Real Time Water Quality Report

Labrador Iron Mines Schefferville Network

Deployment Period 2011-08-13 to 2011-09-19

Newfoundland Labrador

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 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 August 13, 2011 to September 19, 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, 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	2011-08-13	2011-09-19	2011-08-13	2011-09-19
Temperature	Excellent	Excellent	Excellent	Excellent
pH	Excellent	Good	Excellent	Excellent
Conductivity	Excellent	Excellent	Excellent	Excellent
Dissolved Oxygen	Excellent	Excellent	Excellent	Good
Turbidity	Excellent	Poor	Fair	Excellent

- With the exception of turbidity, the performances of all sensors were rated fair to excellent during the deployment period (Table 1).
- The performance of the turbidity sensor at James Creek was rated poor at the end of deployment. This was attributed to biofouling (Figure 1), which was suspected of affecting turbidity readings between the dates of September 13, 2011 and September 19, 2011.

Figure 1. Algae were found on the instrument's sensors at the James Creek station on September 19, 2011.

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 0.77 m to 0.82 m at James Creek and from 1.12 m to 1.16 m at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 2).
- With the exception of a slight change in stage on August 18, 2011 (i.e., decreased at the Unnamed Tributary and increased at James Creek), stage levels were generally consistent throughout the deployment period.
- Daily fluctuations were observed at both stations with increases occurring in the afternoon and decreases occurring at night. Diurnal fluctuations were attributed to temperature-related atmospheric pressure changes.
- 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.

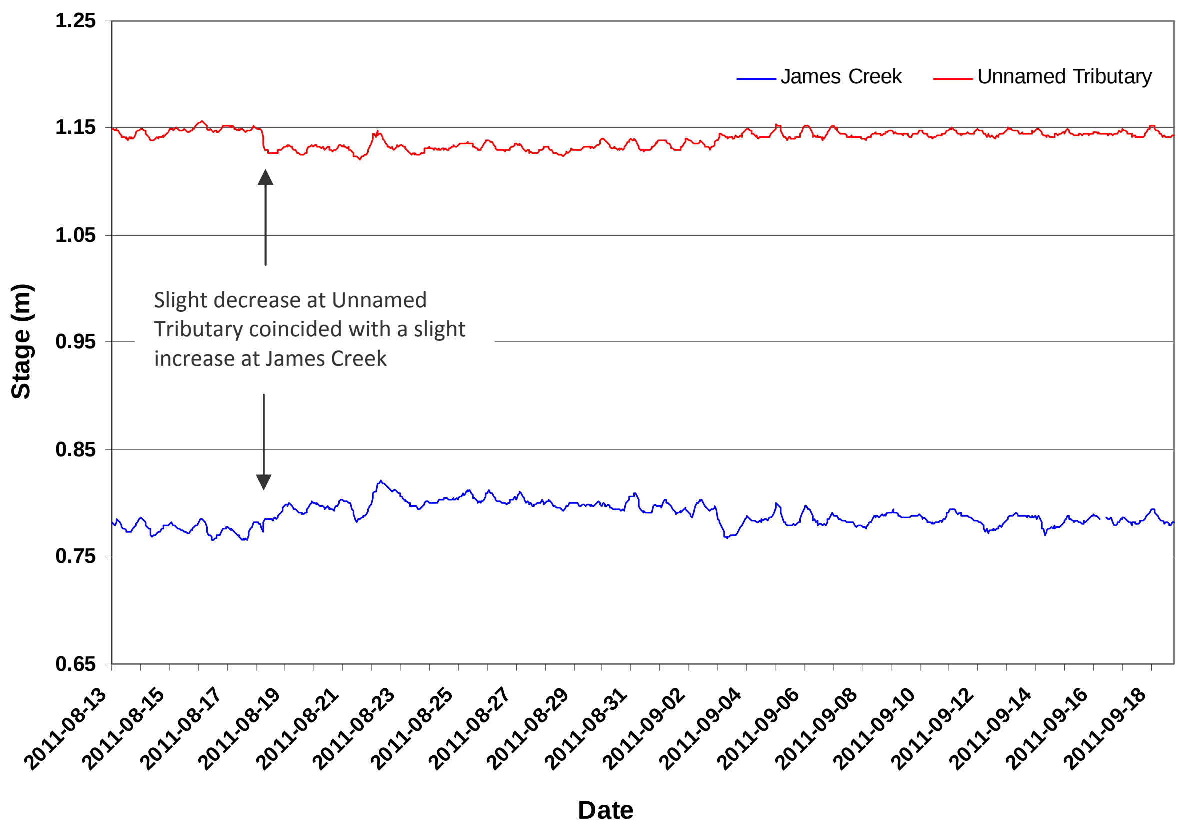

Figure 2. Hourly stage (m) values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011.

Temperature

- Water temperature ranged from 3.6˚C to 14.8˚C at James Creek and from 1.7˚C to 9.8˚C at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 3).
- Water temperatures at both stations display large diurnal variations (Figure 3). This is typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures (Figure 3 inset, Appendix C).
- Weekly trends in water temperature also corresponded well with ambient air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 3 inset, Appendix C).
- Water temperatures at the Unnamed Tributary were on average 4.0°C colder than water temperatures at James Creek. Indeed, the Unnamed Tributary station is close to its groundwater source, and groundwater generally maintains a colder temperature than surface water in the summertime.

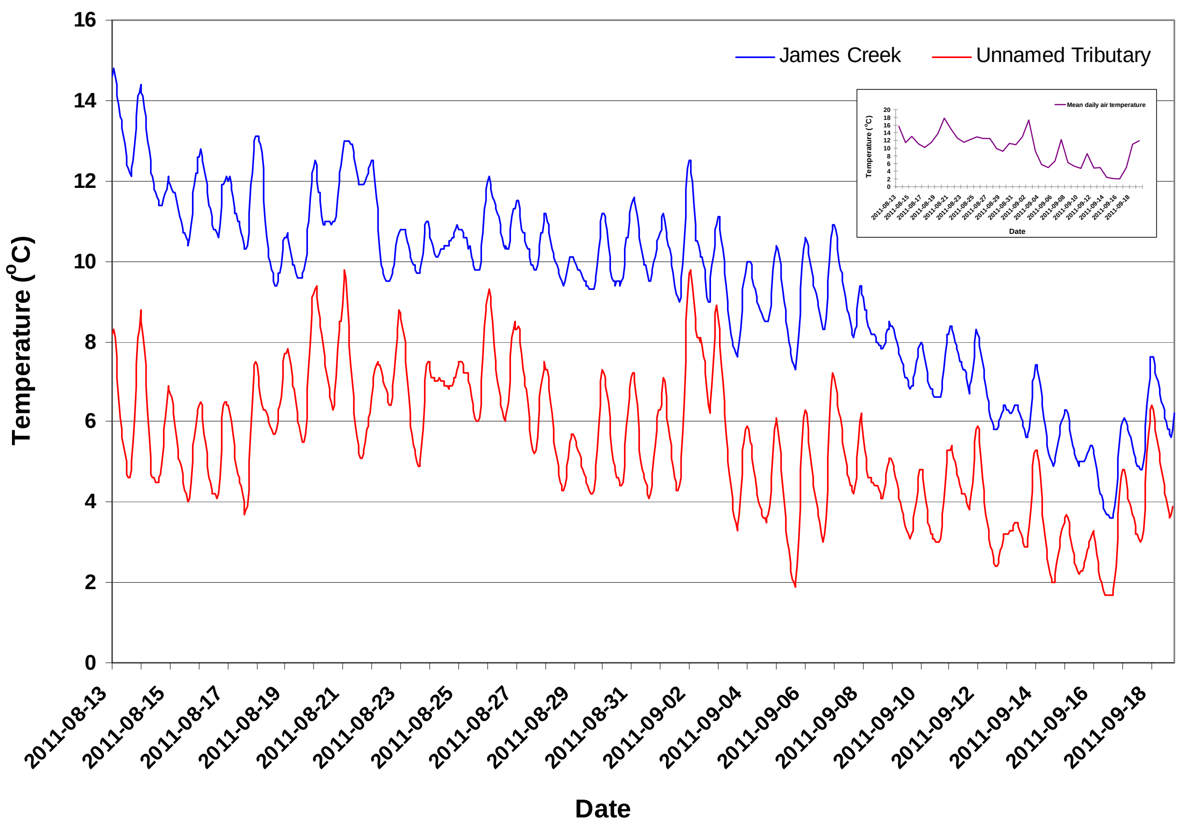

Figure 3. Hourly water temperature (°C) values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011. The inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 6.61 units to 8.53 units at James Creek and from 6.53 units to 7.28 units at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 4).
- pH 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.
- There was a slight decrease in pH observed at both stations after September 3-4, 2012. The onset of this decrease coincided with high winds on September 3, 2011 (average wind speeds were 30.8 km/hr with maximum wind gusts of 80 km/hr). Biofouling associated with high winds and blowing debris may have caused this drift in pH at both stations. After cleaning and recalibration of the instruments on September 19, 2011, pH readings were back within the range that is typical and expected at these sites.
- A sudden drop in pH at the James Creek station on September 16, 2011, coincided with high turbidity values (~1000 NTU) and missing data values for specific conductivity, TDS, and stage. It was thought that biofouling by algae caught on the instrument had caused this change in pH.
- On average, pH was 0.88 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).

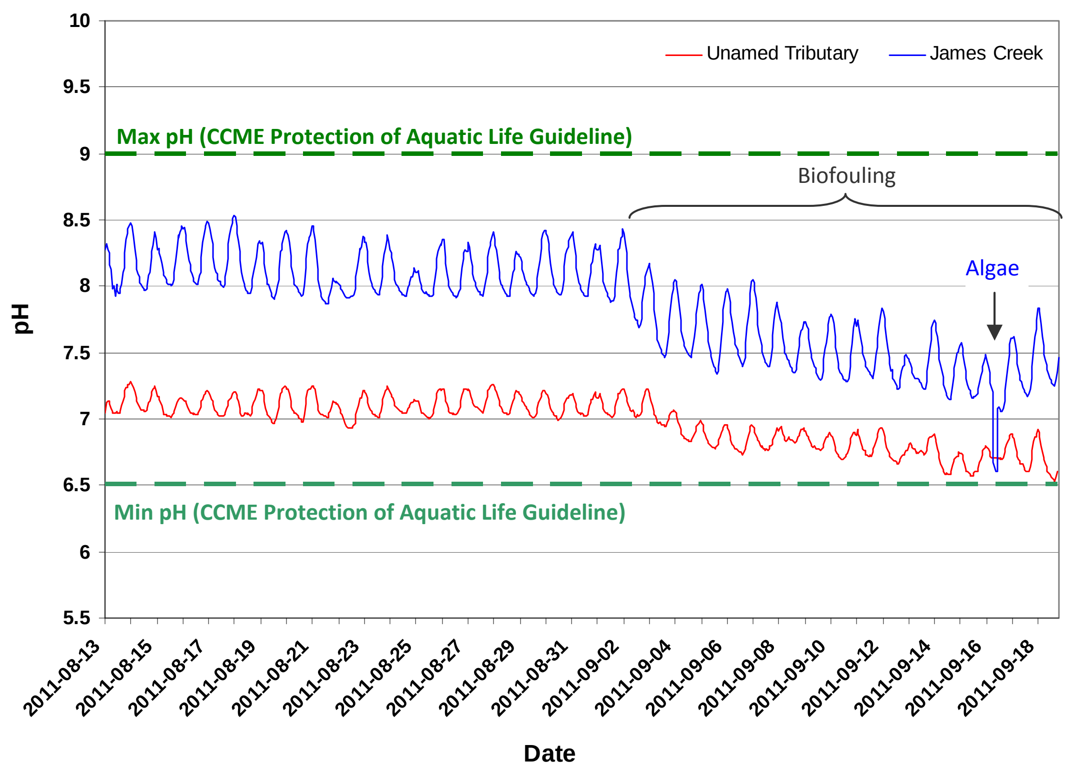

Figure 4. Hourly pH values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011.

Specific Conductivity

- Specific Conductivity ranged from 136.4 µs/cm to 153.1 µs/cm at James Creek and from 33.5 µs/cm to 57.1 µs/cm at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 5).
- Specific conductivity decreased slightly and abruptly at James Creek on August 18, 2011. This decrease could have been attributed to a dilution of dissolved solids resulting from an increase in stage.
- Specific conductivity decreased at the Unnamed Tributary between the dates of September 4, 2011 and September 6, 2011. This decrease was attributed to biofouling; leaves were found trapped in and around the instrument probe and when removed, specific conductance returned to normal levels.
- On average, specific conductivity was 94.9 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.

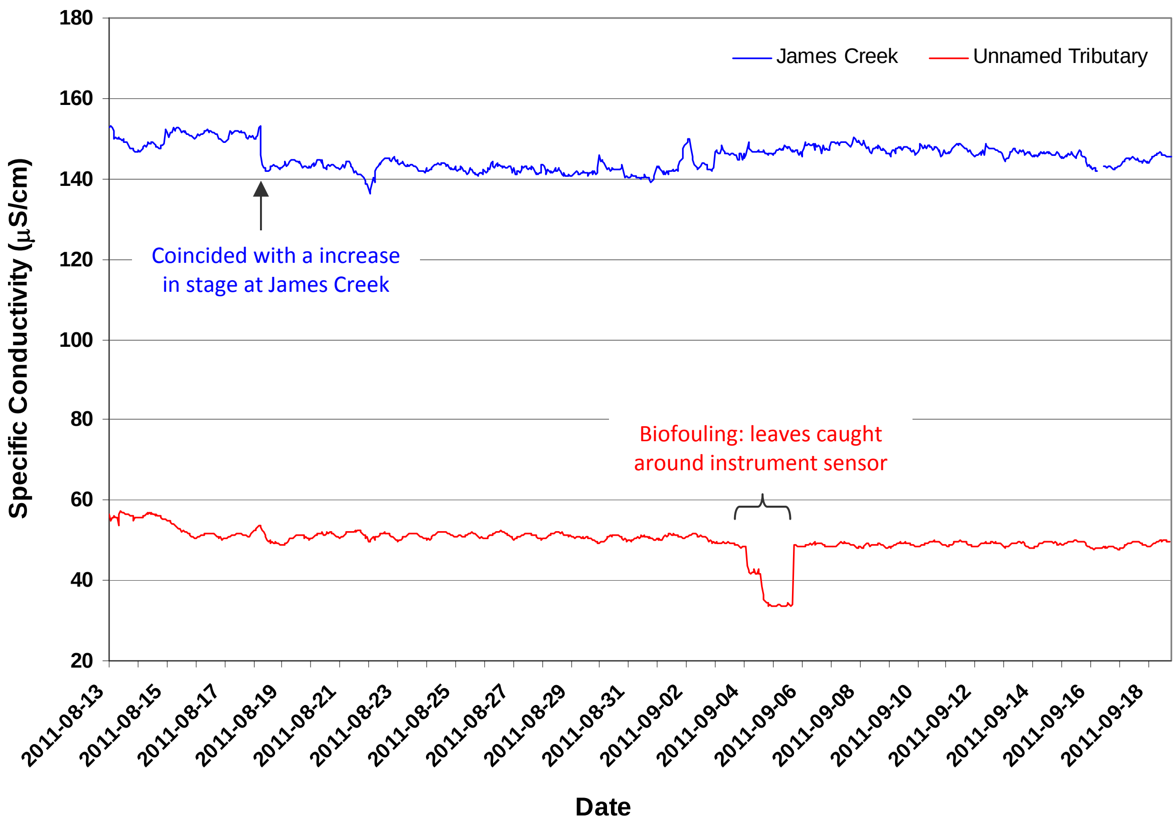

Figure 5. Hourly specific conductivity (µs/cm) values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011.

Total Dissolved Solids

- Total Dissolved Solids (TDS) values ranged from 0.0873 g/l to 0.0980 g/l at James Creek and from 0.0214 g/l to 0.0365 g/l at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 6).
- TDS is calculated directly from specific conductance and temperature, and as a result TDS values (Figure 6) show a similar trend to specific conductance (Figure 5).
- TDS values were on average 0.06113 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.

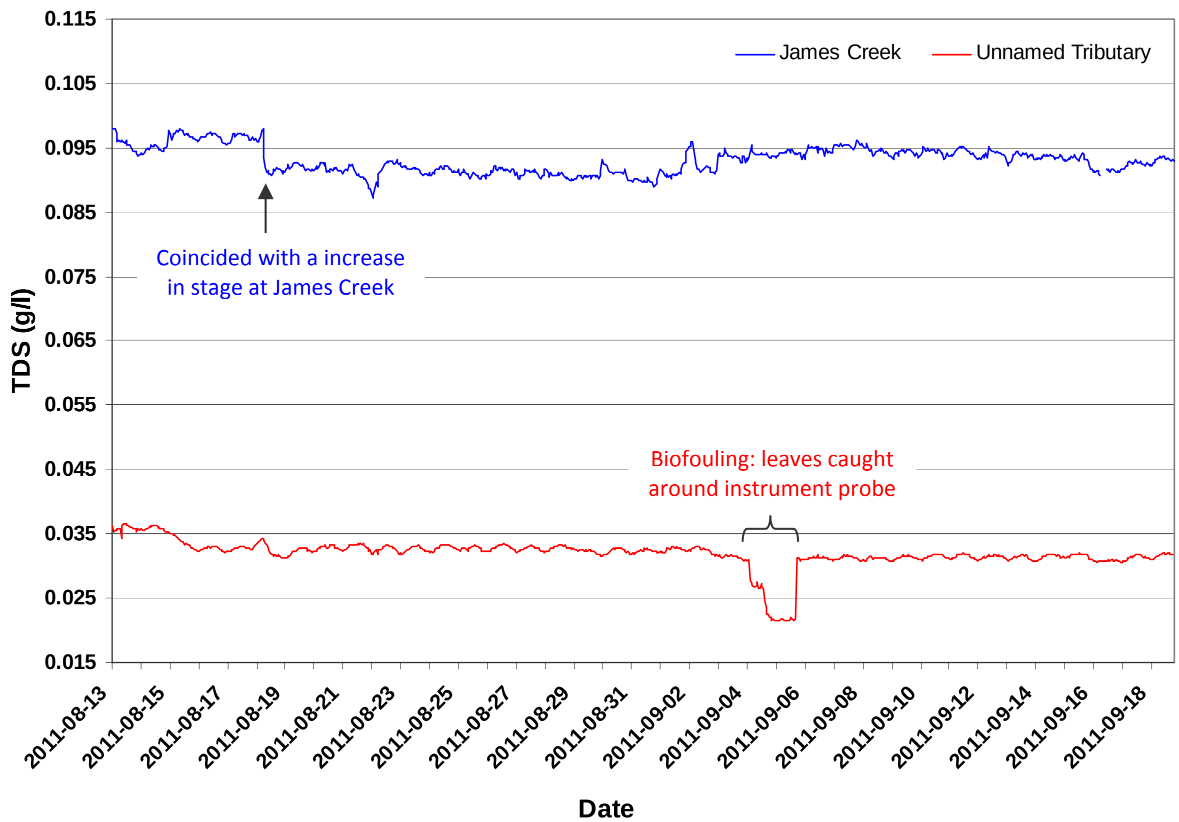

Figure 6. Hourly TDS (g/l) values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011.

Dissolved Oxygen

- Dissolved Oxygen [DO] values ranged from 9.47 mg/l to 12.82 mg/l at James Creek and from 9.69 mg/l to 12.78 mg/l at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 7).
- 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 3), since colder water has a greater potential to dissolve oxygen compared to warmer water.
- On average, DO values were 0.61 mg/l higher at Unnamed Tributary compared to James Creek. This difference can be largely attributed to colder water temperatures at Unnamed Tributary than at James Creek (Figure 3).
- DO values at both stations were, for the majority of time, 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).

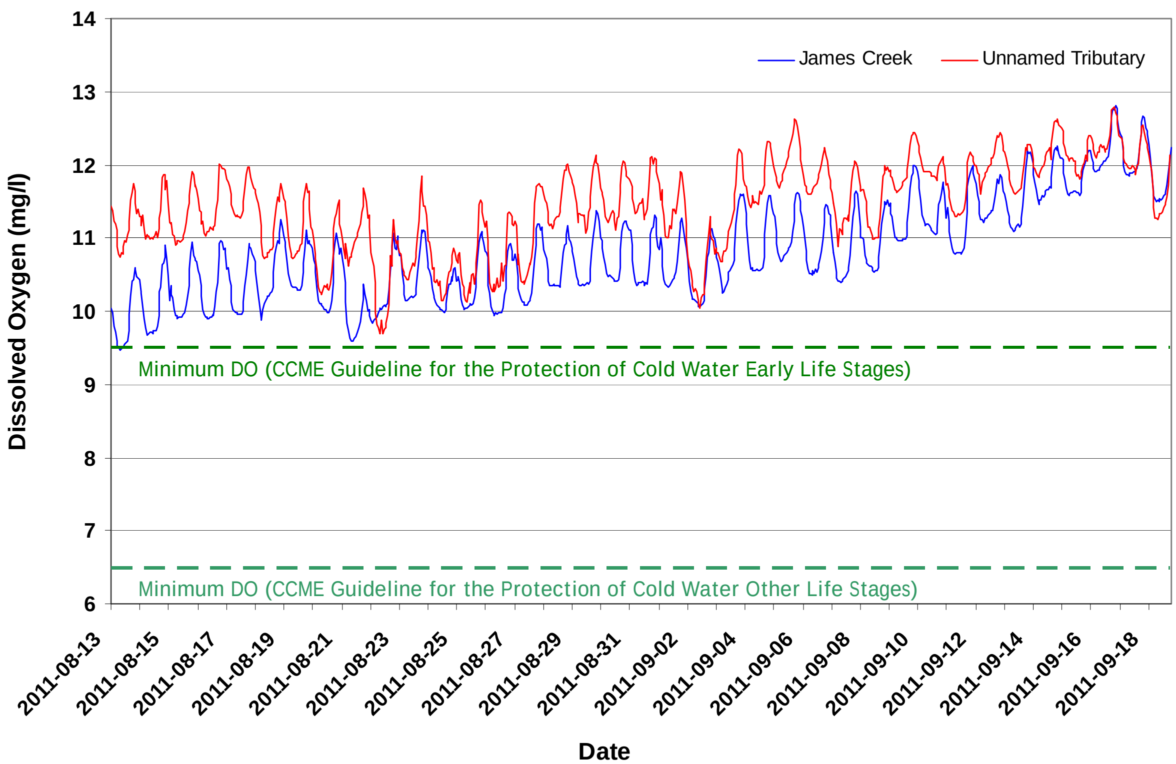

Figure 7. Hourly dissolved oxygen (mg/l) values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011.

Turbidity

- Turbidity values ranged from 0.0 NTU to 2588.0 NTU at James Creek and from 0.0 NTU to 182.8 NTU at Unnamed Tributary from August 13, 2011 to September 19, 2011 (Figure 8).
- Two large turbidity events occurred at the Unnamed Tributary on August 22, 2011 (182.8 NTU) and on September 4, 2011 (125.2 NTU). Both events were short-lived, and as such, were not of great concern. The cause of the August 22, 2011, turbidity event was unknown. The turbidity event on September 4, 2011, was caused by biofouling (i.e., leaves caught around instrument probe).
- There were numerous turbidity events at James Creek station with peaks typically occurring at two separate time periods (i.e., August 30-31, 2011 and September 13-19, 2011). Biofouling resulting from algae caught around the turbidity probe were attributed to causing these large increases in turbidity.

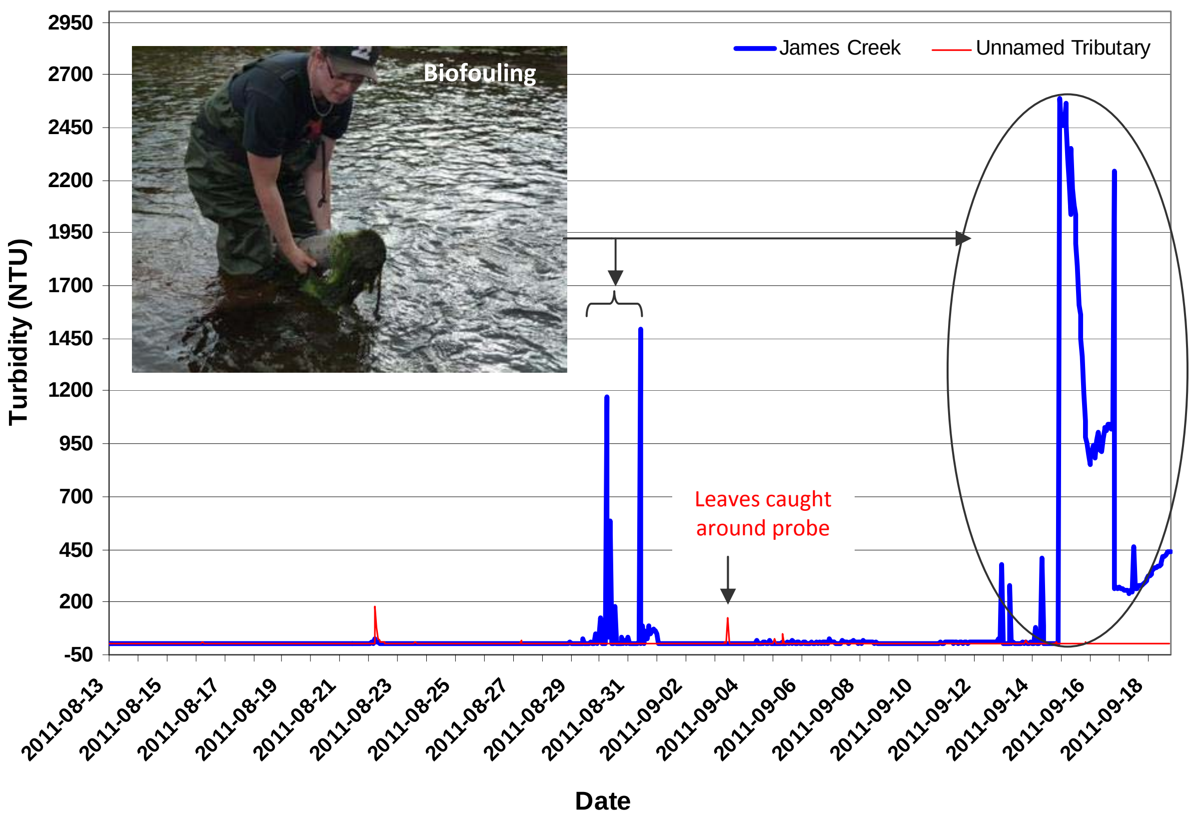

Figure 8. Hourly turbidity (NTU) values recorded at James Creek and Unnamed Tributary from August 13, 2011 to September 19, 2011. Corey McLister with LIM is displaying algae caught on the water quality instrument at the James Creek station on September 1, 2011. Similar biofouling was observed at James Creek on September 19, 2011 (Figure 1).

Conclusion

- This monthly deployment report, presents water quality and water quantity data recorded at the James Creek and Unnamed Tributary stations from August 13, 2011 to September 19, 2011.
- With the exception of turbidity, the performances of all sensors were rated fair to excellent during the deployment period.
- The performance of the turbidity sensor at James Creek was rated poor at the end of deployment, due to biofouling.
- Variations in water quality/quantity values recorded at each station are summarized below:
  - With the exception of a slight change in stage on August 18, 2011 (i.e., decrease at the Unnamed Tributary and an increase at James Creek), stage levels were generally consistent throughout the deployment period and daily variations were attributed to temperature-related atmospheric pressure changes.
  - Fluctuations in water temperature corresponded with fluctuations in air temperature. Differences in water temperature between stations were attributed to the source of water: groundwater versus surface water.
  - There was a slight decrease in pH observed at both stations after September 3-4, 2012. Biofouling associated with high winds and blowing debris may have caused this drift in pH at both stations. After cleaning and recalibration of the instruments on September 19, 2011, pH readings were back within the range that is typical and expected at these sites. Daily variations in pH coincided with the photosynthetic cycling of CO_2 by aquatic organisms.
  - Specific conductivity and TDS values were mostly consistent during the deployment period. A slight and abrupt decrease at James Creek on August 18, 2011 could have been attributed to a dilution of dissolved solids resulting from an increase in stage. Specific conductivity and TDS values also decreased at the Unnamed Tributary between the dates of September 4, 2011 and September 6, 2011. This decrease was attributed to biofouling.
  - 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 biofouling (e.g., algae and leaves caught around turbidity probe).
- 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.
- Newly calibrated and cleaned field instruments were redeployed at both stations on September 19, 2011.

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 (August 13, 2011 to September 19, 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
2011-08-13	20.3	11.1	15.7	2.3	0	M	M	1	M	30	37
2011-08-14	16.1	6.6	11.4	6.6	0	M	M	0	M	30	35
2011-08-15	17	9	13	5	0	M	M	6.5	M	21	39
2011-08-16	15.1	7.1	11.1	6.9	0	M	M	1	M	32	35
2011-08-17	13	7.3	10.2	7.8	0	M	M	0	M	30	33
2011-08-18	17.3	5.7	11.5	6.5	0	M	M	0	M	0	0
2011-08-19	17.6	10	13.8	4.2	0	M	M	3	M	0	0
2011-08-20	22.3	13.2	17.8	0.2	0	M	M	3.5	M	0	0
2011-08-21	20.5	9.5	15	3	0	M	M	3	M	0	0
2011-08-22	16.6	8.5	12.6	5.4	0	M	M	27.5	M	14	56
2011-08-23	14.5	8.5	11.5	6.5	0	M	M	2	M	30	46
2011-08-24	16.9	7.5	12.2	5.8	0	M	M	3.5	M	18	52
2011-08-25	16.9	8.8	12.9	5.1	0	M	M	14	M	33	44
2011-08-26	17.3	7.7	12.5	5.5	0	M	M	0.5	M	33	41
2011-08-27	16.7	8.3	12.5	5.5	0	M	M	2.5	M	20	50
2011-08-28	12.6	7.1	9.9	8.1	0	M	M	0	M	29	35
2011-08-29	11.8	6.5	9.2	8.8	0	M	M	4	M	6	33
2011-08-30	15.2	7.1	11.2	6.8	0	M	M	2.5	M	0	0
2011-08-31	15.4	6.4	10.9	7.1	0	M	M	2.5	M	33	35
2011-09-01	18.4	7.4	12.9	5.1	0	M	M	0	M	27	37
2011-09-02	22.6	11.9	17.3	0.7	0	M	M	4	M	3	74
2011-09-03	15	3.5	9.3	8.7	0	M	M	1	M	27	80
2011-09-04	9.2	2.3	5.8	12.2	0	M	M	0	M	31	35
2011-09-05	10.7	-0.7	5	13	0	M	M	0	M	0	0
2011-09-06	15	-1.7	6.7	11.3	0	M	M	0	M	0	0
2011-09-07	17.8	6.6	12.2	5.8	0	M	M	0.5	M	25	56
2011-09-08	9.8	2.8	6.3	11.7	0	M	M	7.5	M	24	56
2011-09-09	8.3	2.4	5.4	12.6	0	M	M	6	M	2	35
2011-09-10	7.3	2	4.7	13.3	0	M	M	0.5	M	33	37
2011-09-11	13.8	3.4	8.6	9.4	0	M	M	6	M	25	56
2011-09-12	8.2	1.4	4.8	13.2	0	M	M	1	M	31	50
2011-09-13	9.4	0.3	4.9	13.1	0	M	M	9	M	16	50
2011-09-14	7.6	-2.8	2.4	15.6	0	M	M	0	M	30	56
2011-09-15	7.2	-3.1	2.1	15.9	0	M	M	1.5	M	0	0
2011-09-16	3.9	0.1	2	16	0	M	M	12	M	33	61
2011-09-17	9.3	0.5	4.9	13.1	0	M	M	4	M	32	50
2011-09-18	15	7	11	7	0	M	M	0	M	26	44
2011-09-19	17.3	6.4	11.9	6.1	0	M	M	0	M	25	46

- = 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 (August 13, 2011 to September 19, 2011)

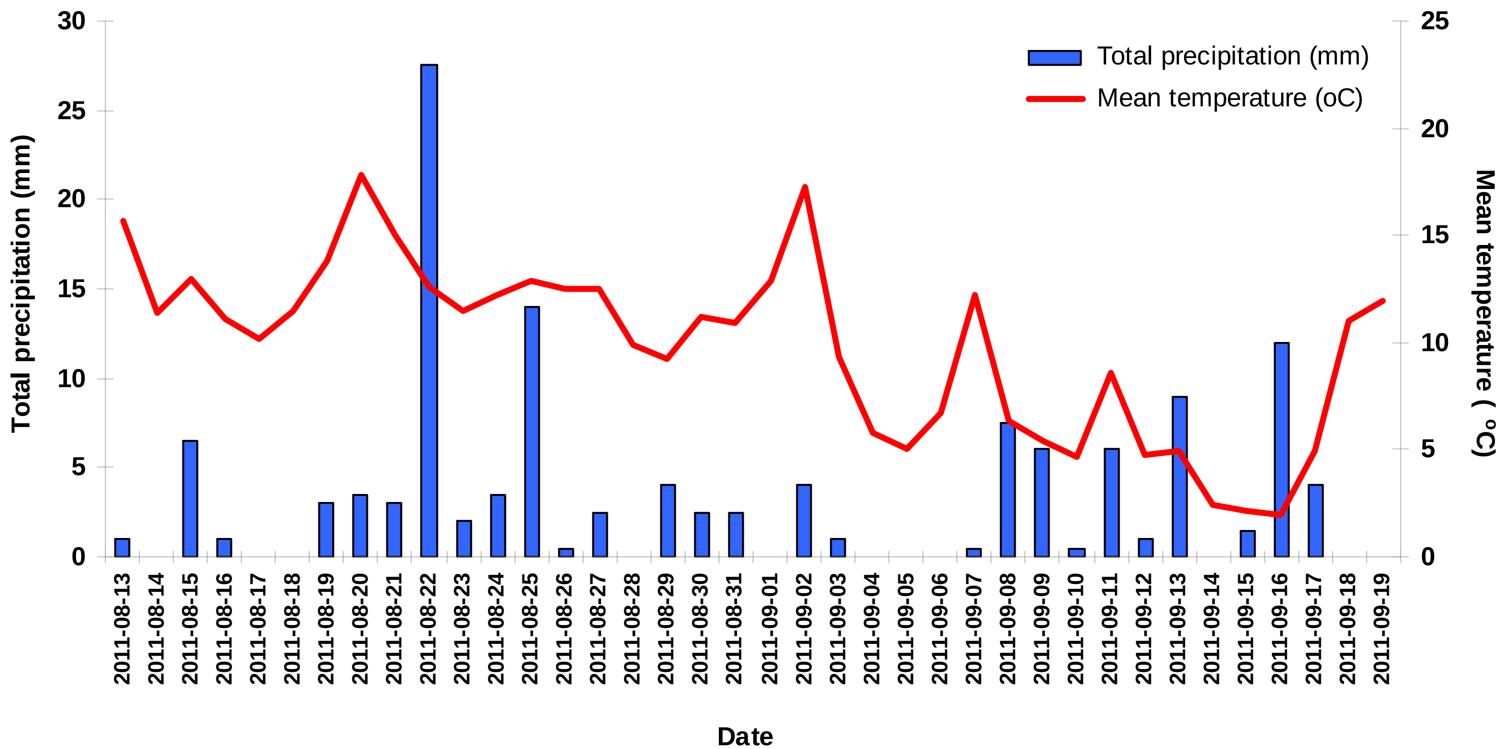

Figure 1. Daily precipitation and mean temperature recorded at the Schefferville Weather Station by Environment Canada from August 13, 2011 to September 19, 2011.

APPENDIX C (continued...)

Environment Canada Weather Data - Schefferville (August 13, 2011 to September 19, 2011)

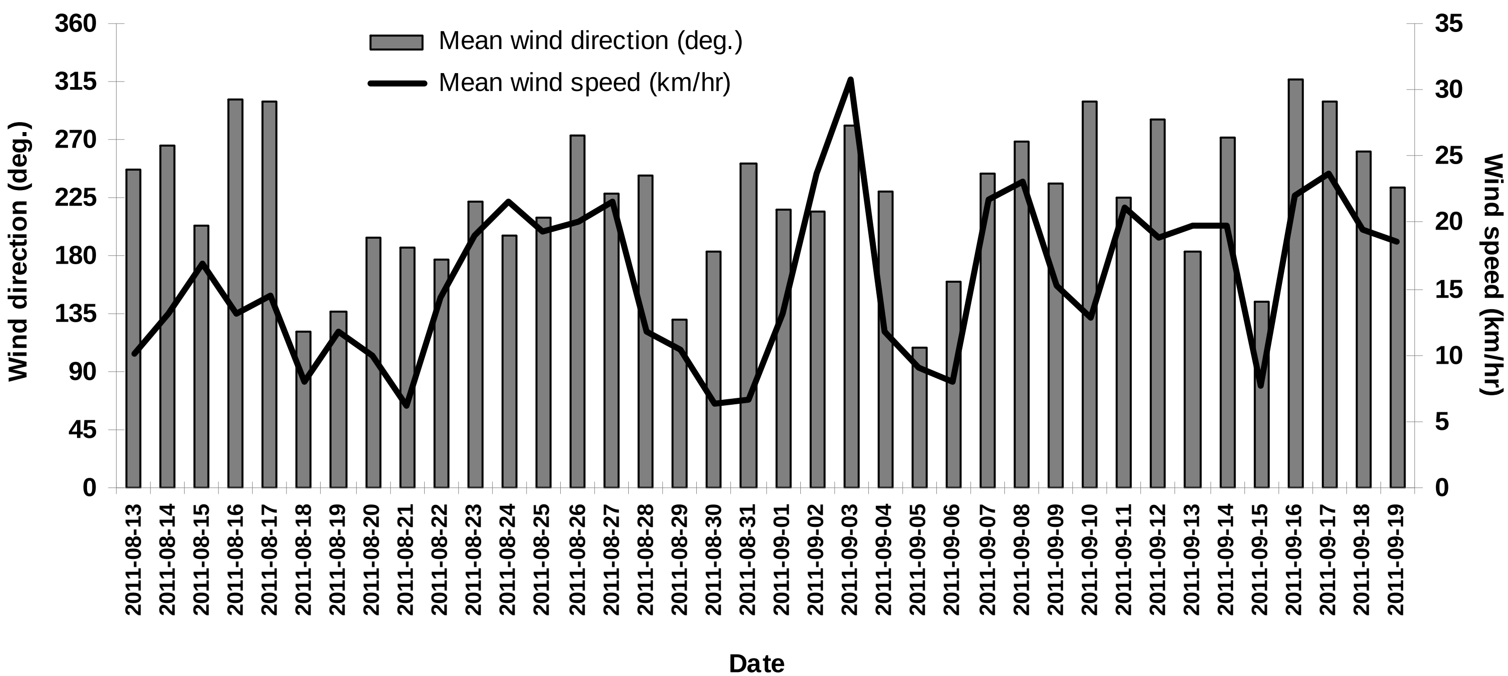

Figure 2. Mean daily wind direction and wind speed recorded at the Schefferville Weather Station by Environment Canada from August 13, 2011 to September 19, 2011.