Real Time Water Quality Report

Labrador Iron Mines Schefferville Network

Annual Deployment Report 2014

2014-06-10 to 2014-10-07

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
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Acknowledgements

The Real-Time Water Quality/Quantity Monitoring Program at the James deposit near Schefferville is fully funded by Labrador Iron Mines (LIM) and its success is dependent on a joint partnership between LIM, Environment Canada (EC), and the Newfoundland & Labrador Department of Environment & Conservation (ENVC). Managers and program leads from each organization, namely Renee Paterson (ENVC), Larry Ledrew (LIM), and Howie Wills (EC), are committed to the operation of this network and ensuring that it continually provides meaningful and accurate water quality/quantity data.

In addition to funding this program, LIM also provided support to ENVC and EC staff during site visits, including transportation, food, workspace, tools, and field assistance. LIM also provided storage facilities, information on LIM mining operations, and station checks when water quality events arise. LIM employees involved in carrying out these duties include Karen Phong and Christian Gabriel.

EC plays an essential role in the data logging/communication aspect of the network. In particular, EC staff of the Water Survey of Canada, including Brent Ruth, Perry Pretty, Roger Ellsworth, Taylor Krupa, Dwayne Ackerman and Mike Ludwicki, visited network stations regularly to ensure that the data logging and data transmitting equipment was working properly. EC also plays the lead role in dealing with stage and flow issues.

ENVC is responsible for recording and managing water quality data. Ian Bell, under the supervision of Renee Paterson, is ENVC’s main contact for Real-Time Water Quality Monitoring operations at the James deposit, 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. Steve Duffy with the Water Resources Management Division provided assistance with field work for two deployments during the 2014 field season. Instrument performance evaluation and repairs, during the winter of 2014 were conducted in-house by Ryan Pugh.

Introduction

- The Newfoundland & Labrador Department of Environment & Conservation (ENVC), in partnership with Labrador Iron Mines (LIM) and Environment Canada (EC), established two real-time water quality/quantity (RTWQ) stations in September 2010 at the James Iron Ore deposit in western Labrador, near Schefferville, QC. An additional station was established in 2013 at Houston Creek, near the Houston deposit (Figure 1).

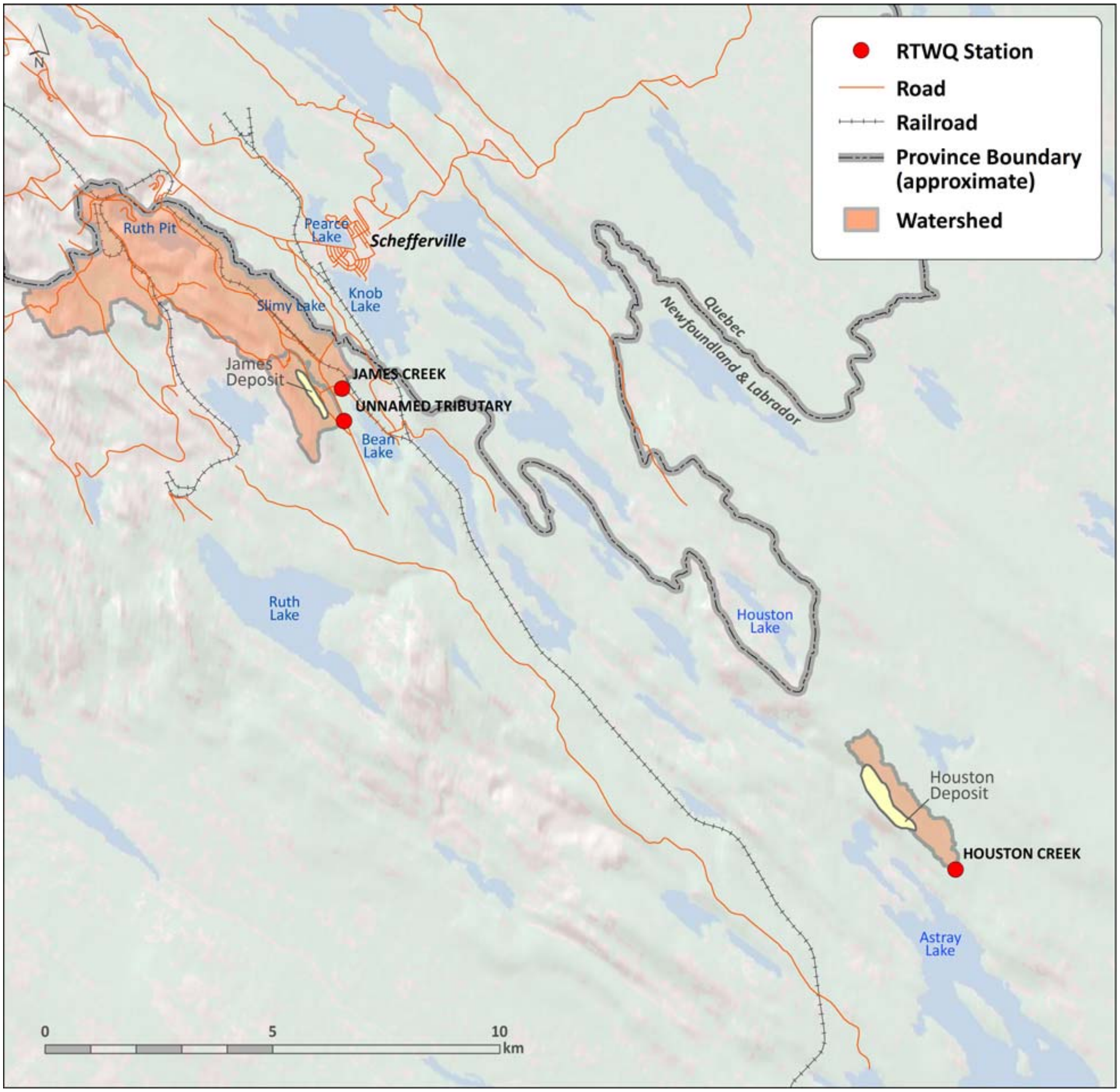

Figure 1. Map of Schefferville Project Area in Western Labrador showing three RTWQ Monitoring Stations at James Creek , Unnamed Tributary and Houston Creek.

- The official name of each station is *James Creek Above Bridge*, *Unnamed Tributary Below Settling Pond*, and *Houston Creek above Road Culvert,* hereafter referred to as the *James Creek* station, the *Unnamed Tributary* station, and the *Houston Creek* station, respectively (Figure 2).

a. Unnamed Tributary b. James Creek c. Houston Creek

Figure 2. RTWQ stations are located alongside (a) the Unnamed Tributary, (b) James Creek and (c) Houston Creek.

- Unnamed Tributary station monitors water outflow from a series of multi-cell retention and settling ponds (Figure 1). This station is currently idled as dewatering operations have ceased and flow in this stream is significantly reduced to the point where it is dry most of the time.
- James Creek station monitors water outflow from the multi-cell retention and settling pond system, as well as outflow from Ruth Pit (Figure 1).
- Houston Creek station monitors water outflow from the Houston deposit which is scheduled for future development. The station is currently collecting baseline information (Figure 1).
- 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 destined to Ruth Pit. During the spring of 2014 dewatering operations were decommissioned, and there was no further outflow from the retention and settling pond system into the Unnamed Tributary and/or James Creek (Figure 1).
- Ruth Pit is used as a settling pond for reject rock originating from the beneficiation area at the Silver Yard, as well as receiving water from pit dewatering pumps. The outflow from Ruth Pit is the start of James Creek (Figure 1). As there were no active mine operations during 2014 and pit dewatering operations were suspended, there was less water flowing into Ruth Pit than in previous years.

- Six water parameters are measured at each station, including five water quality parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen and turbidity) and one water quantity parameter (i.e., stage).
- Water quality parameters are recorded on an hourly basis, typically from late-May to mid-October, when streams are ice-free. ENVC is responsible for collecting and managing this dataset.
- Stage is recorded year-round on an hourly basis. EC is responsible for collecting and managing this dataset.
- EC is responsible for logging and transmitting all water quality and water quantity data to a central repository via satellite communications.
- The purpose of the real-time network at these stations is to monitor, process, and distribute water quality and water quantity data to LIM, ENVC, and EC, for assessment and management of water resources, as well as to provide an early warning of any potential or emerging water issues, such that mitigative measures can be implemented in a timely manner.
- ENVC informs LIM of any significant water quality events by email notification. Monthly and annual deployment reports serve to document water parameters measured at these stations.
- This annual deployment report, presents water quality and water quantity data recorded at the James Creek and Houston Creek stations from June 10, 2014 to October 7, 2014.

Quality Assurance & Quality Control

- Water quality parameters are measured at each station using a Hydrolab DataSonde instrument (Figure 3).

Figure 3. Hydrolab DataSonde used for monitoring five water quality parameters.

- 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 four instrument sensors (i.e., pH, specific conductivity, dissolved oxygen, and turbidity sensors)[1].

[1] By design, the DataSonde temperature sensor cannot be calibrated using Hydras 3LT software; it is a factory calibration.

- Quality assurance procedures are carried out every four to five weeks, before the start of a new deployment period. Deployment start and end dates are summarized in Table 1.

Table 1. Water quality instrument deployment start and end dates for 2014 at James Creek and Houston Creek.

Station	Start date	End date	Duration (days)	Instrument
James Creek	2014-06-10	2014-07-15	35	49199
	2014-07-15	2014-08-12	28	49200
	2014-08-12	2014-09-10	29	49199
	2014-09-10	2014-10-06	26	49200
Houston Creek	2014-06-10	2014-07-15	35	49200
	2014-07-15	2014-08-12	28	49201
	2014-08-12	2014-09-08	27	49200
	2014-09-10	2014-10-07	29	64680

- As part of 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 rating (i.e., poor, marginal, fair, good or excellent) for each water quality parameter measured.
- Table 2 shows the performance ratings of the instrument sensors (i.e., temperature, pH, conductivity, dissolved oxygen and turbidity) deployed at James Creek and Houston Creek.
- Based on quality control procedures, instrument sensor performance ranged from poor-to-excellent in 2014 (Table 2).

Table 2. Instrument sensor performance at the start and end of each deployment period for the James Creek and Houston Creek RTWQ stations.

Station	Stage of deployment	Date (yyyy-mm-dd)	Instrument	Temperature (°C)	pH	Specific conductivity (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (NTU)
James Creek	Start	2014-06-10	49199	Good	Good	Excellent	Excellent	Excellent
	End	2014-07-15	49199	Good	Marginal	Poor	Excellent	Poor
	Start	2014-07-15	49200	Good	Fair	Excellent	Excellent	Excellent
	End	2014-08-12	49200	Good	Excellent	Excellent	Excellent	Good
	Start	2014-08-12	49199	Excellent	Excellent	Excellent	Excellent	Good
	End	2014-09-10	49199	Excellent	Excellent	Excellent	Excellent	Good
	Start	2014-09-10	49200	Excellent	Good	Excellent	Excellent	Excellent
	End	2014-10-06	49200	Excellent	Excellent	Excellent	Excellent	Good
Houston Creek	Start	2014-06-10	49200	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2014-07-15	49200	Excellent	Excellent	Excellent	Excellent	Excellent
	Start	2014-07-15	49201	Excellent	Good	Excellent	Excellent	Excellent
	End	2014-08-12	49201	Excellent	Excellent	Excellent	Excellent	Excellent
	Start	2014-08-12	49200	Good	Excellent	Excellent	Excellent	Excellent
	End	2014-09-08	49200	Excellent	Good	Excellent	Excellent	Excellent
	Start	2014-09-08	64680	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2014-10-07	64680	Excellent	Excellent	Excellent	Fair	Excellent

- The pH sensor at the James Creek station was given a marginal performance rating at the end of the first deployment, while the specific conductivity and turbidity probes were both given a poor performance rating. During the deployment period sediment can gradually accumulate on the instrument throwing off readings over the course of the deployment. It should be noted that the first deployment period covered spring runoff, when sediments levels would normally be higher, and also that it was the longest deployment period of the 2014 field season (35 days) allowing more time for sediment to accumulate on the instrument.

Deployment Notes

- Mining operations at James and Redmond were completed at the end of 2013. The iron ore resource at James Pit was exhausted and due to the characteristics of the ore, Redmond was deemed un-economic. Therefore, closure and rehabilitation was initiated for both James and Redmond including the decommissioning of the dewatering wells. With approval from ENVC and the Department of Fisheries and Oceans, the final dewatering well was decommissioned on May 29, 2014. While LIM halted all mining activities for 2014; a focus was put onto other projects around the mining area in anticipation of resuming operations in 2015. These include the construction of a new dry materials landfill, seeding of the newly constructed fish habitat, and the expansion of the Silver Yard Rail.

Data Interpretation

- Performance issues and data records were interpreted for each station during the deployment period for the following six parameters:

  (i.) Stage (m)
  (ii.) Temperature (^{o}C)
  (iii.) pH
  (iv.) Specific conductivity (μS/cm)
  (v.) Dissolved oxygen (mg/l)
  (vi.) Turbidity (NTU)

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

Stage

- Figure 4 displays stage values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014. These values are provisional. A complete dataset of quality assured and quality controlled stage values should be available upon request through EC after March 2015 (http://www.ec.gc.ca/rhc-wsc/default.asp).
- Stage values ranged from 0.712 m to 0.801 m at James Creek from June 10, 2014 to October 6, 2014, and from 1.279 m to 1.377 at Houston Creek from June 10, 2014 to October 7, 2014.

- Weekly trends in stage at the James Creek and Houston Creek stations corresponded well with rainfall events (Figure 4 inset). Spikes in the stage height associated with several rainfall events are highlighted on the graph inside red ovals.
- 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. To facilitate graphing, stage values from James Creek were adjusted to be in the 0 to 1 range.

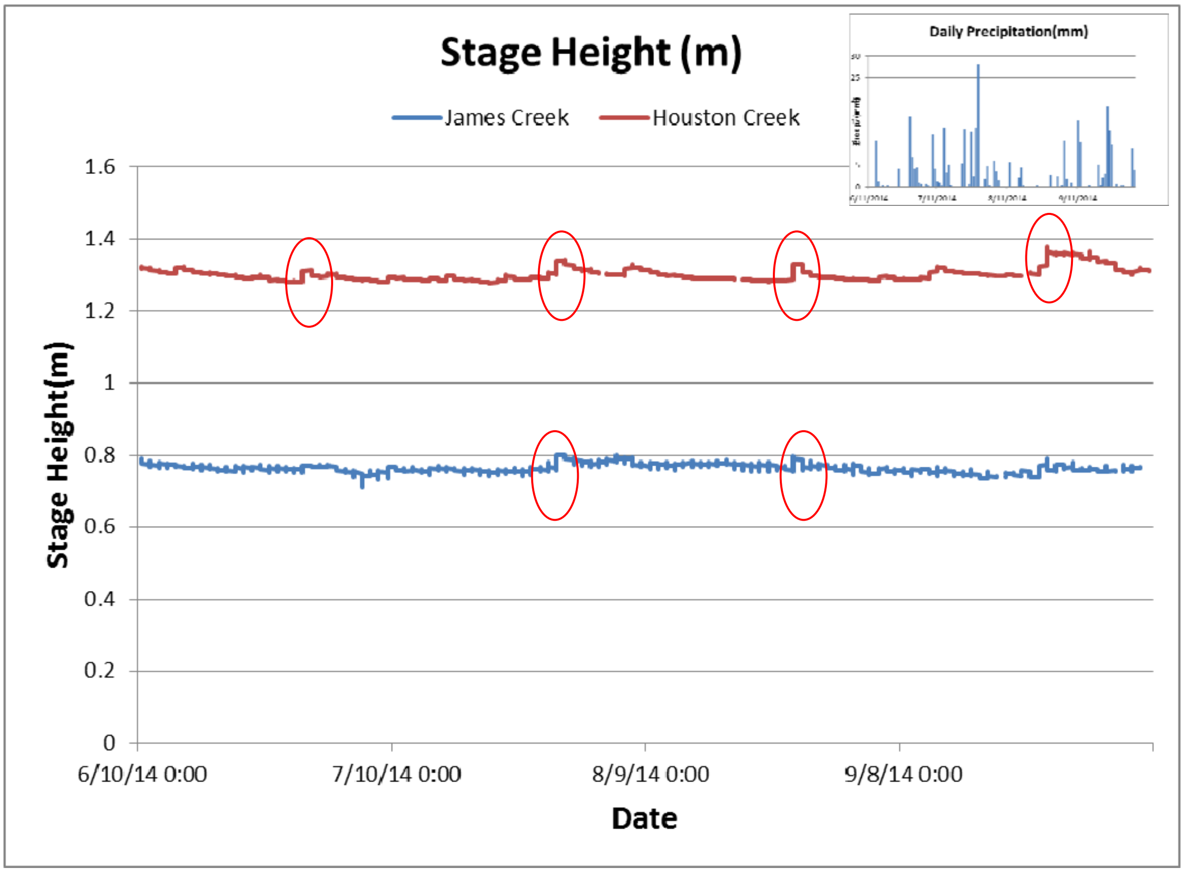

Figure 4. Hourly stage (m) values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014. The inset chart shows daily precipitation (mm) recorded at the Schefferville weather station during the same time period. All data was recorded by Environment Canada.

Temperature

- Water temperature ranged from 1.0˚C to 18.5˚C at James Creek from June 10, 2014 to October 6, 2014. Water temperature ranged from 1.0 ˚C to 19.3˚C at Houston Creek from June 10, 2014 to October 7, 2013. (Figure 5).
- 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 corresponded well with ambient air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 5 inset & Appendix C).

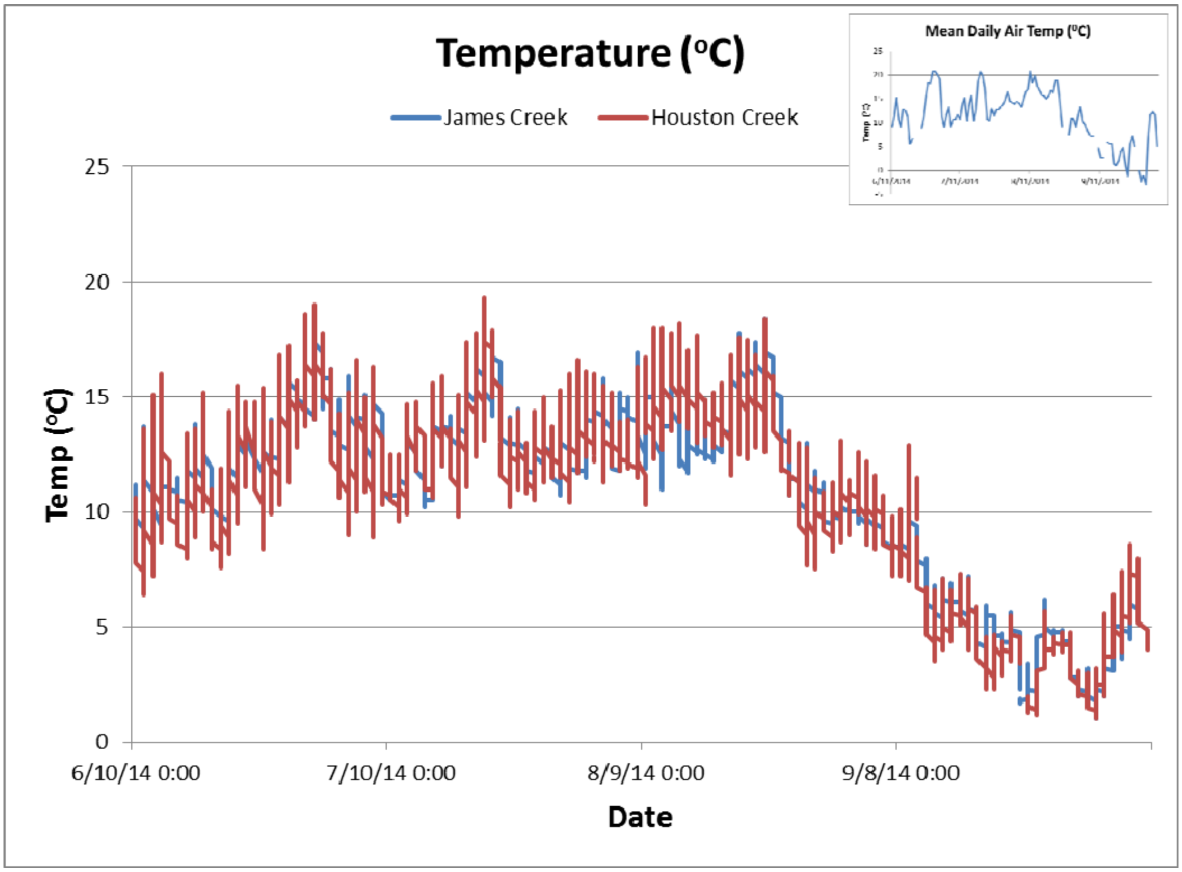

Figure 5. Hourly water temperature (°C) values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014. Inset chart shows mean daily air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 6.74 units to 8.83 units at James Creek from June 10, 2014 to October 6, 2014. pH values ranged from 6.34 units to 7.08 units at Houston Creek from June 10, 2014 to October 7, 2014. (Figure 6)
- At times of calibration and redeployment pH can take a significant jump(see inside red ovals) which reflects the fact that the sensor has drifted off calibration during the previous deployment period. This is most pronounced at James Creek where there are higher levels of suspended material than at Houston Creek.
- At Houston Creek the pH takes a noticeable drop around September 25, 2014 (See inside grey oval) which is due to significant rainfall causing a spike in flow.
- While most of the 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), some at Houston Creek were below the lower limit of 6.5. It should be noted that acidic waters are quite common in Canada, particularly in boreal and northern ecoregions, and pH is often naturally below this 6.5 unit guideline.

- pH values at both stations fluctuated daily with peaks typically occurring in the late afternoon/ early evening. These variations coincide with diurnal temperature trends as well as the photosynthetic cycling of CO_2 by aquatic organisms.

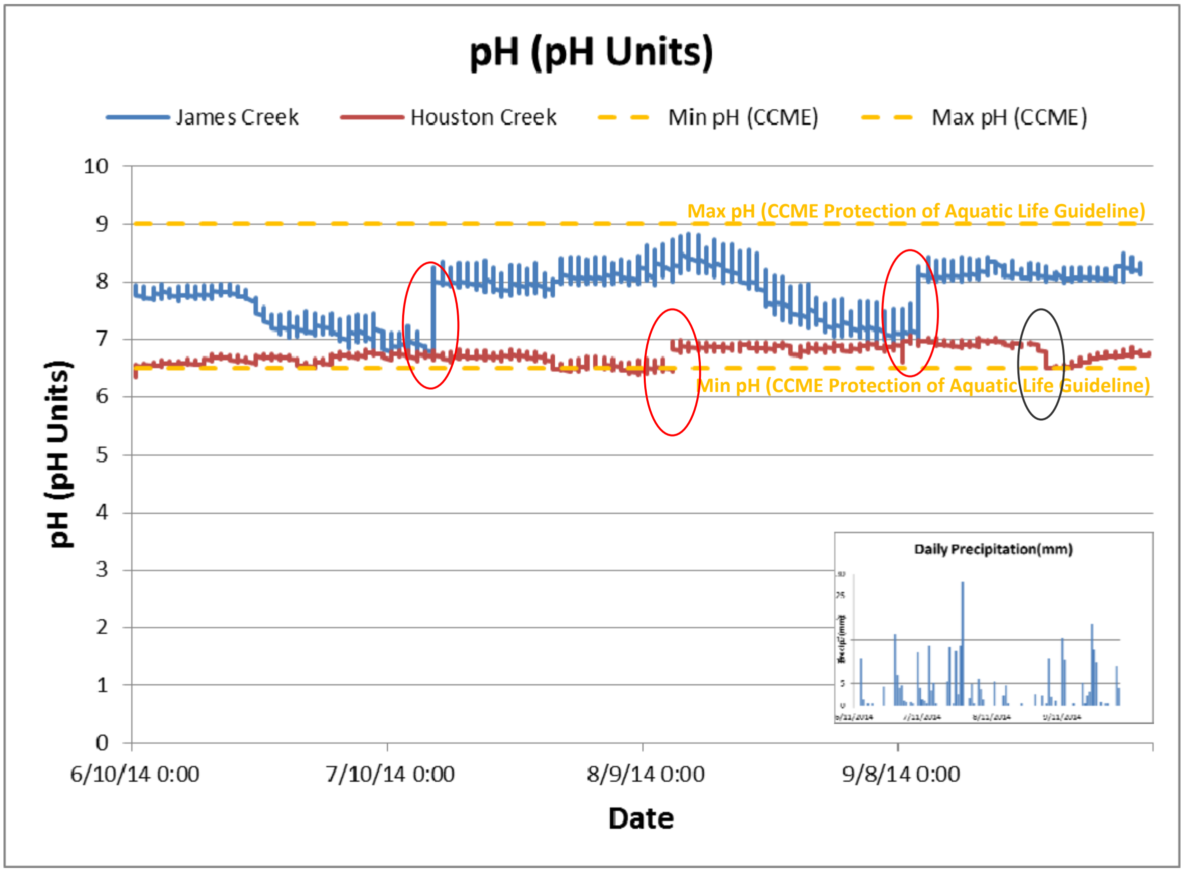

Figure 6. Hourly pH values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014. The inset chart shows daily precipitation (mm) recorded at the Schefferville weather station during the same time period.

Specific Conductivity

- Specific Conductivity ranged from 143.0 μs/cm to 205.0 μs/cm at James Creek from June 10, 2014 to October 7, 2014. Specific Conductivity ranged from 27.0 μs/cm to 46.7 μs/cm at Houston Creek from June 10, 2014 to October 7, 2014 (Figure 7).
- Specific conductivity values at both stations fluctuated daily with peaks typically occurring late evening/early morning. Diurnal fluctuations could be attributed to a number of variables including the diurnal temperature fluctuations as well as photosynthetic cycling of CO_2 by aquatic organisms.

- During an extended period in early July to mid-July specific conductivity at James Creek was elevated well above the normal range (see inside red oval). This elevated specific conductivity was most likely caused by heavy fouling of the sensor by suspended sediment settling out. After the calibration and maintenance on July 15 the specific conductivity readings returned to their normal range.
- Rainfall events, and the resulting increases in flow, can cause a noticeable dip in specific conductivity values. While this is more difficult to discern at James Creek there is a noticeable example of it for James creek, when there is a noticeable dip around September 24th to 26th, 2014 (see inside grey oval) . At James Creek a similar looking dip around September 10th, 2014 (see inside green oval) was actually the result of the monthly calibration of the DataSonde.
- Specific conductivity was consistently higher at James Creek than at Houston Creek. This difference could be attributed to the underlying geology of the areas as well as the impacts of past and present mining activity in the James Creek watershed.

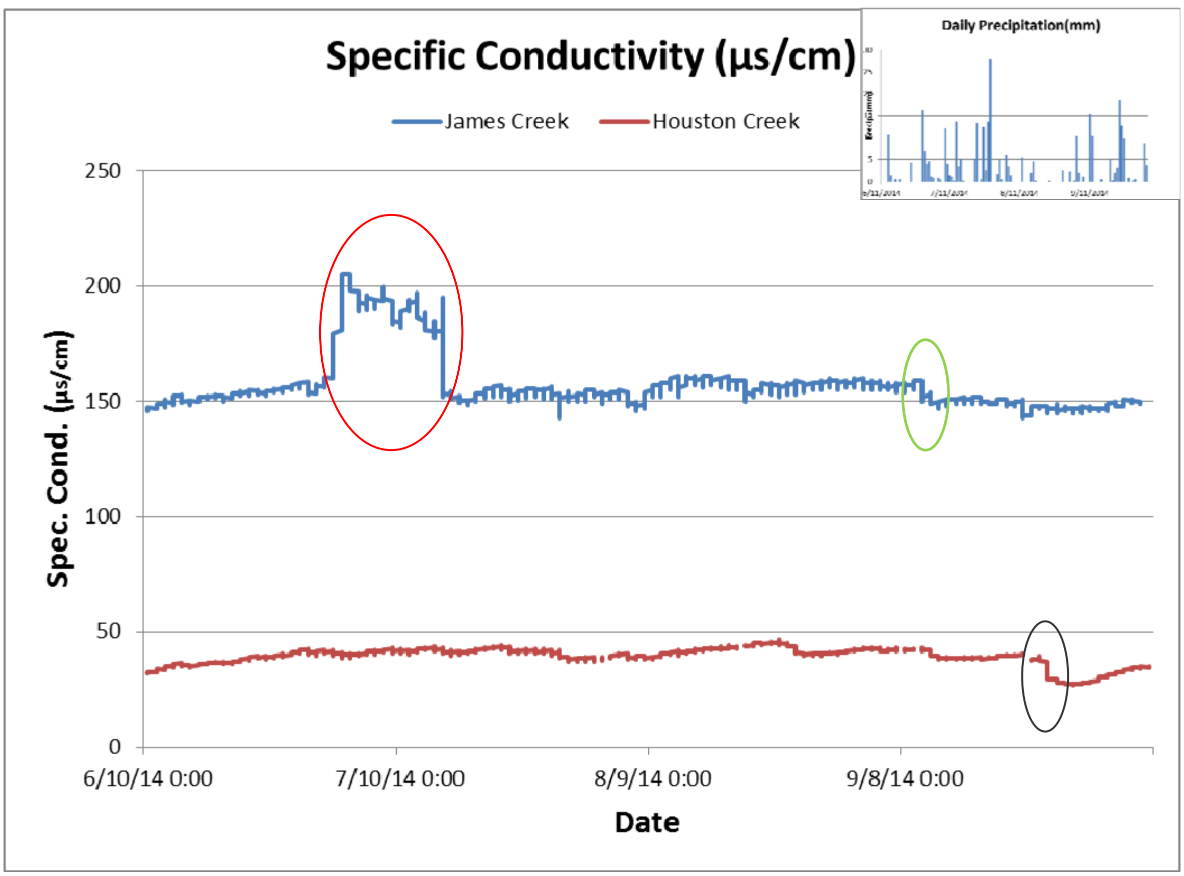

Figure 7. Hourly specific conductivity (µS/cm) values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014. The inset chart shows daily precipitation (mm) recorded at the Schefferville weather station during the same time period.

Dissolved Oxygen

- Dissolved Oxygen (DO) values ranged from 7.32 mg/l to 12.89 mg/l at James Creek from June 10, 2014 to October 6, 2014 and from 7.53 mg/l to 11.83 mg/l at Houston Creek from June 10, 2014 to October 7, 2014 (Figure 8).
- DO levels at both stations were above the minimum guideline set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007), for the whole deployment season. DO levels were above the cold water minimum guideline set for aquatic life during the early life stages period(9.5 mg/l) for the critical time of salmonid spawning and invertebrate emergence.
- DO levels fluctuate daily, with increases in DO observed in the afternoon and decreases observed at night. These diurnal variations can be attributed to a number of variables including temperature and the photosynthetic activity of aquatic organisms.
- Weekly trends in DO corresponded well with the inverse of water temperature (Figure 5), since colder water has a greater potential to dissolve oxygen compared to warmer water.

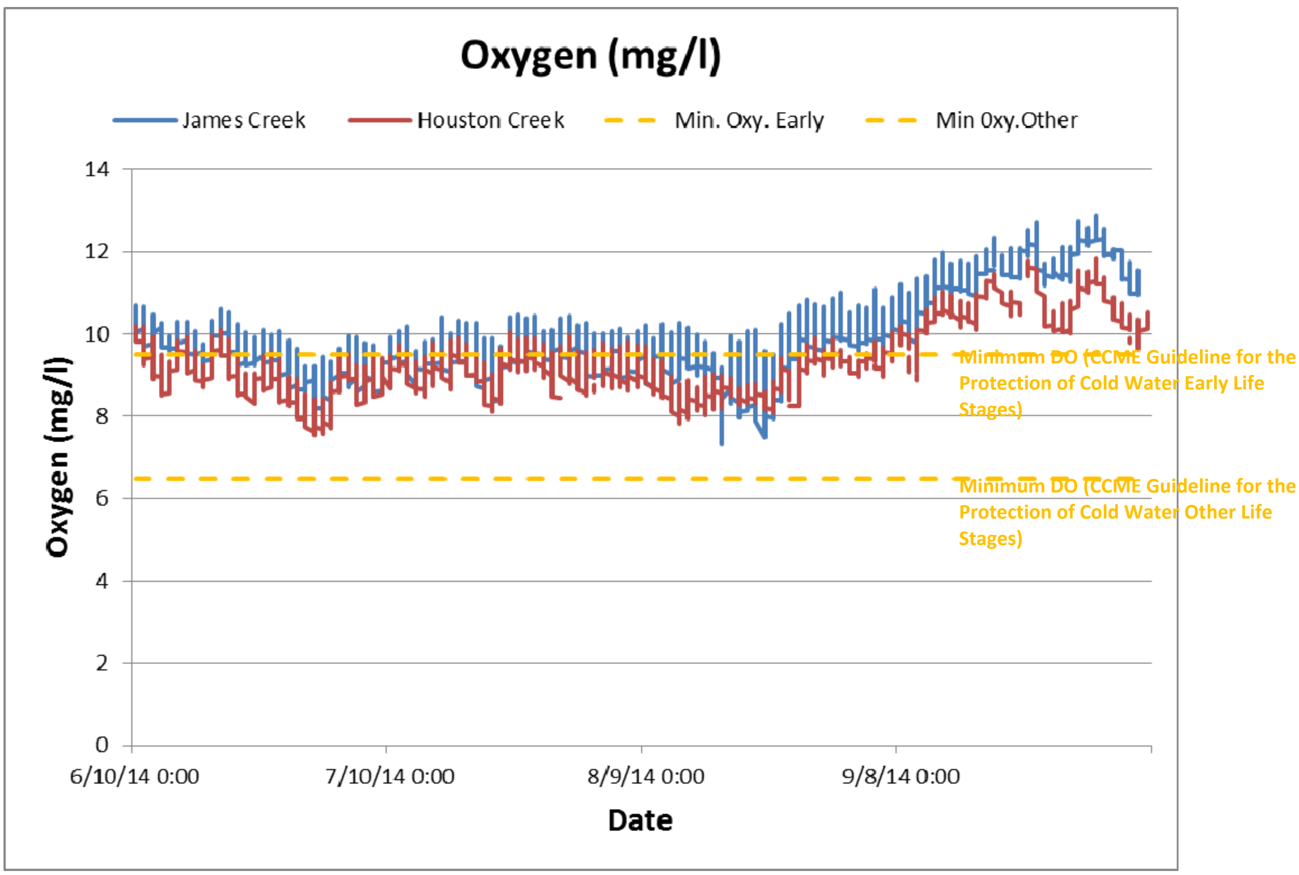

Figure 8. Hourly dissolved oxygen (mg/l) values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014.

Turbidity

- Turbidity values ranged from 0.0 NTU to 229.2 NTU at James Creek from June 10, 2014 to October 6, 2014. Turbidity values ranged from 0.0 NTU to 61.6 NTU at Houston Creek from June 10, 2014 to October 7, 2014 (Figure 9).
- There were numerous turbidity events measured at James Creek and Houston Creek. At James Creek there were high turbidity readings recorded for most of the first deployment period from June 10, 2014 to July 15, 2014. It should be noted that at removal the field instrument and the QA/QC did not compare well and the QA/QC ranking was poor with the field instrument reading 37.4 NTU and the QA/QC instrument reading 3.5 NTU. Given this poor comparison it is likely that some of these high reading were false high readings caused by heavy fouling of the sensor by suspended sediment settling out. After the calibration and maintenance on July 15 the turbidity readings returned to their normal range.
- Some of the turbidity events at James Creek and Houston Creek and others may be related to ongoing and historical mining and related land use activities in the watershed areas.

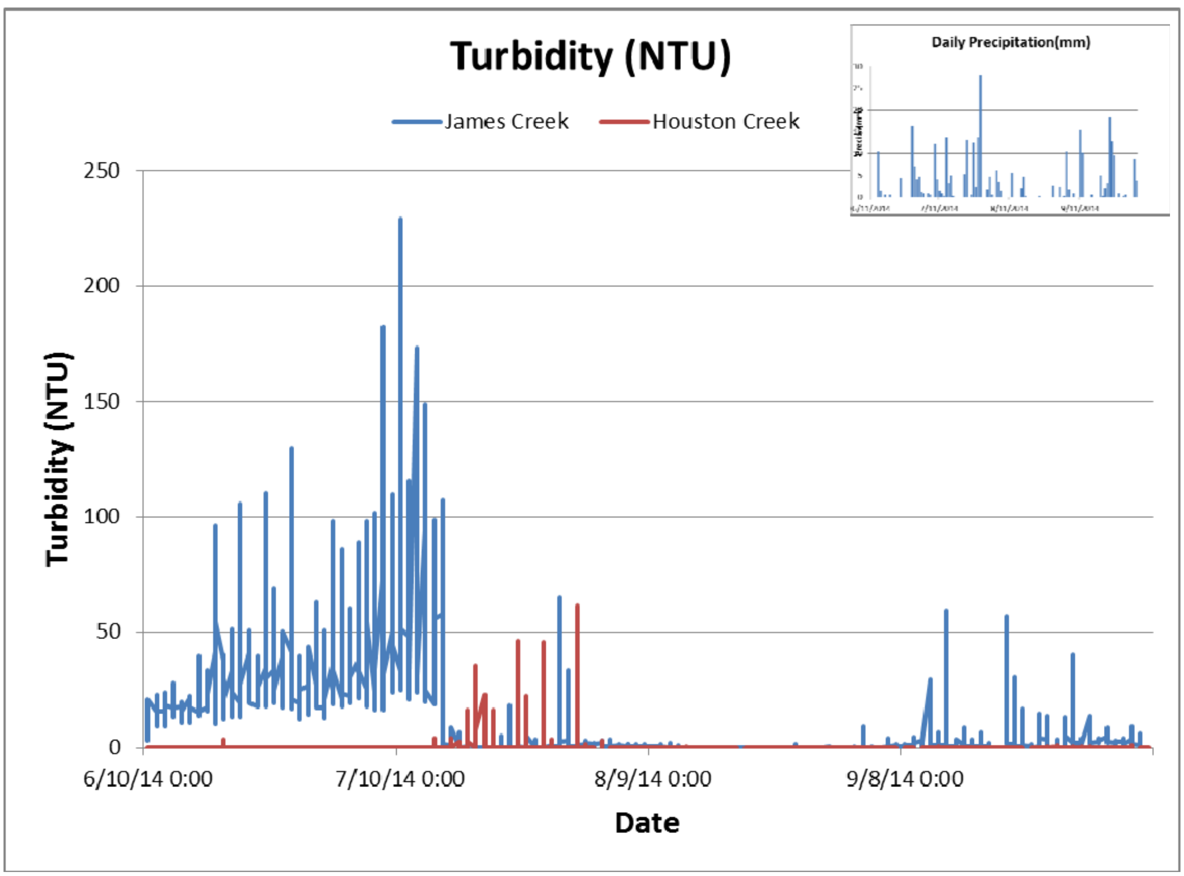

Figure 9. Hourly turbidity (NTU) values recorded at James Creek and Houston Creek from June 10, 2014 to October 7, 2014. The inset chart shows daily precipitation (mm) recorded at the Schefferville weather station during the same time period.

Conclusions

- During the 2014 field season water quality monitoring instruments were deployed at James Creek and Houston Creek over four deployment periods between June 10, 2014 and October 7, 2014.
- There was no active mining activity at the James deposit during the 2014 field season however closure and rehabilitation work was initiated for both James and Redmond, including the decommissioning of the dewatering wells. A focus was put onto other projects around the mining area in anticipation of resuming operations in 2015. These include the construction of a new dry materials landfill, seeding of the newly constructed fish habitat, and the expansion of the Silver Yard Rail.
- The performance ratings of all instrument sensors ranged between fair to excellent at the beginning and poor to excellent at the end of each of the four deployment periods. The poor ranking were most likely the result of sediment accumulating on the various probes during the first deployment which was the longest (35 days) of the 2014 field season and also covered the spring runoff period when sediment levels tend to be higher.
- Variations in water quality/quantity values recorded at each station are summarized below:

  STAGE: Stage values ranged from 0.712 m to 0.801 m at James Creek and from 1.279 m to 1.377 at Houston Creek from June 10, 2014 to October 7, 2014. Weekly trends in stage at the James Creek and Houston Creek stations corresponded well with rainfall events.

  WATER TEMPERATURE: Water temperature ranged from 1.0˚C to 18.5˚C at James Creek from June 10, 2014 to October 6, 2014. Water temperature ranged from 1.0 ˚C to 19.3˚C at Houston Creek from June 10, 2014 to October 7, 2013. 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 corresponded well with ambient air temperatures recorded by Environment Canada at the Schefferville weather station.

  pH: pH values ranged from 6.74 units to 8.83 units at James Creek from June 10, 2014 to October 6, 2014. pH values ranged from 6.34 units to 7.08 units at Houston Creek from June 10, 2014 to October 7, 2014. pH values at both stations fluctuated daily with peaks typically occurring in the late afternoon/ early evening. These variations coincide with diurnal temperature trends as well as the photosynthetic cycling of CO_2 by aquatic organisms. While most of the 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), some at Houston Creek were below the lower limit of 6.5. It should be noted that acidic waters are quite common in Canada, particularly in boreal and northern ecoregions, and pH is often naturally below this 6.5 unit guideline.

  SPECIFIC CONDUCTIVITY: Specific Conductivity ranged from 143.0 μs/cm to 205.0 μs/cm at James Creek from June 10, 2014 to October 6, 2014. Specific Conductivity ranged from 27.0 μs/cm to 46.7 μs/cm at Houston Creek from June 10, 2014 to October 7, 2014. Specific conductivity values at both stations fluctuated daily with peaks typically occurring late evening/early morning. Diurnal fluctuations could be attributed to a number of variables including the diurnal temperature fluctuations as well as photosynthetic cycling of CO_2 by aquatic organisms. During an extended period in early July to mid-July specific conductivity at

James Creek was elevated well above the normal range which was was most likely caused by heavy fouling of the sensor by suspended sediment settling out.

DISSOLVED OXYGEN: Dissolved Oxygen (DO) values ranged from 7.32 mg/l to 12.89 mg/l at James Creek from June 10, 2014 to October 6, 2014 and from7.53 mg/l to 11.83 mg/l at Houston Creek from June 10, 2014 to October 7, 2014. DO levels fluctuate daily, with increases in DO observed in the afternoon and decreases observed at night. These diurnal variations can be attributed to a number of variables including temperature and the photosynthetic activity of aquatic organisms. DO levels at both stations were above the minimum guidelines set for other life stages (6.5 mg/l) , as determined by the Canadian Council of Ministers of the Environment (2007), for the whole deployment season and above the cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l) period during the time of salmonid spawning and invertebrate emergence. Weekly trends in DO corresponded well with the inverse of water temperature, since colder water has a greater potential to dissolve oxygen compared to warmer water.

TURBIDITY: Turbidity values ranged from 0.0 NTU to 229.2 NTU at James Creek from June 10, 2014 to October 6, 2014. Turbidity values ranged from 0.0 NTU to 61.6 NTU at Houston Creek from June 10, 2014 to October 7, 2014. There were numerous turbidity events measured at the James Creek and Houston Creek. At James Creek there was high turbidity reading recorded for most of the first deployment period from June 10, 2014 to July 15, 2014. It is likely that some of these high reading were false high readings caused by heavy fouling of the sensor by suspended sediment settling out. After the calibration and maintenance on July 15 the turbidity readings returned to their normal range. Some of the turbidity events at James Creek and Houston Creek may be related to rainfall events and others may be related to ongoing and historical mining and related land use activities in the watershed areas.

Path Forward

- Field instruments for both stations will undergo Performance Testing and Evaluation over the Winter of 2015 and any necessary repairs will be carried out to ensure they are performing effectively for the 2015 field season.
- ENVC staff will redeploy RTWQ instruments at James Creek and Houston Creek in the spring 2015, when site conditions are suitable. They will also carry out regular site visits throughout the 2015 deployment season, on roughly a monthly basis, for calibration and maintenance of the instruments.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- ENVC staff will update LIM staff 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.
- LIM will continue to be informed of data trends and any significant water quality events in the form of email and/or monthly deployment reports, when the deployment season begins. LIM will also receive an annual report, summarizing the events of the deployment season. ENVC will

be hosting a hands on training workshop for industry partners in the spring of 2015 and LIM staff will have the opportunity to attend.

- Parameter alerts will be set prior to the 2015 deployment season to notify ENVC staff by email of any emerging water quality issues.
- ENVC has begun development of models using water quality monitoring data and grab sample data to estimate a variety of additional water quality parameters (e.g., TSS and major ions). This work will continue with a goal in implementing these models for RTWQ data collected.
- ENVC will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- ENVC will be active in creating new value added products using the RTWQ data and water quality indices.
- Open communication will continue to be maintained between ENVC, EC and LIM employees involved with the agreement, in order to respond to emerging issues on a proactive basis.

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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	> ±10 to 15	> ±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

[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 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 C

Environment Canada Weather Data - Schefferville (June 10, 2014 to Oct.7, 2014)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
6/10/2014	15.7	1.6	8.7	9.3	0	0
6/11/2014	17.4	0.9	9.2	8.8	0	0
6/12/2014	21.8	1	11.4	6.6	0	0
6/13/2014	23.3	7.1	15.2	2.8	0	0
6/14/2014	14.9	6.5	10.7	7.3	0	10.7
6/15/2014	12.9	5.1	9	9	0	1.3
6/16/2014	19.4	6.2	12.8	5.2	0	0
6/17/2014	19.9	5.2	12.6	5.4	0	0.5
6/18/2014	18	4.4	11.2	6.8	0	0
6/19/2014	8.5	2.4	5.5	12.5	0	0.5
6/20/2014	9.8	3.6	6.7	11.3	0	0
6/21/2014						
6/22/2014	22.5	5.3	13.9	4.1	0	0
6/23/2014						
6/24/2014	13.4	4.3	8.9	9.1	0	4.3
6/25/2014	17.7	4.3	11	7	0	0
6/26/2014	20.5	10.6	15.6	2.4	0	0
6/27/2014	25.1	11.5	18.3	0	0.3	0
6/28/2014	25.9	10.5	18.2	0	0.2	0
6/29/2014	26.2	15.2	20.7	0	2.7	16.3
6/30/2014	25.7	15.9	20.8	0	2.8	6.9
7/1/2014	25.2	15	20.1	0	2.1	4.1
7/2/2014	22.9	15.4	19.2	0	1.2	4.6
7/3/2014	15.6	6.7	11.2	6.8	0	1.1
7/4/2014	12.5	5.6	9.1	8.9	0	0.8
7/5/2014	18.1	5.5	11.8	6.2	0	0
7/6/2014	18.4	7.9	13.2	4.8	0	0.8
7/7/2014	15	3.4	9.2	8.8	0	0.5
7/8/2014	18.1	3.1	10.6	7.4	0	0
7/9/2014	13.8	7.4	10.6	7.4	0	12.1
7/10/2014	14.7	8.6	11.7	6.3	0	4.1
7/11/2014	13.2	8.1	10.7	7.3	0	1.3
7/12/2014	19.4	8	13.7	4.3	0	1
7/13/2014	18.8	11.6	15.2	2.8	0	0.3
7/14/2014	11.5	9.3	10.4	7.6	0	13.6
7/15/2014	17.2	10.1	13.7	4.3	0	3.3
7/16/2014	20.2	11.4	15.8	2.2	0	5.1
7/17/2014	14.5	6.2	10.4	7.6	0	0.3
7/18/2014	20.5	4.8	12.7	5.3	0	0

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
7/19/2014	25.7	11.4	18.6	0	0.6	
7/20/2014	27.9	13.2	20.6	0	2.6	0
7/21/2014	27.8	12.1	20	0	2	0
7/22/2014	21.8	12.9	17.4	0.6	0	5.3
7/23/2014	13.5	7.7	10.6	7.4	0	13.3
7/24/2014	14.9	5.9	10.4	7.6	0	0
7/25/2014	16.1	9.6	12.9	5.1	0	0.6
7/26/2014	14.8	8.2	11.5	6.5	0	12.5
7/27/2014	17.3	8.2	12.8	5.2	0	2.4
7/28/2014	16.6	8.9	12.8	5.2	0	13.6
7/29/2014	18.4	8.4	13.4	4.6	0	28.1
7/30/2014	19.6	8	13.8	4.2	0	0
7/31/2014	22.1	7.3	14.7	3.3	0	0
8/1/2014	21.7	11.2	16.5	1.5	0	1.8
8/2/2014	18	10.9	14.5	3.5	0	4.8
8/3/2014	18	10.4	14.2	3.8	0	0.5
8/4/2014	20.3	7.7	14	4	0	0
8/5/2014	18.2	10.5	14.4	3.6	0	6.1
8/6/2014	17.5	10.7	14.1	3.9	0	3.6
8/7/2014	16.3	10.3	13.3	4.7	0	1.5
8/8/2014	19.9	9.6	14.8	3.2	0	0
8/9/2014	23.6	9.4	16.5	1.5	0	0
8/10/2014	23.6	10.6	17.1	0.9	0	0
8/11/2014	27.5	13.8	20.7	0	2.7	0
8/12/2014	23.1	13.6	18.4	0	0.4	5.5
8/13/2014	25	14.6	19.8	0	1.8	0
8/14/2014	22.1	13	17.6	0.4	0	0
8/15/2014	22.1	11.7	16.9	1.1	0	0
8/16/2014	19.1	12.4	15.8	2.2	0	2.1
8/17/2014	19	12.2	15.6	2.4	0	4.6
8/18/2014	19.2	10.6	14.9	3.1	0	0.3
8/19/2014	22.3	9	15.7	2.3	0	0
8/20/2014	23.3	10.3	16.8	1.2	0	
8/21/2014	23.6	9.2	16.4	1.6	0	0
8/22/2014	25.5	12.2	18.9	0	0.9	0
8/23/2014	27.3	10.6	19	0	1	0
8/24/2014	21.5	8.7	15.1	2.9	0	0.3
8/25/2014	11.7	6.6	9.2	8.8	0	
8/26/2014		8				
8/27/2014						
8/28/2014	14.5	0.5	7.5	10.5	0	0

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
8/29/2014	17.6	4	10.8	7.2	0	0
8/30/2014	16.1	5.2	10.7	7.3	0	2.6
8/31/2014	12	6.1	9.1	8.9	0	0
9/1/2014	16.9	6.3	11.6	6.4	0	0
9/2/2014	18.7	8	13.4	4.6	0	2.3
9/3/2014	13.8	6.5	10.2	7.8	0	0
9/4/2014	13.9	5.6	9.8	8.2	0	0.3
9/5/2014	12.4	4.8	8.6	9.4	0	10.6
9/6/2014	12.7	2.3	7.5	10.5	0	1.9
9/7/2014	10.5	3.8	7.2	10.8	0	
9/8/2014	11	3.6	7.3	10.7	0	1
9/9/2014		3.6				
9/10/2014	7.7	1.5	4.6	13.4	0	
9/11/2014	5.5	-0.3	2.6	15.4	0	15.3
9/12/2014	5.5	-0.1	2.7	15.3	0	10.3
9/13/2014						
9/14/2014	8.2	3.6	5.9	12.1	0	0
9/15/2014	9.9	1.3	5.6	12.4	0	0
9/16/2014	10.5	0.6	5.6	12.4	0	0.5
9/17/2014	4.8	-2	1.4	16.6	0	
9/18/2014	4.8	-2.9	1	17	0	0
9/19/2014	5.1	-1	2.1	15.9	0	0
9/20/2014	7.6	0.3	4	14	0	5.1
9/21/2014	7.2	2.2	4.7	13.3	0	0.3
9/22/2014	2.6	-0.9	0.9	17.1	0	2.1
9/23/2014	0.3	-2.7	-1.2	19.2	0	3.1
9/24/2014	12.3	-1.2	5.6	12.4	0	18.5
9/25/2014	12.5	1.7	7.1	10.9	0	12.8
9/26/2014	8.6	1.6	5.1	12.9	0	9.8
9/27/2014		1.1				
9/28/2014	3.4	-3.5	-0.1	18.1	0	0.8
9/29/2014	-0.6	-4.1	-2.4	20.4	0	0
9/30/2014	3.1	-5	-1	19	0	0.3
10/1/2014	1.3	-7.3	-3	21	0	0.5
10/2/2014	13.8	-0.5	6.7	11.3	0	0
10/3/2014	15.1	8.2	11.7	6.3	0	0
10/4/2014	19	5.6	12.3	5.7	0	0
10/5/2014	16	7.4	11.7	6.3	0	8.8
10/6/2014	9.7	0.6	5.2	12.8	0	3.8
10/7/2014	13.9	1.5	7.7	10.3	0	3.6

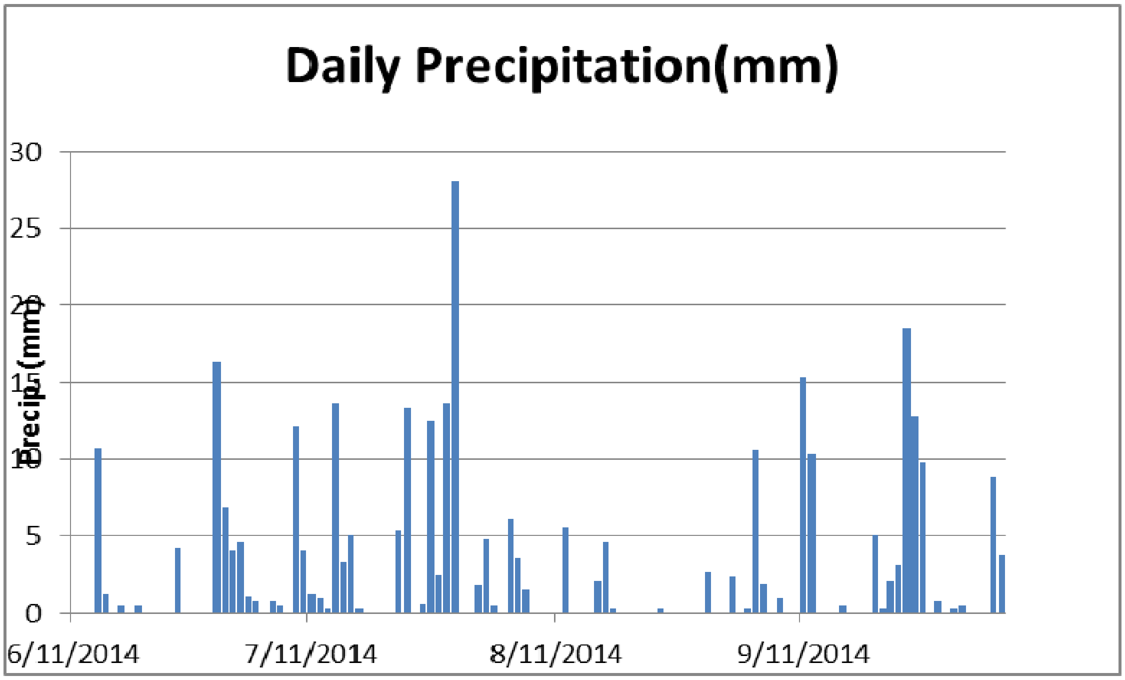

Figure 1. Daily precipitation recorded at the Schefferville Weather Station by Environment Canada from June 11, 2014 to October 6, 2014.

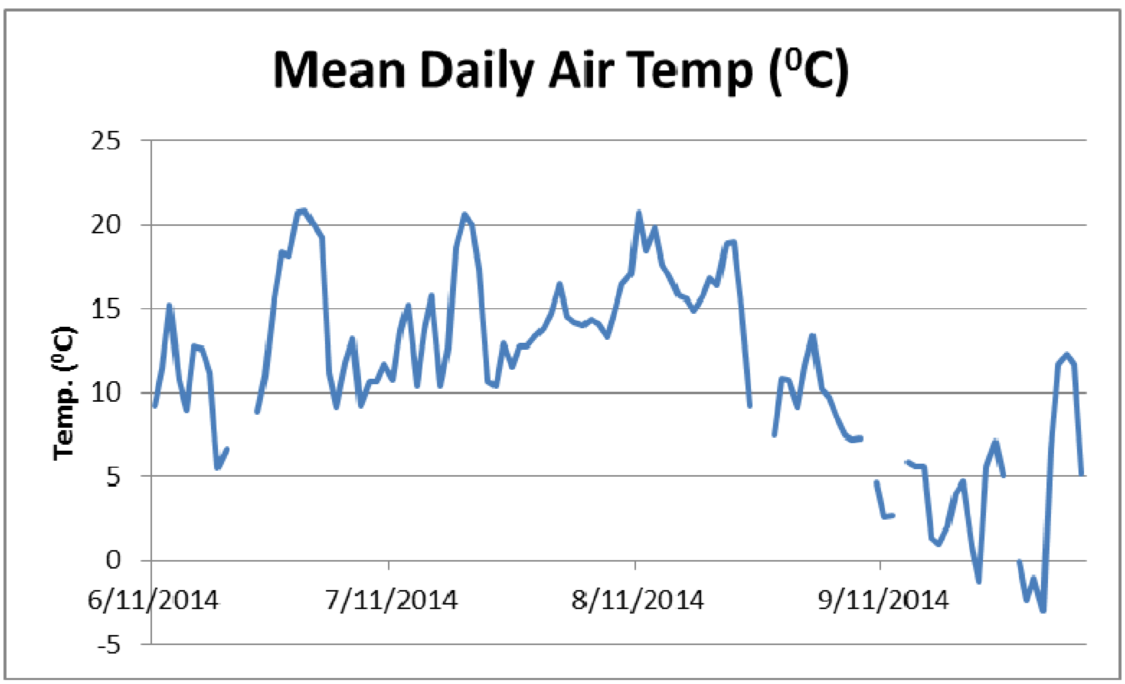

Figure 2. Mean Daily Temperature recorded at the Schefferville Weather Station by Environment Canada from June 11, 2014 to October 6, 2014.