Government of
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VOISEY'S BAY NICKEL
COMPANY LIMITED

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Voisey's Bay Real-Time Water Quality Monitoring Network Annual Report 2004

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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.

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.

Numerous individuals from DOEC have been integral in ensuring the smooth operation of such a technologically advanced network. Renée Paterson has taken on the role of coordinator and liaison between the major agencies involved, thus, ensuring open communication lines at all times. In addition, Renée is responsible for the data management/reporting along with ensuring the quality assurance/quality control measures are satisfactory. Kent Slaney, Joanne Sweeney and Paula Dawe have travelled to Voisey's Bay to ensure all procedures were being followed and to provide technical assistance. Paul Neary 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. Finally, Rob Holloway has enhanced the network by providing a GIS component to the project with the development of topographic/basin maps; digital elevation model maps; slope maps and satellite imagery maps.

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 was first established in Voisey's Bay during the summer of 2003. There were three real-time water quality stations established on some of the main water bodies within the vicinity of the Voisey's Bay development. The locations of the three stations (**Upper Reid Brook – 03NE001**; **Camp Pond Brook – 03NE002**; **Lower Reid Brook – 03NE011**) can be seen in Figure 1 below.

The selection of these particular sites was an involved process whereby the water quality instruments were placed in areas that would provide meaningful data. The Upper Reid Brook station was chosen to represent the control station due to the pristine nature of the water body with no developmental impacts. The Camp Pond Brook station was chosen as a site that would capture any emerging water quality events due to the nearby development of the mine/mill site. Finally, the Lower Reid Brook station 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. In addition, the Lower Reid Brook station was also chosen to capture direct impacts on water quality as the development moves down closer to this station in the upcoming years.

Voisey's Bay Real-Time Water Quality Network

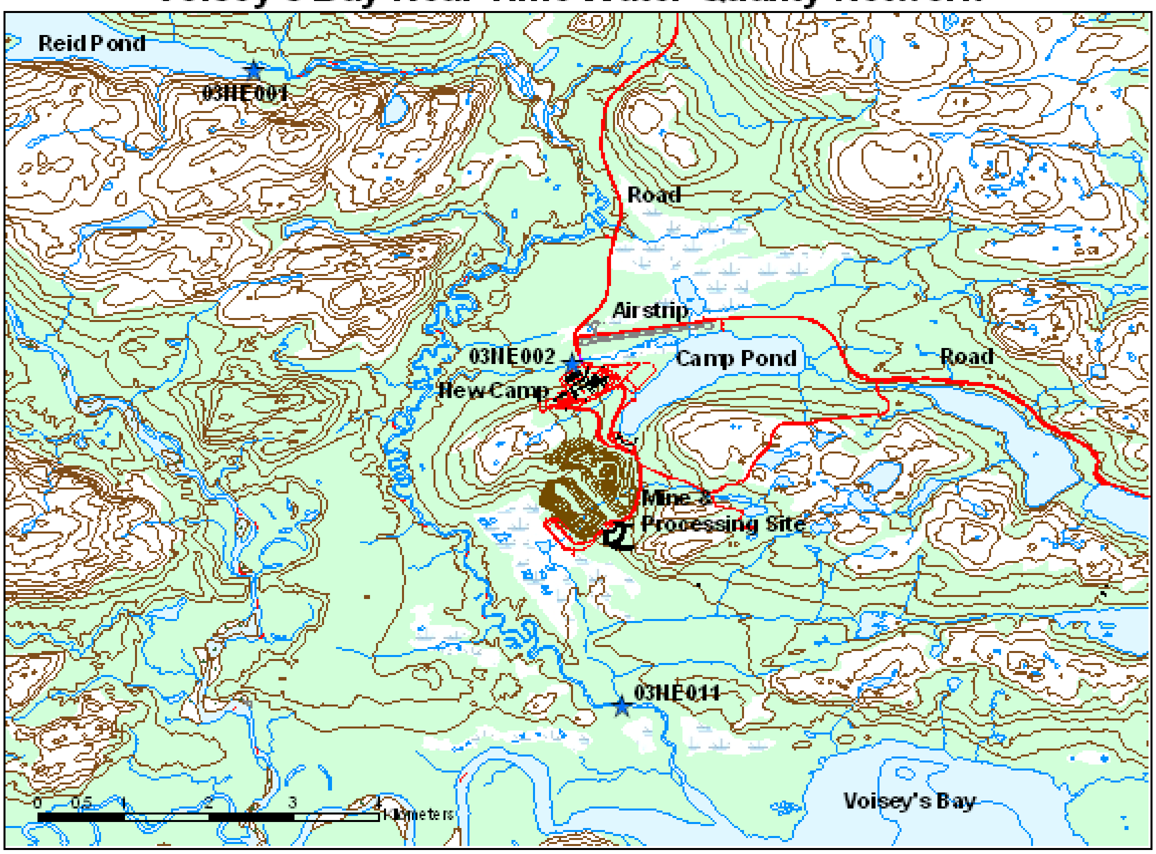

Figure 1: Real-Time Water Quality Station Locations

Working together, VBNC, DOEC and EC staff carried out the initial deployment during the summer of 2003. For the first season, the water quality monitoring instruments were deployed from July – November at which point the rivers began to freeze and the instruments were removed for the winter months. The first season of operation proved to be very successful with many lessons learned on how to more efficiently and effectively operate the network.

Throughout the winter months of 2004 while the instruments were in storage, much work was completed by DOEC on the GIS component of the project. This will be discussed in greater detail in Section 5.0.

In June 2004, Renée Paterson of DOEC gave a presentation entitled *"From the Rivers to the Oceans – Real-Time Water Quality Monitoring for Coastal Zone Management"* at the Coastal Zone Canada Conference 2004. The Real-Time Water Quality Monitoring Network at Voisey's Bay was used as a case study to demonstrate how continuous water quality monitoring equipment can be used to assess the water quality entering the coastal zone area. This will be discussed in greater detail in Section 5.0.

In the spring of 2004, when the ice began to break apart, it was decided that the instruments should be returned to the water. Upon initial testing of the instruments after the long winter storage period, it was found that the instruments needed servicing and warranty work thus delaying the first deployment. Additionally, changes to the programming of one of the data loggers that was made throughout the winter months interfered with the order of which the parameters read data into the web page. In mid-July both the EC and DOEC staff travelled to Voisey's Bay to rectify the data logger issue and ensure the instruments were deployed and properly collecting data. The results for the 2004 deployment period are discussed in greater detail in Section 3.0.

In September 2004, both the EC and DOEC staff travelled once again to Voisey's Bay to ensure that the proper procedures were being followed and at the same time provided technical assistance to the VBNC staff.

In October 2004, Amir Ali Khan of DOEC gave a presentation at an Automated Electronic Water Quality Monitoring Workshop in Vancouver, BC. The presentation given was entitled *"Real-time Water Quality Monitoring as a Regulatory Performance Tool – The Voisey's Bay Experience"*. This will be discussed in greater detail in Section 5.0.

In October 2004, three VBNC staff members as well as DOEC staff members attended an Advanced Hydrolab Training Course offered in St. John's by the Canadian supplier of Hydrolab equipment – Campbell Scientific Canada Corporation. This will be discussed in greater detail in Section 5.0.

In November 2004, the rivers began to freeze and the instruments were removed once again for the winter months.

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. It is important to note that some deployment periods were slightly 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	July 11, 2004	August 10th, 2004	31	Strictly followed maintenance/calibration schedule
	August 11, 2004	September 23, 2004	44	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 24, 2004	November 12, 2004	50	Extended deployment to allow more data collection before removal for winter months
Camp Pond Brook	July 11, 2004	August 10th, 2004	31	Strictly followed maintenance/calibration schedule
	August 12, 2004	September 23, 2004	43	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 24, 2004	October 16, 2004	23	Instrument was removed early and sent to St. John's for use in the Advanced Hydrolab Training Course
Lower Reid Brook	Instrument was away for repairs			
	August 11, 2004	September 23, 2004	44	Extended deployment to correspond the maintenance/calibration with the site visit by EC and DOEC staff
	September 24, 2004	November 12, 2004	50	Extended deployment to allow more data collection before removal for winter months

Section 3.0 Data Interpretation

Upper Reid Brook

As stated in the introduction, the Upper Reid Brook site was chosen to represent a control station that is not directly impacted by development. Throughout the deployment period form July to November 2004, the water quality remained pristine with only one period of variability.

As can be seen in **Figures 1a and 1b**, the pH of the water at the Upper Reid Brook station remained very consistent throughout the deployment period with the exception of a period in September. Generally, Upper Reid Brook demonstrates a background pH of approximately 6 pH units. From the period of September 7th – 17th, the pH values spiked and plummeted. It is highly unlikely that these spikes were caused by an actual water quality event. It is more likely that the instrument was knocked out of position by some means (ie: wildlife). It may not be possible to identify the exact cause of this disturbance. It is important to note that the pH values returned to normal background levels after September 17th. Also, the data remained consistent at the other two sites downstream (Camp Pond Brook and Lower Reid Brook) thus indicating this was an isolated incident. The drops in the graph to zero in Figure 1a indicate the periods when the instrument was out of the water for maintenance/calibration purposes.

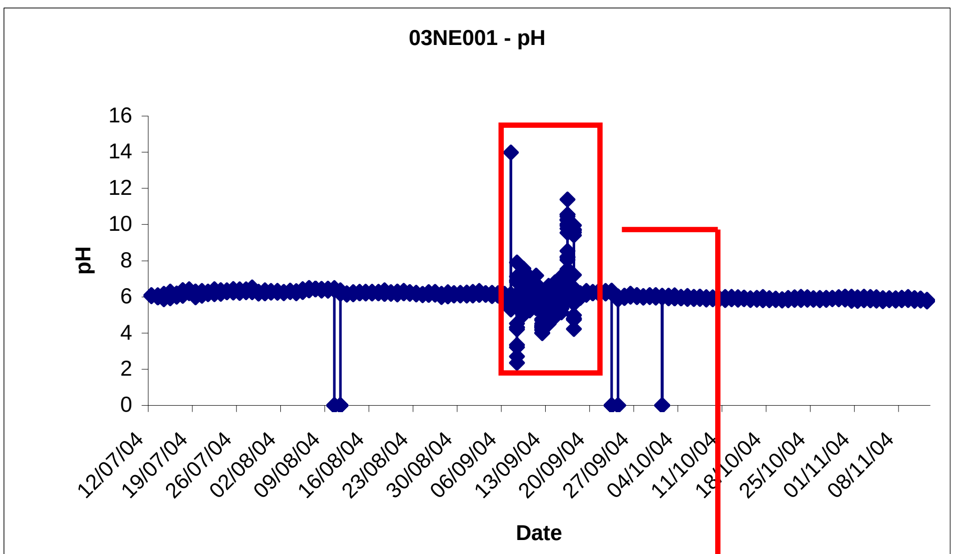

Figure 1a

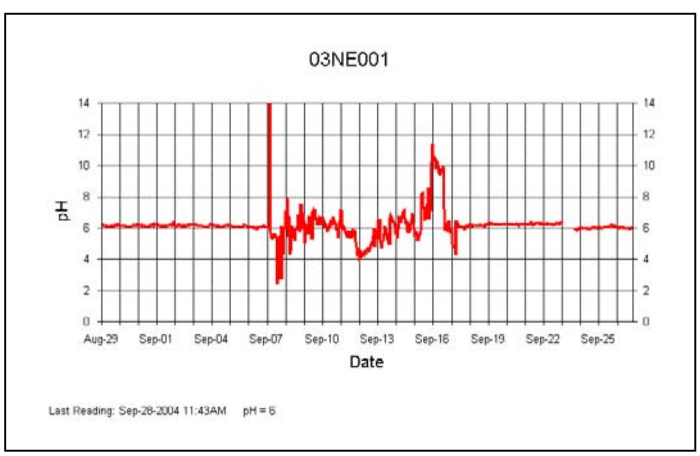

Figure 1b

As can be seen in **Figures 2a and 2b**, the conductivity of the water at the Upper Reid Brook station remained very consistent throughout the deployment period with the exception of the same period (Sept. 7th – 17th) that caused changes in the pH values. The conductivity values were obviously affected by the same disturbance as the pH values discussed previously. Generally, Upper Reid Brook demonstrates a very low background conductivity of approximately 8 to 10 uS/cm. Again, it is important to note that the conductivity values returned to normal background levels after September 17th. The drops in the graph to zero in Figure 2a indicate the periods when the instrument was out of the water for maintenance/calibration purposes with the exception of the zeros recorded in the red box.

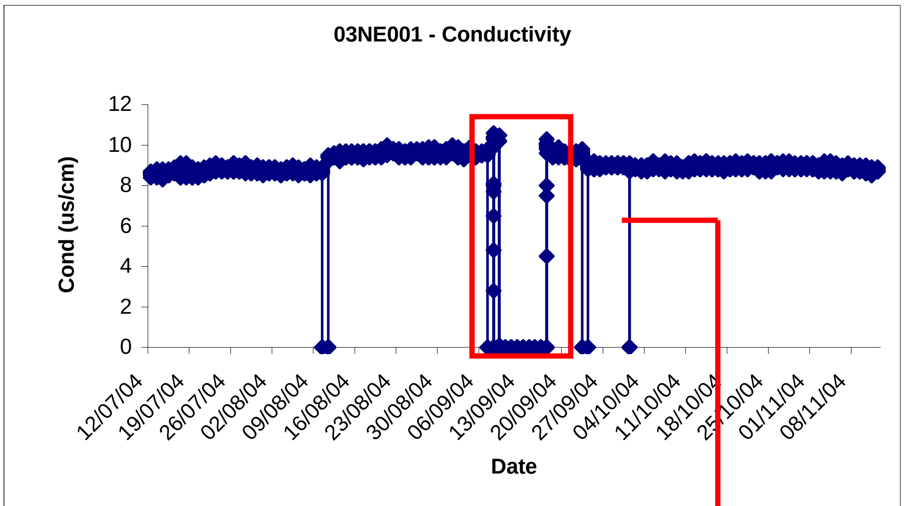

Figure 2a

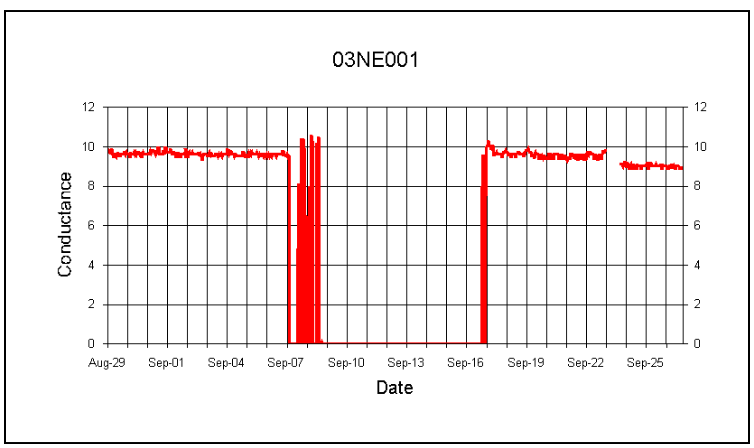

Figure 2b

As can be seen in **Figures 3a and 3b/Figures 4a and 4b**, the dissolved oxygen of the water at the Upper Reid Brook station demonstrated an expected increase as the water temperature decreased throughout the deployment period. The period from September 7th to 17th showed a similar disturbance as discussed previously with the dissolved oxygen values spiking and the temperature values plummeting. Again, it is important to note that the dissolved oxygen values and temperature values returned to normal background levels after September 17th. Most significantly, even during the warmest summer months, the dissolved oxygen values did not drop down into the range that is harmful to aquatic life. The drops in the graph to zero in Figure 3a and 4a indicate the periods when the instrument was out of the water for maintenance/calibration purposes.

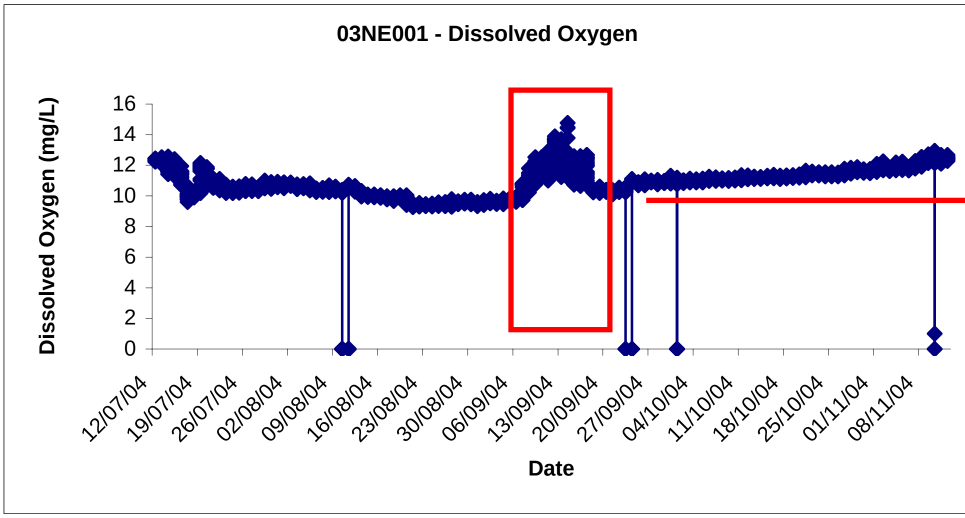

Figure 3a

Figure 3b

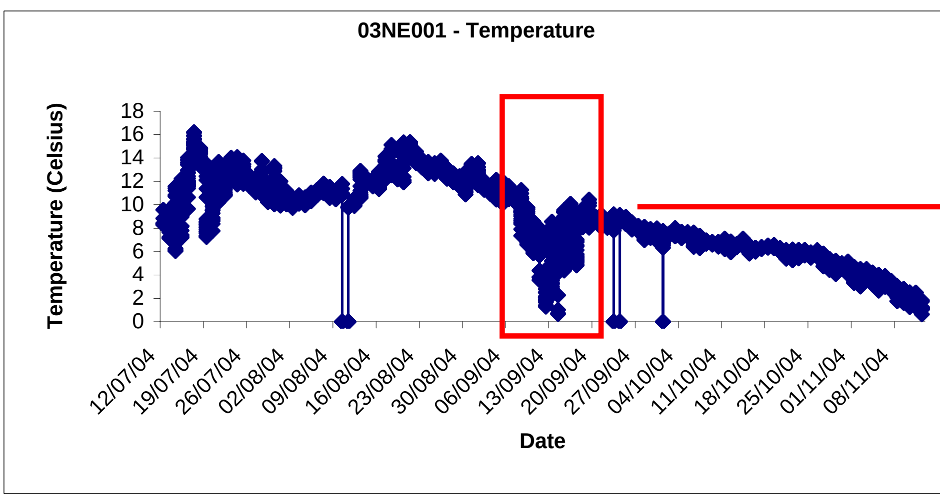

Figure 4a

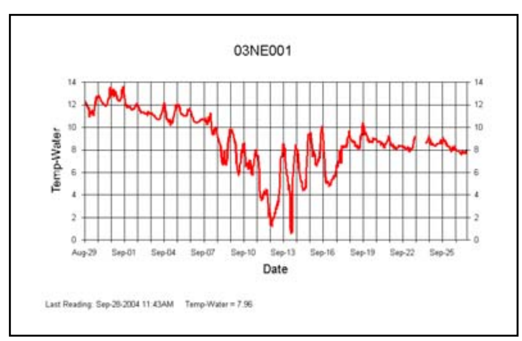

Figure 4b

As can be seen in **Figures 5a and 5b** the turbidity of the water at the Upper Reid Brook station remained consistently low throughout the deployment period. Again, the period from September 7th to 17th showed a similar disturbance with the turbidity values spiking. It is important to note that the turbidity values returned to normal background levels in the range of 0 to 10 NTU after September 17th. The low turbidity values are a clear indication that the water is not being impacted by development.

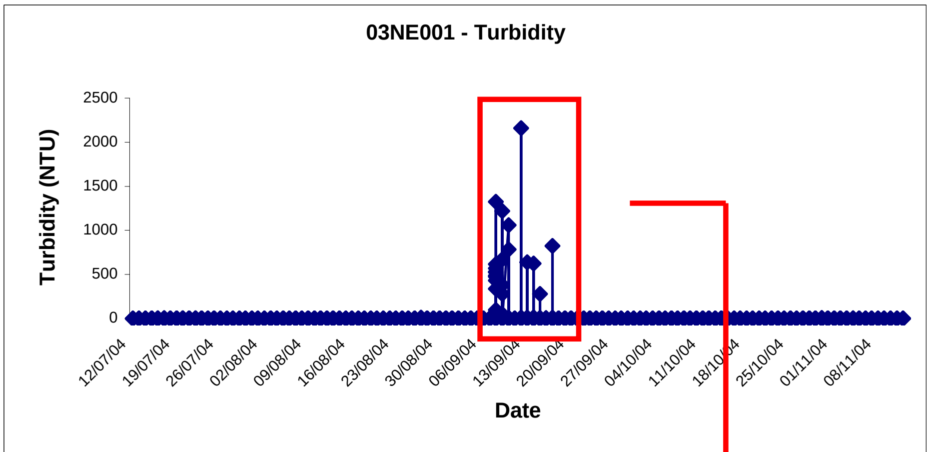

Figure 5a

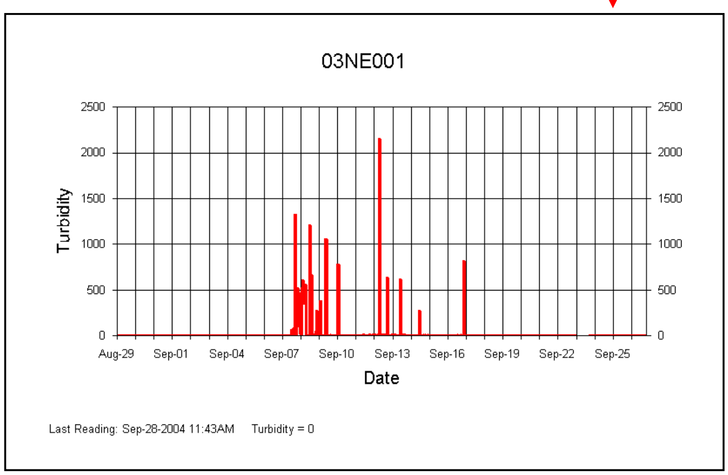

Figure 5b

Overall, the Upper Reid Brook station displayed very consistent values for all major parameters over the deployment period with the exception of the 10-day period in September. 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

As stated in the introduction, 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 deployment period form July to October 2004, the water quality remained very consistent with only short periods of variability that can be attributed to the nearby development.

As can be seen in **Figure 6a**, the pH of the water at the Camp Pond Brook station remained very consistent throughout the deployment period. There was a slight change in pH after the instrument was cleaned/calibrated in mid-August. From that point onward, the pH values remained just slightly above 7 pH units. The drops in the graph to zero in Figure 6a indicate the periods when the instrument was out of the water for maintenance/calibration purposes. The pH of the Camp Pond Brook station is slightly higher than that of the control station (Upper Reid Brook) and may possibly be attributed to the nearby development.

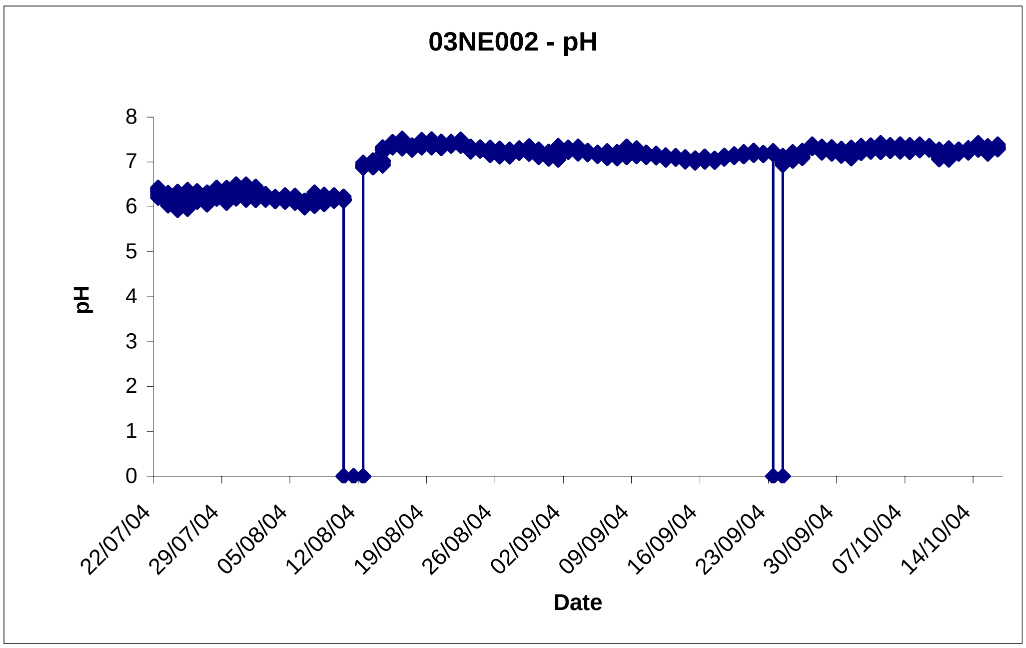

Figure 6a

As can be seen in **Figure 7a**, the conductivity of the water at the Camp Pond Brook station remained very consistent throughout the deployment period. The conductivity values of Camp Pond Brook generally remained in the range of approximately 20 to 30 uS/cm. This range is slightly higher than that of the control station (Upper Reid Brook) but is expected due to the level of development surrounding Camp Pond Brook. The drops in the graph to zero in Figure 7a indicate the periods when the instrument was out of the water for maintenance/calibration purposes.

There were two instances throughout the deployment period where the conductivity values increased from background levels. On September 17th, the conductivity values reached a maximum value of 39.4 uS/cm (**Figure 7b**). It is highly likely that this increase in conductivity was due to increased rainfall and runoff at that time since the stage also showed a slight increase. On October 11th, the conductivity values reached a maximum value of 70.6 uS/cm (**Figure 7c**). This increase was caused by the failure of a generator used to power pumps located in the temporary sumps near Camp Pond Brook. It is important to note that this was a short water quality episode that was not reflected at the downstream station (Lower Reid Brook). The mechanical problem was rectified quickly.

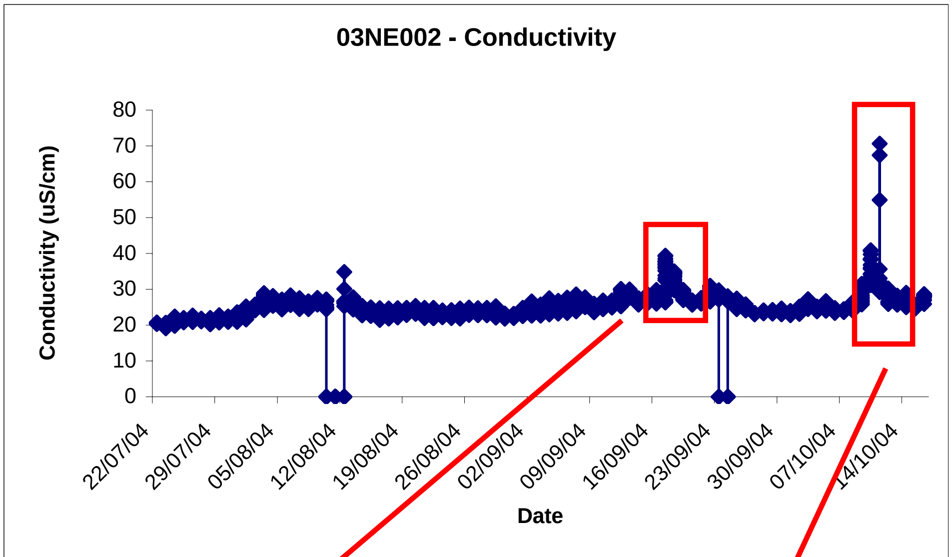

Figure 7a

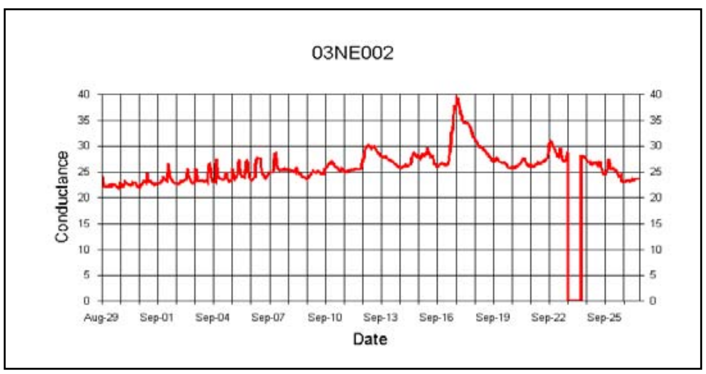

Figure 7b

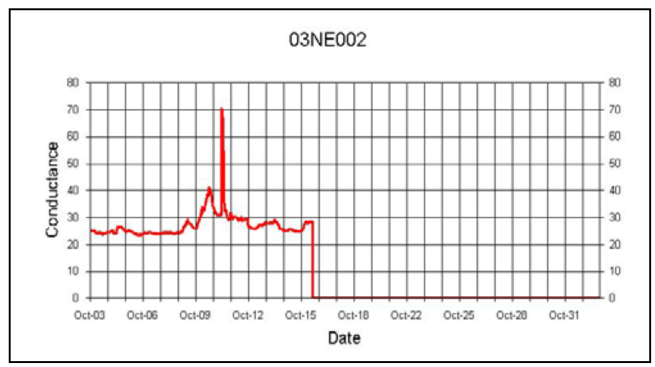

Figure 7c

As can be seen in **Figures 8a and 9a**, the dissolved oxygen of the water at the Camp Pond Brook station demonstrated an expected increase as the water temperature decreased throughout the deployment period. Again, even during the warmest summer months with a large amount of development in the surrounding area, the dissolved oxygen values did not drop down into the range that is harmful to aquatic life. The drops in the graph to zero in Figure 8a and 9a indicate the periods when the instrument was out of the water for maintenance/calibration purposes.

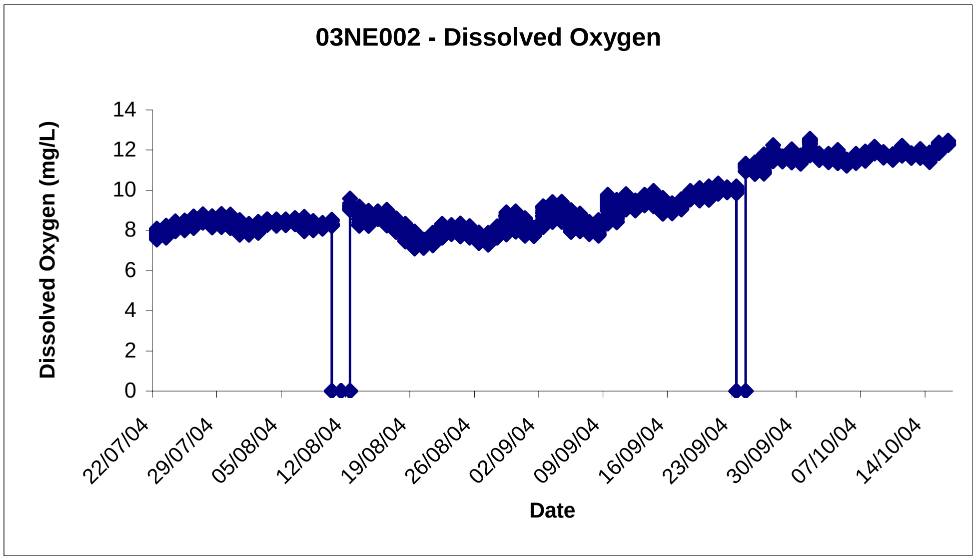

Figure 8a

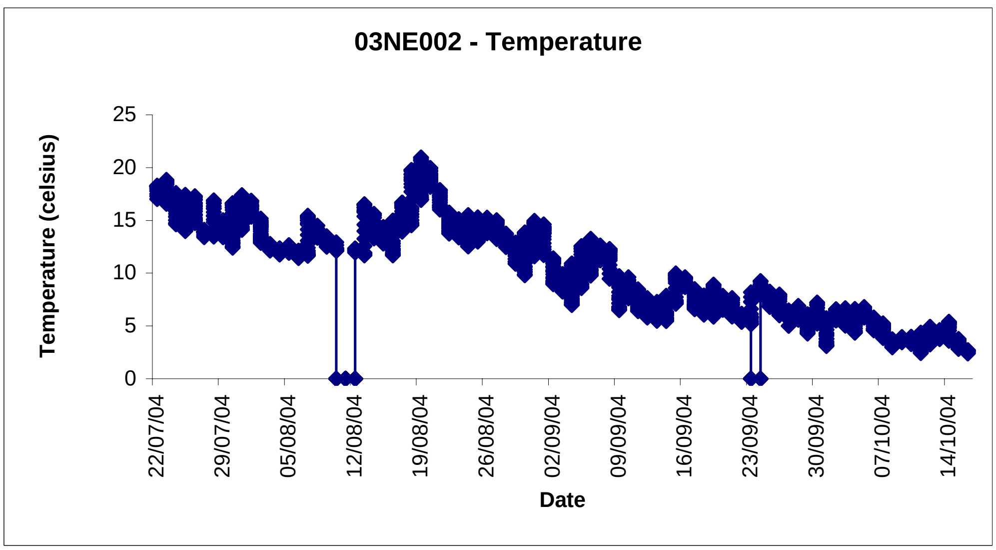

Figure 9a

As can be seen in **Figures 10a and 10b** the turbidity of the water at the Camp Pond Brook station remained consistently low throughout the deployment period with most turbidity values falling in the 0 to 20 NTU range. This is a clear indication that the mitigation measures put into place to decrease the amount of silt entering the water body are working effectively. There was only one very noticeable spike in turbidity values on October 11th whereby a maximum value of 657 NTU was recorded but then dropped significantly in a one-hour period. This spike can be attributed to the failure of the generator used to power pumps located in the temporary sumps near Camp Pond Brook (as was the cause of increased conductivity values discussed previously). Again, this increase in turbidity was not reflected at the downstream station (Lower Reid Brook).

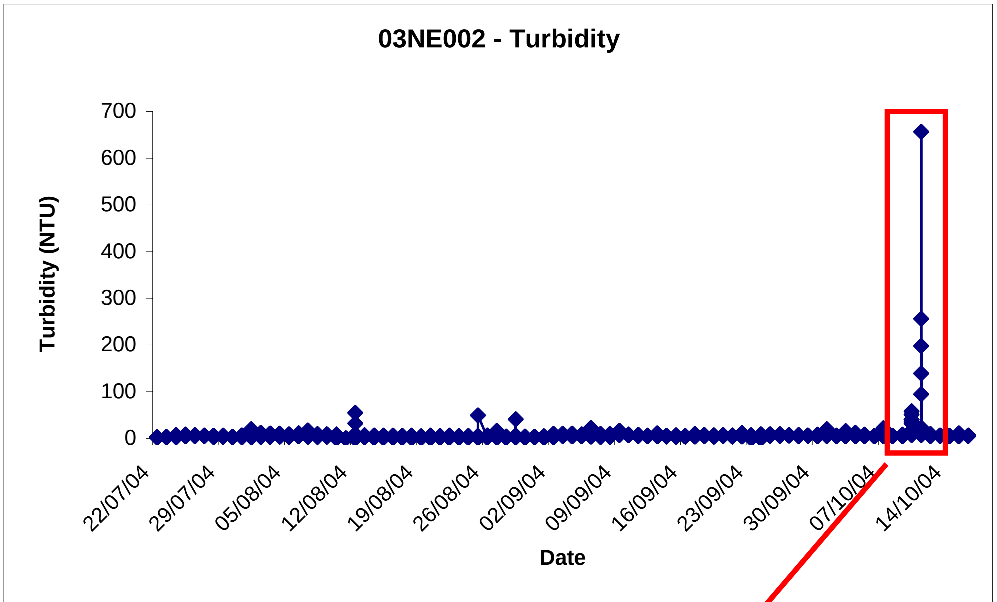

Figure 10a

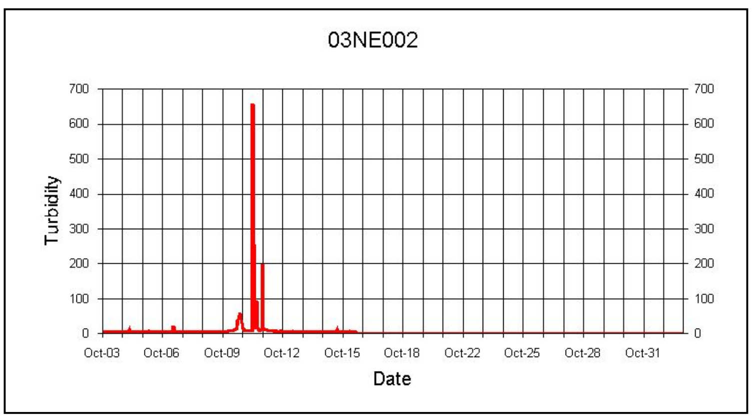

Figure 10b

Overall, the Camp Pond Brook station displayed very consistent values for all major parameters over the deployment period with the exception of the water quality event that occurred on October 10th and 11th. The overall range of pH, conductivity and turbidity values are only slightly above those recorded at the control station (Upper Reid Brook). It is evident that the mitigation measures and policies in place at the mine/mill development site are effectively protecting the water resources in the area. In the case of Camp Pond Brook, the real-time water quality monitoring network played a significant role in capturing the emerging issues as they happened which allowed the VBNC staff to respond quickly and efficiently.

Lower Reid Brook

As stated in the introduction, 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 August to November 2004, 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 **Figure 11a**, the pH of the water at the Lower Reid Brook station was fairly consistent throughout the deployment period with the pH values remaining around the 7 pH units mark. 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 drop in the graph to zero in Figure 11a indicates the period when the instrument was out of the water for maintenance/calibration purposes.

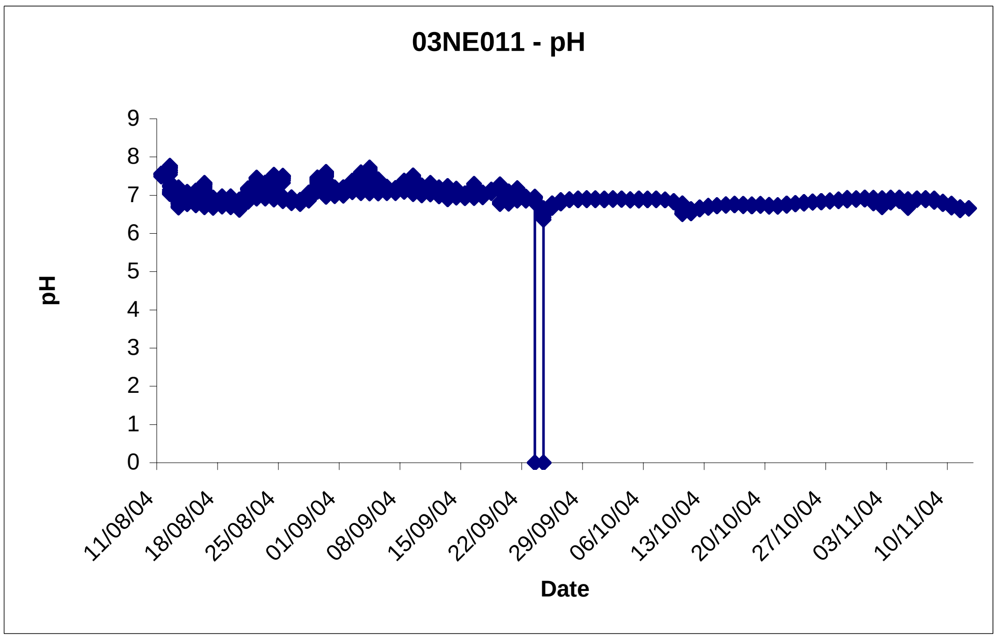

Figure 11a

As can be seen in **Figure 12a**, the conductivity of the water at the Lower Reid Brook station was somewhat variable throughout the deployment period, however the conductivity values generally remained in the range of approximately 20 to 35 uS/cm. Again, this range is slightly higher than that of the control station (Upper Reid Brook), however, it is very similar to that of the Camp Pond Brook station. The drop in the graph to zero in Figure 12a indicates the period when the instrument was out of the water for maintenance/calibration purposes.

There were two noticeable spikes in conductivity values on November 2nd (maximum value of 45.9 uS/cm) and November 5th (maximum value of 47.3 uS/cm). It is highly likely that the increased rainfall and resulting fluctuation in stage caused the increases in conductivity values (**Figure 13a**).

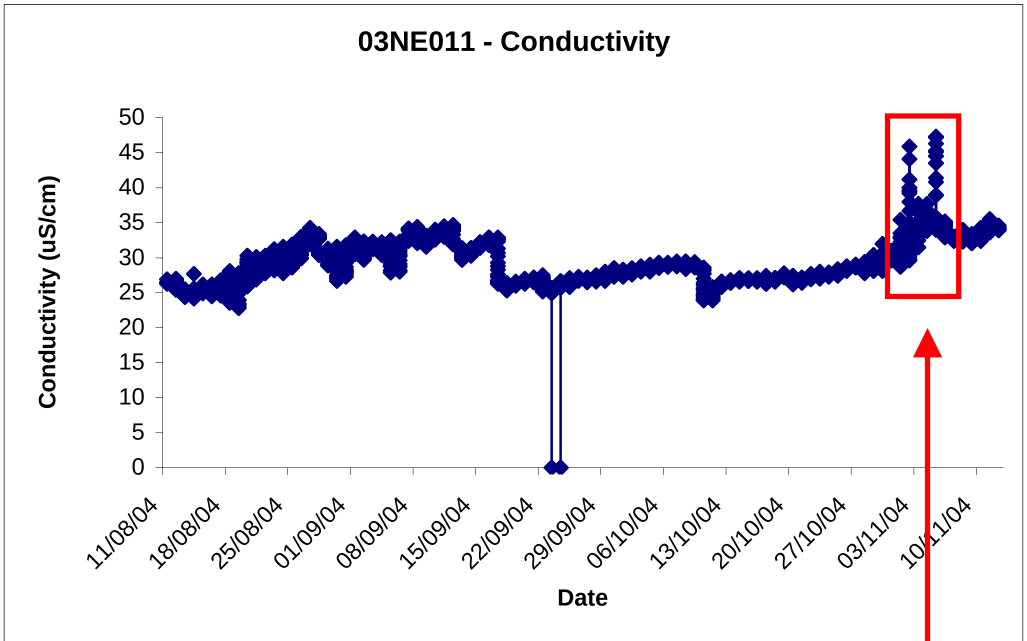

Figure 12a

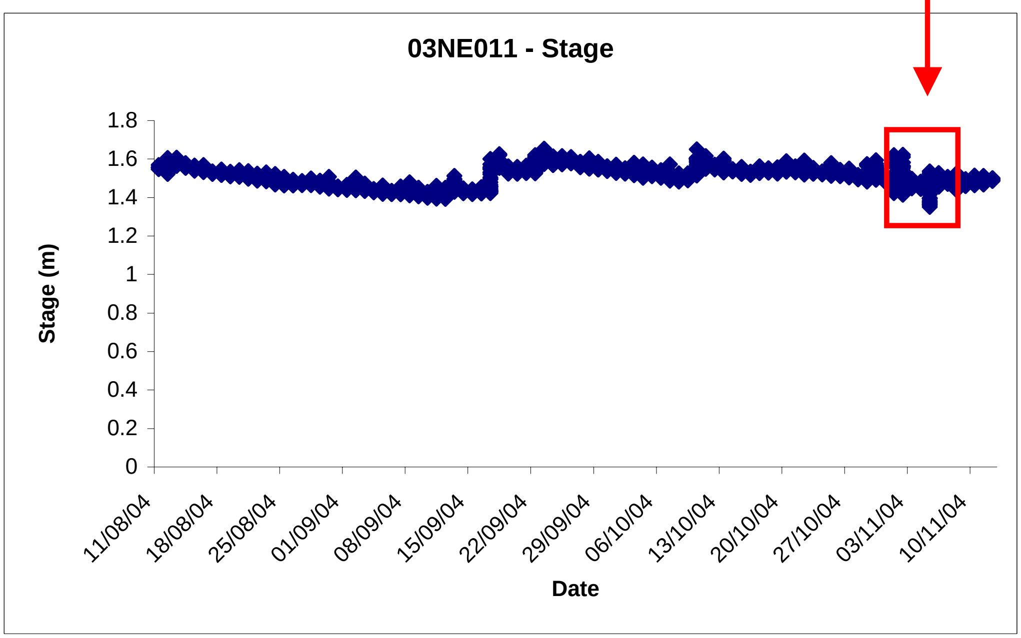

Figure 13a

As can be seen in **Figures 14a and 15a**, the dissolved oxygen of the water at the Lower Reid Brook station demonstrated an expected increase as the water temperature decreased throughout the deployment period. Again, even during the warmest summer months, the dissolved oxygen values did not drop down into the range that is harmful to aquatic life. The drop in the graph to zero in Figure 14a and 15a indicates the period when the instrument was out of the water for maintenance/calibration purposes.

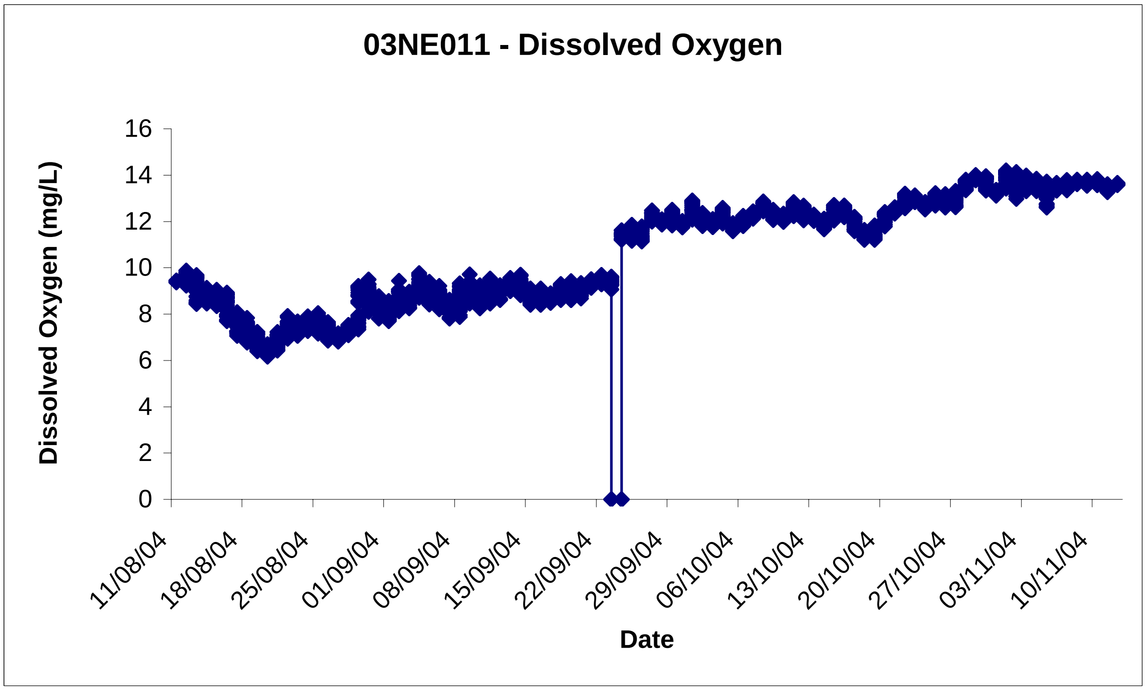

Figure 14a

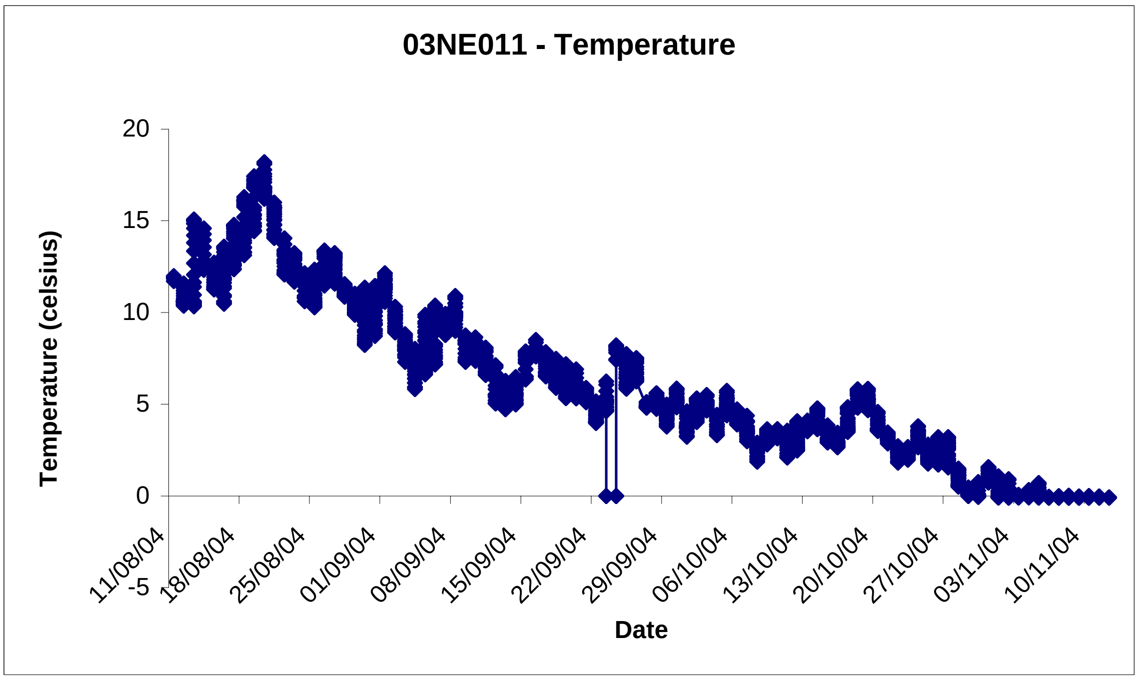

Figure 15a

As can be seen in **Figure 16a,** the turbidity of the water at the Lower Reid Brook station was somewhat variable throughout the deployment period. There were two very noticeable spikes in turbidity values over the deployment period. A maximum turbidity value of 314.2 NTU was recorded on September 17th (**Figure 16b**), however, it is important to note that there was no increase in turbidity values at the same time upstream at Camp Pond Brook. A second maximum value of 575 NTU was recorded on October 22nd (**Figure 16c**). These spikes can most likely be attributed to the increases in rainfall at those particular times thus stirring up the soft sediment bottom where the instrument is located. Plans are being made to design a different deployment setup for this particular station to ensure the silty bottom does not interfere with the readings in the upcoming season. It is highly unlikely that these events were caused by development activities upstream.

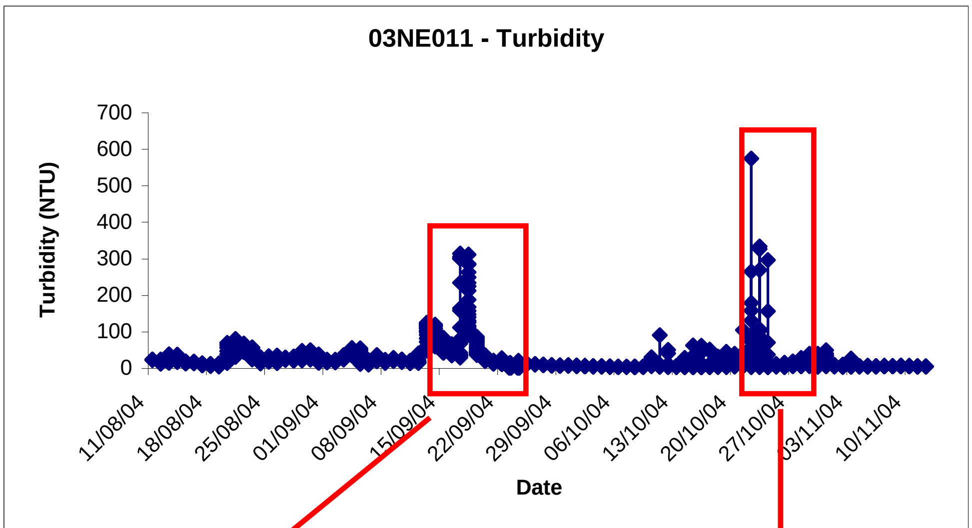

Figure 16a

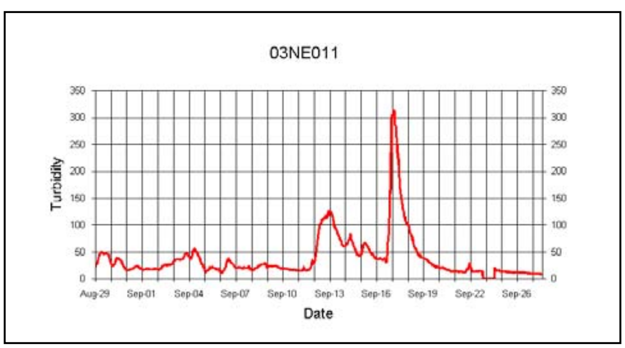

Figure 16b

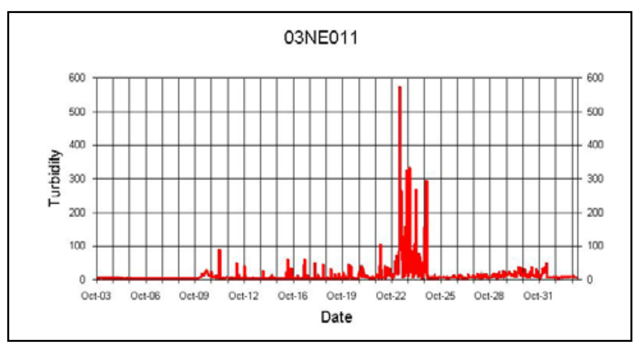

Figure 16c

Overall, the Lower Reid Brook station displayed fairly consistent values for all major parameters during the deployment period with the exception of some variability of conductivity and turbidity values. It appears as though the deployment structure may need to be upgraded in the upcoming season to ensure the silty bottom does not interfere with readings during times of heavy rainfall.

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; total dissolved solids).

As can be seen in **Table 2**, the QA/QC comparison between the Datasondes and the Minsonde at the time of redeployment for all stations is very good. One problem encountered was that on September 24th, 2004 no Minisonde readings were taken at any of the stations for comparison purposes. This was due to the fact that the Environmental Officer on-site was performing the QA/QC procedures for the first time and did not realize that Minisonde readings were required at the time of redeployment. The DOEC staff visiting the site at that time also made this oversight. After all the forms were submitted, the DOEC staff member responsible for following up on all QA/QC measures/data informed the VBNC staff member of the omission. Until both Environmental Officers on-site become intimately familiar with the proper procedures, slight omissions and oversights are expected during the learning process.

Additionally, on July 11th, 2004 the data was not reading correctly into the database for the Camp Pond Brook station thus there was no Datasonde values for comparison purposes.

Finally, there was a problem with the dissolved oxygen QA/QC value on August 11th at the Lower Reid Brook station whereby it did not fall within the specified range. However, it only slightly fell outside the allowable limit by 0.56 mg/L.

As can be seen in **Table 3**, the QA/QC comparison between the Datasondes and laboratory data was also fairly good. The laboratory results will become more useful when DOEC begins working on regression analysis in the upcoming year that will allow predictions of other parameters from the ones being measured by the real-time water quality probes.

Overall, the QA/QC measures taken throughout the summer/fall months were very successful in ensuring that the real-time water quality data that is being collected in Voisey's Bay is accurate. QA/QC measures will continue to be upgraded by DOEC in the upcoming year.

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

Station	Reinstallation Date	Parameters	Datasonde Data	Minisonde Data	Remarks*
Upper Reid Brook	July 11, 2004	Temp (°C)	9.579	7.25	X
		pH (units)	6.039	6.61	✓
		Conductivity (uS/cm)	8.6	8.7	✓
		Dissolved Oxygen (mg/L)	12.23	12.96	✓
		Dissolved Oxygen (%)	107.4	107.4	✓
		Total Dissolved Solids (g/L)	0.0055	0.0055	✓
	August 11, 2004	Temp (°C)	9.77	9.82	✓
		pH (units)	6.36	6.44	✓
		Conductivity (uS/cm)	9.39	8.7	✓
		Dissolved Oxygen (mg/L)	10.72	10.64	✓
		Dissolved Oxygen (%)	94.49	94.2	✓
		Total Dissolved Solids (g/L)	0.006	0.0056	✓
	September 24, 2004	Temp (°C)	8.64	No Minisonde readings were taken by VBNC staff	NA
		pH (units)	5.94		NA
		Conductivity (uS/cm)	9.1		NA
		Dissolved Oxygen (mg/L)	11.1		NA
		Dissolved Oxygen (%)	95.19		NA
		Total Dissolved Solids (g/L)	0.0058		NA
Camp Pond Brook	July 11, 2004	Temp (°C)	No Datasonde readings available; problem with database	15.62	NA
		pH (units)		6.61	NA
		Conductivity (uS/cm)		19.1	NA
		Dissolved Oxygen (mg/L)		9.89	NA
		Dissolved Oxygen (%)		99.4	NA
		Total Dissolved Solids (g/L)		0.0122	NA
	August 12, 2004	Temp (°C)	12.36	12.29	✓
		pH (units)	6.99	6.83	✓
		Conductivity (uS/cm)	25.3	25.4	✓
		Dissolved Oxygen (mg/L)	9.58	10.02	✓
		Dissolved Oxygen (%)	96.6	94.3	✓
		Total Dissolved Solids (g/L)	0.0162	0.0162	✓
	September 24, 2004	Temp (°C)	7.93	No Minisonde readings were taken by VBNC staff	NA
		pH (units)	6.93		NA
		Conductivity (uS/cm)	28		NA
		Dissolved Oxygen (mg/L)	11.24		NA
		Dissolved Oxygen (%)	94.8		NA
		Total Dissolved Solids (g/L)	0.0179		NA
Lower Reid Brook	Instrument was sent away for repairs				
	August 11, 2004	Temp (°C)	11.98	11.97	✓
		pH (units)	7.49	6.84	✓
		Conductivity (uS/cm)	26.9	30.2	✓
		Dissolved Oxygen (mg/L)	9.41	10.97	X
		Dissolved Oxygen (%)	87.3	94.2	X
		Total Dissolved Solids (g/L)	0.0172	0.0056	✓
	September 24, 2004	Temp (°C)	7.42	No Minisonde readings were taken by VBNC staff	NA
		pH (units)	6.36		NA
		Conductivity (uS/cm)	25.7		NA
		Dissolved Oxygen (mg/L)	11.62		NA
		Dissolved Oxygen (%)	96.8		NA
		Total Dissolved Solids (g/L)	0.0164		NA

***** Notes: X = does not fall within specified range
✓ = falls within specified range
NA = cannot make comparison

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

Station	Reinstallation Date	Parameters	Datasonde Data	Laboratory Data	Remarks*
Upper Reid Brook	July 11, 2004	Temp (°C)	9.579		
		pH (units)	6.039	6.68	✓
		Conductivity (uS/cm)	8.6	24	X
		Dissolved Oxygen (mg/L)	12.23		
		Dissolved Oxygen (%)	107.4		
		Total Dissolved Solids (g/L)	0.0055		
	August 11, 2004	Temp (°C)	9.77		
		pH (units)	6.36	6.19	✓
		Conductivity (uS/cm)	9.39	15	X
		Dissolved Oxygen (mg/L)	10.72		
		Dissolved Oxygen (%)	94.49		
		Total Dissolved Solids (g/L)	0.006		
	September 24, 2004	Temp (°C)	8.64		
		pH (units)	5.94	6.03	✓
		Conductivity (uS/cm)	9.1	10	✓
		Dissolved Oxygen (mg/L)	11.1		
		Dissolved Oxygen (%)	95.19		
		Total Dissolved Solids (g/L)	0.0058		
Camp Pond Brook	July 11, 2004	Temp (°C)	No Datasonde readings available; problem with database		
		pH (units)		7.06	NA
		Conductivity (uS/cm)		20	NA
		Dissolved Oxygen (mg/L)			
		Dissolved Oxygen (%)			
		Total Dissolved Solids (g/L)			
	August 12, 2004	Temp (°C)	12.36		
		pH (units)	6.99	6.46	✓
		Conductivity (uS/cm)	25.3	28	✓
		Dissolved Oxygen (mg/L)	9.58		
		Dissolved Oxygen (%)	96.6		
		Total Dissolved Solids (g/L)	0.0162		
	September 24, 2004	Temp (°C)	7.93		
		pH (units)	6.93	6.44	✓
		Conductivity (uS/cm)	28	28	✓
		Dissolved Oxygen (mg/L)	11.24		
		Dissolved Oxygen (%)	94.8		
		Total Dissolved Solids (g/L)	0.0179		
Lower Reid Brook	Instrument was sent away for repairs				
	August 11, 2004	Temp (°C)	11.98		
		pH (units)	7.49	6.84	✓
		Conductivity (uS/cm)	26.9	30.2	✓
		Dissolved Oxygen (mg/L)	9.41		
		Dissolved Oxygen (%)	87.3		
		Total Dissolved Solids (g/L)	0.0172		
	September 24, 2004	Temp (°C)	7.42		
		pH (units)	6.36	6.31	✓
		Conductivity (uS/cm)	25.7	28	✓
		Dissolved Oxygen (mg/L)	11.62		
		Dissolved Oxygen (%)	96.8		
		Total Dissolved Solids (g/L)	0.0164		

***** Notes: X = does not fall within specified range
✓ = falls within specified range
NA = cannot make comparison

Section 5.0 Additional Activities

GIS Component

During the winter months of 2004, it was decided by DOEC that a GIS component should be added to this project to help better understand the physiographic features of the watersheds within the Voisey's Bay development area. It is believed that this type of mapping information will provide VBNC with knowledge that can be used in making management decisions and implementing environmental policies.

As noted previously, in the Voisey's Bay region there are three real-time water quality stations that collect and transmit water quality information. These three stations also have the ability to collect and transmit water quantity information. In addition to these three stations, there are two more additional stations that solely collect water quantity information.

DOEC, in conjunction with VBNC, has produced a series of maps that depicts the hydrometric/water quality stations and surrounding environment of the Voisey's Bay region. The maps show the locations of the stations and their contributing watersheds against a number of physiographic features. For each station the following set of five maps have been produced:

1. **Topographic / Basin Map**
    - Shows stations and watersheds against provincial NTS topographic data
    - Contains basic information about the stations and watersheds (e.g. drainage area)
    - All other maps of each set are at same scale as the basin map

2. **Digital Elevation Model (DEM)**
    - Shows the stations and watersheds against 1:50 000 scale DEM
    - The DEM was produced from the Canadian Digital Elevation Data (CDED) set produced by Natural Resources Canada
    - Depicts the nature of the terrain and elevation range of the watersheds

3. **Slope Map**
    - Shows the percentage of slope for the watersheds
    - Produced from the 1:50 000 scale DEM data
    - Helps in analysis of watersheds by highlighting steep areas that are sensitive to erosion, runoff, etc.

4. **True Color Landsat Map**
    - Shows watersheds against Landsat 7 satellite image from July 2001
    - Uses bands 1, 2 and 3 (red, green, blue)
    - Features appear in "natural" color (e.g. forests are green, exposed ground are brownish, etc)

5. **False Color Landsat Map**
    - Shows watersheds against Landsat 7 satellite image from July 2001
    - Uses bands 3, 4 and 5 (red and infrared)
    - Highlights specific features (e.g. non-vegetated area are pinks, cleared /developed lands are purples, etc)

A wall-map poster has also been produced which depicts the entire Voisey's Bay real-time water quality/hydrometric network and the surrounding physiography. This poster contains three map frames showing all five stations and their watersheds against the DEM, slope and false color Landsat. All maps are at a scale of 1:100 000. These highlight the coverage of the real-time water quality network/hydrometric network and also the overall nature of the contributing environment of the Voisey's Bay region.

The maps have been distributed both digitally and in hard copy to VBNC for use. Additional copies of these maps can be obtained through DOEC.

Presentation at Coastal Zone Canada Conference 2004

In June 2004, Renée Paterson of DOEC gave a presentation entitled *"From the Rivers to the Oceans – Real-Time Water Quality Monitoring for Coastal Zone Management"* at the Coastal Zone Canada Conference 2004. The Real-Time Water Quality Monitoring Network at Voisey's Bay was used as a case study to demonstrate how continuous water quality monitoring equipment can be used to assess the water quality entering the coastal zone area. The location of the three real-time water quality stations (from upstream to downstream) provide an ideal setting to be able to monitor the water quality as it flows from inland, through the developed area and then into the ocean. The presentation was well received by the audience and clearly demonstrated environmental stewardship on the part of VBNC.

Advanced Hydrolab Training Course

In October 2004, there was a custom Advanced Hydrolab Training Course offered in St. John's by the Canadian supplier of Hydrolab equipment – Campbell Scientific Canada Corporation. DOEC hosted the course in the Confederation Building with a total of five DOEC staff members attending the training. In addition, three VBNC staff members also travelled to St. John's to attend.

The course was designed to provide the participants with more in-depth training on the Hydrolab water quality monitoring equipment. The course covered important topics such as maintenance/calibration procedures; QA/QC procedures; data logging and management; warranty/repair procedures and additional high-level procedures.

Overall, the course was well received by the participants. It allowed the DOEC and VBNC staff to become more familiar with the equipment while at the same time ensuring that everyone is following the proper procedures to ensure accurate data collection.

Presentation at Automated Electronic Water Quality Monitoring Workshop

In October 2004, Amir Ali Khan of DOEC gave a presentation at an Automated Electronic Water Quality Monitoring Workshop in Vancouver, BC. The presentation given was entitled *"Real-time Water Quality Monitoring as a Regulatory Performance Tool – The Voisey's Bay Experience"*. It demonstrated how real-time water quality monitoring is effectively being used as a regulatory performance tool at Voisey's Bay. The presentation was well received by the audience and clearly demonstrated environmental stewardship on the part of VBNC.

Section 6.0 Conclusions

The Vosiey's Bay real-time water quality monitoring network has been very successful as a regulatory tool throughout the past year. It has clearly shown that the ambient water quality surrounding the development area is being protected. The near-real time water quality data allows the VNBC staff to act immediately on emerging water quality events.

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. 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. Additionally, the maintenance/calibration techniques and QA/QC procedures are working to ensure that all water quality data is accurate.

Finally, the partnership between DOEC, VBNC and EC throughout the past year has lead to numerous additional activities that have strengthened the project. A variety of maps have been produced that can be used in the decision-making process and implementation of environmental policies. Additionally, two distinct presentations about the real-time water quality monitoring network in Voisey's Bay were given at the Coastal Zone Canada Conference and the Automated Electronic Water Quality Monitoring Workshop throughout the past year. Finally, both DOEC and VBNC staff took part in additional in-depth training to ensure the water quality monitoring equipment is used properly.

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 some planned activities to be carried out in the upcoming year:

- shipment of instruments for servicing and warranty 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
- design and installation of new deployment structure at Lower Reid Brook station during spring site visitation
- continued monitoring of water quality from late spring to late fall 2005 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
- review and evaluation of site selection/deployment techniques to ensure the most meaningful data is being collected
- continued work on data management/retrieval/archival procedures
- continued transfer of data from DOEC to VBNC staff
- development of a system whereby VBNC staff has access to the real-time water quality data through the web page
- provide on-line statistical analysis of data
- evaluation and upgrading of QA/QC procedures; development of performance ranking system to evaluate the data
- work on extrapolation of other water quality parameters using regression analysis
- work on converting the stage graphs to flow graphs on the web page
- development of GIS interface to real-time water quality data to provide increased and more effective access
- creation of value added products using the real-time water quality data, remote sensing and water quality indices