Real Time Water Quality Report

Labrador Iron Mines
Schefferville Network

Deployment Period
2011-09-19 to 2011-10-16

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

- The Water Resources Management Division, in partnership with Labrador Iron Mines Ltd. and Environment Canada, maintain two real-time water quality and water quantity stations in close proximity to the James Property deposits, near Schefferville, QC.
- The official name of each station is *James Creek Above Bridge* and *Unnamed Tributary Below Settling Pond*, hereafter referred to as the James Creek station and the Unnamed Tributary station, respectively.
- Unnamed Tributary station monitors water outflow from a series of multi-cell retention and settling ponds.
- James Creek station monitors water outflow from the multi-cell retention and settling pond system mentioned above, as well as monitors outflow from Ruth Pit.
- The retention and settling pond system is comprised of four smaller man-made ponds that receive water primarily from groundwater wells constructed along the periphery of the James Property, in addition to storm water from the beneficiation area, flush water from the reject rock pipeline, and in case of pump failure, reject rock inside the pipeline that was destine to Ruth Pit. Outflow from the retention and settling pond system is directed into the Unnamed Tributary and James Creek. Priority is given to the outflow leading into the Unnamed Tributary, with surplus water directed into James Creek.
- Ruth Pit is used as a settling pond for reject rock originating from the beneficiation area at the Silver Yard, as well as receives water from pit dewatering pumps. The outflow from Ruth Pit is the start of James Creek.
- The Water Resources Management Division will inform Labrador Iron Mines Ltd. of any significant water quality events by email notification and by monthly deployment reports.
- This monthly deployment report, presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from September 19, 2011 to October 16, 2011.

Quality Assurance / Quality Control

- Water quality instrument performance is tested at the beginning and end of its deployment period. The process is outlined in Appendix A.
- Instruments are assigned a performance rating (i.e., poor, marginal, fair, good or excellent) for each water quality parameter measured.
- Table 1 shows the performance ratings of five water quality parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen and turbidity) measured by instruments deployed at the water monitoring stations.

Table 1. Water quality instrument performance at the beginning and end of deployment at the James Creek and Unnamed Tributary stations.

	James Creek (Sonde 49199)		Unnamed Tributary (Sonde 49200)	
Stage of deployment	Beginning	End	Beginning	End
Date	2011-09-19	2011-10-16	2011-09-19	2011-10-16
Temperature	Excellent	Excellent	Excellent	Excellent
pH	Excellent	Excellent	Excellent	Excellent
Specific Conductivity	Excellent	Excellent	Excellent	Fair
Dissolved Oxygen	Excellent	Good	Excellent	Good
Turbidity	Excellent	Excellent	Excellent	Excellent

- The performances of all sensors were rated fair to excellent at the beginning and end of the deployment period (Table 1).
- A transmission error had resulted in data loss at the James Creek station on October 1, 2011. This data outage lasted eight hours, from 04:00 ADT to 11:00 ADT. Water quality data was extracted from the instrument's internal log file to fill in this data gap. Unfortunately, stage values are not recorded to this log file and are missing for the time of the outage.

Data Interpretation

- Data records were interpreted for each station during the deployment period for the following seven parameters:

  (i.) Stage (m)
  (ii.) Temperature (^{o}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 B.

Stage

- Stage values ranged from 0.75 m to 0.80 m at James Creek and from 1.12 m to 1.15 m at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 1).
- Daily fluctuations were observed at both stations with increases occurring in the afternoon and decreases occurring at night. These diurnal fluctuations were attributed to temperature-related atmospheric pressure changes.
- Stage levels showed no weekly trends.
- Stage values are based on a vertical reference that is unique to each station. As a result, absolute values of stage are not comparable between stations, but relative changes in stage are.

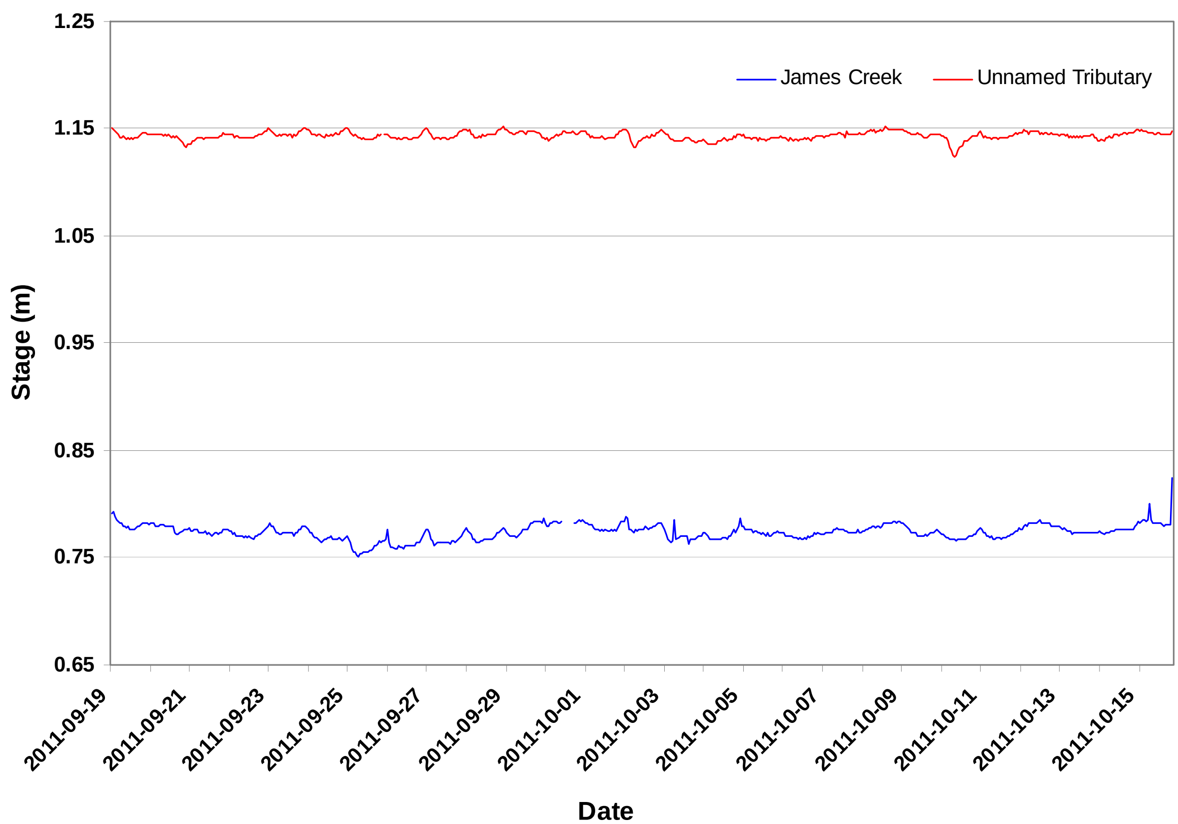

Figure 1. Hourly stage (m) values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011.

Temperature

- Water temperature ranged from 0.9˚C to 8.6˚C at James Creek and from 0.2˚C to 6.6˚C at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 2).
- Water temperatures at both stations display large diurnal variations. This is typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.
- Weekly trends in water temperature also corresponded well with ambient air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 2 inset, Appendix C).
- Water temperatures at the Unnamed Tributary were on average 1.7^{o}C colder than water temperatures at James Creek. Indeed, water flowing into the Unnamed Tributary is close to its groundwater source, and has less exposure to ambient air temperatures, as compared to the surface water source that primarily feeds into James Creek.

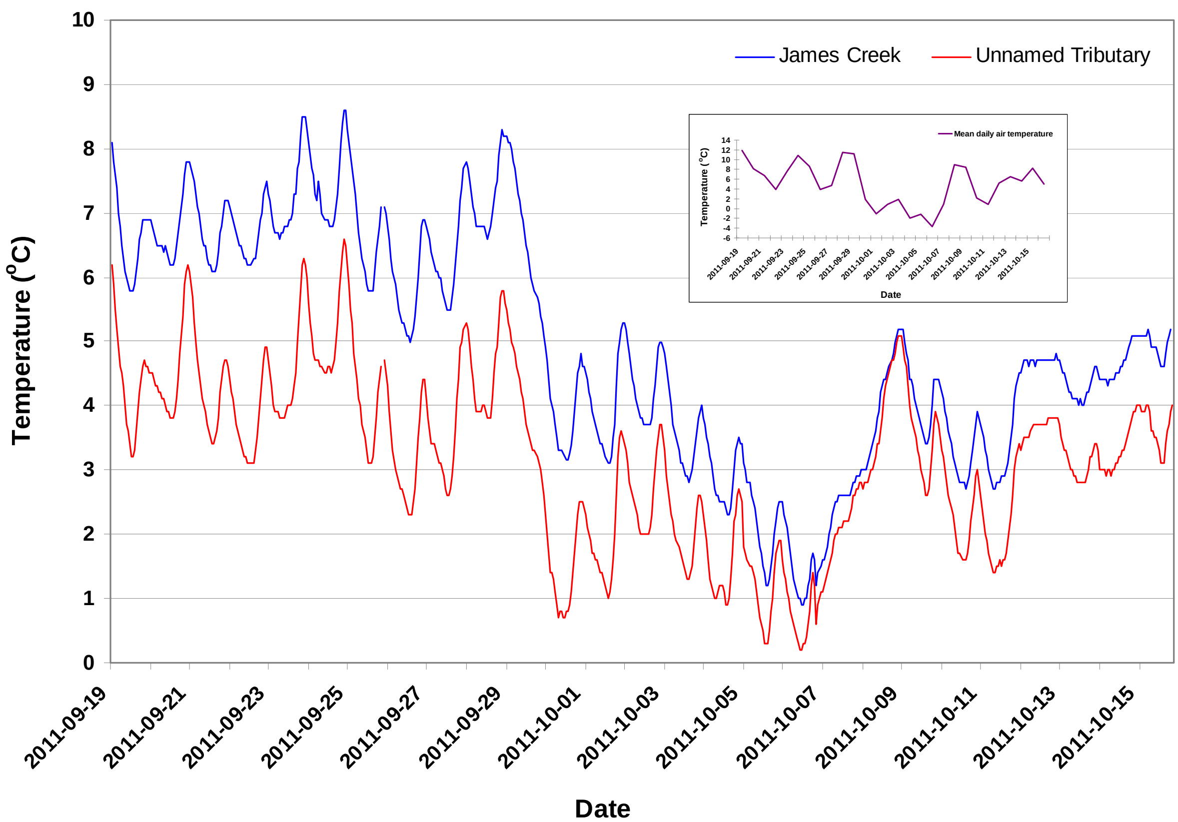

Figure 2. Hourly water temperature (^{o}C) values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011. The inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 7.97 units to 8.46 units at James Creek and from 7.00 units to 7.44 units at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 3).
- pH values at both stations fluctuated daily with peaks typically occurring in the late afternoon/ early evening. These variations coincide with the photosynthetic cycling of CO_2 by aquatic organisms.
- pH levels showed no weekly trends.
- On average, pH was 0.83 units higher at James Creek than at Unnamed Tributary. This difference could be attributed to the mining effluent discharged into Ruth Pit and detected at the James Creek station.
- All pH values were within the acceptable range for the protection of aquatic life (i.e., 6.5 to 9.0 units), as defined by the Canadian Council of Ministers of the Environment (2007).

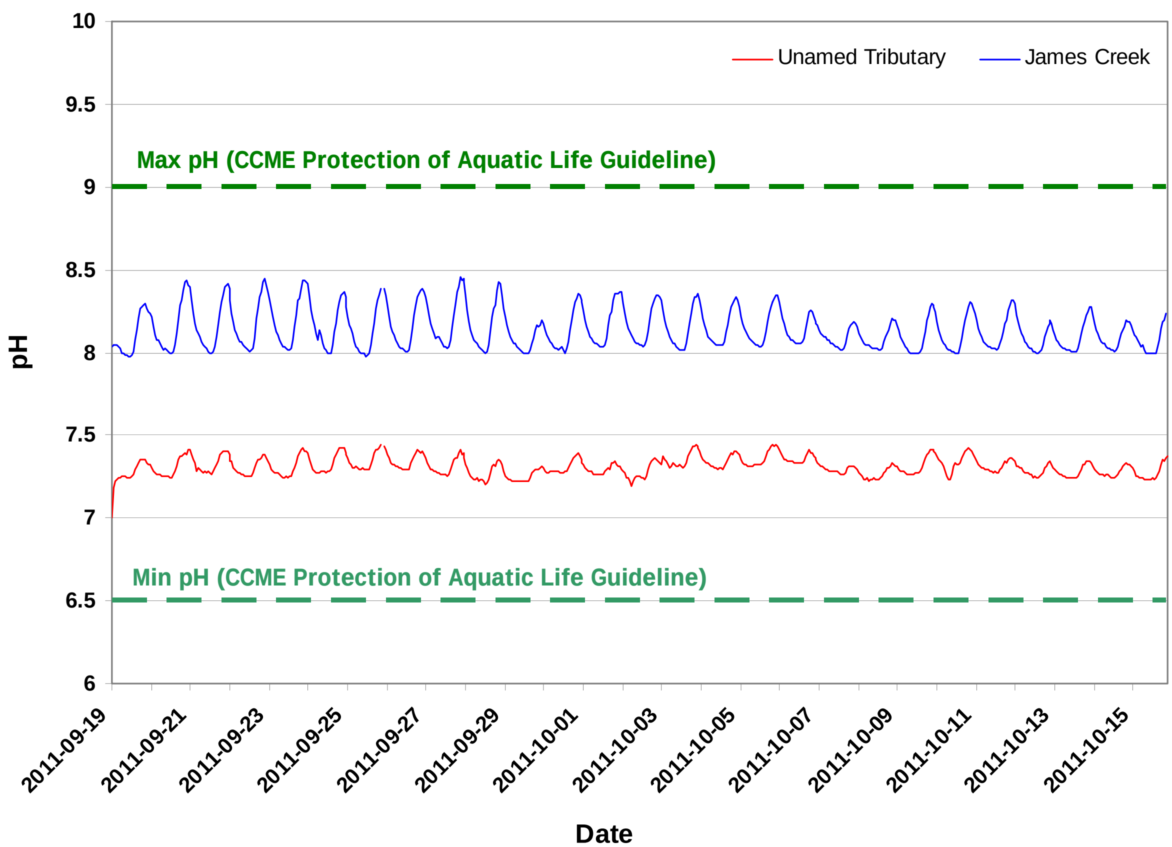

Figure 3. Hourly pH values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011.

Specific Conductivity

- Specific Conductivity ranged from 138.4 µs/cm to 150.1 µs/cm at James Creek and from 38.9 µs/cm to 52.1 µs/cm at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 4).
- For the most part, specific conductivity was consistent at both stations during the deployment period. A small decrease in specific conductivity was observed at the James Creek station on September 30, 2011. This decrease corresponded with a large rainfall event (27.5mm) on September 30, 2011 (Appendix C).
- On average, specific conductivity was 96.8 µS/cm higher at James Creek than at Unnamed Tributary. This difference could be attributed to the increased concentration of dissolved solids from the iron ore tailings deposited into Ruth Pit, which feeds into James Creek.

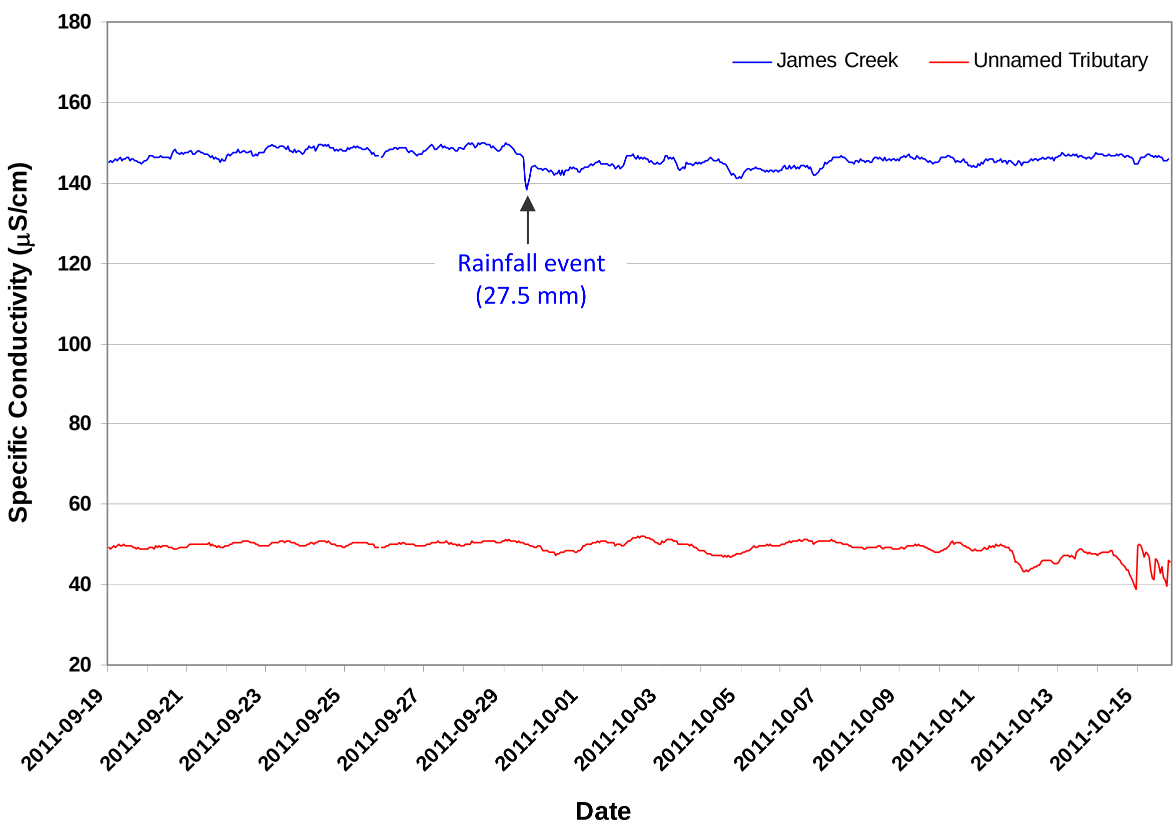

Figure 4. Hourly specific conductivity (µs/cm) values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011.

Total Dissolved Solids

- Total Dissolved Solids (TDS) values ranged from 0.0885 g/l to 0.0961 g/l at James Creek and from 0.0249 g/l to 0.0333 g/l at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 5).
- TDS is calculated directly from specific conductance and temperature, and as a result TDS values show a similar trend to specific conductance (Figure 4).
- TDS values were on average 0.06083 g/l higher at James Creek compared to Unnamed Tributary. This difference can be attributed to the past and present deposit of iron ore tailings into Ruth Pit, upstream of James Creek.

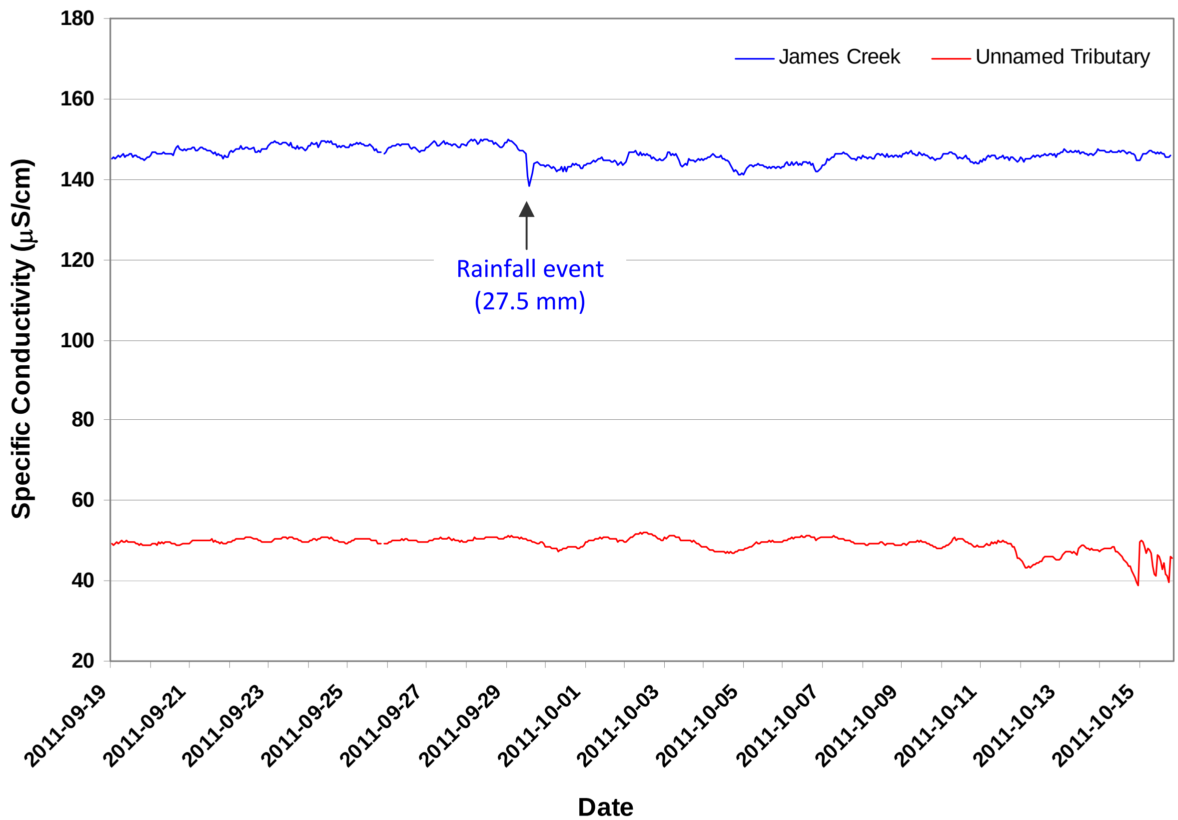

Figure 5. Hourly TDS (g/l) values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011.

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 10.91 mg/l to 13.81 mg/l at James Creek and from 11.58 mg/l to 14.02 mg/l at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 6).
- DO (mg/l) fluctuated daily, with increases in DO observed in the afternoon and decreases observed at night. These diurnal variations can be attributed to the photosynthetic activity of aquatic organisms.
- Weekly trends in DO (mg/l) corresponded well with the inverse of water temperature (Figure 2), since colder water has a greater potential to dissolve oxygen compared to warmer water.
- On average, DO values were 0.48 mg/l higher at Unnamed Tributary compared to James Creek. This difference can be attributed to colder water temperatures at Unnamed Tributary than at James Creek (Figure 2).
- DO values at both stations were above cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l) period, and above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007).

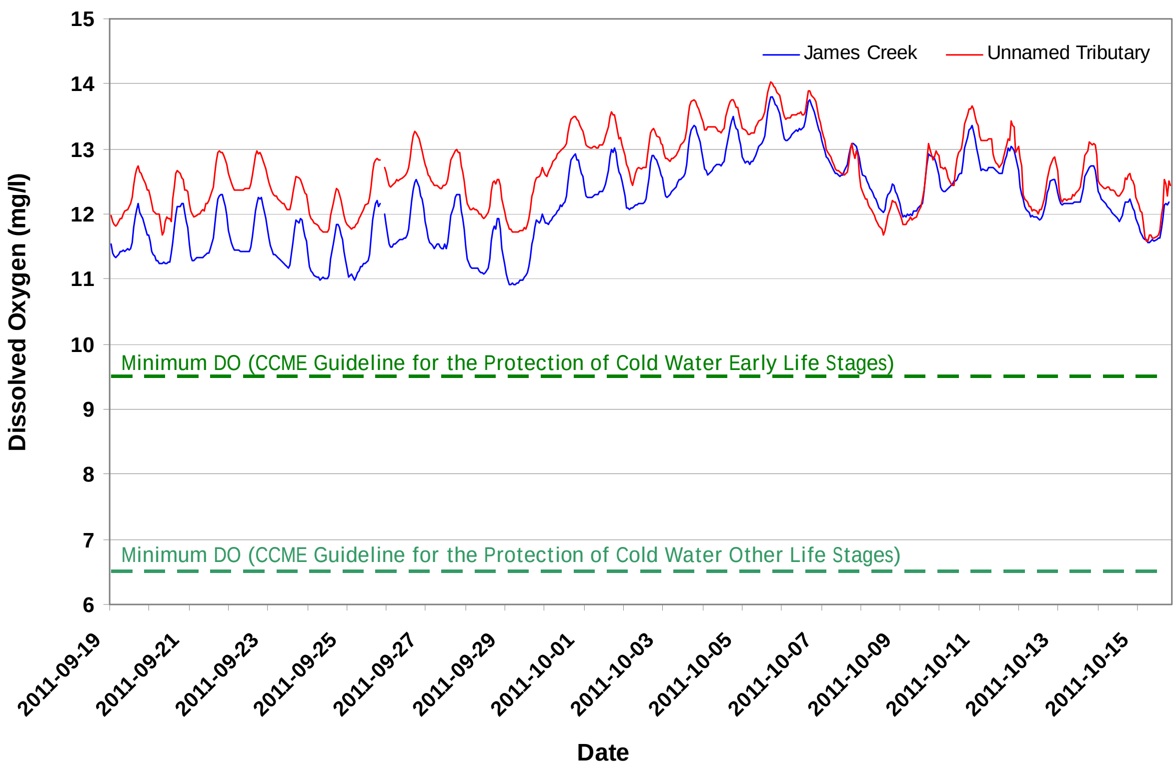

Figure 6. Hourly dissolved oxygen (mg/l) values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011.

Turbidity

- Turbidity values ranged from 0.0 NTU to 26.4 NTU at James Creek and from 0.0 NTU to 3000.0 NTU at Unnamed Tributary from September 19, 2011 to October 16, 2011 (Figure 7).
- There were several large turbidity events measured at the Unnamed Tributary. Turbidity events that occurred on September 22 and 28, 2011 were short-lived, and as such, were not of any great concern. Two longer-lasting turbidity events occurring around October 1-3, 2011, and October 6-7, 2011, were attributed to biofouling, caused by a build-up of leaves around the water quality instrument sensors (Figure 8).
- There were some smaller turbidity events observed at the James Creek station. The largest of these events occurred on September 30, 2011 (26.4 NTU), which corresponded with a major rainfall event (27.5 mm) on that same day (Appendix C).

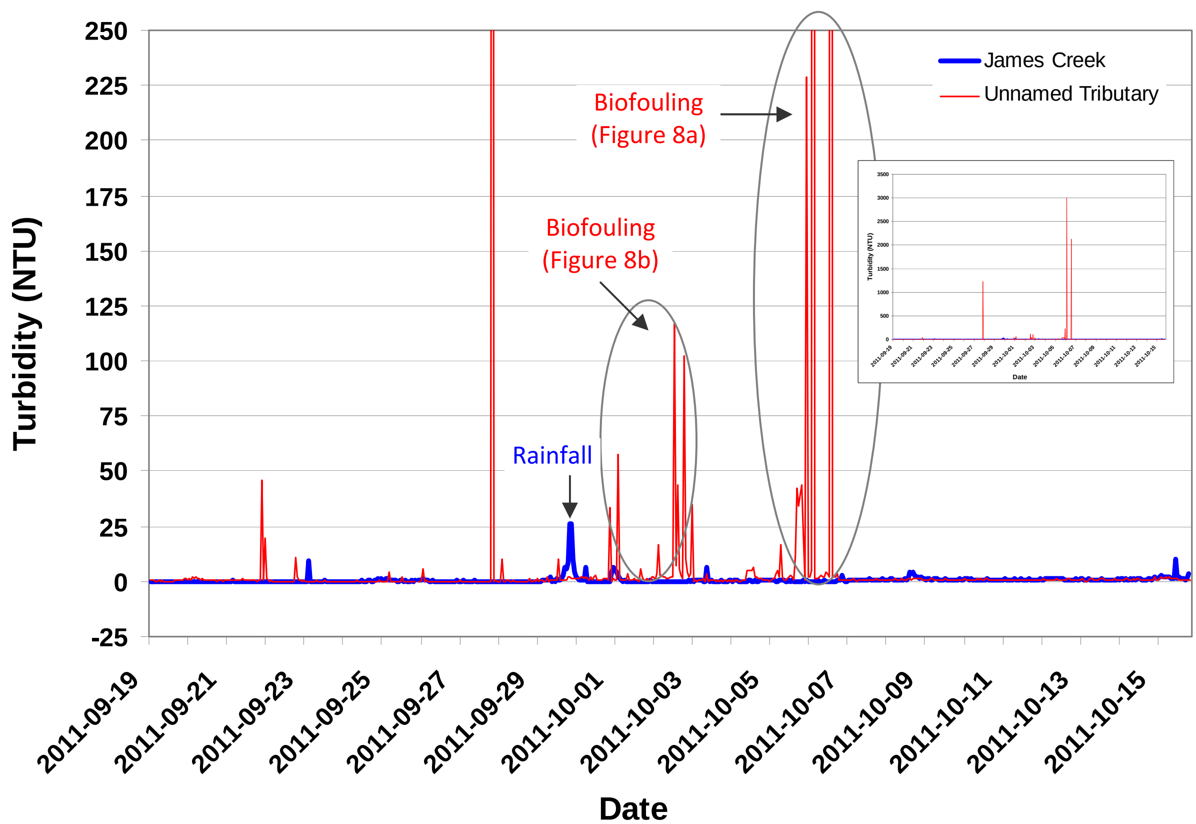

Figure 7. Hourly turbidity (NTU) values recorded at James Creek and Unnamed Tributary from September 19, 2011 to October 16, 2011.

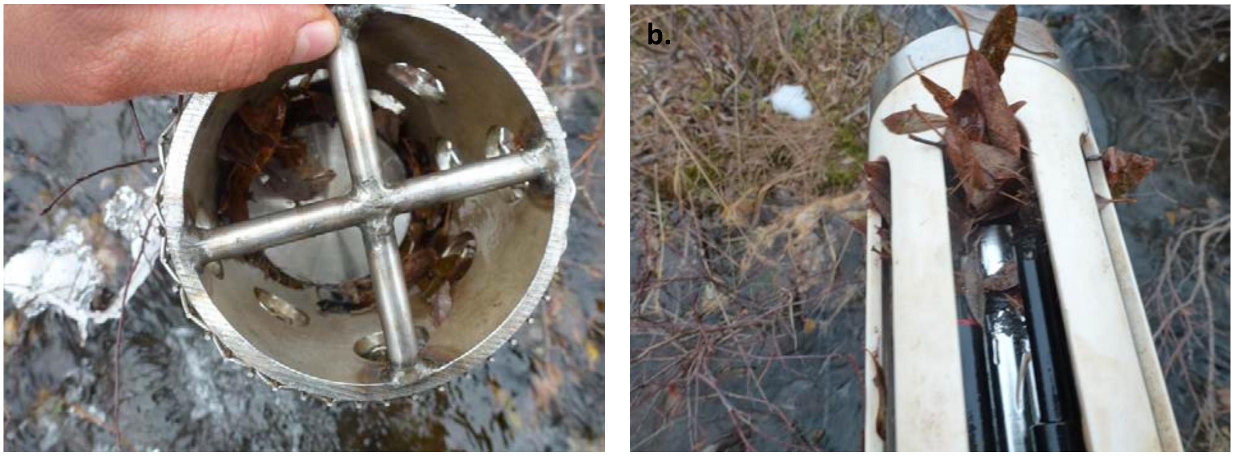

Figure 8. Biofouling due to leaves getting caught around the instrument sensors resulted in spikes in turbidity at the Unnamed Tributary station on (a) October 3, 2011 and (b) October 7, 2011.

Conclusion

- This monthly deployment report, presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from September 19, 2011 to October 16, 2011.
- Sensor performance was rated fair to excellent at both stations at the beginning and end of the deployment period.
- Variations in water quality/quantity values recorded at each station are summarized below:
  - Stage levels displayed no weekly trends; however, daily variations were attributed to temperature-related atmospheric pressure changes.
  - Fluctuations in water temperature corresponded with fluctuations in air temperature.
  - Daily variations in pH coincided with the photosynthetic cycling of CO_2 by aquatic organisms and weekly trends in pH were absent.
  - Specific conductivity and TDS values were, for the most part, consistent during the deployment period.
  - DO (mg/l) variations were related to changes in water temperature and the photosynthetic activity and aerobic respiration of aquatic organisms.
  - Turbidity events were mainly attributed to rainfall and biofouling (e.g., leaves caught around turbidity probe at the Unnamed Tributary).
- Field instruments for both stations will undergo Proficiency, Testing, and Evaluation, and are scheduled for redeployment in late spring (i.e., May or June 2012).
- An annual deployment report, which summarizes all water quality/quantity data recorded at the Unnamed Tributary and James Creek stations from June 4, 2011, to October 16, 2011, will be available in March 2012.
- The Water Resources Management Division in partnership with Labrador Iron Mines Ltd. and Environment Canada will continue monitoring the water quality and water quantity of James Creek and Unnamed Tributary in 2012.

References

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

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. (Website: http://ceqg-rcqe.ccme.ca/download/en/222/)

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)

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 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 (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) 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 25^{o}C. 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 C
Environment Canada Weather Data – Schefferville (September 19, 2011 to October 16, 2011)

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	Snow on Grnd cm	Avg Wind Spd km/hr	Avg Wind Dir deg
2011-09-19	17.3	6.4	11.9	6.1	0	M	M	0	M	18.6	233.3
2011-09-20	11.6	4.5	8.1	9.9	0	M	M	0	M	16.1	184.6
2011-09-21	10.7	2.6	6.7	11.3	0	M	M	0.5	M	17.5	292.5
2011-09-22	6.2	1.6	3.9	14.1	0	M	M	0	M	6.6	180.0
2011-09-23	12.8	2.4	7.6	10.4	0	M	M	0.5	M	8.0	192.1
2011-09-24	12.8	9	10.9	7.1	0	M	M	0.5	M	19.6	266.3
2011-09-25	12.8	4.3	8.6	9.4	0	M	M	0	M	28.5	305.4
2011-09-26	6.6	1.2	3.9	14.1	0	M	M	0	M	23.5	319.6
2011-09-27	9	0.4	4.7	13.3	0	M	M	0	M	12.0	266.3
2011-09-28	17.2	5.8	11.5	6.5	0	M	M	0	M	16.2	238.8
2011-09-29	17.7	4.7	11.2	6.8	0	M	M	9	M	11.7	267.1
2011-09-30	4.7	-1	1.9	16.1	0	M	M	27.5	M	23.0	198.8
2011-10-01	1.2	-3.4	-1.1	19.1	0	M	M	8	M	16.6	326.7
2011-10-02	5.6	-3.8	0.9	17.1	0	M	M	1	M	13.9	201.3
2011-10-03	5.2	-1.5	1.9	16.1	0	M	M	0.5	M	21.2	305.8
2011-10-04	1	-5	-2	20	0	M	M	0	M	10.1	239.6
2011-10-05	2.7	-5	-1.2	19.2	0	M	M	1	M	16.1	248.8
2011-10-06	-0.6	-6.8	-3.7	21.7	0	M	M	0	M	17.5	284.2
2011-10-07	8.5	-6.8	0.9	17.1	0	M	M	9.5	M	12.8	260.4
2011-10-08	13.6	4.3	9	9	0	M	M	6	M	13.0	187.1
2011-10-09	13.8	2.9	8.4	9.6	0	M	M	2.5	M	22.2	274.2
2011-10-10	5.1	-0.7	2.2	15.8	0	M	M	0	M	25.3	307.5
2011-10-11	3.8	-2.1	0.9	17.1	0	M	M	0	M	13.0	269.2
2011-10-12	11	-0.6	5.2	12.8	0	M	M	5.5	M	16.8	197.9
2011-10-13	10.5	2.5	6.5	11.5	0	M	M	0	M	10.8	179.6
2011-10-14	8.5	2.7	5.6	12.4	0	M	M	0.5	M	13.8	146.3
2011-10-15	9.3	7	8.2	9.8	0	M	M	7.5	M	22.4	135.0
2011-10-16	8.3	1.6	5	13	0	M	M	5	M	16.8	163.8

- = No data available
M = Missing
E = Estimated
A = Accumulated
C = Precipitation occurred, amount uncertain
L = Precipitation may or may not have occurred
F = Accumulated and estimated
N = Temperature missing but known to be > 0
Y = Temperature missing but known to be < 0
S = More than one occurrence
T = Trace
* = The value displayed is based on incomplete data
† = Data for this day has undergone only preliminary quality checking

APPENDIX C (continued...)

Environment Canada Weather Data – Schefferville (September 19, 2011 to October 16, 2011)

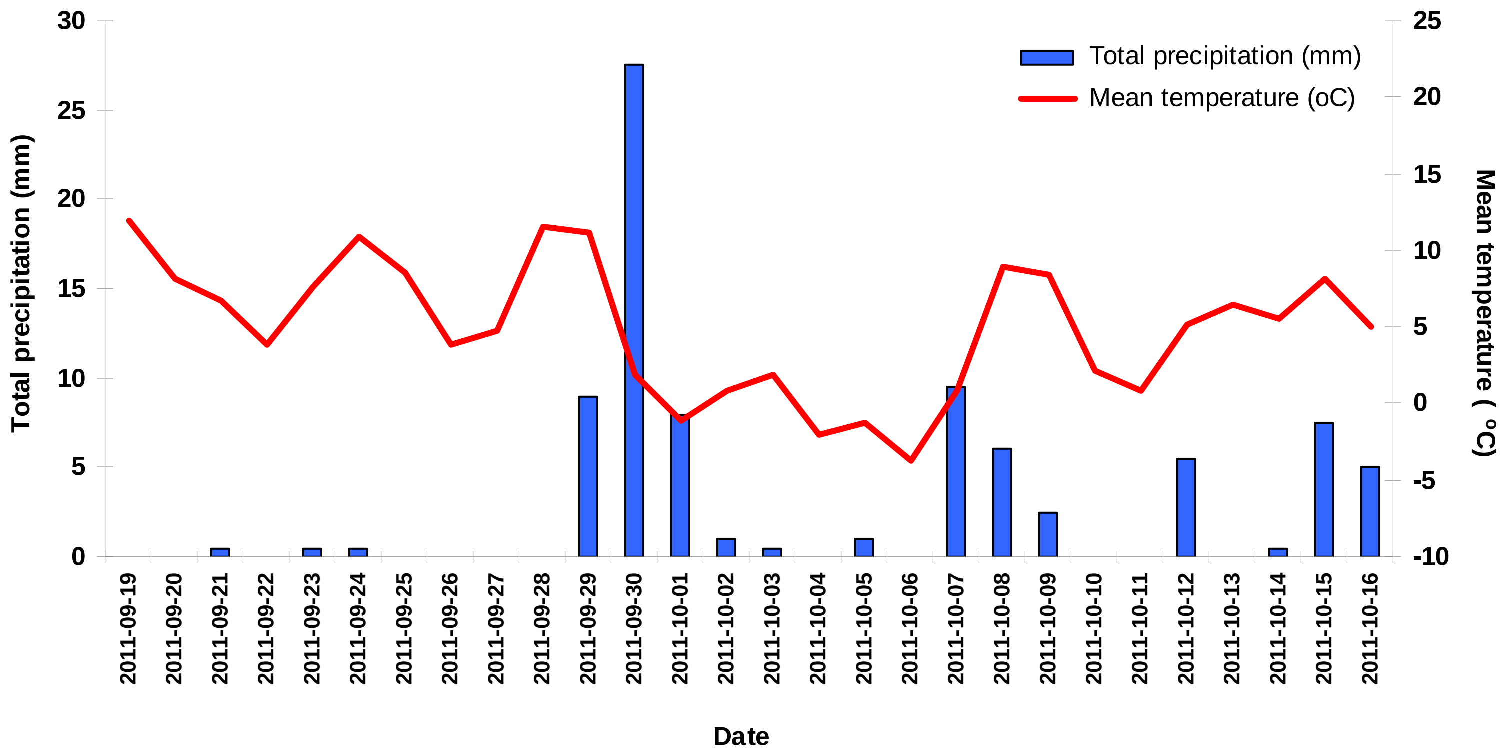

Figure 1. Daily precipitation and mean temperature recorded at the Schefferville Weather Station by Environment Canada from September 19, 2011 to October 16, 2011.

APPENDIX C (continued...)

Environment Canada Weather Data - Schefferville (September 19, 2011 to October 16, 2011)

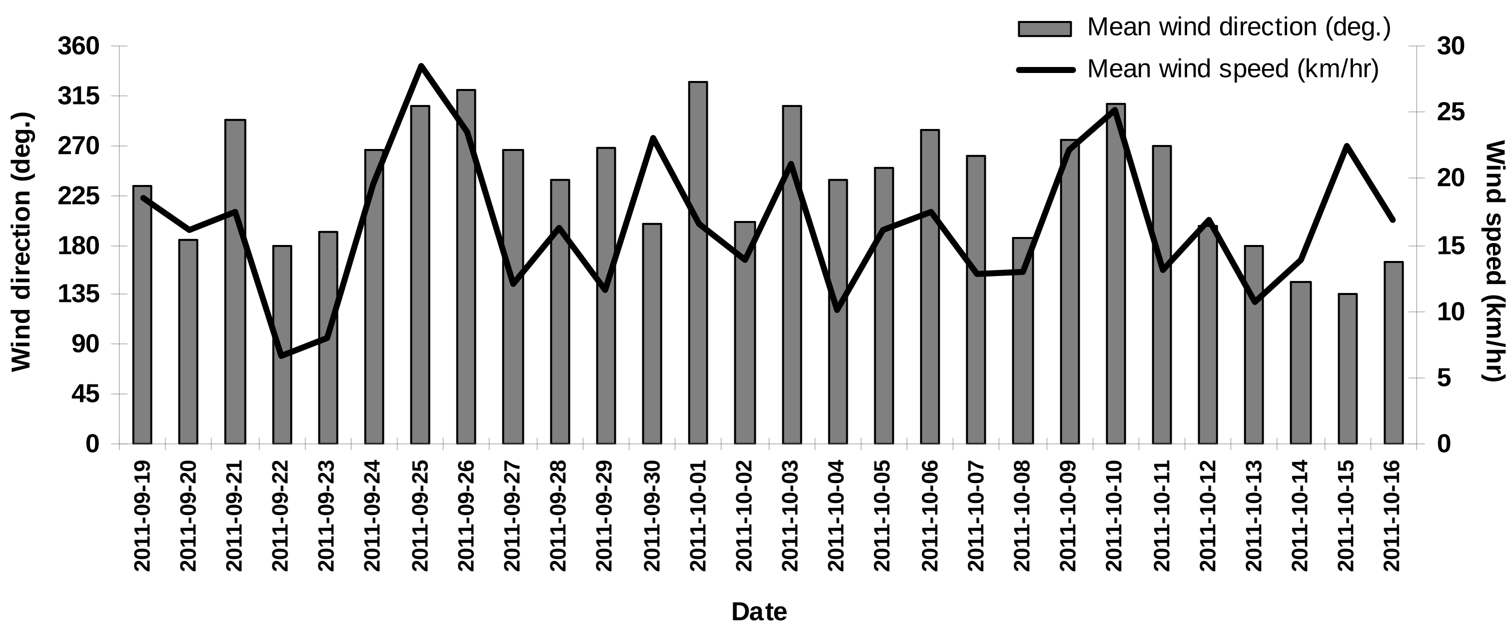

Figure 2. Mean daily wind direction and wind speed recorded at the Schefferville Weather Station by Environment Canada from September 19, 2011 to October 16, 2011.