Real-Time Water Quality Deployment Report

Voisey's Bay Network

September 24, 2014 to November 5, 2014

Newfoundland Labrador

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

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Contents

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Real Time Water Quality Monitoring

Department of Environment and Conservation staff monitors the real-time web pages regularly.

This deployment report discusses water quality related events occurring at four stations in the Voisey's Bay Network; Upper Reid Brook, Camp Pond Brook, Tributary to Lower Reid Brook, and Lower Reid Brook.

On September 24, 2014, Vale Environment staff deployed real-time water quality monitoring instruments at the four real time stations in the Voisey's Bay network for a period of 43 days. Instruments were removed by Vale Environment staff on November 5, 2014 for the winter season.

Quality Assurance and Quality Control

As part of the Quality Assurance and Quality Control protocol (QAQC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.

At deployment and removal, a QAQC Instrument is temporarily deployed along side the Field Instrument. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the Field Instrument and QAQC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 1).

Table 1: Ranking classifications for deployment and removal

	Rank				
Parameter	**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

It should be noted that the temperature sensor on any instrument is the most important. All other parameters can be broken down into three groups: temperature dependant, temperature compensated and temperature independent. Because the temperature sensor is not isolated from the rest of the instrument the entire instrument must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.

Deployment and removal comparison rankings for the Voisey's Bay Network stations are summarized in Table 2

Table 2: Comparison rankings for Voisey's Bay Network stations

Station Voisey's Bay	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Reid Brook at Outlet (62884)	Sept 24 2014	Deployment	Excellent	Good	Excellent	Good	Excellent
	Nov 5 2014	Removal	Excellent	Excellent	Good	Excellent	Excellent
Camp Pond Brook (62885)	Sept 24 2014	Deployment	Excellent	Fair	Excellent	Excellent	Excellent
	Nov 5 2014	Removal	Excellent	Excellent	Fair	Fair	Excellent
Tributary to L. Reid B. (62886)	Sept 24 2014	Deployment	Excellent	Marginal	Excellent	Excellent	Good
	Nov 5 2014	Removal	Excellent	Good	Fair	Good	Excellent
Lower Reid Brook (62887)	Sept 24 2014	Deployment	Excellent	Fair	Excellent	Fair	Excellent
	Nov 5 2014	Removal	Excellent	Excellent	Marginal	Fair	Excellent

During the deployment for Reid Brook at Outlet of Reid Pond, the temperature, conductivity and turbidity data all ranked as 'excellent'. The pH and dissolved oxygen data ranked as 'good'. During removal temperature, pH, dissolved oxygen and turbidity all ranked as 'Excellent' and conductivity data ranked as 'good'. These rankings provide confidence in the monthly data for this station.

At the station on Camp Pond Brook, temperature, specific conductivity, dissolved oxygen and turbidity all ranked as 'Excellent' with pH data ranking as 'fair'. During removal the field instrument ranked as 'Excellent' for temperature, pH and turbidity water quality parameters, however conductivity and dissolved oxygen ranked as 'fair'. There is the possibility that debris was interfering with the values at those times.

At Tributary to Lower Reid Brook station, the water quality parameters that ranked as 'excellent' where temperature, conductivity and dissolved oxygen. Turbidity data ranked as 'good' at deployment and pH ranked as 'marginal' at deployment. The low pH ranking may be an indication that the sensor wasn't left long enough to stabilize before a reading was take. The comparison rankings of the data during removal were, excellent' for temperature and turbidity, with pH and dissolved oxygen ranking as 'good' and conductivity ranking as 'fair'. The differences between the QA reading and the field readings at removal were not great enough to cause concern that the instrument was not performing accurately. These rankings may have been a result of biofouling on the sensors after a month in the water.

During deployment at the station on Lower Reid Brook, water temperature, conductivity and turbidity ranked as 'excellent' when compared to the QA instrument. pH and dissolved oxygen data ranked as 'fair' at deployment. At removal of the instrument the temperature, pH and turbidity data all ranked as 'excellent', conductivity data ranked as 'marginal' and dissolved oxygen data as 'fair' again. The 'marginal' ranking for the conductivity data may have been a result of fouling of the sensor.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from September 24th to November 5th 2014 in the Voisey's Bay Real Time Water Quality Monitoring Network.
- With the exception of water quantity data (stage), all data used in the preparation of the graphs and subsequent discussion below adhere to this stringent QAQC protocol. Water Survey of Canada is responsible for QAQC of water quantity data. Corrected data can be obtained upon request.
- Reid Brook at Outlet of Reid Pond had technical issues with the communication capability of the station during this deployment. The station was unable to transmit quality and quantity real-time data for the beginning of deployment. On October 7th 2014 the transmitted real-time data came back online and was available to include in this report.
- Camp Pond Brook below Camp Pond had technical issues on October 17th that caused the stage and streamflow data to come in spotty and inconsistent for the remainder of the deployment period. Therefore there is only stage and streamflow data until October 17th.
- Tributary to Lower Reid Brook had technical issues and streamflow data came in spotty and inconsistently during this deployment period. There is only a small amount of streamflow data available for this station.
- Lower Reid Brook below Tributary had technical issues on September 17th that stopped the streamflow transmission at that time. There is no streamflow data from September 17th to September 23rd for this deployment report.

Reid Brook at Outlet from Reid Pond

Water Temperature

During this deployment period water temperature ranged from a minimum of 2.73°C to a maximum of 8.14°C (Figure 1). Air temperature had an average high of 10.4°C on October 7th, 2014 and an average low of -4.5°C which was on the last day of deployment, November 5th 2014.

The water temperature is decreasing over the deployment period. The linear trendline indicates a slight slope downward as this deployment enters into the winter season.

The median water temperature is 6.20°C for the deployment period, slightly lower than last deployment. This trend is expected given the cooling of the ambient air temperatures as the summer months come to an end and the cooler fall temperatures have started (Figure 1).

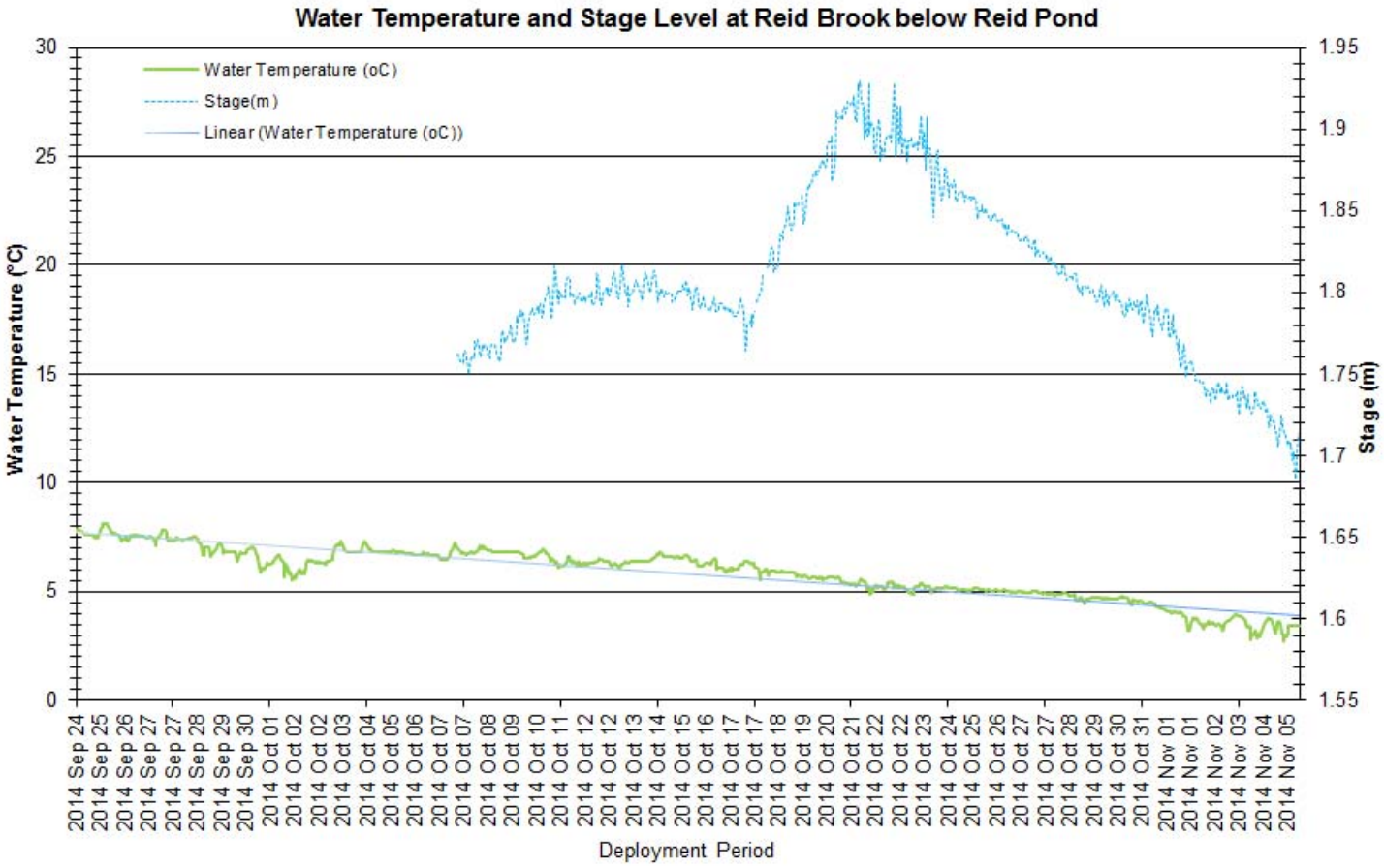

Figure 1: Water temperature at Reid Brook at Outlet of Reid Pond and Air Temperature from Nain Weather Station

pH Levels

During the deployment pH ranges were between a minimum of 6.28 and a maximum of 6.82 pH units (Figure 2).

Stage data was included on this graph to indicate how it can influence a change in pH values. Generally higher stage levels will increase the pH acidity (decrease values) for a short span of time. This is evident on this graph on October 14th, October 18th -19thand again on October 26th.

Reid Brook at Outlet of Reid Pond is a larger body of water and generally isn't largely influenced from environmental factors as the smaller brooks.

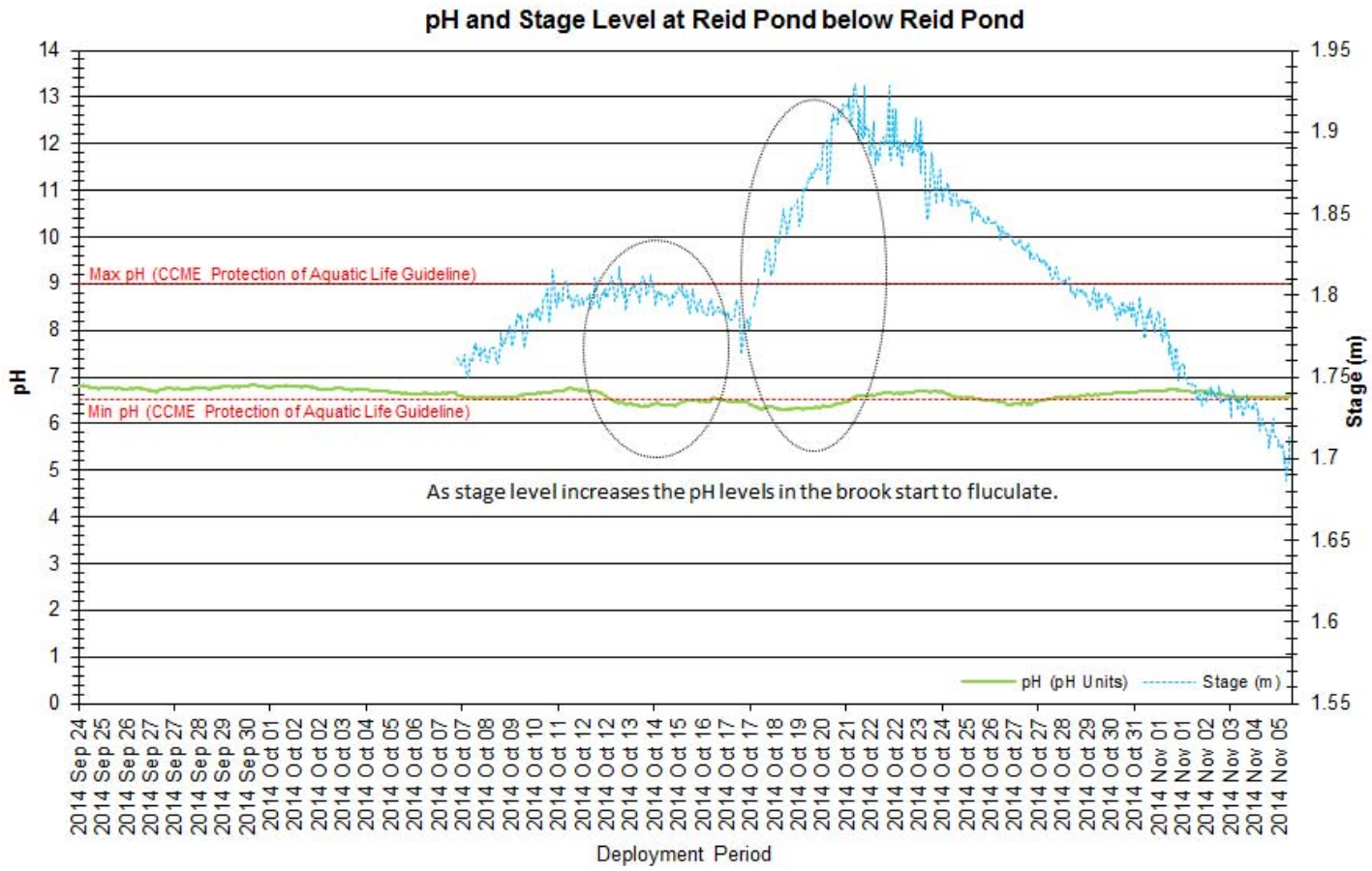

Figure 2: pH level at Reid Brook at Outlet of Reid Pond

Specific Conductivity

Specific conductivity values range from 11.0µS/cm to 13.0µS/cm during the deployment period, with a median of 12.0µS/cm (Figure 3) which was the same as the previous deployment median. There is not much movement in conductivity levels at Reid Brook.

Total Dissolved Solid data was included on Figure 3, the readings graphed were log file values from the instrument and it does not record past 0.0 therefore the readings were almost 0.00 g/L.

Specific conductivity remains low throughout the deployment period at Reid Brook. This is expected at this site as it is pristine in nature and a larger distance from any anthropogenic disturbances that could affect water parameters.

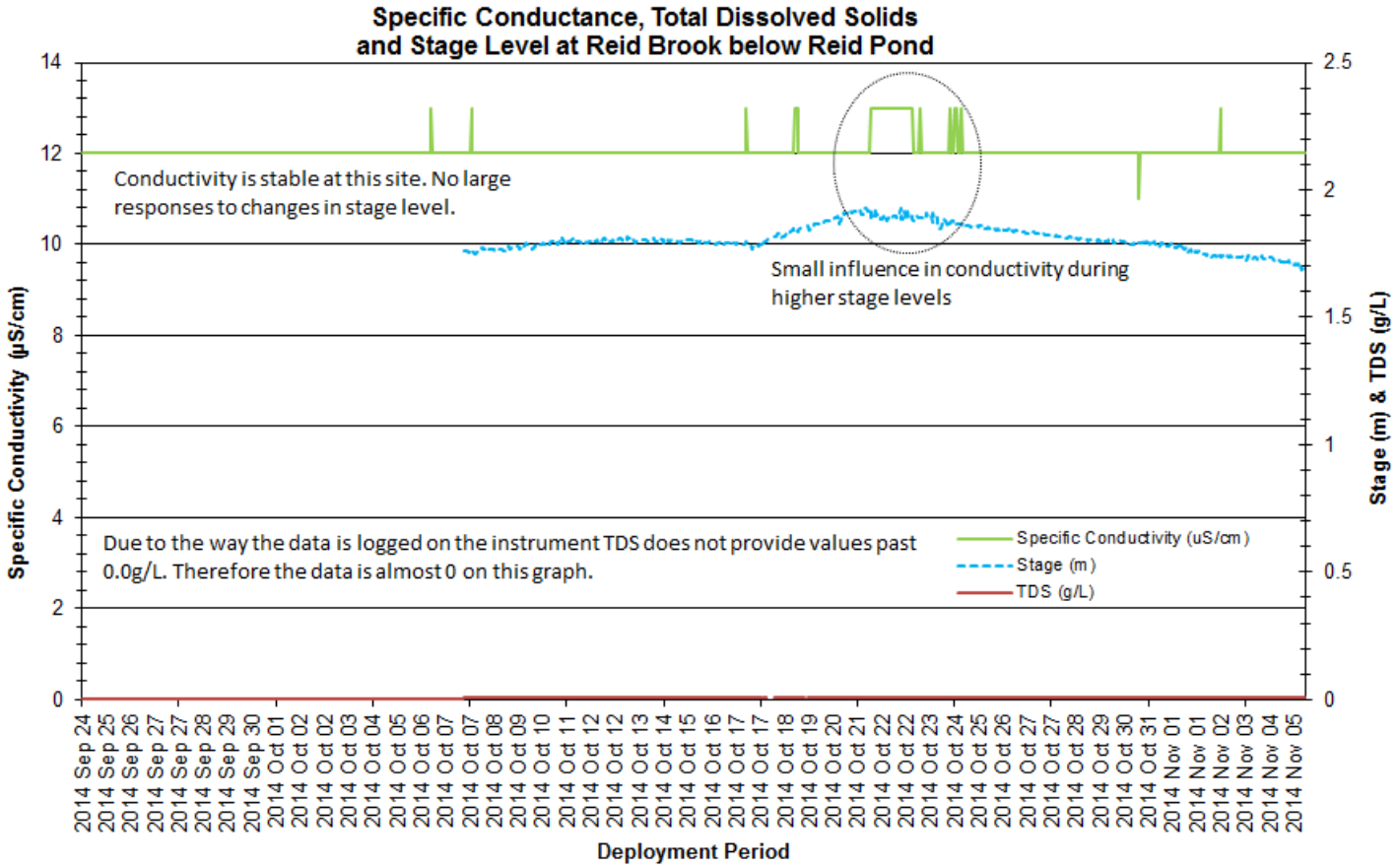

Figure 3: Specific conductivity at Reid Brook at Outlet of Reid Pond

Dissolved Oxygen

During this deployment period the dissolved oxygen content ranges between 11.51mg/l and 12.82mg/l. The saturation of dissolved oxygen ranges from 93.2% to 99.1% (Figure 4).

Dissolved Oxygen (DO) in mg/L is directly recorded by the water quality instrument. Dissolved oxygen percent saturation is a calculated value derived from DO mg/L and water temperature. Dissolved Oxygen is directly influenced by the temperature of the water; therefore as water temperatures in Figure 4 decrease the Dissolved Oxygen concentration increases slightly in the water column. This is a normal reaction between the two parameters.

The DOmg/L levels are above the minimum CCME Guidelines for the Protection of Cold Water Biota at Other Life Stages (6.5mg/l) and Early Life Stages (9.5mg/l). The guidelines are indicated in red on Figure 4.

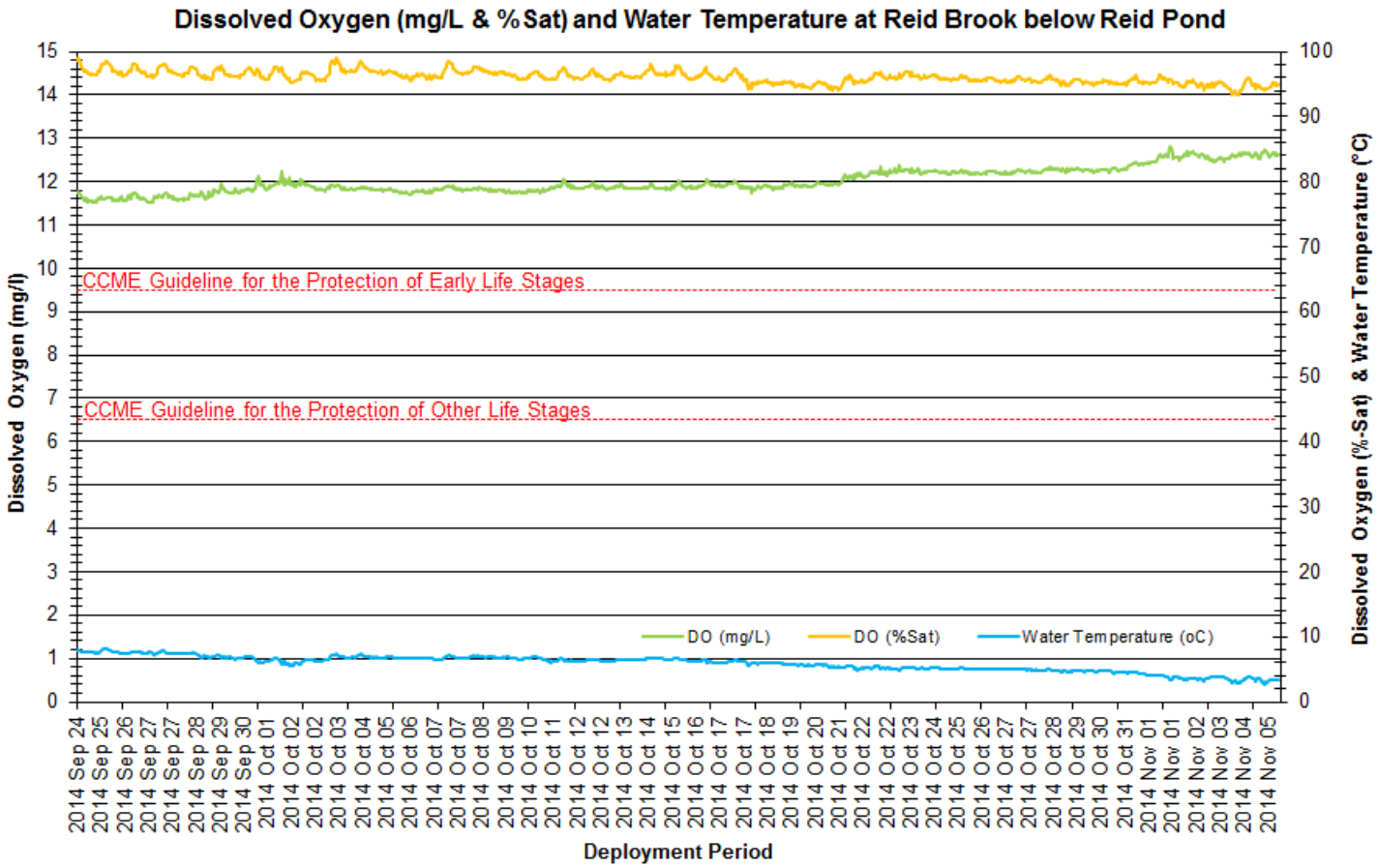

Figure 4: Dissolved Oxygen (mg/L & %sat) and Water Temperature at Reid Brook at Outlet of Reid Pond

Turbidity

During deployment the turbidity values ranged between a minimum of 0.0NTU and a maximum of 14.1NTU.

Besides the event on October 13th, the turbidity levels during this deployment were low. It is not unusual for this station to have low turbidity readings, as the water flowing from the lake is typically very clean; clear and cold (Figure 5).

The turbidity event on October 13th corresponds with a slight increase in stage level at the same time.

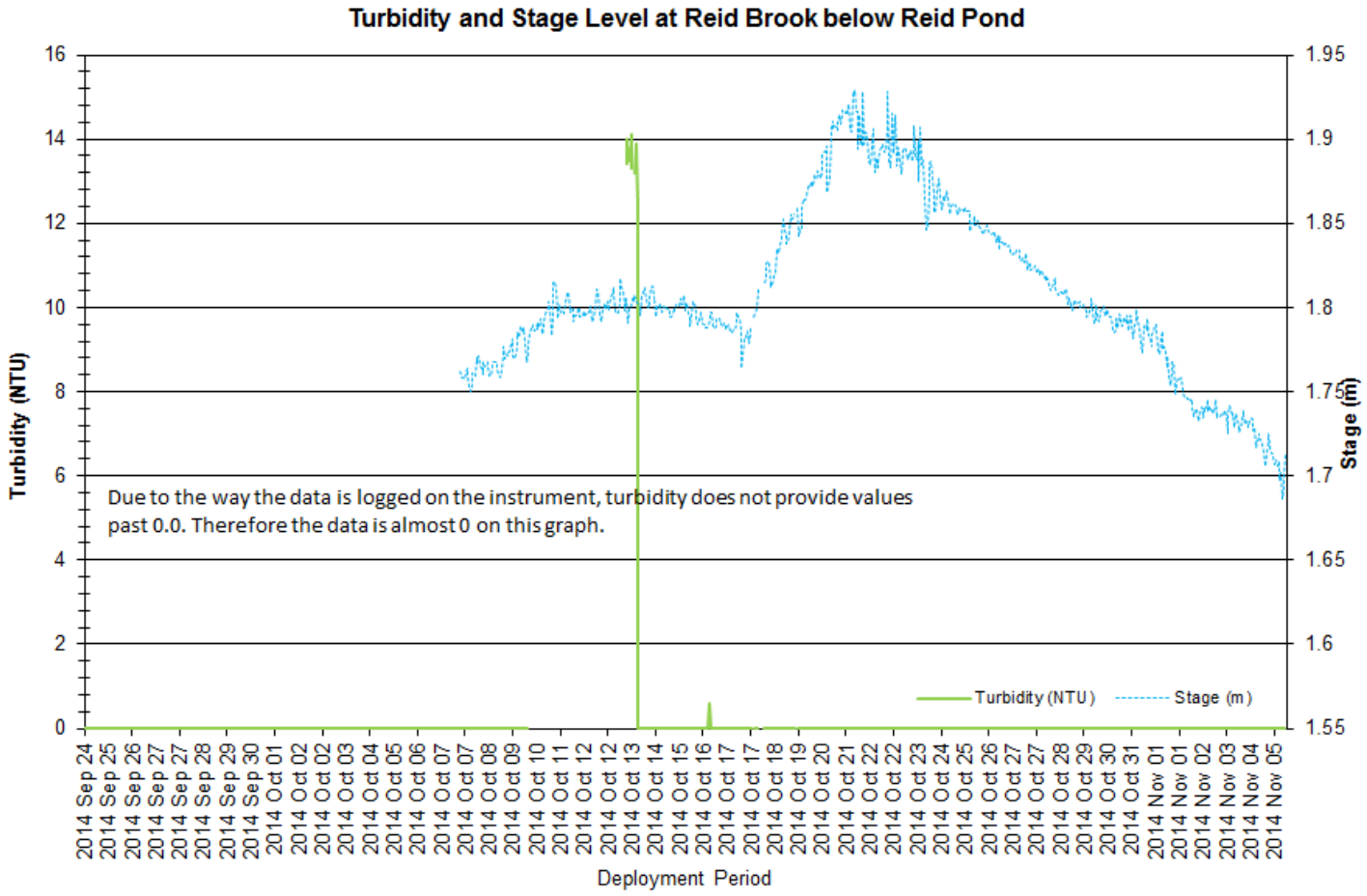

Figure 5: Turbidity and Precipitation at Reid Brook at Outlet of Reid Pond

Daily Average Stage, Streamflow & Precipitation

Daily average stage, streamflow and precipitation are graphed below to show the relationship between each parameter (Figure 6). The precipitation data used in this report came from the weather station in Nain.

During deployment the highest averaged stage was 1.91m with a recorded average low of 1.70m at the end of deployment. Streamflow had an average minimum of 0.91m^3/s and a maximum of 2.432m^3/s. Total precipitation had a minimum of 0mm and a maximum of 14mm on October 19th, 2014.

After several days of rainfall from October 17th to October 21st there is a noticeable increase in streamflow and a slight increase in stage. Due to the nature of the large pond it takes a longer period of time for the Reid Brook at Outlet of Reid Pond to be influenced by precipitation.

The data graphed below indicates how natural factors can influence the water quality parameters over the deployment period.

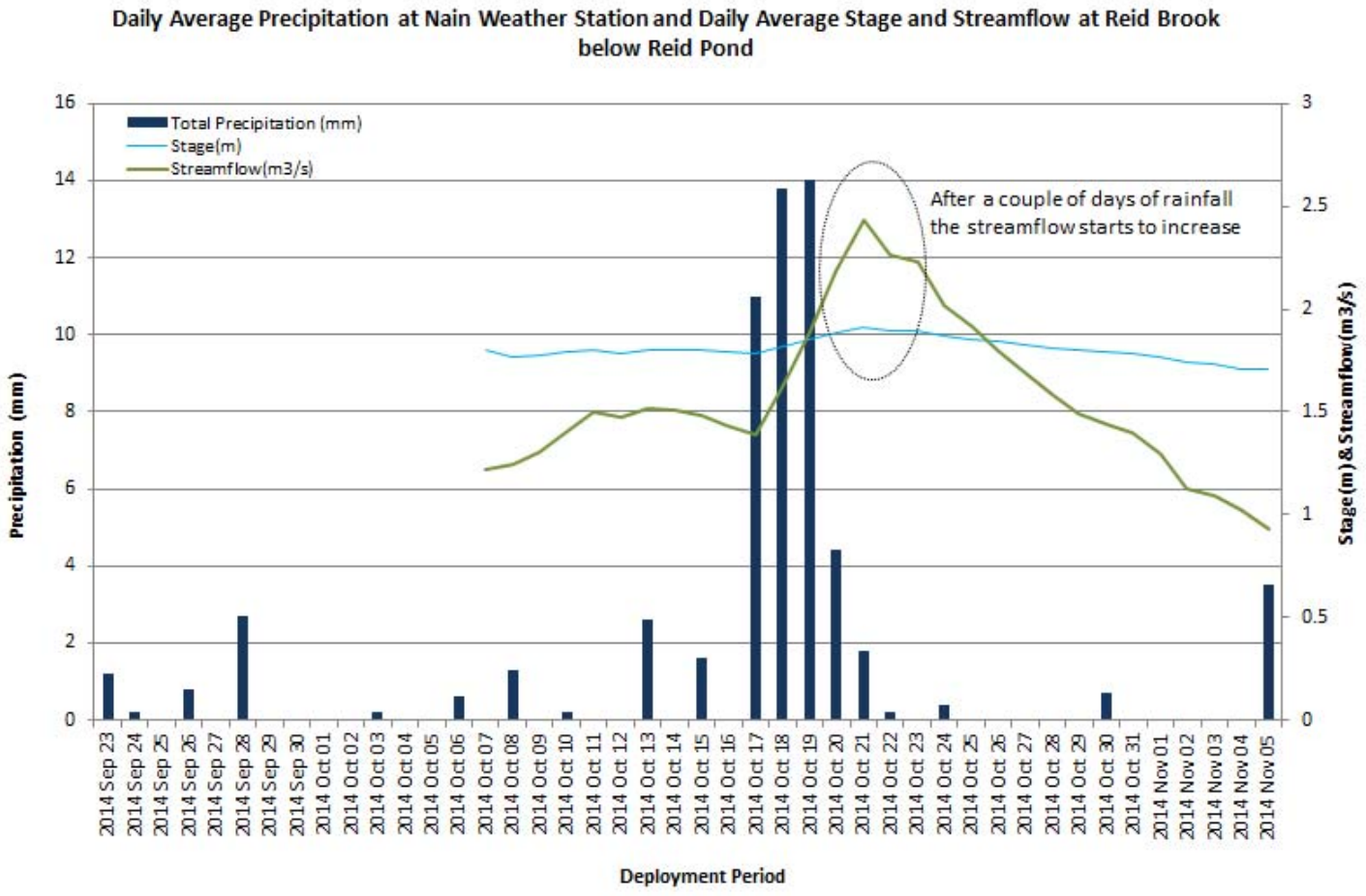

Figure 6: Daily precipitation in Nain and average daily stage & flow level at Reid Brook at Outlet of Reid Pond

Camp Pond Brook

Water Temperature

Water temperature ranges from 0.06°C to 7.96°C during the deployment period (Figure 7).

Water temperature is decreasing during this deployment period. The trend is expected as the air temperatures decrease with the onset of fall/winter months. The median water temperature is 2.76°C for the deployment period.

This stream is sensitive to changes in the ambient air temperature and fluctuates considerably depending on the weather and time of day. As the stage level increases on October 1st -2nd the water temperatures dip in response.

The trend line on Figure 7 displays the gradual water temperature decrease as the surrounding air temperatures start to cool as the temperatures adjusts to a cooler climate. This station typically has the highest water temperatures and greatest fluctuations when compared to the other stations in the network.

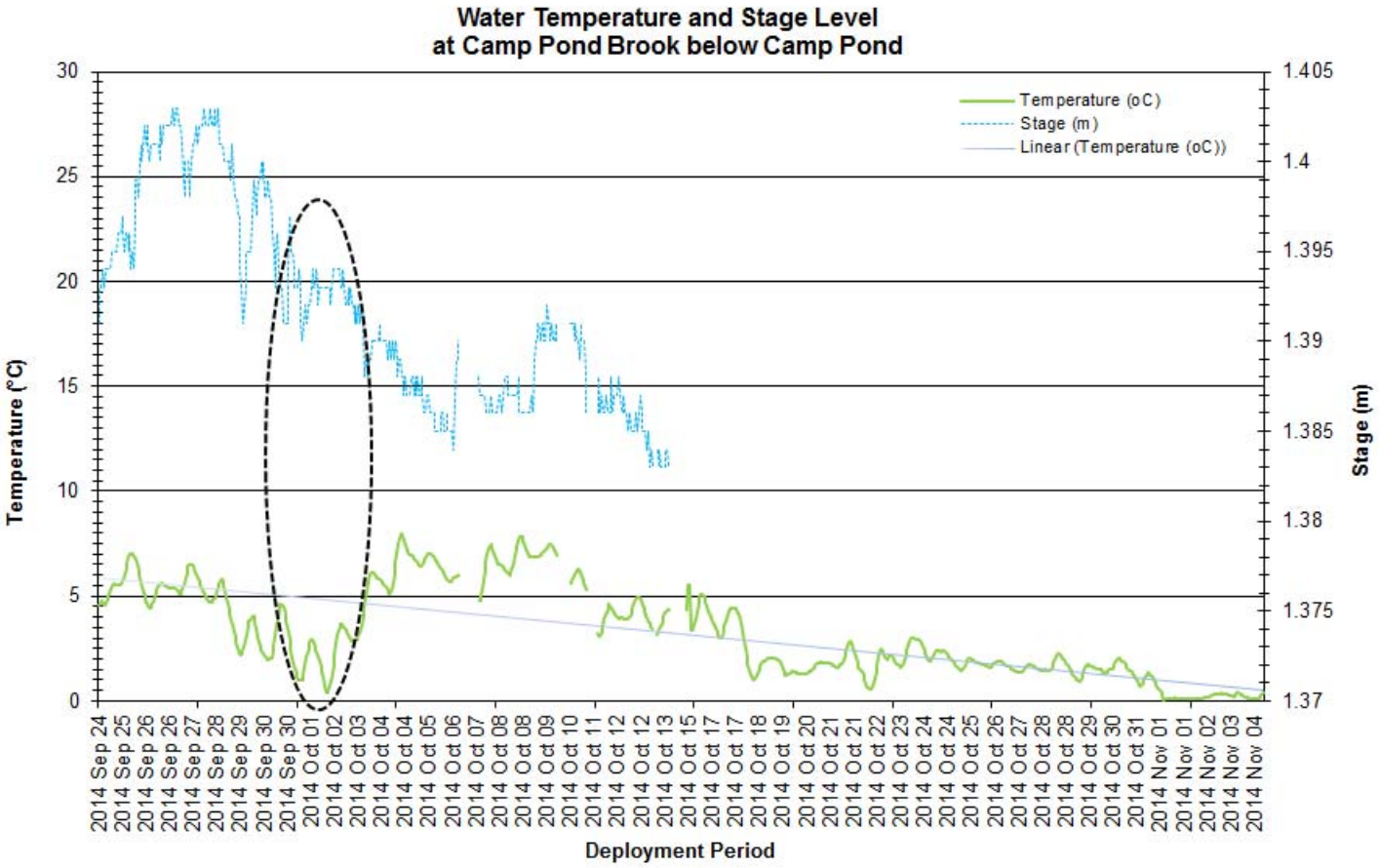

Figure 7: Water Temperature & Stage Level at Camp Pond Brook

pH

During this deployment period the pH ranged between a minimum of 6.60 and a maximum of 7.00 pH units (Figure 8).

The pH values are very stable at this station, only fluctuating diurnally during the deployment period. On October 21st, the pH values decrease slightly for a couple of days.

All pH values during this deployment are within the recommended guidelines for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (>6.5 and <9.0 pH units). Guidelines are indicated in red on Figure 8.

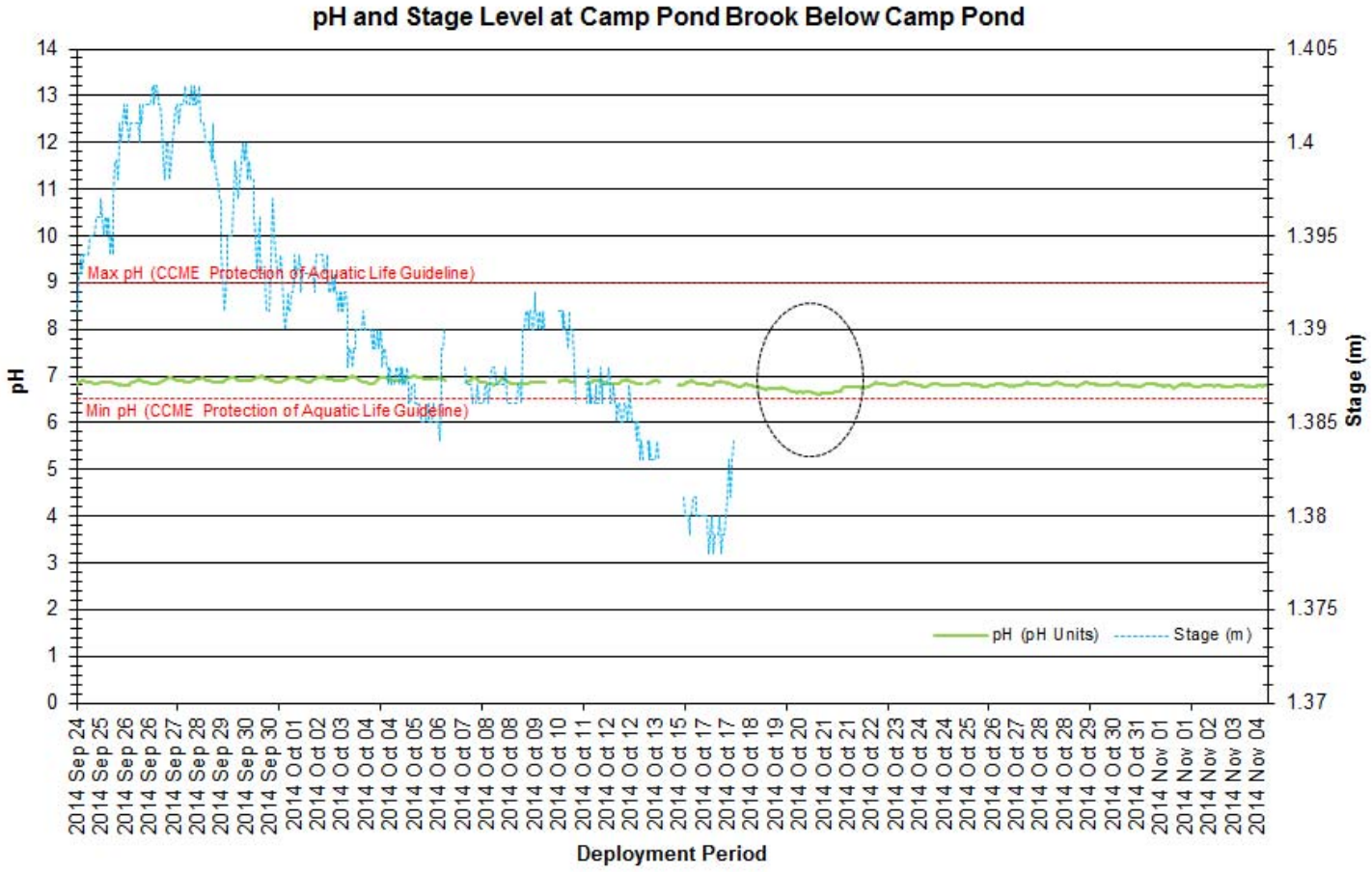

Figure 8: pH & Stage Level at Camp Pond Brook below Camp Pond

Specific Conductivity

During the deployment the specific conductivity data ranged between a minimum of 32.0µS/cm to a maximum of 53.0µS/cm, with a median of 37.7µS/cm (Figure 9).

There are a few peaks in conductivity during the deployment period. This stations data increases during higher stage levels.

It can be assumed that due to precipitation, the stage levels increased and in turn suspended matter was flushed into the water column which created an increase in the conductivity.

Outside of the larger peaks, the remainder of the conductivity data was stable.

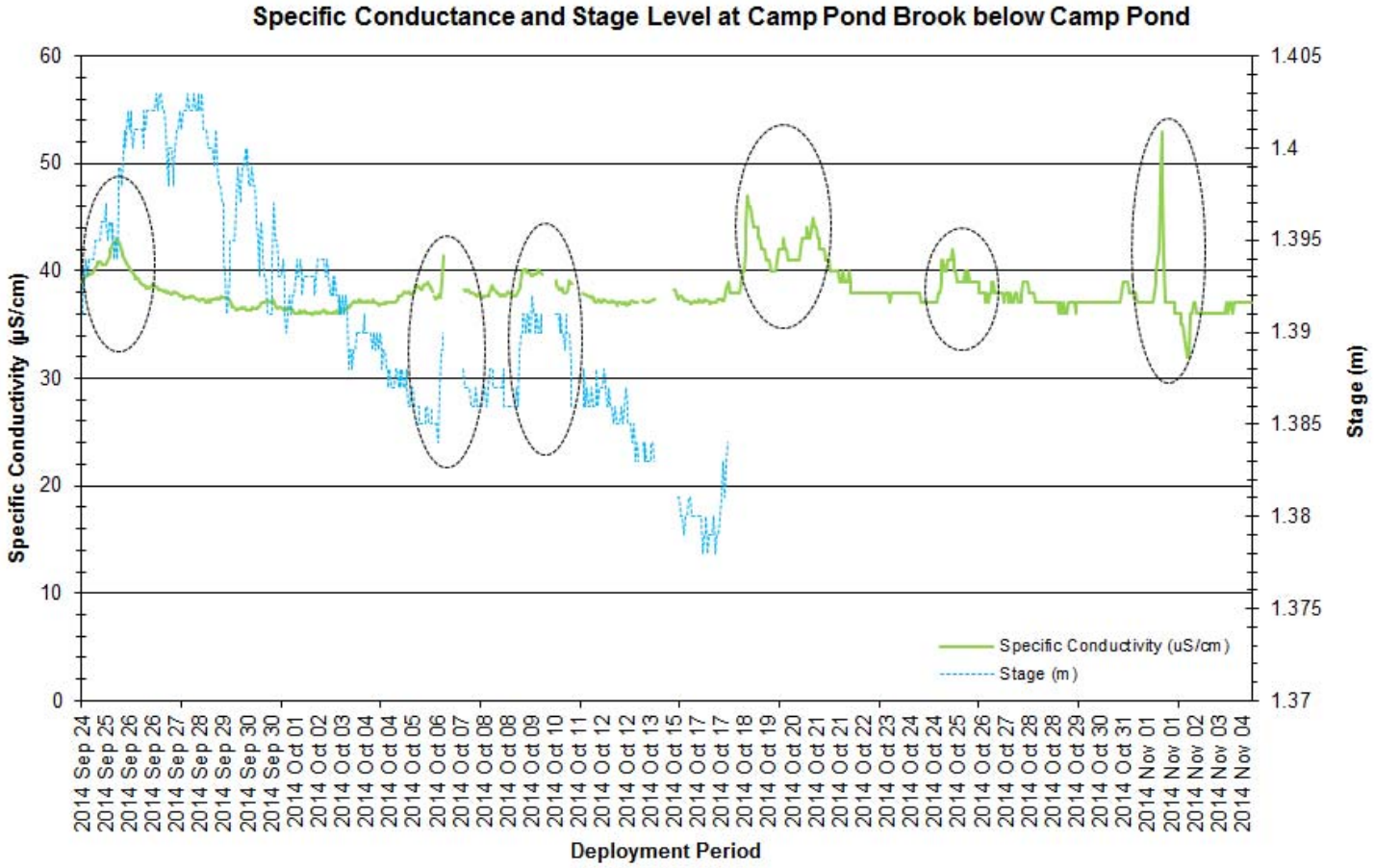

Figure 9: Specific Conductivity & Stage Level at Camp Pond Brook

Dissolved Oxygen (mg/L & % Saturation)

The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe and then the instrument calculates percent saturation (% Sat) with water temperature.

Dissolved oxygen content ranges between 11.20mg/l and 14.06mg/l. The saturation of dissolved oxygen ranges from 89.8% to 98.9% (Figure 10).

Dissolved Oxygen (%Sat) remains stable throughout this deployment period. Dissolved Oxygen mg/L is responding to the cooler water temperatures and over the deployment period the mg/L increases. This is indicated by the trend line as it slopes upward. This is to be expected as water temperature directly influences the level of dissolved oxygen present in a water column.

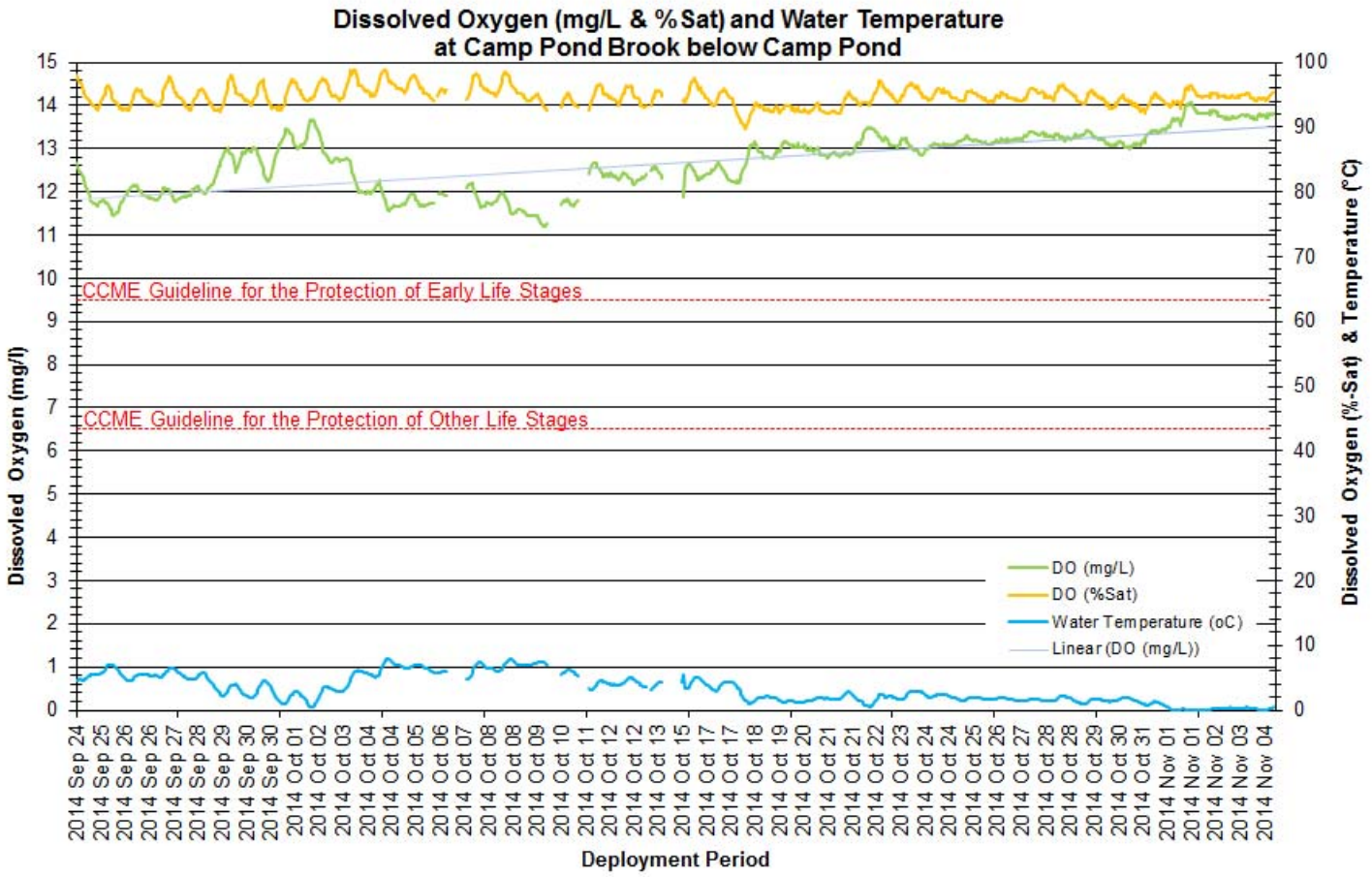

Figure 10: Dissolved Oxygen & Percent Saturation at Camp Pond Brook below Camp Pond

Turbidity

Turbidity values range between 0 NTU and 117.7 NTU (Figure 11). A median value of 0.0 NTU indicates there is very little natural background turbidity at this station during this deployment period.

There are a number of low - medium turbidity events at this station throughout the duration of this deployment. Due to the stage data stopping on October 18th, it is hard to determine if the turbidity events that occurred after October 18th are related to stage increases. However Figure 12 displays the precipitation events for the deployment month and the largest turbidity event of 117.7NTU on October 20th corresponds with rainfall that occurred on October 18th, 19th and 20th.

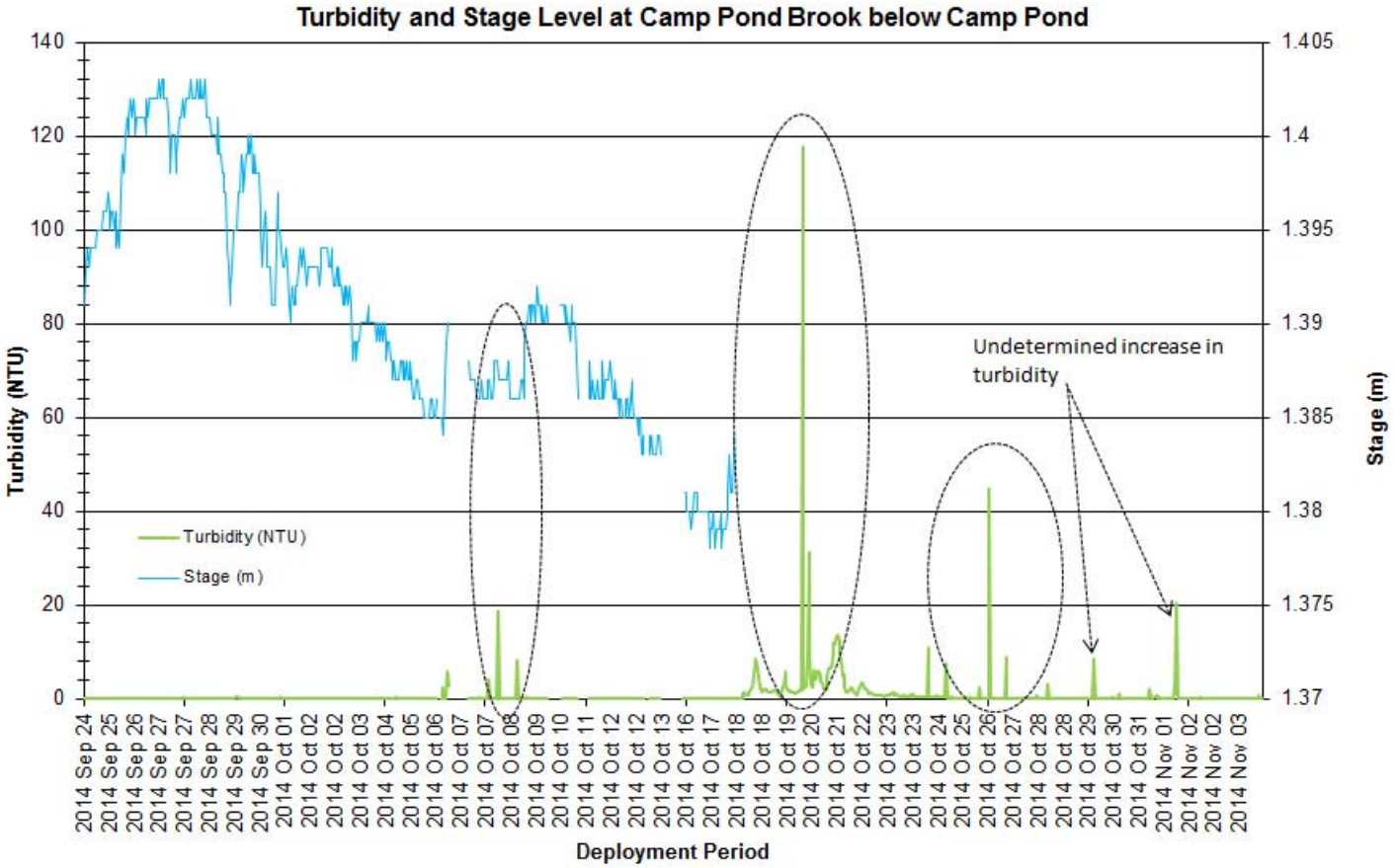

Figure 11: Turbidity & Stage Level at Camp Pond Brook

Stage, Streamflow and Precipitation

Camp Pond Brook below Camp Pond had technical issues on October 17th that caused the stage and streamflow data to come in spotty and inconsistent for the remainder of the deployment period. Therefore there is only stage and streamflow data until October 17th.

Precipitation data was obtained from the Environment Canada weather station at Nain. The highest recorded rainfall for this deployment was on October 19th, with an average high of 14mm that day.

During the deployment period, the stage values ranged from 1.38m to 1.40m. Streamflow had a minimum amount of 0.03m^3/s and a maximum flow of 0.33m^3/s.

Stage, Streamflow and precipitation are graphed below to show the relationship between rainfall and water level (Figure 12). It is evident that the peaks in stage (m) and streamflow data are a result of precipitation.

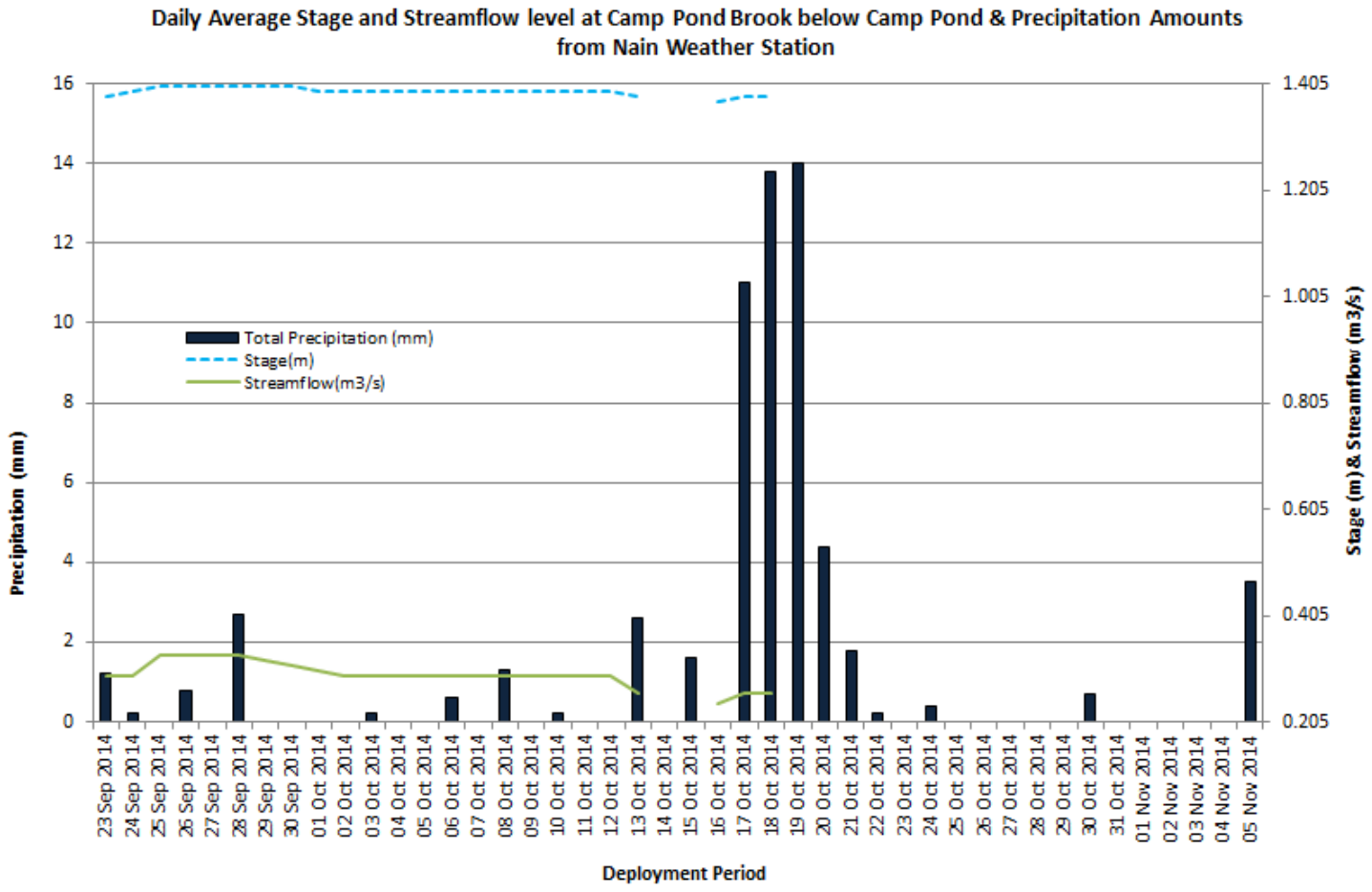

Figure 12: Daily Precipitation, Average Daily Stage & Flow level at Camp Pond Brook

(Weather data recorded at Nain)

Tributary to Lower Reid Brook

Water Temperature

Water temperature ranges from 0.0°C to 6.10°C during the deployment period (Figure 13). The data set for this deployment had a median of 2.50°C.

Water temperature is decreasing during this deployment period. This trend is expected as the ambient air temperatures decrease with the fall/winter season approaching (Figure 13). Streams and brooks are sensitive to changes in the ambient air temperature and water temperature will fluctuate considerably depending on the weather and the time of day.

The lower dips in water temperature correspond with higher stage values in the same time frame. Precipitation can cause the water temperature to lower slightly for a short period of time. This is evident on Figure 13 on October 11th – 13th, October 21st and November 2nd and again towards the very end of deployment on November 5th.

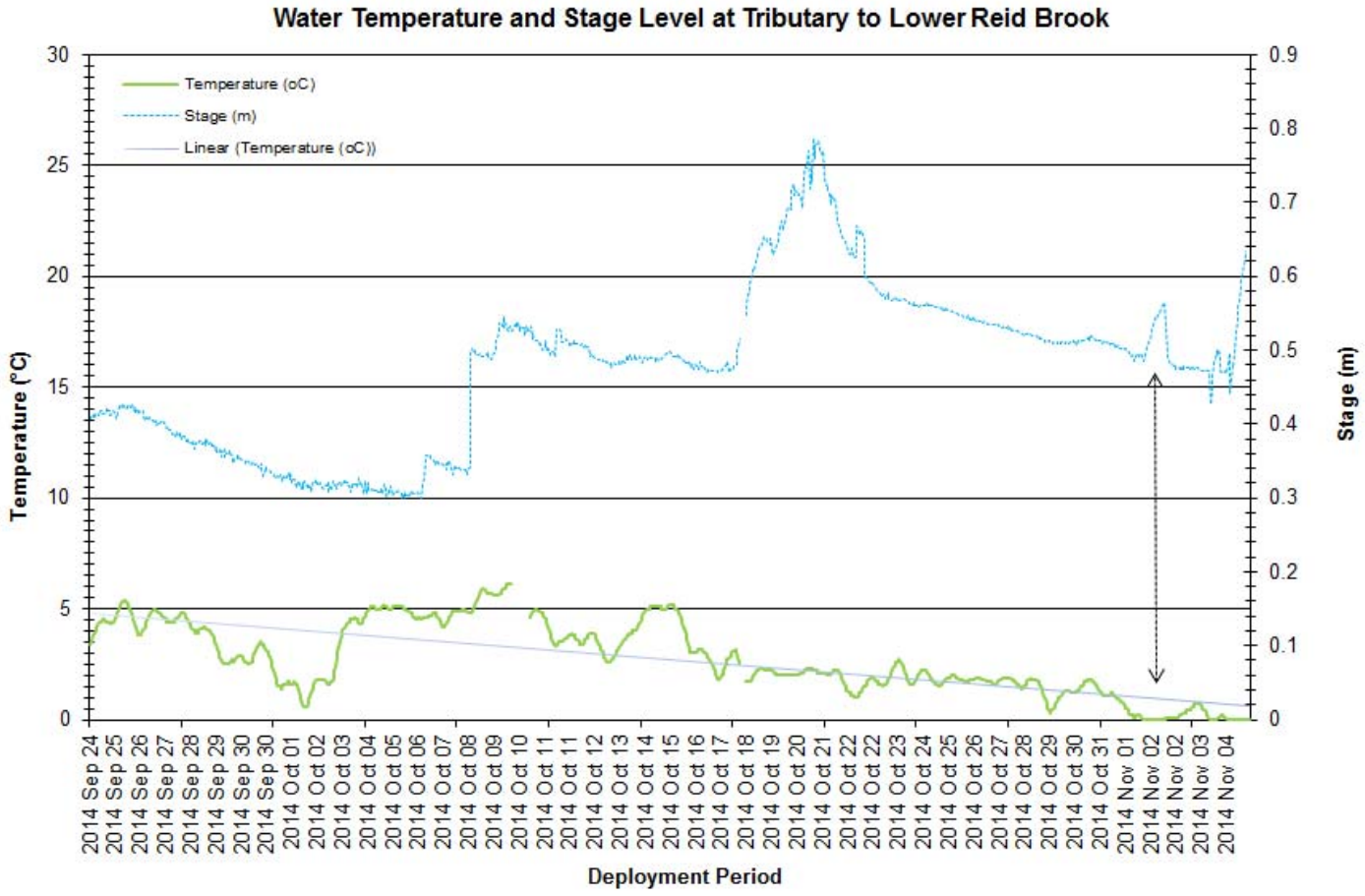

Figure 13: Water temperature and Stage at Tributary to Lower Reid Brook

pH

During this deployment period pH data ranged between a minimum of 6.30 and a maximum of 6.90 pH units (Figure 14). pH values had a median of 6.78 pH units, which is slightly lower than the previous deployment of 6.92 pH units for this station.

For the majority of this deployment period the pH data remains stable. There is a relationship between pH and stage level, this is evident on Figure 14 as stage levels increase on several occasions (indicated by black circles on Figure 14), the pH values drop slightly as a response.

As the deployment period continues pH levels start to increase. This increase coincides with a decrease in stage levels. This is a natural reaction between these two parameters. Despite a couple of days in October, the pH levels remain just above the minimum CCME guideline. The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different.

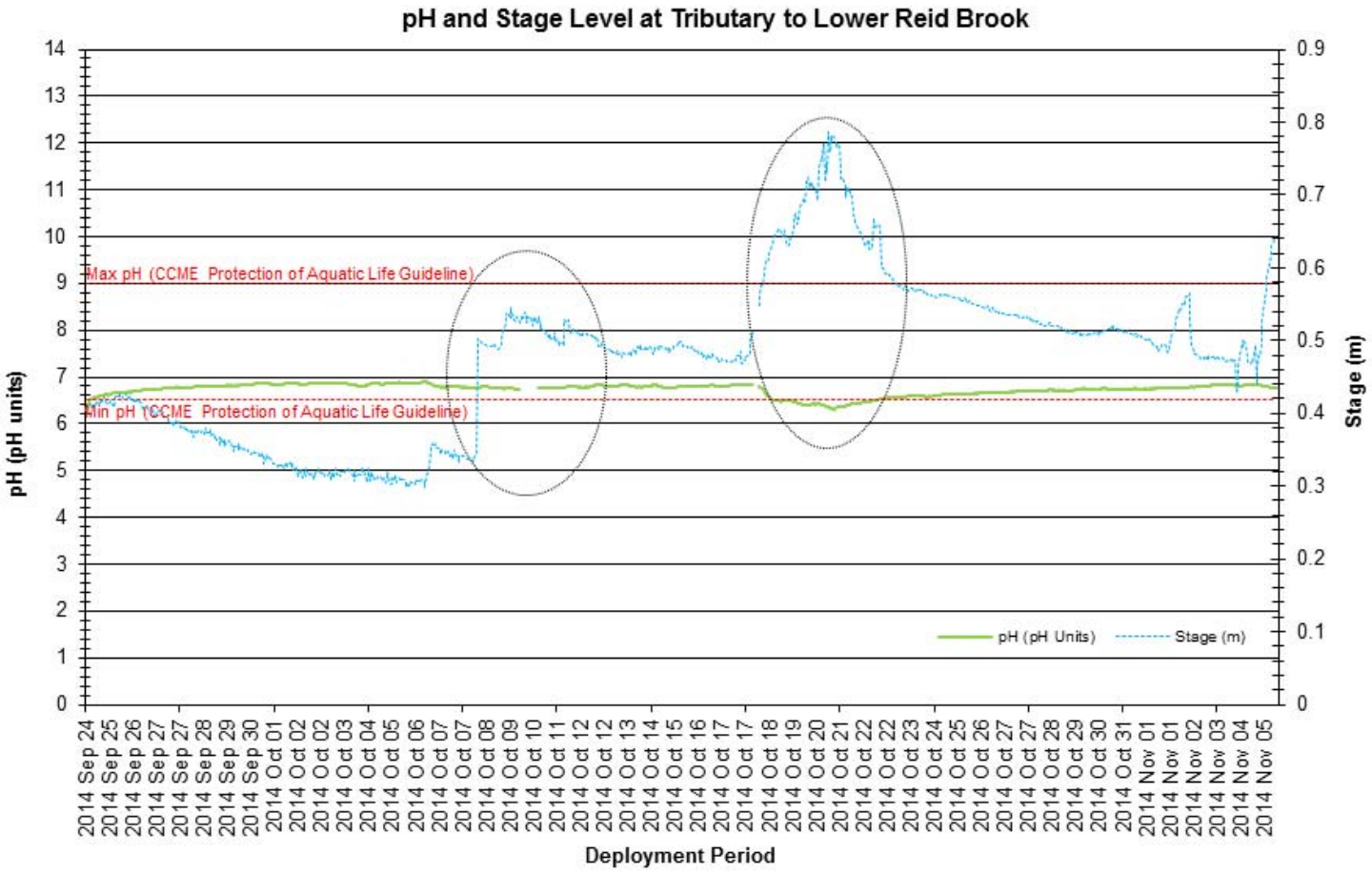

Figure 14: pH and stage level at Tributary to Lower Reid Brook

Specific Conductivity

Specific conductivity ranges between 28.3µS/cm and 46.1µS/cm during the deployment period, with a median for the deployment period of 35.5µS/cm (Figure 15).

Stage is included in Figure 15 to illustrate the inverse relationship between conductivity and water level. Specific conductivity changes with the varying water level. As stage decreases, specific conductivity generally increases due to the increase in concentration of dissolved solids in the water column. Inversely, as stage increases, specific conductivity decreases as the concentration of dissolved solids is diluted. This relationship is highlighted with the data displayed on Figure 15.

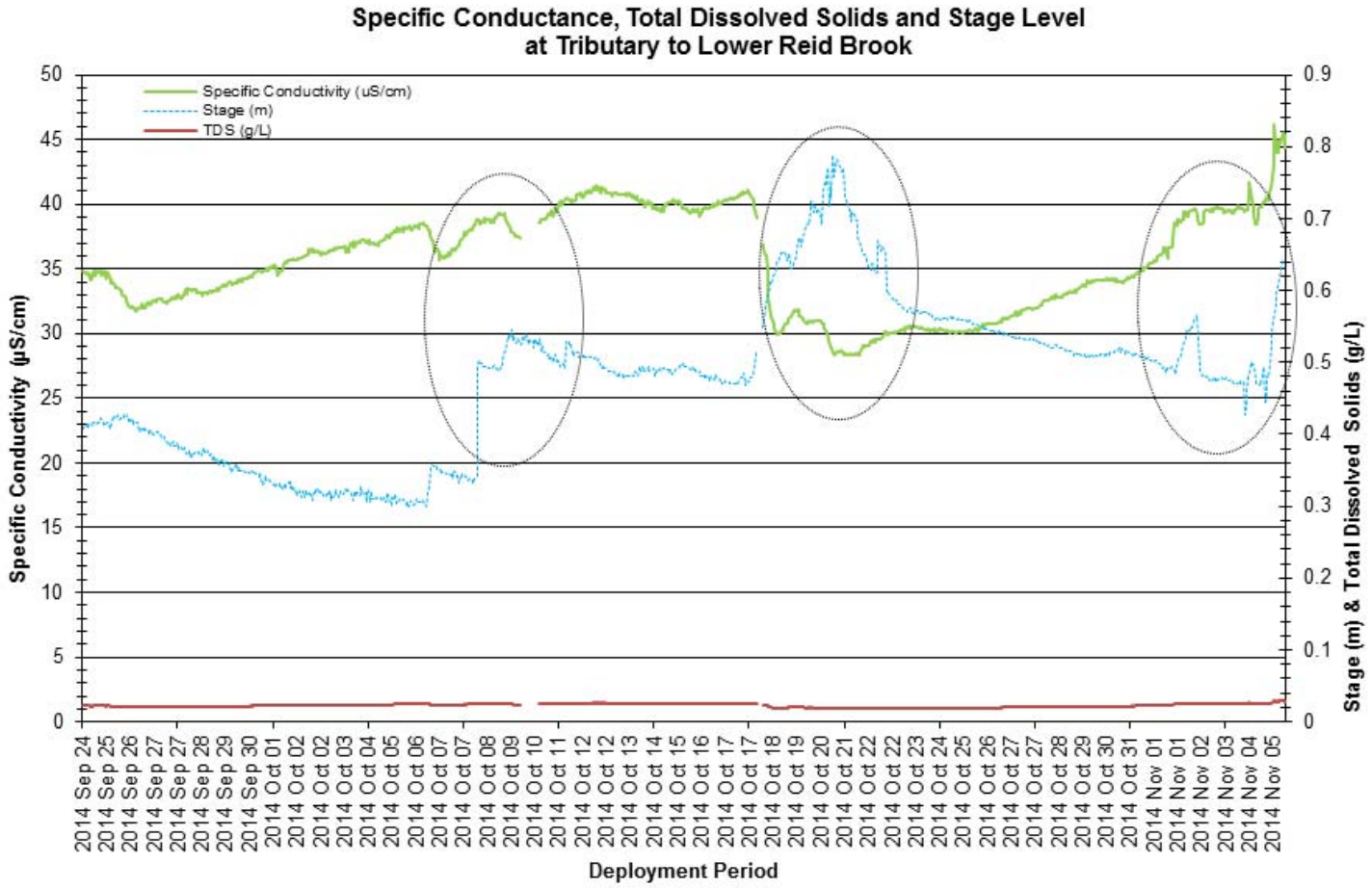

Figure 15: Specific conductivity and Stage Level at Tributary to Lower Reid Brook

Dissolved Oxygen

Dissolved oxygen content ranges between 11.67mg/l and 14.21mg/l. The saturation of dissolved oxygen ranges from 93.7% to 98.4% (Figure 16). The water quality instrument measures dissolved oxygen (mg/L) with the dissolved oxygen probe and then the instrument calculates percent saturation (% Sat) with water temperature.

The highlighted arrows on Figure 16 indicate the relationship between water temperature and dissolved oxygen. As water temperature decreases the level of dissolved oxygen consumed decreases, which means there is more available dissolved oxygen in the brook during the cooler temperatures. This relationship is indicated on Figure 16 by the arrows.

During this deployment the dissolved oxygen mg/L levels remained above both CCME guidelines for the protection of early/other life stages.

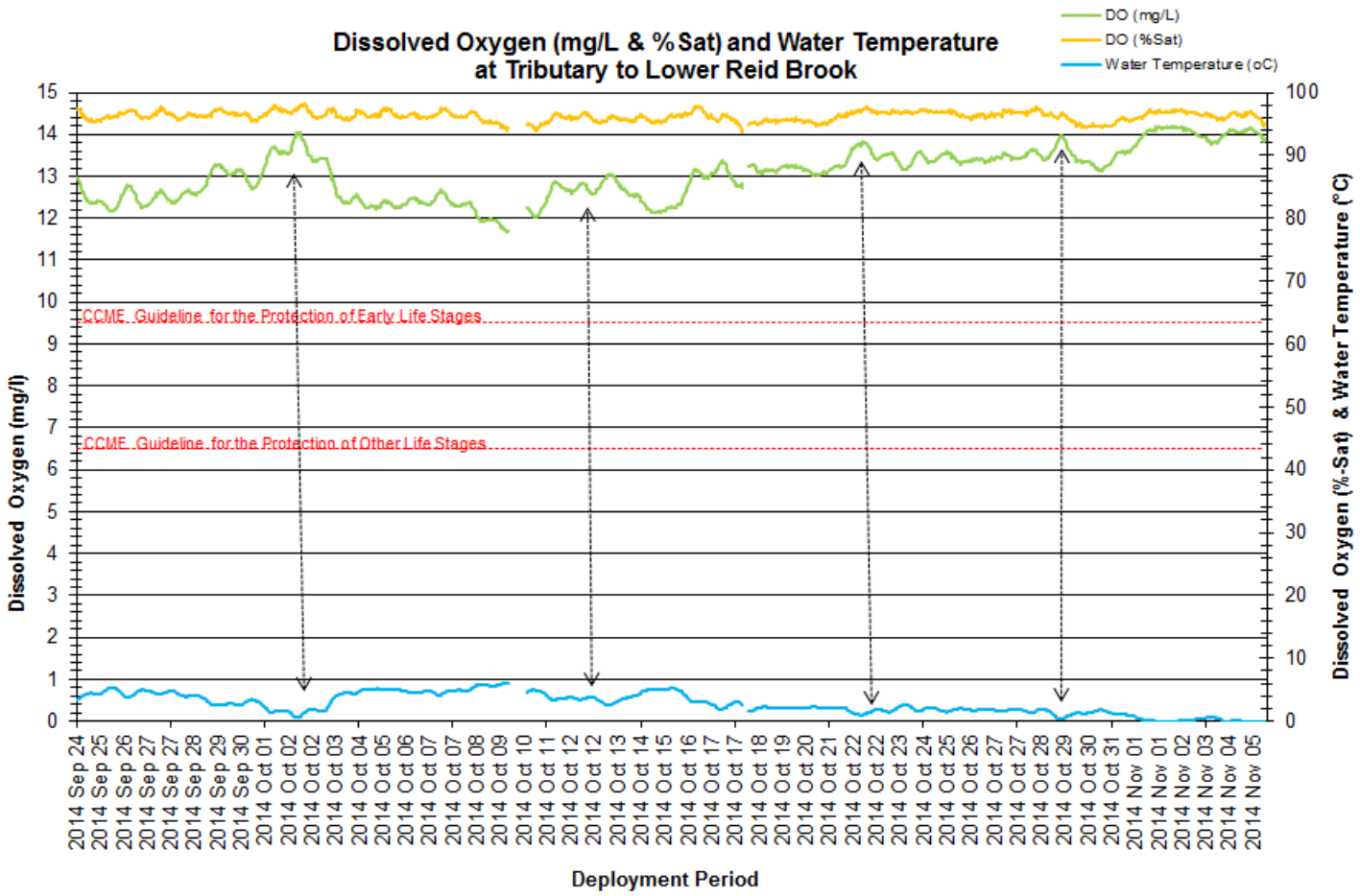

Figure 16: Dissolved oxygen (%Sat & mg/L) and Stage Level at Tributary to Lower Reid Brook

Turbidity

During this deployment period the turbidity data for this deployment ranged within a minimum of 0.0NTU and a maximum of 32.7NTU (Figure 17). The median for this data set was 0.0NTU; indicating turbidity is generally quite low at this site.

The majority of the turbidity peaks correspond with higher stage values during the same time frame. These are highlighted on Figure 17 by the black circles and arrows. As the stage levels increase so does the presence of suspended solids and particles in the water column which is captured by the turbidity sensor.

On October 3rd there is a brief turbidity peak that doesn't correspond with higher stage levels; it is likely the turbidity was a result of debris passing over the sensor at the exact time the instrument was logging.

There are several other small turbidity peaks at the end of October that were likely capturing turbidity as the stage levels are decreasing slightly.

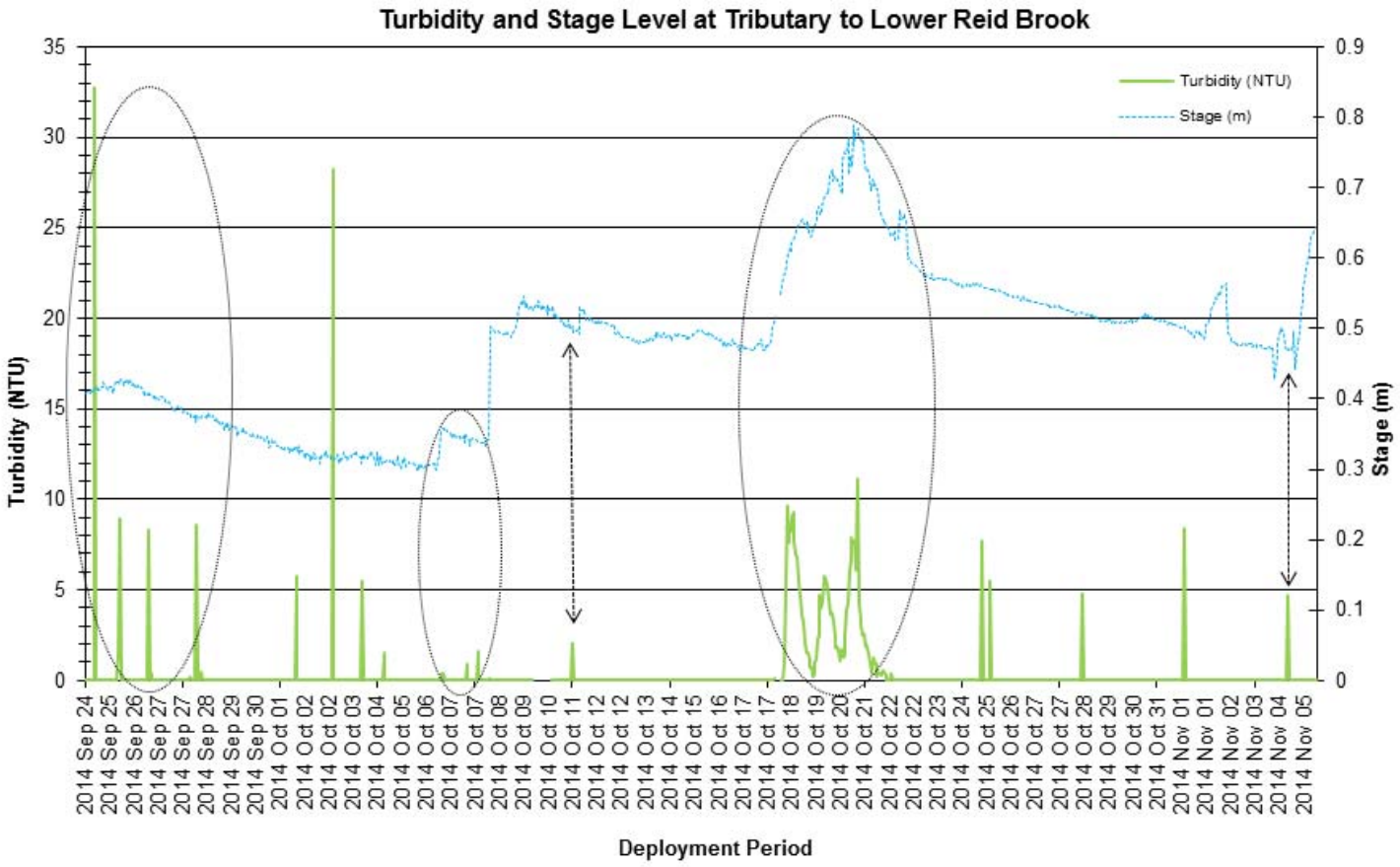

Figure 17: Turbidity and Stage level at Tributary to Lower Reid Brook

Stage, StreamFlow and Precipitation

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level). Stage is important to display as it provides an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity). Streamflow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second.

Stage and Streamflow will increase during rainfall events (Figure 18) and during any surrounding snow or ice melt as runoff will collect in the brooks. However, direct snowfall will not cause them to rise significantly. During the deployment period, the daily averaged stage levels ranged from 0.31m to 0.74m. Streamflow averaged daily data ranged within 0.01m^3/s to a maximum of 1.07$m^{3/}$s.

Precipitation data was obtained from the Environment Canada weather station in Nain. Precipitation ranges for the deployment period were a minimum of 0.0mm and a maximum of 14mm on October 19th.

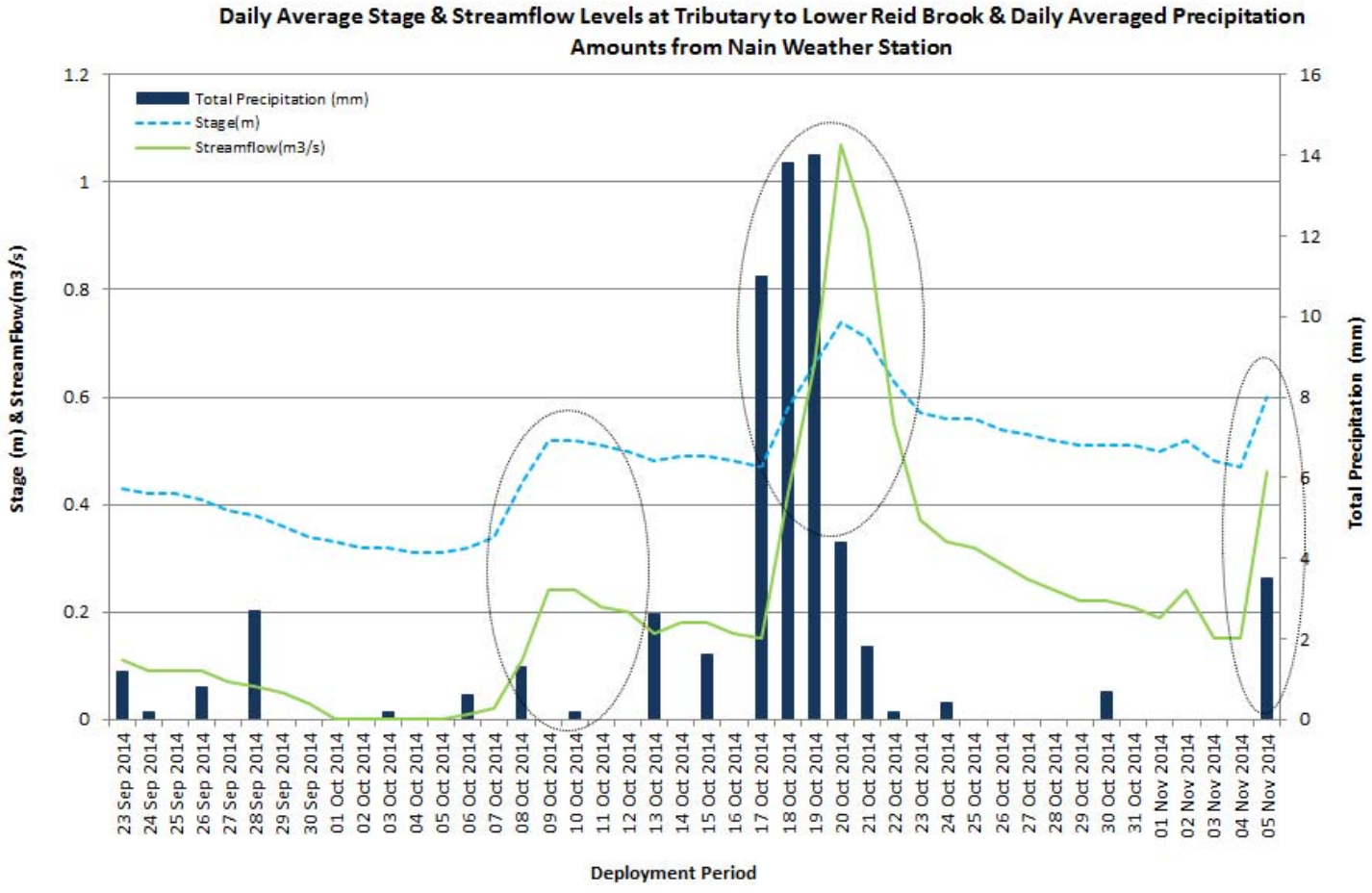

Figure 18: Daily Averaged Stage and Streamflow at Tributary to Lower Reid Brook and Daily Averaged Precipitation data from Nain Weather Station

Lower Reid Brook below Tributary

Water Temperature

At this station the water temperature ranged from 0.15°C to 6.54°C during the deployment period (Figure 19). The water temperature median for deployment was 2.69 °C.

The linear trend line shows that water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures as the winter season approaches (Figure 19).

The relationship between stage level and water temperature can be seen on Figure 19. As the stage level increases water temperature decreases. When the stage level increased on November 1st and 2nd the water temperature decreased to some of its lowest readings for the deployment.

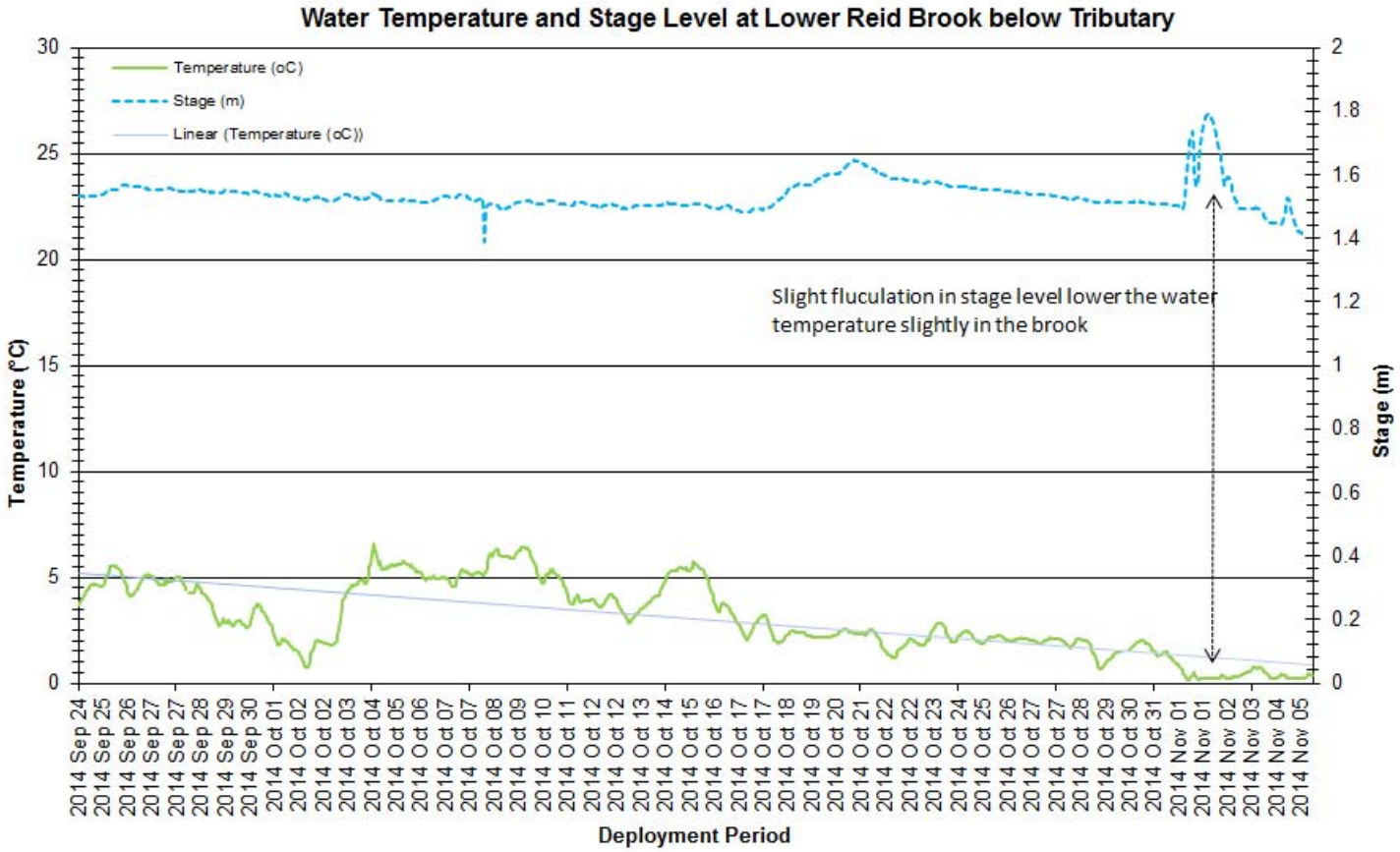

Figure 19: Water temperature and Stage levels at Lower Reid Brook below Tributary

pH

pH data at this station ranged within a minimum of 6.07 and a maximum of 7.04 pH units (Figure 20).

There are slight decreases in pH during the higher stage periods, on October 22nd and November 2nd. These events are circled in black on Figure 20.

Initially the pH data sits just above the CCME guidelines until a little over halfway through the deployment period. As the stage level starts to fluctuate the pH values decrease slightly with each large stage increase.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams and brooks are different. During this deployment period the median pH level was 6.71 pH units.

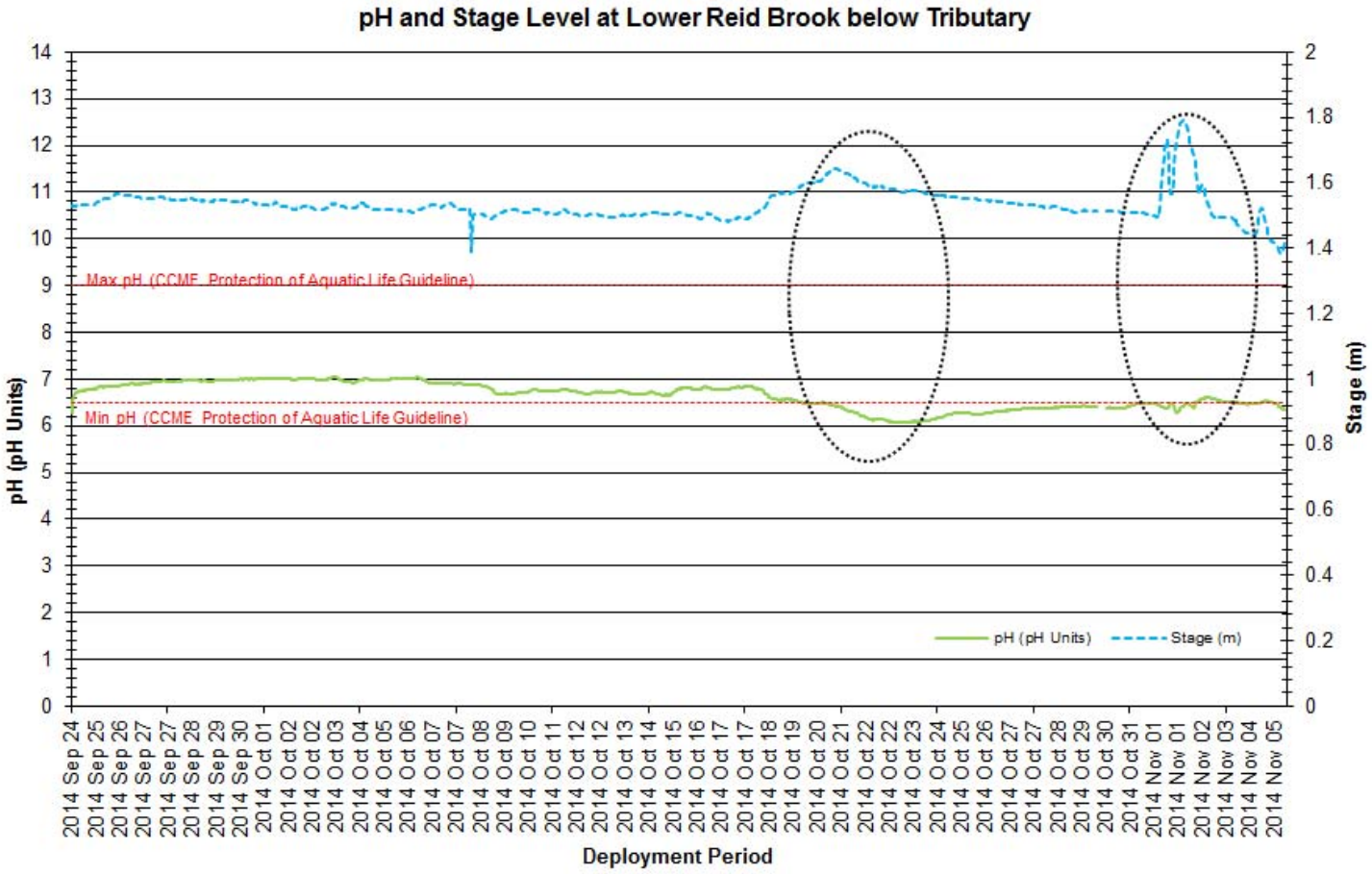

Figure 20: pH and stage level at Lower Reid Brook below Tributary

Specific Conductivity

During this deployment the specific conductivity data ranged between 29.6µS/cm and 48.1µS/cm, with a median of 34.9µS/cm (Figure 21).

Stage is included in Figure 21 to illustrate the inverse relationship between conductivity and water level. As stage decreases, specific conductivity increases because of the increased concentration of dissolved solids.

Inversely, as stage increases, specific conductivity decreases due to the dilution of dissolved solids in the water column. This is evident on October 19th and 20th, with several small events towards the end of deployment.

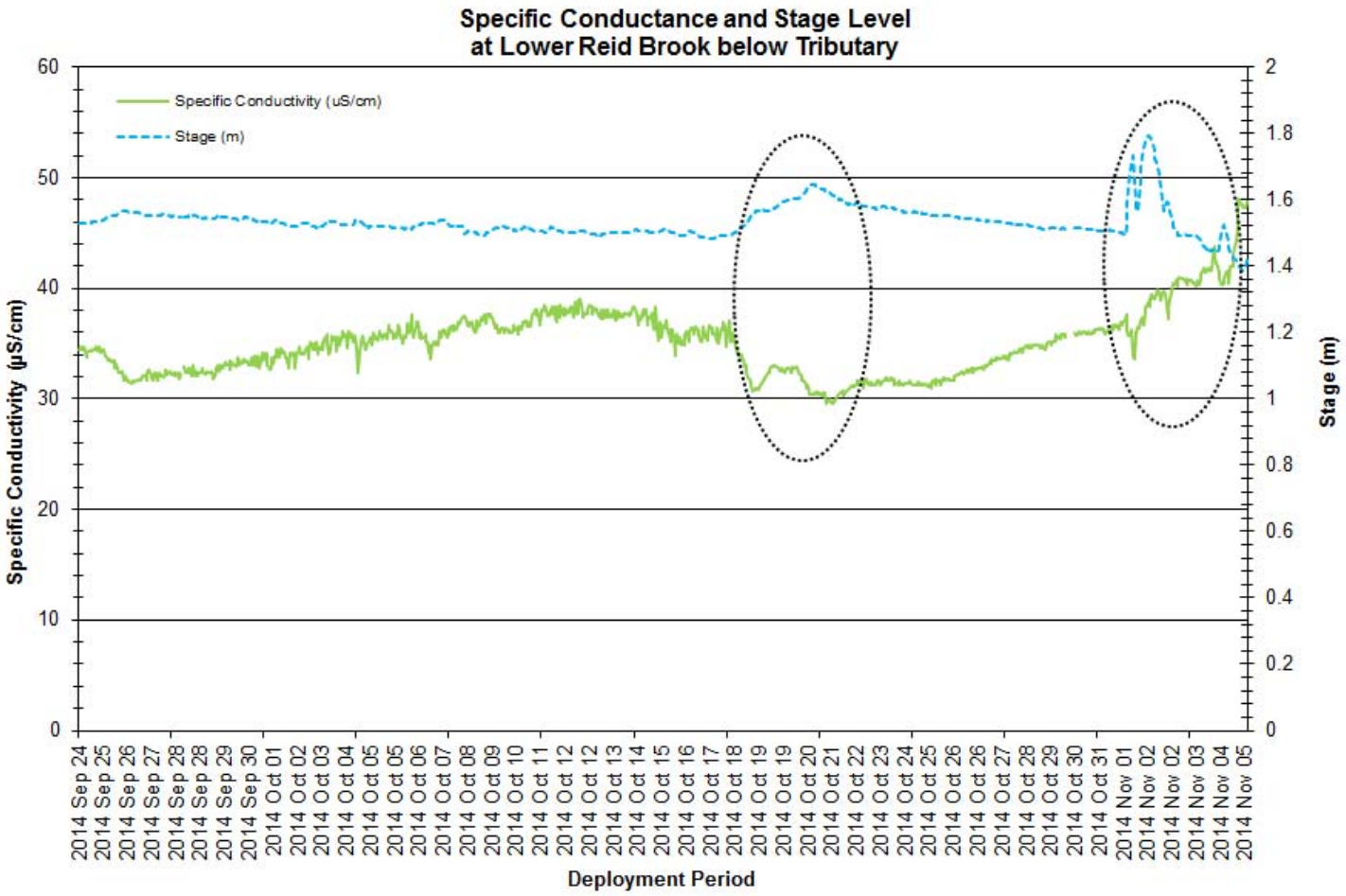

Figure 21: Specific conductivity and stage level at Lower Reid Brook below Tributary

Dissolved Oxygen

Dissolved oxygen content ranges between 11.53mg/l and 13.96mg/l. The saturation of dissolved oxygen ranges from 92.7% to 99.1% (Figure 22).

Dissolved oxygen percent saturation is relatively consistent throughout the deployment period. Dissolved oxygen mg/L increases throughout the deployment period as the water temperature decreases.

The dissolved oxygen levels are stable for this deployment period. The dissolved oxygen mg/L is above both CCME guidelines for the protection of early life stages and other life stages for the deployment period.

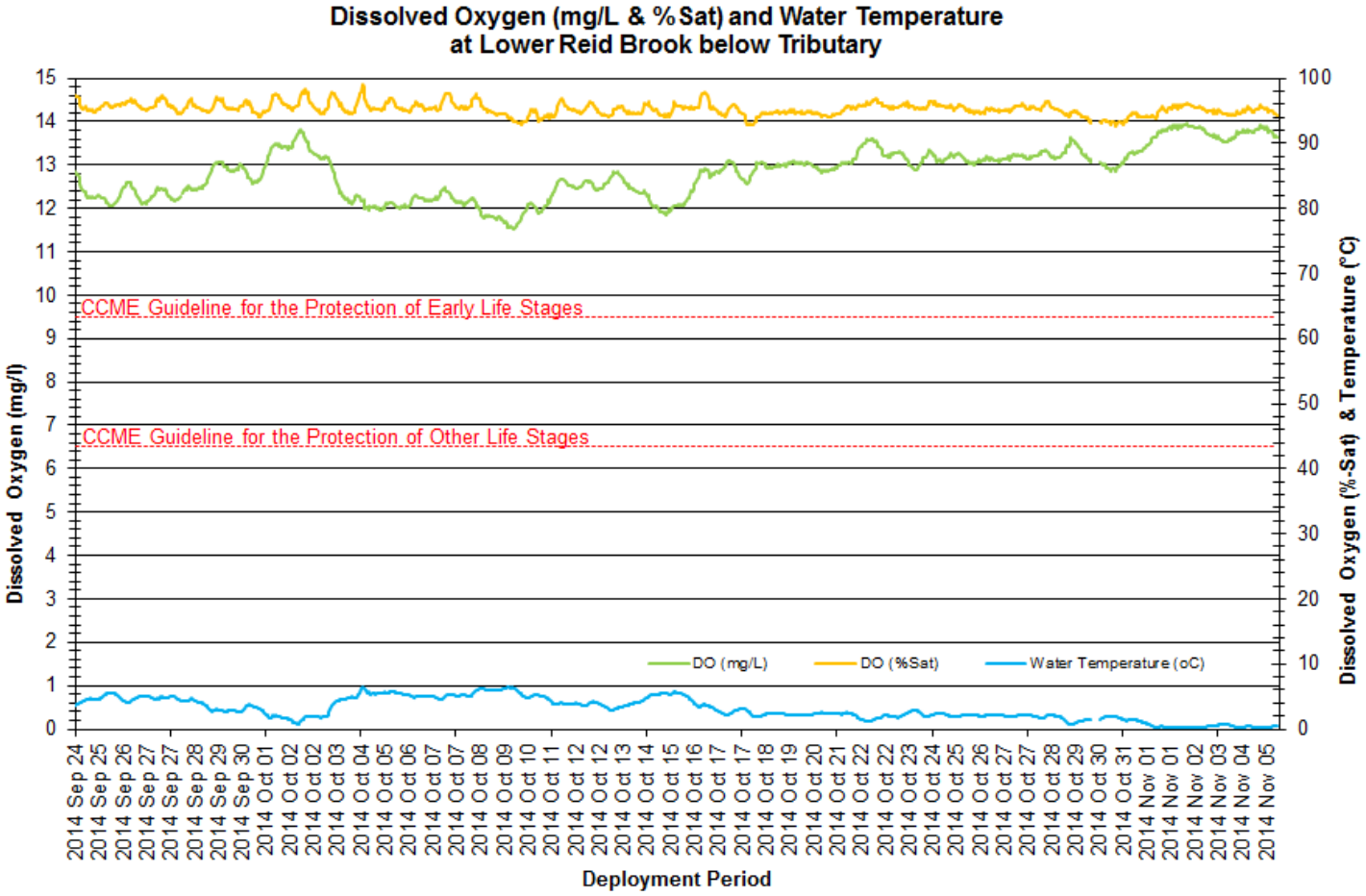

Figure 22: Dissolved oxygen (mg/L & %Sat) at Lower Reid Brook below Tributary

Turbidity

During the deployment period the turbidity values ranged between a minimum of 0 NTU and a maximum of 8.8 NTU (Figure 23). A median value of 0.0 NTU indicates there is no natural background turbidity data for this deployment period.

There is a cluster of turbidity increases captured on October 18th to October 21st and one event occurred on November 5th. All turbidity increases correspond with high stage levels for the same timeframe. All other data for the deployment is stable.

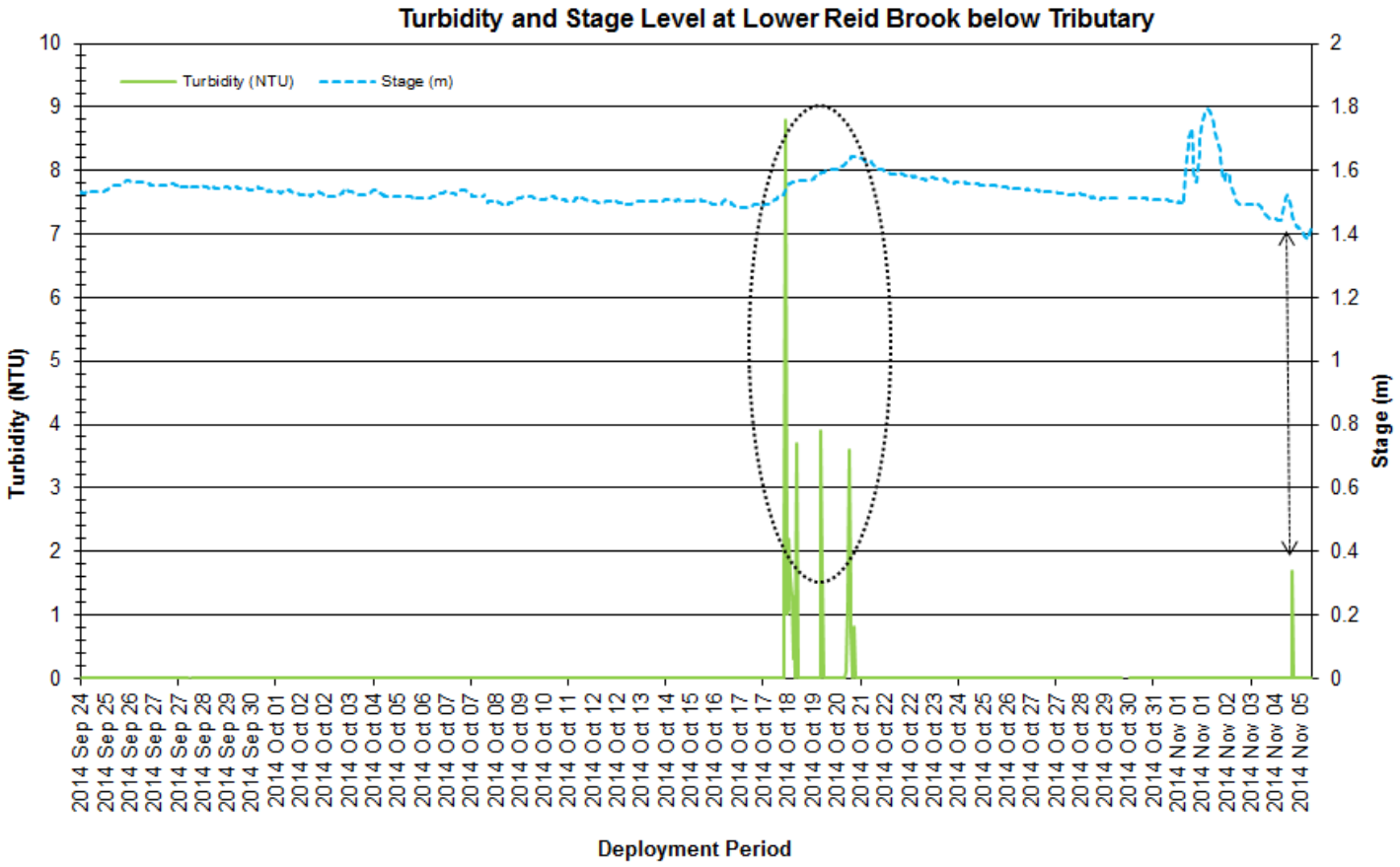

Figure 23: Turbidity and stage level at Lower Reid Brook below Tributary

Stage and Streamflow

Stage can be defined as the height or elevation of the stream's water surface above a reference elevation (sea level, gage level)**.** Stage is important to display as it provides an estimation of water level at the station and can explain some of the events that are occurring with other parameters (i.e. Specific Conductivity, DO, turbidity).

Streamflow can be defined as the volume of water in a river at a specific location and time. It is measured in cubic meters per second. The streamflow values ranged from 0.83 m^3/s to 12.12m^3/s. Most of the larger peaks in streamflow correspond with substantial rainfall events as highlighted by the black circles on Figure 24. However the largest peak on November 2nd does not have corresponding rainfall events.

During the deployment period, the stage values ranged from 1.41m to 1.79m. Precipitation data was obtained from the Environment Canada weather station at Nain. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 14mm on October 19th.

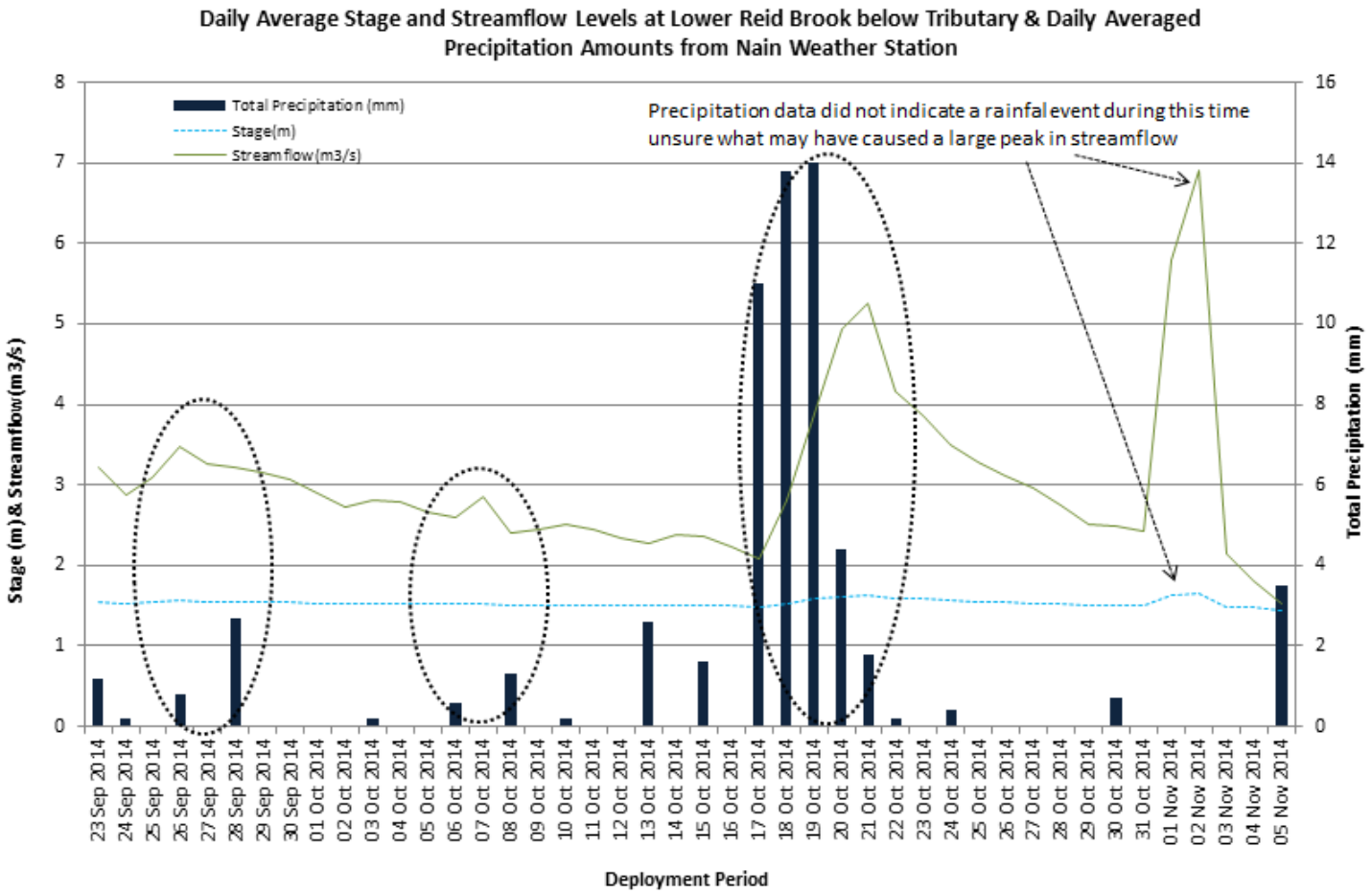

Figure 24: Daily precipitation and average daily stage and stream flow level at Lower Reid Brook below Tributary (Weather data recorded at Nain)

Conclusions

- The overall water temperatures across all stations were within a minimum of 0.00°C found at Tributary to Lower Reid Brook and a maximum of 8.14°C recorded again at Reid Brook below Reid Pond. Overall the water temperature was decreasing across the network of stations. The stations on Camp Pond Brook, Tributary to Lower Reid Brook and Lower Reid Brook are more sensitive to changes in the ambient air temperatures. These three stations have the lowest minimum temperatures for this deployment period. Reid Brook at Outlet of Reid Pond is a large body of water and takes a longer time to adjust to the ambient air temperatures. Hence Reid Brook at Outlet of Reid Pond having the highest minimum water temperature during the deployment period at 2.73°C.
- The pH values for this deployment ranged between a minimum of 6.07 pH units at Lower Reid Brook below Tributary and maximum of 7.04 pH units also at Lower Reid Brook below Tributary. The remaining stations pH graphs were similar in display with the larger decreases in pH occurring during precipitation events. On October 22nd the Lower Reid Brook pH data behaved differently from the other stations. Lower Reid Brook's pH values dropped when the other stations pH data increased.
- The overall conductivity ranges within the four stations was a minimum of 11.0µS/cm at Reid Brook at Outlet of Reid Pond and a maximum value of 53µS/cm at Camp Pond Brook below Camp Pond. Conductivity values at Reid Brook at Outlet of Reid Pond have been the lowest all deployment season when compared to the other stations. Camp Pond Brook below Camp Pond maintains the highest median at 37.7µS/cm for September to August deployment period. This is to be expected with Camp Pond Brook being slightly closer to the mine site and the increased potential for roadway runoff and other influences. This is actually evident on October 7th, October 11th, October 19th and again on November 1st when all of the other stations indicate a lowering in conductivity from rainfall, Camp Pond Brook data actually increases.
- Dissolved oxygen levels for the deployment period ranged between a minimum of 11.20mg/l at Camp Pond Brook below Camp Pond and a maximum of 14.21mg/l found at Tributary to Lower Reid Brook. Dissolved oxygen content was increasing slightly at all stations. As the seasonal change from fall to winter starts there is a decrease in air temperatures and in turn water temperatures. During the cooler seasons there is increase in dissolved oxygen present in water bodies.
- Turbidity levels for the four real-time stations ranged within a minimum of 0.0NTU from all stations and a maximum of 117.7NTU at Camp Pond brook below Camp Pond. Tributary to Lower Reid Brook has the second highest maximum reading of 32.7NTU. The high turbidity reading for Camp Pond Brook occurred during a high stage event and it can be linked to a precipitation event on October 18th and 19th of 13-14mm. The turbidity event at Tributary to Lower Reid Brook that occurred at the beginning of deployment on September 24th was likely a result of several smaller rainfall events that occurred on September 23rd and 24th.

APPENDIX I

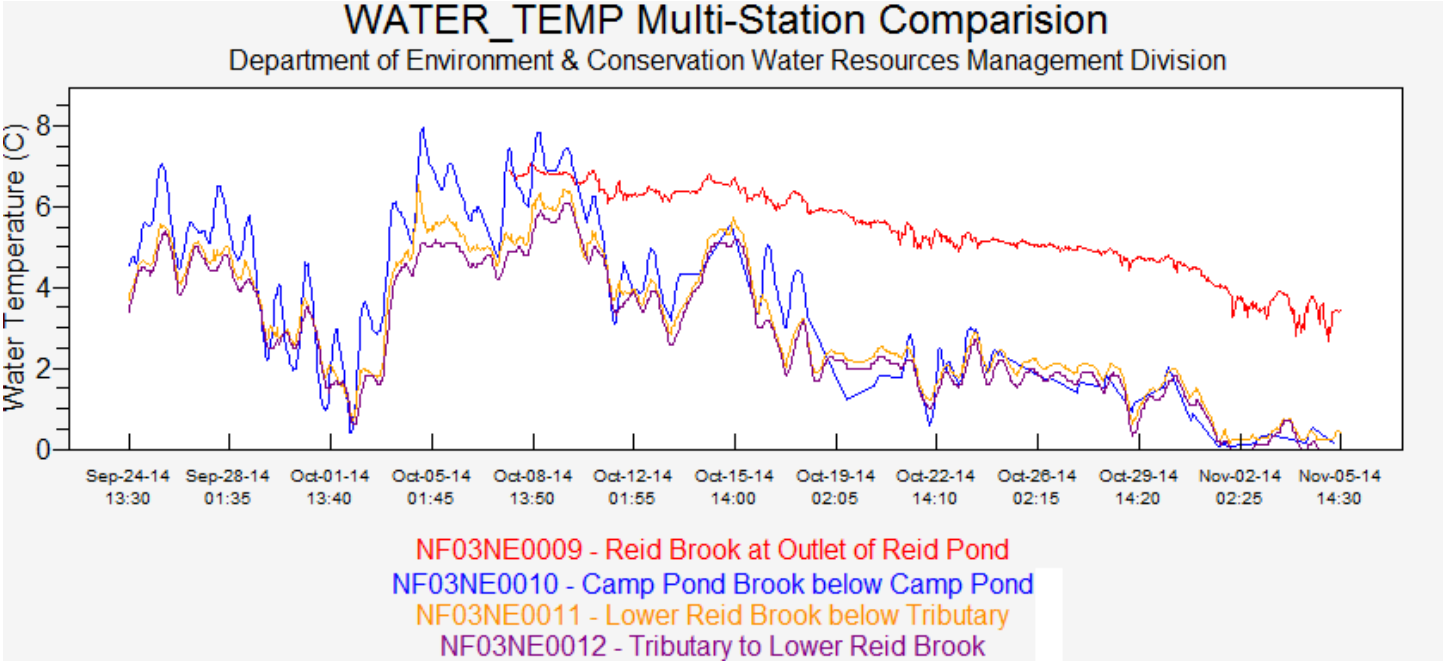

Figure A1: Comparison of Water Temperature at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook real time data does not start to graph until October 6th, 2014)

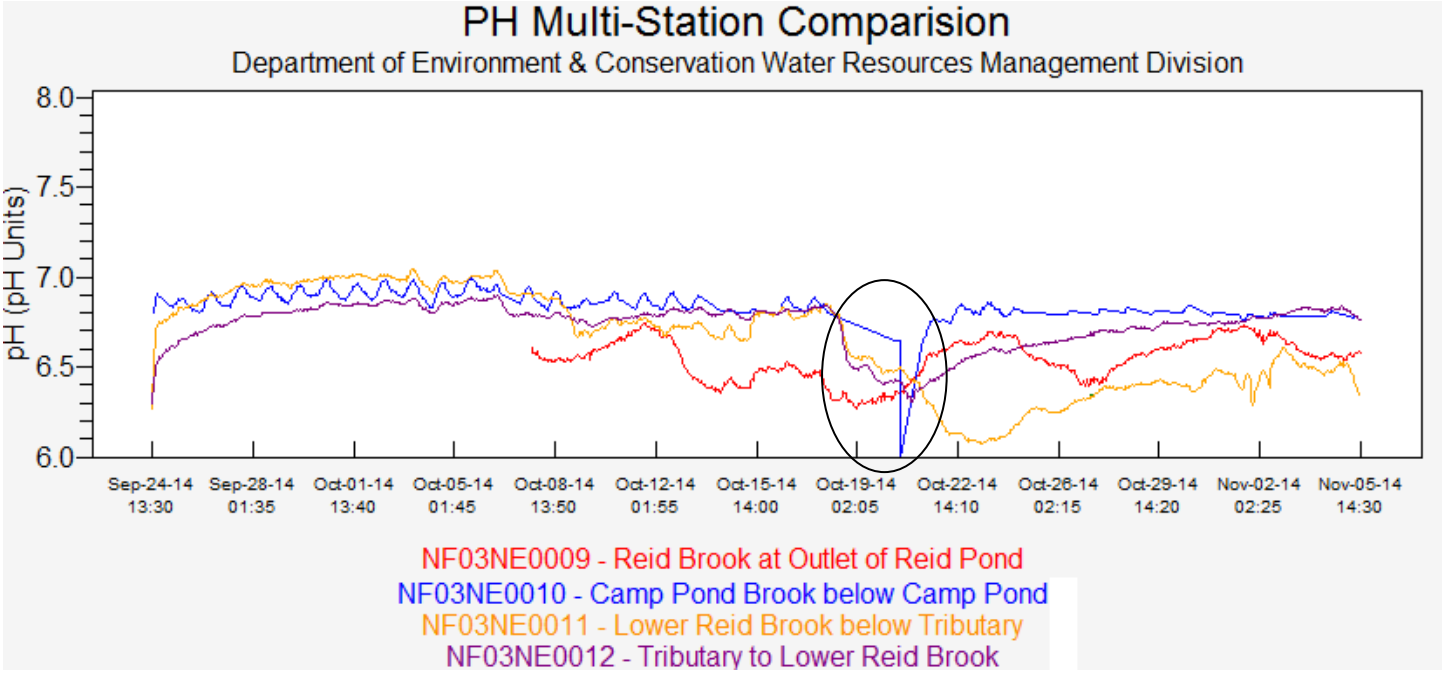

Figure A2: Comparison of pH at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook real time data does not start to graph until October 6th, 2014)

*The circled pH data for Camp Pond Brook is indicating that due to a transmission issue the data is missing at that time. Log file data was used in this report.

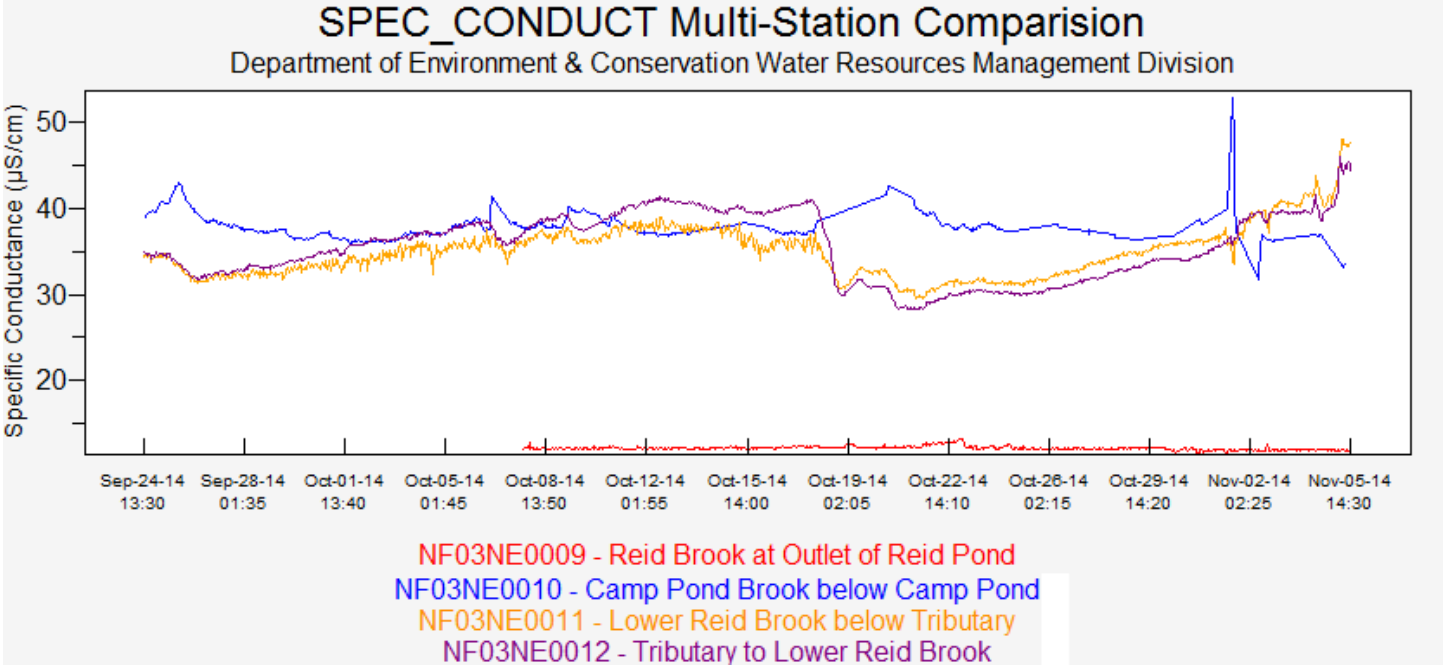

Figure A3: Comparison of Conductivity at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook real time data does not start to graph until October 6th, 2014).

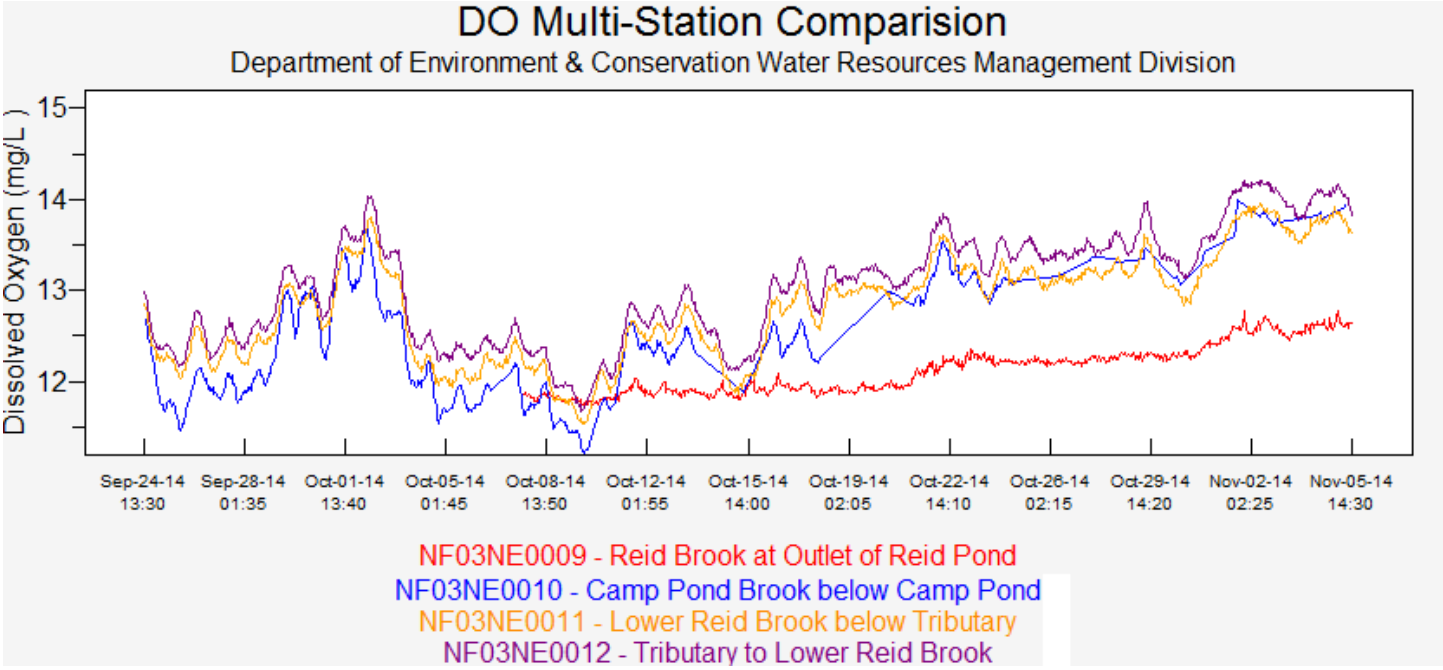

Figure A4: Comparison of Dissolved Oxygen (mg/L) at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook real time data does not start to graph until October 6th, 2014).

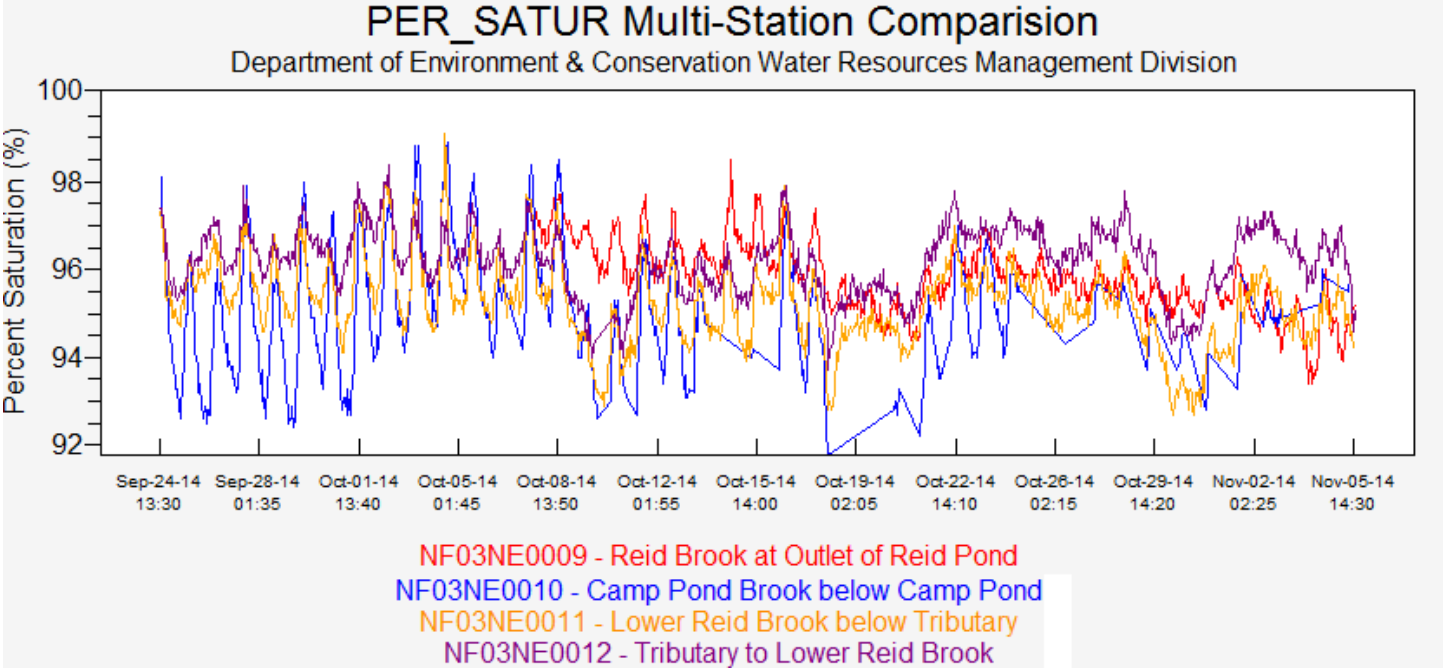

Figure A5: Comparison of Dissolved Oxygen (%Sat) at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook real time data does not start to graph until October 6th, 2014)

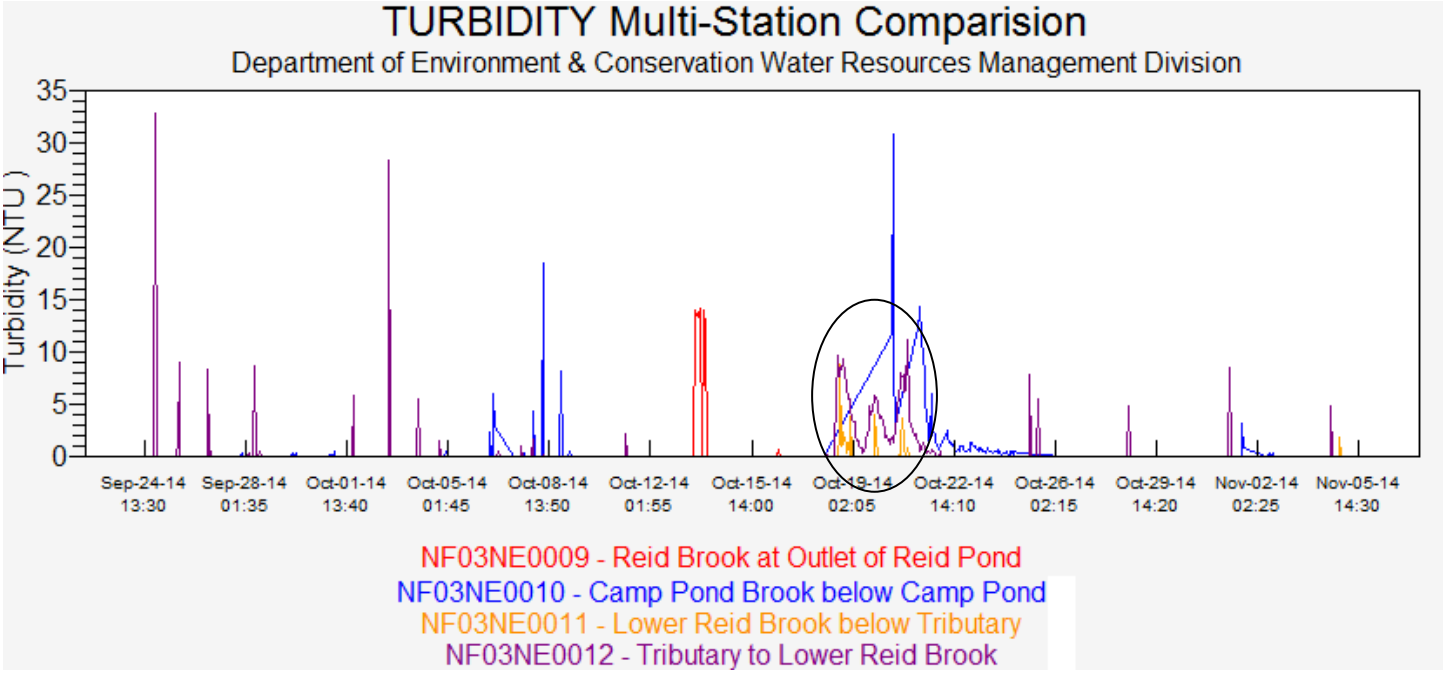

Figure A6: Comparison of Turbidity at the Real-Time Stations in Voisey's Bay (due to transmission issues Reid Brook real time data does not start to graph until October 6th, 2014)

* The circled data for Camp Pond Brook is indicating that there is a gap in this stations data and the high turbidity reading of 117.1 NTU is missing. Log file data was used in this report.

APPENDIX II

REPORT OF ANALYSIS

Lab Report Number: 1420768

Cient:	Department of Environment	**COC Number:**	2817
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1136447	WS-S-0000 Reid Bk @ Outlet of Reid Pd	2014-6412-00-SI-SP	2014-09-24

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	<5
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	<1
Colour	TCU	2	8
Conductivity	uS/cm	5	14
Dissolved Organic Carbon	mg/L	0.5	2.4
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	2
N-NH3 (Ammonia)	mg/L	0.02	0.08
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.87
Sulphate	mg/L	1	<1
Total Dissolved Solids (COND - CALC)	mg/L	1	9
Total Kjeldahl Nitrogen	mg/L	0.10	0.14
Total Organic Carbon	mg/L	0.5	2.1
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	0.3
Aluminum	mg/L	0.01	0.05
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	1
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1420768**

Cient:	Department of Environment	**COC Number:**	2817
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1136447	WS-S-0000 Reid Bk @ Outlet of Reid Pd	2014-6412-00-SI-SP	2014-09-24	Copper	mg/L	0.001	<0.001
				Iron	mg/L	0.03	<0.03
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	<1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	<0.005
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	<2
				Strontium	mg/L	0.001	0.005
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: 1420768

Cient:	Department of Environment	**COC Number:**	2817
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1136448	WS-S-0000 Camp Pond Bk Below Camp Pond	2014-6413-00-SI-SP	2014-09-24

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	8
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	3
Colour	TCU	2	23
Conductivity	uS/cm	5	41
Dissolved Organic Carbon	mg/L	0.5	4.0
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	14
N-NH3 (Ammonia)	mg/L	0.02	0.09
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	7.05
Sulphate	mg/L	1	5
Total Dissolved Solids (COND - CALC)	mg/L	1	27
Total Kjeldahl Nitrogen	mg/L	0.10	0.25
Total Organic Carbon	mg/L	0.5	4.2
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	1.2
Aluminum	mg/L	0.01	0.06
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	4
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1420768**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1136448	WS-S-0000	2014-6413-00-SI-SP	2014-09-24	Copper	mg/L	0.001	0.003
	Camp Pond Bk Below Camp Pond			Iron	mg/L	0.03	0.16
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	1
				Manganese	mg/L	0.01	<0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	0.024
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	2
				Strontium	mg/L	0.001	0.020
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1420768**

Cient:	Department of Environment	**COC Number:**	2817
Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1136449	WS-S-0000 Lower Reid Bk Blelow Tributary	2014-6414-00-SI-SP	2014-09-24

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	7
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	4
Colour	TCU	2	54
Conductivity	uS/cm	5	36
Dissolved Organic Carbon	mg/L	0.5	7.3
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	12
N-NH3 (Ammonia)	mg/L	0.02	0.11
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.96
Sulphate	mg/L	1	3
Total Dissolved Solids (COND - CALC)	mg/L	1	23
Total Kjeldahl Nitrogen	mg/L	0.10	0.38
Total Organic Carbon	mg/L	0.5	7.4
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	1.0
Aluminum	mg/L	0.01	0.18
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	3
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

Lab Report Number: **1420768**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1136449	WS-S-0000 Lower Reid Bk Blelow Tributary	2014-6414-00-SI-SP	2014-09-24	Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.80
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	0.010
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	2
				Strontium	mg/L	0.001	0.019
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

Lorna Wilson
Laboratory Supervisor, Inorganics

REPORT OF ANALYSIS

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date
1136450	WS-S-0000 Tributary to Reid Brook	2014-6415-00-SI-SP	2014-09-24

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

ANALYTE	UNIT	MRL	RESULT
Alkalinity as CaCO3	mg/L	5	7
Bromide	mg/L	0.25	<0.25
Chloride	mg/L	1	4
Colour	TCU	2	54
Conductivity	uS/cm	5	36
Dissolved Organic Carbon	mg/L	0.5	6.9
Fluoride	mg/L	0.10	<0.10
Hardness as CaCO3	mg/L	1	12
N-NH3 (Ammonia)	mg/L	0.02	0.08
N-NO2 (Nitrite)	mg/L	0.10	<0.10
N-NO3 (Nitrate)	mg/L	0.10	<0.10
pH		1.00	6.93
Sulphate	mg/L	1	3
Total Dissolved Solids (COND - CALC)	mg/L	1	23
Total Kjeldahl Nitrogen	mg/L	0.10	0.39
Total Organic Carbon	mg/L	0.5	7.5
Total Phosphorus	mg/L	0.01	<0.01
Turbidity	NTU	0.1	1.4
Aluminum	mg/L	0.01	0.15
Antimony	mg/L	0.0005	<0.0005
Arsenic	mg/L	0.001	<0.001
Barium	mg/L	0.01	<0.01
Boron	mg/L	0.01	<0.01
Calcium	mg/L	1	3
Cadmium	mg/L	0.0001	<0.0001
Chromium	mg/L	0.001	<0.001

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

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REPORT OF ANALYSIS

Lab Report Number: **1420768**

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Attention:	Ms. Melissa McComiskey	**Date Reported:**	2014-10-01
Client Project:	St Johns	**Date Submitted:**	2014-09-29
Purchase Order:	214004545	**Sample Matrix:**	Water

LAB ID	Supply / Description	Client Sample ID	Sample Date	ANALYTE	UNIT	MRL	RESULT
1136450	WS-S-0000 Tributary to Reid Brook	2014-6415-00-SI-SP	2014-09-24	Copper	mg/L	0.001	0.001
				Iron	mg/L	0.03	0.58
				Lead	mg/L	0.001	<0.001
				Magnesium	mg/L	1	1
				Manganese	mg/L	0.01	0.01
				Mercury	mg/L	0.0001	<0.0001
				Nickel	mg/L	0.005	0.010
				Potassium	mg/L	1	<1
				Selenium	mg/L	0.001	<0.001
				Sodium	mg/L	2	2
				Strontium	mg/L	0.001	0.020
				Uranium	mg/L	0.001	<0.001
				Zinc	mg/L	0.01	<0.01
				Total Suspended Solids	mg/L	2	<2

Sample comment:

Holding time for turbidity analysis was exceeded.

Report comment:

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

APPROVAL:

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