Real Time Water Quality Report

Tata Steel Minerals Canada Elross Lake Network

Deployment Period 2015-06-03 to 2015-07-09

Newfoundland Labrador

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General

- During the 2015 field season the Water Resources Management Division, in partnership with Tata Steel Minerals Canada Limited and Environment Canada, maintained two real-time water quality and water quantity stations in close proximity to the 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.
- Station sites were selected to monitor all surface water outflows from the Elross Lake mining site. The Elross Creek Station is situated downstream of the Timmins 1 pit, and downstream of Pinette Lake. The Goodream Creek Station will serve to monitor potential impacts from groundwater flowing from Timmins 6 pit into the surface water of Goodream Creek.
- The Water Resources Management Division will inform Tata Steel Minerals Canada Limited of any significant water quality events by email notification and by monthly deployment reports.
- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from June 03, 2015 to July 09, 2015, which was the first deployment of the 2015 field season.

Quality Assurance / Quality Control

- Water quality instrument performance is tested at the beginning and end of its deployment period. The process is outlined in Appendix A.
- Instruments are assigned a performance rating (i.e., poor, marginal, fair, good or excellent) for each water quality parameter measured.
- Table 1 shows the performance ratings of five water quality parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen and turbidity) measured by instruments deployed at the water monitoring stations.
- **With the exception of water quantity data (stage height), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QA/QC protocol. The stage data is raw data that is transmitted via satellite and published on our web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request**.

Table 1: Water quality instrument performance at the beginning and end of deployment

	Elross Creek			Goodream Creek	
Stage of deployment	Beginning	End		Beginning	End
Date	2015-06-03	2015-07-08		2015-06-04	2015-07-09
Temperature	Excellent	Excellent		Excellent	Excellent
pH	Excellent	Poor		Poor	Excellent
Specific Conductivity	Excellent	Excellent		Excellent	Excellent
Dissolved Oxygen	Excellent	Excellent		Excellent	Excellent
Turbidity	Fair	Excellent		Excellent	Fair

- The performances of the Temperature, Specific Conductivity, and Dissolved Oxygen sensors were rated excellent at the beginning and end of the deployment period for both Elross and Goodream Creeks (Table 1).

- The pH sensor at Elross Creek was rated excellent at the beginning of the deployment period and poor at the end, while at Goodream Creek the opposite is true. Given the background turbidity levels at Elross Creek the poor performance of the pH sensor at the end of the deployment period can be attributed to build-up of fine suspended particles on the Teflon junction of the pH sensor over the duration of the deployment period. At Goodream Creek, the poor rating at deployment is related to the slow response time of the pH sensor when deployed in extremely low conductivity waters (see further explanation in the Data Interpretation section for pH – Figure 6: pH at Goodream Creek).
- The Turbidity sensor at Elross Creek was rated fair at the beginning of the deployment period and excellent at the end, while at Goodream Creek the opposite is true. The cause of these ratings is related to the typical background turbidity levels at both sites as well as site conditions at the time of deployment and removal.

Deployment Notes

- Water quality monitoring for this deployment period season started at Elross Creek on June 3, 2015 at 2:30 pm and at Goodream Creek on June 4, 2015 at 10:50 am. Continuous real-time monitoring continued at both sites without any significant operational issues until July 8, 2015 at Elross Creek and July 9, 2015 at Goodream Creek, when the instruments were removed for maintenance and calibration.

Data Interpretation

- Data records were interpreted for each station during the deployment period for the following six parameters:
  - (i.) Stage (m)
  - (ii.) Temperature (^oC)
  - (iii.) pH
  - (iv.) Specific conductivity (□S/cm)
  - (v.) Dissolved oxygen (mg/l)
  - (vi.) Turbidity (NTU)

Stage

- During the deployment periods covered by this report, stage height values ranged from 1.08 m to 1.28 m at Elross Creek and from 1.80 m to 2.10 m at Goodream Creek (Figures 1 and 2). Stage height is directly related to the volume of flow in a stream as defined by a rating curve which is unique for every site.
- For both Elross Creek and Goodream Creek there is a gentle declining trend for the first three to four weeks of the deployment period, which is typical for this time of the year when spring runoff is a dominant factor in local hydrological conditions. For both stations the last week or so of the deployment is dominated by increased flow related to significant rainfall events (Climate data located in Appendix B).
- For both Elross and Goodream Creeks there is a significant spike in stage height from around July 7 to the end of the deployments, (see inside red ovals) which is related to significant rainfall for the Schefferville area totaling over 41 mm for July 7th and 8th.

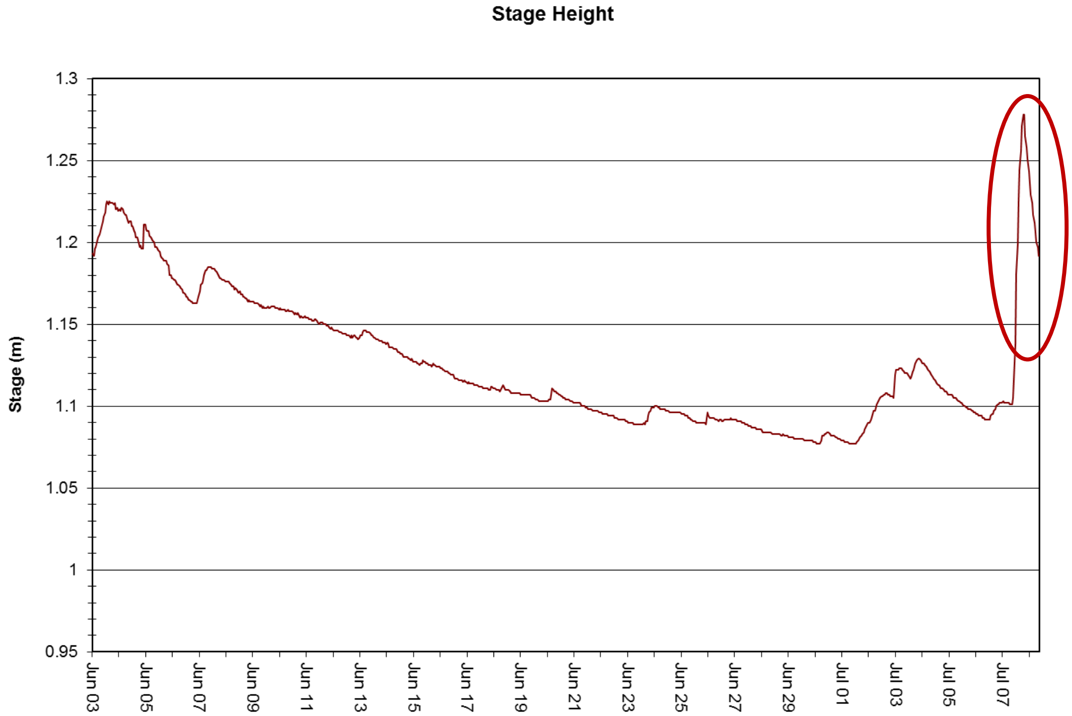

Figure 1: **Stage Height (m) at Elross Creek –June 03, 2015 to July 08, 2015**

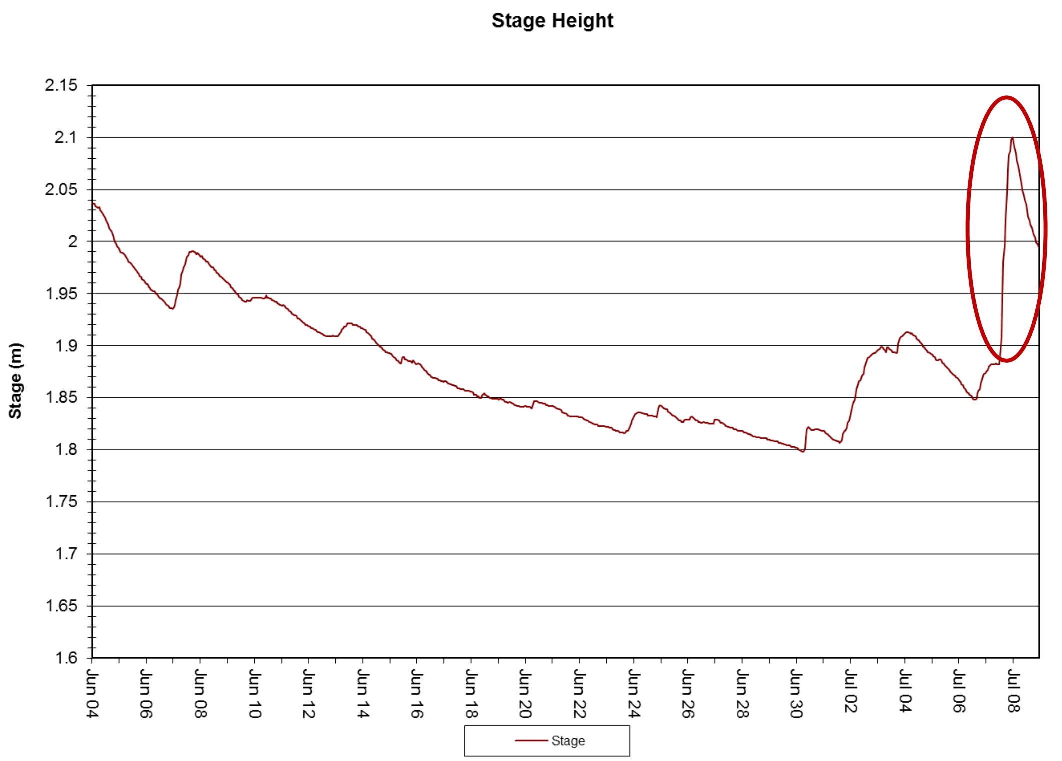

Figure 2: **Stage Height (m) at Goodream Creek – June 04, 2015 to July 09, 2015**

Temperature

- During the deployment periods covered by this report, water temperature ranged from 2.40˚C to 14.30˚C at Elross Creek and from 3.70˚C to 17.90˚C at Goodream Creek (Figures 3 & 4).
- For both Elross Creek and Goodream Creek there is an increasing temperature trend over the deployment period which is consistent with the transition from spring to summer.
- Both Goodream and Elross stations display noticeable diurnal variations, typical of shallow water streams and ponds that are highly influenced by diurnal variations in ambient air temperatures.
- At both Elross and Goodream Creeks temperature takes a noticeable dip (see inside red ovals) over the last two days of the deployment due to a significant increase in flow in relation to heavy rain for the corresponding timeframe.

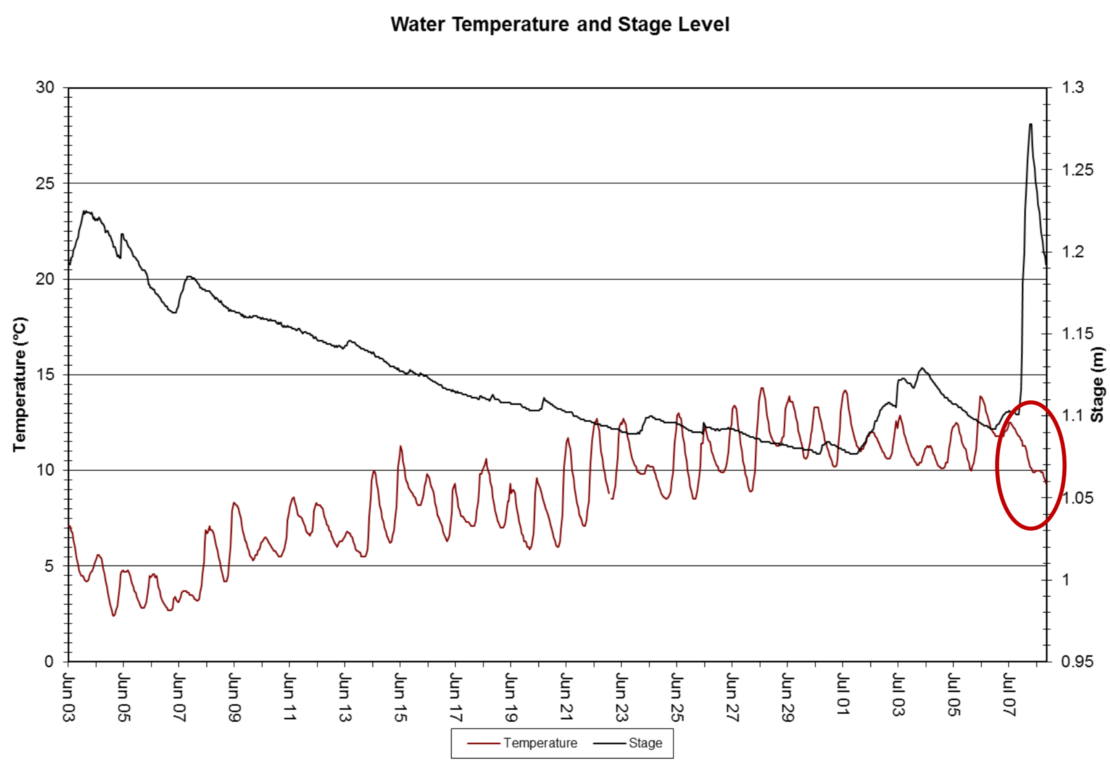

Figure 3: Temperature (^oC) - Elross Creek – June 03, 2015 to July 08, 2015

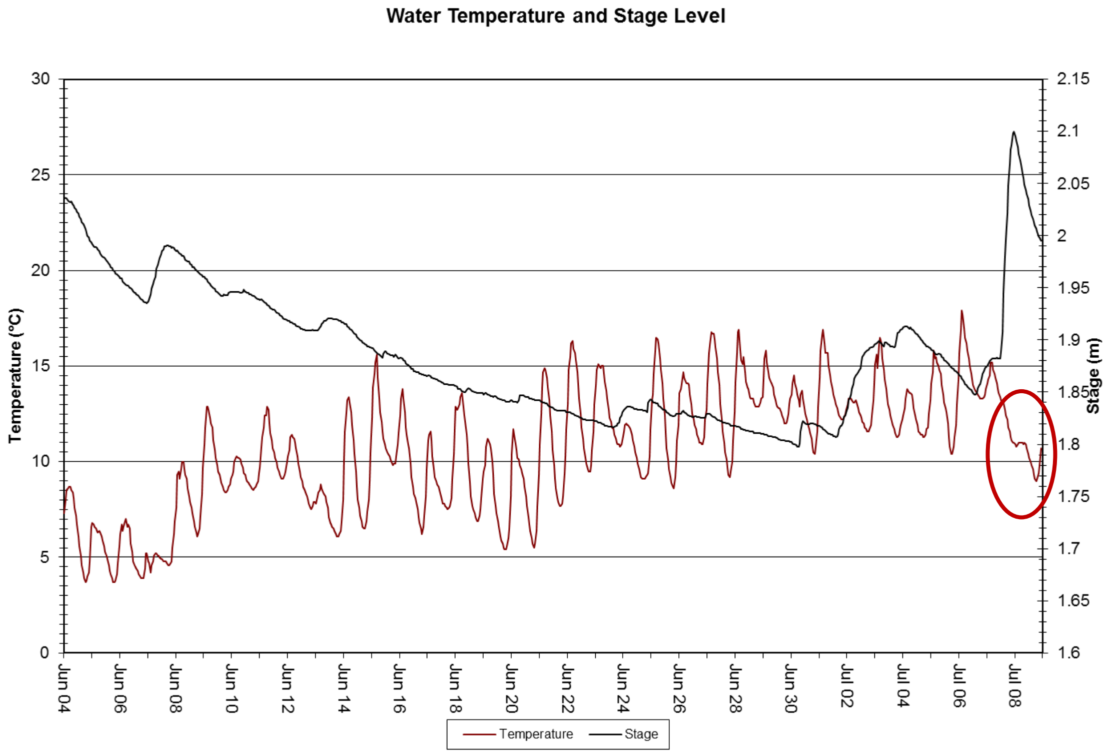

Figure 4: Temperature (°C) - Goodream Creek - June 04, 2015 to July 09, 2015

pH

- During the deployment periods covered by this report, pH values ranged from 5.77 units to 6.40 units at Elross Creek, and from 4.27 units to 5.76 units at Goodream Creek (Figures 5 & 6).
- pH tends to show a diurnal trend which is related to the diurnal temperature trend. This diurnal trend is fairly weak during this deployment period but is still discernible for the two stations.
- At Goodream Creek it appears that pH was affected by low flow conditions (see inside red oval) from about June 29 to July 2. During the low flow conditions it appears that pH is more variable than normal. Low flow can affect water quality and have an impact on indicator parameters such as pH, dissolved oxygen, and specific conductivity, tending to push them outside their normal range.
- At Goodream Creek pH was very slow to stabilize during the first few hours of the deployment (See inside green oval). This slowness to stabilize is partially due to the slow response time of the pH sensor when deployed in extremely low conductivity waters such as Goodream Creek. This slow response time can be also be exaggerated by an aging pH sensor which is nearing the end of its life.

- At Goodream Creek pH was affected by a significant spike in flow at the end of the deployment period (See inside orange oval) when a rapid increase in flow pushed pH down by one pH unit in less than 12 hours.
- At both Elross Creek and Goodream Creeks pH is 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(CCME) (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.

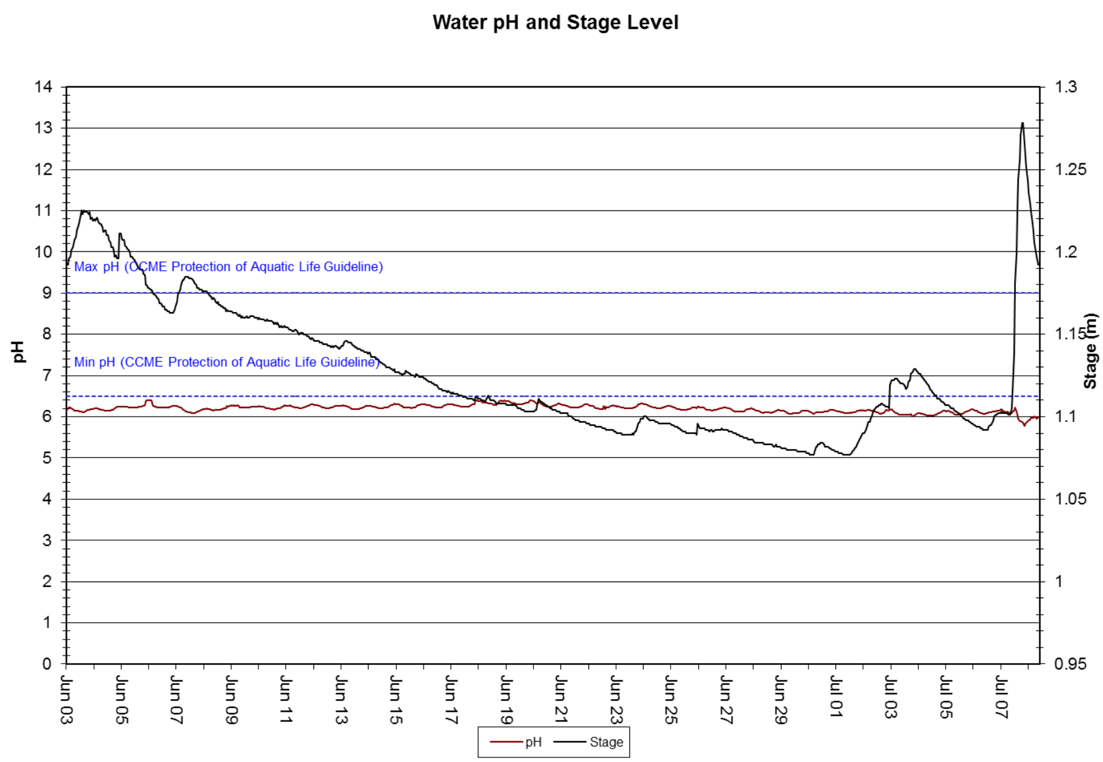

Figure 5: pH at Elross Creek – June 03, 2015 to July 08, 2015

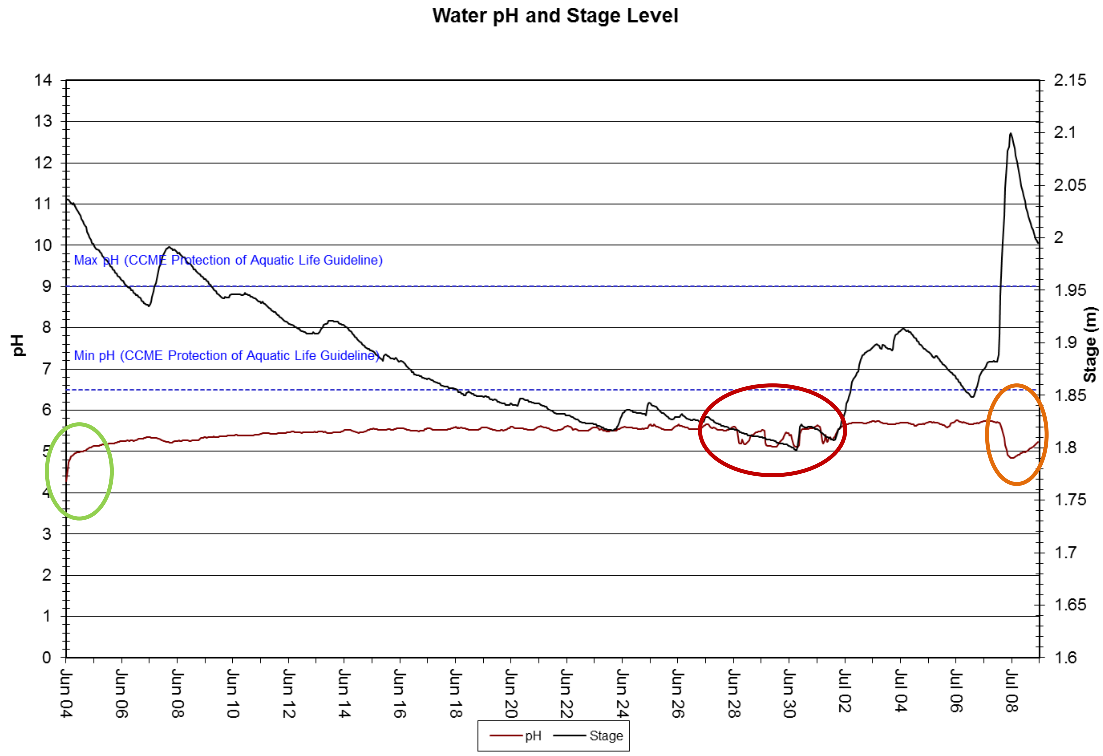

Figure 6: pH at Goodream Creek – June 04, 2015 to July 09, 2015

Specific Conductivity

- During the deployment periods covered by this report, specific conductivity ranged from 4.6 µs/cm to 8.9 µs/cm at Elross and 2.2 µs/cm to 4.9 µs/cm at Goodream Creek (Figures 7 & 8).
- At both Elross and Goodream creeks, specific conductivity shows diurnal trends which are related to the diurnal temperature trend.
- At Goodream Creek, the increasing temperature trend over the deployment period is clearly impacting the specific conductivity trend over the same timeframe, with a comparable increasing trend. At Elross creek, this trend is masked by complicating impacts from other variables as indicated by higher background turbidity readings.
- Rapid increases in flow due to significant precipitation events tends to impact specific conductivity and for both Elross and Goodream Creeks there are spikes in specific conductivity in the last few days of the deployment period (see inside red ovals).
- At Goodream Creek specific conductivity was impacted by low flow conditions (see inside green oval). It appears that during low flow conditions, when the proportional input from groundwater (vs surface water) is higher, specific conductivity is slightly elevated.

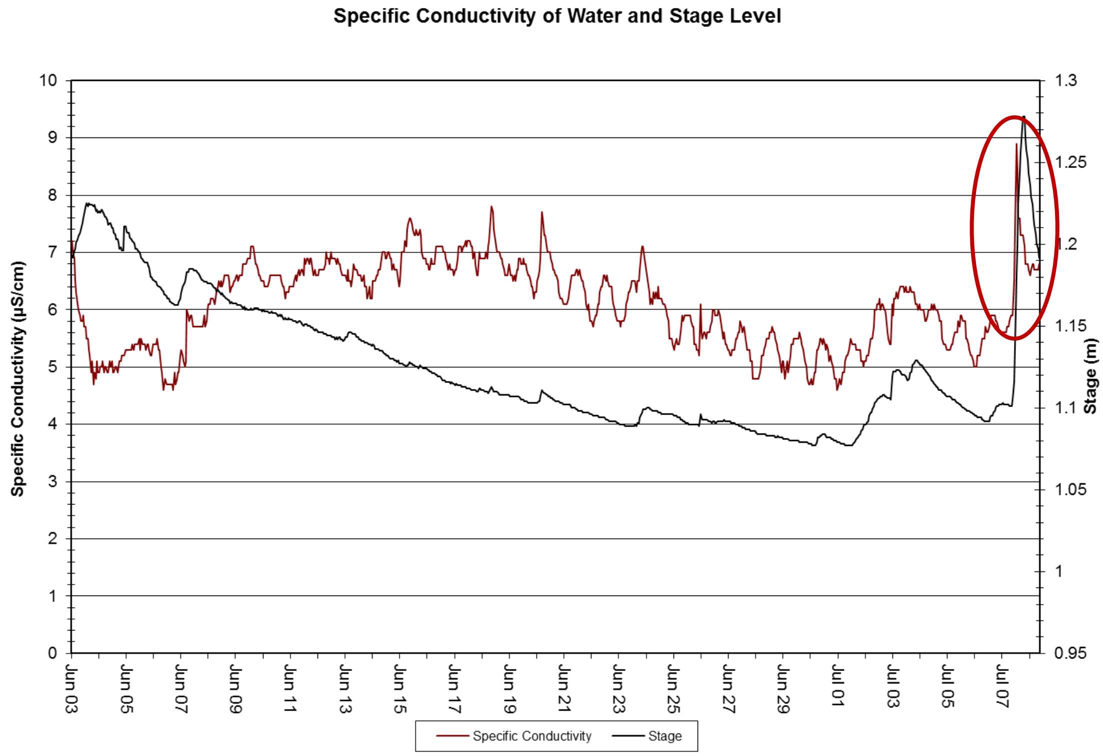

Figure 7: **Specific conductivity (us/cm) - Elross Creek – June 03, 2015 to July 08, 2015**

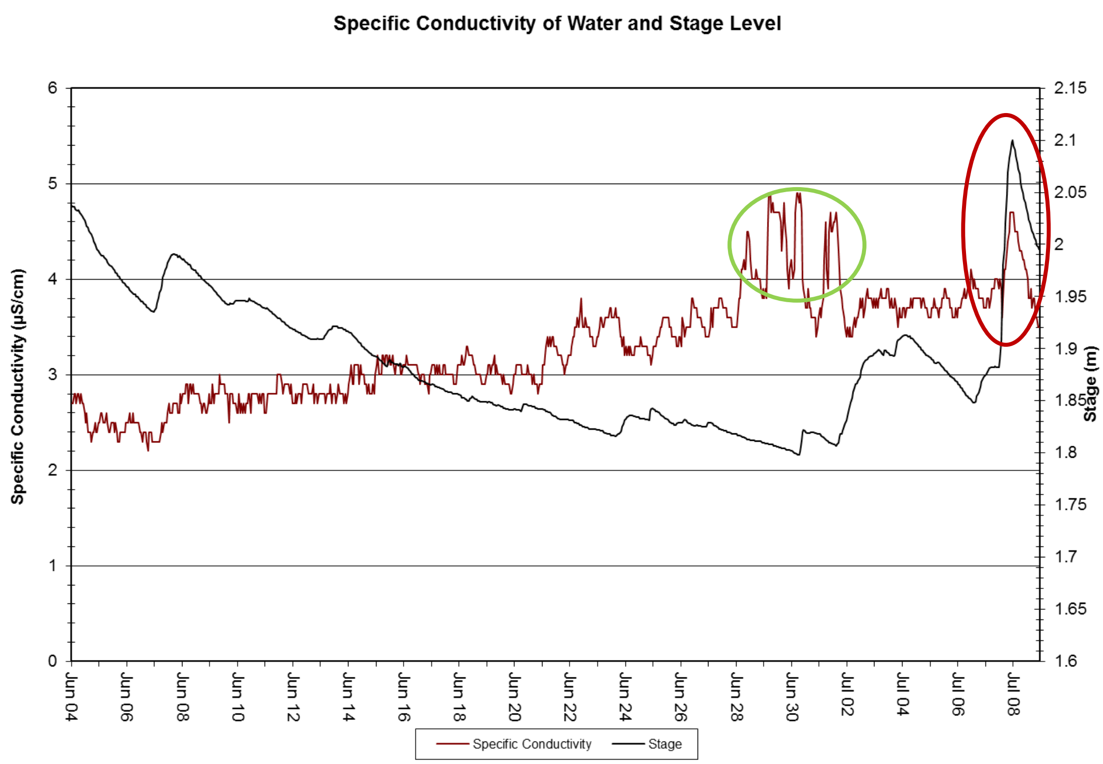

Figure 8: **Specific conductivity (us/cm) - Goodream Creek – June 04, 2015 to July 09, 2015**

Dissolved Oxygen

- During the deployment periods covered by this report, dissolved oxygen (DO) values ranged from 8.74 mg/l (81.6% saturation) to 12.31 mg/l (97.6% saturation) at Elross Creek (Figure 9). At Goodream Creek DO values were significantly impacted by low flow conditions and ranged from 4.26 mg/l (40.6% saturation) to 12.24 mg/l (95.2% saturation) (Figure 10).
- DO remains relatively stable over the deployment period for Elross Creek, with a gentle declining trend which is directly related to the increasing temperature trend. At Goodream Creek this general decreasing DO trend is noticeable, however the impacts of low flow conditions are far more significant.
- At Goodream Creek DO there is a period from approximately June 28 to July 2 when low flow conditions had a significant impact on DO values (see inside green oval). In general this is due to the fact that reduced flows lead to reduced turbulent flow which is the most significant pathway for the input of oxygen into water.
- The DO values at Elross Creek were at, or slightly below, minimum guideline set for cold-water biota during early life stages (9.5 mg/l), and above minimum guidelines set for other life stages (6.5 mg/l), as determined by the Canadian Council of Ministers of the Environment (2007). The same is true at Goodream Creek, with the exception of the period of extreme low flow.

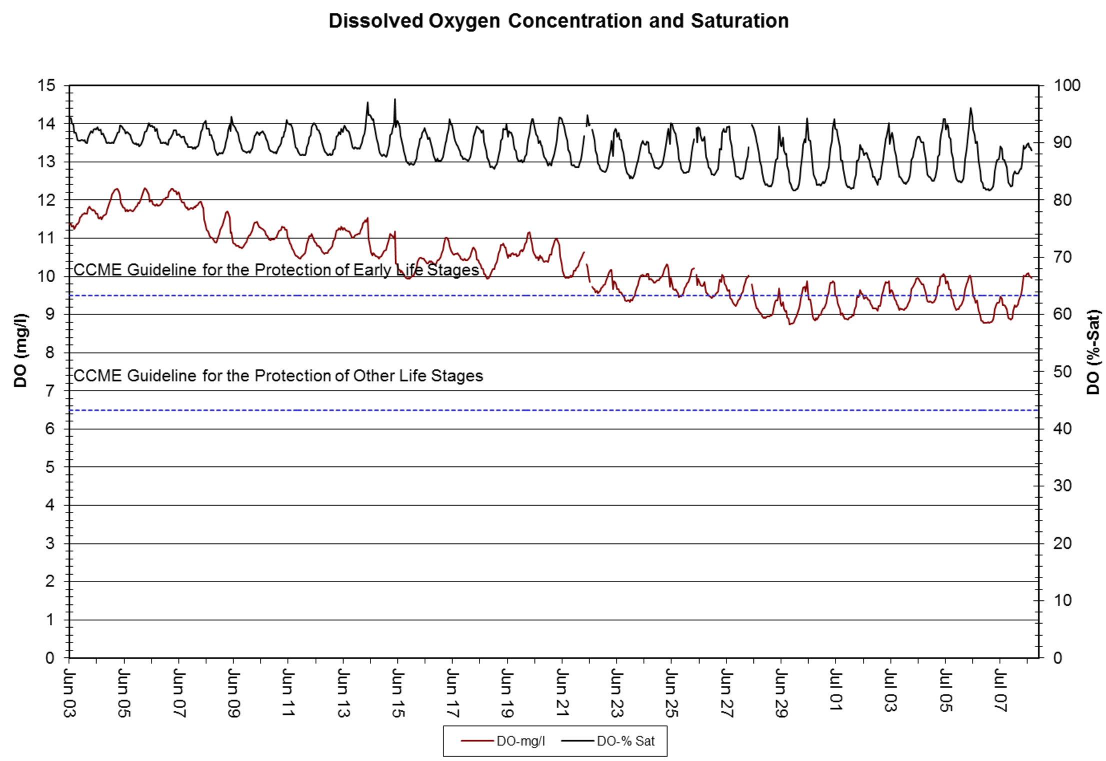

Figure 9: DO (mg/l & % saturation) at Elross Creek – June 03, 2015 to July 08, 2015

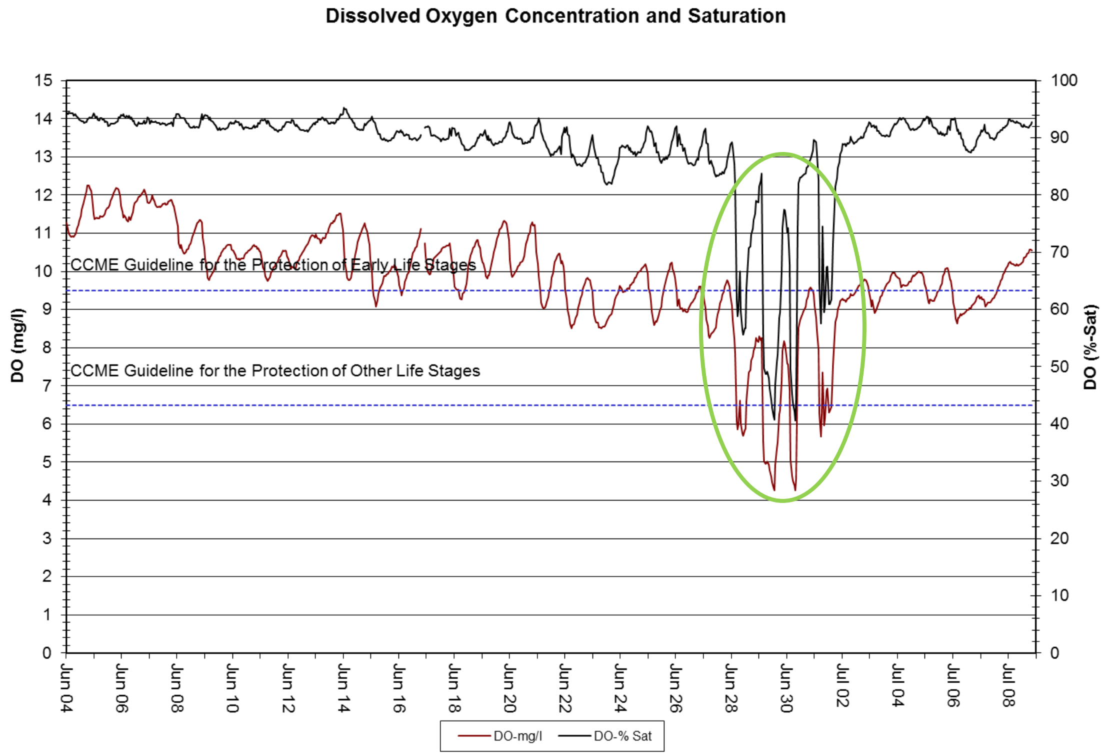

Figure 10: **DO (mg/l & % saturation) at Goodream Creek – June 04, 2015 to July 09, 2015**

Turbidity

- During the deployment periods covered by this report, turbidity values ranged from 0.0 NTU to 685.0 NTU at Elross Creek (Figure 11) and from 0.0 NTU to 27.0 NTU at Goodream Creek (Figure 12). In order to give a better indication of background turbidity levels at Elross Creek, Figure 13 shows only the turbidity data which was less than 50 NTU. This required removing 7 datum from the June dataset.
- A significant spike in turbidity at both Elross Creek and Goodream Creek (see inside red ovals) corresponds with significant rainfall events and a subsequent increase in flow which took place during the last few days of the deployment period.
- The turbidity levels at Goodream Creek are typically much lower than Elross Creek and are indicative of natural background water quality in the general area. At Goodream Creek spikes in turbidity due to significant runoff events tend to be relatively small and short term.
- At Elross Creek water quality is impacted by ground disturbance, erosion and sedimentation in relation to historical mining activity in the area. As a result, background levels are higher (see Figure 13), and the impact of significant runoff events is more pronounced. Given the relatively high background turbidity levels at Elross and the tendency of turbidity readings to fluctuate and be highly variable in the short term, it is often difficult to achieve excellent comparisons between the field and QA/QC sonde at the time of deployment.

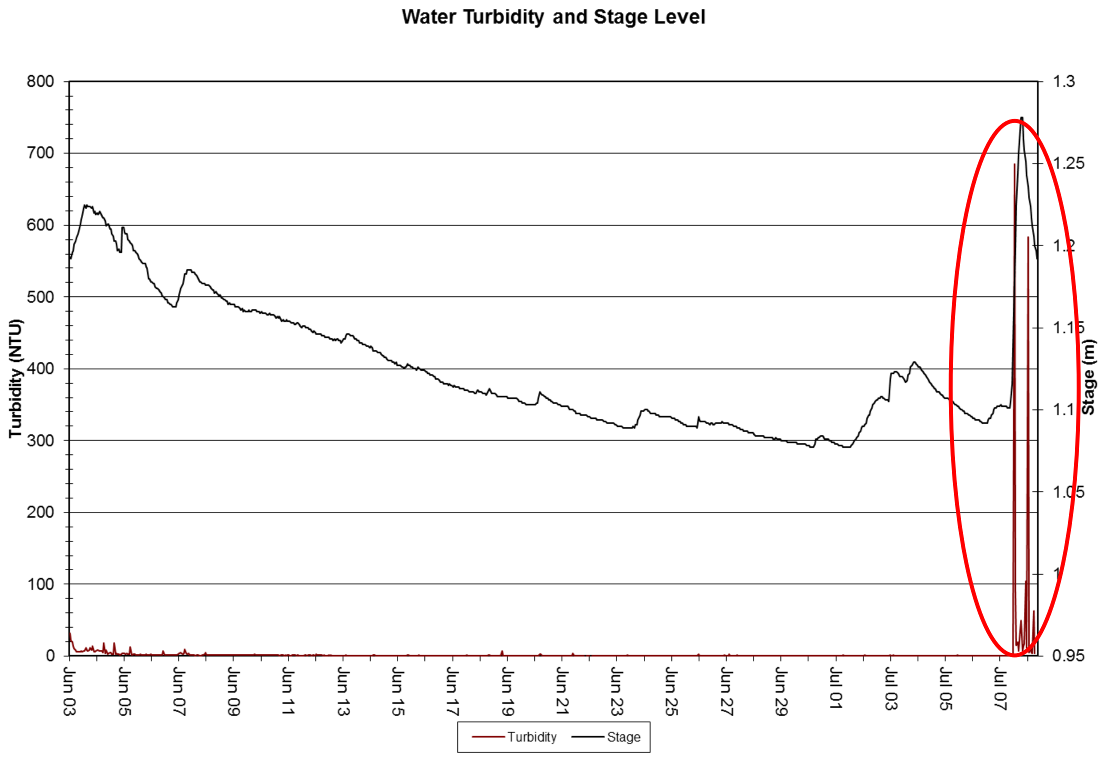

Figure 11: Turbidity (NTU) at Elross Creek – June 03, 2015 to July 08, 2015

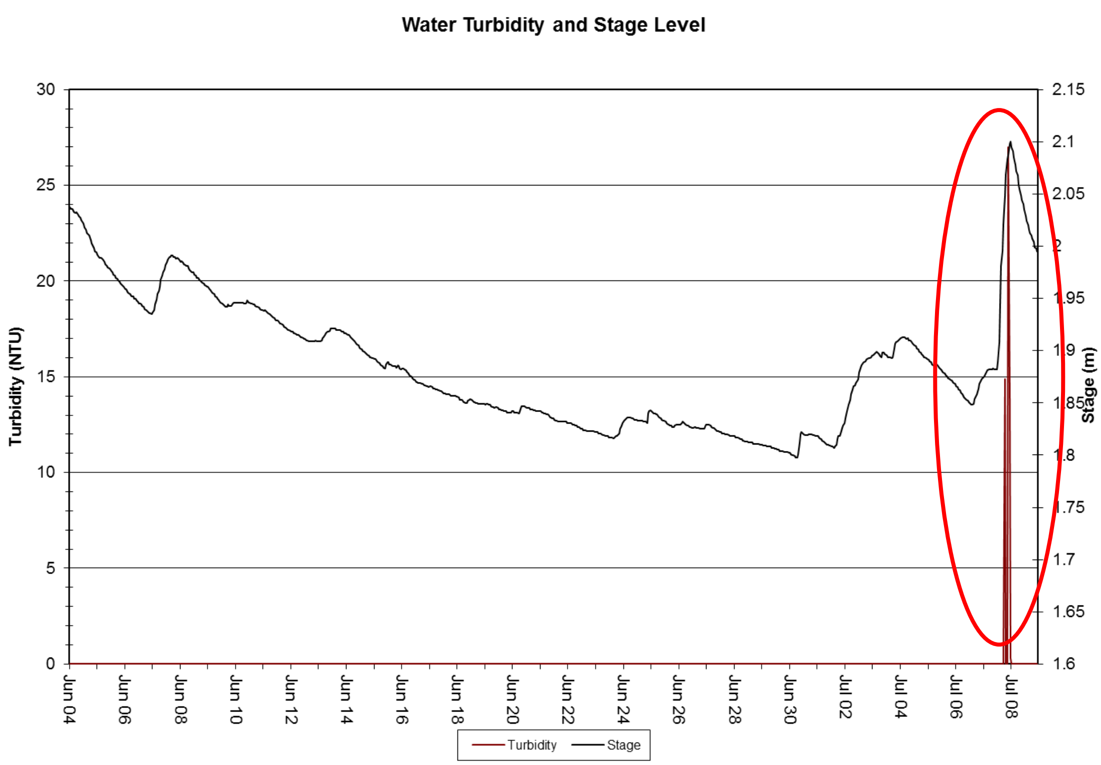

Figure 12: Turbidity (NTU) at Goodream Creek – June 04, 2015 to July 09, 2015

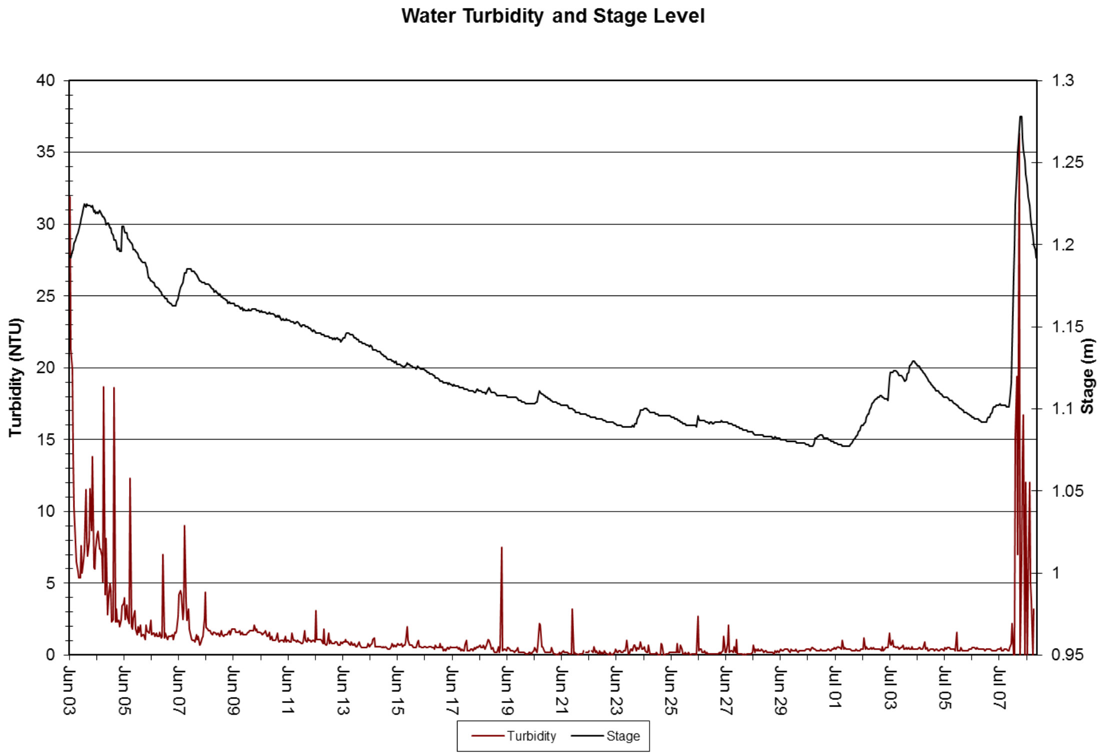

Figure 13: Turbidity (< 50 NTU) at Elross Creek – June 03, 2015 to July 08, 2015

Conclusions

- This monthly deployment report, presents water quality and water quantity data recorded at the Elross Creek and Goodream Creek stations from June 03, 2015 to July 09, 2015.
- Field instruments for both stations performed well over the deployment period with no significant maintenance issues.
- Variations in water quality/quantity values recorded at each station are summarized below:
    - Stage height for both Elross Creek and Goodream Creek was typical for the time of this deployment period, when the hydrology of the area is dominated by spring runoff and the transition to summer when significant rainfall events cause sharp spikes in stream flow.
    - For both Elross Creek and Goodream Creek temperature shows a general rising trend which is typical of the season and the transition from spring to summer.
    - During the deployment periods covered by this report, pH values ranged from 5.77 units to 6.40 units at Elross Creek, and from 4.27 units to 5.76 units at Goodream Creek.

- Specific conductivity ranged from 4.6 µs/cm to 8.9 µs/cm at Elross and 2.2 µs/cm to 4.9 µs/cm at Goodream Creek during the deployment periods covered by this report.
- The DO values at Elross Creek were at, or slightly below, minimum guideline set for cold-water biota during early life stages (9.5 mg/l), and above minimum guidelines set for other life stages (6.5 mg/l), as determined by the CCME (2007). The same is true at Goodream Creek, with the exception of a period of extreme low flow from June 28 to July 2.
- During the deployment periods covered by this report, turbidity values ranged from 0.0 NTU to 685.0 NTU at Elross Creek and from 0.0 NTU to 27.0 NTU at Goodream Creek .

References

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. (Website: http://ceqg-rcqe.ccme.ca/download/en/222/)

APPENDIX A
Quality Assurance / Quality Control Procedures

As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the beginning and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].

At the beginning of the deployment period, a fully cleaned and calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is placed *in-situ* with the fully cleaned and calibrated Field Sonde. After Sonde readings have stabilized, which may take up to five minutes in some cases, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde. If the readings from both Sondes are in close agreement, the QA/QC Sonde can be removed from the water. If the readings are not in close agreement, there will be attempts to reconcile the problem on site (e.g., removing air bubbles from sensors, etc.). If no fix is made, the Field Sonde may be removed for recalibration.

At the end of the deployment period, a fully cleaned and calibrated QA/QC Sonde is once again deployed *in-situ* with the Field Sonde, which has already been deployment for 30-40 days. After Sonde readings have stabilized, water quality parameters, as measured by both Sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde.

Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
pH (unit)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Sp. Conductance (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Sp. Conductance > 35 µS/cm (%)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Dissolved Oxygen (mg/l) (% Sat)	≤ ±0.3	> ±0.3 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Turbidity <40 NTU (NTU)	≤ ±2	> ±2 to 5	> ±5 to 8	> ±8 to 10	> ±10
Turbidity > 40 NTU (%)	≤ ±5	> ±5 to 10	> ±10 to 15	> ±15 to 20	> ±20

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at *http://pubs.water.usgs.gov/tm1d3*

APENDIX B

Environment Canada Weather Data – Schefferville (June 3, 2015 to July 9, 2015)

Date/Time	Max Temp (°C)	Min Temp (°C)	Mean Temp (°C)	Heat Deg Days (°C)	Cool Deg Days (°C)	Total Precip (mm)
6/3/2015	19.4	8.5	14	4	0	0
6/4/2015	12.9	0.7	6.8	11.2	0	0.3
6/5/2015	11.1	-1.1	5	13	0	0
6/6/2015	6.8	-0.3	3.3	14.7	0	1.5
6/7/2015	8.9	0.4	4.7	13.3	0	9.8
6/8/2015	19.5	6.3	12.9	5.1	0	0
6/9/2015	14.8	5.5	10.2	7.8	0	0.3
6/10/2015	12.7	7	9.9	8.1	0	5.8
6/11/2015	14.6	7.3	11	7	0	0.6
6/12/2015	9.3	4.9	7.1	10.9	0	7.8
6/13/2015	5.7	2.2	4	14	0	3.8
6/14/2015	14	1.1	7.6	10.4	0	0
6/15/2015	22.6	1.6	12.1	5.9	0	1.5
6/16/2015	12.3	2.2	7.3	10.7	0	0.8
6/17/2015	10.9	0.7	5.8	12.2	0	0
6/18/2015	21.6	1.2	11.4	6.6	0	4.6
6/19/2015	8.7	0.8	4.8	13.2	0	0.8
6/20/2015	16.1	0.7	8.4	9.6	0	5.8
6/21/2015	18.5	2	10.3	7.7	0	0
6/22/2015	23.7	7.5	15.6	2.4	0	0
6/23/2015	25.4	10.3	17.9	0.1	0	0
6/24/2015	14.2	8	11.1	6.9	0	9.1
6/25/2015	19.4	5.8	12.6	5.4	0	
6/26/2015	17.4	4.9	11.2	6.8	0	6.1
6/27/2015	21.2	5.5	13.4	4.6	0	0.3
6/28/2015	23.8	5.2	14.5	3.5	0	0
6/29/2015	24.2	11.9	18.1	0	0.1	0
6/30/2015	23.6	7.4	15.5	2.5	0	5
7/1/2015	18	6.3	12.2	5.8	0	0.3
7/2/2015	14.4	10.4	12.4	5.6	0	18.8
7/3/2015	17.8	10	13.9	4.1	0	8.1
7/4/2015	13.9	9.1	11.5	6.5	0	2.9
7/5/2015	15.9	10.2	13.1	4.9	0	6.1
7/6/2015	22.6	9.2	15.9	2.1	0	0.5
7/7/2015	20.4	14.5	17.5	0.5	0	24.6
7/8/2015	14.5	7.2	10.9	7.1	0	16.8
7/9/2015	22	8.3	15.2	2.8	0	0.6