Long Harbour Real-Time

Water Quality Monitoring Network

Annual Report

2009

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Introduction

The monitoring of Rattling Brook in Long Harbour, Newfoundland and Labrador has been ongoing since a Real-Time Water Quality station was commissioned in 2006. In October, 2009 the original station, Rattling Brook below Bridge, was supplemented by the expansion of a station upstream and a new station downstream. The hydrometric station monitoring stage level on Rattling Brook Big Pond was upgraded to provide both hydrometric data and water quality data. A new station, Rattling Brook below Plant Discharge, was commissioned to monitor hydrometric and water quality data at the outfall of the storm water discharge from the nickel processing plant and surrounding area (See **Figure 1:** Rattling Brook Real-Time Network).

On April 1st, 2009, the approval for site clearing was given followed by the approval for excavation and grading on June 18th, 2009. Work is ongoing and construction of the plant is slated to begin in spring 2010.

Since clearing and earthworks began, turbidity and siltation have been common problems identified by the water quality monitoring network in Long Harbour. An underestimate of bog and rock requiring removal resulted in an inusufficient settling capacity. Compounding this problem was a number of high-volume precipitation events occuring in the fall. Precipitation resulted in high turbidity runoff from the plant site and Unsuitable Materials Site #1 during October and November. Precipitation also caused the dewatering of ponds P-24 and P-25 to run much longer than expected. Excavation in such wet conditions caused further turbidity issues during November and December.

Problems were addressed by installation and modification of berms, check dams and filter fabric applications.

Figure 1: Rattling Brook Real-Time Network

Maintenance and Calibration

Adhering to strict maintenance and calibration schedules is very important in ensuring the integrity of data from the real-time instrumentation. Deployment periods are limited to approximately one month (~30 days). At the end of a deployment period, a trip is planned to visit the site and retrieve the instruments for maintenance and calibration in a laboratory setting. The following day, another trip is made to the site to redeploy the instruments and perform QA/QC assessments in the form of a grab sample and side-by-side readings from the field sonde and a freshly calibrated QAQC sonde.

Dates of maintenance trips to the Rattling Brook sites have been compiled in **Table 1** and include the total number of days for the deployment. Deployment intervals ranged from 26 to 45 days and averaged 34.25 days.

Table 1: Deployment dates and duration

Installation Date	Removal Date	Duration of Deployment (Days)	Remarks
2008/12/01	2009/01/06	35	
2009/01/07	2009/02/10	33	
2009/02/11	2009/03/10	29	
2009/03/11	2009/04/24	43	
2009/04/24	2009/05/20	26	Instrument s/n 44604 was swapped with s/n 44975 on the same day.
2009/05/20	2009/07/02	42	Instrument s/n 44975 was swapped with s/n 44604 on the same day
2009/07/03	2009/08/10	37	
2009/08/11	2009/09/09	28	
2009/09/10	2009/10/15	35	
2009/10/16	2009/11/17	31	
2009/11/18	2009/12/15	27	
2009/12/16	2010/02/01	45	

Results and Discussion

Rattling Brook below Bridge provides significant baseline data for the Rattling Brook system unlike the new stations installed in October, 2009. It must be noted that the data for Rattling Brook below Bridge cannot be directly compared to the data for Rattling Brook Big Pond and Rattling Brook below Plant Discharge since the dataset for these two stations are not complete for 2009. For a more appropriate comparison of the three stations, summary data for Rattling Brook below Bridge post-October data is included in each parameter table.

Several years of data gathered by the below Bridge station allows for a year-to-year comparison of select water quality parameters examined below.

Water Temperature

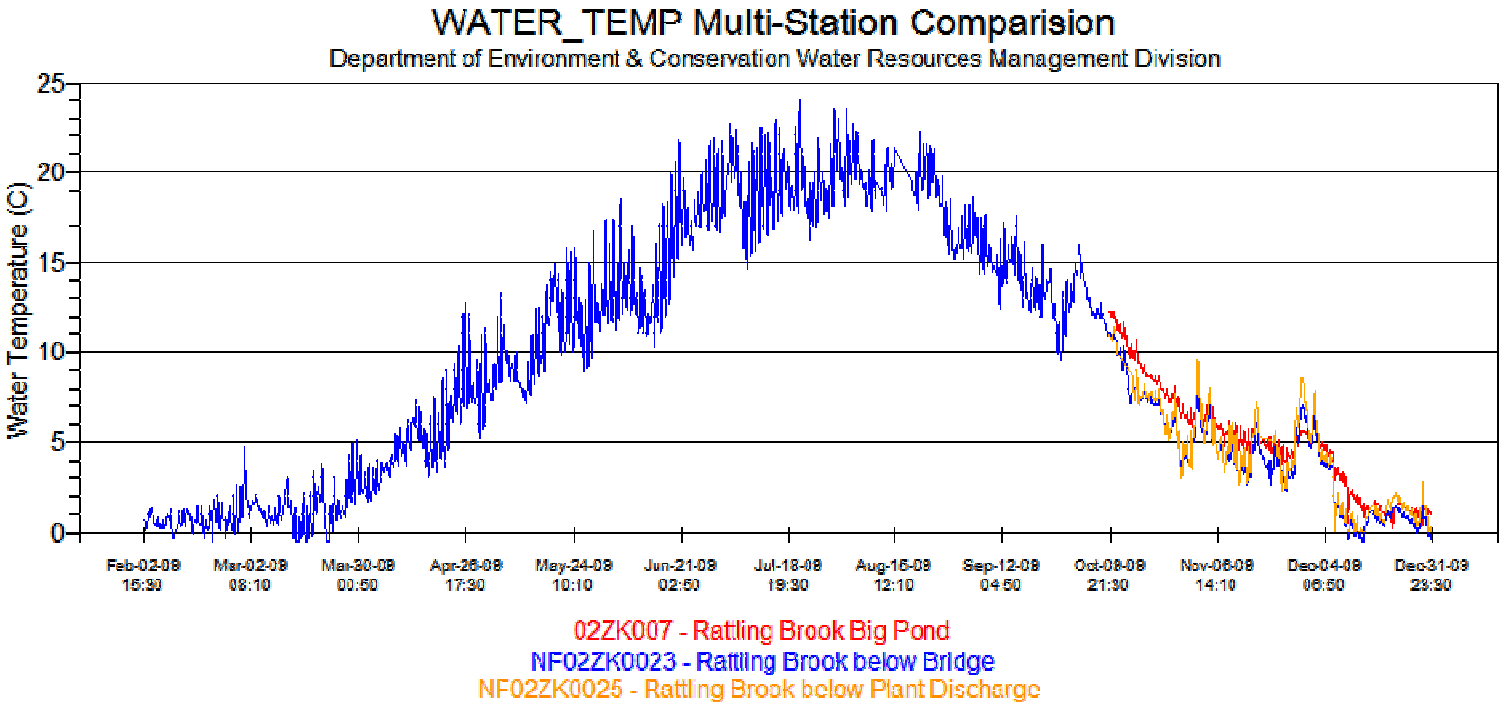
Water temperature is shown in **Figure 2** for all three stations in the network. Water temperature as recorded by the below Bridge station reached a maximum of 23.97^{o}C and a minimum of -0.50^{o}C (mean = 9.14^{o}C) throughout 2009. This is similar to the temperatures recorded in 2008 (-0.42^{o}C to 21.9^{o}C). See **Table 2** for summary statistics.

At Big Pond station, the water temperature ranged from 0.20 to 12.26°C during the period of October 9 to December 31st. During this same time period temperature at Below Bridge ranged from -0.5 to 11.56°C and 0.02 to 11.37°C at Below Plant Discharge. A shallow, shoreline deployment at Big Pond may experience a greater degree of direct sunshine compared to the stations lower on Rattling Brook causing a relatively high spread of recorded temperature values. Further in the system, Below Bridge station has a more variable record of temperatures than the Below Plant Discharge station, possibly due to the small pond between these two stations. It is possible that the small pond acts as a heat sink and imposes a moderating effect on temperature at Below Plant Discharge.

Table 2: Summary of Water Temperature recorded by the Rattling Brook Network in 2009

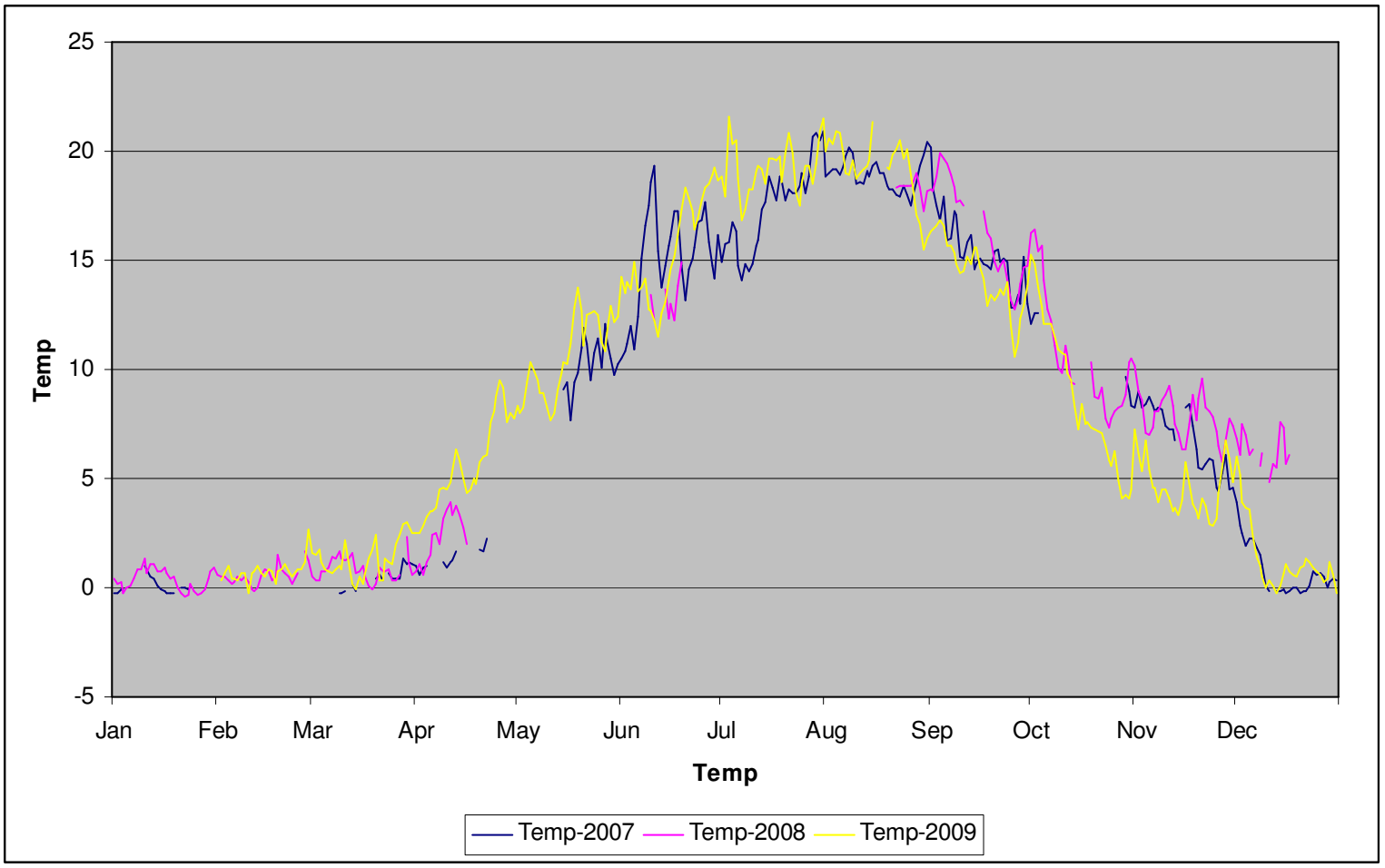
Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	5.13	5.15	12.26	0.20	2.96
Below Bridge (Full Year)	9.14	8.03	23.97	-0.50	6.92
Below Bridge (Post-October)	4.11	4.04	11.56	-0.50	2.93
Below Plant Discharge	4.02	4.20	11.37	0.02	2.55

Figure 2: Water Temperature recorded by the Rattling Brook Network in 2009



Water temperature for 2009 (**Figure 3**) does not show any unusual trends compared to past seasons. A close look suggests that water temperatures were slightly higher in the spring compared to other years and were slightly lower in the fall compared to other years.

Figure 3: Water Temperature at Rattling Brook below Bridge for the years 2007 to 2009



Dissolved Oxygen and Percent Saturation

Dissolved Oxygen is presented in **Figure 4**. Rattling Brook below Bridge ranged from 7.72 mg/l to 14.61 mg/l in 2009 (compared to 8.06 mg/l to 17.71 mg/l in 2008); this corresponds to an oxygen saturation ranging from 88.3 to 102.6 %. See **Table 3** and **Table 4** for summary statistics.

For the time frame of October to December 31st, Big Pond recorded the lowest DO concentrations of the three stations (9.42 to 12.88 mg/l) while Below Bridge was highest (10.13 to 14.30 mg/l). Below Plant Discharge was slightly lower at 9.86 to 14.10 mg/l, likely due to the characteristics of river flow in that reach of Rattling Brook.

In 2009, Rattling Brook below Bridge accumulated a total of 70.7 days below the CCME Guideline of 9.5 mg/l DO for the protection of early life stage cold water biota. Since installation of Big Pond station in October, 2009 0.7 days were found to be below the CCME Guideline of 9.5 mg/l. Rattling Brook below Plant Discharge did not show any Guidelines infractions and no incidences of DO values below the CCME Guideline of 6.5 mg/l for the protection of other life stages were recorded at either of the three stations.

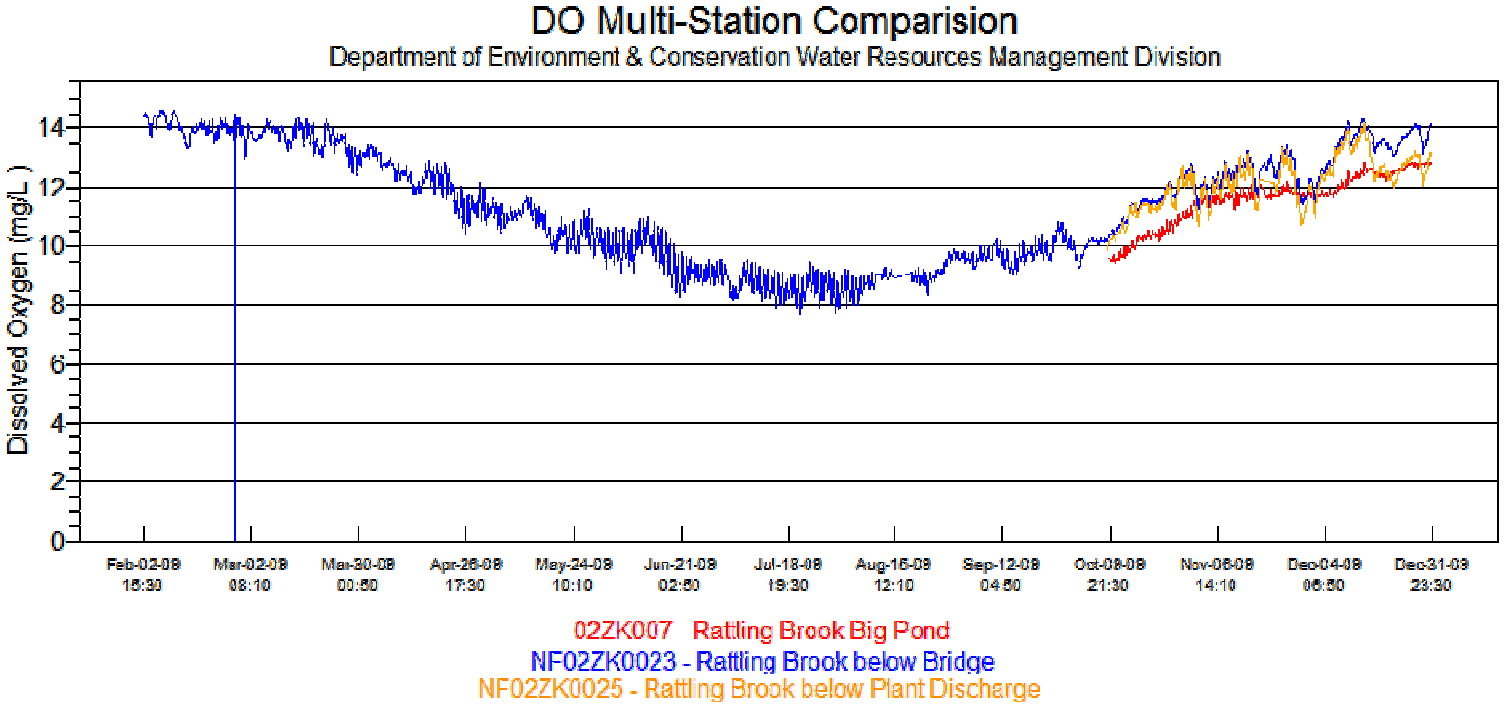
Table 3: Summary of Dissolved Oxygen (mg/l) recorded by the Rattling Brook Network in 2009

Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	11.56	11.72	12.88	9.42	0.87
Below Bridge (Full Year)	11.30	11.26	14.61	7.72	1.90
Below Bridge (Post-October)	12.52	12.55	14.30	10.13	0.98
Below Plant Discharge	12.23	12.27	14.10	9.86	0.77

Table 4: Summary of Dissolved Oxygen (% Saturation) recorded by the Rattling Brook Network in 2009

Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	92.14	91.8	98.90	86.80	2.20
Below Bridge (Full Year)	96.09	96.3	102.60	88.30	2.59
Below Bridge (Post-October)	96.53	96.5	101.20	91.90	1.51
Below Plant Discharge	94.93	95.5	101.60	88.10	2.78

Figure 4: Dissolved Oxygen recorded by the Rattling Brook Network in 2009



Specific Conductivity

Conductivity, as shown by **Figure 5**, ranged from 27.5 to 51.6 µS/cm and averaged 36.91 µS/cm at Rattling Brook below Bridge compared to 2008 where conductivity ranged from 21.6 to 44.4 µS/cm.

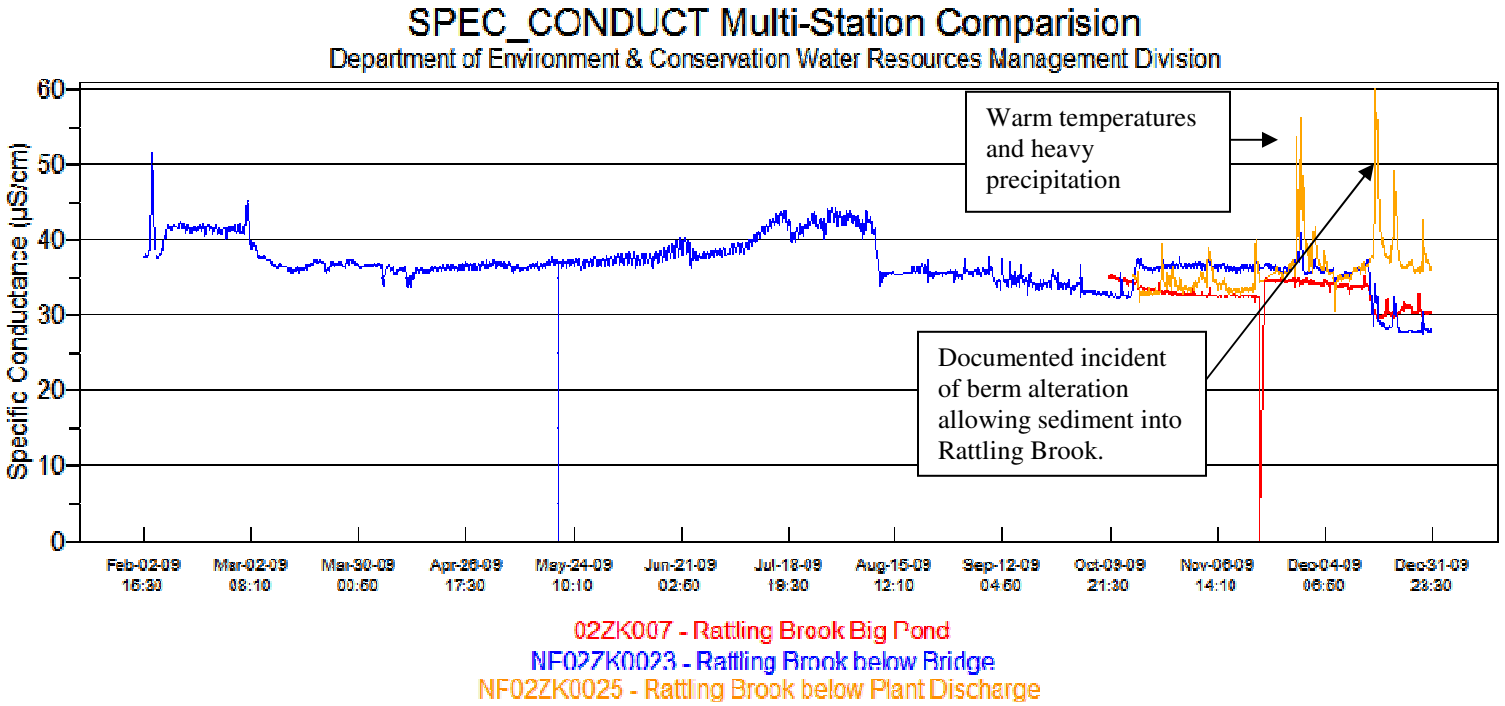
Specific Conductivity at Rattling Brook Big Pond ranged from 29.6 to 35.4 µS/cm and ranged from 30.6 to 60.0 µS/cm at below Plant Discharge. **Table 5** reports the mean, max and min of Specific Conductivity as recorded by the Rattling Brook Network. It should be noted that the below Plant Discharge station has recorded a greater maximum values in 2009 (60.0 µS/cm) compared to Big Pond and below Bridge stations (35.4 and 51.6 µS/cm). This is likely due to the lower reaches of Rattling Brook intercepting a greater degree of muddy runoff from roads adjacent to the river and a drainage ditch that releases water into the river during precipitation events.

Two major spikes are seen in conductivity at Rattling Brook below Plant discharge in late November and mid-December, 2009. Heavy precipitation during a period of mild air temperatures resulted in heavy inflow to Rattling Brook. On December 17th, an incident was documented where a berm was altered upstream of the Rattling Brook below Bridge and below plant Discharge stations allowing heavily silted water to flow into the river.

Table 5: Summary of Specific Conductivity (µS/cm) recorded by the Rattling Brook Network in 2009

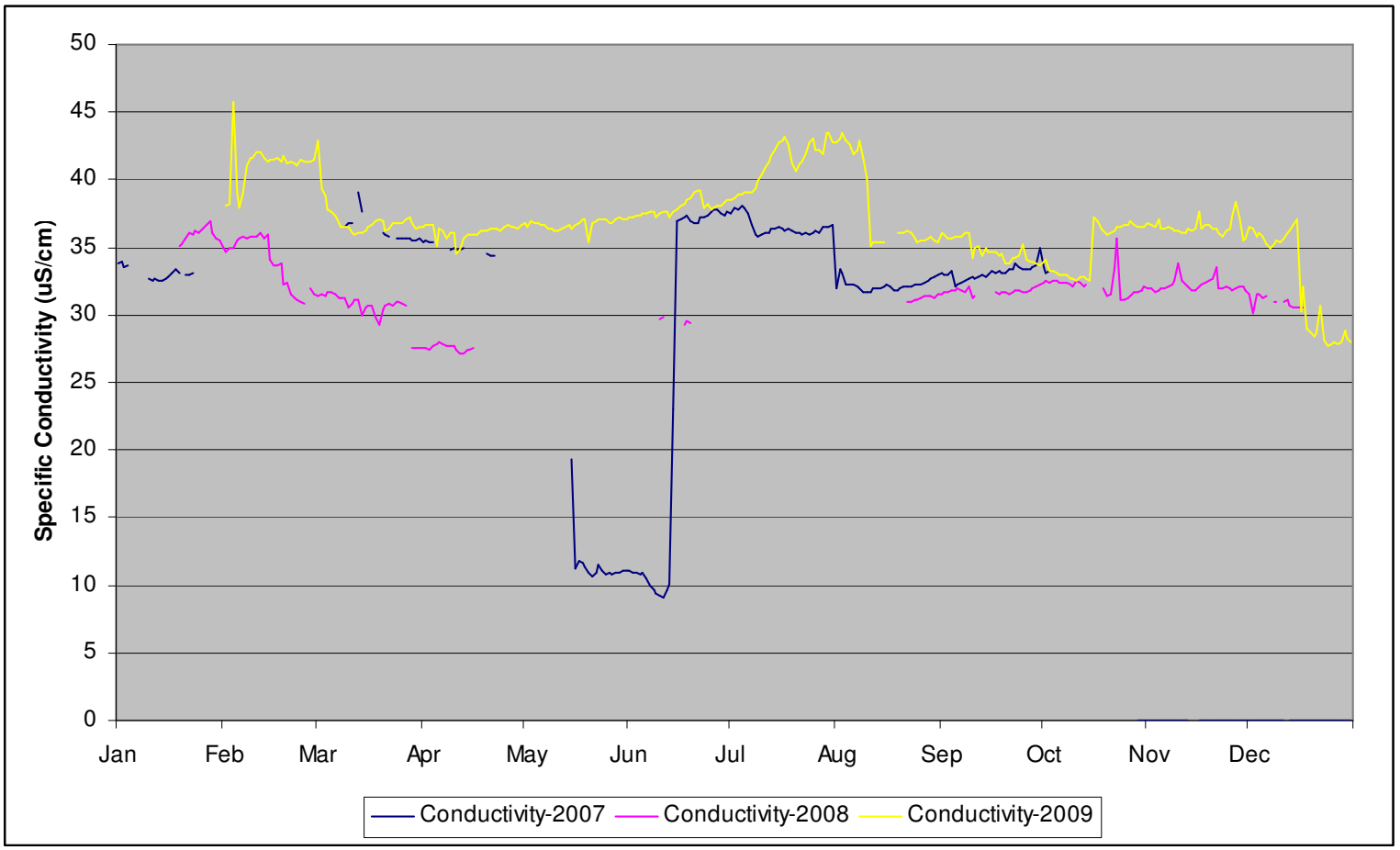
Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	33.05	33.2	35.40	29.60	1.50
Below Bridge (2009)	36.91	36.5	51.60	27.50	3.15
Below Bridge (Post-October)	34.58	36.1	40.90	27.50	3.12
Below Plant Discharge	36.24	35.5	60.00	30.60	3.75

Figure 5: Specific Conductivity recorded by the Rattling Brook Network in 2009



Specific Conductivity at below Bridge is presented for 2007 to 2009 in **Figure 6**. Due to gaps in the data, it is difficult to draw any conclusions from the graph; however, it appears that conductivity is higher in 2009 compared to 2007 and 2008. Conductivity appears to have returned to the typical values near the end of 2009.

Figure 6: Specific Conductivity at Rattling Brook below Bridge for the years 2007 to 2009



pH

Variation of pH values differs with season in Rattling Brook. Variability is highest in the summer with increased flora, fauna and microbial growth and lowest in winter when biological activity is at the minimum (**Figure 7**). The spread of values is relatively small compared to other parameters and ranged from 5.25 to 6.71 at below Bridge (mean = 5.98). Most values are found to be below the CCME Guideline for the Protection of Aquatic Life; however, given the multi-year background for this system, the values appear to be as expected for 2009.

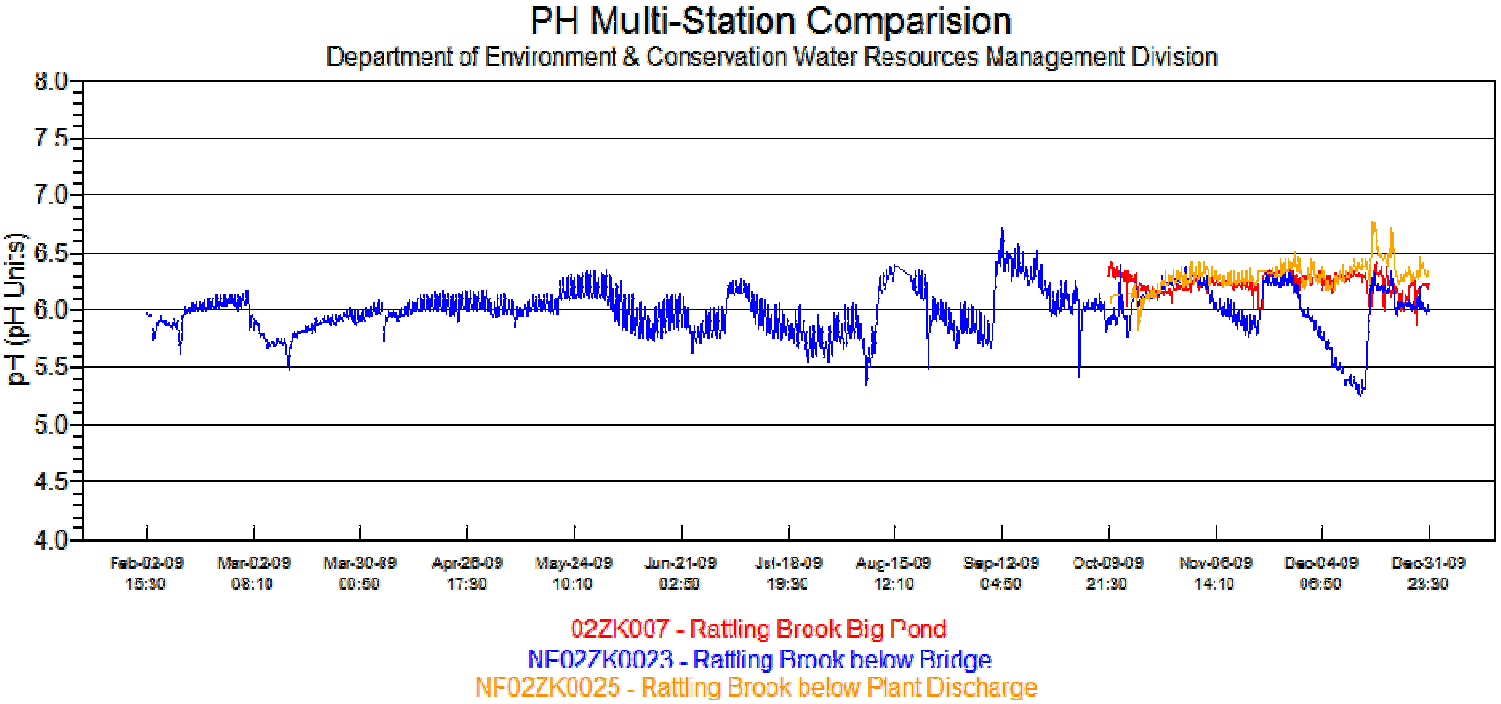
pH ranged from 5.86 to 6.41 at Rattling Brook Big Pond and from 5.82 to 6.78 at below Plant Discharge station. Big Pond is a much more stable water body given its size, depth and lack of flow compared to Rattling Brook. This manifests itself in the spread of pH values at Big Pond versus below Plant Discharge; standard deviation 0.07 and 0.12, respectively. See **Table 6** for summary statistics.

The mean pH value for all stations is below the CCME Guideline of 6.5 for the Protection of Aquatic life, however, rivers in this region of the province are slightly acidic in nature.

Table 6: Summary of pH recorded by the Rattling Brook Network in 2009

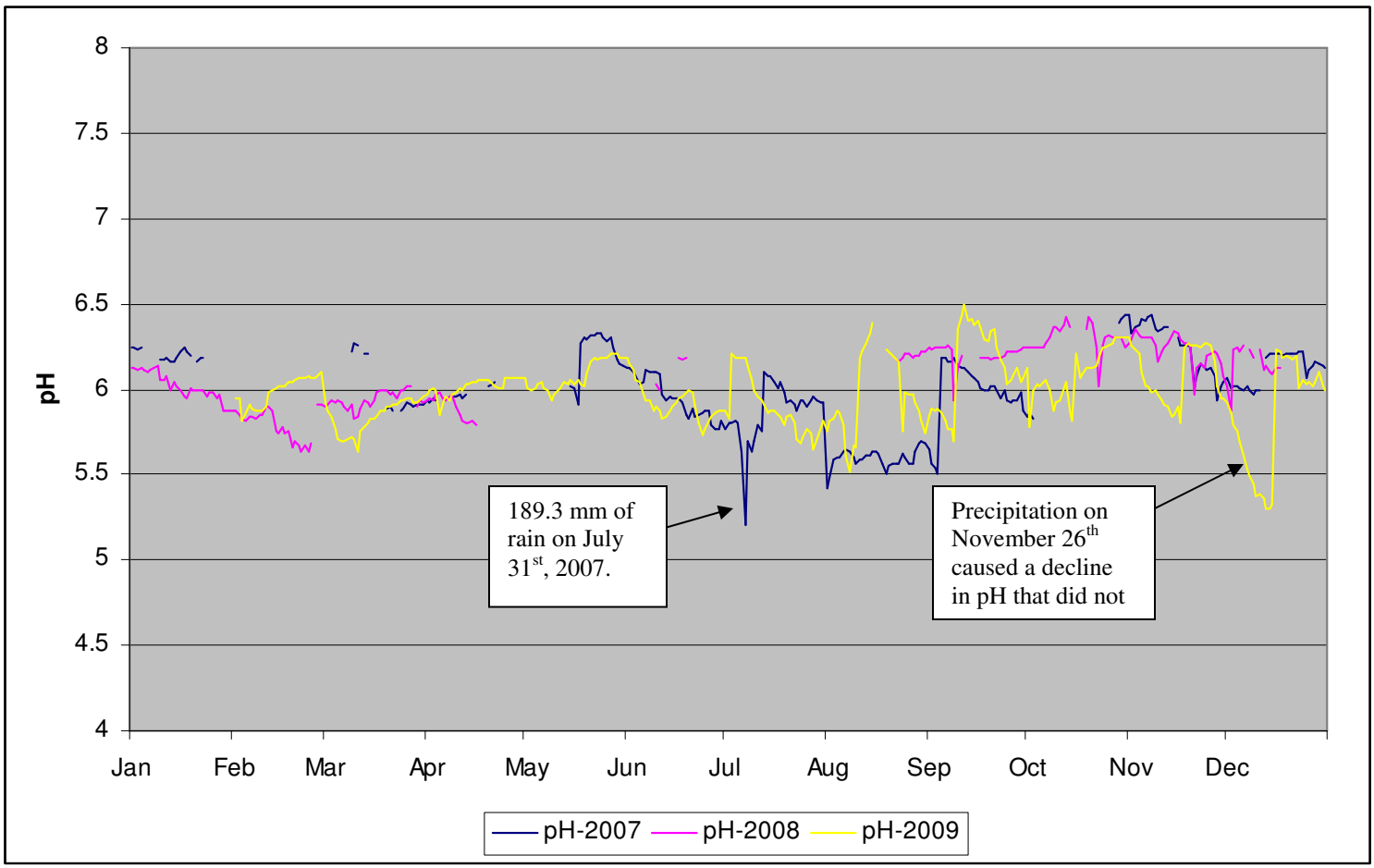
Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	6.24	6.24	6.41	5.86	0.07
Below Bridge (2009)	5.98	5.99	6.71	5.25	0.21
Below Bridge (Post-October)	6.00	6.04	6.39	5.25	0.27
Below Plant Discharge	6.30	6.29	6.78	5.82	0.12

Figure 7: pH recorded by the Rattling Brook Network in 2009



A comparison of pH for 2007 – 2009 at Rattling Brook below Bridge in **Figure 8** shows no noticeable trend in the data. It is apparent that the pH is similar in 2009 to other years.

Figure 8: pH at Rattling Brook below Bridge for the years 2007 to 2009



Total Dissolved Solids

Total dissolved solids refers to the concentration of all inorganic and organic compounds < 2µm in size. While not an indicator of pollution in and of itself, TDS gives an indication of the total load of compounds dissolved in the water and the changes in dissolved load.

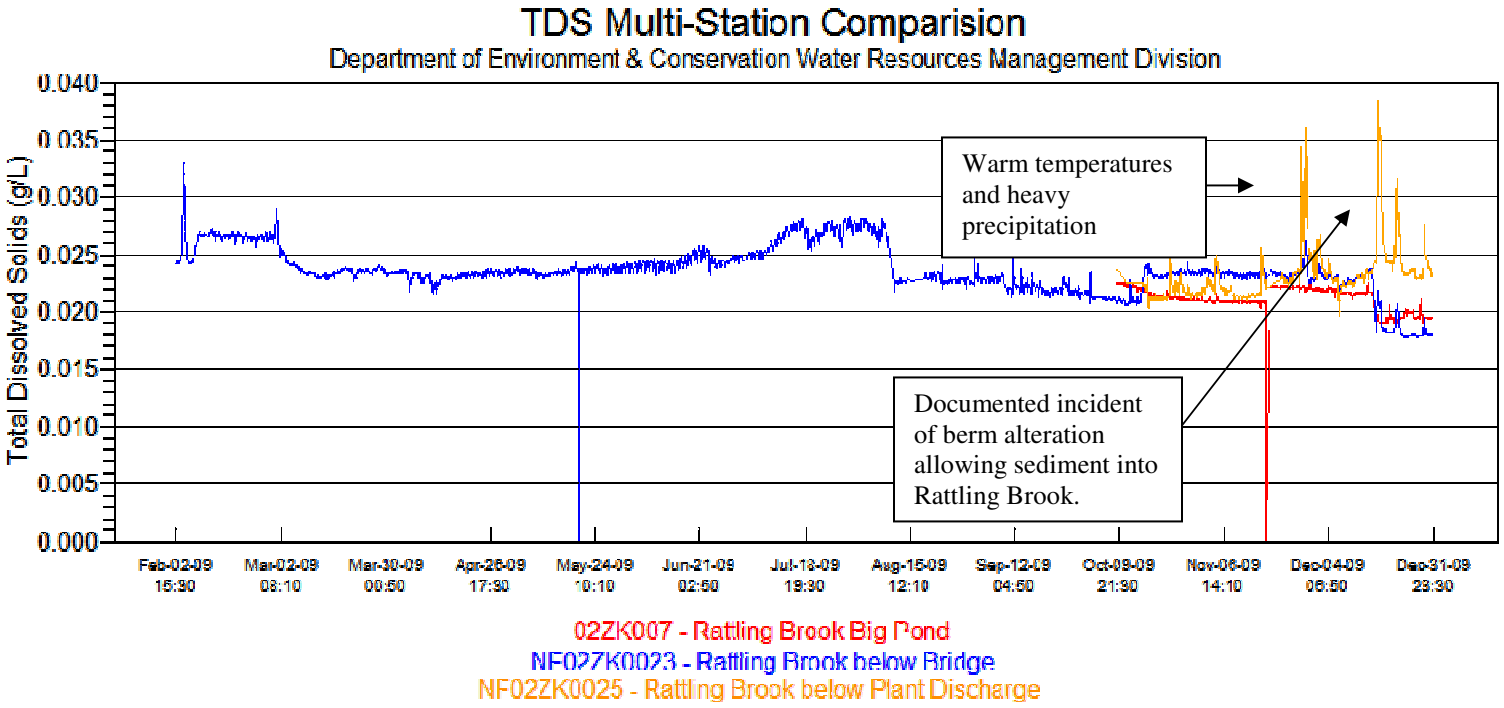
TDS at Rattling Brook below Bridge ranged from 0.0176 to 0.0330 g/l and averaged 0.0236 g/l. Big Pond ranged from 0.0189 to 0.0226 g/l (mean = 0.0211 g/l) and below Plant Discharge ranged from 0.0196 to 0.0384 g/l (mean = 0.0232 g/l) as shown in

Table 7. This indicates that TDS increases as water travels through the Rattling Brook system. **Figure 9** clearly shows, where three stations are reporting, that TDS is lowest in Big Pond, moderate in below Bridge and highest at below Plant Discharge.

Table 7: Summary of Total Dissolved Solids Station recorded by the Rattling Brook Network in 2009

Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	0.0211	0.0213	0.0226	0.0189	0.0010
Below Bridge (2009)	0.0236	0.0234	0.0330	0.0176	0.0020
Below Bridge (Post-October)	0.0221	0.0231	0.0262	0.0176	0.0020
Below Plant Discharge	0.0232	0.0227	0.0384	0.0196	0.0024

Figure 9: Total Dissolved Solids recorded by the Rattling Brook Network in 2009



Turbidity

Prior to June 2009, turbidity was sporadic and confined to heavy precipitation events. Generally, turbidity would return to normal levels within 24 hours. Since construction began in early summer, turbidity has been unsettled and a low- to mid- grade turbidity has been consistent in the Rattling Brook below Plant Discharge station (min = 4.3 NTU).

Lower stretches of Rattling Brook become progressively more developed and receive a greater amount of turbid runoff. Rattling Brook Big Pond has been left more or less undeveloped until the end of 2009 and this is reflected in the summary of turbidity in **Table 8** as the mean turbidity at this station is 3.36 NTU.

Big Pond and below Plant Discharge stations were installed following the commencement of construction, however, **Figure 10** clearly shows that the water quality stations on Rattling Brook proper show a highly variable and consistently elevated turbidity compared to the water quality station on Big Pond.

Table 8: Summary of Turbidity recorded by the Rattling Brook Network in 2009

Station	Mean	Median	Max	Min	Standard Deviation
Big Pond	3.36	1.7	22.00	0.00	3.16
Below Bridge (2009)	10.42	0	1486.00	0.00	53.31
Below Bridge (Post-October)	21.73	8.8	689.00	1.40	49.87
Below Plant Discharge	67.66	24	1094.00	4.30	123.87

Figure 10: Turbidity recorded by the Rattling Brook Network in 2009

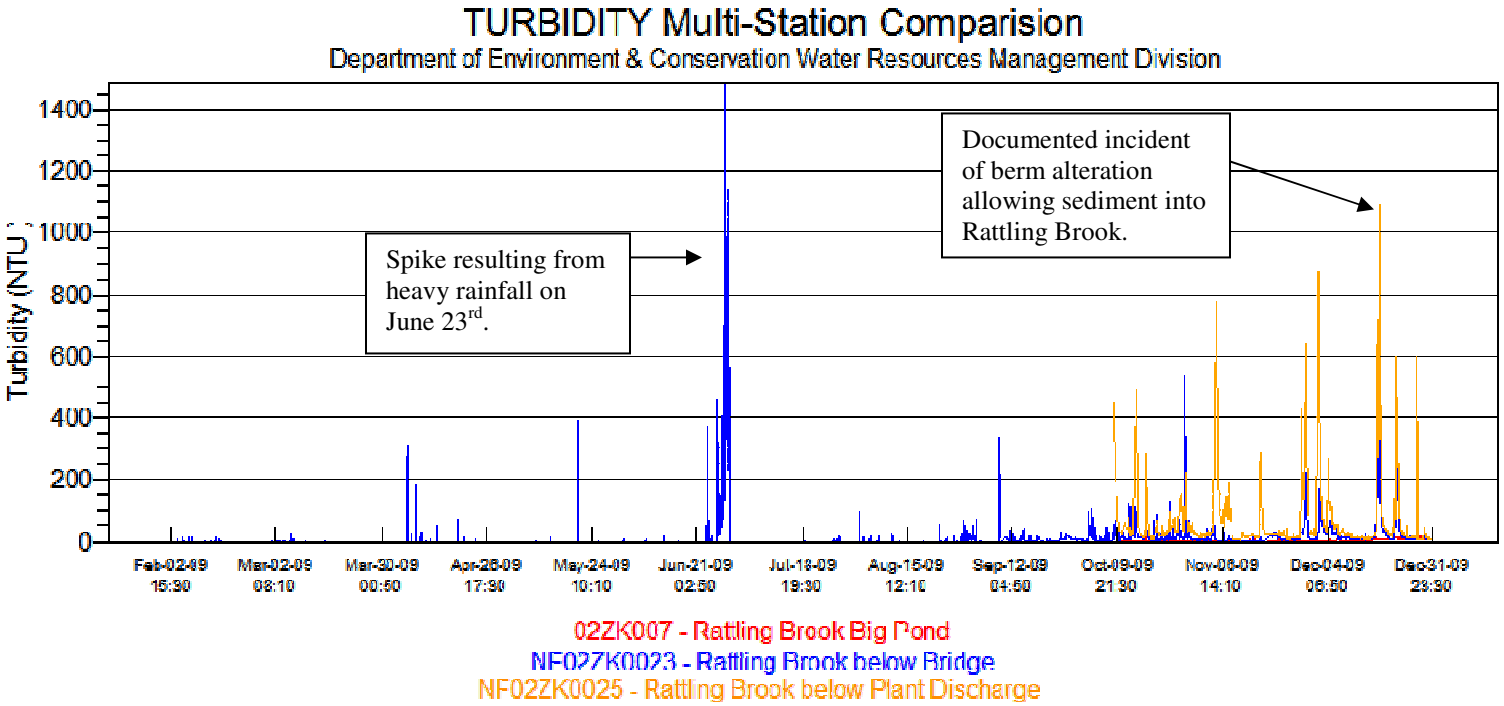


Figure 11 below depicts turbidity data from 2007 – 2009. Historically, the turbidity at Rattling Brook below Bridge has been low and generally recorded as 0 NTU. Upon commencement of work at the Long Harbour site, turbidity escalated and remained elevated from late July 2009 to the end of 2009. While an increase in turbidity events was expected with the beginning of construction, the duration of elevated turbidity has resulted in requests to Vale Inco to increase runoff settling capacity and other efforts related to silt control.

Figure 11: Turbidity at Rattling Brook below Bridge for the years 2007 to 2009

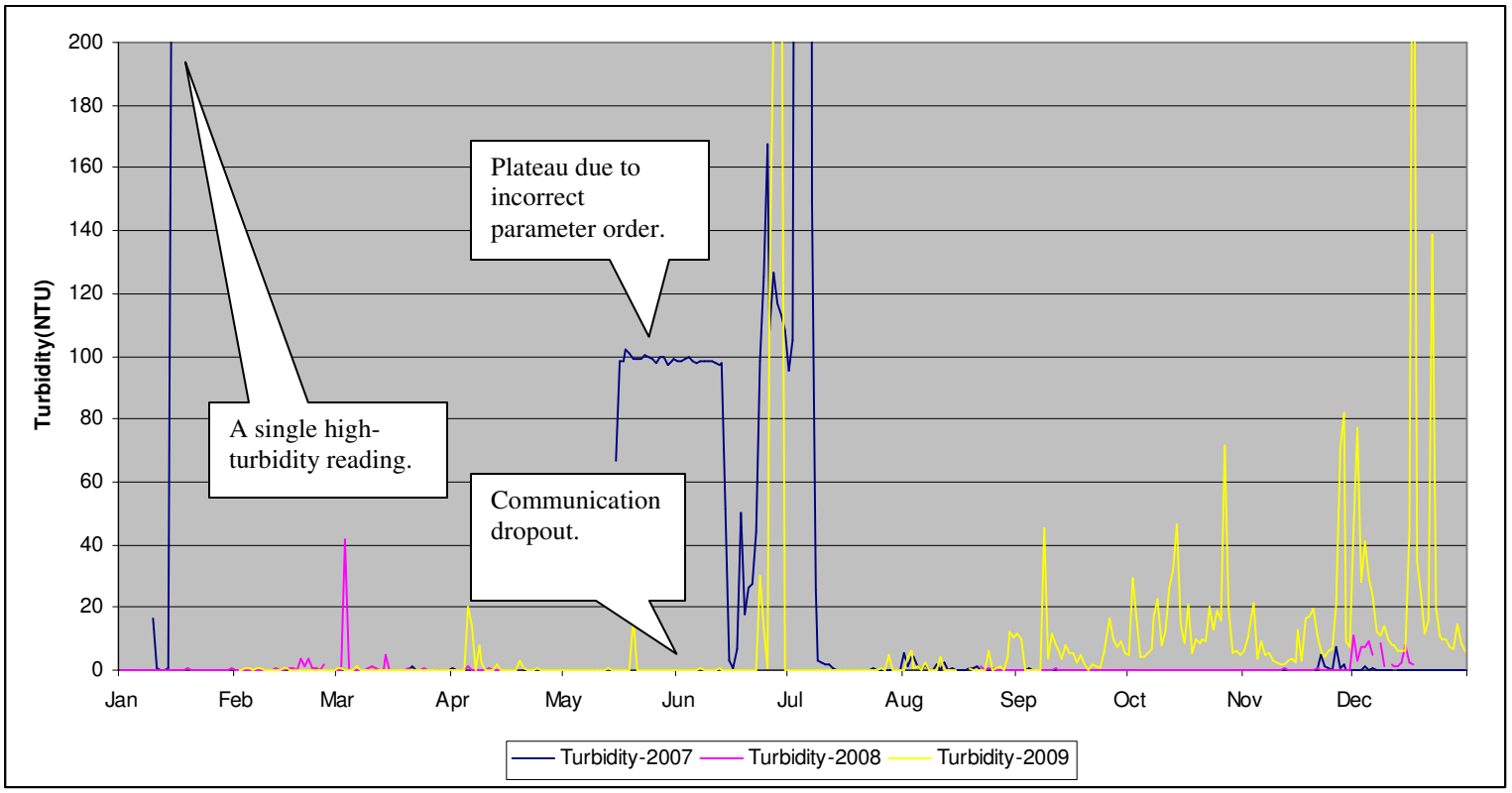


Figure 11 is also useful for pointing out potential errors in turbidity data, especially in the early history of Rattling Brook below Bridge station. In February 2007, a peak in turbidity greater than 200 NTU occurred for a brief period of time. Generally, peaks such as these that are sustained for only a reading or two are erroneous and should not be considered to represent actual turbidity values. Often, instances such as these are the result of a temporary fouling of the lens on the turbidity sensor – leaf debris or other small particles can foul the sensor and cause inflated readings.

In early deployments, individuals unfamiliar with Hydrolab equipment would occasionally fail to notice a change in the parameter order used to send data to the logger; such is the case in mid-May to mid-June. During this time, data being sent to the logger by the sonde was in the improper sequence. Consequently, the logger was expecting a string of turbidity values and recorded percent dissolved oxygen saturation in its place. The result of this mix-up is a month of turbidity data reading close to 100. Lastly, data drop outs also plague earlier deployment periods. In 2007 – 2008, dropouts were common due to the particular set of satellite modems and data loggers in use plus incorrect antennae installation.

Current plans are to address obvious problems within the historical dataset through the use of a new Data Variance Process. This procedure will allow for a more intuitive use of the real-time dataset by individuals unfamiliar with common problems outlined above.

Quality Control/Quality Assurance (QA/QC) Measures

At the beginning of a deployment period and prior to removal of the instrument, a freshly-calibrated Quality Assurance (QA) sonde is placed adjacent to the field sonde. Readings are taken from both devices simultaneously and the difference between each sonde is calculated. Depending on the degree of difference between the in situ sonde and the QA device, the agreement is ranked as "Excellent", "Good", "Fair", "Marginal", or "Poor". **Table 2** relates the Quality Assurance rankings between the freshly-calibrated QA sonde and the field sonde after a one month deployment period.

As shown in **Table 2**, most comparisons are ranked as either 'Excellent' or 'Good' with few instances of lesser quality. Rattling Brook offers an excellent deployment location consisting of a rocky and gravel bottom with little silt and mud to foul the multiparameter probe over the 30 day deployment period.

Table 9: Quality Assurance Rankings during installation and removal of field sonde

Station	Date	Activity	QA/QC Rating				
			Temperature	pH	Specific Conductance	Dissolved Oxygen	Turbidity
Below Bridge	2008-Dec-01	Deployment	Excellent	Fair	Good	Excellent	NA
	2009-Jan-06	Removal	Excellent	Marginal	Excellent	Good	Fair
Below Bridge	2009-Jan-7	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	2009-Feb-10	Removal	Excellent	Fair	Good	Excellent	Excellent
Below Bridge	2009-Feb-11	Deployment[1]	NA	NA	NA	NA	NA
	2009-Mar-10	Removal	Excellent	Fair	Good	Excellent	Excellent
Below Bridge	2009-Mar-11	Deployment	Excellent	Good	Good	Good	Excellent
	2009-Apr-24	Removal	Excellent	Good	Excellent	Excellent	Excellent
Below Bridge	2009-Apr-24	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	2009-May-20	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
Below Bridge	2009-May-20	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	2009-Jul-02	Removal	Excellent	Good	Excellent	Excellent	Excellent
Below Bridge	2009-Jul-03	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	2009-Aug-10	Removal	Good	Fair	Good	Excellent	Excellent
Below Bridge	2009-Aug-11	Deployment	Good	Good	Excellent	Excellent	Excellent
	2009-Sep-09	Removal	Good	Excellent	Good	Excellent	Excellent
Below Bridge	2009-Sep-10	Deployment	Good	Good	Fair	Excellent	Excellent
	2009-Oct-15	Removal	Good	Good	Fair	Good	Excellent
Below Bridge	2009-Oct-16	Deployment	Good	Good	Excellent	Good	Good
Below Plant Discharge	2009-Oct-08	Installation	Excellent	Excellent	Excellent	Good	Excellent
Big Pond	2009-Oct-09	Installation	Excellent	Excellent	Excellent	Good	Excellent
Big Pond	2009-Nov-17	Removal	Excellent	Fair	Excellent	Excellent	Excellent
Below Bridge			Good	Good	Good	Good	Excellent
Below Plant Discharge			Excellent	Good	Excellent	Excellent	Good
Big Pond	2009-Nov-18	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent

[1] No QAQC sonde was available on February 11th. Accordingly, all ratings for deployment are indicated Not Available.

Station	Date	Activity	QA/QC Rating				
			Temperature	pH	Specific Conductance	Dissolved Oxygen	Turbidity
Below Bridge			Good	Excellent	Good	Good	Excellent
Below Plant Discharge			Excellent	Excellent	Good	Good	Poor[2]
Big Pond	2009-Dec-15	Removal	Excellent	Good	Good	Fair	Excellent
Below Bridge			Excellent	Marginal	Good	Excellent	Excellent
Below Plant Discharge			Good	Fair	Good	Good	Excellent
Big Pond	2009-Dec-16	Deployment	Good	Good	Excellent	Fair	Good
Below Bridge			Excellent	Marginal	Excellent	Excellent	Good
Below Plant Discharge			Good	Fair	Good	Poor	Good
Big Pond	2010-Feb-02	Removal[3]	NA	NA	NA	NA	NA
Below Bridge			Excellent	Excellent	Excellent	Excellent	Excellent
Below Plant Discharge			Good	Fair	Excellent	Excellent	Excellent

Conclusions

In anticipation of potential Vale Inco development in the area surrounding Rattling Brook, the Rattling Brook below Bridge water quality monitoring station was commissioned in December 2006. Since then, a significant amount of background data has been recorded and an expansion of the network on this river system – including headwaters – was completed in October, 2009. The Department of Environment and Conservation has learned a great deal about the natural state of this system and is in an excellent position to monitor the effects of development.

Development began in this area in the summer of 2009 and has come with documented incidents of excessive turbidity in Rattling Brook related to insufficient capacity to manage silt-laden runoff from bare ground, pond drainage and unsuitable materials disposal.

Vale Inco representatives met with ENVC in late December and agreed to expedite the excavation of the Storm Water Capture Pond and the Effluent Holding Pond at the northern end of the plant site. It is anticipated that these two ponds, of 46500 cubic metres and 29000 cubic metres, respectively, will provide sufficient settling capacity to handle all site runoff during the spring of 2010.

The real-time monitoring network at Long Harbour has been an invaluable tool for identifying turbidity events and other water quality concerns. Because of this system, the Department of Environment and Conservation is able to visit the Long Harbour site while problems are still developing to observe conditions first-hand. Indeed, when industrial operators know that water quality parameters are being recorded and transmitted for public consumption in near-real time, it encourages a greater degree of diligence.

[2] The Poor rating for turbidity on November 18th was due to a failure in the turbidity probe on the QAQC instrument. Data from the field sonde was nominal for the deployment.
[3] Failure of the battery pack in the Rattling Brook Big Pond instrument on February 2, 2010 prevented the acquisition of QAQC data.

Path Forward

The Water Resources Management Division has made great strides in the monitoring of Rattling Brook in 2009. In October, 2009 a station on Rattling Brook Big Pond was upgraded to a continuous hydrometric and water quality monitoring station and a new station was installed below the original below Bridge station. With these three locations, the WRMD has the ability to trace water quality from the origin of Rattling Brook to the discharge point of storm runoff from the future site of the nickel processing facility.

With increased vigilance, the Department of Environment and Conservation has the ability to identify adverse impacts to the water quality at the Vale Inco construction site. With this ability suggestions have been made to help improve conditions and prevent future damage to the Rattling Brook ecosystem.

To ensure the continued success of this network of stations, future plans include:

- Continual direct communication between Department of Environment and Conservation (ENVC) and Vale Inco staff to respond to emerging issues on a proactive basis.
- Expanded involvement of the Pollution Prevention Division in monitoring activities at the Long Harbour site and suggesting improvements to development practices.
- Continued site visitation and monthly maintenance/calibration by ENVC staff.
- Shipment of instrumentation to the Canadian Supplier for technical proficiency and evaluation testing.
- Continued data analysis in the form of monthly deployment reports; an annual report will be prepared at the end of each calendar year.
- Continued work on Automatic Data Retrieval System to incorporate new capabilities.
- Continued transfer of data from ENVC to Vale Inco through the departmental webpage.
- Provide online statistical analysis of data to provide extrapolation of other water quality parameters using regression analysis.
- Evaluation and upgrading of QA/QC procedures through the production of a Real-Time Water Quality Monitoring Manual to be disseminated in Spring 2010.
- Creation of a Turbidity/Total Suspended Solids model to monitor real-time TSS data using the current parameter suite.
- Continued operation and optimization of the email Alert System.

Appendix

Figure 12: Mean Temperature and Total Precipitation at in 2009 at Environment Canada's Argentia Weather