Voisey's Bay Real-Time Water Quality Monitoring Network Annual Report 2006

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Executive Summary

The 2006 real-time water quality monitoring season at Voisey's Bay Nickel Company Ltd. (VBNC) in Labrador was another successful year. The monitoring stations continued to work as an early warning system to identify water quality related events as they happened thus minimizing the impact on the surrounding water resources. Most notably, the monitoring stations surrounding the mine site area (Camp Pond Brook & Lower Reid Brook stations) recorded significantly fewer water quality events (ie: spikes in turbidity, etc) and to a much lesser extent (ie: lower maximum values recorded) than in previous years. It appears as though moving from the construction phase to the operational phase of the project has reduced the impact on the surrounding water resources.

The network was expanded in 2006 to include an additional surface water quality monitoring station on the Tributary to Lower Reid Brook as well as a new groundwater monitoring station in the vicinity of the tailings dam at Headwater Pond. These new stations bring the number of real-time water quality monitoring stations to a total of five. The new stations are strategically located to ensure the protection of important water bodies in the area.

As in previous years, the wildlife interfered with the real-time water quality monitoring stations during 2006 on a couple of different occasions. The communication cable at the pristine Upper Reid Brook station was chewed and damaged to the point that it needed to be replaced. Also, a bear pulled off the GOES satellite antenna at the Lower Reid Brook station midway through the sampling season thus causing failure in transmission from early July until mid September at which point the damage was repaired by the Environment Canada (EC) staff during a scheduled site visit. Each of these incidents could not be avoided; however, the Department of Environment and Conservation (DOEC) is trying to minimize the impact of such incidents by having backup equipment on-hand to be used for replacement when necessary.

Planning for the upcoming 2007 real-time water quality monitoring sampling season is currently underway. DOEC plans to continue to provide VBNC with accurate water quality data through the departmental web page in near real-time. In-depth analysis of the water quality data will continue in the form of monthly reports to be posted on the departmental web page. As in past years, DOEC and EC staff will be travelling to the VBNC mine site to ensure proper maintenance and calibration procedures are being implemented and to provide troubleshooting to VBNC staff. Many of the VBNC instruments will be upgraded with both ammonium and nitrate sensors to ensure these parameters are within compliance. There will be continual upgrades and additions of new capabilities to the automatic data retrieval system in the upcoming year. The existing quality assurance/quality control procedures will be evaluated and upgraded in 2007. Finally, work will continue on the extrapolation of other parameters using regression analysis techniques.

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Acknowledgements

The Real-Time Water Quality Monitoring Network in Voisey's Bay is successful in tracking emerging water quality issues due to the hard work and diligence of certain individuals. The management and staff of Voisey's Bay Nickel Company Limited (VBNC) work in cooperation with the management and staff of the Department of Environment and Conservation (DOEC) as well as Environment Canada (EC) to ensure the protection of ambient water resources in Voisey's Bay, Labrador.

The VBNC Environmental Officers on-site, Perry Blanchard and Paul Hounsell, work to ensure the Real-Time Water Quality Monitoring Network is operating to the standards set by DOEC. It is only through their dedication to properly maintain and calibrate the equipment that the data can be viewed as reliable and accurate.

Various individuals from DOEC have been integral in ensuring the smooth operation of such a technologically advanced network. Renée Paterson plays the lead role in coordinating and liaising between the major agencies involved, thus, ensuring open communication lines at all times. In addition, Renée is responsible for the data management/reporting, troubleshooting, along with ensuring the quality assurance/quality control measures are satisfactory. Throughout the deployment season of 2006, Renée has travelled to the Voisey's Bay Mine Site on two separate occasions (July & September) to ensure all procedures were being followed and to provide technical assistance. Paul Neary, Leona Hyde and Amir Ali Khan have worked on the communication aspects of the network ensuring the data is being provided to the general public on a near real-time basis through the departmental web page.

The staff of EC under Meterological Service of Canada Water Survey Canada (Percy Roberts, Perry Pretty, Bill Mullins and Brent Ruth) play an essential role in the data logging/communication aspect of the network. These individuals visit the site often to ensure the data logging equipment is operating properly and transmitting the data efficiently. Finally, they play the lead role in dealing with hydrological quantity and flow issues.

The managers from each agency (Earl Dwyer – VBNC; Haseen Khan – DOEC; Howie Wills – EC) are fully committed to improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in the decision-making process. This network is only successful due the cooperation of all three agencies involved.

Section 1.0 Introduction

The Real-Time Water Quality Monitoring Network began in Voisey's Bay during the summer of 2003 with the establishment of three surface water stations (**Upper Reid Brook – NF03NE0009**; **Camp Pond Brook – NF03NE0010**; **Lower Reid Brook – NF03NE0011**). These three stations have been operational (for summer/fall months) on an annual basis since 2003 acting as an early warning system to capture water quality related events. The three above-noted surface water stations have been providing invaluable water quality information over the past three years, thus it was decided to establish an additional surface water station on the **Tributary to Lower Reid Brook – NF03NE0012** in the summer of 2006. This station is located in fairly close proximity to the ovoid and thus it was chosen in particular to capture any water quality events that may result from the actual open-pit mining activities. As a pilot project, DOEC also established its first real-time groundwater monitoring station in a well just after the dam at Headwater Pond (**VNBC Well – NF03NE0008**). All five real-time water quality stations can be seen in **Figure 1**.

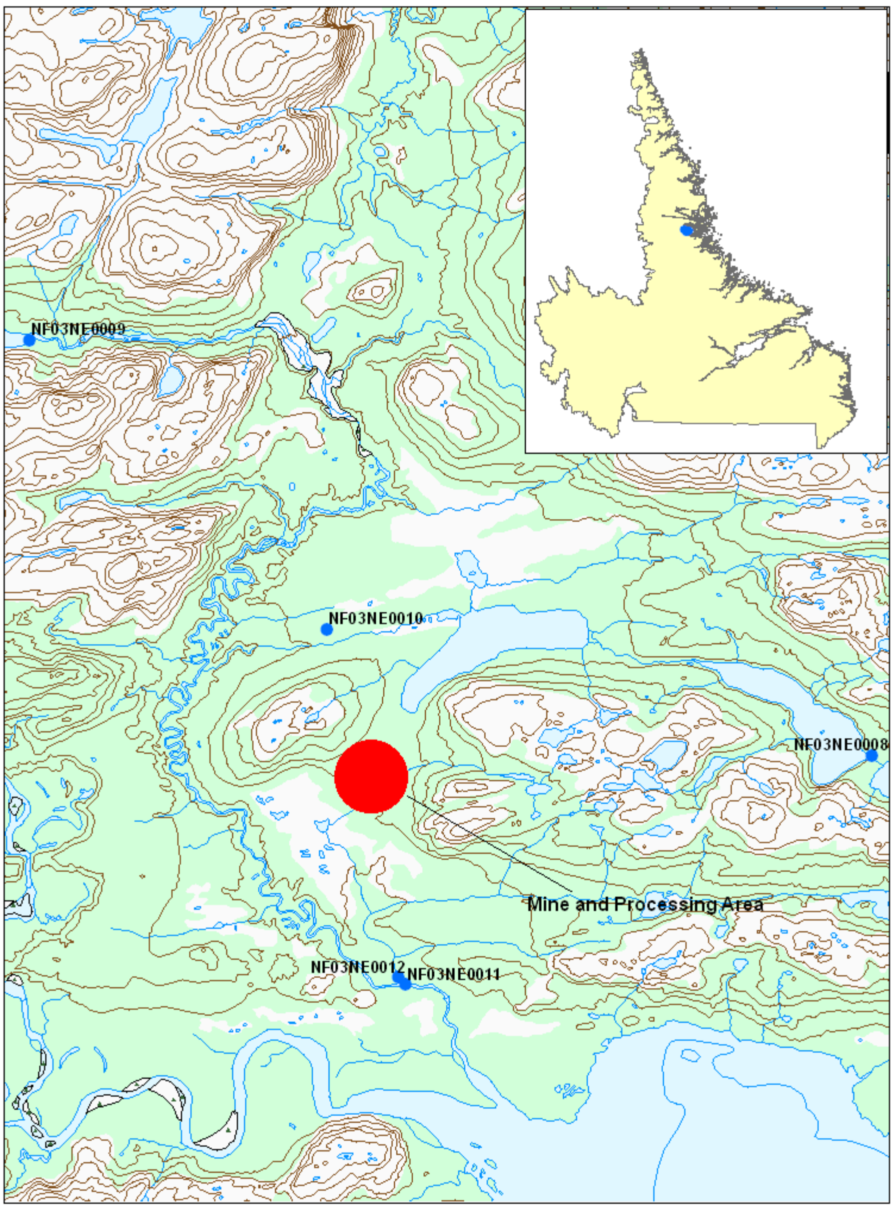


Figure 1: Location of Real-Time Water Quality Monitoring Stations in Voisey's Bay, Labrador

As in previous years, the water quality instruments were removed for the winter months in the fall of 2005 and sent to the DOEC office in St. John's for winter storage. In May 2006, all instruments were removed from storage and cleaned, calibrated and checked by DOEC staff before being shipped to the VBNC mine site.

In the spring of 2006, when the ice began to break apart, it was decided that the instruments should be returned to the water. On May 26th, the EC staff arrived for a site visit with a helicopter available to travel to the remote sites. The VBNC staff accompanied the EC staff and successfully deployed the instruments at the Camp Pond Brook station and Lower Reid Brook station. The Upper Reid Brook instrument could not be deployed at this time because it was found that wildlife had chewed off the end of the communication cable (**Figure 2**) that connects the instrument to the datalogger in the hut. A new communication cable was ordered at that point in time.

Figure 2

In July 2006, both DOEC and EC staff travelled to the VBNC mine site for a site visit to ensure that proper maintenance/calibration procedures were being followed and at the same time provide technical assistance to the VBNC staff. As mentioned previously, it was decided in the spring to order a new instrument to establish a new station on the Tributary to Lower Reid Brook (**Figure 3**). During the trip in July 2006, this new surface water station was established and made operational. Additionally, DOEC and EC staff were successful in deploying the new real-time groundwater monitoring well (**Figure 4**).

Figure 3

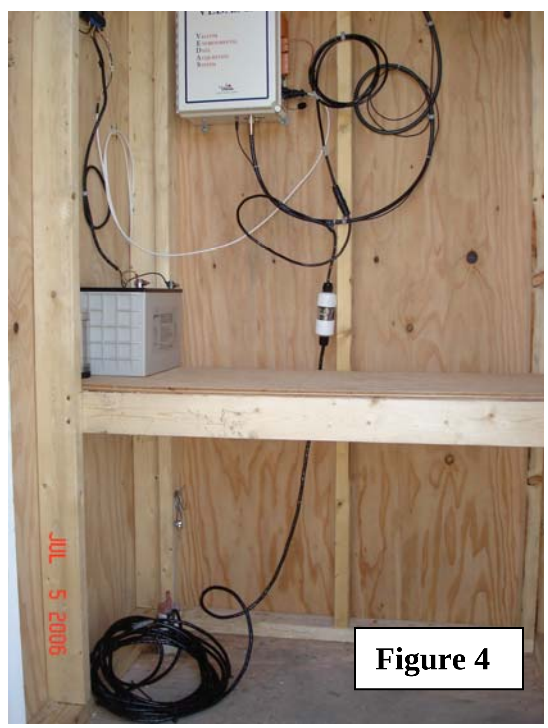


Figure 4

Just after the trip by DOEC and EC staff in July 2006, the data from the Lower Reid Brook station failed to transmit (even though it had been transmitting successfully just a few days prior). When the VBNC staff travelled to the station to investigate, it was evident that a bear had climbed onto the roof of the hut and pulled the antenna cabling out of place (**Figure 5**). The damage was so significant that the VBNC staff were unable to make the necessary repairs, thus the repairs would have to be made in September when the EC staff planned a return site visit.

In August 2006, the VBNC staff performed the regular monthly maintenance/calibration procedures. It was at that point in time that they installed the new communication cable at the Upper Reid Brook station (the cable had been damaged by wildlife) making it operational once again.

In September 2006, both EC and DOEC staff travelled again to Voisey's Bay to assist with regular maintenance and calibration procedures on all stations. The EC staff repaired the antenna cabling that had been damaged by wildlife and the Lower Reid Brook station began transmitting data once again.

In October 2006, Renée Paterson of DOEC gave a presentation entitled "Near Real-Time Water Quality Monitoring at Mining Operations in Newfoundland and Labrador" at the Aquatic Toxicity Workshop 2006 in Jasper, AB. The Real-Time Water Quality Monitoring Network at Voisey's Bay, Labrador was used as a case study to demonstrate how continuous water quality monitoring equipment can be used to identify emerging water quality events and then allow the issues to be addressed in a proactive manner.

In November 2006, the rivers began to freeze and the instruments were removed on November 7^{th} for the winter months. VBNC staff cleaned the instruments and sent them for winter storage to DOEC office in St. John's. The instruments will be sent to Edmonton for servicing/warranty work sometime in early 2007.

Section 2.0 Maintenance/Calibration

It is recommended by DOEC that regular maintenance/calibration take place on a monthly basis in order to ensure accuracy of the data from the real-time water quality monitoring stations. **Table 1** identifies the dates that the instruments were removed/reinstalled for regular maintenance and calibration in 2006. It is important to note that some deployment periods were longer than thirty days due to such issues as availability of helicopters to get to remote locations; timing of site visits from EC and DOEC staff; etc.

Table 1: Dates of Maintenance/Calibration of Instruments

Station	Installation	Removal	Total # of Days	Remarks
Upper Reid Brook	August 11, 2006	September 18, 2006	39	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 20, 2006	November 7, 2006	49	Extended deployment to allow more data collection before removal for winter months
Camp Pond Brook	May 26, 2006	July 5, 2006	41	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	July 6, 2006	August 11, 2006	37	Extended deployment due to inability of VBNC staff to get to sites (ie: poor weather)
	August 12, 2006	September 18, 2006	38	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 19, 2006	November 7, 2006	48	Extended deployment to allow more data collection before removal for winter months
Lower Reid Brook	May 26, 2006	July 5, 2006	41	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	July 6, 2006	August 11, 2006	37	Extended deployment due to inability of VBNC staff to get to sites (ie: poor weather)
	August 11, 2006	September 18, 2006	37	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 20, 2006	November 7, 2006	47	Extended deployment to allow more data collection before removal for winter months

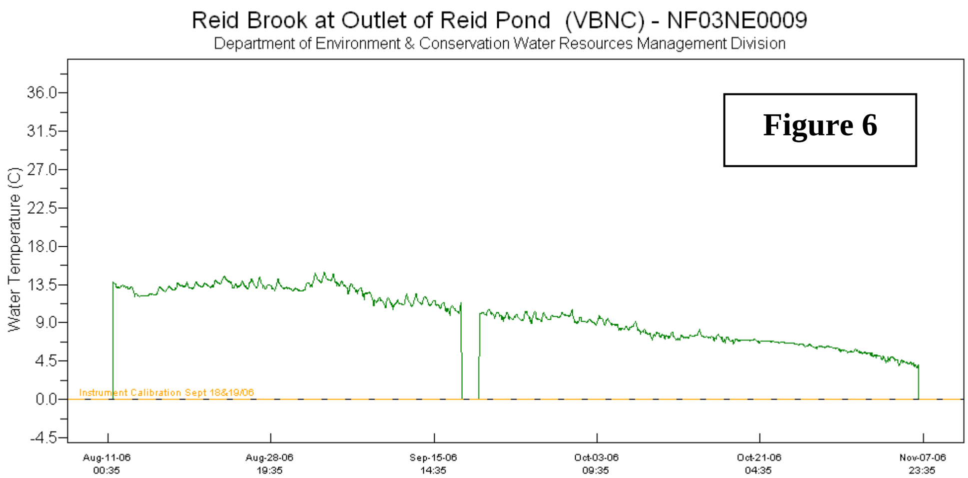
Trib Lower Reid Brook	July 6, 2006	August 11, 2006	37	Extended deployment due to inability of VBNC staff to get to sites (ie: poor weather)
	August 12, 2006	September 18, 2006	38	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 20, 2006	November 7, 2006	47	Extended deployment to allow more data collection before removal for winter months
Well After Tailings Pond	July 5, 2006	September 19, 2006	75	Instrument in well can be deployed for longer periods of time (ie: no fouling of sensors); extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 20, 2006	November 7, 2006	47	Extended deployment to allow more data collection before removal for winter months

Section 3.0 Data Interpretation

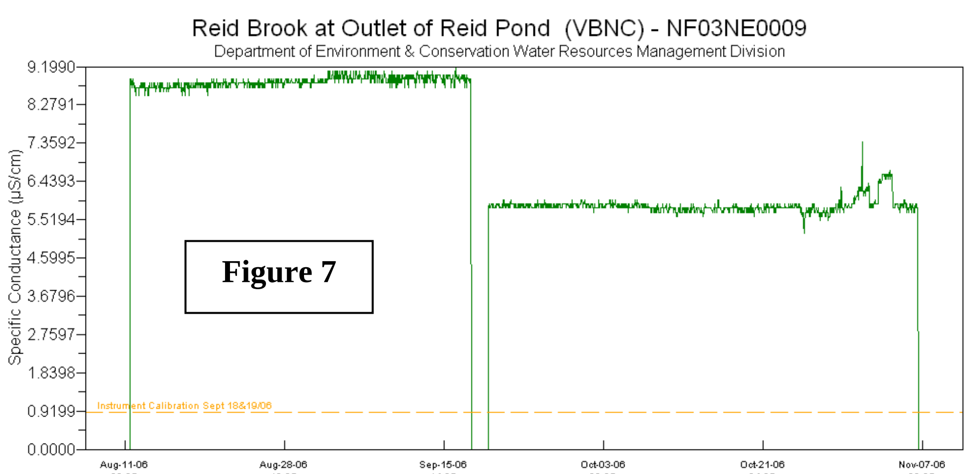
REID BROOK AT OUTLET OF REID POND (UPPER REID BROOK)

The Upper Reid Brook site is a control station that is not directly impacted by development. Throughout the majority of the deployment period from August to November 2006 (late deployment due to wildlife damage to communication cable), the water quality remained pristine.

The water temperature (**Figure 6**) decreased over the deployment period as expected for this time of the year. The points in the graph where the values drop to zero indicate the periods when the instrument was out of the water for maintenance/calibration purposes.

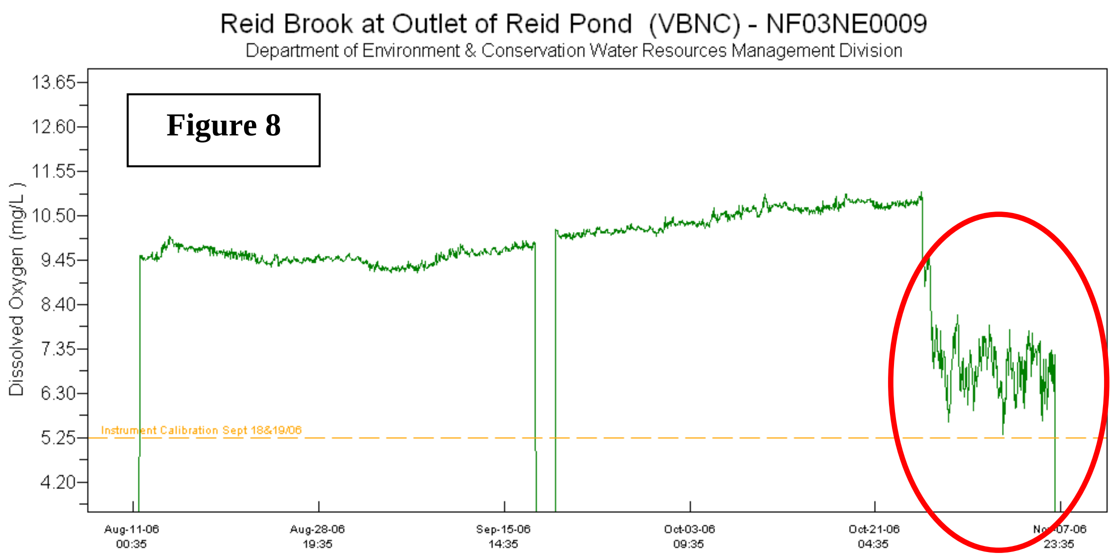


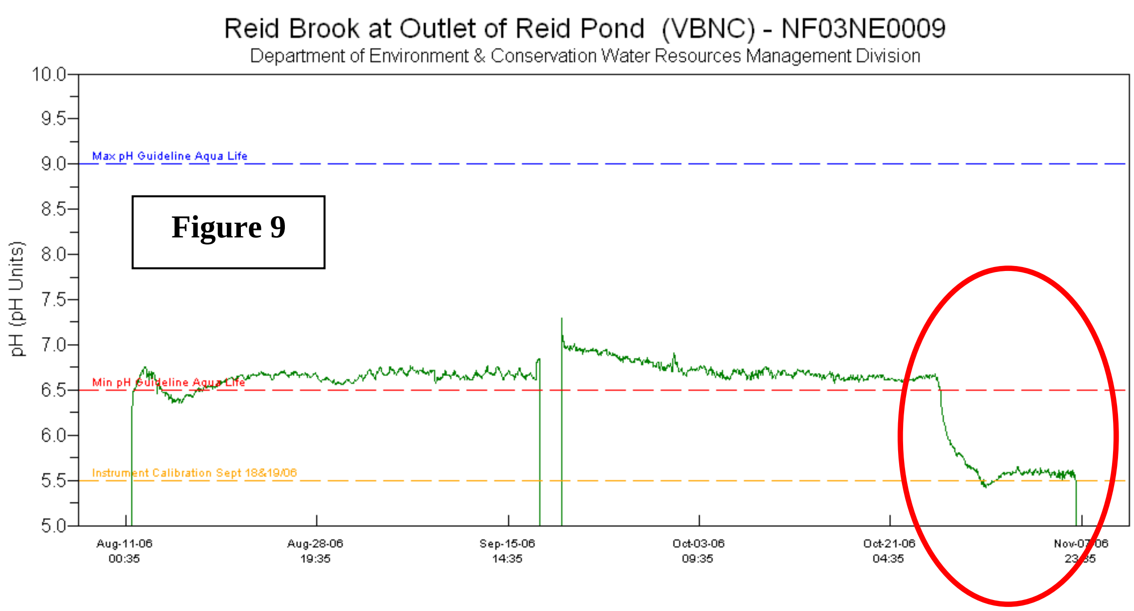
The conductivity values (**Figure 7**) remained very low at this fairly pristine station only ranging from 5.2 uS/cm – 9.2 uS/cm over the deployment period. The values before and after the scheduled maintenance/calibration check in mid-September were noticeably different due to the scale of the graph, however, the change in values from before and after were only in the magnitude of approximately 2.5 uS/cm. There was a slight increase in conductivity towards the end of the deployment period which dropped to background levels in a short time period.

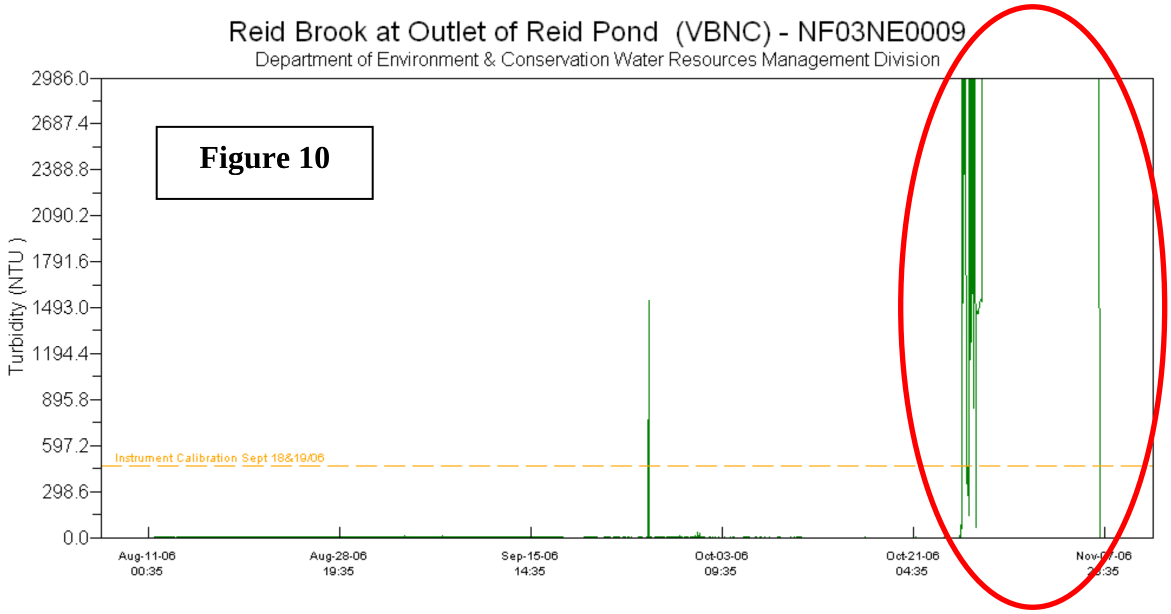


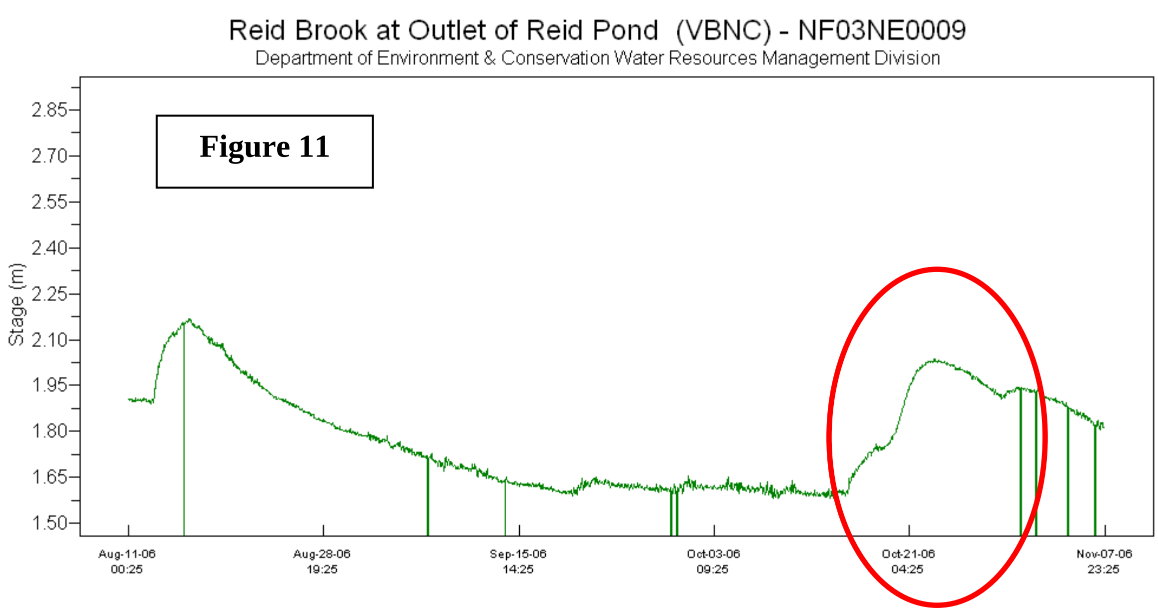
Reid Brook at Outlet of Reid Pond (VBNC) - NF03NE0009

The dissolved oxygen, pH and turbidity (**Figures 8, 9 & 10** respectively) remained consistent throughout the deployment until October 25th. The drop in dissolved oxygen and pH and increase in turbidity is consistent with a significant increase in stage (**Figure 11**) that peaked on October 23rd with a value of 2.036m. It appears as though the increase in stage caused turbidity issues that in turn affected the other sensors such as pH and dissolved oxygen until the removal date. In most cases, if parameters are affected by stage fluctuations, the readings generally return to normal background concentrations after a short period of time. This was not the case at Upper Reid Brook whereby the readings did not return to normal background levels.







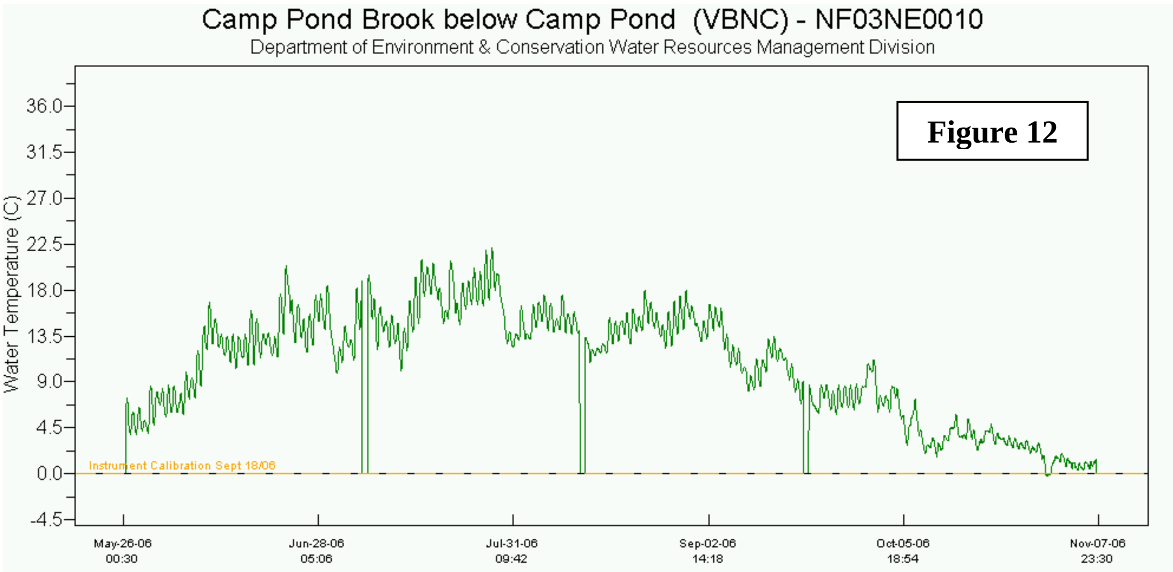


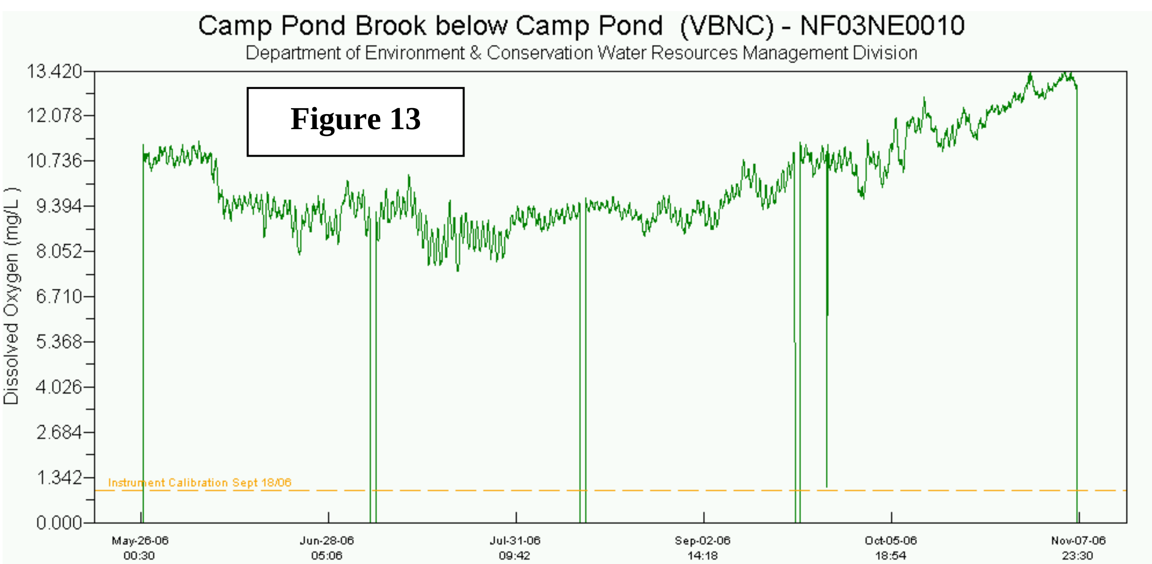
Overall, the Upper Reid Brook station displayed very consistent values for all major parameters over the deployment period. Upper Reid Brook is a pristine water body that can be used successfully as a control station to determine the natural background levels expected in the Voisey's Bay area.

CAMP POND BROOK BELOW CAMP POND

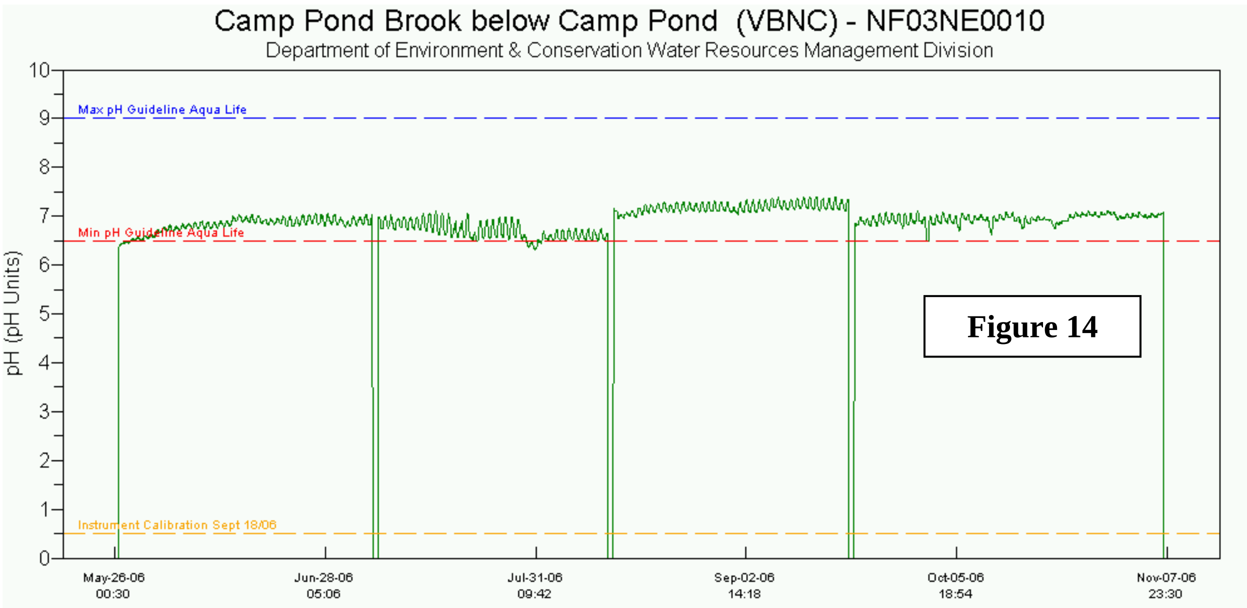
The Camp Pond Brook site was chosen to capture any emerging water quality events due to the nearby development of the mine/mill site. Throughout the majority of the deployment period form May to November 2006 the water quality remained fairly consistent for most parameters monitored. It appears as though many of the specific conductivity and turbidity value spikes can be attributed to times of increased stage due to increased rainfall amounts.

The water temperatures and dissolved oxygen (**Figures 12 & 13** respectively) values followed the expected pattern with water temperatures increasing over the summer months and dissolved oxygen values subsequently decreasing. Then as the fall approached, the water temperatures began to decrease as the dissolved oxygen values increased. The points in the graph where the values drop to zero indicate the periods when the instrument was out of the water for maintenance/calibration purposes.

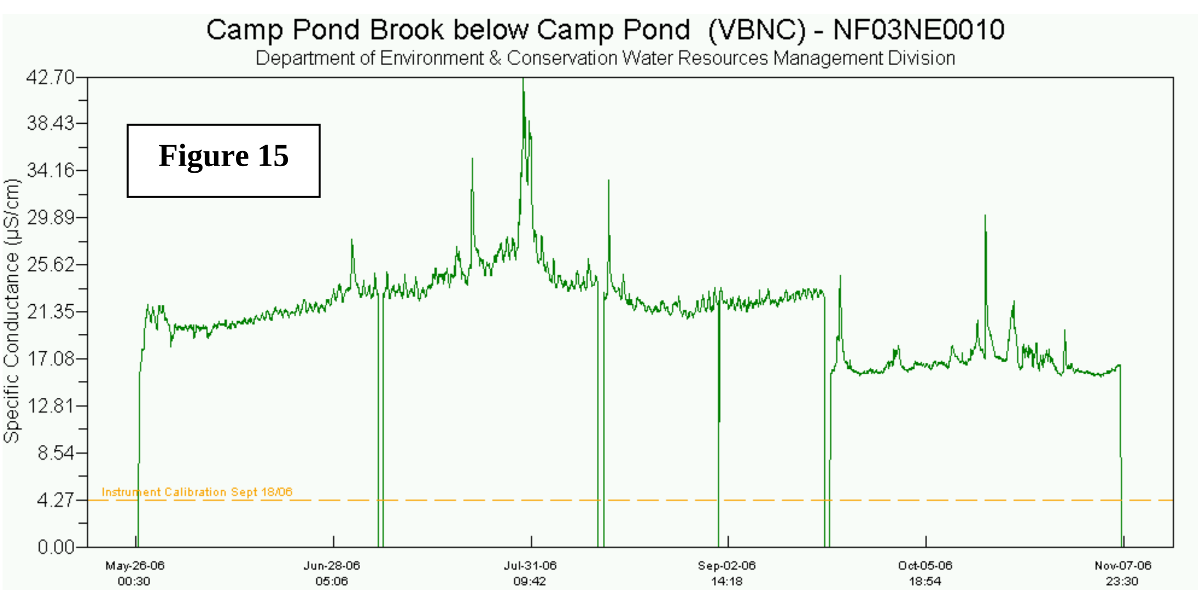




The pH values (**Figure 14**) at the Camp Pond Brook station remained very consistent over the entire deployment period with no major water quality events being captured. The majority of pH values remained in the recommended range (6.5 – 9.0) for the CCME Protection of Aquatic Life guidelines. The pH of the Camp Pond Brook station is only slightly higher than that of the control station (Upper Reid Brook).



The conductivity and subsequent TDS values (**Figures 15 & 16** respectively) remained fairly consistent throughout the deployment period (May – Nov). The conductivity values ranged from 15.2uS/cm – 42.7uS/cm. This range is higher than that of the control station (Upper Reid Brook) but is expected due to the level of development surrounding Camp Pond Brook. The maximum specific conductivity value reached was 42.7 uS/cm. The TDS values ranged from 0.0097 g/L – 0.0273 g/L. In most cases, the increases in conductivity and TDS can be attributed to increases in stage (**Figure 17**) due to increased rainfall (**Appendix A**).



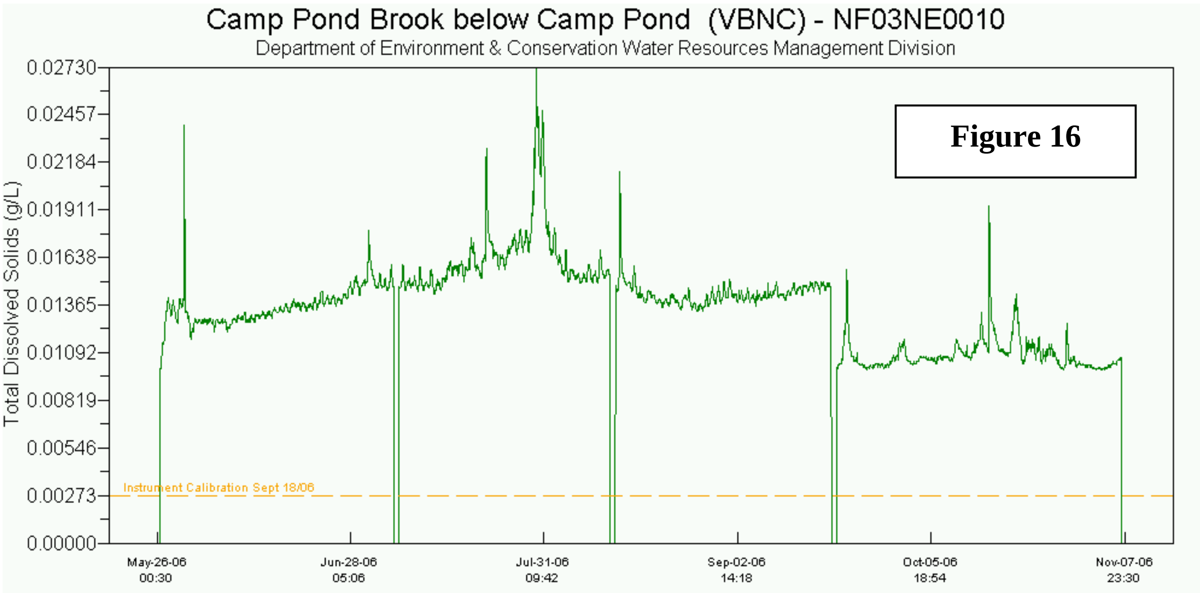


Figure 16

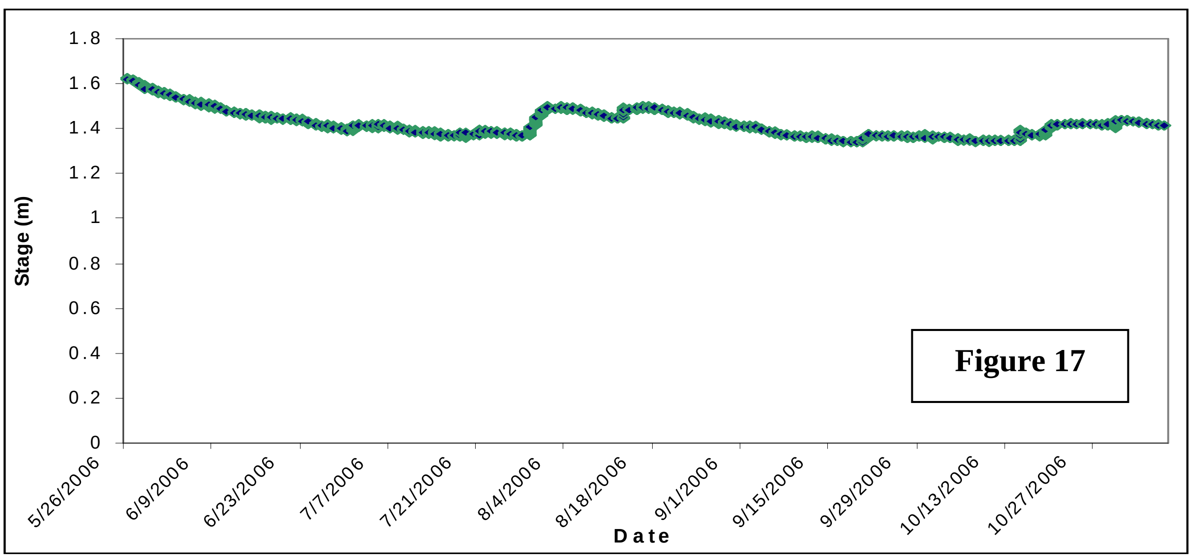
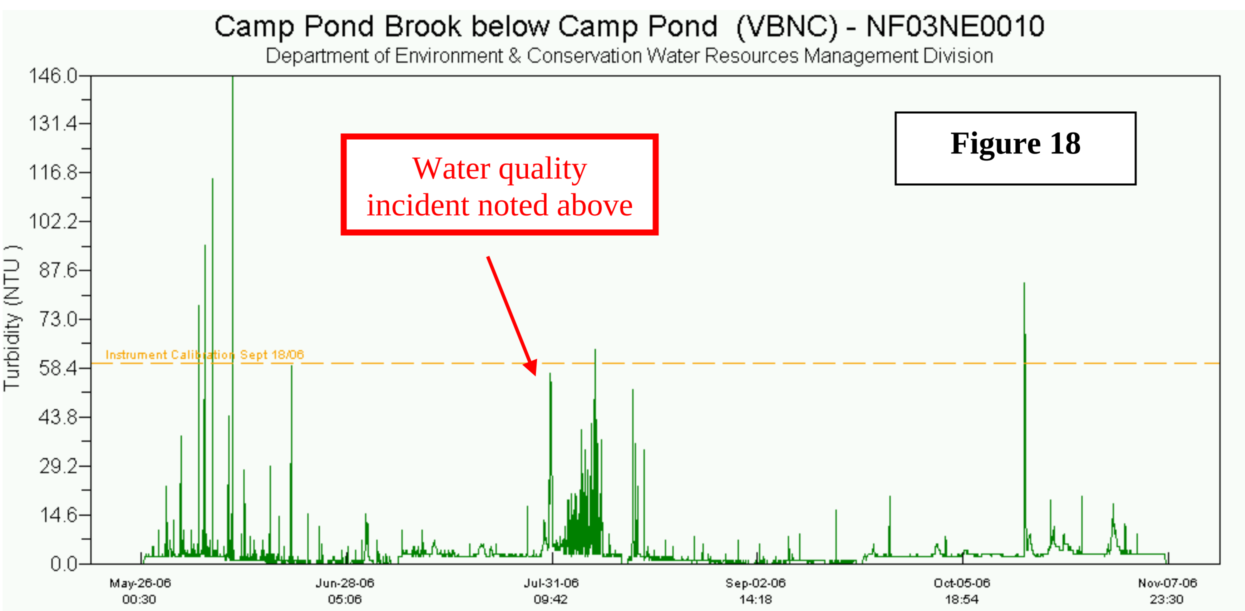


Figure 17

Figure 18 shows the turbidity values for Camp Pond Brook over the deployment period (May – Nov). There were a number of spikes in turbidity over the five month period with the maximum turbidity value being recorded at 146.0 NTU. This is significantly lower than the maximum values recorded in previous years during the construction phase of the project. By moving into the operational phase of the project, the spikes in turbidity values have decreased from previous years in Camp Pond Brook. As was the case with the conductivity values, it appears as though the majority of the turbidity increases are associated with increased stage (**Figure 17** above) due to increased rainfall (**Appendix A**). Of particular note, on July 31st, 2006, there was a point when the turbidity values spiked to a reading of 57 NTU. This increase in turbidity values was caused by sediment-laden water from Sedimentation Pond B being pumped directly into the environment only about 100m from Camp Pond Brook. Some weeks before the incident, the pipeline that allows water to be pumped from Sedimentation Pond B to Sedimentation Pond A was disconnected to allow the pumping down of Sedimentation Pond B using a submersible pump. It was because this pipeline was disconnected that the water accidentally got pumped into the environment. The water flowed over ~50m of exposed material prior to reaching the buffer zone. When the incident was discovered by VBNC staff, the central control room was contacted and the pump was immediately shut down. Additionally, the VBNC staff on-site promptly contacted the Water Resources Management Division (along with other government departments) to report the incident.

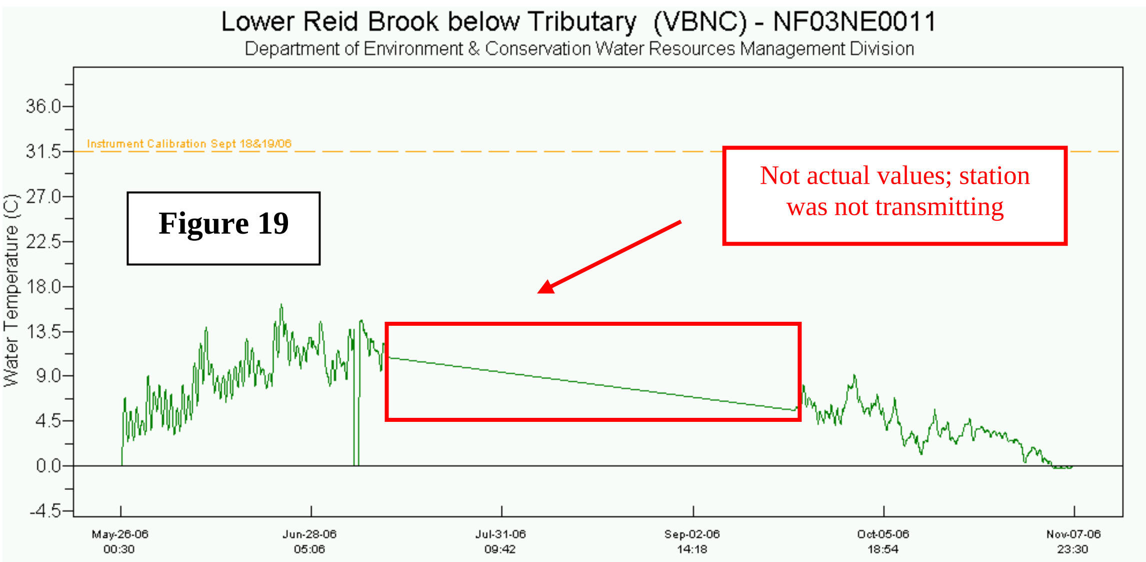


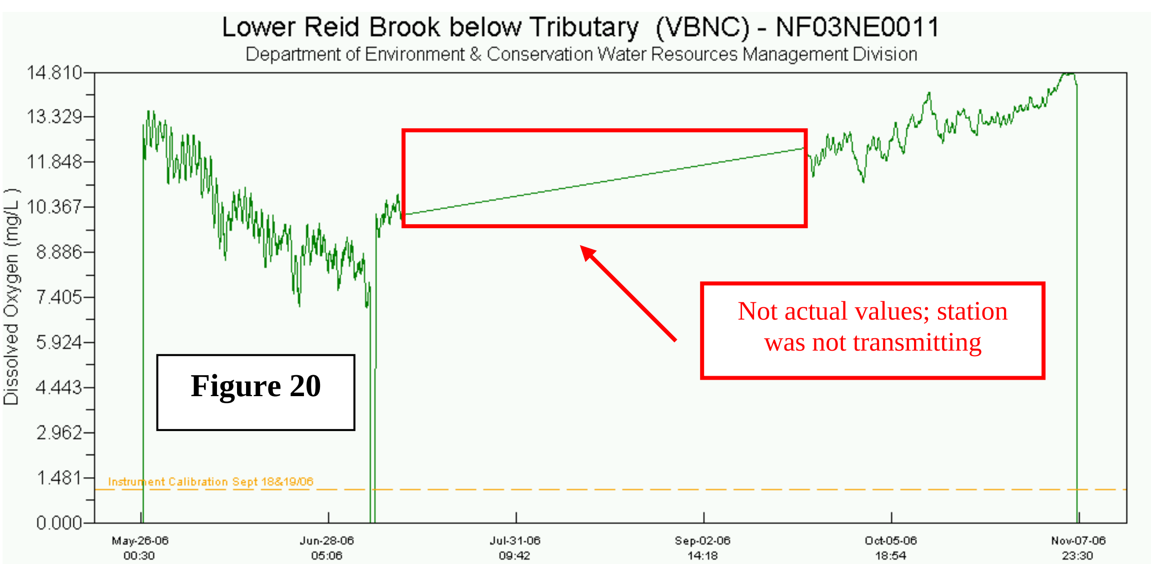
Overall, the Camp Pond Brook station displayed consistent values for all major parameters over the deployment period. The pH values in particular remained very consistent. The movement in both the specific conductivity and turbidity values can be attributed to increased stage height due to increased rainfall amounts in most cases. As noted above, there was only one water quality incident reported at Camp Pond Brook throughout the deployment period of which turbidity was slightly affected.

Lower Reid Brook below Tributary

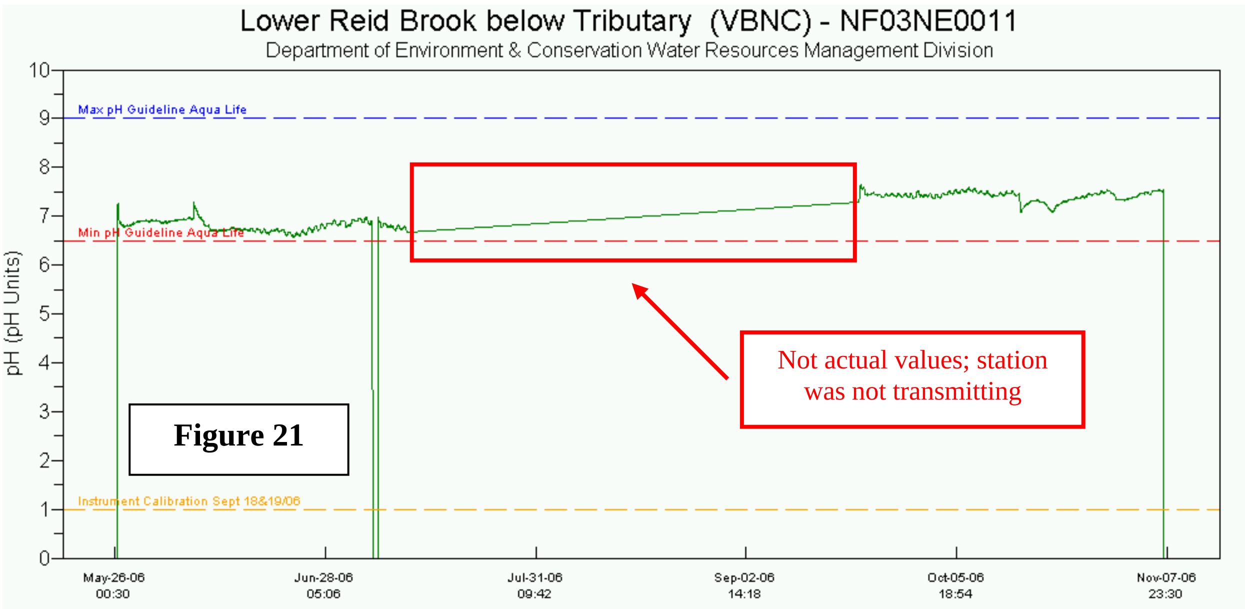
The Lower Reid Brook site was chosen as a downstream location that could be used to determine if water quality events from the upstream development area were still having an impact downstream just before the stream runs into the ocean. Throughout the deployment period from May to November 2006, the water quality at this station was slightly more variable than both the Upper Reid Brook and Camp Pond Brook stations.

As can be seen in **Figures 19** and **20**, the dissolved oxygen of the water at the Lower Reid Brook station demonstrated an expected decrease as the water temperature increased from late May until early July. At that point, as noted previously, damage to the antenna did not allow values to be transmitted until the antenna was repaired in mid-Sept. From September until early November, the water temperatures decreased while the dissolved oxygen values increased. The drop to zero in the graphs indicates the period when the instrument was out of the water for maintenance/calibration purposes.

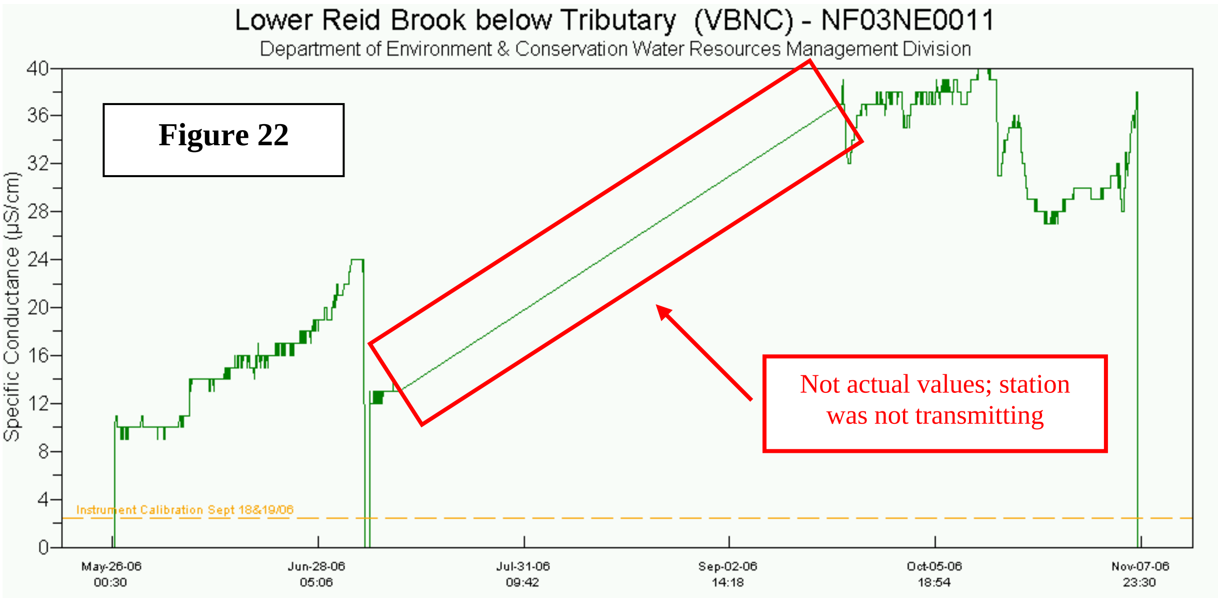




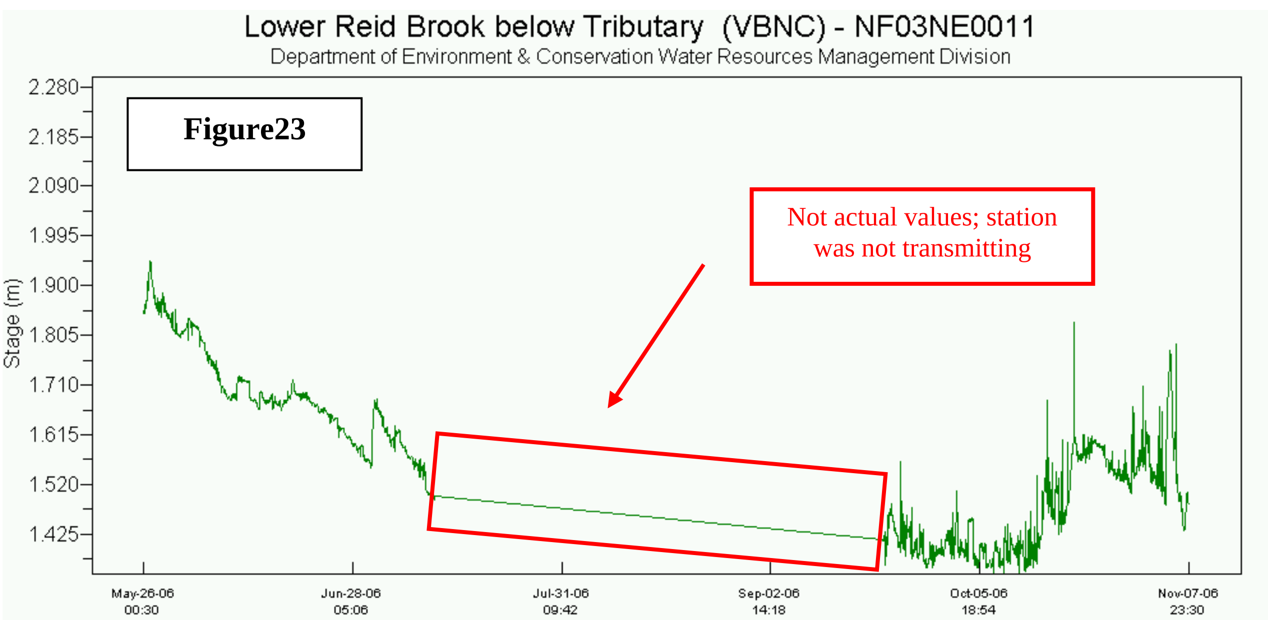
As can be seen in **Figure 21**, the pH of the water at the Lower Reid Brook station was fairly consistent throughout the deployment period with no major water quality events being captured. The pH values remained in the recommended range (6.5 – 9.0) for the CCME Protection of Aquatic Life guidelines. This range of pH values is slightly higher than that of the control station (Upper Reid Brook) but very similar to that of the Camp Pond Brook station.



The conductivity values (**Figure 22**) during the early months of deployment (late May to early July) remained low only ranging from 9 uS/cm - 24 uS/cm for the Lower Reid Brook station. As mentioned previously, the station stopped transmitting from July until mid September due to wildlife damage. However, when the station resumed transmitting in September there was a noticeable increase in conductivity values ranging from 27 uS/cm - 40 uS/cm. By comparing the conductivity graph to the stage graph (**Figure 23**), it is evident that rainfall clearly influences the conductivity readings at the Lower Reid Brook station. From May to July as the stage decreased, the conductivity values increased indicating that the ions were becoming more concentrated in the system. From September until November, the stage values and conductivity values showed mirror-image increases and decreases. Again, the overall range of conductivity values for the Lower Reid Brook station is higher than that of the control station (Upper Reid Brook), however, it is very similar to that of the Camp Pond Brook station.

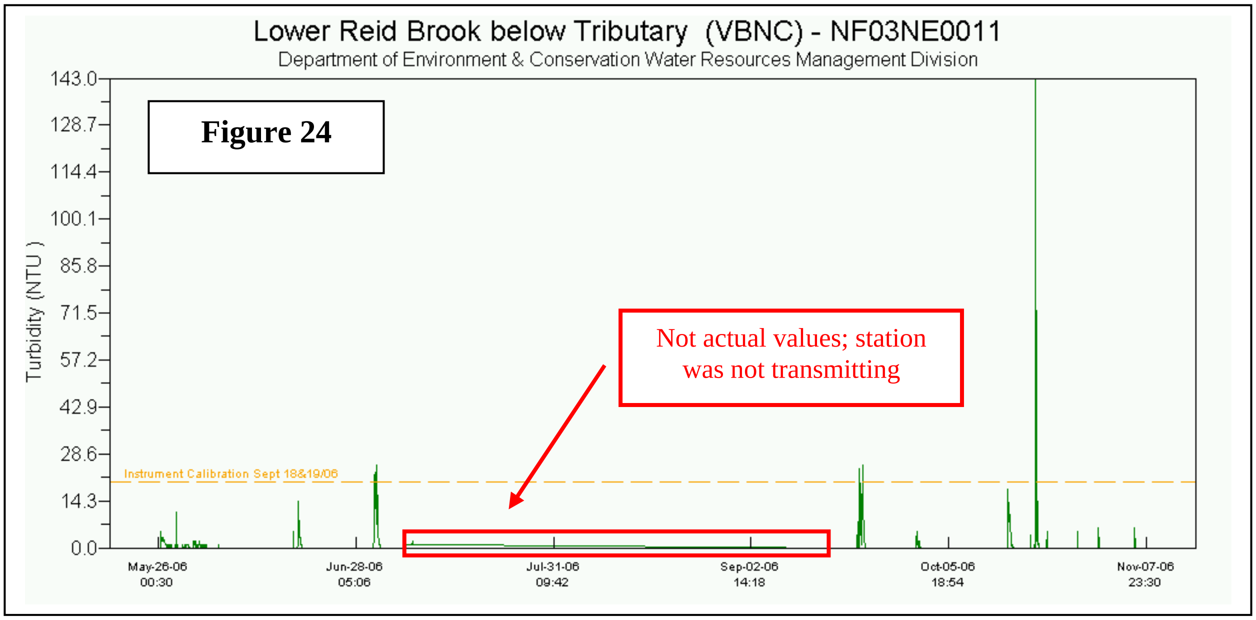


Lower Reid Brook below Tributary (VBNC) - NF03NE0011
Department of Environment & Conservation Water Resources Management Division
Figure 22
Specific Conductance (µS/cm)
40
36
32
28
24
20
16
12
8
4
0
Not actual values; station was not transmitting
Instrument Calibration Sept 18&19/06
May-26-06 00:30
Jun-28-06 05:06
Jul-31-06 09:42
Sep-02-06 14:18
Oct-05-06 18:54
Nov-07-06 23:30



Lower Reid Brook below Tributary (VBNC) - NF03NE0011
Department of Environment & Conservation Water Resources Management Division
Figure23
Stage (m)
2.280
2.185
2.090
1.995
1.900
1.805
1.710
1.615
1.520
1.425
Not actual values; station was not transmitting
May-26-06 00:30
Jun-28-06 05:06
Jul-31-06 09:42
Sep-02-06 14:18
Oct-05-06 18:54
Nov-07-06 23:30

As can be seen in **Figure 24,** the turbidity of the water at the Lower Reid Brook station remained very consistent with very few spikes throughout the deployment period. The maximum turbidity value recorded (143 NTU) took place on October 20th. The spike only occurred over a one-hour time period and then decreased immediately to background levels indicating there may have been a disturbance to the turbidity sensor. As was noted with the Camp Pond Brook station, the number of spikes in turbidity at the Lower Reid Brook station during this past sampling season (May-Nov 2006) is significantly less than the activity in turbidity values of previous years. Moving from the construction phase into the operational phase of the project has alleviated many of the turbidity issues encountered in the past.



Overall, the Lower Reid Brook station displayed fairly consistent values for all major parameters during the deployment period. Parameters are typically slightly higher than the control site, Upper Reid Brook, but similar to Camp Pond Brook.

Tributary to Lower Reid Brook

As mentioned previously, it was jointly decided by VBNC and DOEC that an additional surface water quality monitoring station be established on a tributary that runs into Reid Brook. This station is located in fairly close proximity to the ovoid and thus it was chosen in particular to capture any water quality events that may result from the actual open-pit mining activities. The deployment period extended from July 6th, 2006 – Nov. 7th, 2006.

As expected, the water temperatures (**Figure 25**) at the tributary station decreased over the deployment period while the dissolved oxygen values increased (**Figure 26**). The drop to zero in the graphs indicates the period when the instrument was out of the water for maintenance/calibration purposes.

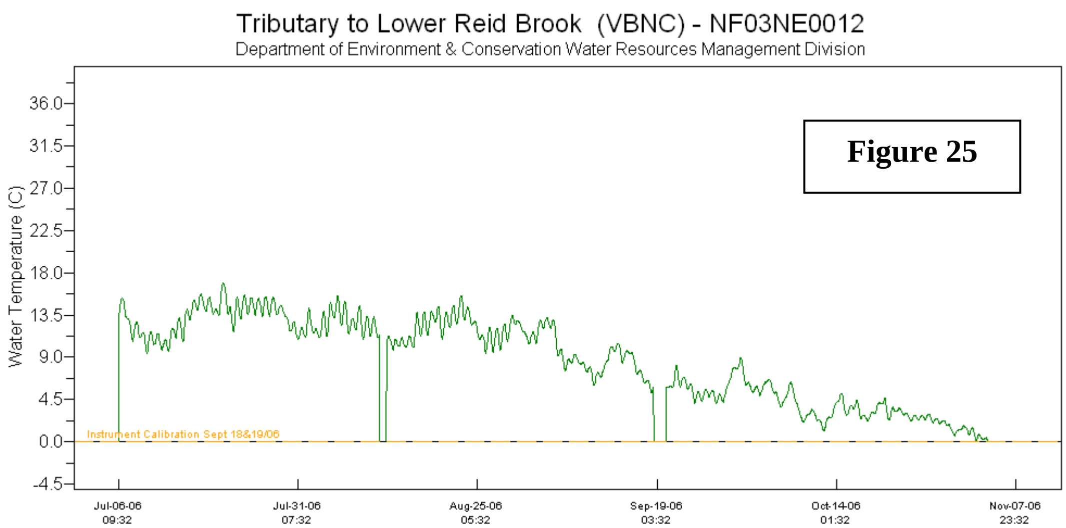


Figure 25

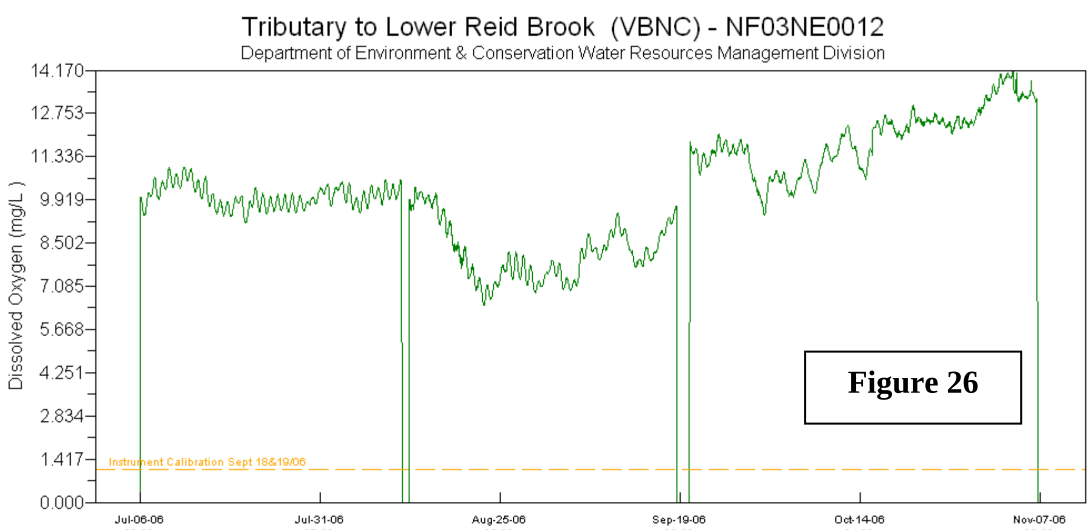


Figure 26

As can be seen in **Figure 27**, the pH of the water at the Tributary to Lower Reid Brook station was fairly consistent throughout the deployment period with no major water quality events being captured. The majority of pH values remained in the recommended range (6.5 – 9.0) for the CCME Protection of Aquatic Life guidelines. This range of pH values is slightly higher than that of the control station (Upper Reid Brook) but very similar to that of both the Camp Pond Brook and the Lower Reid Brook stations. By comparing the pH graph to the stage graph (**Figure 28**) it is evident that increases in stage (due to increased rainfall) have an effect on the pH values.

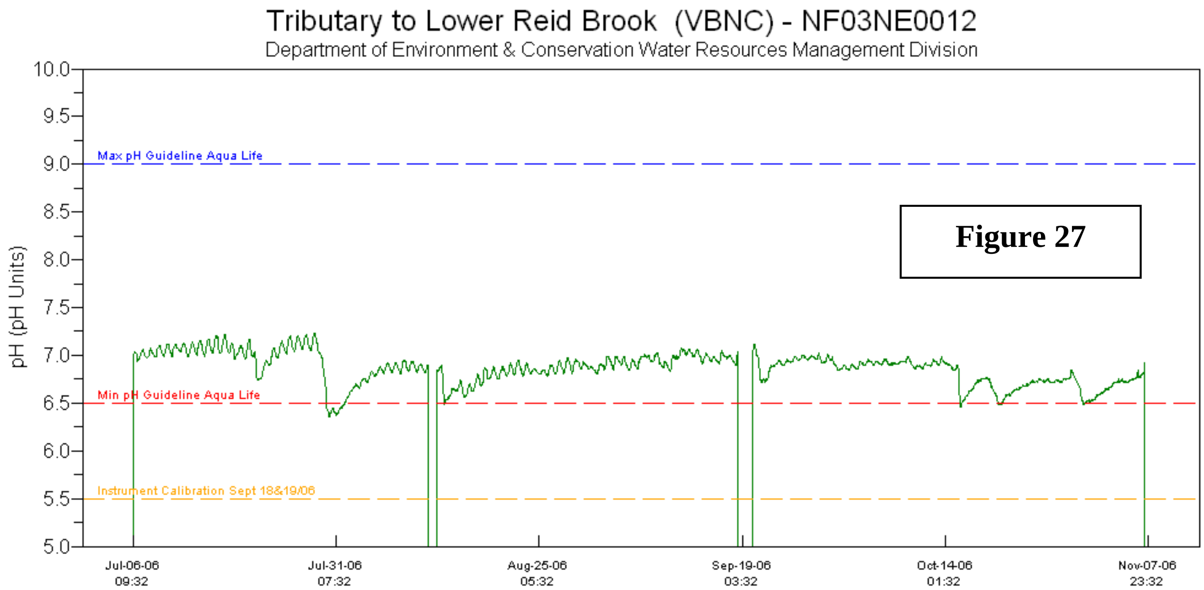


Figure 27

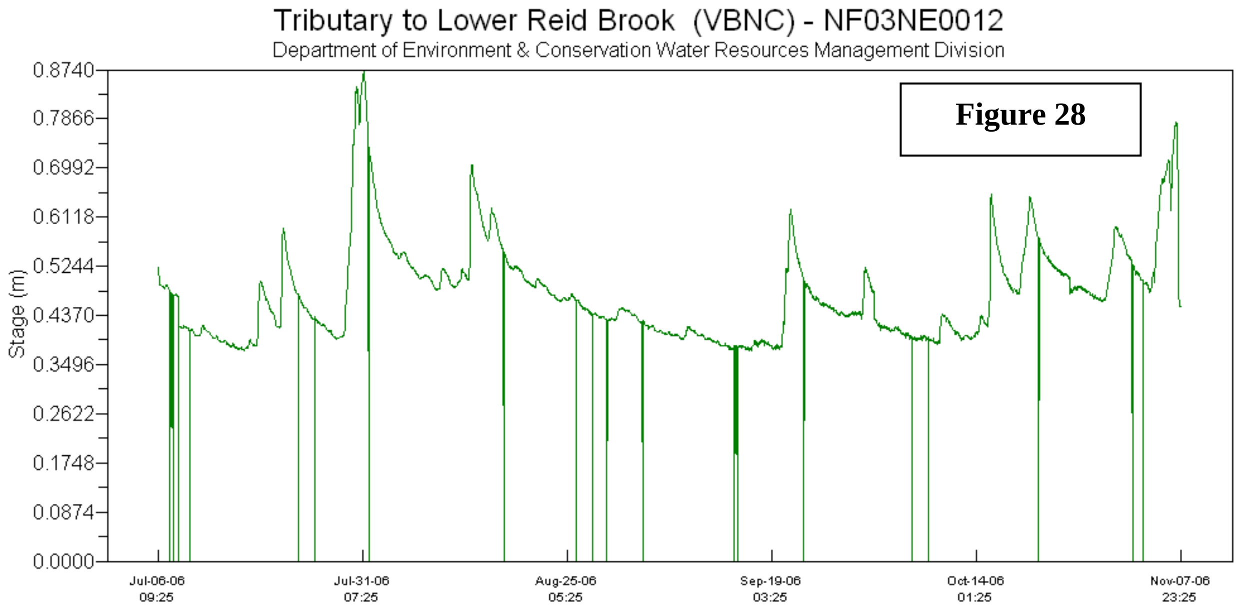


Figure 28

The conductivity values (**Figure 29**) at the Tributary to Lower Reid Brook station showed a decrease over the deployment period from July to November. The conductivity values ranged from 11.3 uS/cm – 35.1 uS/cm. This range is very comparable to that of the Camp Pond Brook and Lower Reid Brook stations. As was the case with the Lower Reid Brook station, the times when the conductivity values decreased can be attributed to increases in the stage graph (**Figure 28** above). It appears as though the increased rainfall amounts work to dilute the river system thus seeing a noticeable drop in ion concentrations.

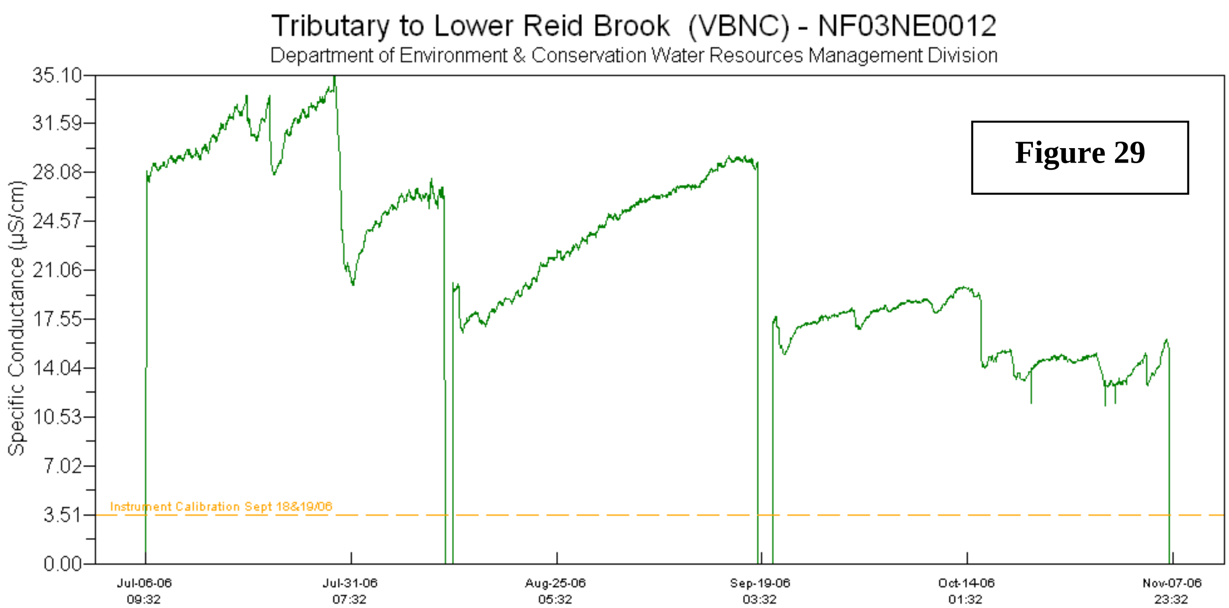
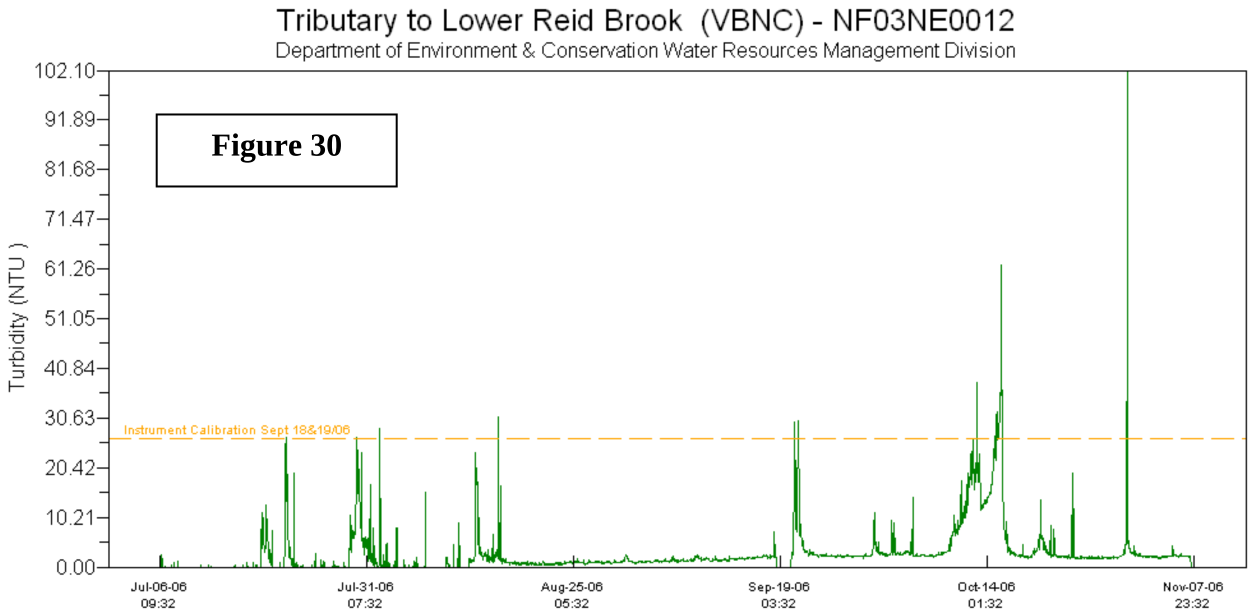


Figure 29

As can be seen in **Figure 30,** the turbidity of the water at the Tributary to the Lower Reid Brook station remained very consistent with only minor spikes throughout the deployment period. The maximum turbidity value recorded (102.1 NTU) took place on October 30th. The spike only occurred over a one-hour time period and then decreased immediately to background levels indicating there may have been a disturbance to the turbidity sensor. It appears as though the majority of the turbidity increases are associated with increased stage (**Figure 28** above) due to increased rainfall (**See Appendix A**).



Overall, the Tributary to the Lower Reid Brook station displayed fairly consistent values remaining in expected ranges for all major parameters during the deployment period. Parameters are typically slightly higher than the control site, Upper Reid Brook, but similar to both the Camp Pond Brook and Lower Reid Brook stations.

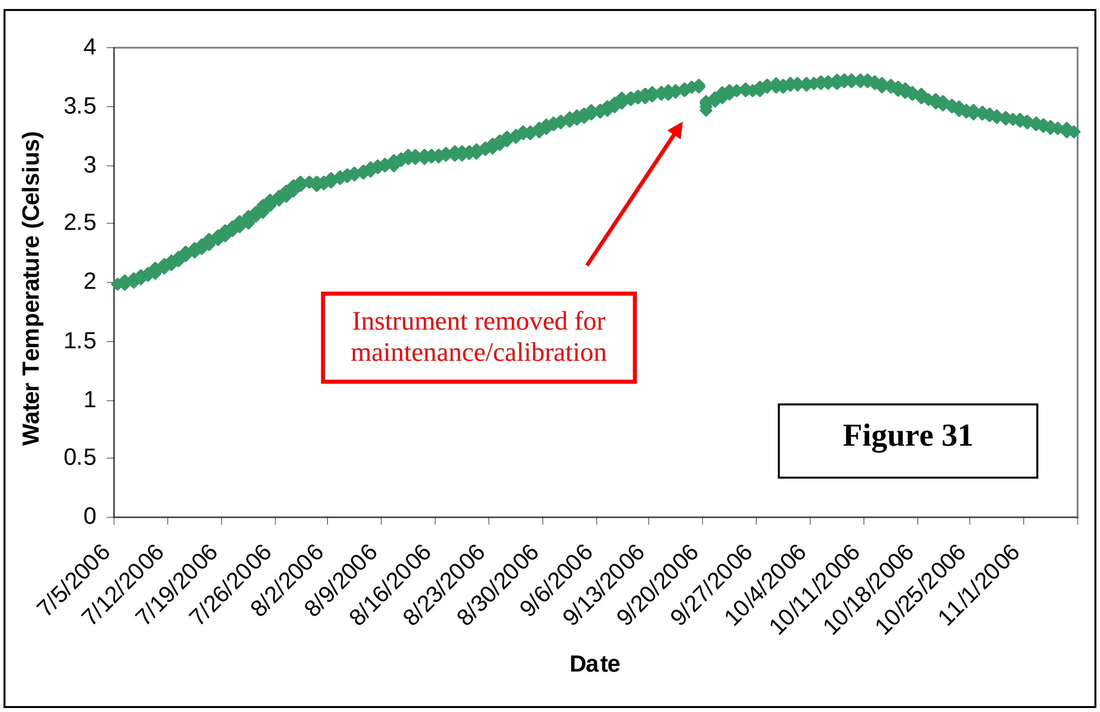
Groundwater Well

As mentioned previously, during the 2006 sampling season it was decided to put in a new real-time groundwater monitoring instrument located in a well on the outer edge of the tailings dam of Headwater Pond on the end closest to Otter Pond. This particular location was chosen to capture any groundwater quality events that may result from leakage of the tailings pond through the tailings dam area via the groundwater. The installation of a real-time groundwater monitoring well at VBNC was the first of its kind in Newfoundland and Labrador.

The instrumentation used in groundwater monitoring is the Quanta manufactured by Hydrolab (same manufacturer of surface water instruments). Therefore, many of the maintenance/calibration techniques are similar between the two types of instruments with only minor differences. The parameters measured in the groundwater well by the Quanta are slightly different than the parameters measured at the surface water station. They include: a) water temperature b) pH c) oxidation reduction potential (ORP) d) specific conductivity e) depth.

The instrument was deployed from July 5th to November 7th, 2006. Since this was considered a pilot project, it was interesting to see how the various parameters reacted overtime. There were no water quality events captured throughout the deployment period with all parameters remaining very consistent.

The water temperature within the well remained consistent only ranging from 1.98 – 3.73 °C. As can be seen in **Figure 31**, the water temperature increased throughout the summer months and began to decrease as the winter approached. The break in the graph indicates the period of time that the instrument was removed for maintenance/calibration.



The pH values (**Figure 32**) within the groundwater well remained very consistent only ranging from 8.3 – 9.07 pH units. This range of pH values is significantly more basic than that recorded at all of the surface water stations. This is an indication of the natural basic properties of the surrounding bedrock into which the well is drilled. The oxidation/reduction potential is also measured at the groundwater well, however, the proper solution (Zorbell's Solution) was not used to calibrate the probe, therefore this data cannot be analysed accurately. The use of the proper calibration solution will be implemented into the procedures for the upcoming sampling season in 2007.

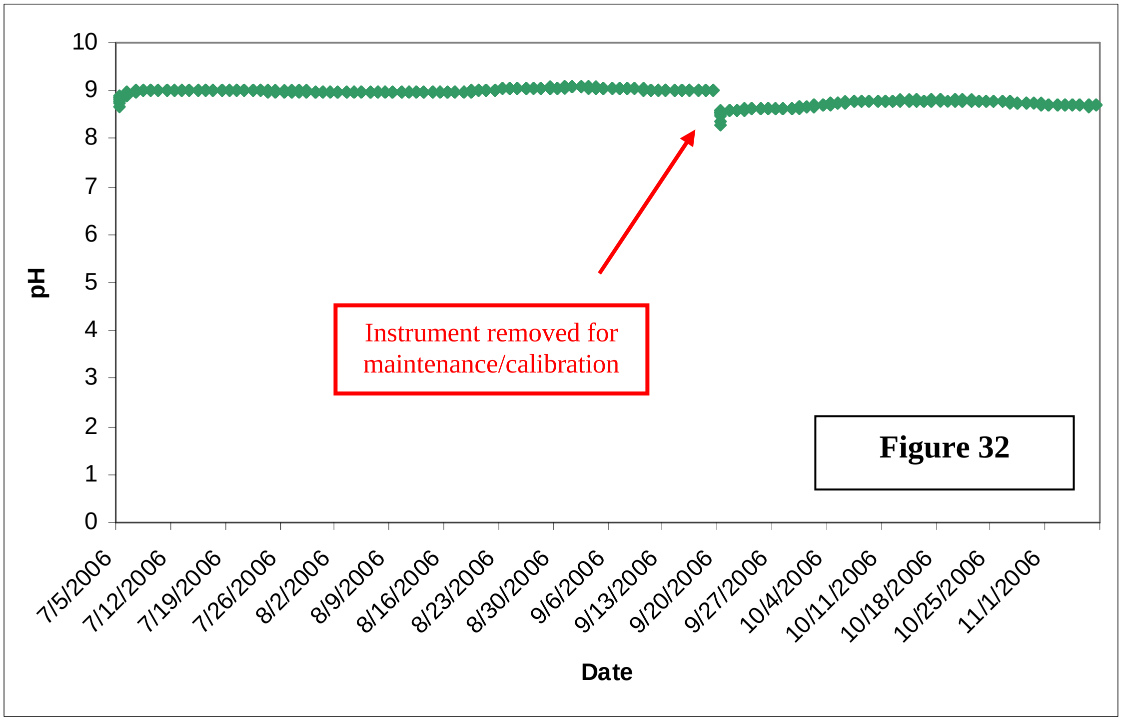
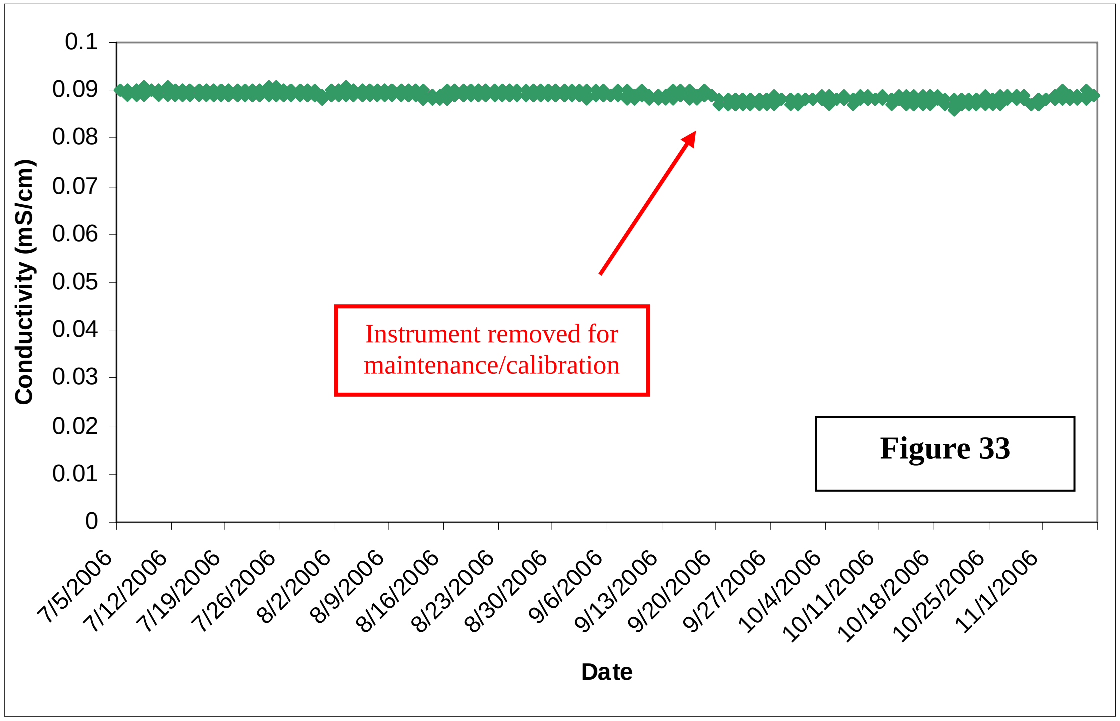
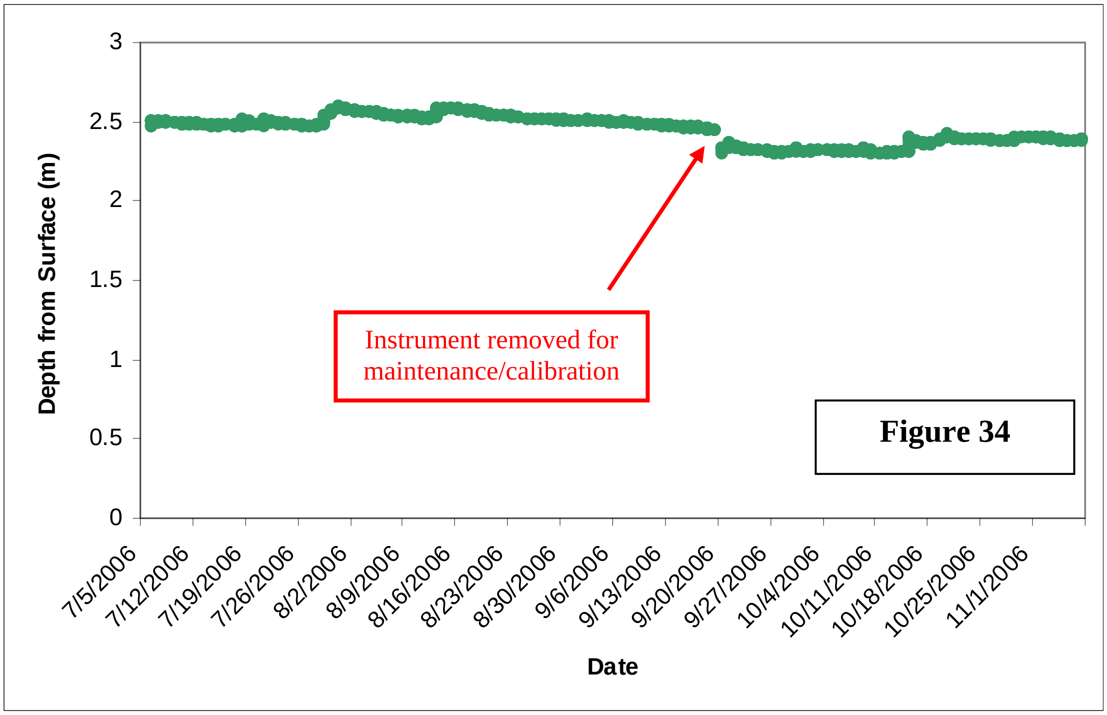


Figure 32

As can be seen in **Figure 33**, the specific conductivity values also remained very consistent over the deployment period only ranging from 0.086mS/cm – 0.091 mS/cm (86 uS/cm – 91 uS/cm). This baseline range of conductivity values in the groundwater is somewhat higher that that recorded at the surface water stations mainly due to the increased dissolved ions that are present in the groundwater from the surrounding rock.



The depth from the surface (**Figure 34**) did not change significantly over the deployment period only ranging from 2.299m – 2.599m.



As expected, there was very little activity of any of the parameters being recorded in the groundwater well over the deployment period. This sampling season provided a solid baseline record of the groundwater quality in the area of the tailings pond.

Section 4.0 Quality Assurance/Quality Control (QA/QC) Measures

Quality Assurance/Quality Control (QA/QC) measures are a very important aspect of the Real-Time Water Quality Monitoring Network in Voisey's Bay. These measures are put in place to ensure that the instruments are reading data accurately. The QA/QC procedures established by DOEC are two-fold:

1) Data from the water quality monitoring instrument in-situ (Datasonde) are compared to data from a portable instrument in-situ (Minisonde) at the time of redeployment after maintenance/calibration procedures have been performed; data must fall within a specified range. **Table 2** summarizes the QA/QC results comparing the Datasonde readings against the Minisonde readings for each real-time water quality station.

2) Grab water samples are taken from each station at the time of redeployment and sent to a laboratory for analysis; the results are then compared to those of the water quality monitoring instrument in-situ (Datasonde); data must fall within a specified range. **Table 3** summarizes the QA/QC results comparing the Datasonde readings against the laboratory readings (only three readings available from the lab for comparison – pH; conductivity; turbidity).

As can be seen in **Table 2**, the QA/QC comparison between the Datasondes and the Minisonde at the time of redeployment for all stations is generally good or excellent. One problem encountered was that on May26th, 2006 no Minisonde readings were taken at any of the stations for comparison purposes. This was because the Minisonde was not sufficiently charged at the time, a fact which was not discovered by the Environmental Officer until arrival in the field.

There are some instances throughout the deployment period when the QA/QC comparison rankings fell in the marginal, fair and poor categories. For the most part, it is the dissolved oxygen probes (membrane) that are somewhat variable and fall outside the good or excellent categories.

It should be noted that the conductivity values from the Minisonde in the months of August and September were not recorded due to a malfunction in the sensor leading to erroneous values. The Minisonde will be sent to Edmonton for servicing early in 2007 to address this issue.

As can be seen in **Table 3**, the QA/QC comparison between the Datasondes and laboratory data was excellent for all turbidity sample comparisons. The rankings were excellent and good in eight of the ten sample comparisons for pH. However, the conductivity comparisons ranked poor in the majority of cases. This issue has recently been encountered with a variety of the QA/QC samples for a number of other real-time water quality samples and will be looked at in more detail in the upcoming months.

Table 2: QA/QC Results (Datasonde vs. Minisonde)

Station	Reinstallation Date	Parameters	Datasonde Data	Minisonde Data	Rating
Upper Reid Brook	August 11, 2006	Temp (°C)	13.78	13.63	**Excellent**
		pH (units)	6.28	6.4	**Excellent**
		Conductivity (µS/cm)	8.899	NA	**NA**
		Dissolved Oxygen (mg/L)	9.569	10.55	**Marginal**
	September 20, 2006	Temp (°C)	10.03	9.79	**Good**
		pH (units)	7.3	7.09	**Good**
		Conductivity (µS/cm)	5.8	NA	**NA**
		Dissolved Oxygen (mg/L)	10.18	10.23	**Excellent**
Camp Pond Brook	May 26, 2006	Temp (°C)	6.15	No Minisonde readings were taken	**NA**
		pH (units)	6.28		**NA**
		Conductivity (µS/cm)	15.2		**NA**
		Dissolved Oxygen (mg/L)	11.22		**NA**
	July 6, 2006	Temp (°C)	17.82	17.49	**Good**
		pH (units)	6.92	6.76	**Excellent**
		Conductivity (µS/cm)	23	24.6	**Good**
		Dissolved Oxygen (mg/L)	9.23	8.67	**Fair**
	August 12, 2006	Temp (°C)	13.33	13.22	**Excellent**
		pH (units)	7.16	6.77	**Good**
		Conductivity (µS/cm)	23.1	NA	**NA**
		Dissolved Oxygen (mg/L)	9.64	9.91	**Excellent**
	September 19, 2007	Temp (°C)	8.46	8.24	**Good**
		pH (units)	6.42	7.15	**Fair**
		Conductivity (µS/cm)	15.7	NA	**NA**
		Dissolved Oxygen (mg/L)	11.31	11.38	**Excellent**
Lower Reid Brook	May 26, 2006	Temp (°C)	3.72	No Minisonde readings were taken	**NA**
		pH (units)	7.2		**NA**
		Conductivity (µS/cm)	10		**NA**
		Dissolved Oxygen (mg/L)	13.08		**NA**
	July 6, 2006	Temp (°C)	13.8	13.69	**Excellent**
		pH (units)	6.98	6.67	**Good**
		Conductivity (µS/cm)	13	21.8	**Poor**
		Dissolved Oxygen (mg/L)	10.14	9.46	**Fair**
	August 11, 2006	Temp (°C)	Datalogger not transmitting – no data available	11.49	**NA**
		pH (units)		6.82	**NA**
		Conductivity (µS/cm)		25.1	**NA**
		Dissolved Oxygen (mg/L)		10.84	**NA**
	September 20, 2006	Temp (°C)	5.64	5.5	**Excellent**
		pH (units)	7.28	7.03	**Good**
		Conductivity (µS/cm)	37	NA	**NA**
		Dissolved Oxygen (mg/L)	12.33	11.75	**Fair**
Trib. to Lower Reid Brook	July 6, 2006	Temp (°C)	13.43	13.36	**Excellent**
		pH (units)	7.0	6.55	**Good**
		Conductivity (µS/cm)	28.2	26.4	**Good**
		Dissolved Oxygen (mg/L)	10	9.81	**Excellent**
	August 12, 2006	Temp (°C)	10.78	10.75	**Excellent**
		pH (units)	6.82	6.53	**Good**
		Conductivity (µS/cm)	20.2	NA	**NA**
		Dissolved Oxygen (mg/L)	9.93	11.5	**Poor**
	September 20, 2006	Temp (°C)	5.79	5.7	**Excellent**
		pH (units)	7.04	7.04	**Excellent**
		Conductivity (µS/cm)	17.4	NA	**NA**
		Dissolved Oxygen (mg/L)	11.81	11.64	**Excellent**

Table 3: QA/QC Results (Datasonde Data vs. Laboratory Data)

Station	Reinstallation Date	Parameters	Datasonde Data	Laboratory Data	Rating
Upper Reid Brook	August 11, 2006	Temp (°C)	13.78		**NA**
		pH (units)	6.28	6.35	**Excellent**
		Conductivity (µS/cm)	8.899	12	**Poor**
		Dissolved Oxygen (mg/L)	9.569		**NA**
		Turbidity (NTU)	0.5	0.2	**Excellent**
	September 20, 2006	Temp (°C)	10.03		**NA**
		pH (units)	7.3	6.22	**Poor**
		Conductivity (µS/cm)	5.8	12	**Poor**
		Dissolved Oxygen (mg/L)	10.18		**NA**
		Turbidity (NTU)	0.2	1.0	**Excellent**
Camp Pond Brook	July 6, 2006	Temp (°C)	17.82		**NA**
		pH (units)	6.92	6.48	**Good**
		Conductivity (µS/cm)	23	27	**Marginal**
		Dissolved Oxygen (mg/L)	9.23		**NA**
		Turbidity (NTU)	2.0	1.0	**Excellent**
	August 12, 2006	Temp (°C)	13.33		**NA**
		pH (units)	7.16	6.66	**Good**
		Conductivity (µS/cm)	23.1	30	**Poor**
		Dissolved Oxygen (mg/L)	9.64		**NA**
		Turbidity (NTU)	1.0	1.5	**Excellent**
	September 19, 2006	Temp (°C)	8.46		**NA**
		pH (units)	6.42	6.84	**Good**
		Conductivity (µS/cm)	15.7	30	**Poor**
		Dissolved Oxygen (mg/L)	11.31		**NA**
		Turbidity (NTU)	2.0	1.0	**Excellent**
Lower Reid Brook	July 6, 2006	Temp (°C)	13.8		**NA**
		pH (units)	6.98	6.48	**Good**
		Conductivity (µS/cm)	13	27	**Poor**
		Dissolved Oxygen (mg/L)	10.14		**NA**
		Turbidity (NTU)	1.0	0.9	**Excellent**
	August 11, 2006	Temp (°C)	Datalogger not transmitting – no data available		**NA**
		pH (units)		6.61	**NA**
		Conductivity (µS/cm)		30	**NA**
		Dissolved Oxygen (mg/L)			**NA**
		Turbidity (NTU)		1.4	**NA**
	September 20, 2006	Temp (°C)	5.64		**NA**
		pH (units)	7.28	6.53	**Fair**
		Conductivity (µS/cm)	37	38	**Excellent**
		Dissolved Oxygen (mg/L)	12.33		**NA**
		Turbidity (NTU)	0.0	2.4	**Excellent**
Trib. to Lower Reid Brook	July 6, 2006	Temp (°C)	13.43		**NA**
		pH (units)	7.0	6.67	**Good**
		Conductivity (µS/cm)	28.2	30	**Good**
		Dissolved Oxygen (mg/L)	10		**NA**
		Turbidity (NTU)	0.0	1.0	**Excellent**
	August 12, 2006	Temp (°C)	10.78		**NA**
		pH (units)	6.82	6.71	**Excellent**
		Conductivity (µS/cm)	20.2	30	**Poor**
		Dissolved Oxygen (mg/L)	9.93		**NA**
		Turbidity (NTU)	1.5	2.2	**Excellent**
	September 20, 2006	Temp (°C)	5.79		**NA**
		pH (units)	7.04	6.57	**Good**
		Conductivity (µS/cm)	17.4	38	**Poor**
		Dissolved Oxygen (mg/L)	11.81		**NA**
		Turbidity (NTU)	2.9	1.7	**Excellent**

Section 5.0 Additional Activities

Development/Implementation of new Data Retrieval System

In 2006, the Water Resources Management Division spent a significant amount of time and resources to develop and implement a new Automatic Data Retrieval System (ADRS) that could efficiently and effectively retrieve the real-time water quality and quantity data from the GOES satellite system. Essentially, this system is designed to retrieve the pertinent data, place it in a newly designed database structure and then graph each parameter for all stations and populate it to the public web page every two hours. It is this timely data management and reporting that allows the real-time water quality monitoring to identify emerging water quality events as they happen at Voisey's Bay, Labrador. In order to provide full transparency, the real-time water quality and quantity data from all stations can be downloaded directly from the public webpage in both CSV and XML formats (line data last 7 days; daily summaries for past 35 days; monthly summaries for past 12 months).

In association with the development and implementation of the new data retrieval system, an intranet web application was also developed to give water quality experts the opportunity to better utilize and understand the water quality and quantity data. Through the web application, the water quality experts can:

- change the scales of the graphs
- add new graphs when new parameters are added to instrumentation
- add annotation lines (Ex: min/max guideline limit lines; customized notes; etc.)
- determine quickly if there are transmission problems with any stations
- set email alerts to inform experts (within government) when parameter limits have been surpassed
- view/export to Excel all available water quantity and quality line data for all stations
- automatically graph desired parameters for each station over any specified time frame

Overall, the development and implementation of the new ADRS and all of its associated products have allowed the real-time water quality monitoring program to move forward. There are plans to implement additional functionality to the system in 2007.

Presentation at the Aquatic Toxicity Workshop 2006

In October 2006, Renée Paterson of DOEC gave a presentation entitled "Near Real-Time Water Quality Monitoring at Mining Operations in Newfoundland and Labrador" at the Aquatic Toxicity Workshop 2006 in Jasper, AB. The Real-Time Water Quality Monitoring Network at Voisey's Bay, Labrador was used as a case study to demonstrate how continuous water quality monitoring equipment can be used to identify emerging water quality events and then allow the issues to be addressed in a proactive manner. The presentation was well received by the audience and clearly demonstrated environmental stewardship on the part of VBNC.

Section 6.0 Conclusions

The Voisey's Bay real-time water quality monitoring network has been very successful as a regulatory tool throughout the past year. The near-real time water quality data allows the VNBC staff to act immediately on emerging water quality events. It has clearly shown that the ambient water quality surrounding the development area is being protected. Moving from the construction phase to the operational phase of the project has decreased the number of water quality events significantly (ie: number/extent of turbidity spikes is greatly reduced).

Upper Reid Brook is a pristine area that can effectively be used as a control station that provides reliable natural background water quality data for comparison purposes. Most importantly, the water quality of both Camp Pond Brook and Lower Reid Brook did not change drastically from the natural background concentrations even though there is a significant amount of development occurring in the watersheds. Additionally, the water quality at the new surface water station (tributary to Lower Reid Brook) also remained within expected levels with no major water quality events being captured. It is evident that the mitigation measures that have been established by VBNC have significantly reduced the effect of development on the overall water quality.

Section 7.0 Path Forward

In order for a program to be successful, it is essential to continually evaluate and move forward. The following is a list of planned activities to be carried out in the upcoming year. The list also includes some multi-year activities planned in the previous year that are still in progress.

- shipment of instruments for servicing work during the winter months
- testing/preparation of instruments in St. John's office prior to spring deployment to ensure all instruments are functioning properly
- spring site visitation to install all instruments and make changes to data logger programming
- continued monitoring of water quality from late spring to late fall 2006 with continued data analysis in the form of monthly reports
- continued direct communication between DOEC and VBNC staff to respond to emerging issues on a proactive basis
- continued site visitation and training by DOEC staff throughout the summer and fall
- retraining of VBNC staff on the updated maintenance/calibration procedures for real-time water quality instrumentation
- continued work on Automatic Data Retrieval System to incorporate new capabilities
- continued transfer of data from DOEC to VBNC staff through the departmental web page
- provide on-line statistical analysis of data
- evaluation and upgrading of QA/QC procedures
- work on extrapolation of other water quality parameters using regression analysis
- increased understanding/knowledge of groundwater quality
- upgrade of specific instruments (Lr. Reid Brook; Tributary to Lr. Reid Brook; Camp Pond Brook) with ammonium and nitrate sensors
- creation of value added products using the real-time water quality data, remote sensing and water quality indices

Appendix A

Climate Data for Nain, Labrador

Daily Data Report for May 2006

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	9.9	2.6	6.3	11.7	0.0			0.0	0		
02	7.7	1.9	4.8	13.2	0.0			0.0	0		
03	4.1	-0.8	1.7	16.3	0.0			0.0	0		
04	5.8	-2.1	1.9	16.1	0.0			0.0	0		
05	10.5	0.8	5.7	12.3	0.0			2.6	0		
06	7.7	2.2	5.0	13.0	0.0			0.7	0		
07	2.0	-0.4	0.8	17.2	0.0			7.8	0		
08	4.2	-1.6	1.3	16.7	0.0			0.0	0		
09	6.7	-0.2	3.3	14.7	0.0			0.6	0		
10	16.1	1.5	8.8	9.2	0.0			0.0	0		
11	19.8	3.1	11.5	6.5	0.0			0.0	0		
12	20.3	1.6	11.0	7.0	0.0			0.0	0		
13	23.0	1.6	12.3	5.7	0.0			0.0	0		
14	7.5	4.3	5.9	12.1	0.0			0.6	0		
15	4.7	0.7	2.7	15.3	0.0			0.0	0		
16	5.9	-1.9	2.0	16.0	0.0			0.0	0		
17	3.6	0.2	1.9	16.1	0.0			0.0	0		
18	5.2	-1.2	2.0	16.0	0.0			0.0	0		
19	6.5	1.3	3.9	14.1	0.0			0.0	0		
20	6.7	-1.9	2.4	15.6	0.0			0.0	0		
21	3.8	0.8	2.3	15.7	0.0			3.5	0		
22	3.7	1.2	2.5	15.5	0.0			0.0	0		
23	5.9	1.4	3.7	14.3	0.0			0.0	0		
24	7.6	1.4	4.5	13.5	0.0			0.0	0		
25	9.8	-0.3	4.8	13.2	0.0			5.1	0		
26	10.1	2.5	6.3	11.7	0.0			0.0	0		
27	8.9	-0.1	4.4	13.6	0.0			0.0	0		
28	10.3	2.8	6.6	11.4	0.0			1.3	0		
29	9.0	1.5	5.3	12.7	0.0			0.0	0		
30	16.2	3.5	9.9	8.1	0.0			0.0	0		
31	10.8	-0.9	5.0	13.0	0.0			1.5	0		
Sum				407.5	0.0			23.7			
Avg	8.8	0.8	4.9								
Xtrm	23.0	-2.1									

Daily Data Report for June 2006

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	11.5	4.2	7.9	10.1	0.0			0.0	0		
02	12.3	4.7	8.5	9.5	0.0			0.0	0		
03	10.4	3.9	7.2	10.8	0.0			0.0	0		
04	10.3	-0.4	5.0	13.0	0.0			3.2	0		
05	8.6	1.0	4.8	13.2	0.0			0.0	0		
06	7.7	1.3	4.5	13.5	0.0			0.0	0		
07	16.2	1.3	8.8	9.2	0.0			0.0	0		
08	22.7	3.9	13.3	4.7	0.0			0.0	0		
09	29.1	5.7	17.4	0.6	0.0			0.0	0		
10	12.6	7.8	10.2	7.8	0.0			0.0	0		
11	7.7	4.2	6.0	12.0	0.0			0.0	0		
12	10.1	3.7	6.9	11.1	0.0			0.0	0		
13	14.4	4.4	9.4	8.6	0.0			0.0	0		
14	18.5	5.1	11.8	6.2	0.0			3.5	0		
15	12.7	5.5	9.1	8.9	0.0			0.0	0		
16	25.5	3.2	14.4	3.6	0.0			8.3	0		
17	15.3	3.8	9.6	8.4	0.0			6.2	0		
18	14.7	3.5	9.1	8.9	0.0			3.4	0		
19	9.7	5.2	7.5	10.5	0.0			1.3	0		
20	17.4	3.7	10.6	7.4	0.0			0.0	0		
21	25.6	5.8	15.7	2.3	0.0			0.0	0		
22	18.7	8.3	13.5	4.5	0.0			0.6	0		
23	16.1	9.5	12.8	5.2	0.0			0.0	0		
24	17.7	6.7	12.2	5.8	0.0			0.0	0		
25	14.1	8.3	11.2	6.8	0.0			0.0	0		
26	16.1	6.9	11.5	6.5	0.0			0.0	0		
27	13.7	6.7	10.2	7.8	0.0			0.0	0		
28	11.9	7.0	9.5	8.5	0.0			4.1	0		
29	19.5	5.0	12.3	5.7	0.0			0.0	0		
30	6.1	4.5	5.3	12.7	0.0			26.8	0		
Sum				243.8	0.0			57.4			
Avg	14.9	4.8	9.9								
Xtrm	29.1	-0.4									

Daily Data Report for July 2006

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01†	10.1	4.9	7.5	10.5	0.0	M	M	24.9		6	46
02†	10.1	4.3	7.2	10.8	0.0	M	M	0.0		9	37
03†	10.5	3.8	7.2	10.8	0.0	M	M	0.7			<31
04†	14.6	3.7	9.2	8.8	0.0	M	M	0.0		9	32
05†	17.7	5.0	11.4	6.6	0.0	M	M	0.0			<31
06†	20.3	7.3	13.8	4.2	0.0	M	M	0.0		30	72
07†	14.5	7.3	10.9	7.1	0.0	M	M	2.5		31	76
08†	15.6	5.4	10.5	7.5	0.0	M	M	0.0		30	44
09†	10.9	6.7	8.8	9.2	0.0	M	M	0.6			<31
10†	16.3	7.8	12.1	5.9	0.0	M	M	0.0		30	63
11†	17.0	8.3	12.7	5.3	0.0	M	M	1.9		29	78
12†	15.1	6.4	10.8	7.2	0.0	M	M	0.0		30	72
13†	20.0	6.8	13.4	4.6	0.0	M	M	0.0		30	44
14†	15.6	5.8	10.7	7.3	0.0	M	M	0.0			<31
15†	18.8	5.1	12.0	6.0	0.0	M	M	0.0		16	52
16†	24.0	11.0	17.5	0.5	0.0	M	M	0.6			<31
17†	23.1	11.0	17.1	0.9	0.0	M	M	4.8		30	46
18†	20.8	11.4	16.1	1.9	0.0	M	M	12.4		25	50
19†	20.8	12.8	16.8	1.2	0.0	M	M	1.5		28	83
20†	29.4	13.0	21.2	0.0	3.2	M	M	0.0		27	50
21†	19.5	7.1	13.3	4.7	0.0	M	M	13.1		8	37
22†	19.2	6.5	12.9	5.1	0.0	M	M	0.0			<31
23†	19.1	7.3	13.2	4.8	0.0	M	M	0.6		30	35
24†	20.4	8.6	14.5	3.5	0.0	M	M	0.0		8	35
25†	15.9	8.0	12.0	6.0	0.0	M	M	0.0		8	33
26†	12.4	5.6	9.0	9.0	0.0	M	M	0.0		[illegible]	[illegible]
27†	13.8	6.0	9.9	8.1	0.0	M	M	0.0		[illegible]	[illegible]
28†	14.5	7.0	10.8	7.2	0.0	M	M	3.1		[illegible]	[illegible]
29†	9.3	7.5	8.4	9.6	0.0	M	M	18.9		[illegible]	[illegible]
30†	9.0	6.9	8.0	10.0	0.0	M	M	41.2		[illegible]	[illegible]
31†	10.1	7.6	8.9	9.1	0.0	M	M	M		32	[illegible]
Sum				**193.4**	**3.2**	**M**	**M**	**126.8***			
Avg	**16.4**	**7.3**	**11.8**								
Xtrm	**29.4**	**3.7**								[illegible]	[illegible]

Daily Data Report for August 2006

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	12.6	8.9	10.8	7.2	0.0			0.0	0		
02	10.6	6.3	8.5	9.5	0.0			0.0	0		
03	14.4	7.4	10.9	7.1	0.0			0.0	0		
04	18.8	7.8	13.3	4.7	0.0			1.4	0		
05	17.9	10.8	14.4	3.6	0.0			0.0	0		
06	18.7	7.1	12.9	5.1	0.0			0.0	0		
07	14.1	8.0	11.1	6.9	0.0			0.0	0		
08	18.3	10.1	14.2	3.8	0.0			0.0	0		
09	16.8	5.4	11.1	6.9	0.0			6.5	0		
10	15.8	8.5	12.2	5.8	0.0			1.5	0		
11	9.1	7.0	8.1	9.9	0.0			16.5	0		
12	9.7	7.1	8.4	9.6	0.0			33.4	0		
13	9.6	7.8	8.7	9.3	0.0			20.4	0		
14	8.8	6.7	7.8	10.2	0.0			1.4	0		
15	12.8	6.4	9.6	8.4	0.0			9.0	0		
16	21.1	7.9	14.5	3.5	0.0			0.0	0		
17	19.0	10.7	14.9	3.1	0.0			0.0	0		
18	21.4	10.8	16.1	1.9	0.0			5.8	0		
19	19.9	14.4	17.2	0.8	0.0			0.0	0		
20	18.3	7.5	12.9	5.1	0.0			2.0	0		
21	15.9	10.6	13.3	4.7	0.0			1.6	0		
22	19.8	7.3	13.6	4.4	0.0			0.0	0		
23	16.5	7.7	12.1	5.9	0.0			0.0	0		
24	12.2	7.6	9.9	8.1	0.0			2.2	0		
25	11.2	6.1	8.7	9.3	0.0			0.6	0		
26	16.4	3.2	9.8	8.2	0.0			0.0	0		
27	14.2	5.3	9.8	8.2	0.0			0.0	0		
28	16.8	4.8	10.8	7.2	0.0			0.0	0		
29	13.2	5.7	9.5	8.5	0.0			0.0	0		
30	10.1	7.2	8.7	9.3	0.0			0.7	0		
31	9.3	6.9	8.1	9.9	0.0			0.7	0		
Sum				**206.1**	**0.0**			**103.7**			
Avg	**14.9**	**7.7**	**11.4**								
Xtrm	**21.4**	**3.2**									

Daily Data Report for September 2006											
Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	14.8	5.9	10.4	7.6	0.0			0.0	0		
02	24.7	7.8	16.3	1.7	0.0			0.0	0		
03	22.4	13.6	18.0	0.0	0.0			0.0	0		
04	19.1	13.9	16.5	1.5	0.0			0.0	0		
05	13.2	5.5	9.4	8.6	0.0			0.0	0		
06	13.6	3.0	8.3	9.7	0.0			0.0	0		
07	13.1	6.8	10.0	8.0	0.0			0.0	0		
08	8.4	5.8	7.1	10.9	0.0			5.5	0		
09	9.8	4.6	7.2	10.8	0.0			0.0	3		
10	12.2	2.7	7.5	10.5	0.0			0.0	1		
11	15.3	5.1	10.2	7.8	0.0			0.0	0		
12	21.5	12.4	17.0	1.0	0.0			0.0	0		
13	20.5	10.8	15.7	2.3	0.0			0.0	0		
14	17.2	8.3	12.8	5.2	0.0			0.0	0		
15	8.2	5.6	6.9	11.1	0.0			0.0	0		
16	8.4	3.5	6.0	12.0	0.0			1.5	0		
17	7.7	2.7	5.2	12.8	0.0			0.6	8		
18	8.1	0.7	4.4	13.6	0.0			0.0	8		
19	7.4	-0.7	3.4	14.6	0.0			0.0	1		
20	6.1	3.8	5.0	13.0	0.0			26.0	0		
21	14.6	4.5	9.6	8.4	0.0			0.0	0		
22	10.3	4.4	7.4	10.6	0.0			0.0	0		
23	10.9	3.1	7.0	11.0	0.0			0.0	0		
24	10.9	0.9	5.9	12.1	0.0			0.0	0		
25	11.1	1.1	6.1	11.9	0.0			0.0	0		
26	11.8	5.1	8.5	9.5	0.0			0.0	0		
27	12.7	1.8	7.3	10.7	0.0			0.0	0		
28	14.4	1.3	7.9	10.1	0.0			0.0	0		
29	17.1	9.4	13.3	4.7	0.0			7.2	0		
30	15.2	6.1	10.7	7.3	0.0			0.7	0		
Sum				259.0	0.0			41.5			
Avg	13.4	5.3	9.4								
Xtrm	24.7	-0.7									

Daily Data Report for October 2006											
Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	9.7	2.6	6.2	11.8	0.0			0.0	0		
02	8.9	5.0	7.0	11.0	0.0			0.0	0		
03	12.5	1.1	6.8	11.2	0.0			0.0	0		
04	11.8	3.2	7.5	10.5	0.0			0.0	0		
05	6.7	2.8	4.8	13.2	0.0			0.6	0		
06	10.3	2.6	6.5	11.5	0.0			0.0	0		
07	11.8	5.5	8.7	9.3	0.0			0.0	0		
08	5.9	1.8	3.9	14.1	0.0			0.7	0		
09	4.7	-1.0	1.9	16.1	0.0			9.8	0		
10	4.4	1.9	3.2	14.8	0.0			1.4	0		
11	5.0	0.9	3.0	15.0	0.0			0.0	0		
12	5.5	0.9	3.2	14.8	0.0			0.0	0		
13	7.0	3.6	5.3	12.7	0.0			1.5	0		
14	9.5	4.5	7.0	11.0	0.0			2.2	0		
15	8.6	0.9	4.8	13.2	0.0			17.1	0		
16	9.2	2.8	6.0	12.0	0.0			0.0	0		
17	6.3	2.2	4.3	13.7	0.0			0.0	0		
18	6.5	2.3	4.4	13.6	0.0			3.9	0		
19	5.7	2.3	4.0	14.0	0.0			6.9	0		
20	5.0	3.9	4.5	13.5	0.0			1.7	0		
21	5.0	0.5	2.8	15.2	0.0			1.4	0		
22	4.4	2.5	3.5	14.5	0.0			0.0	0		
23	3.6	1.4	2.5	15.5	0.0			0.0	0		
24	3.8	0.3	2.1	15.9	0.0			0.6	0		
25	3.5	1.2	2.4	15.6	0.0			0.0	0		
26	3.5	1.9	2.7	15.3	0.0			0.6	0		
27	3.6	0.2	1.9	16.1	0.0			0.0	0		
28	4.5	-1.9	1.3	16.7	0.0			0.0	0		
29	2.7	0.3	1.5	16.5	0.0			26.6	0		
30	3.1	0.6	1.9	16.1	0.0			9.7	0		
31	4.6	1.1	2.9	15.1	0.0			0.6	1		
Sum				429.5	0.0			85.3			
Avg	6.4	1.9	4.1								
Xtrm	12.5	-1.9									

Daily Data Report for November 2006											
Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days C	Cool Deg Days C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01	3.6	-0.7	1.5	16.5	0.0			0.0	0		
02	2.2	-3.6	-0.7	18.7	0.0			0.0	0		
03	1.4	-2.2	-0.4	18.4	0.0			0.0	0		
04	-0.7	-3.7	-2.2	20.2	0.0			0.0	0		
05	0.1	-7.4	-3.7	21.7	0.0			0.0	0		
06	-0.4	-4.2	-2.3	20.3	0.0			0.0	0		
07	4.2	-6.6	-1.2	19.2	0.0			1.4	0		
08	-2.2	-4.2	-3.2	21.2	0.0			0.0	0		
09	1.0	-10.0	-4.5	22.5	0.0			6.1	0		
10	2.6	-3.7	-0.6	18.6	0.0			19.0	3		