown in Table 2.

- Instruments were not deployed for the period of January 8 to February 5, 2013 due to heavy ice conditions at both stations. Ice movement can damage the cables and sondes, so all equipment was removed until ice conditions improved.

- Overall, there is little difference between parameter values at each of the stations. TDS and specific conductivity values range higher at Clovelly Golf Course than below Airport, though the median values are almost identical. Dissolved oxygen depletion is also a bigger issue at Clovelly Golf Course due to vegetation, especially during the summer months, as indicated by the minimum and average values. pH is generally higher at the below Airport station, while temperature is generally higher at the Clovelly Golf Course station.

Table 2: Maximum, minimum, average and median values for each parameter measured at the Outer Cove Brook stations during the January 1 to December 31, 2013 deployment season

	Temperature (°C)		pH		Specific Cond. (µS/cm)		TDS (g/L)		DO (mg/L)		Turbidity (NTU)	
	Airport	Clovelly	Airport	Clovelly	Airport	Clovelly	Airport	Clovelly	Airport	Clovelly	Airport	Clovelly
Max	21.8	22.73	7.34	7.22	2141	3896	1.37	2.49	13.42	12.69	2373	327.5
Min	-0.1	-0.06	5.79	5.52	58.6	100.2	0.0375	0.0641	1.36	5.33	0	0
Average	8.2	8.5	6.55	6.4	418.5	438.1	0.2673	0.2804	10.21	9.5	31.7	12.5
Median	8.3	8.6	6.54	6.39	414	415	0.266	0.266	10.29	9.56	1.7	2.7

- Algae and biofouling slime are naturally present in abundance at both stations, and can affect turbidity readings at each station.

- Variations in water quality and quantity values recorded by the Outer Cove Brook network are summarized below:

  - Variations in stage are attributed to precipitation events. Both stations displayed a trend of decreasing stage values from spring to summer as spring thaw ends, lowest stage levels in the summer, followed by increased stage levels throughout fall due to numerous precipitation events.

  - Water temperature trends over this period fluctuate diurnally, dependant on the ambient air temperature, warming as summer approaches, peaking in August, and falling as winter approaches. Precipitation and resultant increases in stage level may also decrease water temperatures.

  - pH values at both stations hover around the CCME guideline minimum pH value of 6.5, naturally decreasing with stage increases. As Newfoundland waters are naturally acidic, the pH of Outer Cove Brook does not have any significant issues, and is generally within the normal range for stream water in St. John's, with the exception of the values collected during the event described below.

- Fluctuations in specific conductivity and TDS are influenced by precipitation events, decreasing with rainfalls due to dilution, and increasing with snowfall and low ambient air temperatures due to the addition of salts from nearby roadways.

- DO values at both stations fall below the CCME recommended minimum guideline for DO of 9.5 mg/L during the summer months, when the warmer water can hold less oxygen. This is likely due to the increase in plant production in the river system during these warm months, depleting the water of its oxygen.

- Increases in turbidity corresponding to stage increases are the results of resuspension of the river's sediments with the higher flow. Large, persistant peaks in turbidity are attributed to sensor interference from algae, biofouling or leaf debris.

Water Quality Impairment Event

- During April 2013, an issue with water quality was noted during a routine station visit. A prolific 'furry-slime' substance, later determined to be a 'fungi bloom' was coating the sonde, casing, riverbed and surrounding vegetation.

- Noticeably high pH values and low oxygen levels during the month of April indicated water quality impairment. pH values were also elevated during the month of February.

Figure 17: (a) Slime on sonde casing (b) Slime coating riverbed and vegetation

- Environment Canada (EC)'s Enforcement Division was contacted, and conducted a site visit to the brook with ENVC on April 15th. It was determined that the 'slime' was present in the brook up to the point of discharge from the airport. No 'slime' was present in the brook upstream of the airport. The downstream extent reached as far as the bridge at Logy Bay Road, though the quantity did decrease with distance downstream.

- As this issue is classified as a ‘discharge from a federal property’, the investigation was handed over to EC’s Enforcement Division for action. ENVC continued to monitor real-time pH and dissolved oxygen values for any further indication of water quality impairments.

- Over the summer months, the white ‘slime’ eventually lessened and ‘died’, forming a thick reddish-brown layer on the riverbed which flaked off when touched.

- Routine monitoring of the below airport station in December noted that pH was again elevated to near or above 7.00 pH units, while dissolved oxygen was lower than normal, indicating that there may be inputs into this brook again at this time which may harm the aquatic life. No ‘slime’ was observed in the river during a field visit on December 19th. EC’s Enforcement Division was again notified of the issues in this river for their follow-up and action.

Path Forward

- Field instruments underwent performance testing during 2013, with turbidity sensors on both sondes being replaced. ENVC will continue to inform the City of St. John’s of any instrument performance issues.

- ENVC staff will continue monthly deployments of real-time instruments at both stations when ice conditions allow, and perform regular site visits, as well as calibration and maintenance of the instruments.

- ENVC staff will update the City of St. John’s on any changes to processes and procedures with handling, maintaining and calibrating the real-time instruments.

- EC staff will perform regular site visits to ensure water quantity instrumentation is correctly calibrated and providing accurate measurements.

- The City of St. John’s will continue to be informed of data trends and any significant water quality events in the form of email and/or monthly deployment reports. The City will also receive an annual report, summarizing the water quality events of the preceding year.

- ENVC will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.

- Open communication will continue to be maintained between ENVC, EC and City of St. John’s employees involved with the agreement, in order to respond to emerging issues on a proactive basis.

APPENDIX A
Quality Assurance / Quality Control Procedures

- As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the start and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].
- At the start of the deployment period, a fully cleaned and calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is placed *in-situ* with the fully cleaned and calibrated Field Sonde. After Sonde readings have stabilized, which may take up to five minutes in some cases, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde. If the readings from both Sondes are in close agreement, the QA/QC Sonde can be removed from the water. If the readings are not in close agreement, there will be attempts to reconcile the problem on site (e.g., removing air bubbles from sensors, etc.). If no fix is made, the Field Sonde may be removed for recalibration.
- At the end of the deployment period, a fully cleaned and calibrated QA/QC Sonde is once again deployed *in-situ* with the Field Sonde, which has already been deployment for 30-40 days. After Sonde readings have stabilized, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde.
- Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (^{o}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 ≤ 35 (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Sp. Conductance > 35 (µS/cm)	≤ ±3%	> ±3% to 10%	> ±15% to 20%	> ±15% to 20%	> ±20%
Dissolved Oxygen (mg/l)	≤ ±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 (NTU)	≤ ±5%	> ±5% to 10%	> ±10% to 15%	> ±15% to 20%	> ±20%

APPENDIX B
Sensor Performance Rankings for Deployment Periods

Station	Stage of Deployment	Date	Instrument	Temperature °C	pH	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
Below Airport	Start	1/8/2013	n/a	n/a	n/a	n/a	n/a	n/a
	End	2/5/2013	n/a	n/a	n/a	n/a	n/a	n/a
	Start	2/5/2013	62277	Good	Excellent	Good	Excellent	Excellent
	End	3/6/2013	62277	Excellent	Fair	Excellent	Excellent	Poor
	Start	3/6/2013	62277	Excellent	Excellent	Good	Excellent	Excellent
	End	4/9/2013	62277	Excellent	Good	Good	Excellent	Poor
	Start	4/9/2013	62277	Good	Good	Marginal	Good	Excellent
	End	5/3/2013	62277	Good	Excellent	Poor	Poor	Poor
	Start	5/3/2013	62277	Good	Excellent	Fair	Excellent	Excellent
	End	6/4/2013	62277	Good	Fair	Poor	Poor	Poor
	Start	6/5/2013	62277	Good	Excellent	Excellent	Good	Excellent
	End	7/3/2013	62277	Good	Excellent	Excellent	Fair	Poor
	Start	7/3/2013	62277	Fair	Excellent	Excellent	Excellent	Fair
	End	8/6/2013	62277	Excellent	Good	Good	Excellent	Fair
	Start	8/6/2013	62277	Good	Excellent	Excellent	Excellent	Poor
	End	9/4/2013	62278*	Excellent	Excellent	Excellent	Excellent	Excellent
	Start	9/4/2013	45036*	Good	Excellent	Excellent	Excellent	Excellent
	End	10/8/2013	45036	Good	Excellent	Excellent	Excellent	Fair
	Start	10/8/2013	45036	Good	Good	Excellent	Excellent	Excellent
	End	11/6/2013	45036	Fair	Excellent	Good	Excellent	Excellent
	Start	11/6/2013	62277	Poor	Excellent	Good	Good	Good
	End	12/17/2013	62277	Good	Fair	Excellent	Marginal	Good
	Start	12/19/2013	62277	Good	Fair	Excellent	Fair	Fair
	End	Jan. 2014	62277	n/a	n/a	n/a	n/a	n/a
Clovelly Golf Course	Start	1/8/2013	n/a	n/a	n/a	n/a	n/a	n/a
	End	2/5/2013	n/a	n/a	n/a	n/a	n/a	n/a
	Start	2/5/2013	62278	Good	Excellent	Excellent	Excellent	Excellent
	End	3/6/2013	62278	Excellent	Good	Excellent	Excellent	Poor
	Start	3/6/2013	62278	Excellent	Good	Good	Excellent	Good
	End	4/9/2013	62278	Good	Excellent	Excellent	Excellent	Poor
	Start	4/9/2013	62278	Good	Good	Good	Excellent	Excellent
	End	5/3/2013	62278	Excellent	Good	Fair	Excellent	Poor
	Start	5/3/2013	62278	Good	Excellent	Good	Excellent	Good
	End	6/4/2013	62278	Excellent	Excellent	Good	Good	Poor
	Start	6/5/2013	46323*	Good	Good	Excellent	Fair	Excellent
	End	7/3/2013	46323	Excellent	Excellent	Good	Good	Excellent
	Start	7/3/2013	46323	Good	Excellent	Good	Excellent	Excellent
	End	8/6/2013	46323	Good	Excellent	Excellent	Excellent	Poor
	Start	8/6/2013	45036*	Excellent	Excellent	Excellent	Excellent	Poor
	End	9/4/2013	45036	Good	Excellent	Excellent	Excellent	Excellent
	Start	9/4/2013	62278	Excellent	Excellent	Excellent	Good	Excellent
	End	10/8/2013	62278	Excellent	Excellent	Excellent	Good	Good
	Start	10/8/2013	62278	Excellent	Excellent	Excellent	Excellent	Excellent
	End	11/6/2013	62278	Poor	Good	Good	Good	Good
	Start	11/6/2013	62278	Poor	Good	Good	Good	Excellent
	End	12/17/2013	62278	Good	Good	Marginal	Fair	Excellent
	Start	12/19/2013	62278	Good	Good	Excellent	Good	Good
	End	Jan. 2014	62278	n/a	n/a	n/a	n/a	n/a

* Sonde normally deployed at this location undergoing repairs

APPENDIX C
Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).

pH - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).

Specific conductivity - Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Stage – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature - Essential to the measurement of most water quality parameters, temperature (^{o}C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965).

APPENDIX D
References

Allan, D. (2010). Advanced Water Quality Instrumentation Training Manual. Edmonton, AB: Allan Environmental Services Inc. (pp. 160).

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Hach (2006) Important water quality factors - H2O University. Hach Company. Online: http://www.h2ou.com/index.htm (accessed August 24, 2010).

Swanson, H.A., and Baldwin, H.L., 1965. A Primer on Water Quality, U.S. Geological Survey. Online: http://ga.water.usgs.gov/edu/characteristics.html (accessed August 24, 2010)

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APPENDIX E
Air Temperature and Precipitation Data

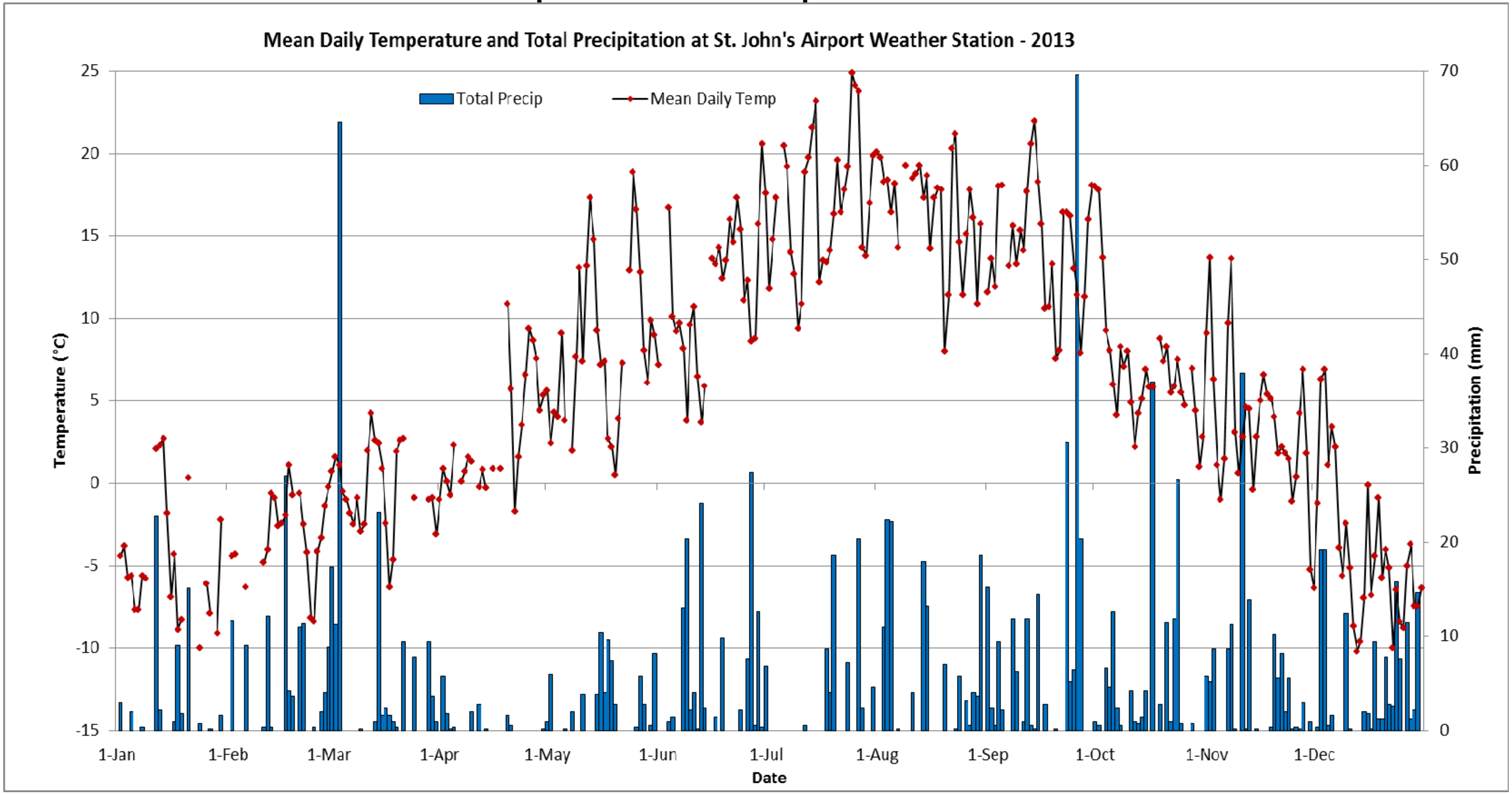

Figure 17: Mean daily temperature and total precipitation values for the period January 1 to December 31, 2013, from Environment Canada's St. John's International Airport weather station.