Real Time Water Quality Report

Tata Steel Minerals Canada Elross Lake Network

Annual Deployment Report 2014

2014-06-11 to 2014-10-06

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
St. John's, NL, A1B 4J6 Canada

Prepared by:

Ian Bell
Environmental Scientist
Department of Environment & Conservation
Water Resources Management Division
Government of Newfoundland & Labrador
3rd Floor, Noton Building
PO Box 2006, Corner Brook, NL, A2H 6J8

t. 709.637.2431
f. 709.637.2541
e. ianbell@gov.nl.ca

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, 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, 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 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. 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 2013-2014, were conducted in-house by Ryan Pugh.

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 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 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 11, 2014 to October 6, 2014.

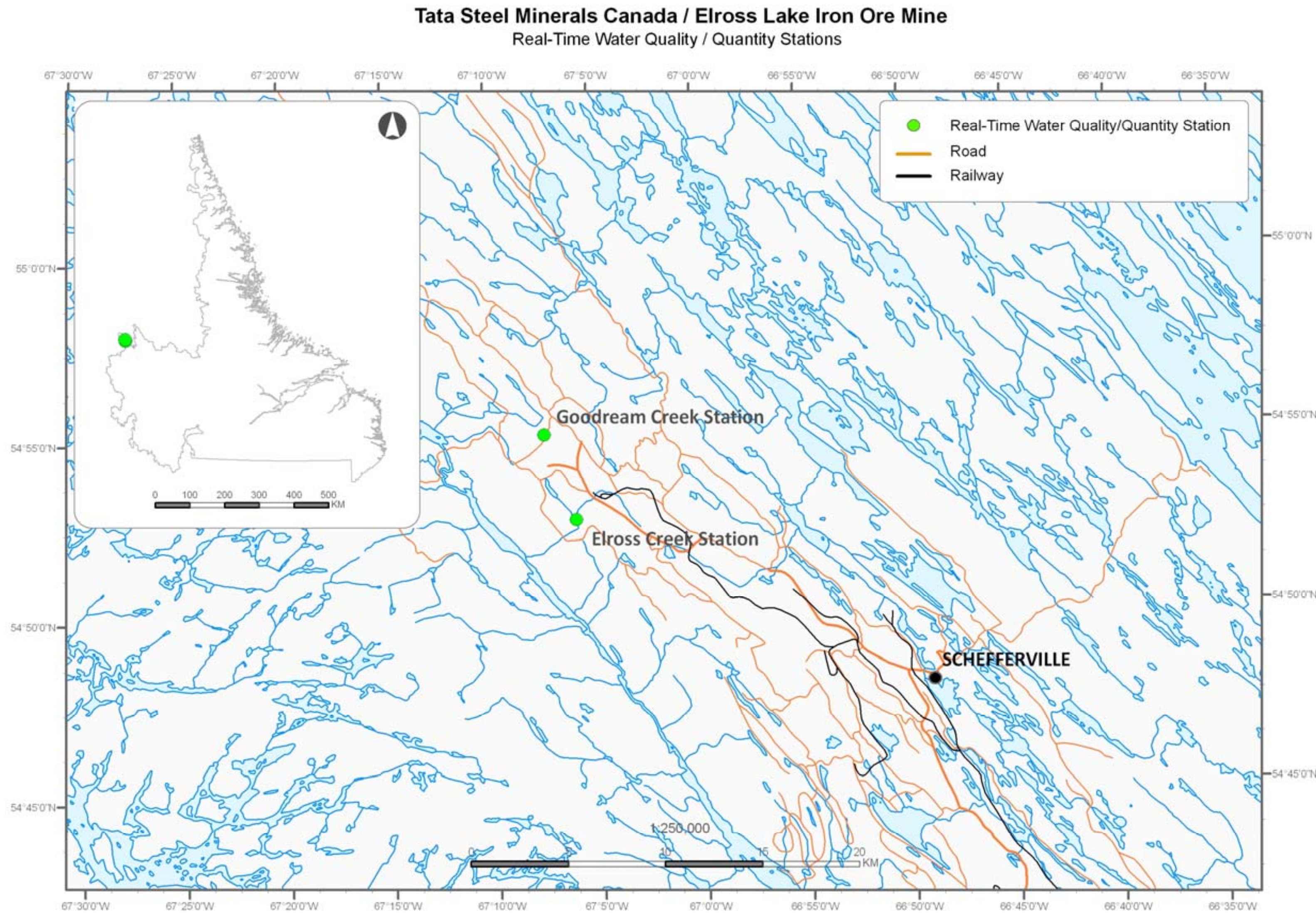

Figure 2. Map of real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in Western Labrador.

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 2014 at Elross Creek and Goodream Creek.

Station	Start date	End date	Duration (days)	Instrument
Elross Creek	2014-06-11	2014-07-16	35	62065
	2014-07-16	2014-08-13	28	62068
	2014-08-13	2014-09-10	28	62065
	2014-09-10	2014-10-06	26	62069
Goodream Creek	2014-06-12	2014-07-16	34	62068
	2014-07-16	2014-08-13	28	62069
	2014-08-13	2014-09-09	27	*
	2014-09-09	2014-10-06	27	62068

***The Goodream Creek hydrolab could not be deployed due to extreme low flow conditions

[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 2014.

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 (µS/cm)	Dissolved oxygen (mg/L)	Turbidity (NTU)
Elross Creek	Start	2014-06-11	62065	Excellent	Excellent	Excellent	Excellent	Excellent
	End	2014-07-16		Excellent	Excellent	Excellent	Excellent	Excellent
	Start	2014-07-16	62068	Excellent	Good	Excellent	Excellent	Excellent
	End	2014-08-13		Excellent	Good	Excellent	Excellent	Excellent
	Start	2014-08-13	62065	Good	Excellent	Excellent	Excellent	Excellent
	End	2014-09-10		Excellent	Fair	Excellent	*	Excellent
	Start	2014-09-10	62069	Excellent	Fair	Excellent	*	Excellent
	End	2014-10-06		Excellent	Good	Excellent	Good	Excellent
Goodream Creek	Start	2014-06-12	62068	Excellent	Good	Excellent	Excellent	Excellent
	End	2014-07-16		Good	Excellent	Excellent	Excellent	Excellent
	Start	2014-07-16	62069	Excellent	Good	Excellent	Excellent	Excellent
	End	2014-08-13		**	**	**	**	**
	Start	2014-08-13	***					
	End	2014-09-09						
	Start	2014-09-09	62068	Excellent	Good	Excellent	Excellent	Excellent
	End	2014-10-06		Excellent	Good	Excellent	Good	Excellent

***During removal of the instrument for the third deployment, and installation for the fourth deployment, at Elross Creek, the oxygen sensor on the QA/QC instrument failed and it was not possible to take a reading**

****At the end of the second deployment period there was extreme low flow and QA/QC measurements were not taken**

*****The Goodream Creek hydrolab could not be deployed due to extreme low flow conditions**

- Bath tests conducted in the winter of 2014 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 2014 field season were relatively minor and within the range normally experienced under rigours field conditions.

Deployment Notes

- No active mining took take place during 2014. This was due to multiple logistical issues with dispatching (railing) and shipment arrangements (Port). The dry circuit of the wet plant, primary and secondary sizing was commissioned in Q3 2014 with stockpiled Timmins 4 ore that was mined in 2013. The 2013 stockpiled ore that could be processed through the dry plant was utilized. Processed ore (final product) was moved by train in Q3 and Q4 2014 to the port in Sept Iles. The dome and wet plant is slated for commissioning in April 2015, and a 25km road was constructed in 2014 to access the deposits necessary for the long term supply of ore to the plant and maintaining TSMC's desired product quality.
- During the third deployment period, from August 13th, 2014 to September 9th, 2014, it was not possible to install a DataSonde at the Goodream Creek Station due to extremely low flow conditions which meant it was impossible to submerse the instrument in flowing water.
- From June 11th, 2014 to August 1st, 2014 there were data transmission issues at the Elross Creek station. While the water quality data was available through the internal log files, some stage data was missing for this period.

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 11, 2014 to October 6, 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 1.015 m to 1.181m at Elross Creek and from 1.742 m to 2.035 m at Goodream Creek from June 11, 2014 to October 6, 2014.
- Fluctuations in stage corresponded well with rainfall events (Figure 4 inset).
- At the end of the second deployment period on August 13, 2014 the stage height at the Goodream Creek station was critically low and it was not possible to redeploy a DataSonde and ensure that it would be fully submerged in flowing water for the following deployment period. As a result no water quality data was recorded at Goodream Creek for 27 days from August 13, 2014 to September 9, 2014.

- Data transmission issues at Elross Creek led to missing stage data from July 16, 2014 to August 1, 2014.
- 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.

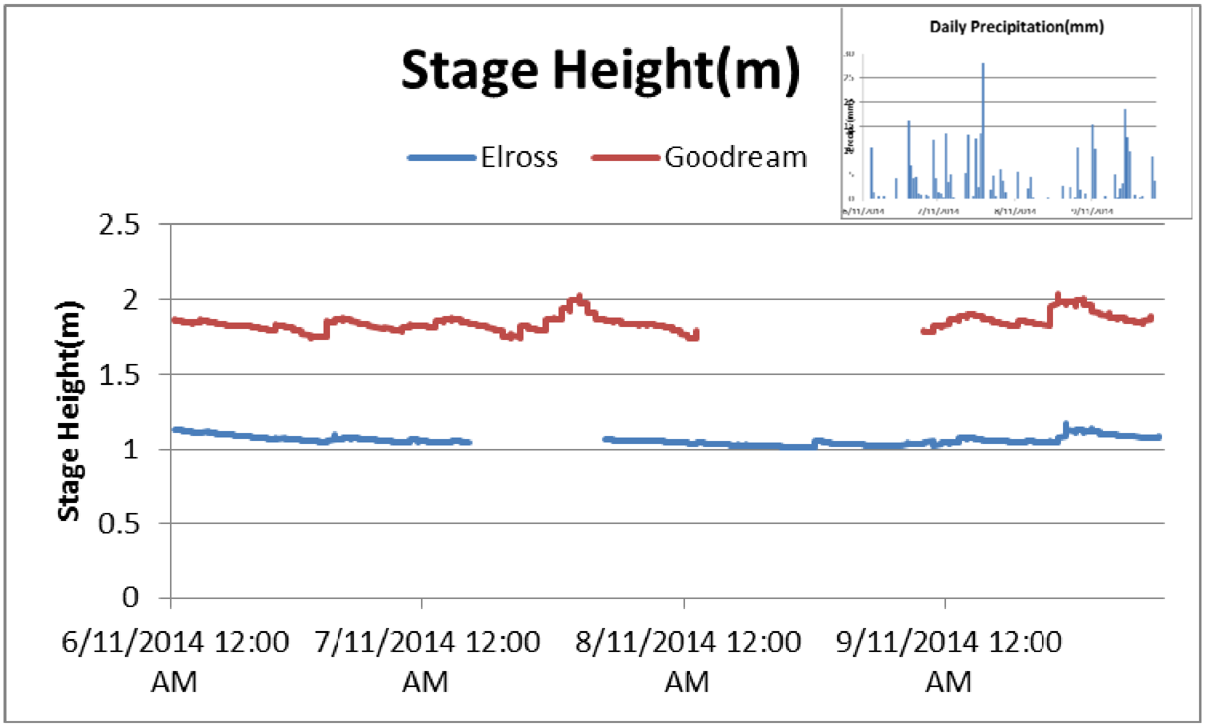

Figure 4. Hourly stage (m) values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014. The inset chart shows total precipitation (mm) recorded at the Schefferville weather station during the same time period. All data was recorded by Environment Canada.

Temperature

- Water temperature ranged from 1.2˚C to 16.3˚C at Elross Creek and from 0.0˚C to 21.5˚C at Goodream Creek from June 11, 2014 to October 6, 2014 (Figure 5).
- No temperature data was recorded at Goodream Creek for 27 days from August 13, 2014 to September 9, 2014, because extreme low flow conditions prevented the deployment of the Hydrolab DataSonde.
- 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).

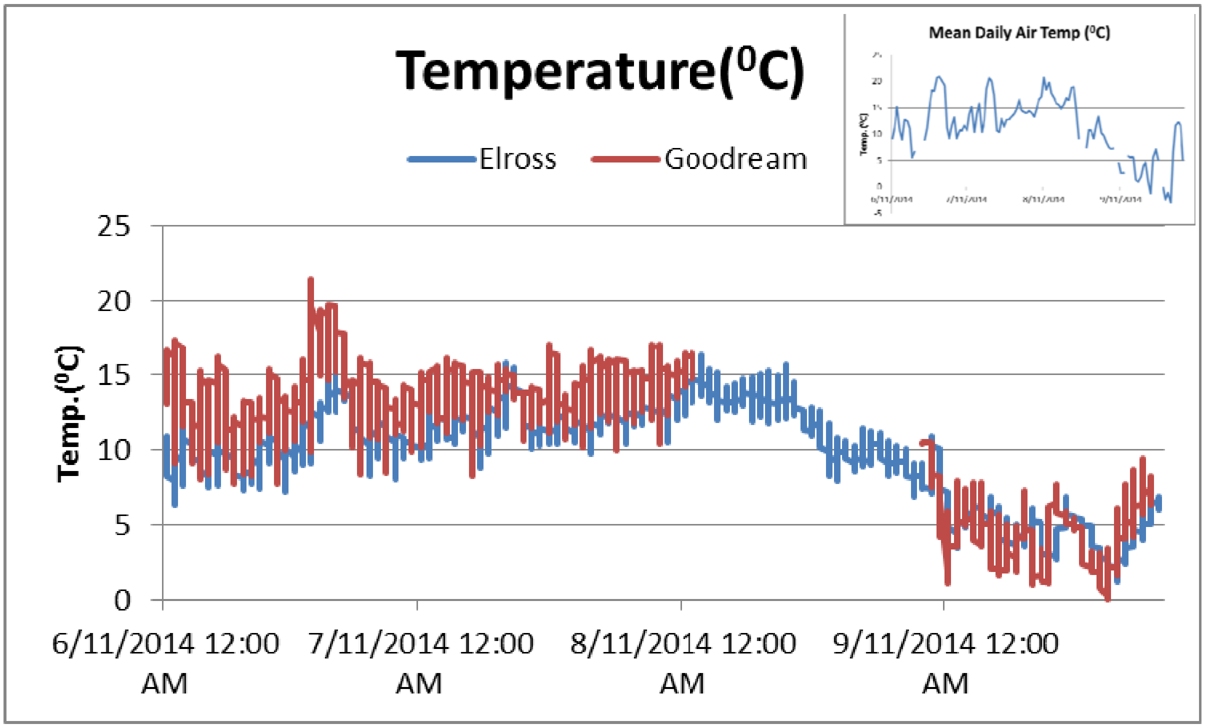

Figure 5. Hourly water temperature (°C) values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014. Inset chart shows air temperature during the same period, as recorded by Environment Canada at the Schefferville weather station.

pH

- pH values ranged from 5.47 units to 6.71 units at Elross Creek and from 3.49 to 6.86 at Goodream Creek from June 11, 2014 to October 6, 2014 (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.
- Around June 29, 2014, it appears that the pH probe fails to operate (see inside blue oval). This failure is most likely due to extreme low flow conditions when the pH probe was exposed to air. Data for this period was groomed out of the final dataset during the QA/QC process.
- No pH data was recorded at Goodream Creek for 27 days from August 13, 2014 to September 9, 2014, because extreme low flow conditions prevented the deployment of the Hydrolab DataSonde.
- 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). Indeed, baseline data was highly variable and acidic at times at the DSO3-15 sampling site (5.8-7.78 units) that is in close proximity to the Elross Creek station, as well as at sampling sites DSO3-11 and DSO3-14 (5.6-7.2 units) that are upstream from the Goodream Creek station.

- During the 2014 field season the median pH at Elross Creek was 6.14, while at Goodream Creek it was 6.09.

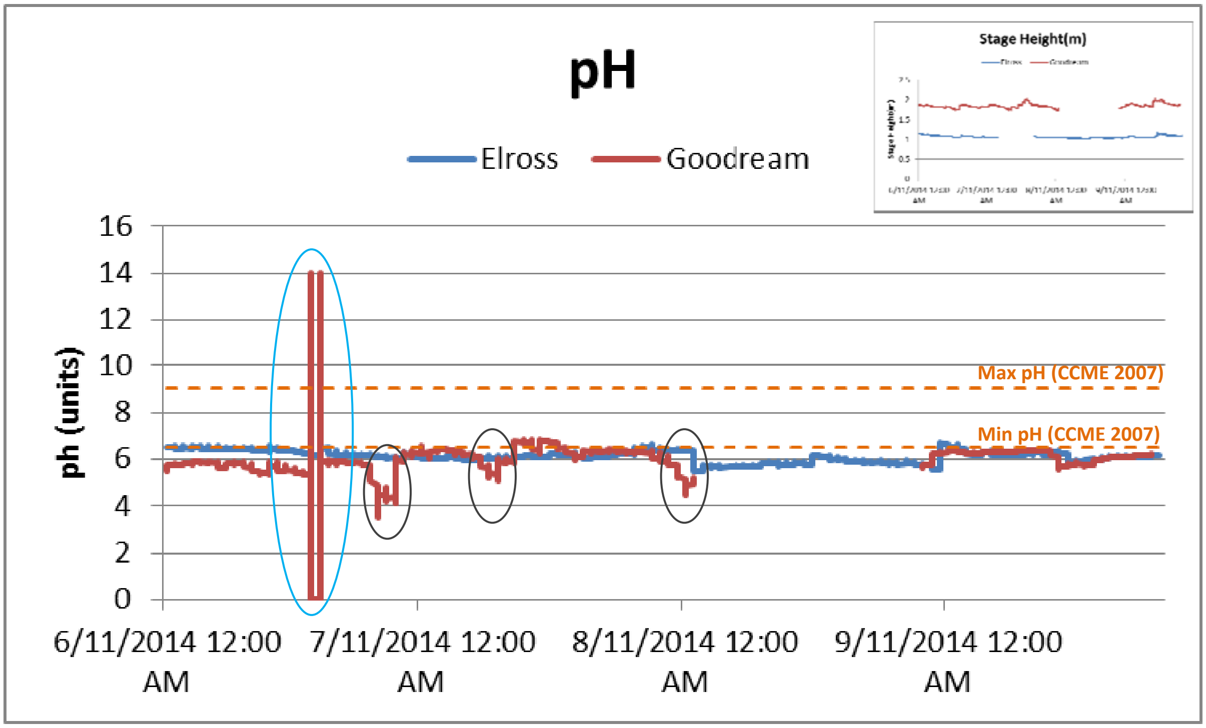

Figure 6. Hourly pH values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014.

Specific Conductivity

- Specific Conductivity ranged from 5.3 µs/cm to 15.0 µs/cm at Elross Creek and from 3.3 µs/cm to 20.0 µs/cm at Goodream Creek from June 11, 2014 to October 6, 2014 (Figure 7).
- At Goodream Creek specific conductivity dropped to zero around June 29, 2014 (see inside grey oval), which is most likely caused by the conductivity probe being exposed to the air during extreme low flow conditions. Data for this period was groomed out of the final dataset during the QA/QC process.
- Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations.

- Trends in specific conductivity were primarily influenced by rainfall events and surface runoff (see stage height inset in Figure 7). Specific conductivity appeared to be elevated during three periods of the deployment season (see inside blue ovals) which were all during times when stage height and stream flow were extremely low. Presumably, during these periods of low flow, the groundwater component of the flow is more significant relative to surface flow, and specific conductivity tends to be elevated as a result.
- During the 2014 field season the median specific conductivity was 7.0 µs/cm at Elross Creek while at Goodream Creek it was 5.0 µs/cm.

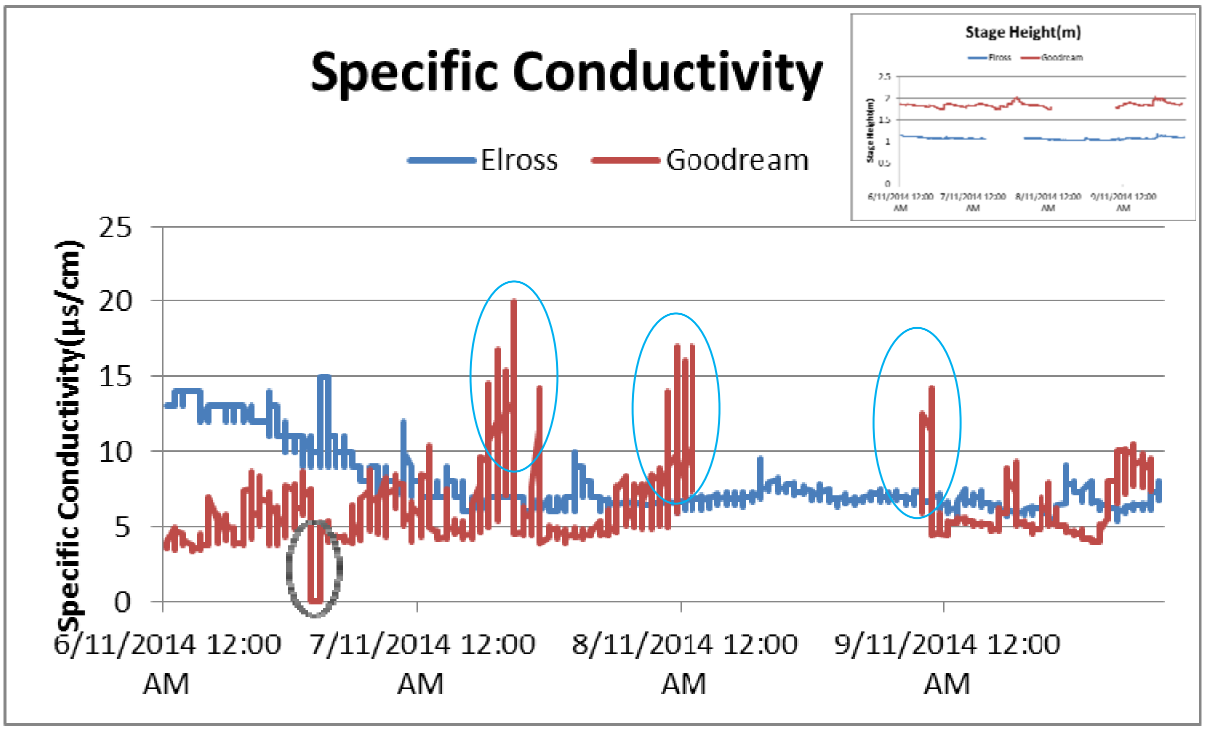

Figure 7. Hourly specific conductivity (µS/cm) values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014.

Dissolved Oxygen

- Dissolved Oxygen (DO) values ranged from 6.87 mg/l (70.4%) to 12.44 mg/l (94.6%) at Elross Creek and from 0.59 mg/l (6%) to 12.85 mg/l (96.3%) at Goodream Creek from June 11, 2014 to October 6, 2014 (Figure 8).
- Around June 29, 2014, DO dropped to 0.0 mg/l (see inside blue oval) which most likely indicates that the probe was exposed to air during extreme low flow conditions. Data during this period was groomed out of the final dataset during the QA/QC process.

- 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.
- 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 2014 field season.

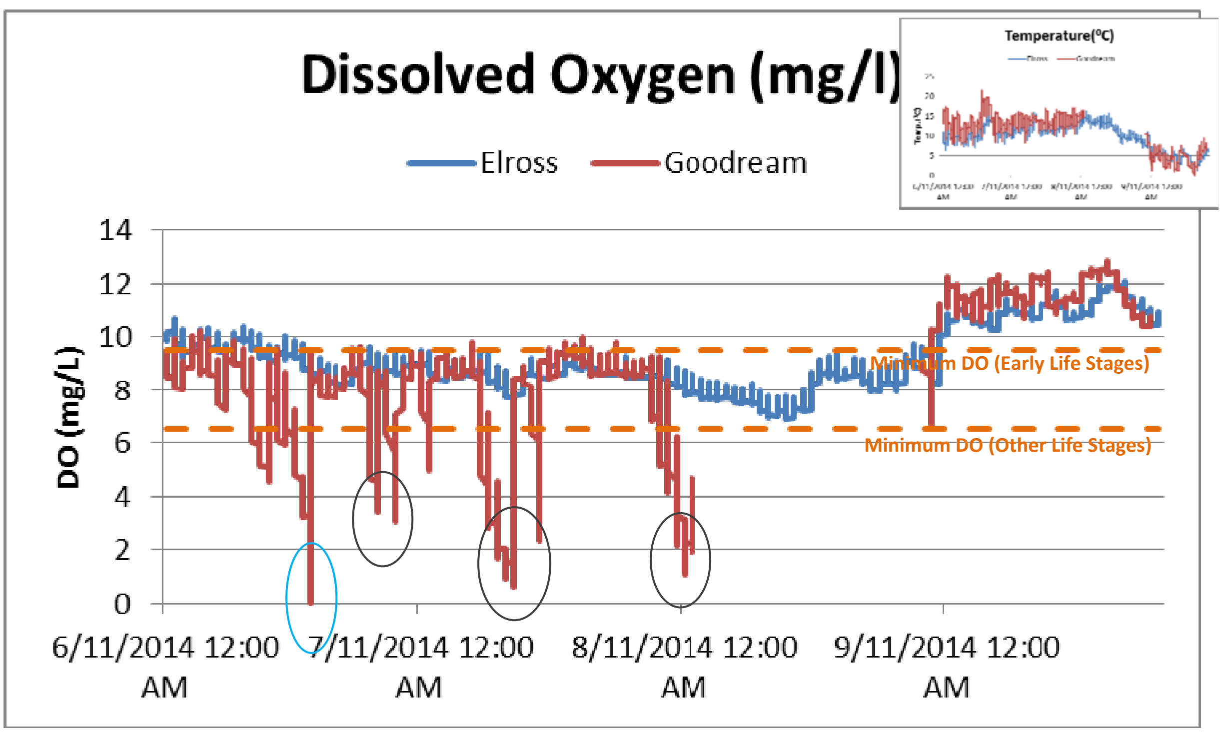

Figure 8. Hourly dissolved oxygen (mg/l) values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014.

Turbidity

- Turbidity values ranged from 0.0 NTU to 722.0 NTU at Elross Creek and 0.0 NTU to 12.3 NTU at Goodream Creek from June 11, 2014 to October 6, 2014 (Figure 9).
- In Figure 9 there are three significant spikes in turbidity at Elross Creek. 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.
- Median turbidity at Elross Creek was 1.0 NTU, while at Goodream Creek it was 0.0 NTU.

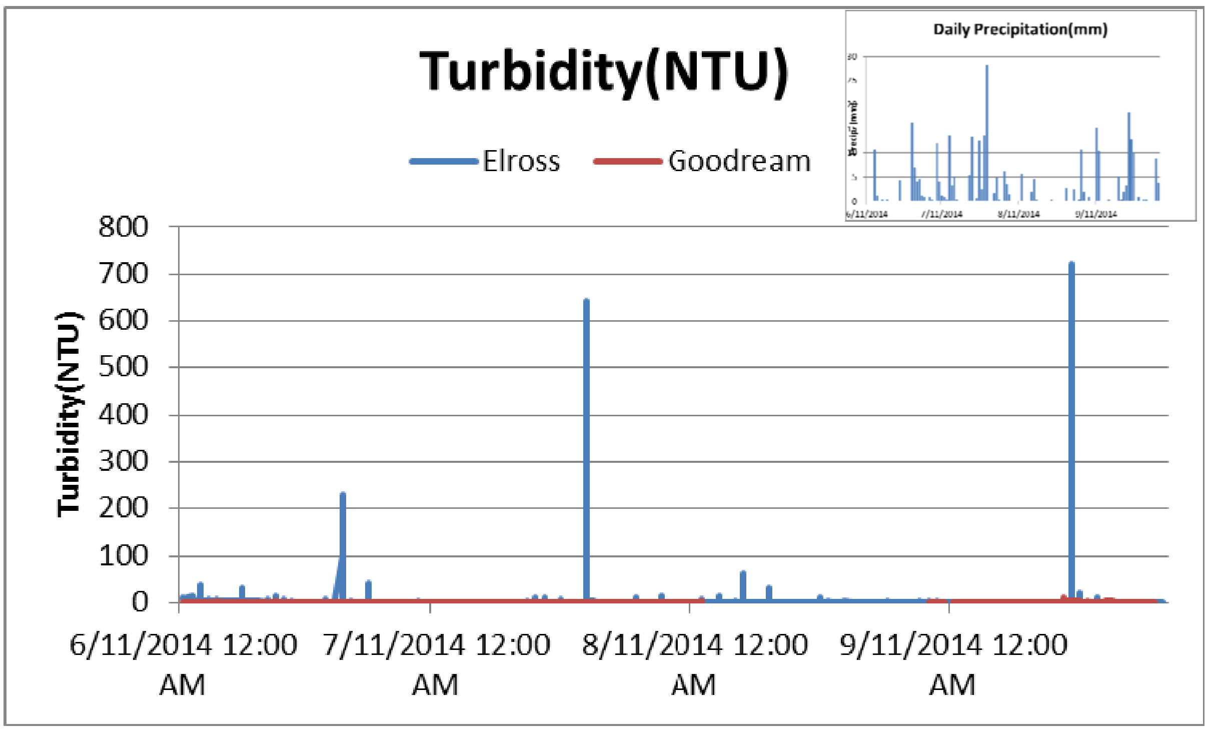

Figure 9. Hourly turbidity (NTU) values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014.

- 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.

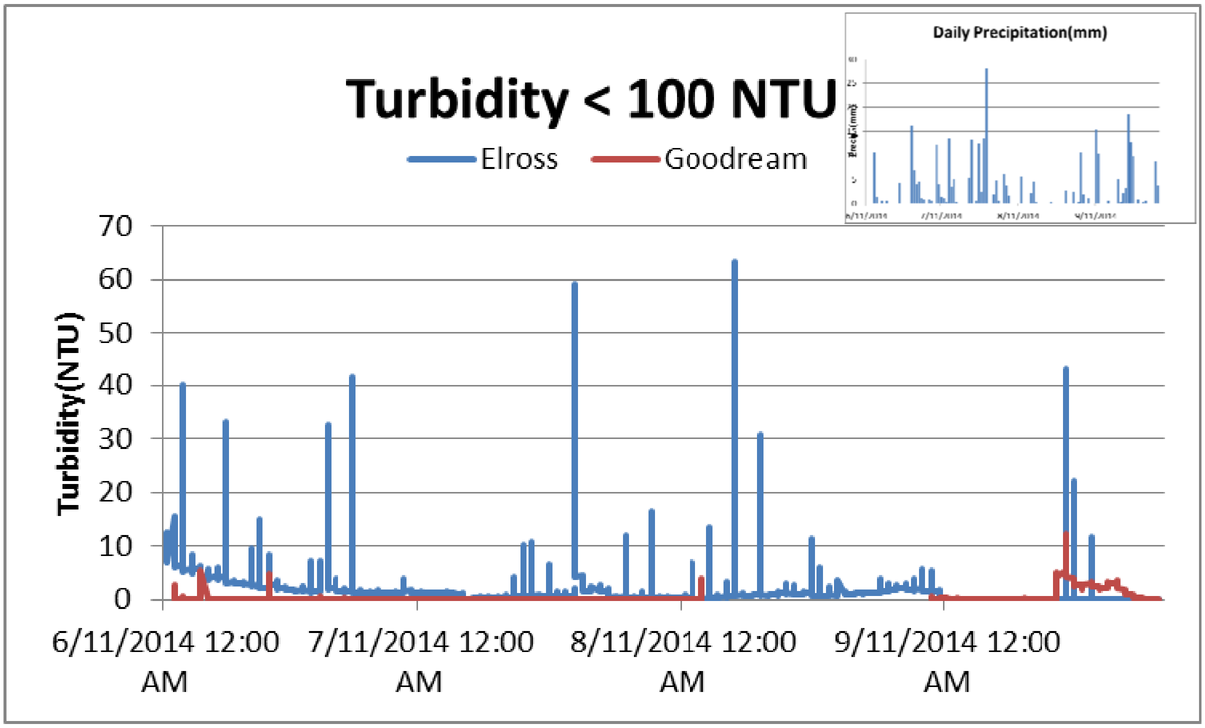

Figure 10. Hourly turbidity (NTU) values recorded at Elross Creek and Goodream Creek from June 11, 2014 to October 6, 2014 with values > 100NTU groomed out.

Conclusions

- Water quality monitoring instruments were deployed at two stations near the Elross Lake, Iron Ore Mine between June 11, 2014 and October 6, 2014. The stations are located on Elross Creek and Goodream Creek.
- The water quality monitoring instruments were deployed for four consecutive deployment periods; however for the third deployment period it was impossible to redeploy the DataSonde at Goodream Creek due to extreme low flow conditions.
- The performance ratings of all instrument sensors ranged between fair and excellent at the beginning and end of each of the four deployment periods. It should be noted that at Goodream Creek at the end of the second deployment period there was extremely low flow conditions and QA/QC readings were not taken and it was not possible to redeploy the DataSonde for the third deployment period.
- 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 1.015 m to 1.181 m at Elross Creek and from 1.742 m to 2.035 m at Goodream Creek from June 11, 2014 to October 6, 2014. Fluctuations in

stage corresponded well with rainfall events. Extreme low flow meant that the DataSonde could not be redeployed at Goodream Creek for the third deployment period. Data transmission issues at Elross Creek led to missing stage height data from July 16, 2014 to August 1, 2014.

- WATER TEMPERATURE: Water temperature ranged from 1.2˚C to 16.3˚C at Elross Creek and from 0.0˚C to 21.5˚C at Goodream Creek from June 11, 2014 to October 6, 2014. Extreme low flow conditions prevented deployment of the DataSonde during the third deployment period and most likely led to elevated temperatures on several occasions throughout the field season. Water temperatures at both stations display large diurnal variations which are related to diurnal trends in air temperatures. Trends in water temperature corresponded well with trends in air temperatures.
- pH: pH values ranged from 5.47 units to 6.71 units at Elross Creek and from 3.49 units to 6.91 units at Goodream Creek from June 11, 2014 to October 6, 2014. pH values show diurnal variations at both stations which are related to diurnal fluctuations in temperature. Extreme low flow conditions meant the DataSonde could not be deployed at Goodream Creek during the third deployment period and may have also caused pH to vary outside its normal range several times and fail completely around June 29, 2014. 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), however low pH levels are normal for this area. During the 2014 field season the median pH at Elross Creek was 6.14, while at Goodream Creek it was 6.09
- SPECIFIC CONDUCTIVITY: Specific Conductivity ranged from 5.3 µs/cm to 15.0 µs/cm at Elross Creek and from 3.3 µs/cm to 20.0 µs/cm at Goodream Creek from June 11, 2014 to October 6, 2014. Specific conductivity values at both stations showed regular diurnal fluctuations which are related to diurnal temperature fluctuations. Trends in specific conductivity were primarily influenced by rainfall events and surface runoff. Specific Conductivity dropped to 0 around June 29, 2014, which was mostly likely caused by extreme low flows exposing the probe to air. During the 2014 field season the median specific conductivity was 7.0 µs/cm at Elross Creek, while at Goodream Creek it was 5.0 µs/cm.
- DISSOLVED OXYGEN: Dissolved Oxygen (DO) values ranged from 6.87 mg/l (70.4%) to 12.44 mg/l (94.6%) at Elross Creek and from 0.59 mg/l (6.0%) to 12.85 mg/l (96.3%) at Goodream Creek from June 11, 2014 to October 6, 2014. Unusually low oxygen levels at Goodream Creek on several occasions were caused by the natural conditions of extremely low water levels. 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, since colder water has a greater potential to dissolve oxygen compared to warmer water. 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). At Goodream Creek DO values fell below the 6.5 mg/l guideline on a number of occasions during extreme low flow conditions.

- TURBIDITY: Turbidity values ranged from 0.0 NTU to 722.0 NTU at Elross Creek and 0.0 NTU to 12.3 NTU at Goodream Creek from June 11, 2014 to October 6, 2014. Median turbidity at Elross Creek was 1.0 NTU, while at Goodream Creek it was 0.0 NTU. 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 2015, when ice conditions allow, and perform regular site visits throughout the 2015 deployment season, for calibration and maintenance of the instruments.
- ENVC staff will continue to rely on input and assistance from TSMC staff in the operation and maintenance of the Elross Creek and Goodream Creek stations. Every effort will be made to coordinate in advance with TSMC staff for site visits during the 2015 field season. ENVC staff are very appreciative of the field assistance provided by TSMC staff during the 2014 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 the spring of 2015 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 2015 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 (°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 (^oC) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965).

APPENDIX C

Environment Canada Weather Data - 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)
6/11/2014	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

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
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
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	

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
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
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

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
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

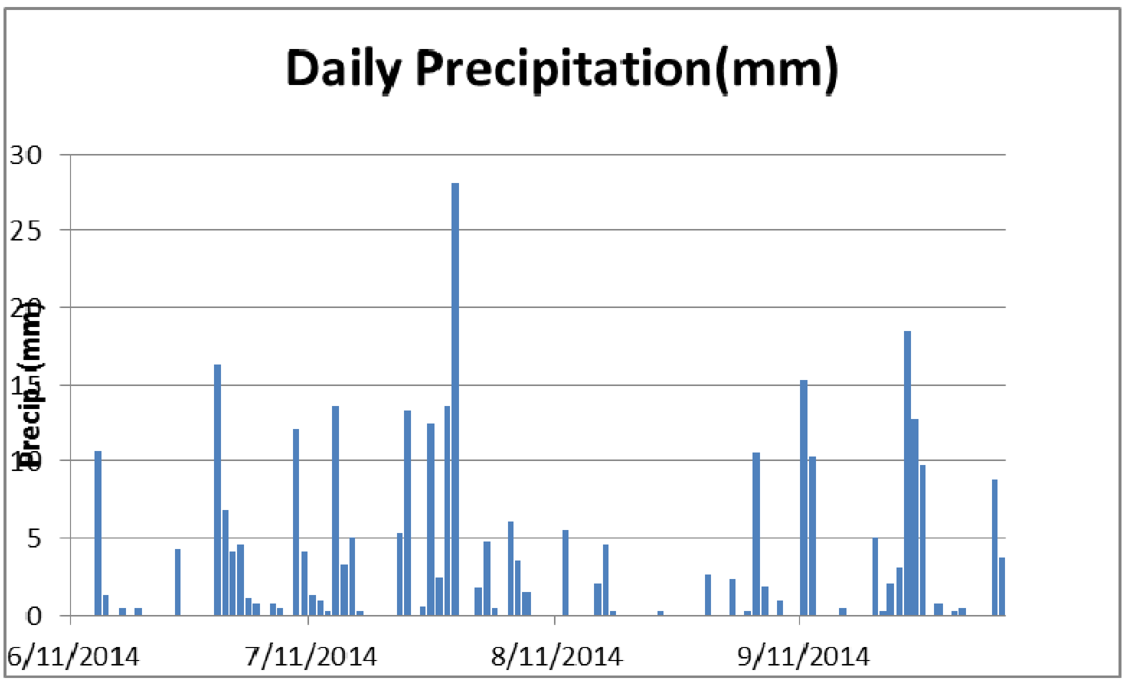

Figure 1. Daily precipitation recorded at the Schefferville Weather Station by Environment Canada from June 1, 2014 to October 6, 2014.

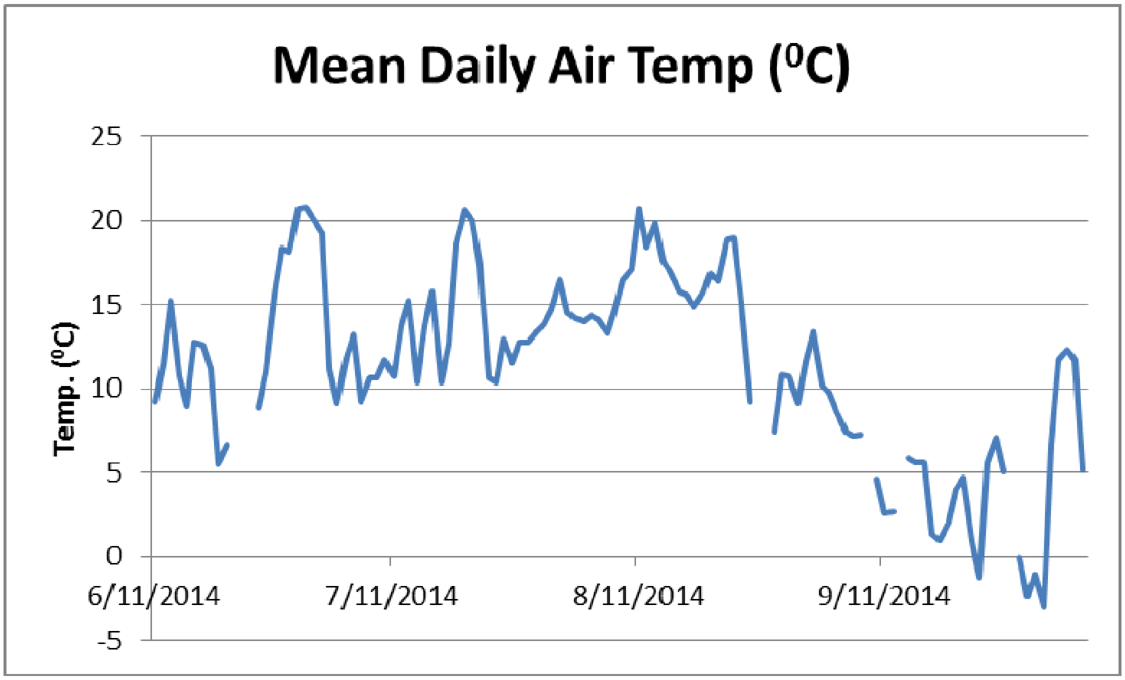

Figure 2. Daily mean temperature recorded at the Schefferville Weather Station by Environment Canada from June 11, 2014 to October 6, 2014.