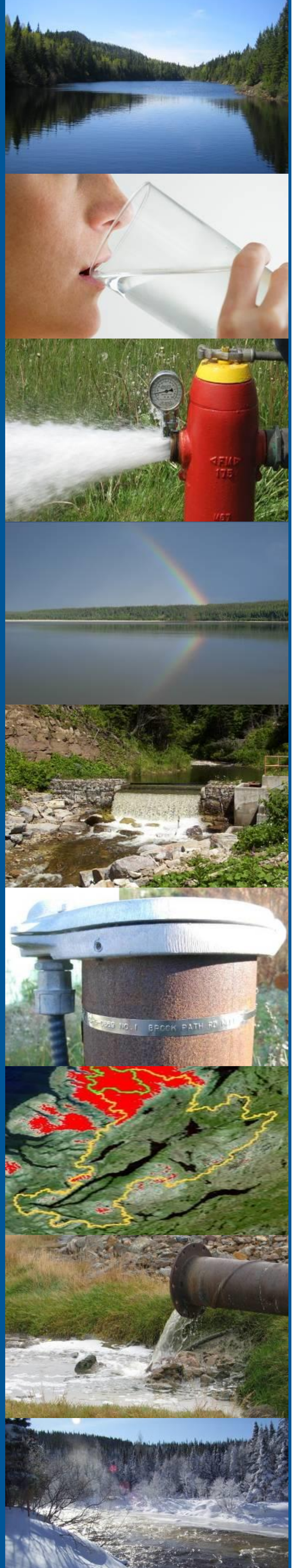

Real-Time Water Quality Report

Waterford River
@
Kilbride

NF02ZM0009

Deployment Period
January 31 to April 29, 2014

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

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General

- The Water Resources Management Division monitors real-time water quality data on a daily basis.
- The instrument used for the deployment period of January 31, 2014 to April 29, 2014 was a YSI 6600 series multi-probe, which continuously measured water temperature, pH, dissolved oxygen, specific conductivity and turbidity.
- The instrument was deployed for 88 days.

Quality Assurance and Quality Control

- As part of the Quality Assurance and Quality Control (QA/QC), an assessment of the reliability of data recorded by the instrument is made at the beginning and end of the deployment period.
- This procedure is based on the approach used by the United States Geological Survey and is outlined in Appendix A.
- 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 difference between the parameters measured on the Field Sonde and the QA/QC Sonde at deployment and 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 importance of this parameter it is necessary for temperature to stabilize first, if a reading is taken too soon it may not accurately portray the water body.
- Deployment and removal instrument performance rankings for the station at Waterford River at Kilbride for the period of January 31, 2014 to April 29, 2014 are summarized in Table 2.

Table 2: Instrument performance rankings for Waterford River at Kilbride

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Waterford River	January 31, 2014	Deployment	Good	Excellent	Excellent	N/A (Poor)	N/A (Poor)
	April 29, 2014	Removal	Excellent	Excellent	Fair	N/A (Good)	N/A (Poor)

- During the deployment at Waterford River at Kilbride Station, pH and conductivity ranked as 'excellent'. With temperature ranking as 'good'.
- At removal, water temperature and pH ranked as 'excellent'. Conductivity ranked as 'fair'.
- Rankings for the dissolved oxygen and turbidity sensors are not applicable during this deployment period due to sensor failure. The data gathered from these sensors has been deemed not valid and replacement sensors have been ordered.

Data Interpretation

- Performance issues and data records were interpreted, for each station during the deployment period, for the following eight parameters:
  - Temperature (oC)
  - pH
  - Stage (m)
  - Flow (m^3/s)
  - Specific conductivity (µS/cm)
  - Total dissolved solids (g/l)
  - Dissolved oxygen (mg/l or % saturation)
  - Turbidity (NTU)
- With the exception of water quantity data (stage & flow), all data in the preparation of the graphs and subsequent discussions below adhere to this QAQC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.
- A brief description of each parameter is provided in Appendix B.
- The Waterford River at Kilbride instrument's DO and turbidity sensors failed during deployment and the data was deemed not valid. Replacement probes were ordered for future deployments.

Water Temperature

The graph indicates an increasing trend in water temperature, which corresponds with seasonally increasing air temperatures. Fluctuations in water temperature are related to changes in air temperature, precipitation, run-off and anthropogenic inputs. Environment Canada's Daily Climate Data for the deployment period are shown in Appendix C at the end of this report.

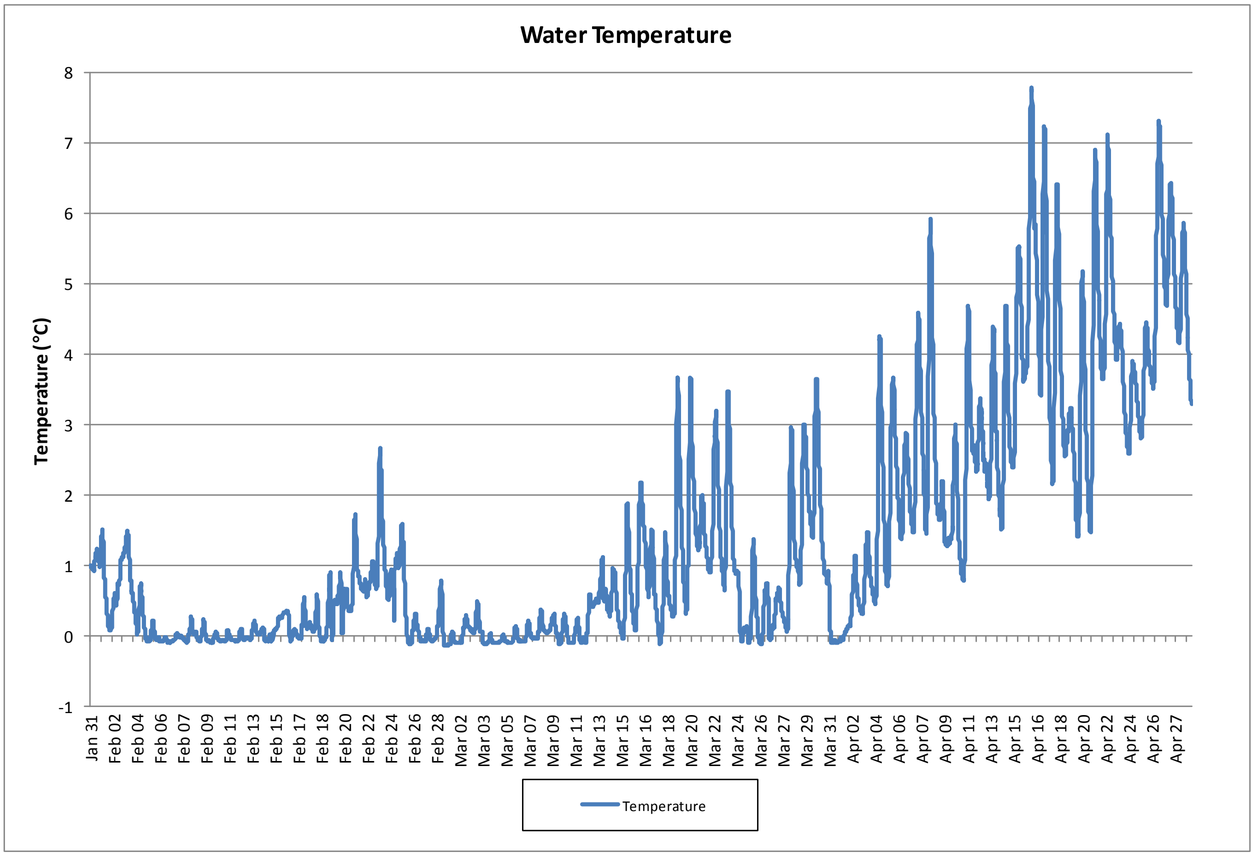

Figure 1: Water temperature (°C) values at Waterford River at Kilbride Station

pH

The pH of water is a measure of the concentration of hydrogen ions, with pH decreasing as the concentration of hydrogen ions increases. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals. The pH of pure water is 7.0 pH units, but both natural (geology, precipitation) and human (forest harvesting, urban run-off) processes can alter the pH of water.

Metals tend to be more toxic at lower pH because they are more soluble. Photosynthesis uses up hydrogen molecules, which causes the concentration of hydrogen ions to decrease and therefore the pH to increase. For this reason, pH may be higher during daylight hours and during the growing season, when photosynthesis is at a maximum.

pH values during this deployment period were quite stable, hovering near neutral pH values and ranging from 6.84 to 7.22 pH units. All pH measurements were within the CCME recommended guideline range for the protection of aquatic life, of 6.5 - 9.0 pH units. pH values for this deployment are shown in blue in the graph in Figure 2.

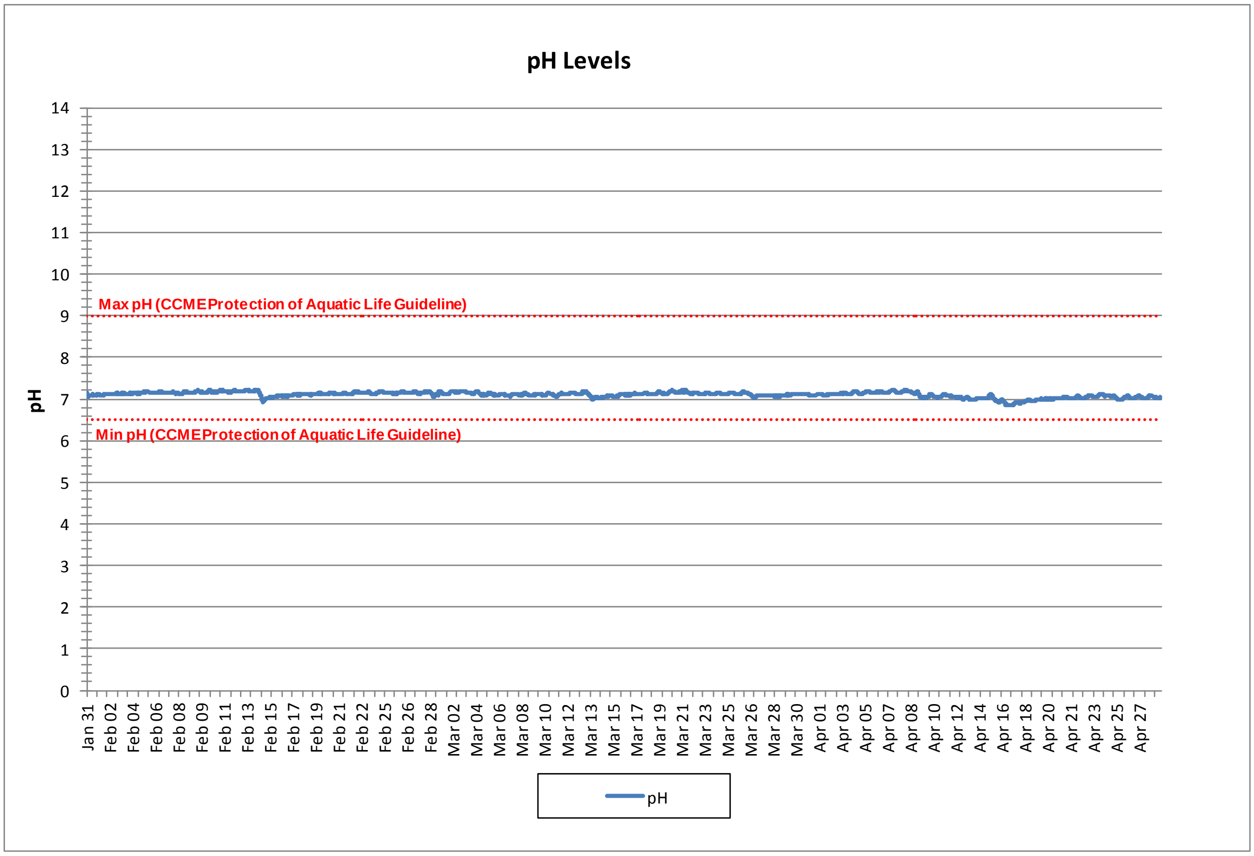

Figure 2: pH levels at Waterford River at Kilbride Station

Specific Conductivity & Stage

Specific conductivity measures the ability of water to pass an electrical current. Conductivity in streams and rivers is affected by the geology of the area through which the water flows. High specific conductivity readings are often influenced by urban run-off, and the effects of urban run-off are dependent upon the season. During warmer temperatures, when road salt is not being used for ice control, rainfall and urban run-off can have a dilution effect causing specific conductivity levels to decrease as stage level increases. However, during the winter months when road salting operations are in effect, urban run-off can be laden with salt, resulting in spikes in conductivity.

Environment Canada's Daily Climate Data for January to April 2014 are presented in Appendix C. Figure 3 demonstrates the variable impacts that changes in stage height can have on conductivity, depending on the climate factors and anthropogenic factors. Specific conductivity is shown in blue and stage height in green in the graph in Figure 3. February 14-16 demonstrates a direct relationship between conductivity and stage height whereby conductivity levels increase as stage height increases. This is due to the sudden warmer temperatures that occurred at this time along with 20mm of rainfall, while there were approximately 34cm of salt laden snow on the ground. The red circle on the far left of the graph in Figure 3 marks this concurrent increase.

In contrast, the middle red circle on the graph identifies several spikes in conductivity with very little corresponding change in stage height. The weather during the same period, from February 19 – March 6, consistently hovered around freezing temperatures and precipitation was in the form of snow, resulting in very little run-off, however conductivity levels increased due to continued road salting applications during this time period.

The red circle on the right in the graph demonstrates the dilution effect that increased stage height can have on conductivity, as conductivity levels plummeted while stage height showed several spikes from April 9 – 16. The climate at the time, as shown in Appendix C, indicates that approximately 37mm of rain fell during this period when air temperatures were consistently above freezing. Several days of warm air temperatures preceded this period, which would also indicate that road salt was no longer being used for ice control, and urban run-off did not contain high concentrations of salt.

Specific conductivity levels at the Waterford River monitoring station ranged from 253 to 3203µS/cm during this deployment.

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. TDS generally always mirrors specific conductivity. TDS ranged from 0.1640 g/L to 2.0820 g/L during the deployment period and mirrored specific conductivity.

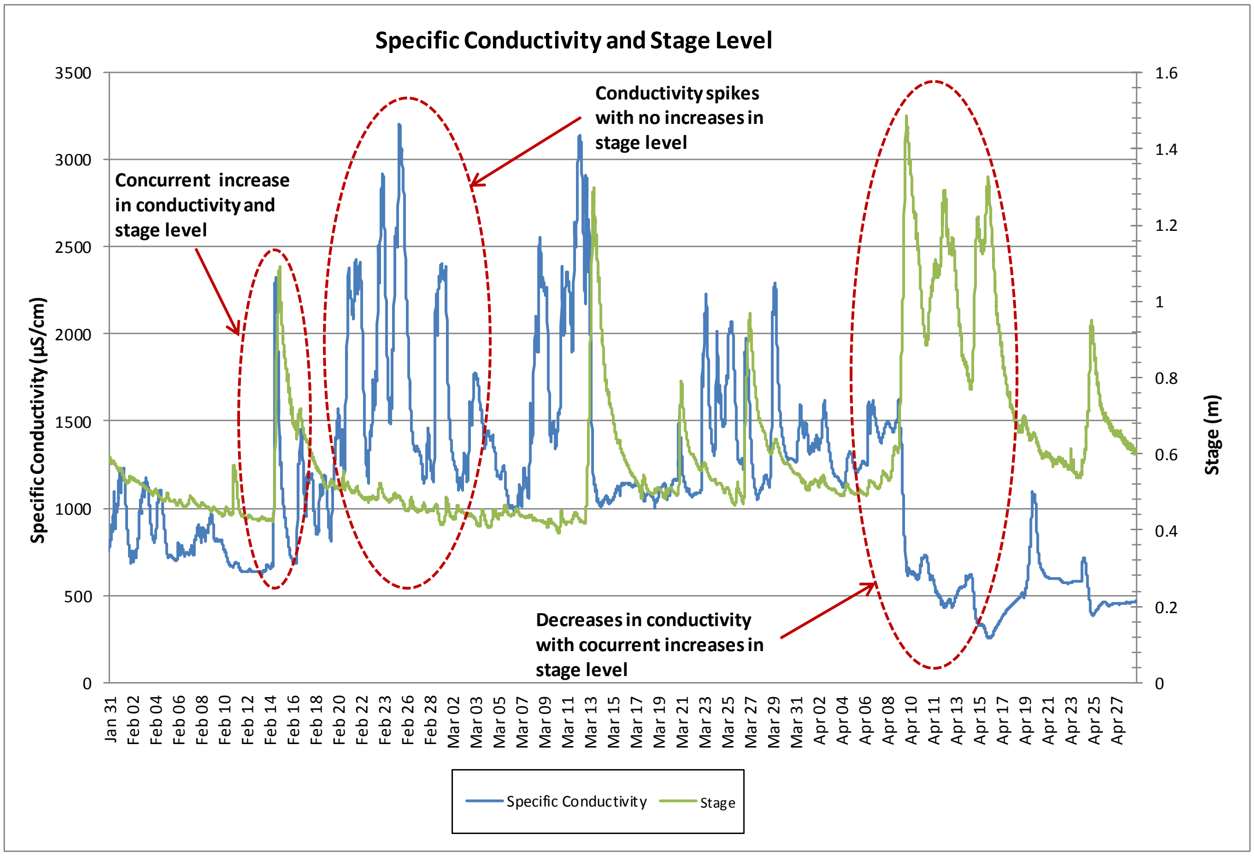

Figure 3: Specific conductivity (uS/cm) and stage (m) values for Waterford River at Kilbride Station

Stage & Stream Flow

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).

Stream flow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second.

Stage and Stream flow will increase during rainfall events and during any surrounding snow or ice melt as runoff will collect in the river. However, direct snowfall will not cause them to rise significantly. During the deployment period, the stage values ranged from 0.39m to 1.49m. The stream flow values ranges from 0.44m^3/s to 23.10m^3/s .The larger peaks in stage and stream flow do correspond with substantial rainfall events as noted on Figure 4 and in Appendix C at the end of this report.

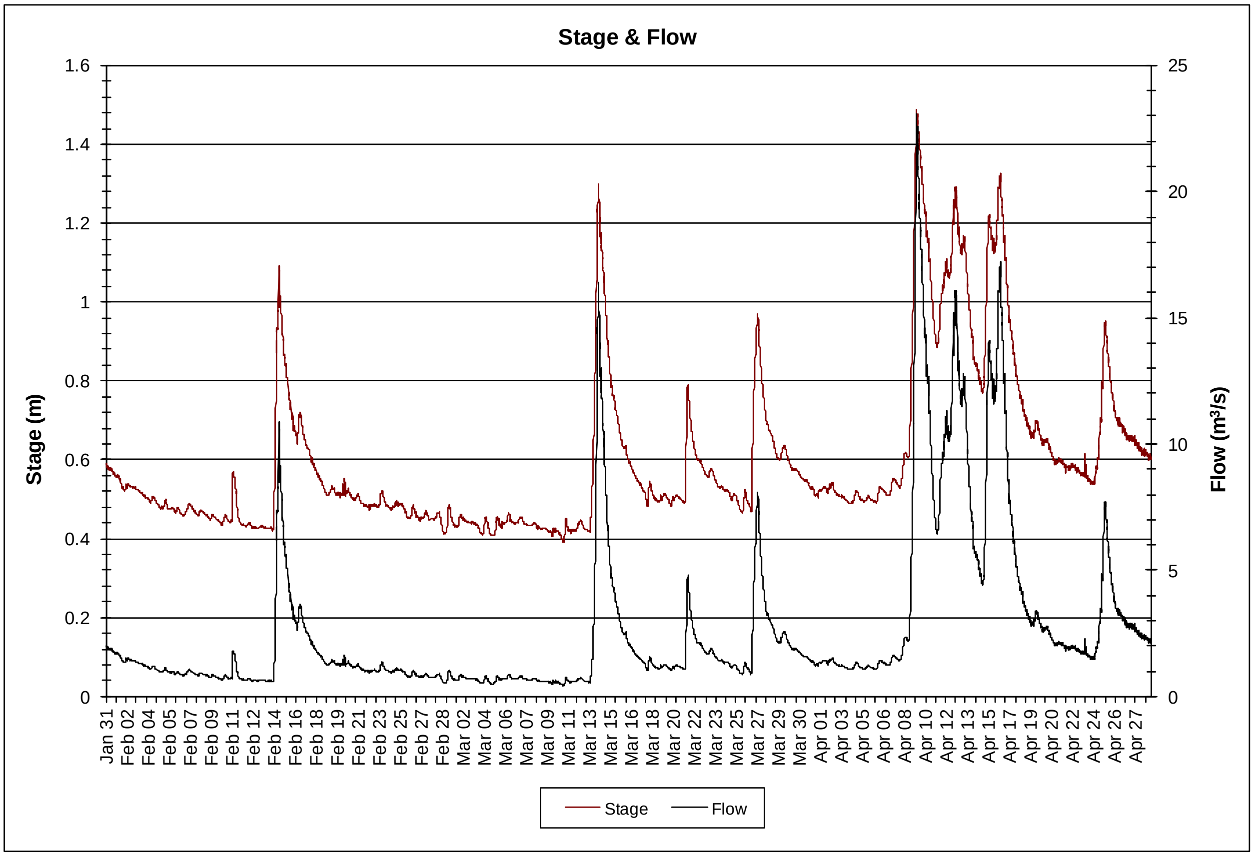

Figure 4: Stage and Flow

Conclusion

- The data indicates an increasing trend in water temperature, which corresponds with seasonally increasing air temperatures. Fluctuations in water temperature are related to changes in air temperature, precipitation, run-off and anthropogenic inputs.

- pH values during this deployment period were quite stable, hovering near neutral pH values and ranging from 6.84 to 7.22 pH units. All pH measurements were within the CCME recommended guideline range for the protection of aquatic life, of 6.5 - 9.0 pH units

- Specific conductivity levels at the Waterford River monitoring station ranged from 253 to 3203µS/cm during this deployment.

- During the deployment period, the stage values ranged from 0.39m to 1.49m. The stream flow values ranged from 0.44m^3/s to 23.10m^3/s

- This river flows through significantly developed areas, including residential, commercial, and industrial zones 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.

- Dissolved oxygen and turbidity data from this deployment period were deemed not valid due to sensor failure.

References

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
Online: http://st-ts.ccme.ca/en/index.html?chems=154,162&chapters=1

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)

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 beginning 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 beginning of the deployment period, a newly calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is temporarily deployed *in-situ* and along side the newly calibrated Field Sonde. A grab sample is also taken from the water body at this time and sent away to a laboratory for analysis. Field Sonde performance ratings for *temperature (°C)* and *Dissolved Oxygen (% saturation)* are based on differences recorded by the Field Sonde and QA/QC Sonde. Field Sonde performance ratings for *specific conductivity (µS/cm)*, *pH (unit)* and *turbidity (NTU)* are based on differences between Field Sonde readings and grab sample results.
- At the end of the deployment period, water quality parameters are recorded by the Field Sonde before and after a thorough cleaning of its probes. Error caused by *bio-fouling* (E_f) is assessed by comparing these readings with readings made by a newly calibrated QA/QC Sonde, which is temporarily deployed *in-situ* and along side the Field Sonde. An assessment of *instrument drift error* (E_d) is made during laboratory calibration of the Field Sonde, and the two error values are added to give an estimate of total error ($E_t = E_f + E_d$). If E_t exceeds a predetermined data correction criterion, a correction factor is applied to the dataset based on linear interpolation of E_t. The Field Sonde performance is also rated at the end of the deployment period, based on the E_t value.
- Performance ratings are based on differences listed in the table below.

	Rating				
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

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at *http://pubs.water.usgs.gov/tm1d3*

APPENDIX B
Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l or % saturation) 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).

Flow – Flow (m3/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.

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 (oC) 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 C

Environment Canada Weather Data – St. John's International Airport (January 31, 2014 to April 29, 2014)

Date yyyy-mm-dd	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days °C	Cool Deg Days °C	Total Rain mm	Total Snow cm	Total Precip mm
2014-01-31	2.1	-10.8	-4.4	22.4	0	0	1	1
2014-02-01	0	-8.6	-4.3	22.3	0	0	0	0
2014-02-02	-1.1	-9.2	-5.2	23.2	0	0	17.4	9.8
2014-02-03	-2.2	-12.5	-7.4	25.4	0	0	1.2	0.4
2014-02-04	-8.4	-13.3	-10.9	28.9	0	0	1	0.2
2014-02-05	-8.8	-11.9	-10.4	28.4	0	0	2	1.6
2014-02-06	-7.4	-15.7	-11.6	29.6	0	0	30.6	12.2
2014-02-07	-6.2	-14.4	-10.3	28.3	0	0	0	0
2014-02-08	-4.3	-12.3	-8.3	26.3	0	0	1	0.6
2014-02-09	-7.9	-15	-11.5	29.5	0	0	0	0
2014-02-10	-10.8	-17.1	-14	32	0	0	0.2	0
2014-02-11	-11.2	-14.8	-13	31	0	0	0	0
2014-02-12	-7.4	-15.5	-11.5	29.5	0	0	0	0
2014-02-13	-2.4	-10.4	-6.4	24.4	0	0	0	0
2014-02-14	7.8	-4.2	1.8	16.2	0	15.8	4.6	20
2014-02-15	2.5	-4.3	-0.9	18.9	0	0	0	0
2014-02-16	4.6	-4.7	-0.1	18.1	0	3.8	4.4	11.8
2014-02-17	-4	-6.2	-5.1	23.1	0	0	4.6	1.6
2014-02-18	-4.9	-8.4	-6.7	24.7	0	0	3.2	2
2014-02-19	0.6	-8.8	-4.1	22.1	0	0	12	8.4
2014-02-20	2.7	-3.4	-0.4	18.4	0	-	-	1.5
2014-02-21	-1.5	-3.1	-2.3	20.3	0	-	-	2.4
2014-02-22	0.7	-4.6	-2	20	0	1	5.4	5.1
2014-02-23	2.3	-3.8	-0.8	18.8	0	0	0	0
2014-02-24	0.9	-4.6	-1.9	19.9	0	2.2	10.8	11.2
2014-02-25	0.2	-9.1	-4.5	22.5	0	0	4	2.2
2014-02-26	-5.9	-10	-8	26	0	0	2.8	0.4
2014-02-27	-5.4	-9.4	-7.4	25.4	0	0	7.6	4.8
2014-02-28	0.4	-10.1	-4.9	22.9	0	0	2.2	1.5
2014-03-01	-6.8	-12	-9.4	27.4	0	0	0	0
2014-03-02	-1.5	-12.9	-7.2	25.2	0	0	2.6	2.6

2014-03-03	-6.3	-13.4	-9.9	27.9	0	0	6.2	3.2
2014-03-04	-10.7	-17.8	-14.3	32.3	0	0	0.2	0
2014-03-05	-9.2	-17.7	-13.5	31.5	0	0	0	0
2014-03-06	-9.4	-17.3	-13.4	31.4	0	0	0	0
2014-03-07	-3.3	-15.9	-9.6	27.6	0	0	0	0
2014-03-08	1.6	-5.8	-2.1	20.1	0	0	2.2	2.2
2014-03-09	-1.6	-11.9	-6.8	24.8	0	0	3.4	1.4
2014-03-10	-7.6	-16.7	-12.2	30.2	0	0	4	1.4
2014-03-11	-4.2	-16.3	-10.3	28.3	0	0	0	0
2014-03-12	1.6	-5.5	-2	20	0	0	10.2	8
2014-03-13	10.6	-3.4	3.6	14.4	0	10.4	0	10.4
2014-03-14	7	-9	-1	19	0	4.6	0	4.6
2014-03-15	-4.6	-11.3	-8	26	0	0	0	0
2014-03-16	2.7	-9.3	-3.3	21.3	0	0.4	0	0.4
2014-03-17	-2	-9.8	-5.9	23.9	0	0	0.6	0
2014-03-18	-3	-11	-7	25	0	0	0	0
2014-03-19	0.3	-6.5	-3.1	21.1	0	0	0	0
2014-03-20	-0.5	-7.4	-4	22	0	0	0	0
2014-03-21	3.4	-3.4	0	18	0	13	0	13
2014-03-22	2.7	-4.9	-1.1	19.1	0	0	0	0
2014-03-23	2.3	-4.2	-1	19	0	0	4.6	2.8
2014-03-24	-2.9	-3.9	-3.4	21.4	0	0	22.4	16.8
2014-03-25	-3.8	-10.3	-7.1	25.1	0	0	1	0.4
2014-03-26	2	-13.6	-5.8	23.8	0	13.8	11.8	25.6
2014-03-27	4.3	-4.2	0.1	17.9	0	3.6	0.4	3.8
2014-03-28	0.5	-4.5	-2	20	0	0	0	0
2014-03-29	3.3	-3.7	-0.2	18.2	0	0	2	1.4
2014-03-30	-1	-5.5	-3.3	21.3	0	0	0	0
2014-03-31	-3.3	-5.8	-4.6	22.6	0	0	18.2	17.6
2014-04-01	-0.6	-3.5	-2.1	20.1	0	0	18.6	12.8
2014-04-02	-0.9	-3.8	-2.4	20.4	0	0	0	0
2014-04-03	-3	-6.3	-4.7	22.7	0	0	0	0
2014-04-04	1.3	-6	-2.4	20.4	0	0	0	0
2014-04-05	0.2	-3.8	-1.8	19.8	0	0	0	0
2014-04-06	3	-3.1	-0.1	18.1	0	3	0	3
2014-04-07	3.7	-2.4	0.7	17.3	0	0	0	0
2014-04-08	4.5	-3.8	0.4	17.6	0	0.2	0.4	1

2014-04-09	10.3	-0.8	4.8	13.2	0	21	0.2	21.6
2014-04-10	4	-3.8	0.1	17.9	0	2	0	2
2014-04-11	8.4	-3.9	2.3	15.7	0	0	0	0
2014-04-12	7.6	1	4.3	13.7	0	12.4	0	12.4
2014-04-13	7.6	-4.2	1.7	16.3	0	0.2	0	0.2
2014-04-14	3.2	-5.1	-1	19	0	1.4	0.4	1.8
2014-04-15	14	0.3	7.2	10.8	0	0.2	0	0.2
2014-04-16	18.8	3.5	11.2	6.8	0	0	0	0
2014-04-17	6	-4.9	0.6	17.4	0	0	0	0
2014-04-18	1.6	-7	-2.7	20.7	0	0	0	0
2014-04-19	-0.6	-3.6	-2.1	20.1	0	1.4	3.8	4.4
2014-04-20	0.6	-4.6	-2	20	0	0	1.2	0.4
2014-04-21	6.8	-4.8	1	17	0	0	0	0
2014-04-22	8.5	-0.7	3.9	14.1	0	0.4	0	0.4
2014-04-23	0.2	-1.3	-0.6	18.6	0	0	0	0
2014-04-24	1.5	-0.9	0.3	17.7	0	4	0	4
2014-04-25	2.6	-0.2	1.2	16.8	0	11.6	0	11.6
2014-04-26	7.7	0	3.9	14.1	0	0	0	0
2014-04-27	4	0.3	2.2	15.8	0	0.8	0	0.8
2014-04-28	2.8	-0.5	1.2	16.8	0	0	0.6	0.6
2014-04-29	1.2	-2	-0.4	18.4	0	0	0.2	0