Real Time Water Quality Report

Tata Steel Minerals Canada Elross Lake Network

Annual Deployment Report 2015

2015-06-03 to 2014-10-06

Government of Newfoundland & Labrador
Department of Environment and Conservation
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Acknowledgements

The Real-Time Water Quality/Quantity Monitoring Network in the vicinity of the Elross Lake Iron Ore Mine in western Labrador is fully funded by Tata Steel Minerals Canada Limited (TSMC) and its success is dependent on a joint partnership between TSMC, Environment Canada (EC), and the Newfoundland & Labrador Department of Environment & Conservation (ENVC). Managers and program leads from each organization, namely Loic Didillon (TSMC), Renee Paterson (ENVC), and Howie Wills (EC), are committed to the operation of this network and ensuring that it provides meaningful and accurate water quality/quantity data.

In addition to funding this program, TSMC also assisted ENVC and EC staff with fieldwork operations. TSMC employees who were helpful in this regard included Loic Didillon, Lisa Clancey, Michael Lewis, Delali Ajiboye, Shane Jackson, and Jean-Francois Dion.

EC plays an essential role in the data logging/communication aspect of the network. In particular, EC staff of the Water Survey of Canada, includin 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 Elross Lake Mine, 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. Paul Rideout with the Water Resources Management Division provided assistance with field work for three deployments during the 2015 field season. Instrument performance evaluation and repairs, during the winter of 2014-2015, were conducted in-house by Tara Clinton.

Introduction

- An agreement was signed on April 18, 2011, between the Newfoundland & Labrador Department of Environment & Conservation (ENVC) and Tata Steel Minerals Canada Limited (TSMC), to establish two real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in western Labrador, near Schefferville, QC.
- The official name of each station is ELROSS CREEK BELOW PINETTE LAKE INFLOW and GOODREAM CREEK 2KM NORTHWEST OF TIMMINS 6, hereafter referred to as the *Elross Creek Station* and the *Goodream Creek Station*, respectively (Figure 1).

a. Elross Creek Station b. Goodream Creek Station

Figure 1. RTWQ stations are located alongside (a) Elross Creek and (b) Goodream Creek.

- Table 1 lists the geographic coordinates of each station, including the location of the water quality instrument, gauge house, and helicopter pad.

Table 1. Geographic coordinates of the Elross Creek Station and Goodream Creek Station components.

	Elross Creek Station		Goodream Creek Station	
	Latitude	Longitude	Latitude	Longitude
Instrument	54.877757	-67.099728	54.917549	-67.124027
Gauge house	54.877698	-67.099848	54.917564	-67.123939
Helicopter pad	54.877604	-67.100014	54.917699	-67.123763

- Station sites were selected to monitor all surface water outflows from the Elross Lake mining site (Figure 2).
- The Elross Creek Station monitors surface water downstream of the Timmins 1 pit, and downstream of Pinette Lake.
- The Goodream Creek Station monitors potential impacts from groundwater flowing from Timmins 6 pit into the surface water of Goodream Creek.
- The stations went into operation October 17-18, 2011, recording only stage values for the first 7 months until June 5, 2012, when water quality instruments were first deployed.
- Six parameters are measured at each station during ice-free months, 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 early-June to early-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 TSMC, 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 TSMC 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 Elross Creek and Goodream Creek stations from June 3, 2015 to October 6, 2015.

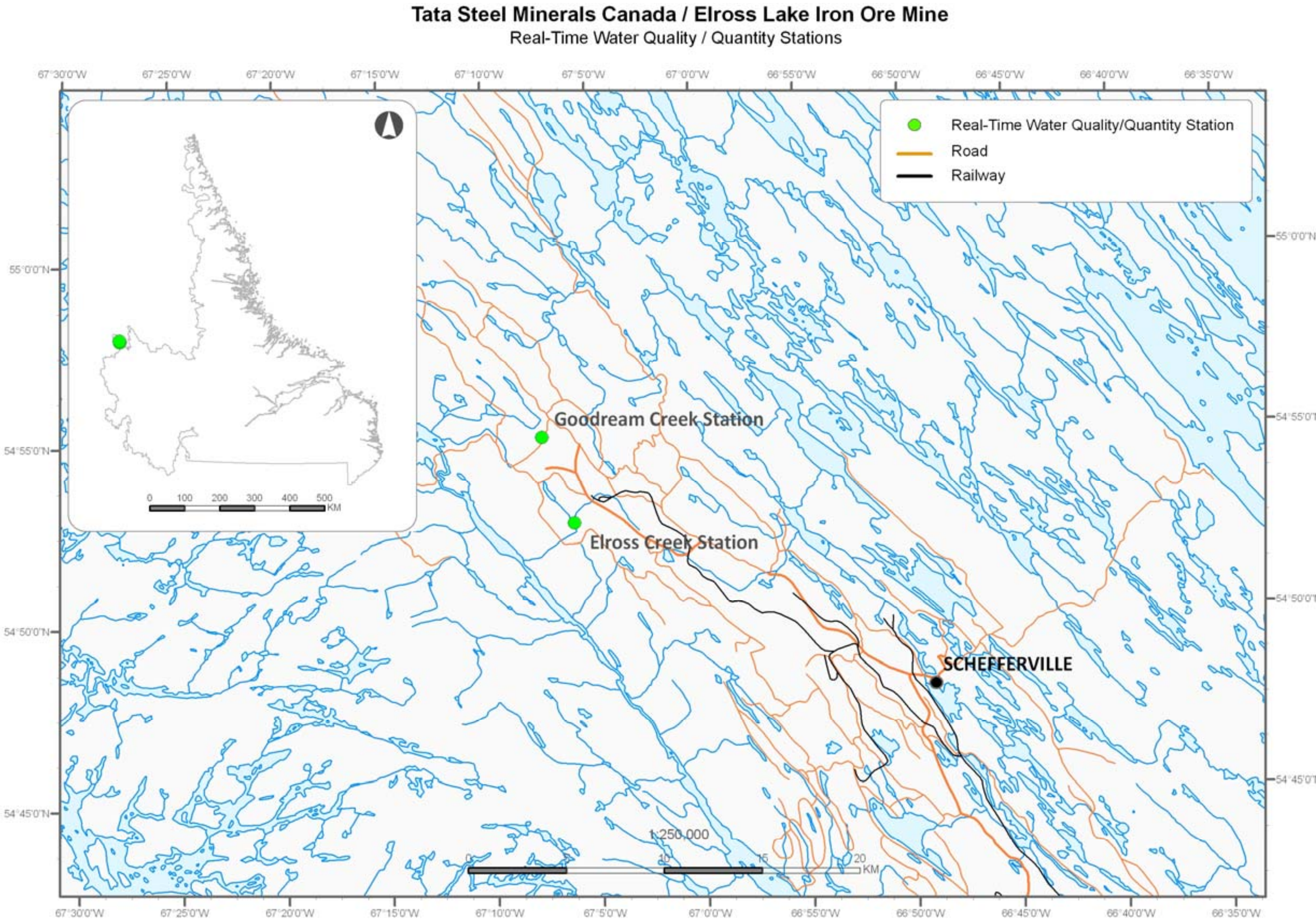

Figure 2. Map of real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in Western Labrador.

Quality Assurance & Quality Control

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

Model DS5 © 2005 Hach Company

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].
- Quality assurance procedures are carried out every 27-35 days, before the start of a new deployment period. Deployment start and end dates are summarized in Table 2.

Table 2. Water quality instrument deployment start and end dates for 2015 at Elross Creek and Goodream Creek.

Station	Start date	End date	Duration (days)	Instrument
Elross Creek	2015-06-03	2015-07-08	35	62068
	2015-07-08	2015-08-05	28	62065
	2015-08-05	2015-09-01	27	62068
	2015-09-01	2015-10-06	35	62065
Goodream Creek	2015-06-04	2015-07-09	35	62069
	2015-07-09	2015-08-04	26	62068
	2015-08-04	2015-09-02	29	62069
	2015-09-02	2015-10-06	34	62068

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

- 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 3 shows the performance ratings of the instrument sensors (i.e., temperature, pH, conductivity, dissolved oxygen and turbidity) deployed at Elross Creek and Goodream Creek. Based on quality control procedures, instrument sensor performance ranged from fair-to-excellent with the majority of rankings being "good" and "excellent" in 2015.

Table 3. Instrument sensor performance at the start and end of each deployment period for the Elross Creek and Goodream Creek RTWQ stations.

Station	Stage of deployment	Date (yyyy-mm-dd)	Instrument	Temperature (°C)	pH	Specific conductivity (?S/cm)	Dissolved oxygen (mg/L)	Turbidity (NTU)
Elross Creek	Start	2015-06-03	62068	Excellent	Excellent	Excellent	Excellent	Fair
	End	2015-07-08		Excellent	Poor	Excellent	Excellent	Excellent
	Start	2015-07-08	62065	Excellent	Good	Excellent	Good	Excellent
	End	2015-08-05		Excellent	Good	Good	Good	Excellent
	Start	2015-08-05	62068	Excellent	Excellent	Excellent	Excellent	Good
	End	2015-09-01		Excellent	Good	Excellent	Excellent	Good
	Start	2015-09-01	62065	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2015-10-06		Excellent	Good	Excellent	Excellent	Excellent
Goodream Creek	Start	2015-06-04	62069	Excellent	Poor	Excellent	Excellent	Excellent
	End	2015-07-09		Excellent	Excellent	Excellent	Excellent	Fair
	Start	2015-07-09	62068	Excellent	Excellent	Excellent	Fair	Good
	End	2015-08-04		Good	Excellent	Good	Excellent	Excellent
	Start	2015-08-04	62069	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2015-09-02		Good	Good	Excellent	Excellent	Excellent
	Start	2015-09-02	62068	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2015-10-06		Excellent	Marginal	Excellent	Good	Excellent

- Bath tests conducted in the winter of 2015 prior to the commencement of the field season showed that all sensors performed well for all instruments. The discrepancies between field instruments and QA/QC instruments for the 2015 field season were relatively minor and within the range normally experienced under rigours field conditions.

Deployment Notes

- 2015 was a pivotal year for TSMC as major component construction and commissioning for the processing plant was completed in the fall. Mining operations began in May with development of the Greenfield projects in the DSO 4 area consisting of development Kivivc 1 and Kivivic 2c deposits. DSO ore was crushed, sized and shipped from May to September via the temporary crushing plants on-site, while the commissioning of the wet circuit of the DSO process plant in September 2015 allowed for ore from September onwards to be processed and shipped. TSMC's mining operations will be limited in the winter of 2016 and are planned to resume in the spring of2016 in both the DSO 3 and DSO 4 mining areas.

- The 2015 field season at TSMC ran from June 3rd, 2015 until October 6th, 2015 with four back-to-back deployment periods. There were no significant operational issues with any of the equipment deployed during the 2015 field season. It should be noted that during the first three deployment periods there were occasions at Goodream Creek where streamflow was extremely low and water quality parameters such as specific conductivity, pH and dissolved oxygen were impacted.

Data Interpretation

- Performance issues and 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

- Figure 4 displays stage values recorded at both stations from June 3rd, 2015 to October 6th, 2015. These values are provisional. A complete dataset of quality assured and quality controlled stage values should be available upon request through EC after March 2016 (http://www.ec.gc.ca/rhc-wsc/default.asp).
- Stage values ranged from 1.06 m to 1.28m at Elross Creek and from 1.77 m to 2.10 m at Goodream Creek from June 3rd, 2015 to October 6th, 2015.
- Fluctuations in stage corresponded well with rainfall events (Figure 4 inset).
- During three out of four deployment periods stage height at the Goodream Creek station was critically low and some water quality parameters were pushed outside their normal range. However, despite the fact that stage height was very low it was possible to keep the hydrolab fully submerged in water for the deployment periods and it did not have to be removed. These low flow periods are natural occurrences at Goodream Creek during extended dry spells in the summer season.
- 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.

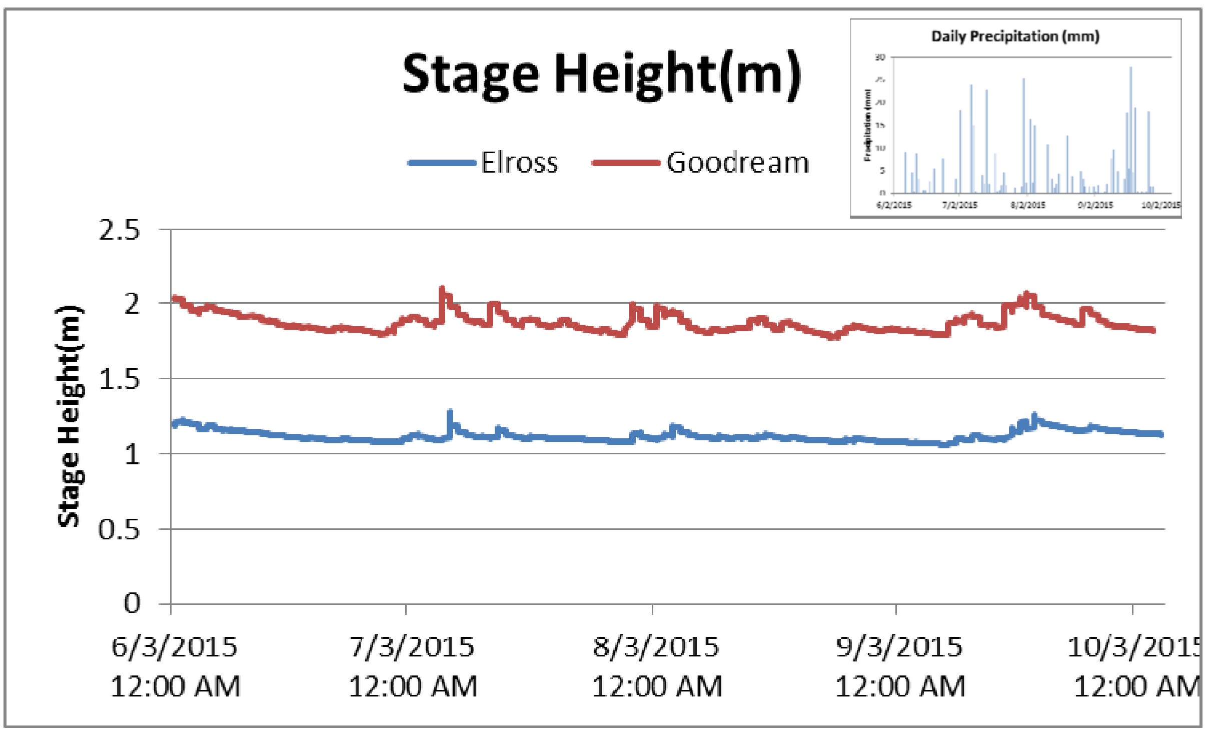

Figure 4. Hourly stage (m) values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015. The inset chart shows total precipitation (mm) recorded at the Schefferville weather station during the same time period. All data was recorded by Environment Canada.

Temperature

- Water temperature ranged from 2.4˚C to 15.9˚C at Elross Creek and from 1.3˚C to 18.1˚C at Goodream Creek from June 3rd, 2015 to October 6th, 2015 (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. Diurnal variations were larger at Goodream Creek compared to Elross Creek, since Goodream Creek is a shallower stream, and as a result, more responsive to diurnal changes in air temperatures.
- Trends in water temperature corresponded very well with trends in air temperatures recorded by Environment Canada at the Schefferville weather station (Figure 5 inset, Appendix C).

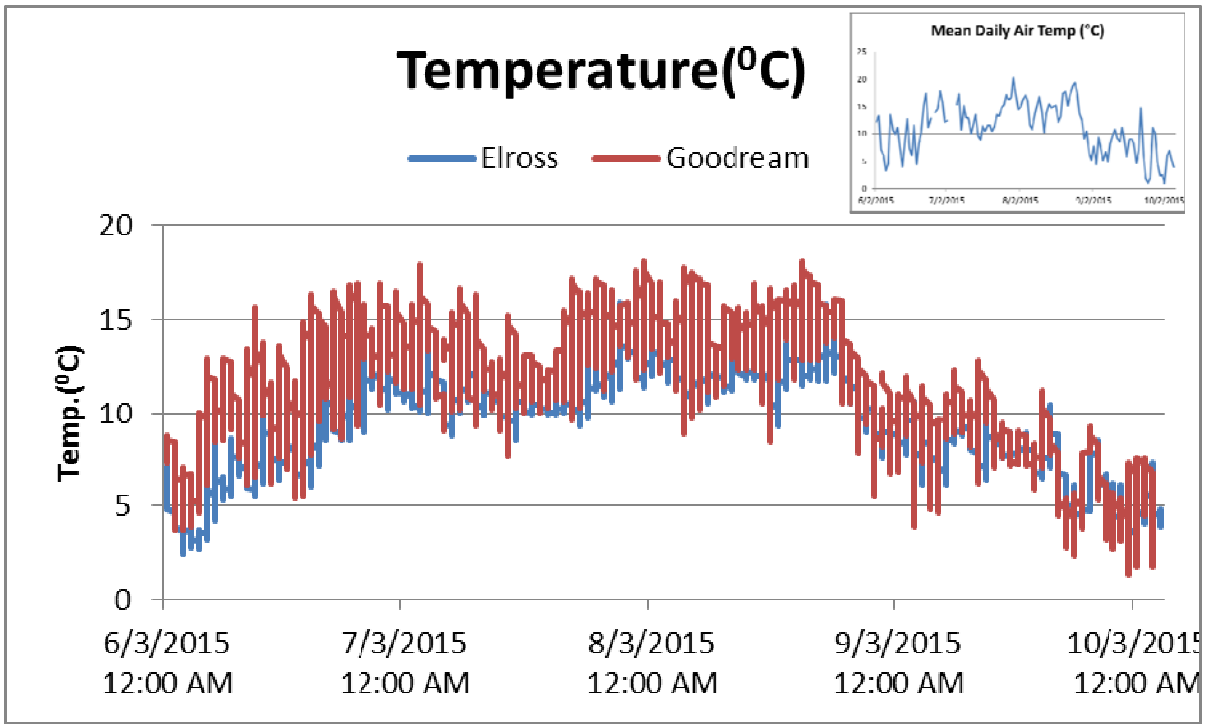

Figure 5. Hourly water temperature (°C) values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015. Inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 5.77 units to 6.83 units at Elross Creek and from 4.27 to 6.53 at Goodream Creek from June 3rd, 2015 to October 6th, 2015 (Figure 6). It should be noted that at Goodream Creek there were several periods when pH dipped below the normal range (see inside grey ovals) for extended periods. These periods of low pH coincide with periods of extremely low flow when pH was likely outside its usual range. It is also possible that the accuracy of the pH probe was impacted during these low flow periods.
- pH values show diurnal variations at both stations which are related to diurnal fluctuations in temperature, oxygen and photosynthetic cycling of CO_2 by aquatic organisms.
- Most pH values recorded at Elross Creek and Goodream Creek were slightly below the minimum pH guideline set for the protection of aquatic life (i.e., 6.5 units), as defined by the Canadian Council of Ministers of the Environment (2007). At Goodream Creek extreme low flows may have also pushed pH significantly lower than its normal range. In general low pH levels were considered normal for this area, based on baseline data collected around July 17-19, 2008 and September 10-12, 2008 (AMEC 2009, as cited in NML 2009). 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.

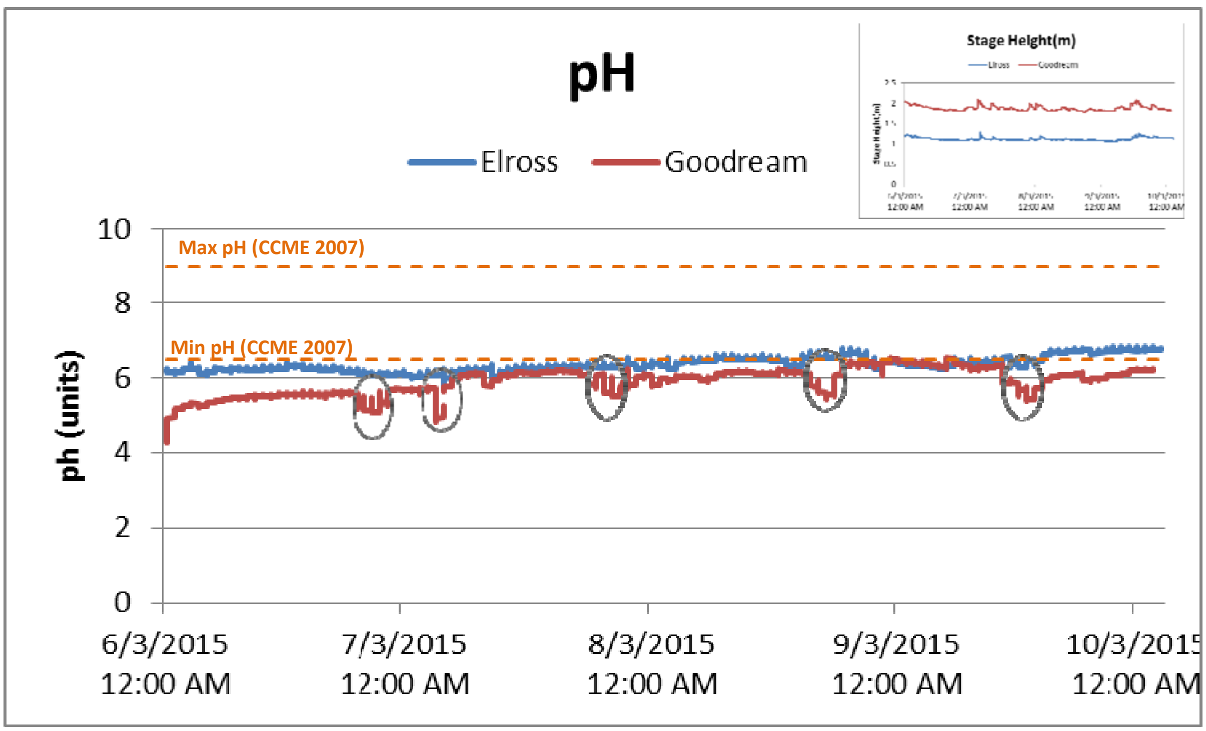

Figure 6. Hourly pH values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015.

Specific Conductivity

- Specific Conductivity ranged from 4.6 µs/cm to 17.6 µs/cm at Elross Creek and from 2.2 µs/cm to 8.7 µs/cm at Goodream Creek from June 3rd, 2015 to October 6th, 2015 (Figure 7).
- Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations.
- Specific conductivity at Elross Creek shows a visible increase over the deployment season, however values are still very low overall.

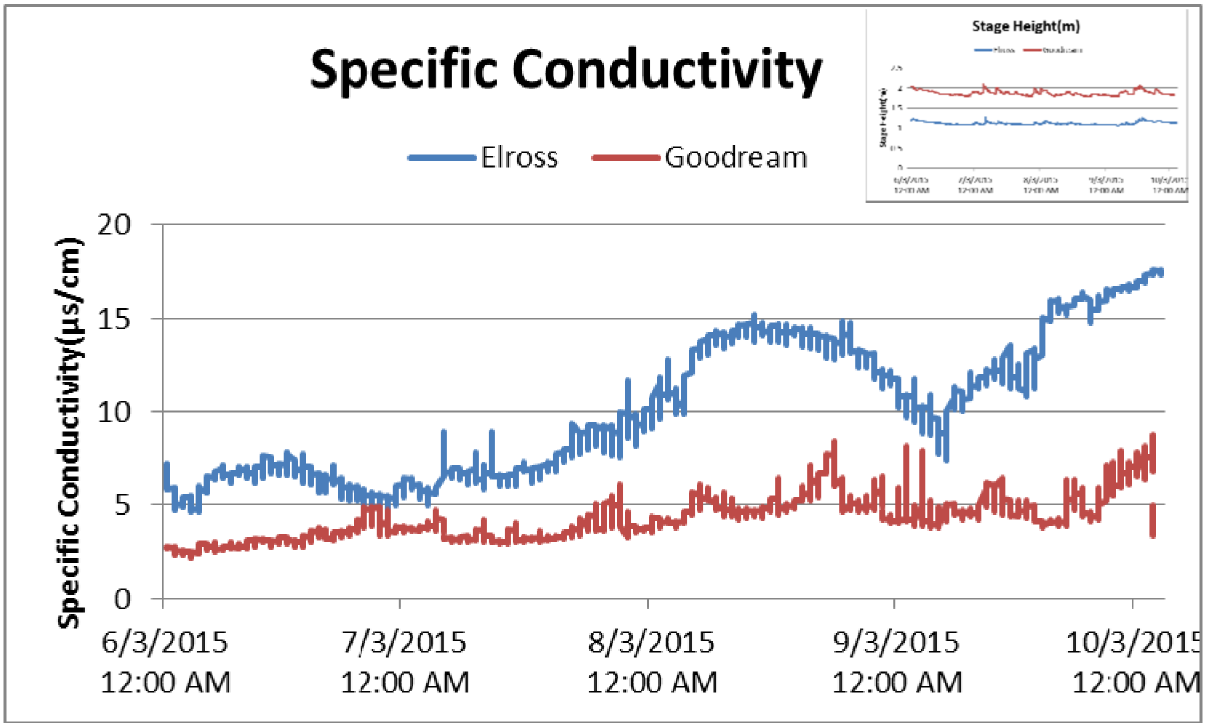

Figure 7. Hourly specific conductivity (µS/cm) values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015.

Dissolved Oxygen

- Dissolved Oxygen (DO) values ranged from 8.15 mg/l (81.3%) to 12.31 mg/l (106.4%) at Elross Creek and from 1.05 mg/l (10.2%) to 12.36 mg/l (103.0%) at Goodream Creek from June 3rd, 2015 to October 6th, 2015 (Figure 8).
- On several occasions at Goodream Creek oxygen levels dipped well below the normal range (see inside grey ovals) to levels dangerously low for fish and other aquatic species. It appears that these low oxygen values were caused naturally, by extremely low water levels due to a relatively dry year. When water levels are extremely low and there is little or no flowing water, oxygen becomes depleted.
- DO levels show diurnal variations at both stations which are related to diurnal fluctuations in temperature and photosynthetic cycling of CO_2 by aquatic organisms.
- Trends in DO corresponded well with the inverse of water temperature (see temperature inset in Figure 9), since colder water has a greater potential to dissolve oxygen compared to warmer water. As a result DO is higher in the spring and fall when water temperatures are cooler.
- DO values at both stations fell below cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l), but were generally above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). During periods of extreme low flow at Goodream Creek, DO values fell below the 6.5 mg/l guideline during the 2015 field season (see inside grey ovals).

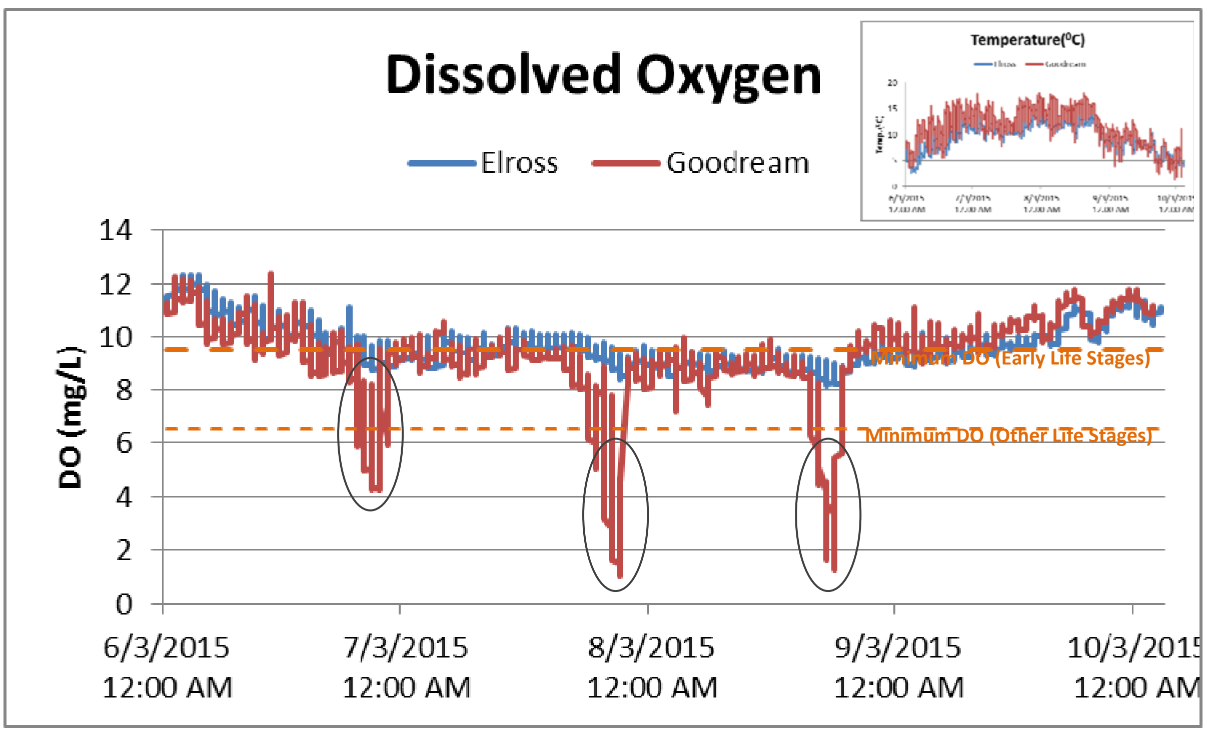

Figure 8. Hourly dissolved oxygen (mg/l) values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015.

Turbidity

- Turbidity values ranged from 0.0 NTU to 2462.0 NTU at Elross Creek and 0.0 NTU to 51.0 NTU at Goodream Creek from June 3rd, 2015 to October 6th, 2015 (Figure 9).
- In Figure 9 there are three significant spikes in turbidity at Elross Creek (see inside grey ovals). All three of these spikes in turbidity are related to periods of significant rainfall.
- In order to better display the turbidity readings in the lower range a second graph was prepared with all values greater than 100 groomed out of the Elross Dataset. This second graph is presented in Figure 10.
- From Figure 10 it can be seen that Turbidity is generally higher and subject to much greater fluctuations at Elross Creek that it is at Goodream Creek. This difference is understandable given the fact that the Elross Creek watershed has significant disturbance from historical and ongoing mining activity, while the Goodream Creek watershed is relatively undisturbed.

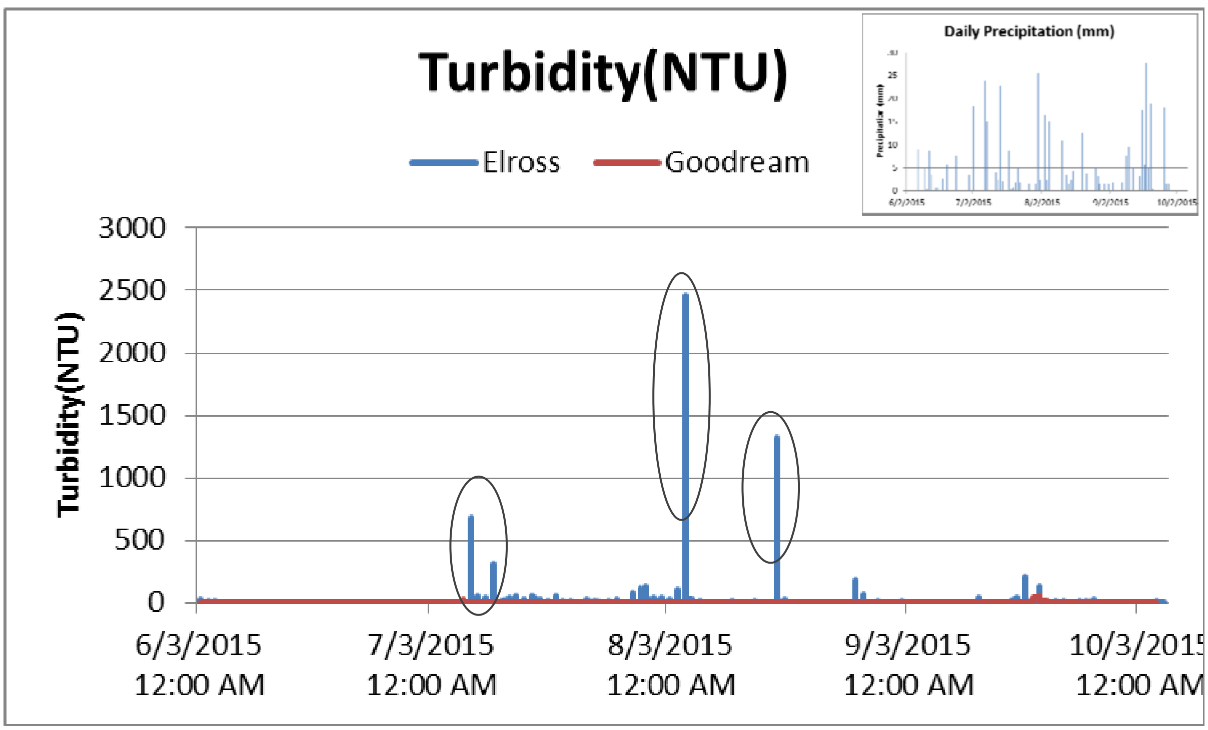

Figure 9. Hourly turbidity (NTU) values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015.

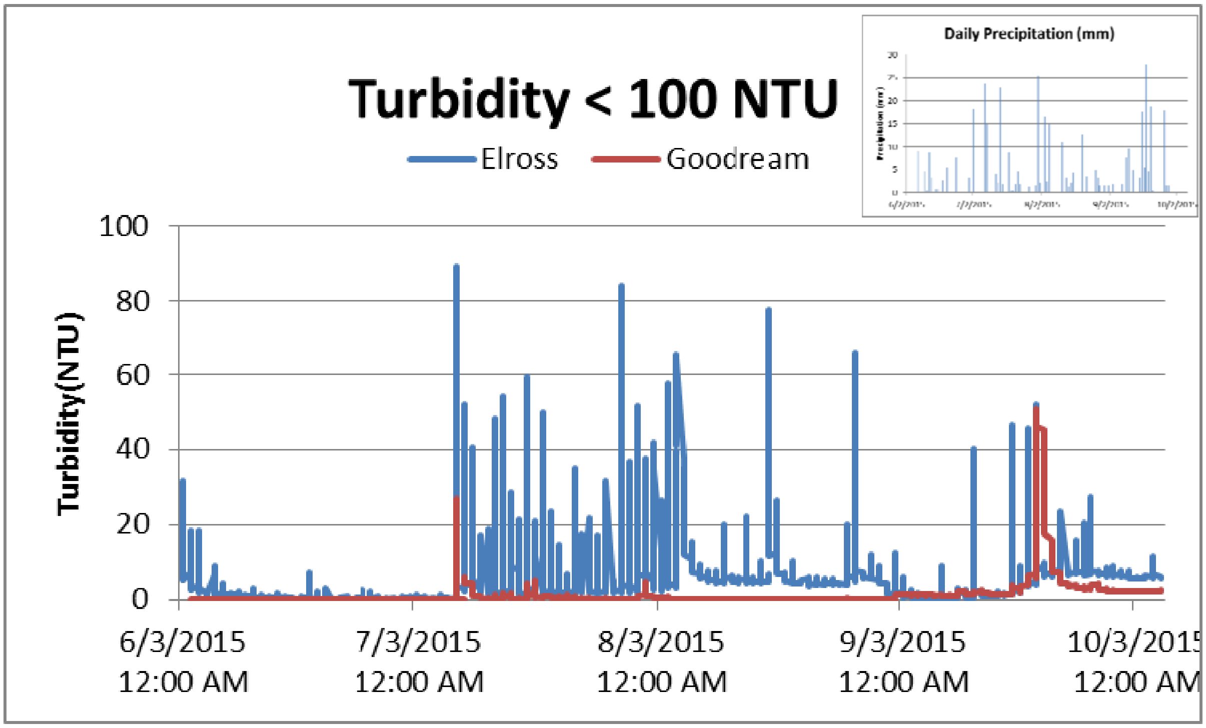

Figure 10. Hourly turbidity (NTU) values recorded at Elross Creek and Goodream Creek from June 3, 2015 to October 6, 2015 with values > 100NTU groomed out.

Conclusions

- Water quality monitoring instruments were deployed at two stations near the Elross Lake, Iron Ore Mine between June 3rd, 2015 and October 6th, 2015. The stations are located on Elross Creek and Goodream Creek.
- The water quality monitoring instruments were deployed for four consecutive deployment periods.
- The performance ratings of all instrument sensors ranged between poor and excellent at the beginning of each of the four deployment periods and marginal and excellent at the end of the deployment periods.
- It should be noted that extreme low flow conditions at Goodream Creek pushed the values of a number of parameters, including; oxygen, specific conductivity and pH, outside their normal range on several occasions.
- Variations in water quality/quantity values recorded at each station are summarized below:

    - STAGE: Stage values ranged from 1.06 m to 1.28m at Elross Creek and from 1.77 m to 2.10 m at Goodream Creek from June 3rd, 2015 to October 6th, 2014. Fluctuations in stage corresponded well with rainfall events. During three out of four deployment periods stage height at the Goodream Creek station was critically low and some water quality parameters were pushed outside their normal range.

- WATER TEMPERATURE: Water temperature ranged from 2.4˚C to 15.9˚C at Elross Creek and from 1.3˚C to 18.1˚C at Goodream Creek from June 3rd, 2015 to October 6th, 2015. Water temperatures at both stations display large diurnal variations and seasonal water temperature trends corresponded very well with trends in air temperatures.
- pH: pH values ranged from 5.77 units to 6.83 units at Elross Creek and from 4.27 to 6.53 at Goodream Creek from June 3rd, 2015 to October 6th, 2015. At Goodream Creek there were several periods when pH dipped below the normal range which was related to periods of extremely low flow. pH values show diurnal variations at both stations which are related to diurnal fluctuations in temperature, oxygen and photosynthetic cycling of CO_2 by aquatic organisms. Most pH values recorded at Elross Creek and Goodream Creek were slightly below the minimum pH guideline set for the protection of aquatic life (i.e., 6.5 units), as defined by the Canadian Council of Ministers of the Environment (2007). 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 4.6 µs/cm to 17.6 µs/cm at Elross Creek and from 2.2 µs/cm to 8.7 µs/cm at Goodream Creek from June 3rd, 2015 to October 6th, 2015. Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations. Specific conductivity at Elross Creek shows a visible increase over the deployment season, however values are still very low overall.

- DISSOLVED OXYGEN: Dissolved Oxygen (DO) values ranged from 8.15 mg/l (81.3%) to 12.31 mg/l (106.4%) at Elross Creek and from 1.05 mg/l (10.2%) to 12.36 mg/l (103.0%) at Goodream Creek from June 3rd, 2015 to October 6th, 2015. On several occasions at Goodream Creek oxygen levels dipped well below the normal range (see inside grey ovals) to levels dangerously low for fish and other aquatic species. It appears that these low oxygen values were caused naturally, by extremely low water levels due to a relatively dry year. DO levels show diurnal variations at both stations which are related to diurnal fluctuations in temperature and photosynthetic cycling of CO_2 by aquatic organisms. Trends in DO corresponded well with the inverse of water temperature and as a result DO is higher in the spring and fall when water temperatures are cooler. DO values at both stations fell below cold water minimum guidelines set for aquatic life during early life stages (9.5 mg/l), but were generally above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). During periods of extreme low flow at Goodream Creek, DO values fell below the 6.5 mg/l guideline for several periods during the 2015 field season

- TURBIDITY: Turbidity values ranged from 0.0 NTU to 2462.0 NTU at Elross Creek and 0.0 NTU to 51.0 NTU at Goodream Creek from June 3rd, 2015 to October 6th, 2015. There are three significant spikes in turbidity at Elross Creek which are related to periods of significant rainfall. Turbidity is generally higher and subject to much greater fluctuations at Elross Creek that it is at Goodream Creek. This difference is understandable given the fact that the Elross Creek watershed has significant disturbance from historical and ongoing mining activity, while the Goodream Creek watershed is relatively undisturbed.

Path Forward

- ENVC staff will redeploy RTWQ instruments at Elross Creek and Goodream Creek in the spring of 2016, when ice conditions allow, and perform regular site visits throughout the 2016 deployment season, for calibration and maintenance of the instruments. In addition a newly installed station in the Joan Brook area will become fully operational during the 2016 field season.
- ENVC staff will continue to rely on input and assistance from TSMC staff in the operation and maintenance of all three TSMC Real Time Water Quality stations at Elross Creek, Goodream Creek and Joan Brook. Every effort will be made to coordinate in advance with TSMC staff for site visits during the 2016 field season. ENVC staff are very appreciative of the field assistance provided by TSMC staff during the 2015 field season and are hoping to carry on with this arrangement again next year. ENVC will be hosting a “hands on” training workshop for industry partners in 2016 and TSMC staff will have the opportunity to attend.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- ENVC staff will update TSMC 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.
- Parameter alerts will be set prior to the 2016 deployment season to notify ENVC staff by email of any emerging water quality issues.
- TSMC 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. TSMC will also receive an annual report, summarizing the events of the deployment season.
- 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 TSMC 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 (□S/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 11, 2014 to Oct.6, 2014)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
6/2/2015	17.9	6.5	12.2	5.8	0	0
6/3/2015	18.8	7.9	13.4	4.6	0	0
6/4/2015	13.2	0.9	7.1	10.9	0	0
6/5/2015	11.4	0.5	6	12	0	0
6/6/2015	6.7	-0.2	3.3	14.7	0	0
6/7/2015	8.9	0.4	4.7	13.3	0	9
6/8/2015	19.5	7.4	13.5	4.5	0	0.2
6/9/2015	15.8	5.3	10.6	7.4	0	0.2
6/10/2015	12.8	7	9.9	8.1	0	4.7
6/11/2015	15	7.2	11.1	6.9	0	0.4
6/12/2015	9.2	4.8	7	11	0	8.8
6/13/2015	5.8	2.2	4	14	0	3.4
6/14/2015	13.9	2.5	8.2	9.8	0	0
6/15/2015	22.5	3	12.8	5.2	0	0.8
6/16/2015	12.3	2.3	7.3	10.7	0	0.8
6/17/2015	11.1	1.1	6.1	11.9	0	0
6/18/2015	21.5	1.4	11.5	6.5	0	2.7
6/19/2015	8.1	1.1	4.6	13.4	0	0
6/20/2015	15.8	1	8.4	9.6	0	5.5
6/21/2015	18.4	1.9	10.2	7.8	0	0
6/22/2015	23.5	6.9	15.2	2.8	0	0
6/23/2015	25.1	9.8	17.5	0.5	0	0
6/24/2015	14.1	8.3	11.2	6.8	0	7.7
6/25/2015	19.9	5.8	12.9	5.1	0	0
6/26/2015						
6/27/2015	21.1	6.8	14	4	0	0
6/28/2015	24.2	5	14.6	3.4	0	0.2
6/29/2015	24.2	11.4	17.8	0.2	0	0
6/30/2015	23.9	7.4	15.7	2.3	0	3.4
7/1/2015	18	6.3	12.2	5.8	0	0
7/2/2015	14.4	10.4	12.4	5.6	0	18.3
7/3/2015						
7/4/2015						
7/5/2015						

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
7/6/2015	22.2	8.6	15.4	2.6	0	0
7/7/2015	20.3	14.3	17.3	0.7	0	23.9
7/8/2015	14.4	7.2	10.8	7.2	0	15
7/9/2015	21.7	8.7	15.2	2.8	0	0.3
7/10/2015	18	7.9	13	5	0	0
7/11/2015	18.5	7.2	12.9	5.1	0	0
7/12/2015	13.3	6.6	10	8	0	4
7/13/2015	17.1	6.3	11.7	6.3	0	2.2
7/14/2015	18.2	8.7	13.5	4.5	0	22.8
7/15/2015	12.8	6.4	9.6	8.4	0	2
7/16/2015	11.6	6.1	8.9	9.1	0	0
7/17/2015	19	3.7	11.4	6.6	0	0
7/18/2015	11.6	9.3	10.5	7.5	0	8.8
7/19/2015	14.1	8.9	11.5	6.5	0	0.4
7/20/2015	14.4	9	11.7	6.3	0	0.6
7/21/2015	11.6	9.2	10.4	7.6	0	1.7
7/22/2015	12.9	10.1	11.5	6.5	0	4.7
7/23/2015	16.9	10	13.5	4.5	0	1.7
7/24/2015	17.7	8.8	13.3	4.7	0	0
7/25/2015	21.4	8.2	14.8	3.2	0	0
7/26/2015	21.4	9.2	15.3	2.7	0	0
7/27/2015	21.5	12.6	17.1	0.9	0	1.3
7/28/2015	22.5	9.8	16.2	1.8	0	0
7/29/2015	24.3	8.9	16.6	1.4	0	0.2
7/30/2015	27.4	13.1	20.3	0	2.3	1.5
7/31/2015	21.2	13.6	17.4	0.6	0	25.4
8/1/2015	19.8	9.1	14.5	3.5	0	2.3
8/2/2015	20.2	9.4	14.8	3.2	0	0
8/3/2015	20.8	11.6	16.2	1.8	0	16.5
8/4/2015	21.8	12.1	17	1	0	2.4
8/5/2015	21.2	10.7	16	2	0	15
8/6/2015	14.3	8.9	11.6	6.4	0	0.2
8/7/2015	15.6	6.2	10.9	7.1	0	0
8/8/2015	21.4	5.7	13.6	4.4	0	0
8/9/2015	23.2	7.1	15.2	2.8	0	0
8/10/2015	24.4	9.2	16.8	1.2	0	0
8/11/2015	18.1	10	14.1	3.9	0	10.9

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
8/12/2015	12.4	7.9	10.2	7.8	0	0
8/13/2015	16.8	10.7	13.8	4.2	0	3.4
8/14/2015	18.4	12.6	15.5	2.5	0	1.3
8/15/2015	17.3	12.1	14.7	3.3	0	2.2
8/16/2015	18.2	11.7	15	3	0	4.2
8/17/2015	23.4	7	15.2	2.8	0	0.2
8/18/2015	17.8	6.5	12.2	5.8	0	0
8/19/2015	20.6	5.8	13.2	4.8	0	0
8/20/2015	23.5	11.5	17.5	0.5	0	12.7
8/21/2015	22.4	12.9	17.7	0.3	0	0
8/22/2015	19.3	10.9	15.1	2.9	0	3.7
8/23/2015	22.2	11.9	17.1	0.9	0	0
8/24/2015	24.9	12.5	18.7	0	0.7	0
8/25/2015	25.2	13.6	19.4	0	1.4	0
8/26/2015	21.2	13.8	17.5	0.5	0	4.9
8/27/2015	19	8.6	13.8	4.2	0	3.3
8/28/2015	17.9	6.8	12.4	5.6	0	1.5
8/29/2015	12.7	5.5	9.1	8.9	0	0
8/30/2015	14.1	6.6	10.4	7.6	0	1.6
8/31/2015	11.1	1.6	6.4	11.6	0	0
9/1/2015	9.4	1.1	5.3	12.7	0	1.6
9/2/2015	13.8	1.8	7.8	10.2	0	0.3
9/3/2015	7.4	1.8	4.6	13.4	0	1.7
9/4/2015	15.5	3	9.3	8.7	0	0
9/5/2015	14.5	0.3	7.4	10.6	0	0.2
9/6/2015	12	-1.8	5.1	12.9	0	0.3
9/7/2015	13.2	0.2	6.7	11.3	0	1.9
9/8/2015	10.5	-1	4.8	13.2	0	0
9/9/2015	14.6	1.7	8.2	9.8	0	7.6
9/10/2015	11.2	8.4	9.8	8.2	0	9.6
9/11/2015	13.6	7.9	10.8	7.2	0	0
9/12/2015	11.8	6.5	9.2	8.8	0	4.9
9/13/2015	13.2	3.9	8.6	9.4	0	0
9/14/2015	19.4	2.9	11.2	6.8	0	0
9/15/2015	13.2	4.1	8.7	9.3	0	3.3
9/16/2015	8.2	3.3	5.8	12.2	0	17.7
9/17/2015	15.2	2.6	8.9	9.1	0	5.5

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
9/18/2015	15.4	2.7	9.1	8.9	0	27.8
9/19/2015	10.5	6	8.3	9.7	0	4.7
9/20/2015	6.5	2.8	4.7	13.3	0	18.8
9/21/2015	12.7	1	6.9	11.1	0	0.4
9/22/2015	19	10.4	14.7	3.3	0	0
9/23/2015	10.4	1.6	6	12	0	0.3
9/24/2015	4.5	-0.8	1.9	16.1	0	0
9/25/2015	3.6	-1.5	1.1	16.9	0	0.3
9/26/2015	5.7	-1.7	2	16	0	18.1
9/27/2015	16.5	5.6	11.1	6.9	0	1.5
9/28/2015	14.7	5.4	10.1	7.9	0	1.6
9/29/2015	8.6	1.1	4.9	13.1	0	0
9/30/2015	5.6	-0.7	2.5	15.5	0	0
10/1/2015	5	0	2.5	15.5	0	0.2
10/2/2015	5.1	-3.2	1	17	0	0
10/3/2015	12.3	-0.4	6	12	0	0
10/4/2015	13.4	0.4	6.9	11.1	0	0
10/5/2015	12.2	-1.6	5.3	12.7	0	0
10/6/2015	9.5	-1.8	3.9	14.1	0	0

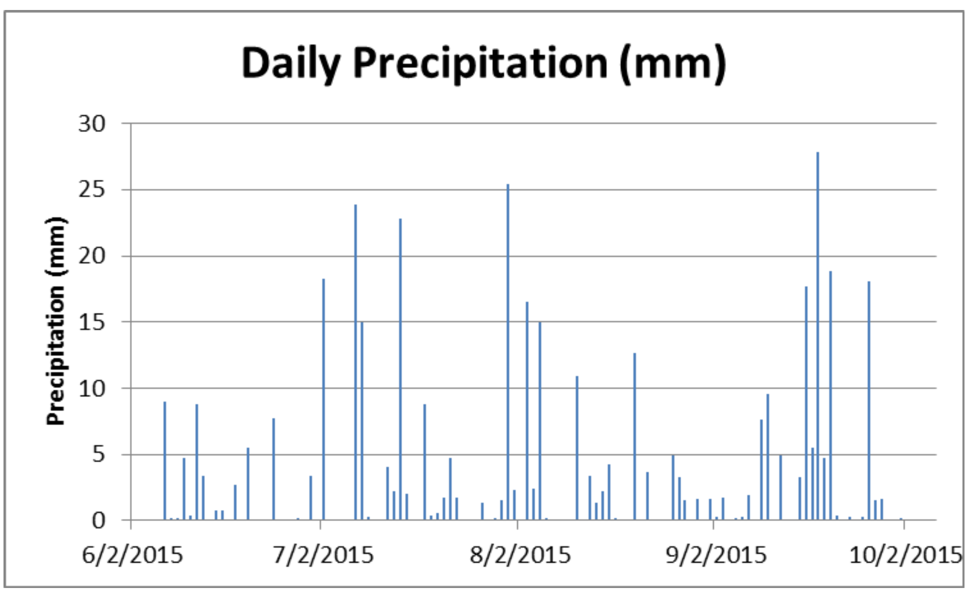

Figure 1. Daily precipitation recorded at the Schefferville Weather Station by Environment Canada from June 2, 2015 to October 6, 2015.

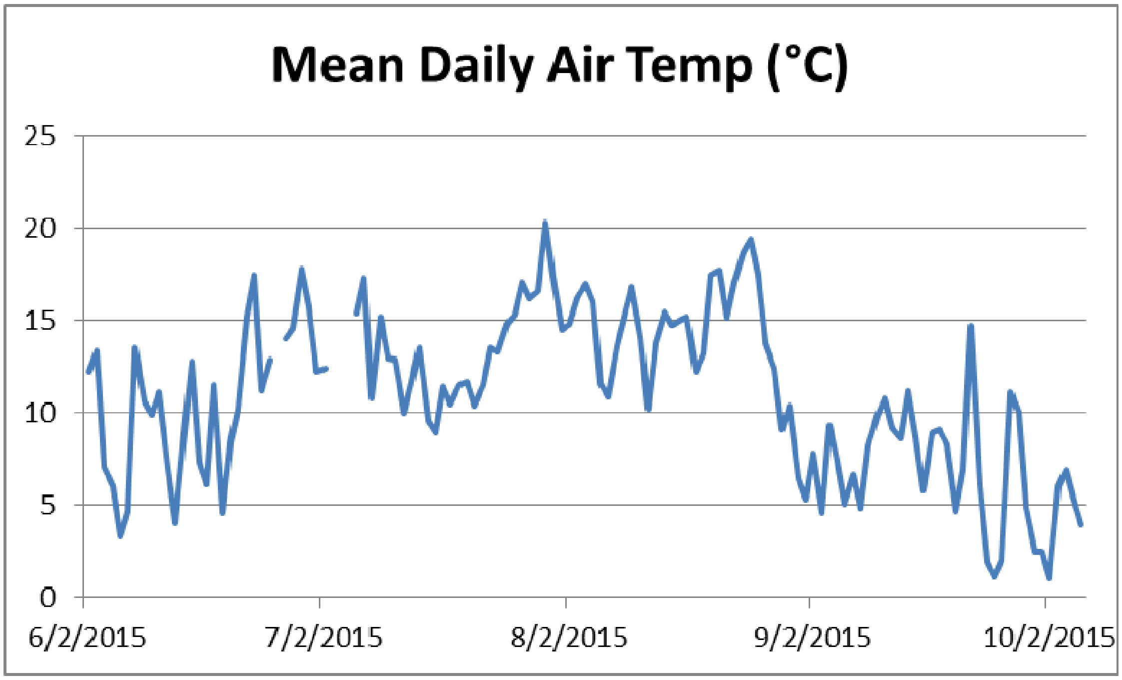

Figure 2. Daily mean temperature recorded at the Schefferville Weather Station by Environment Canada from June 2, 2015 to October 6, 2015.