



Teck Duck Pond Operations Real-Time Water Quality Monitoring Network Annual Report 2014

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Government of Newfoundland & Labrador
Department of Environment and
Conservation
Water Resources Management Division

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Acknowledgements

The Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations is successful in tracking emerging water quality issues due to the hard work and diligence of individuals from three different organizations. The management and staff of Teck Duck Pond Operations work in cooperation with the management and staff of the Department of Environment and Conservation (ENVC) as well as Environment Canada (EC) to ensure the protection of ambient water resources in the vicinity of the mine and mill.

At Teck Duck Pond Operations several staff members including General Manager Larry Bartlett have assisted in ensuring that the real-time system is operating such that data are reliable and accurate. Boyd Gulliford, Jill Kelly, Adam Miller, Ronny Bartlett, Carol-Ann Hayden, and Robert Vaters have provided valuable assistance with the stations and feedback from time to time.

Various individuals from the Department of Environment and Conservation under the direction of Haseen Khan have been integral in ensuring the smooth operation of such a technologically advanced network. Renée Paterson and Robert Wight played the lead roles in coordinating and liaising between the major agencies involved, thus, ensuring open lines of communication at all times. Robert Wight was responsible for the data management/reporting, troubleshooting, along with ensuring the quality assurance/quality control measures are satisfactory. Throughout the year, Robert travelled to Teck Duck Pond Operations sometimes multiple times monthly to maintain and service the equipment and troubleshoot any technical problems as they arose. Leona Hyde and Steve Duffy 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.

Staff of Environment Canada (Water Survey Canada) under the management of Howie Wills play an essential role in the data logging/communication aspect of the network. Brent Ruth, Roger Ellsworth, Perry Pretty, Dwayne Ackerman, Taylor Krupa and Mike Ludwicki visit the site several times throughout the year to ensure the data logging equipment is operating properly and transmitting the data efficiently. They play the lead role in dealing with hydrological quantity and flow issues.

All individuals from each agency are fully committed to maintaining and 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 to the open communication and high level of cooperation of all three agencies involved.

Section 1.0 Introduction

The Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations began in 2006 when the property was being developed by Aur Resources Inc. This network forms part of a larger network of government run and government-industry partnership run real-time water quality stations throughout the Province. **Figure 1** depicts the Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations in relation to the others on the island portion of the Province.

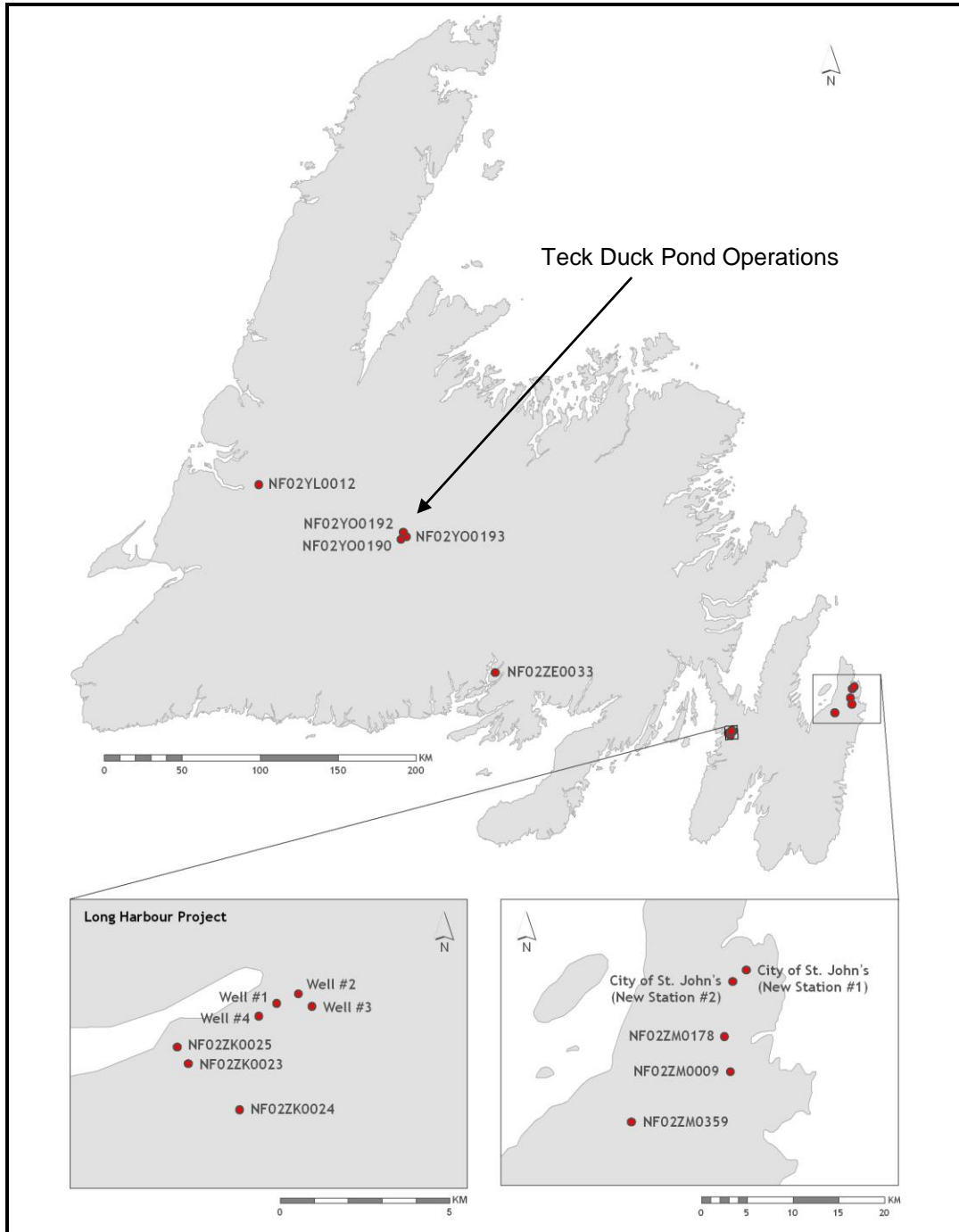
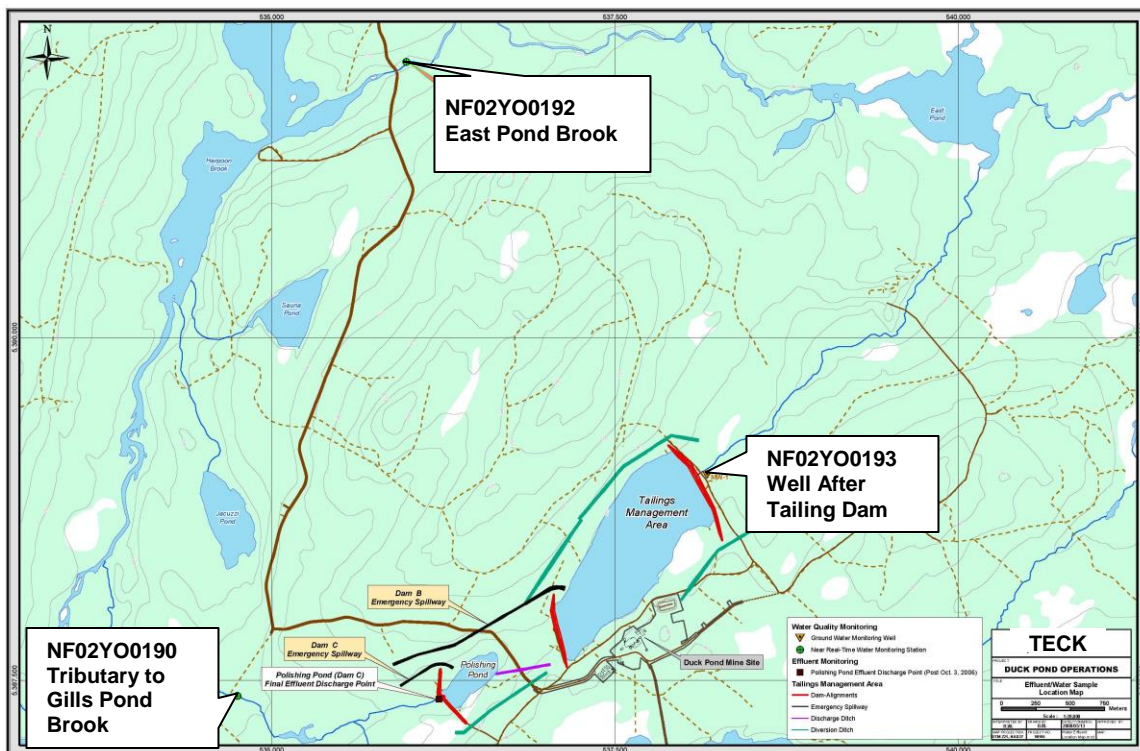


Figure 1: Real-Time Water Quality Monitoring Stations, Newfoundland

Three permanent stations (**Figure 2**) are established at Teck Duck Pond Operations; two in surface water streams and one in a ground water monitoring well:

- **Tributary to Gills Pond Brook Station (NF02YO0190)** is located 1700 m downstream of the final release point for the site's Tailings Management Area / Polishing Pond. This station is located such that any impacts from normal mine/mill discharge on receiving waters can be measured. This station has been fully operational since May 10, 2006 during the mine/mill construction phase.
- **East Pond Brook Station (NF02YO0192)** is located several kilometers downstream of the Tailings Management Area. This station is located such that any surface water impacts from the Tailing Management Area via seepage through Dam A may be measured. This station has been fully operational since September 7, 2006, during the mine/mill construction phase.
- **Monitoring Well After Tailings Dam Station (NF02YO0193)** is located approximately 100 meters below Tailings Dam A. This station is located such that any ground water impacts from the Tailing Management Area via seepage through Dam A may be measured. This station has also been fully operational since September 7, 2006.



**Figure 2: Real-Time Water Quality Monitoring Stations
Teck Duck Pond Operations**

The two surface water stations (Tributary to Gills Pond Brook Station (NF02YO0190) and East Pond Brook Station (NF02YO0192)) are operated under a renewable cost-shared agreement with Teck Duck Pond Operations. The operation of the ground water station (Monitoring Well After Tailings Dam Station (NF02YO0193)) is funded solely under the Canada-Newfoundland and Labrador Water Quality Agreement.

The objective of operating these stations is to provide an early warning of any potential or emerging water quality issues such that mitigative measures can be employed to ensure that discharge from Teck Duck Pond Operations meets all regulatory requirements and has minimal impact on the receiving waters and other water in proximity to the site, which are the headwaters of the Exploits River.

It was initially intended to remove the instruments from the three stations during the winter months, as the instruments are prone to be damaged by freezing. Furthermore, initially, there was no discharge planned for the winter months. However, as the mine and mill have become operational, discharge from the site has been required outside the planned time frame of May through November. Accordingly, the instruments have been deployed continuously whenever possible throughout the year.

The instruments at Tributary to Gills Pond Brook Station (NF02YO0190) and East Pond Brook Station (NF02YO0192) were deployed nearly continuously throughout the year. During the winter months, they remained deployed for longer periods to minimize the risk of damage from freezing during deployment and removal. Up to this point in time no significant negative impacts on the instruments have been observed. During the remaining months, these instruments were changed out approximately monthly, to facilitate regular maintenance and calibration.

As Monitoring Well After Tailings Dam Station (NF02YO0193) freezes at surface, an instrument is deployed continuously over the winter months. Following regular servicing and calibration it was placed in the well on November 13, 2013, and remained deployed until June 3, 2014. However, typical of the past several winters, there were some data communication errors throughout parts of the colder months. This reoccurring problem continues to be investigated, with multiple system components being changed out from time to time. Past experience has indicated that this probe is very stable over the long term, thus deployments up to six months have been recommended by the vendor.

Presently, all instruments are **Hydrolab**[®] brand **DataSonde**[®] probes in the surface water stations and a **Quanta G**[®] probe in the ground water station. To allow for continuous monitoring without extended periods of missing data, and to augment the older fleet of instruments, in 2012 Teck Duck Pond Operations purchased two additional **DataSonde**[®] probes and one additional **Quanta G**[®] probe so that replacement units having the same technical specifications, are always available when one or all three instruments are out of service for an extended period of time. Portable **Hydrolab**[®] brand **MiniSonde**[®] probes having the same technical specifications are used for QA/QC purposes.

From time to time there are transmission errors resulting in a loss of data through our satellite-based communications system. For the surface water-based instruments (**DataSondes**[®]) we have the ability to log the water quality data internally, and augment any missing data, particularly for periods of more than a few hours. This feature is not available on the ground water-based **Quanta G**[®] instrument. Any significant periods of missing satellite-based data which are augmented with internally logged data are noted in specific Deployment Period reports.

Section 2.0 Maintenance and Calibration

All staff involved in the installation, deployment, maintenance and calibration of these probes have undergone training and certification by **Hydrolab**[®]. Maintenance and calibration of these probes are undertaken in controlled conditions at the laboratories of the Department of Environment and Conservation in Grand Falls – Windsor and/or St. John's. Maintenance and calibration procedures, specified by the equipment manufacturer are followed precisely, and all calibration values logged in a database. All replacement parts, reagents and calibration solutions used, meet the manufacturer's specifications.

It is recommended that regular maintenance and calibration of the **DataSonde**[®] instruments take place on a monthly basis in order to ensure the accuracy of the data. Particularly during the warmer months, the sensors are prone to fouling from the accumulation of biofilm and other organic matter in the streams. **Quanta G**[®] instruments are intended for longer term deployments, with less frequent maintenance and calibration, as they may not be as subject to fouling in the well where temperatures are colder and water chemistry more stable. **Table 1** details the dates the instruments were installed and removed for maintenance and calibration in 2014. It is important to note that during the winter months instruments remained deployed for periods longer than a month to minimize the risk of damage from freezing during installation and removal. It has also been demonstrated that during the winter months, due to the colder temperatures, there is less fouling of the sensors, thus allowing them to remain accurate for longer periods of time.

Tributary to Gills Pond Brook Station (NF02YO0190)			
Deployment Period			
Installation Date (yyyy-mm-dd)	Removal Date (yyyy-mm-dd)	Days Deployed	Remarks
2013-11-14	2014-05-13	180	Winter deployment
2014-05-13	2014-06-25	42	
2014-06-25	2014-07-23	28	
2014-07-23	2014-08-27	34	
2014-08-27	2014-09-24	27	
2014-09-24	2014-11-21	57	
2014-11-21			Ongoing winter deployment
East Pond Brook Station (NF02YO0192)			
Deployment Period			
Installation Date (yyyy-mm-dd)	Removal Date (yyyy-mm-dd)	Days Deployed	Remarks
2013-11-14	2013-05-13	180	Winter deployment
2014-05-13	2014-06-25	42	
2014-06-25	2014-07-23	28	
2014-07-23	2014-08-27	34	
2014-08-27	2014-09-24	27	
2014-09-24	2014-11-21	57	
2014-11-21			Ongoing winter deployment
Monitoring Well After Tailings Dam Station (NF02YO0193)			
Deployment Period			
Installation Date (yyyy-mm-dd)	Removal Date (yyyy-mm-dd)	Days Deployed	Remarks
2013-11-13	2014-06-03	202	Winter deployment
2014-06-03	2014-10-29	148	
2014-10-29	2014-11-19	21	
2014-11-19			Ongoing winter deployment

Table 1: Maintenance and Calibration Schedule

Section 3.0 Discharge from Polishing Pond

Under Provincial and Federal regulatory measures, effluent from the mine’s Tailings Management Area may be discharged (controlled release) through the Polishing Pond to receiving waters (Tributary to Gills Pond Brook) provided it meets stringent criteria. During 2014, there were eleven separate Discharge Periods. The number of days discharging each month and the Average Daily Discharge are summarized in **Table 2**.

Month 2014	# of Days Discharging	Average Daily Discharge (m ³ /day)
January	9	3,031
February	28	19,740
March	20	10,439
April	2	16,142
May	10	3,435
June	20	9,217
July	3	1,544
August	31	18,159
September	30	18,711
October	23	8,805
November	19	3,467
December	29	5,121

Table 2

- Figure 3** illustrates the Total Daily Discharge from Polishing Pond in relation to the Average Daily Stage or Water Level in the receiving waters, Tributary to Gills Pond Brook. Increases in Stage above normal baseline levels are quite evident during discharge periods. The peaks during January and December are the result of the backwater effect due to in-stream icing conditions. Other peaks are the result of significant precipitation/runoff events. Please note that the stage illustrated on this graph is the Average Daily Stage, which is different then the hourly stage measurements illustrated and discussed in Section 4.1; some of the extreme high and low hourly values are normalized in the average. The stage data is raw data that is transmitted via satellite and published on our web page. It has not been corrected for backwater effect. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

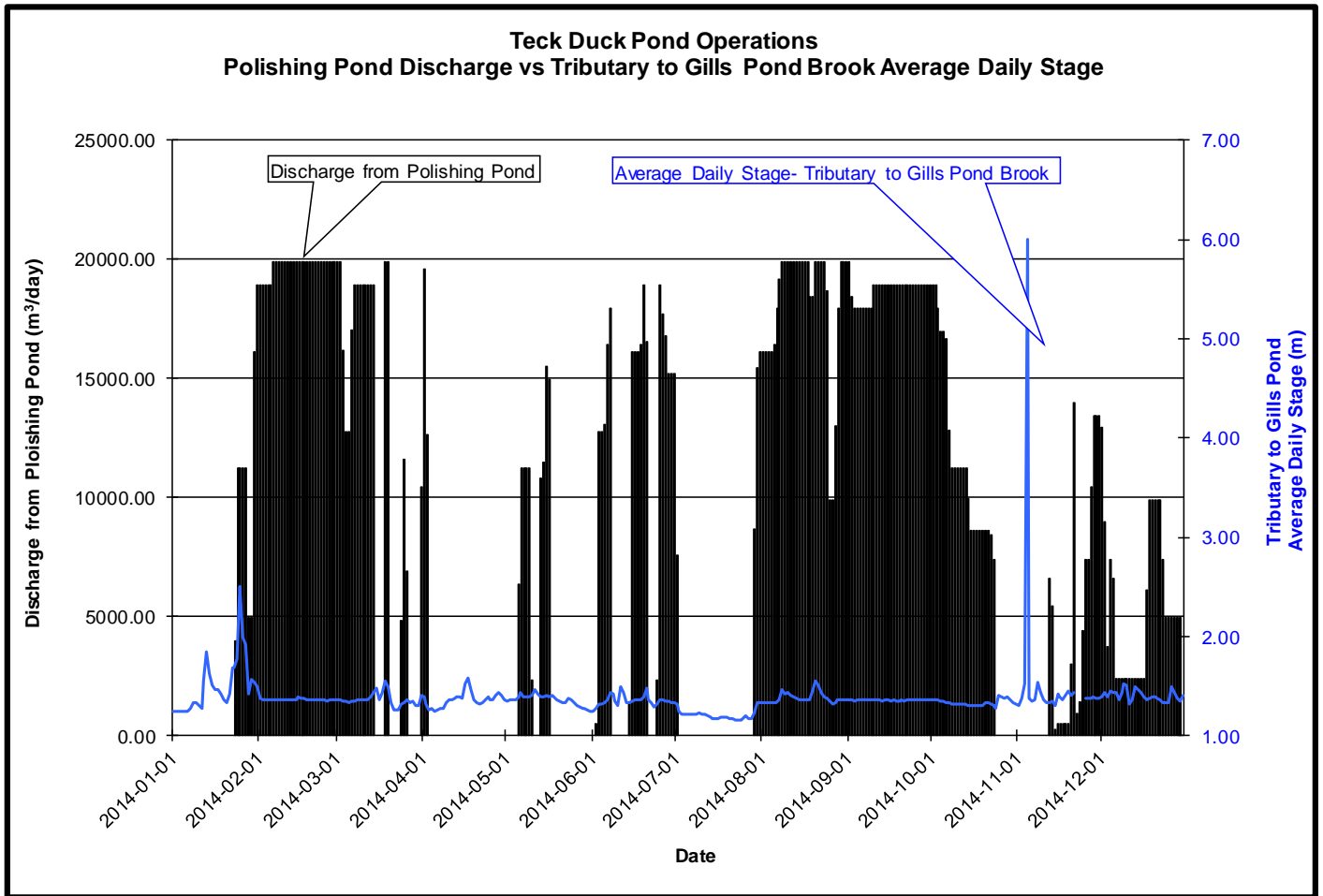


Figure 3

It is important to note, that while meeting the discharge criteria, the physical and chemical characteristics of the discharge water will be different from, and alter the physical and chemical properties in the receiving water. This will be evident in some of the parameters reviewed in Section 4.1.

Section 4.0 Data Interpretation

Section 4.1 Tributary to Gills Pond Brook Station (NF02YO0190)

Tributary to Gills Pond Brook Station is located 1700 m downstream of the final discharge point for the mine's Tailings Management Area - Polishing Pond. This station is located such that any impacts from the mine discharge on receiving waters can be measured.

The water temperature (**Figure 4**) ranged from a minimum of $-0.45\text{ }^{\circ}\text{C}$ to a maximum of $27.34\text{ }^{\circ}\text{C}$. In the winter months, under the cover of ice in the stream, temperatures were generally at or slightly below the freezing point. The highest temperatures were measured in July and August. The temperature profile for this stream is very similar to that of East Pond Brook (**Figure 10**). There are no obvious changes in temperature during discharge periods (**Figure 3**). Accordingly discharge from the Polishing Pond does not appear to have any significant impact on the water temperature at this station.

There is no recommended limit or range for water temperature.

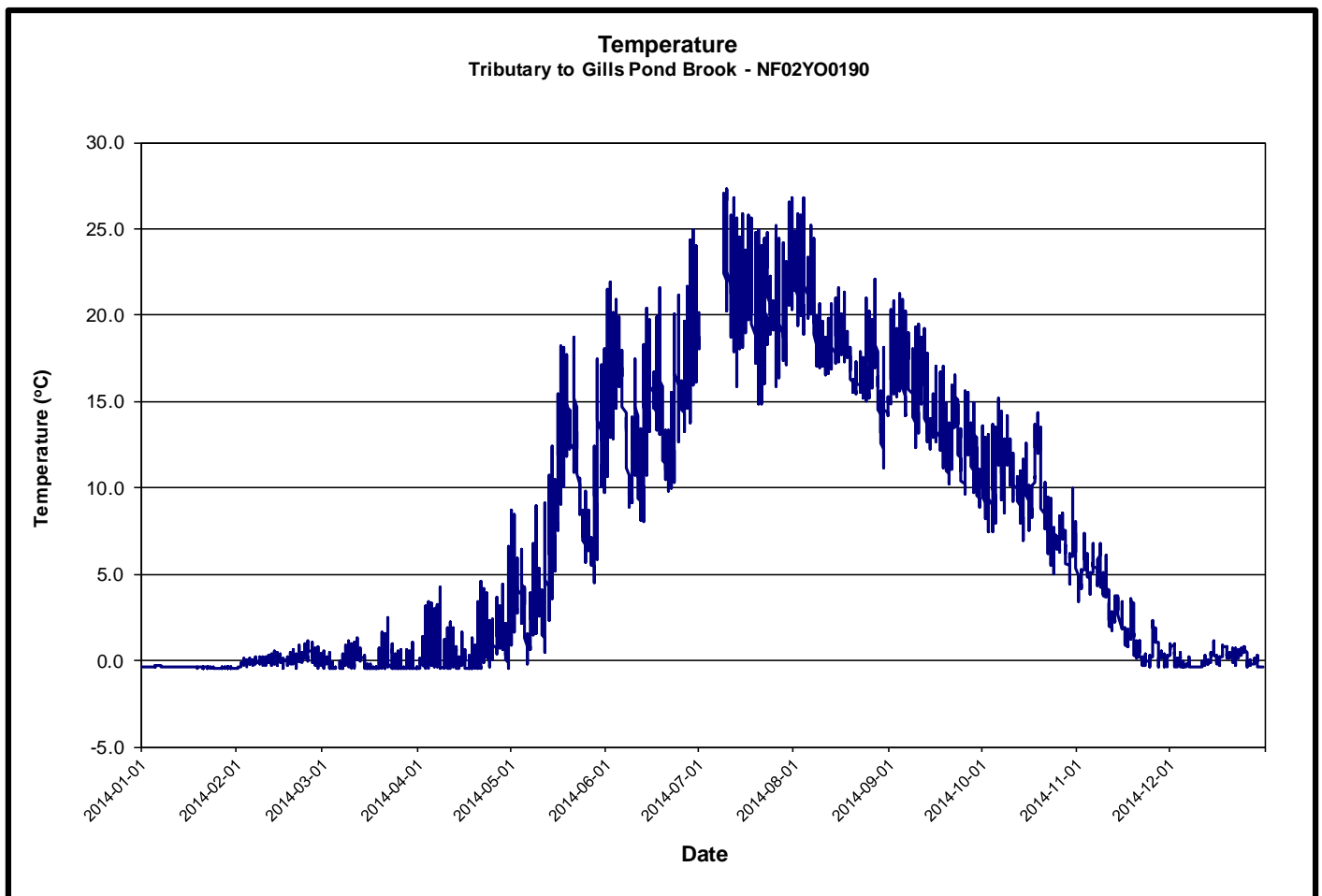


Figure 4

The pH (**Figure 5**) ranged from a minimum of 5.62 to a maximum of 7.49. The pH of this stream is naturally quite low, often being documented to be near or below the lower limit of the recommended range (6.5 – 9.0 – see colored lines on **Figure 5**) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* ⁽¹⁾. It should be noted however, that discharge from Polishing Pond often has a pH higher than the natural background pH of the receiving waters. Thus, when there is discharge from Polishing Pond (**Figure 3**), there is generally an increased pH in the stream at this station, which often brings the water within the pH range recommended by CCME. The pH profile throughout the year is similar to East Pond Brook (**Figure 11**), except for the influences of the discharge periods.

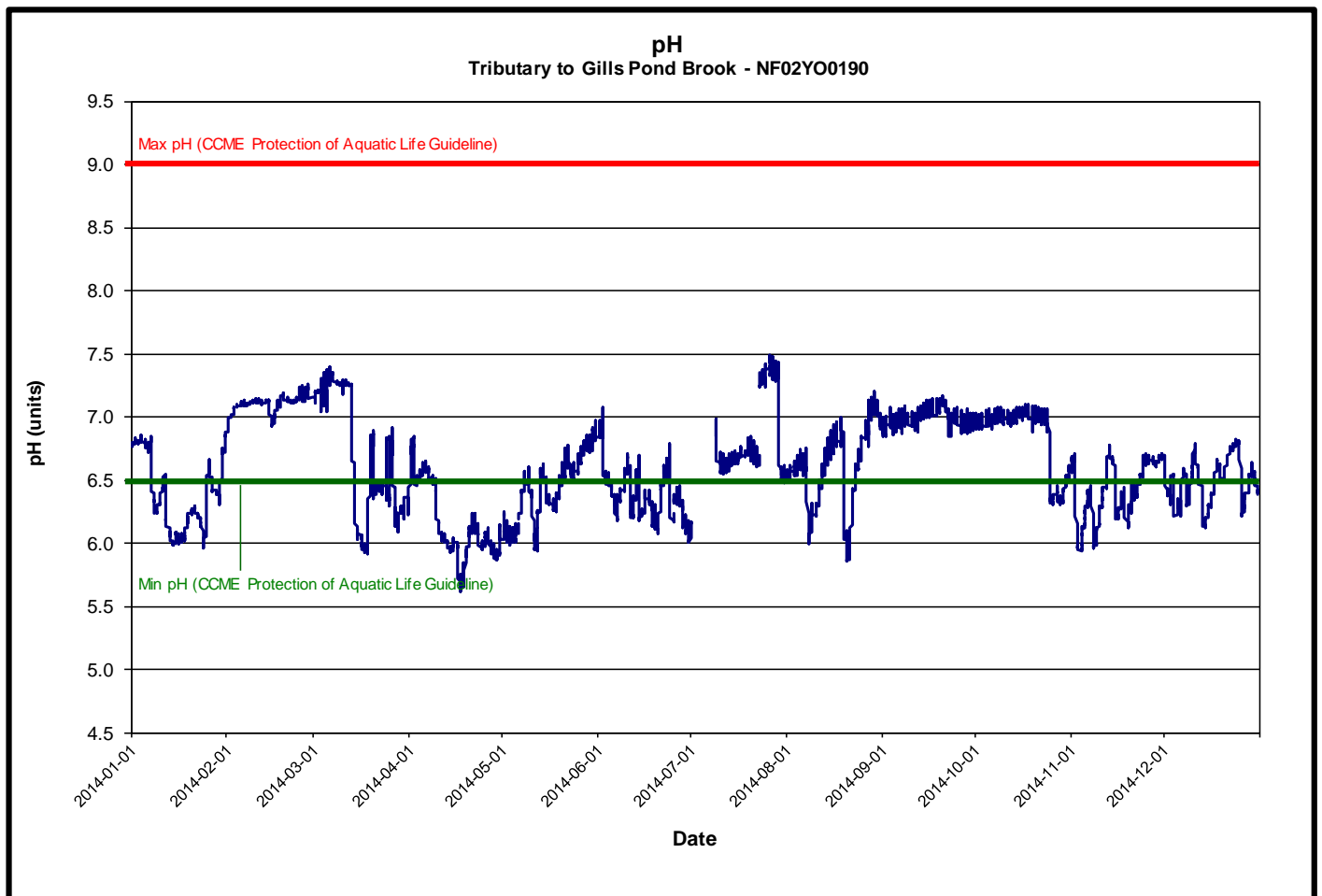


Figure 5

The specific conductivity (**Figure 6**) is affected by the amount of dissolved metals and salts in the water. Pristine waters in this part of the island generally have a specific conductance of less than 50 $\mu\text{S}/\text{cm}$. Outside the periods when there is discharge from Polishing Pond (**Figure 3**), the specific conductivity in this stream would generally be quite low. During the past year, the minimum specific conductivity was measured to be 7.4 $\mu\text{S}/\text{cm}$. When there is discharge from the Polishing Pond, conductivity increases significantly, the highest value being measured to be 1603.0 $\mu\text{S}/\text{cm}$. The significant increases and decreases in specific conductivity correspond closely with the beginning and end of the discharge periods from polishing pond (**Figure 3**).

It is interesting to note, that specific conductivity dips, sometimes significantly, during increased stage following periods of snowmelt or rainfall. Snowmelt and rainfall contributions to the stream's discharge would generally have an extremely low (approaching zero) background specific conductivity and would effectively 'dilute' water in stream. This is particularly more evident when there is discharge from the Polishing Pond.

There is no recommended limit or range for specific conductance, although it is a key indicator of the dissolved metals and salts in the discharge from Polishing Pond.

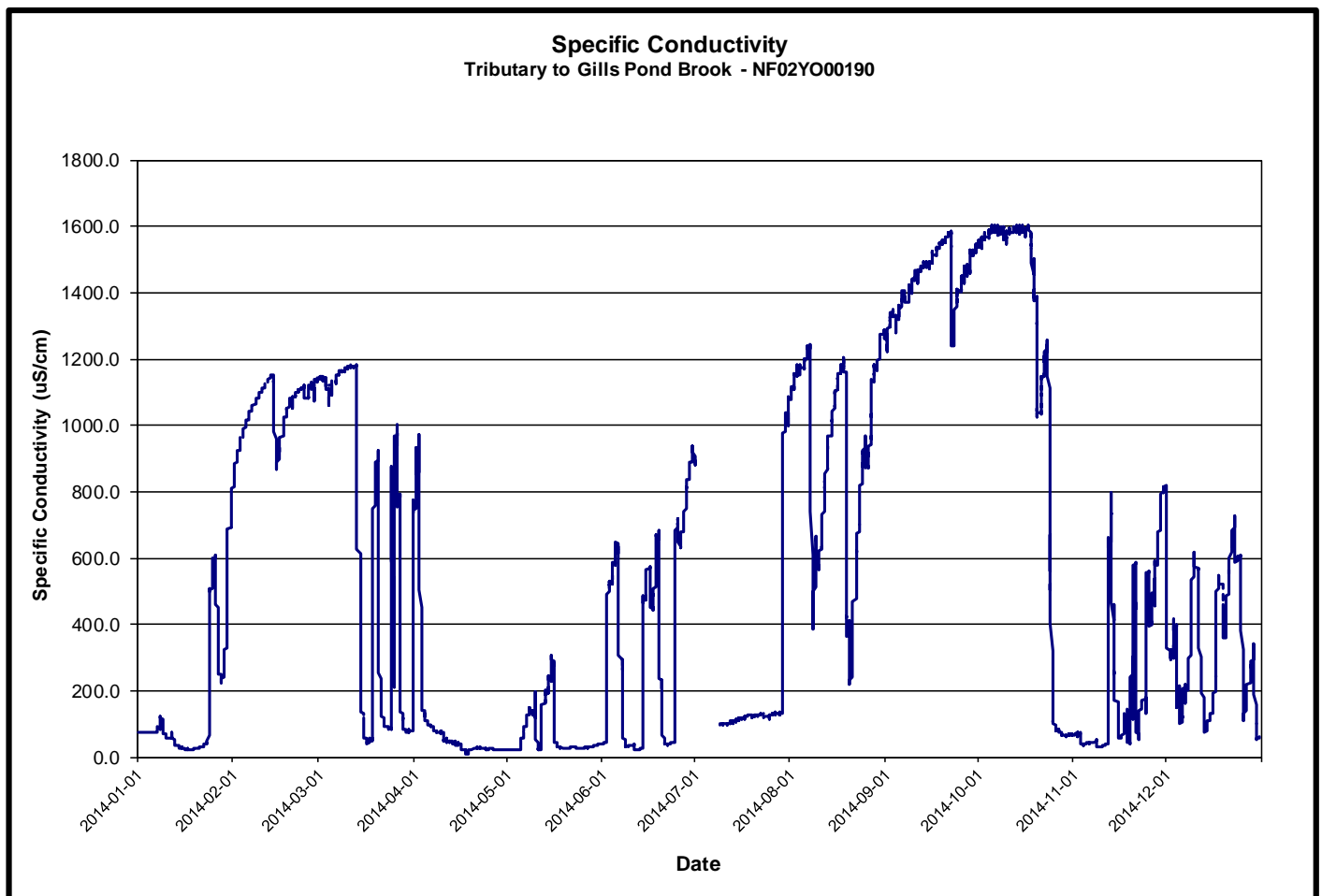


Figure 6

Dissolved oxygen (**Figure 7**) ranged from a minimum of 6.41 mg/L to a maximum of 13.84 mg/L. Generally, dissolved oxygen is inversely proportional to water temperature; this being evident in comparison to **Figure 4**.

The CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* ⁽¹⁾ for dissolved oxygen establish two separate lower limits for cold water biota: other life stages – above 6.5 mg/L; and early life stages – above 9.5 mg/L. While dissolved oxygen generally remained above 6.5 mg/L (apart from three hours in July), in the warmer months, it did not remain above 9.5 mg/L, the recommended lower limit for early life stage cold water biota. This is a function of the inverse relationship to the warmer water temperatures. During the period when dissolved oxygen was below 9.5 mg/L, the percent saturation (DO % Sat) usually remained in the normal range between 80 % and 100 %, indicating that the water was fully saturated with oxygen. In fact, the dissolved oxygen in waters in East Pond Brook (**Figure 13**) has a very similar profile. There does not appear to be any appreciable change in dissolved oxygen resultant from discharge from Polishing Pond.

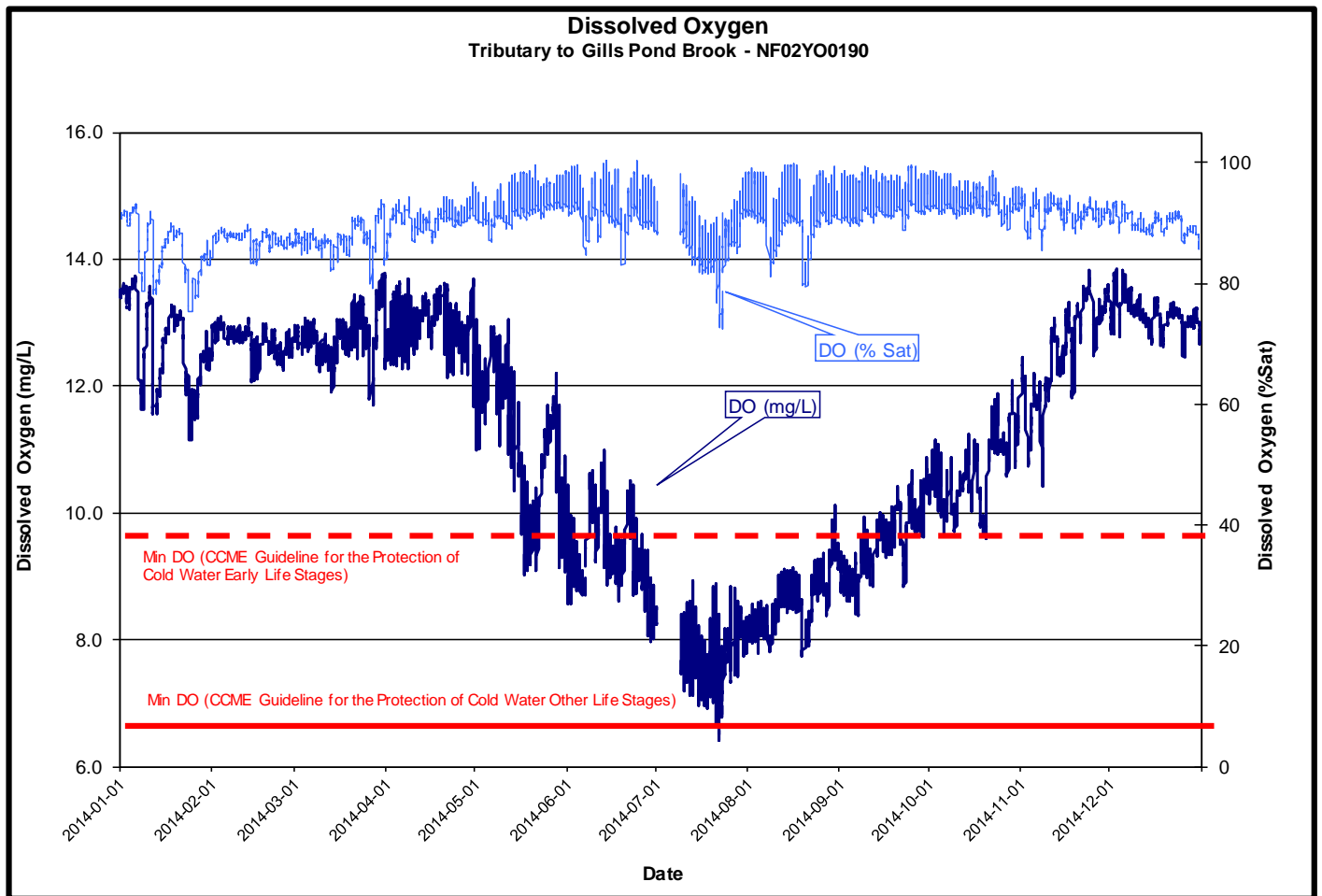


Figure 7

Turbidity (**Figure 8**) ranged from a minimum of 0.0 NTU to a maximum of 382.4 NTU. During periods when there was no discharge from Polishing Pond, turbidity values were generally at or close to zero. The frequency and intensity of turbidity spikes was generally greater during periods of discharge from Polishing Pond (**Figure 3**). The higher spikes in the first half of the year sometimes occur when there was discharge from the Polishing Pond, and often when there was a change in the discharge rate. The more intense and higher peaks in the latter part of April (highest on April 27, 2014) occurred when there was no discharge from Polishing Pond, but when there were increases in natural stream levels due to melting snow and precipitation/runoff events.

From time to time, leaves, algae and other natural in-stream debris became caught on the turbidity sensor, causing interference and false-positive readings. Data for these periods has been removed. Any unusual turbidity measurements will continue to be investigated by staff of the Department of Environment and Conservation and/or Teck Duck Pond Operations.

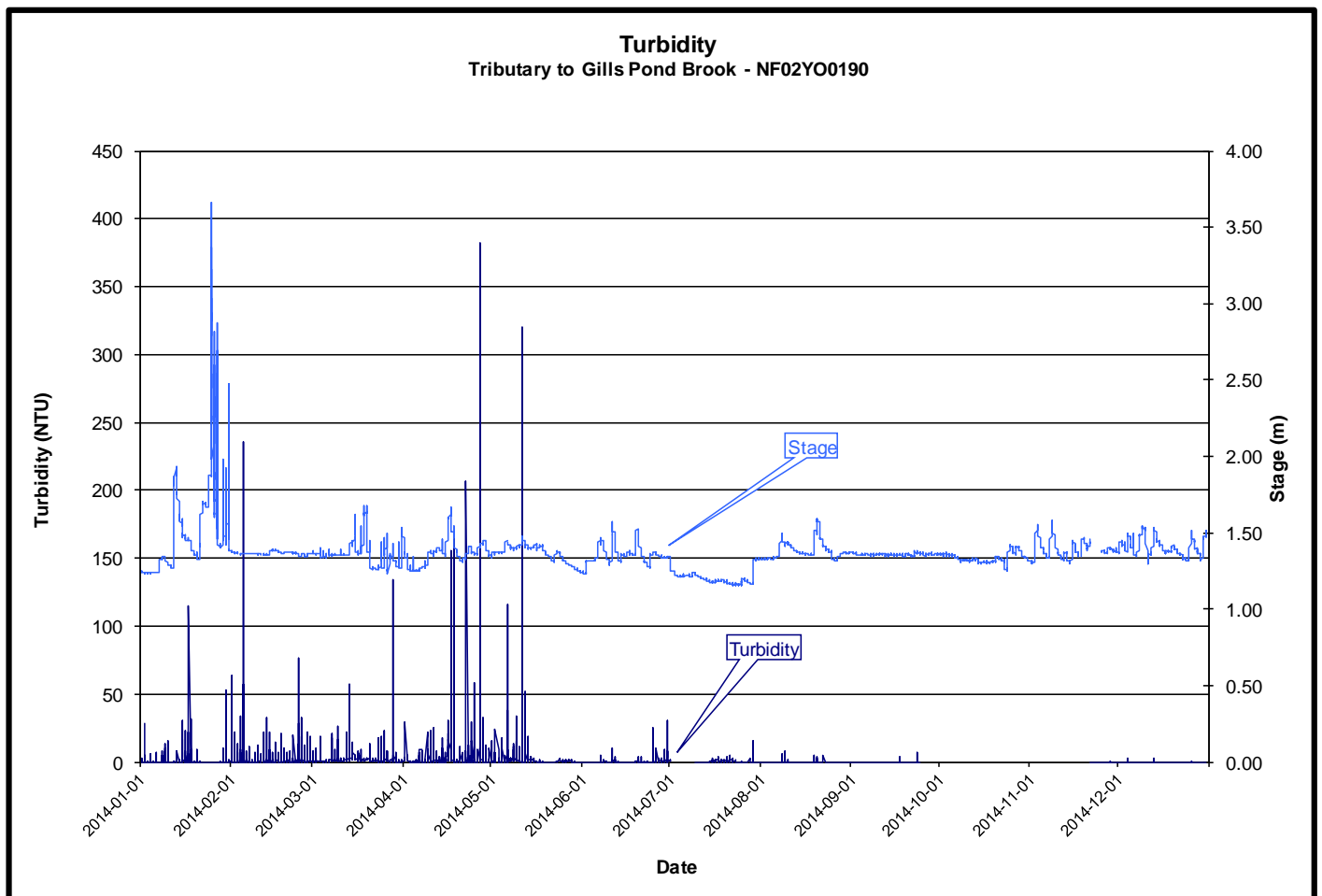


Figure 8

The stage or water level (**Figure 9**) was recorded to be between 1.16 m and 3.66 m. The flow or discharge ranged from a minimum of 0.01 m³/s to a maximum of 2.49 m³/s. At this location, stage is referenced to an arbitrary bench mark. The highest stage was recorded in January, presumably due to the backwater effect from ice formation.

For the remainder of the year, however, stage and flow were within normal ranges, with the higher levels corresponding to periods of controlled release from Polishing Pond (**Figure 3**) and following snow melt and rainfall events.

The flow or discharge is calculated based upon a stage-discharge curve which is developed over time. There are periods during the year, when extreme high and low flows could not be calculated as they were outside the range of the existing curve.

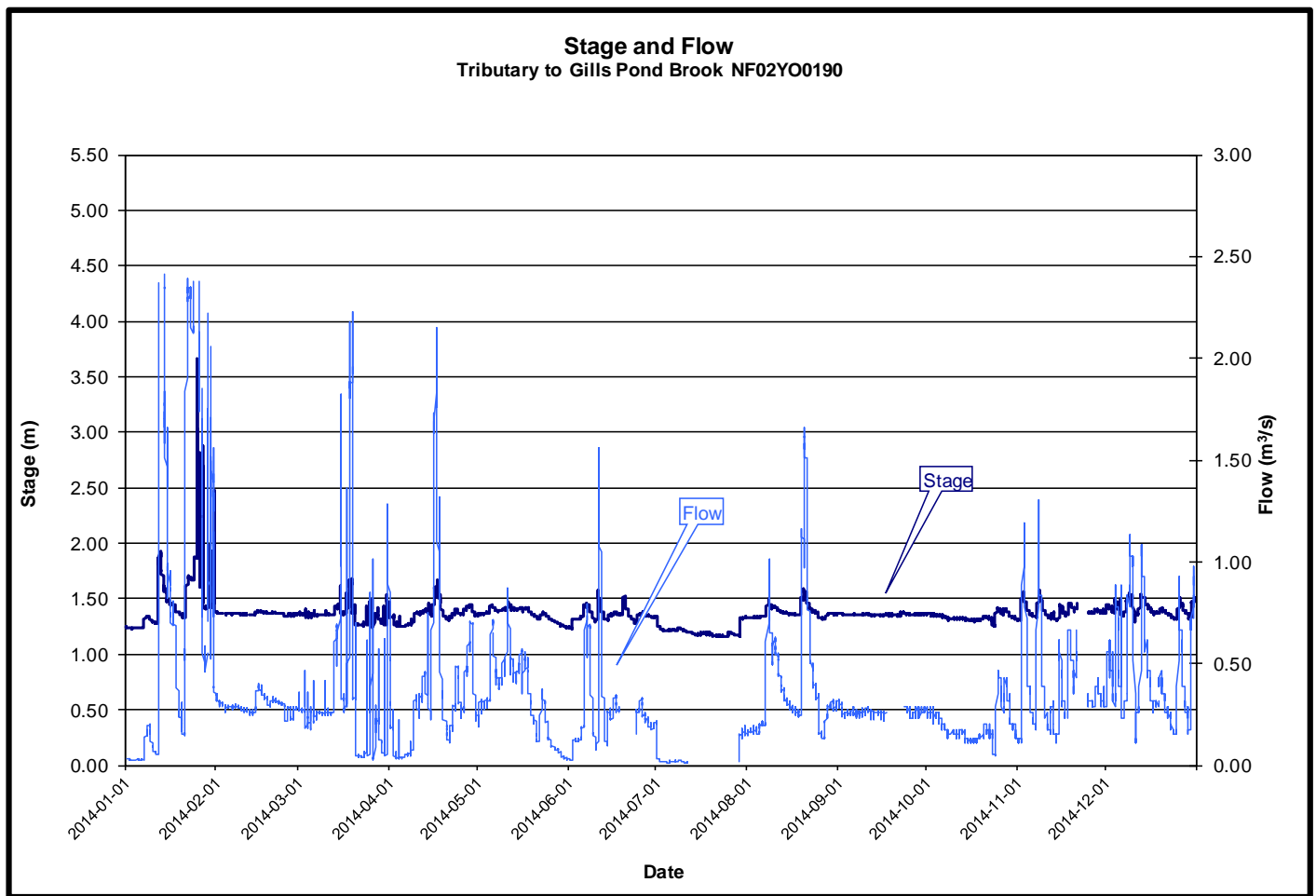


Figure 9

Section 4.2 East Pond Brook Station (NF02YO0192)

East Pond Brook Station is located several kilometres downstream of the Tailings Management Area. This station is located such that any surface water impacts from the Tailing Management Area via seepage through Dam A may be measured.

The water temperature (**Figure 10**) ranged from a minimum of 0.01 °C to a maximum of 28.39 °C. In the winter months, under the cover of ice in the stream, temperatures were generally at or slightly above the freezing point. The highest temperatures were measured in June through August. The temperature profile for this stream is very similar to that of Tributary to Gills Pond Brook (**Figure 4**).

There is no recommended limit or range for water temperature.

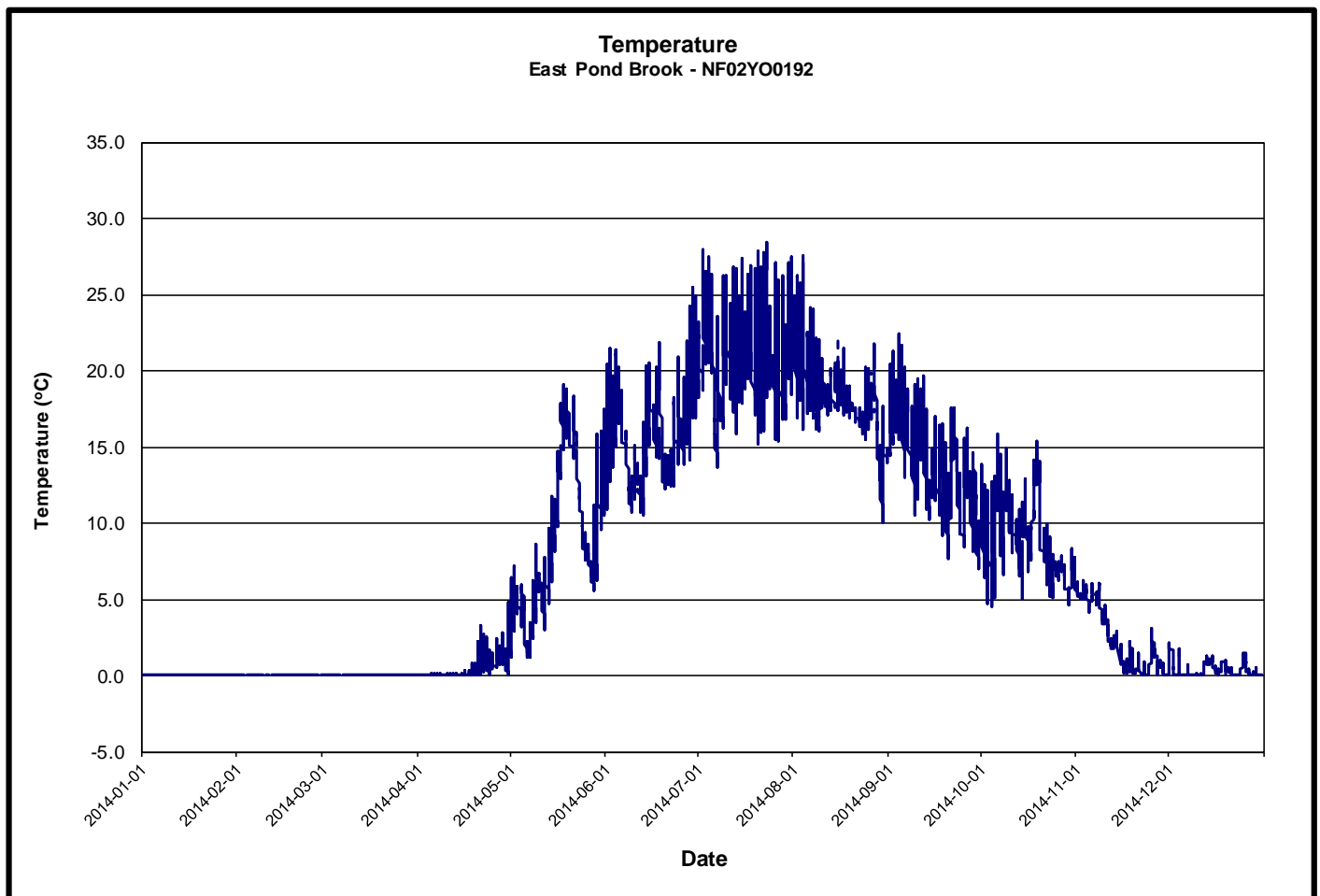


Figure 10

The pH (**Figure 11**) ranged from a minimum of 5.02 to a maximum of 7.26. The pH of this stream is naturally quite low, often being documented to be near or below the lower limit of the recommended range (6.5 – 9.0 – see colored lines on **Figure 11**) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* ⁽¹⁾.

Variation in pH is influenced by a number of factors. For example, there is an inverse relationship with stage (**Figure 15**) which is influenced by snowmelt and precipitation. All variations in pH appear to be due to natural influences.

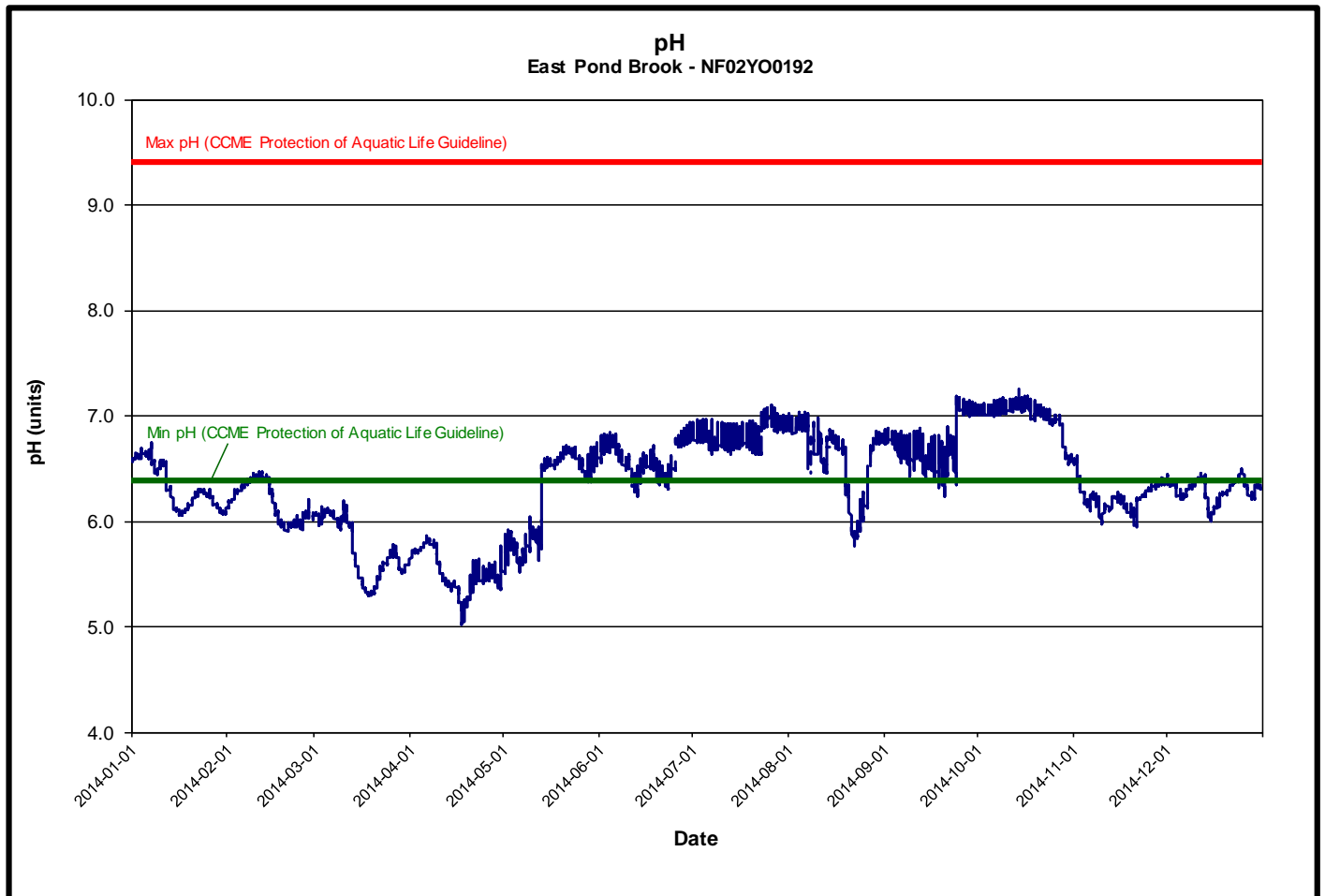


Figure 11

The specific conductivity (**Figure 12**) is affected by the amount of dissolved metals and salts in the water. Pristine waters in this part of the island generally have a specific conductance of less than 50 $\mu\text{S}/\text{cm}$.

During the past year, the specific conductivity ranged between 11.8 $\mu\text{S}/\text{cm}$ and 61.0 $\mu\text{S}/\text{cm}$.

The highest peak on August 11, 2014 is difficult to explain, as there is no stage or flow data available for this time period.

These values are typical for this stream.

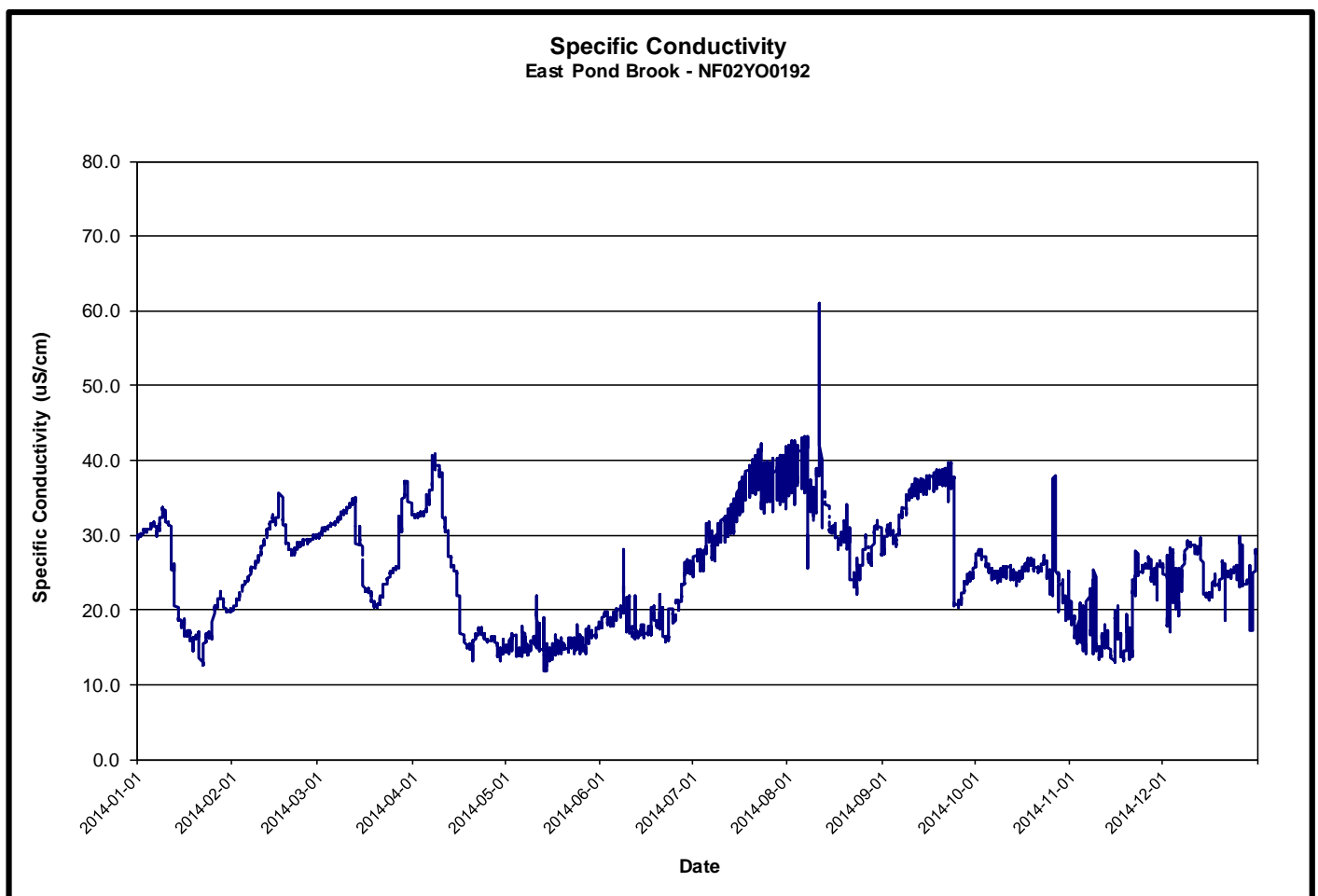


Figure 12

Dissolved oxygen (**Figure 13**) ranged from a minimum of 6.95 mg/L to a maximum of 14.03 mg/L. Generally, dissolved oxygen is inversely proportional to water temperature; this being evident in comparison to **Figure 10**.

A significant drop in dissolved oxygen (mg/L) and (%) is obvious around March 18, 2014 and is highlighted by the red ellipse. This corresponds with a rapid increase in stage, which would have resulted from a precipitation-snowmelt-runoff event.

The CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* ⁽¹⁾ for dissolved oxygen establish two separate lower limits for cold water biota: other life stages – above 6.5 mg/L; and early life stages – above 9.5 mg/L. While dissolved oxygen consistently remained above 6.5 mg/L, in the warmer months, it did not remain above 9.5 mg/L, the recommended lower limit for early life stage cold water biota. This is a natural function of the inverse relationship to the warmer water temperatures. During the period when dissolved oxygen was below 9.5 mg/L, the percent saturation (DO % Sat) remained in the normal range between 80 % and 100 %, indicating that the water was fully saturated with oxygen.

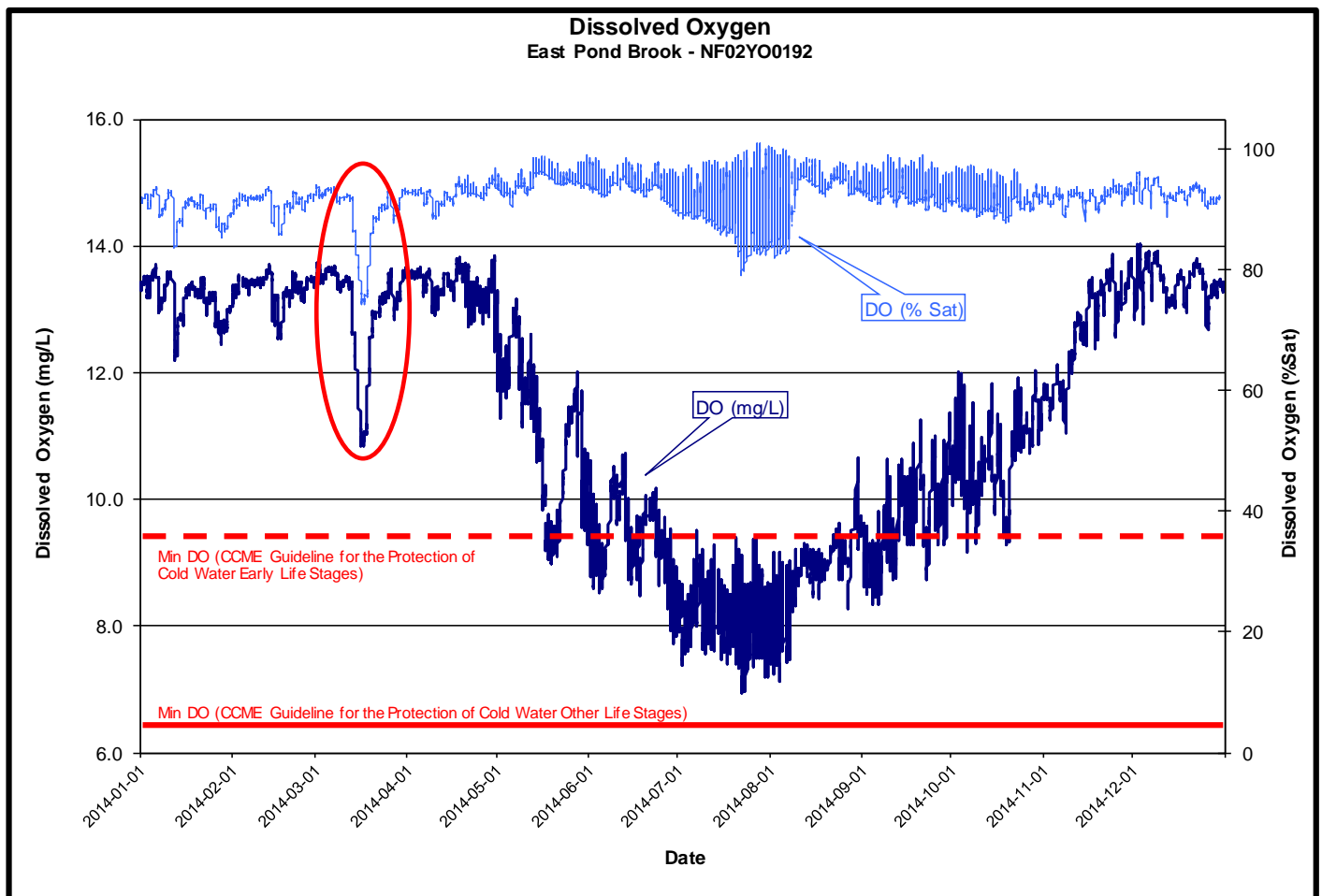


Figure 13

Turbidity (**Figure 14**) ranged from a minimum of 0.0 NTU to a maximum of 123.6 NTU. Generally, turbidity values in this stream are at or close to zero.

Several turbidity spikes occurred during increases in stage, and are likely the result of a precipitation-runoff event. The highest spikes in January 2014 cannot be explained, as it appears the stage data may not have been recording properly due to ice conditions. Turbidity spikes also occurred in mid-July when water levels were extremely low, and there was an accumulation of algae near the sensor, which may have contributed to the turbidity measurements.

There were a couple of occasions when leafy debris was noted to have been caught in the sensor, resulting in false-positive data. Data for these periods have been removed from the data set.

Throughout the year, high turbidity was not visible in the stream nor documented in any water sample results.

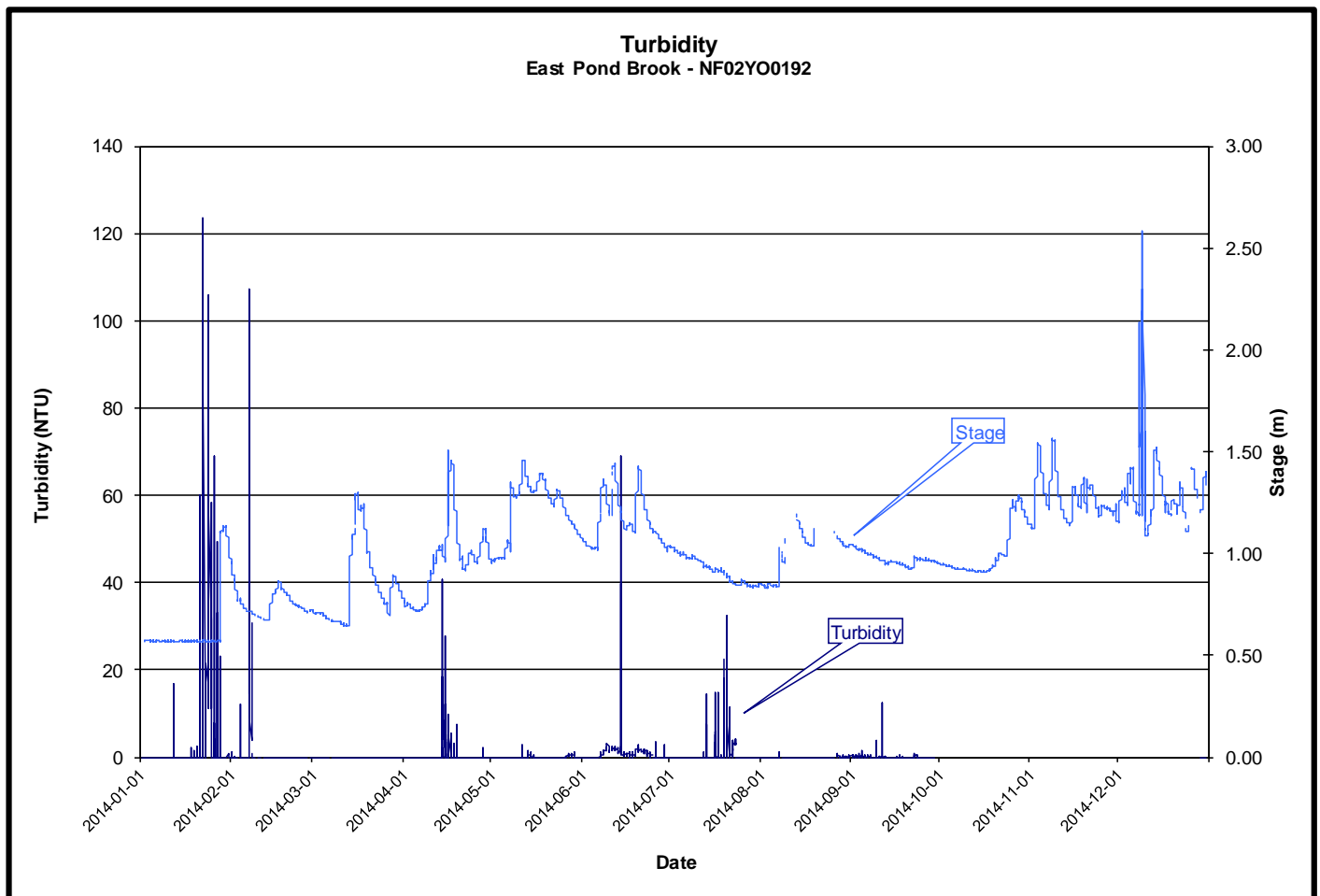


Figure 14

The stage or water level (**Figure 15**) was recorded to be between 0.57 m and 2.59 m. The flow or discharge ranged from a minimum of 0.11 m³/s to a maximum of 21.13 m³/s. At this location, stage is referenced to an arbitrary bench mark. Peaks in stage during December are attributed to the backwater effect from ice formation.

For the remainder of the year, however, stage and flow were within normal ranges, with the higher levels following snow melt and rainfall events.

The flow or discharge is calculated based upon a stage-discharge curve which is developed over time. There are periods during the year, when extreme high and low flows could not be calculated as they were outside the range of the existing curve.

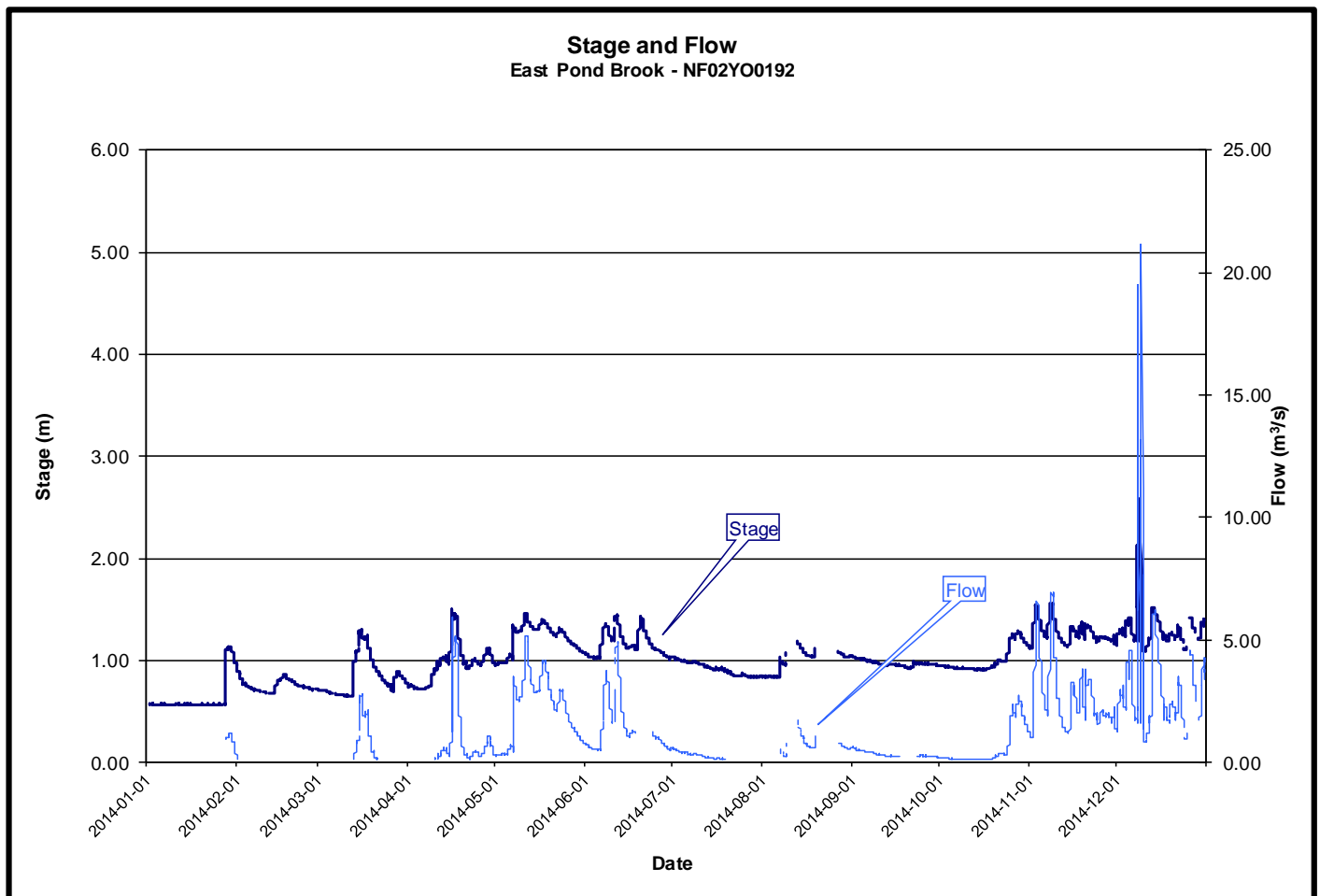


Figure 15

Section 4.3 Monitoring Well After Tailings Dam Station (NF02YO0193)

Monitoring Well After Tailings Dam Station is located near the toe of Tailings Dam A. This station is located such that any ground water impacts from the Tailing Management Area via seepage through Dam A may be measured.

There is a significant period of missing data during the winter months. For some unknown reason, during periods of colder weather, satellite communications from this station become intermittent or cease completely. This matter has been investigated thoroughly, and all components of the system have been changed, replaced or upgraded. We will continue to investigate and work to remedy this problem

Two artifacts in the data are evident. The two red ellipses highlight temperatures recorded approximately 0.25 °C higher than the other deployment periods. It has been determined that the fixed factory temperature calibration on the **Quanta G**[®] probe (s/n 00653) used during these two deployment periods is approximately 0.25 °C higher than the fixed factory temperature calibration on the **Quanta G**[®] probe (s/n 00035) used for the other deployment periods. This variation is however, within the manufacturer's accuracy specification for these instruments (± 0.20 °C x 2).

Water temperature (**Figure 16**) ranged from a minimum of 5.00 °C to a maximum of 6.33 °C. Lower temperatures were recorded in the summer months, while the higher temperatures were recorded in winter months. While the temperature profile is very similar to previous years, it has been noted that despite the seasonal variation, the mean temperature in this well appears to be increasing slightly since 2006. This change and its potential implications will be subject to further analysis in collaboration with Pollution Prevention Division of ENVC.

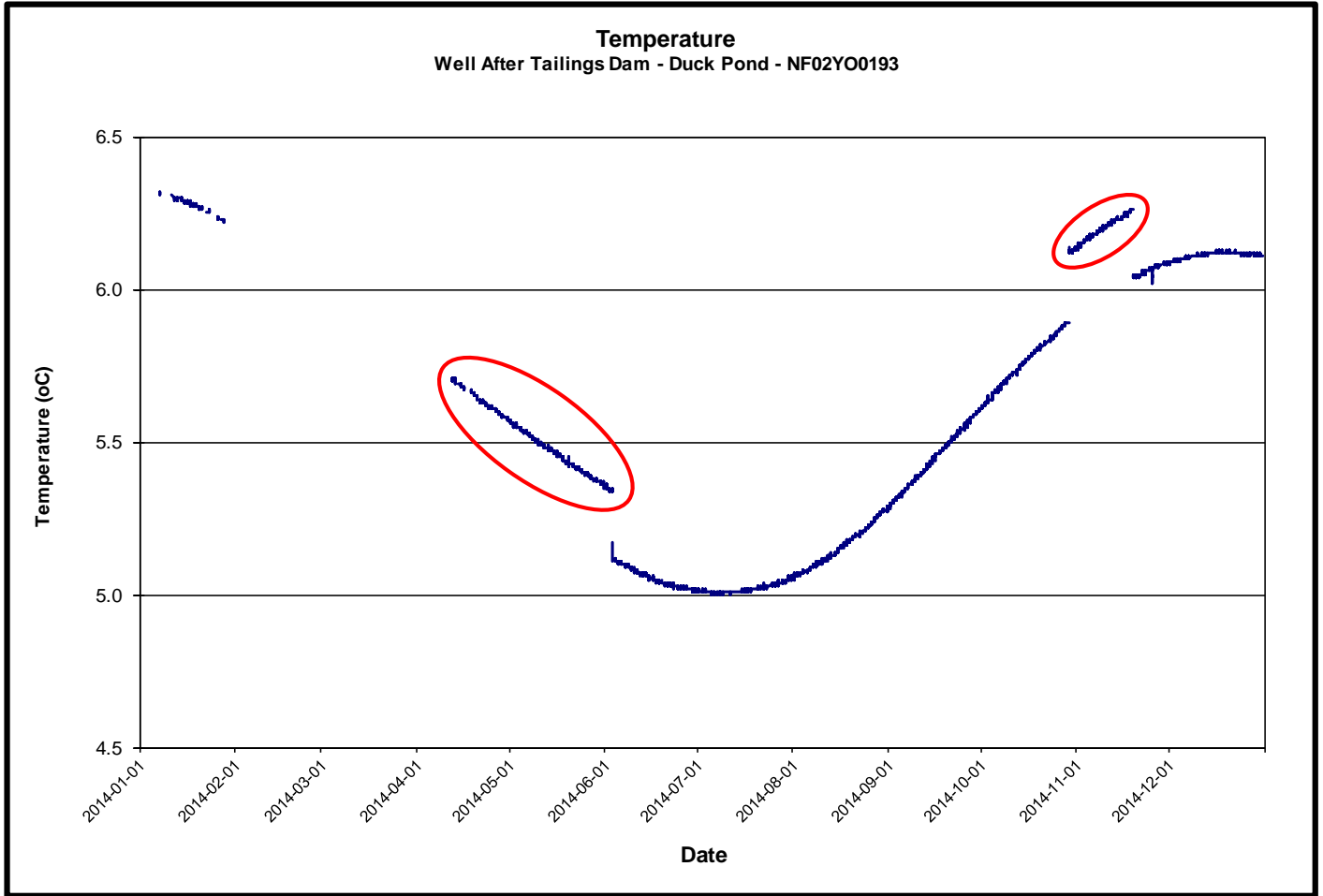


Figure 16

The pH measurements for this well are depicted in **Figure 17**. Values ranged from a minimum of 7.46 to maximum of 8.59.

At the beginning of each deployment period, as highlighted by the red ellipses, there is a significant increase in pH which essentially ‘levels off’ for the remainder of that period. This response in pH is typical of previous deployments. Prior to an investigation of this feature in 2011, it was believed that this was a function of the well being purged. However, it has been determined that the rapid change in pH at the beginning of each deployment is simply a function of the water in the small diameter well being displaced, as the instrument is deployed in the well⁽²⁾, thus temporarily disturbing the relatively ‘static’ nature of the well. Accordingly, it has been decided to minimize the number of deployments of the instrument in this well, and maximize the length of the deployment periods (approximately 6 months). Furthermore, it has also been demonstrated that purging the well has no long term (i.e. less than 60 minutes) effect on the water quality, including pH, in the well⁽⁴⁾. The effects of purging the well at the beginning of deployment, and during deployment continue to be monitored, as it is necessary to sample this well from time to time while the instrument is deployed. A draft Standardized Purging and Sampling Protocol⁽³⁾ has been developed for this particular well.

pH levels appear to be typical based upon historical data.

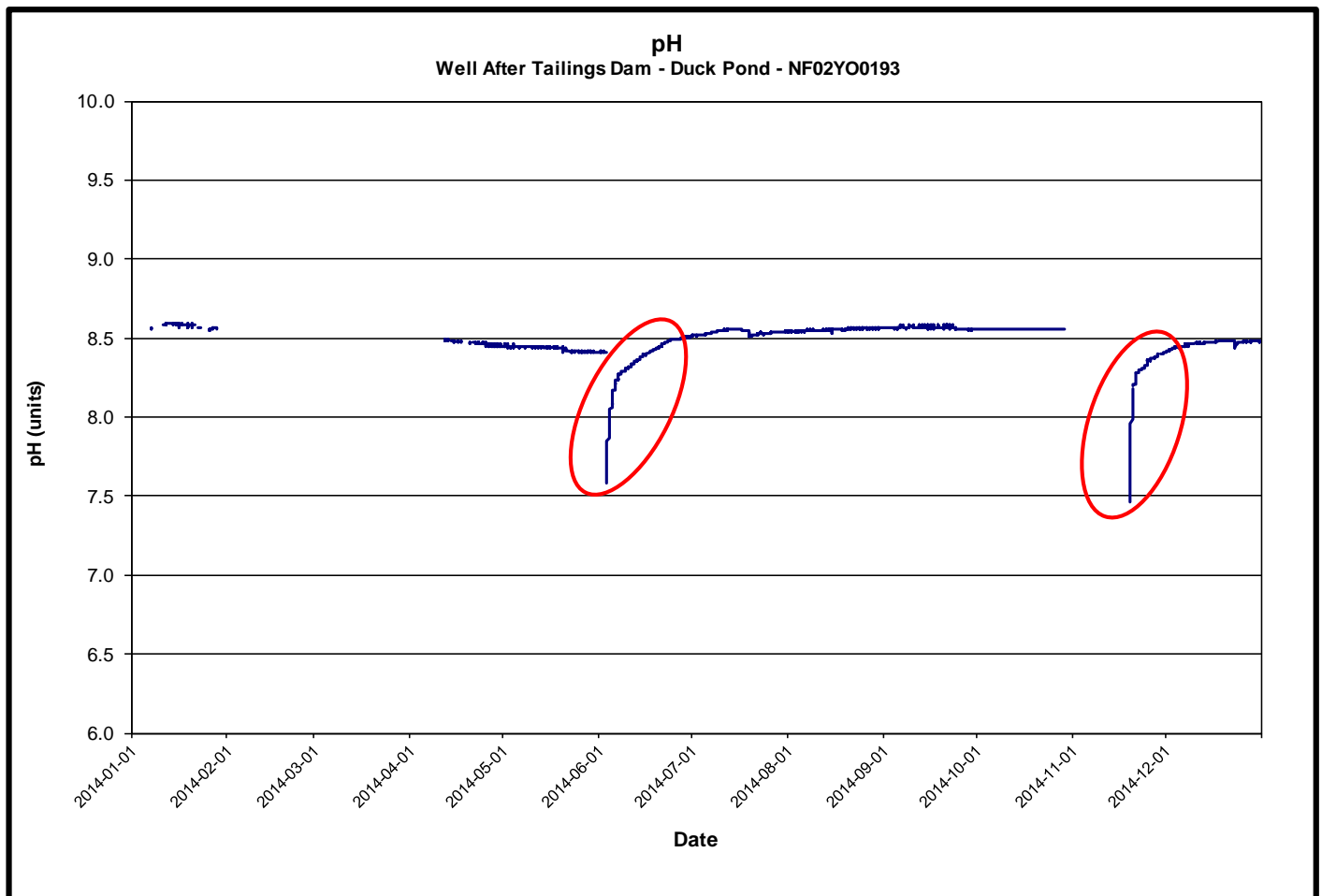


Figure 17

Specific conductivity in this well is higher than surrounding surface waters due to the highly mineralized nature of the material through which it is drilled. The well is also located such that it can be used to measure changes in ground water resultant from seepage from Tailing Dam A.

Specific conductance in this well (**Figure 18**) ranged from a minimum of 0.776 mS/cm to a maximum of 0.817 mS/cm.

There was a slight decrease in specific conductance over 2014. From 2006 to 2013, there was a significant and marked increase (long term trend) in specific conductance in this well.

This change and its potential implications will be subject to further analysis in collaboration with Pollution Prevention Division of ENVC.

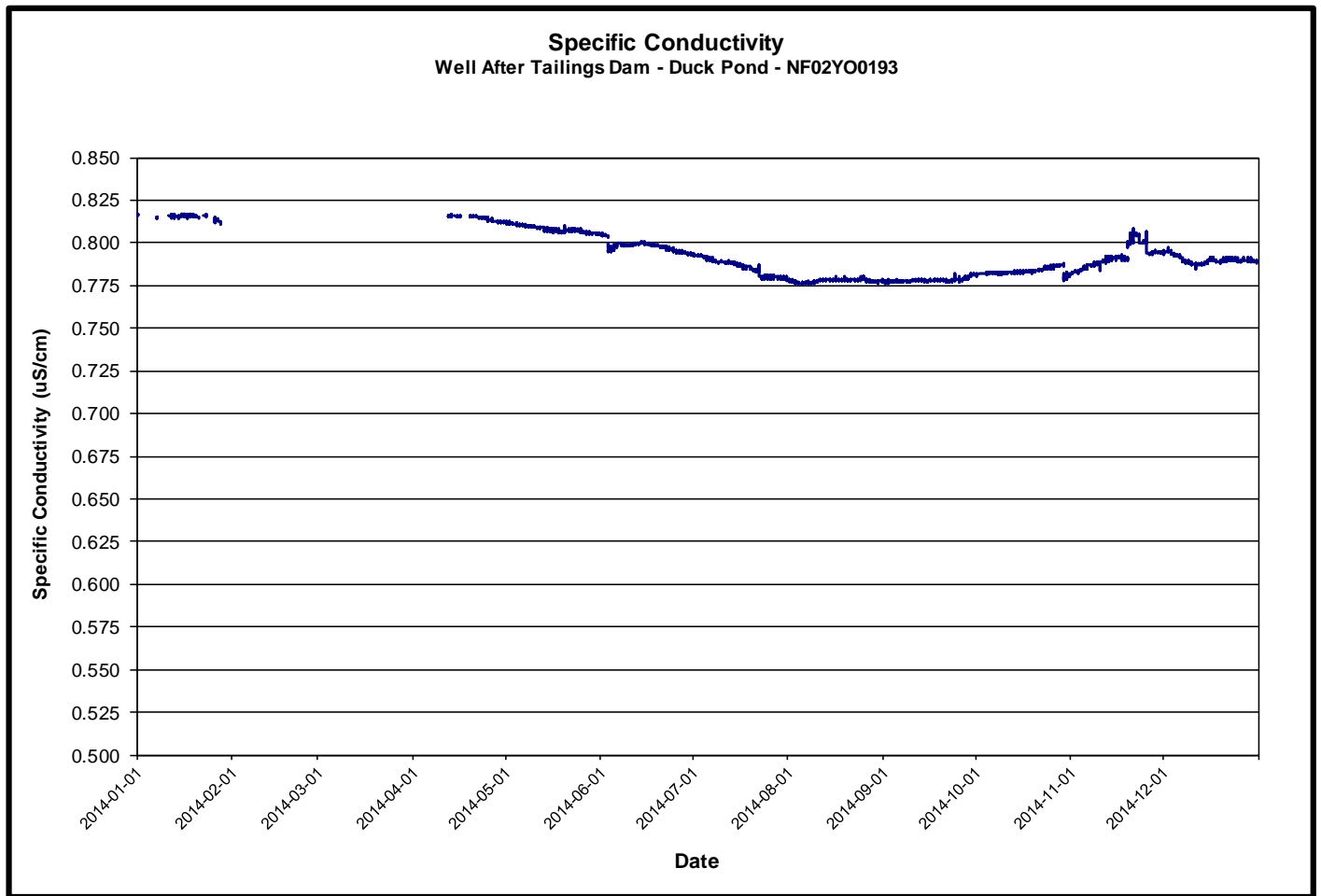


Figure 18

This shallow well is located in a glacial till, less than 100 meters from the toe of Tailings Dam A and less than 50 meters from a small stream (Trout Brook). The water elevation (**Figure 19**) in this well ranged between a minimum of 270.61 m and maximum of 270.90 m.

There is excellent agreement between recorded and measured water elevations throughout the year, with the maximum differential being measured to be 0.016 m. This indicates that the water elevation being logged is extremely accurate.

An analysis of the long term water elevation of this well ⁽⁴⁾, shows a significant correlation (Pearson Correlation Coefficient = 0.84) with the water level in the Tailings Management Area (TMA). Thus as water levels in the TMA rise and fall, so does the water elevation in this well, suggesting as we would expect, a hydraulic connection between the two. During particular seasons, a weak correlation (Pearson Correlation Coefficient = 0.19) exists between the long term water elevation in this well and the water level East Pond Brook, suggesting that, over shorter periods, changes in the well's water elevation may be influenced to some degree by the nearby stream.

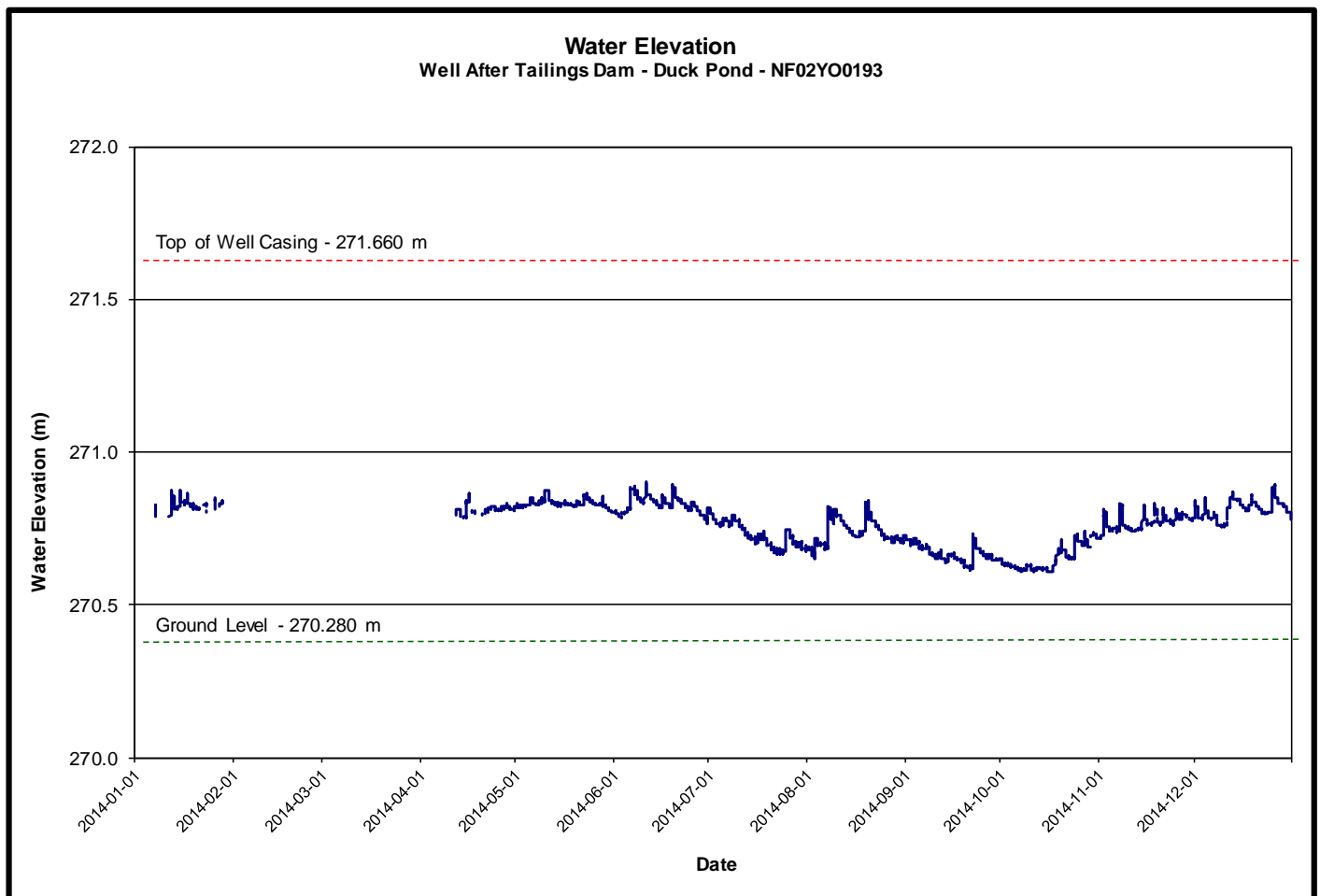


Figure 19

Section 5.0 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 at Teck Duck Pond Operations. These measures are put in place to ensure that the instruments are reading data accurately, and the numbers that are reported are representative of the actual environmental conditions.
- As part of the QA/QC protocol, an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The ranking system is based upon methodology developed by the U.S. Geological Survey ⁽⁵⁾, and uses the formulae in **Table 3** to qualify or rank the accuracy of the instruments.

Parameter	Rank				
	Excellent	Good	Fair	Marginal	Poor
Temperature (oC)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

Table 3

- For the Surface Water Stations, upon deployment and removal, a QA/QC **MiniSonde**[®] is temporarily deployed along side the Field **DataSonde**[®]. Values for each recorded parameter are compared between the two instruments. Based upon the difference between the parameters recorded by the Field **DataSonde**[®] and QA/QC **MiniSonde**[®] a qualitative statement (Ranking) is usually made on the data.
- The ranking at the beginning of the deployment period is shown in **Table 4** for Tributary to Gill’s Pond Brook and **Table 5** for East Pond Brook.
- Because the deployment set-up for Well After Tailings Dam (MW1) is different, comparison with another instrument is not possible. In this case, a grab sample is usually collected at the beginning and end of the deployment period, and the ranking is calculated for pH and Specific Conductance based upon live data and laboratory data. See **Table 6**.
- With the exception of water quantity data (Stage), all data used in the preparation of the graphs above and subsequent discussion below adhere to this stringent QA/QC protocol. Water Survey of Canada is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request.

Tributary to Gills Pond Brook Station (NF02YO0190)				
Parameter	Installation Date (yyyy-mm-dd)	Ranking	Removal Date (yyyy-mm-dd)	Ranking
Temp (°C)	2013-11-14	Good	2014-05-13	Excellent
pH (units)		Good		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Good
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-05-13	Good	2014-06-25	Excellent
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Good		Excellent
Temp (°C)	2014-06-25	Good	2014-07-23	Good
pH (units)		Excellent		Good
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Marginal
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-07-23	Excellent	2014-08-27	Excellent
pH (units)		Excellent		Good
Sp. Conductivity (uS/cm)		Good		Good
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-08-27	Excellent	2014-09-24	Excellent
pH (units)		Good		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-09-24	Excellent	2014-11-21	Excellent
pH (units)		Good		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Fair
Turbidity (NTU)		Excellent		Fair
Temp (°C)	2014-11-21	Good	Ongoing	n/a
pH (units)		Excellent		n/a
Sp. Conductivity (uS/cm)		Excellent		n/a
Dissolved Oxygen (mg/L)		Excellent		n/a
Turbidity (NTU)		Excellent		n/a

Table 4

East Pond Brook Station (NF02YO0192)				
Parameter	Installation Date (yyyy-mm-dd)	Ranking	Removal Date (yyyy-mm-dd)	Ranking
Temp (°C)	2013-11-14	Excellent	2014-05-13	Good
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Fair
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-05-13	Good	2014-06-25	Excellent
pH (units)		Good		Good
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Good		Excellent
Turbidity (NTU)		Fair		Excellent
Temp (°C)	2014-06-25	Excellent	2014-07-23	Good
pH (units)		Excellent		Good
Sp. Conductivity (uS/cm)		Excellent		Good
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Good
Temp (°C)	2014-07-23	Excellent	2014-08-27	Excellent
pH (units)		Good		Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-08-27	Excellent	2014-09-24	Excellent
pH (units)		Excellent		Good
Sp. Conductivity (uS/cm)		Excellent		Excellent
Dissolved Oxygen (mg/L)		Excellent		Excellent
Turbidity (NTU)		Excellent		Excellent
Temp (°C)	2014-09-24	Excellent	2014-11-21	Excellent
pH (units)		Excellent		Excellent
Sp. Conductivity (uS/cm)		Fair		Good
Dissolved Oxygen (mg/L)		Good		Good
Turbidity (NTU)		Excellent		Good
Temp (°C)	2014-11-14	Excellent	Ongoing	n/a
pH (units)		Excellent		n/a
Sp. Conductivity (uS/cm)		Excellent		n/a
Dissolved Oxygen (mg/L)		Excellent		n/a
Turbidity (NTU)		Excellent		n/a

Table 5

Well After Tailings Dam (MW1) Station (NF02YO0193)				
Parameter	Installation Date (yyyy-mm-dd)	Ranking	Removal Date (yyyy-mm-dd)	Ranking
pH (units)	2013-11-13	Poor	2014-06-03	Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
pH (units)	2014-06-03	Fair	2014-10-29	Excellent
Sp. Conductivity (uS/cm)		Excellent		Excellent
pH (units)	2014-10-29	Fair	2014-11-19	Poor
Sp. Conductivity (uS/cm)		Excellent		Excellent
pH (units)	2014-11-19	Fair	Ongoing	n/a
Sp. Conductivity (uS/cm)		Excellent		n/a

Table 6

For Tributary to Gills Pond Brook Station (NF02YO0190) the monitoring instruments performed extremely well. The *in situ* **DataSonde**[®] ranked ‘Excellent’ or ‘Good’ compared to a portable **MiniSonde**[®] results in 62 of 65 measurements.

A ‘Marginal’ ranking was determined for Dissolved Oxygen (mg/L) upon removal on July 23, 2014. The Field **DataSonde**[®] read 7.28 mg/L while the QA/QC **MiniSonde**[®] read 8.17 mg/L. It should be noted that there was a considerable amount of fouling of the probe due to biofilm and algae accumulation, along with bottom sediments that became liberated in the water column once disturbed during the removal process.

The turbidity sensor failed on the **DataSonde**[®] after 7 hours of deployment on September 24, 2014, resulting in potentially inaccurate turbidity readings for most of the deployment period. This resulted in a ‘Fair’ ranking upon removal of the instrument on November 21, 2014. All questionable turbidity data have been removed from the dataset.

A ‘Fair’ ranking for dissolved oxygen was also calculated upon removal on November 21, 2014. However, DO readings were all within normal ranges and the variance between the two probes was 0.53 mg/L.

For East Pond Brook Station (NF02YO0192) the monitoring instruments performed extremely well. The *in situ* **DataSonde**[®] ranked ‘Excellent’ or ‘Good’ compared to a portable **MiniSonde**[®] results in 62 of 65 measurements.

A ‘Fair’ ranking was determined for Dissolved Oxygen (mg/L) upon removal on May 13, 2014. A difference of only 0.56 mg/L was determined after the over-winter deployment.

A ‘Fair’ ranking was determined for Turbidity for upon installation on May 13, 2014. The Field **DataSonde**[®] read 5.5 NTU while the QA/QC **MiniSonde**[®] read 0.0 NTU.

There was a significant difference (12.9 $\mu\text{S}/\text{cm}$) in specific conductivity between the field **DataSonde**[®] and the QA/QC **MiniSonde**[®] upon deployment on September 24, 2014, resulting in a 'Fair' ranking. Based upon historical data for this time of year, and a grab sample collected at the time, it is suspected that the field Sonde calibrated slightly lower than the standard. The data for this period have been kept, as they are within the normal range.

For Well After Tailings Dam (MW1) Station (NF02YO0193), the monitoring instruments performed very well. The *in situ* **Quanta G**[®] ranked 'Excellent' compared to laboratory results in 9 of 14 measurements. A 'Fair' or 'Poor' ranking for pH is related to the depressed pH values at the beginning of each deployment period; for which there is no known remedy. A 'Poor' ranking upon removal on November 19, 2014 corresponds with failure of the pH sensor which necessitated removal of the instrument.

This confirms that the measurements recorded by each of these instruments and transmitted to our web site in real-time are very accurate. However, it is understood drift may increase over time, particularly in the warmer months when bio-fouling is more likely to occur. Accordingly, when conditions and accessibility permit, the instruments will continue to be maintained and calibrated at the intervals recommended by the manufacturer.

Maintenance and calibration are always undertaken by trained staff in accordance with protocols prescribed by the manufacturer. All replaceable parts, reagents and calibration solutions used meet the specifications of the manufacturer. All work is undertaken in a controlled laboratory environment.

In 2014, there were a number of instrumentation issues. Several individual sensors have failed and needed to be replaced. ENVC had worked with the vendor's representative to identify problems and issues causing the failures, with the aim to mitigate future failures. As costs for these repairs are significant, the vendor has worked with the manufacturer to minimize costs to ENVC and Teck by covering some of the repairs outside of the normal warranty period.

In order to ensure long term accuracy for the instruments, they are returned to the vendor and/or our in-house factory-trained staff periodically (approximately every two years, or when problems or issues are observed) for Performance Testing and Evaluations (PTE). At this time, sensors are replaced if required, and the instruments are maintained and calibrated to factory specifications.

Section 6.0 Conclusions

The Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations has again this year proven to be quite useful. The data derived from this network has been used by Teck management and staff to monitor their performance. Government has reviewed the data daily to ensure that equipment is functioning properly, and that discharge from the site remains within the regulated discharge criteria. The public, who have access to this data through the web, have undoubtedly been diligent in monitoring the water quality data as well.

In the two surface water stations (Tributary to Gills Pond Brook and East Pond Brook), while changes to water quality have been observed throughout the year, no serious incidents has been identified which have raised any cause for concern. No mitigative measures have needed to be employed to address any problems or issues resultant from this monitoring.

In Monitoring Well After Tailings Dam (MW1), some long term changes in temperature and specific conductance have been documented. The situation will continue to be monitored and reviewed from time to time in collaboration with Pollution Prevention Division of ENVC.

Continued operation of the Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations is planned for the life of the operation, and throughout the planned closure, rehabilitative and subsequent monitoring phases.

Section 7.0 Path Forward

In order for this program to remain successful, it is essential to continually evaluate, improve and move forward. The following is a list of initiatives and activities to be carried out in the upcoming year:

- 1) The **DataSonde**[®] instruments owned by Teck Duck Pond Operations will be monitored closely to ensure their accuracy and reliability. Should any issues be identified, they will be returned to the vendor and/or Department of Environment and Conservation for factory servicing and calibration.
- 2) Currently, four **DataSonde**[®] instruments owned by Teck Duck Pond Operations are available for service in the surface water - based stations. Two older units, nearing their projected lifecycle of 5 to 10 years continue to be updated with some new sensor tips and software. Two new instruments have been put into regular service on a rotating basis.
- 3) Currently two **Quanta G**[®] instruments (one owned by Teck Duck Pond Operations and one owned by Department of Environment and Conservation) are deployed in Monitoring Well After Dam A on a rotating basis.
- 4) The false-positive turbidity measurements at Tributary to Gills Pond Brook Station (NF02YO0190) that have been investigated for several years have now been fully mitigated. Moving the instrument a little downstream further away from the plunge pool, and re-orienting the probe 180 degrees, such that the sensor tips are downstream has mitigated false-positive readings
- 5) The Standardized Well Purging and Sampling Protocol for Monitoring Well After Tailings Dam A appears to be working well. Its use will continue by ENVC and Teck staff, with feedback and updates as necessary.
- 6) Some minor maintenance work may be needed on the pathways leading to the Real-Time Water Quality Monitoring stations in subsequent years.
- 7) Work will continue to optimize sensor performance, data transmission, and information transfer. Any emerging issues will be addressed in a timely manner.
- 8) Work will continue to enhance and automate the data handling and reporting processes. ENVC is working on extrapolation of other water quality parameters using regression analysis.
- 9) An evaluation of the most recent Closure Plan for the site has been completed. Real time water quality monitoring is planned to continue throughout the completion of the life-of-mine, and the planned closure, rehabilitative and subsequent monitoring phases. New stations can be considered if the need arises.
- 10) Prior to March 31, 2015 ENVC and Teck will meet to discuss any ongoing or emerging issues, and negotiate an extension to the present Memorandum of Agreement to continue the Real-Time Water Quality Monitoring Network at Teck Duck Pond Operations through the remaining life-of-mine, and the planned closure, rehabilitative and subsequent monitoring phases.

Section 8.0 References

1. *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, Canadian Council of Environment Ministers, 1999, Update 7.1, December 2007.
2. *Accuracy and Precision in Real-Time Water Quality Monitoring - How good is my data?* , Proceedings of Real Time Water Quality Workshop, Department of Environment and Conservation, June 7, 2011. <http://www.env.gov.nl.ca/env/waterres/rti/rtwq/workshops.html#2011>
3. *Draft Standardized Purging and Sampling Protocol for MW1@ Teck Duck Pond Operations*, Department of Environment and Conservation, June 15, 2011.
4. Rahman, Shibly, Personal Communication and Internal E-mails, September 6, 2012.
5. *Guidelines and standard procedures for continuous water-quality monitors – Station operation, record computation and data reporting: U.S. Geological Survey Techniques and Methods 1-D3*, U.S Geological Survey, 2006.