# Real-Time Water Quality Deployment Report

## Voisey's Bay Network

**August 16, 2016 to September 19, 2016**

Newfoundland Labrador

**Government of Newfoundland & Labrador**
**Department of Municipal Affairs and Environment**
**Water Resources Management Division**

# Contents



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## Real Time Water Quality Monitoring

Department of Municipal Affairs and Environment 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; Reid Brook at Outlet to Reid Pond, Camp Pond Brook, Tributary to Lower Reid Brook, and Lower Reid Brook.

On August 17th, 2016, Vale Environment Staff redeployed real-time water quality monitoring instruments at the four real time stations in the Voisey's Bay network. The end of the deployment was September 19th, 2016. This was the third deployment for the 2016 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 alongside 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 below 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 | August 16 | Deployment | Excellent | Marginal | Excellent | Excellent | Poor |
| | September 19 | Removal | Excellent | Fair | Good | Poor | Excellent |
| Camp Pond Brook | August 16 | Department | Excellent | Good | Good | Excellent | Fair |
| | September 19 | Removal | Excellent | Excellent | Poor | Excellent | Excellent |
| Reid Brook below Tributary | August 16 | Department | Good | Excellent | Good | Excellent | Fair |
| | September 19 | Removal | Excellent | Fair | Marginal | Good | Excellent |
| Tributary to Reid Brook | August 16 | Department | Excellent | Fair | Good | Excellent | Poor |
| | September 19 | Removal | Excellent | Excellent | Poor | Good | Good |

During the deployment for **Reid Brook at Outlet of Reid Pond**, the temperature, conductivity and dissolved oxygen all ranked as 'Excellent'. pH data ranked as 'Marginal' at deployment. The pH probe does require some time to acclimatize to the water environment thus it is likely that the readings for the pH were taken earlier than necessary. Turbidity data ranked as 'Poor'. Upon removal of the instrument, the water temperature and turbidity ranked as 'Excellent'. pH and conductivity ranked as 'Good' and 'Fair'. Dissolved oxygen ranked as 'Poor'.

At the station on **Camp Pond Brook below Camp Pond**, water temperature, pH, specific conductivity, and dissolved oxygen ranked as 'Excellent' and 'Good'. The turbidity data was ranked as 'Fair' at deployment. During removal, water temperature, pH, dissolved oxygen, and turbidity all ranked as 'Excellent'. At removal the data for specific conductivity ranked as 'Poor'.

During deployment of the field instrument at **Reid Brook below Tributary**, water temperature, pH, specific conductivity, dissolved oxygen all ranked as 'Excellent' and 'Good', with turbidity data ranking as 'Fair'. During removal, water temperature, dissolved oxygen and turbidity ranked as 'Excellent' and 'Good'. The pH data when compared against the QA ranked as 'Fair'. The specific conductivity data when compared was ranked as 'Marginal'.

**Tributary to Reid Brook** water temperature, specific conductivity and dissolved oxygen ranked as 'Excellent' and 'Good' during deployment. pH data ranked as 'Fair' and the turbidity data ranked as 'Poor'. Upon removal, water temperature, pH, dissolved oxygen and turbidity all ranked as 'Excellent' and 'Good'. The specific conductivity data ranked as 'Poor'.

Reviewing the comparison ranking across the stations there is an indication that the turbidity sensor on the QAQC instrument that was used for the deployment rankings was not working to its full capacity. The specific conductivity probe on the QAQC instrument that was used to compare the data from the removal also indicated that it may not be accurate.

## Data Interpretation

The following graphs and discussion illustrate significant water quality-related events from August 16th, to September 19th 2016 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.


**Figure 1: Voisey's Bay Network Station Locations**

## Reid Brook at Outlet of Reid Pond

### Water Temperature

Over the deployment period the water temperature ranged from 8.29 °C to 14.96 °C, with a median value of 12.32 °C (Figure 2).

The water temperature data at this station does not display the common diurnal pattern that water bodies often display. This is likely a result of the instrument being in a pond. This water body takes longer to acclimatize to changes in temperature as it is a larger surface area than the brooks. The water temperature has slower more exaggerated changes at this station than what the air temperature is indicating on Figure 3.

Please note the stage data, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC. Mean Air Temperature on Figure 3 was collected at the Nain Weather Station by Environment Canada.

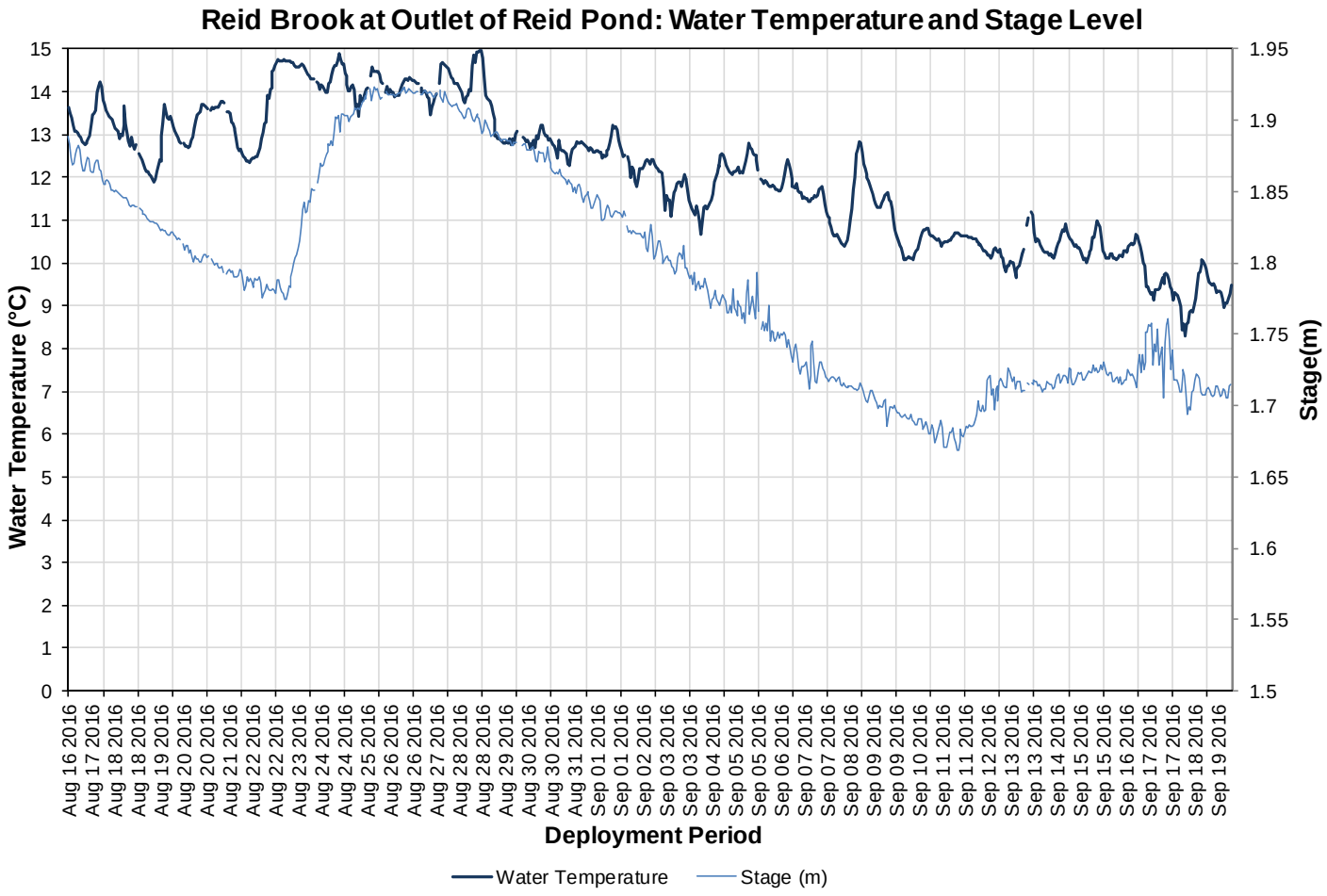


**Figure 2: Water Temperature & Stage at Reid Brook at Outlet of Reid Pond**

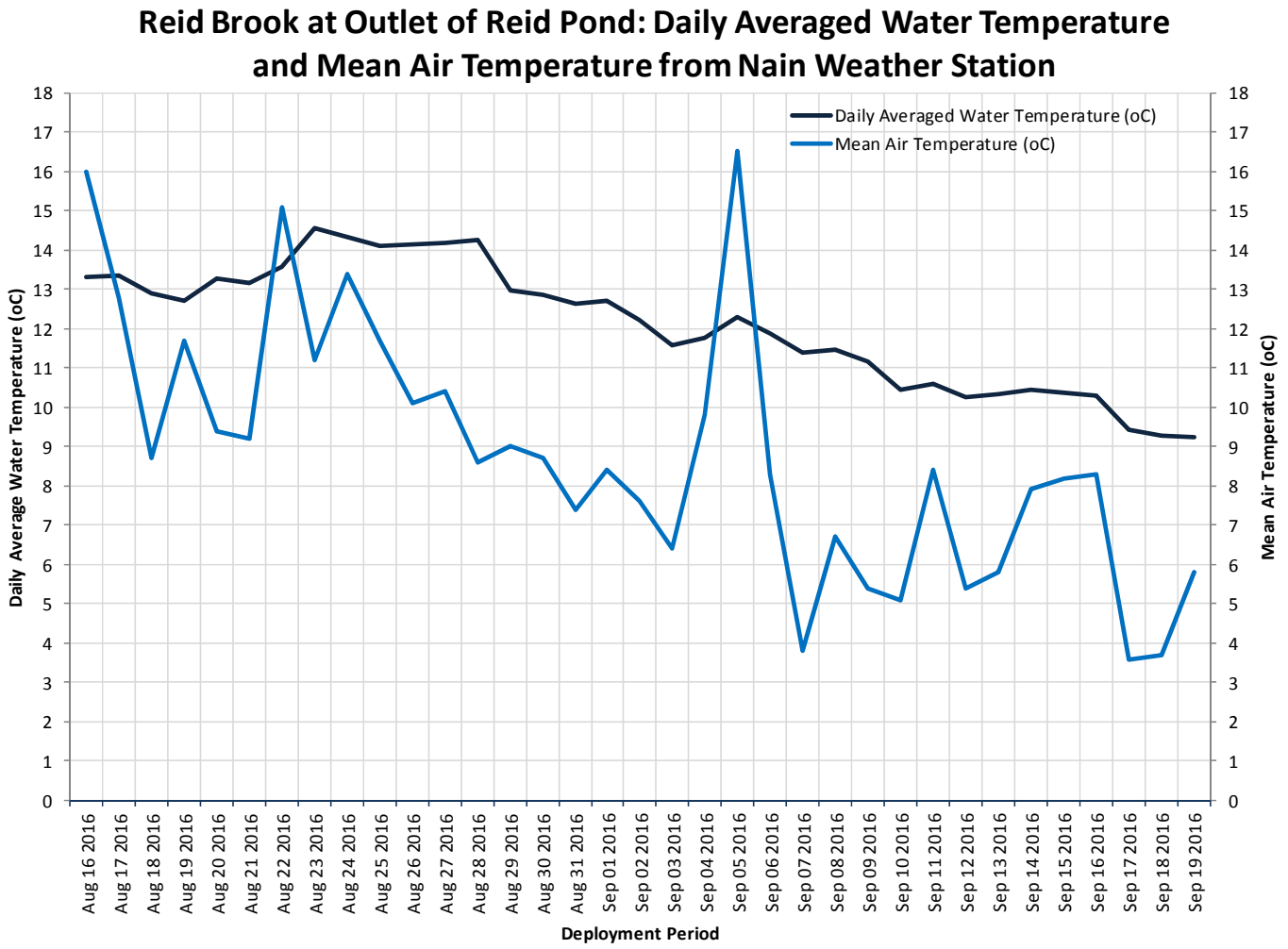


**Figure 3: Daily Averaged Water Temperature at Reid Brook at Outlet of Reid Pond and Mean Air Temperatures from Nain Weather Station**

**pH**

Throughout the deployment period, pH values ranged between 6.08 pH units and 7.51 pH units (Figure 4).

The pH data decreases slowly over the deployment period, whereby the pH dips below the minimum Guideline for Protection of Aquatic Life on September 7th, 2016. This dip corresponds with a decrease in stage around the same time. Natural processes such as rainfall and runoff will alter the pH of a brook for a period of time.

The Canadian Council of Ministers of the Environment (CCME) guidelines are just a basis by which to compare any dramatic change in the pH data within a dataset. Every brook is different with its own natural baseline conditions.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

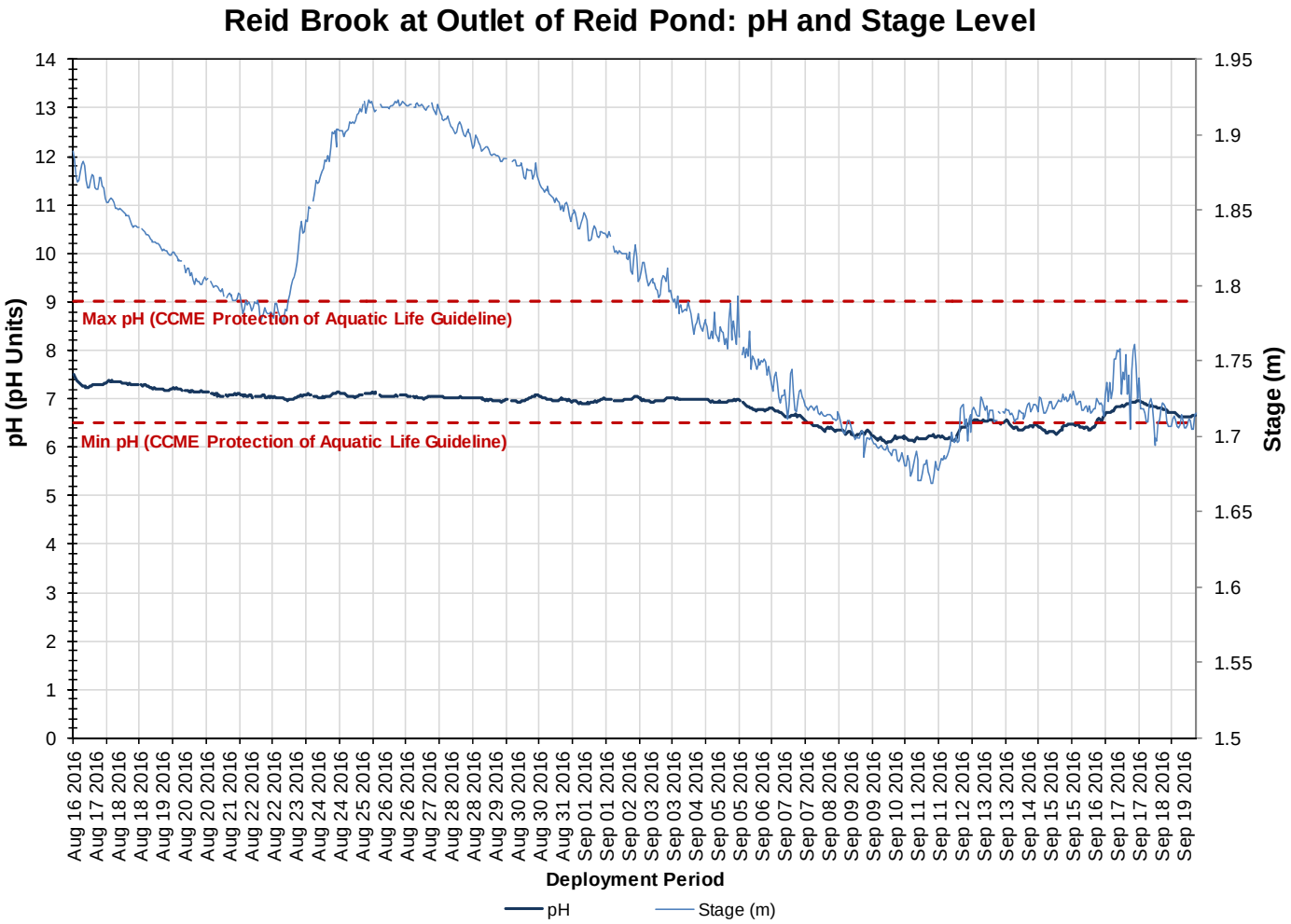


**Figure 4: pH and Stage Level at Reid Brook at Outlet of Reid Pond**

**Specific Conductivity**

The conductivity levels were within 11.3 µS/cm and 12.4 µS/cm during this deployment period. The conductivity at Reid Brook remains very stable. 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.

The common relationship between conductivity and stage level is generally inversed. However, due to this site being a pond environment and a significant distance from any anthropogenic influences, the conductivity at Reid Pond remains stable throughout this deployment (Figure 5).

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

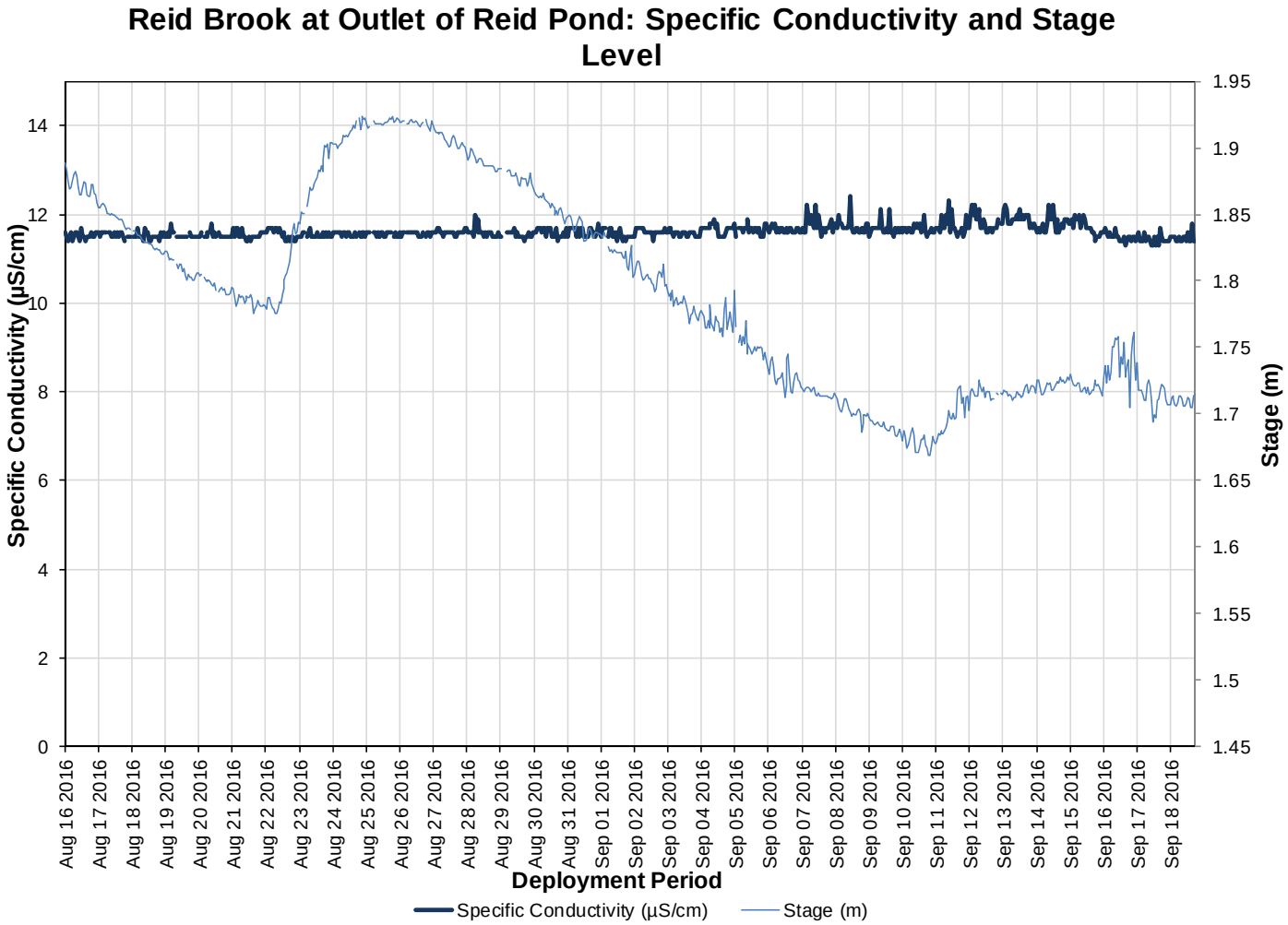


**Figure 5: Specific Conductivity and Stage Level at Reid Brook at Outlet of Reid Pond**

### 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) taking into account the water temperature.

During the deployment the dissolved oxygen concentration levels ranged within a minimum of 10.08 mg/L to a maximum of 11.08 mg/L. The percent saturation levels for dissolved oxygen ranged within 93.2% Saturation to 103.9% Saturation (Figure 6).

The dissolved oxygen concentration remained above the Guideline for the Protection of Early Life Stages (9.5mg/L). As the water temperatures dip with the change into fall there will be a natural increase in dissolved oxygen present in the brook.

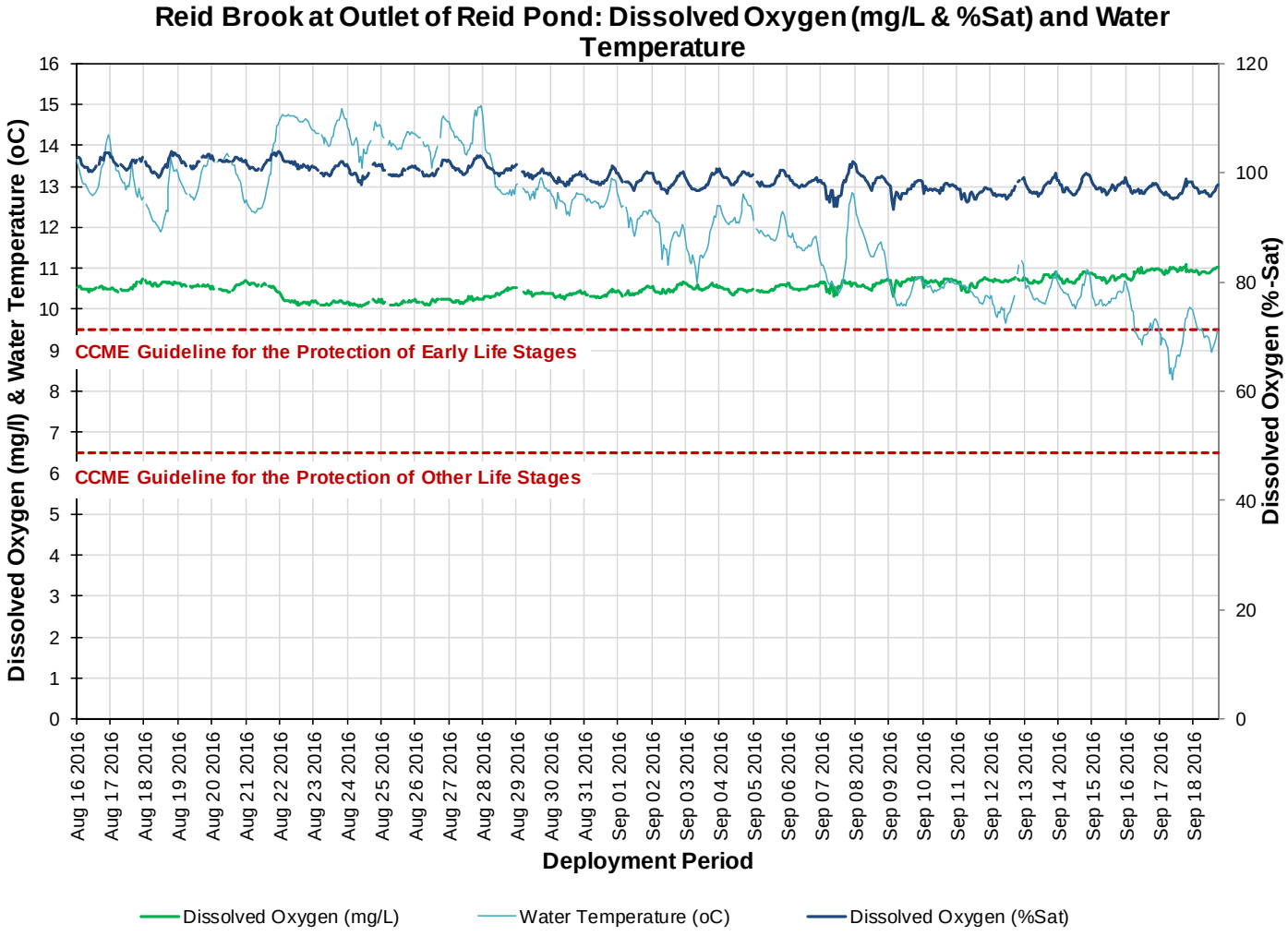


**Figure 6: Dissolved Oxygen (mg/L & %Sat) at Reid Brook at Outlet of Reid Pond**

**Turbidity**

Turbidity levels during the deployment ranged within 0.0 NTU and 1.4 NTU (Figure 7). The deployment data had a median of 0.3 NTU.

Waterbodies all have a natural level of turbidity to the water quality. A significant increase in turbidity that is of concern when monitoring brooks. During rainfall or runoff, higher turbidity readings would be expected. Generally the turbidity levels increase for a short period of time and then return to within the range of the baseline. At this station, the higher turbidity events throughout this deployment period correlate with increases in stage potentially from precipitation. Rainfall and subsequent runoff can increase the presence of suspended material in water.

Turbidity values can also increase if there is a decrease in water level and the natural material in the waterbody becomes concentrated.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

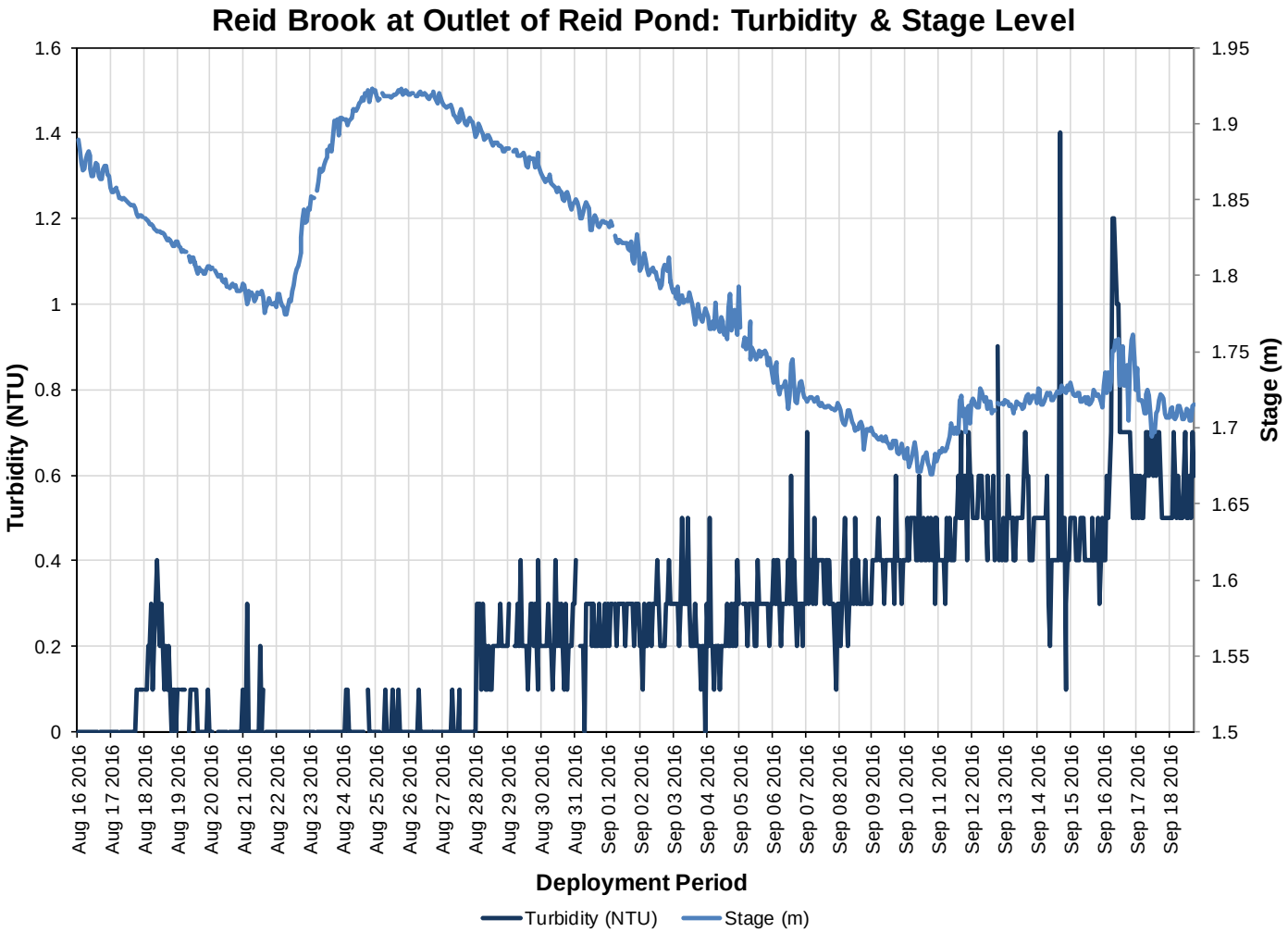


**Figure 7: Turbidity and Stage at Reid Brook at Outlet of Reid Pond**

### Stage, Streamflow & Precipitation

Please note the stage and streamflow data graphed below is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

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). Stage will increase during rainfall events (Figure 8) 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 stage values ranged from 1.67m to 1.92m. The streamflow values ranged between 2.49 $m^3/s$ to 0.74 $m^3/s$. The larger peaks in stage and streamflow do correspond with substantial rainfall events as noted on Figure 8. Precipitation data was obtained from Nain Weather Station. Precipitation ranges for the deployment period were a minimum of 0.0 mm and a maximum of 51.4 mm on August 23rd, 2016.

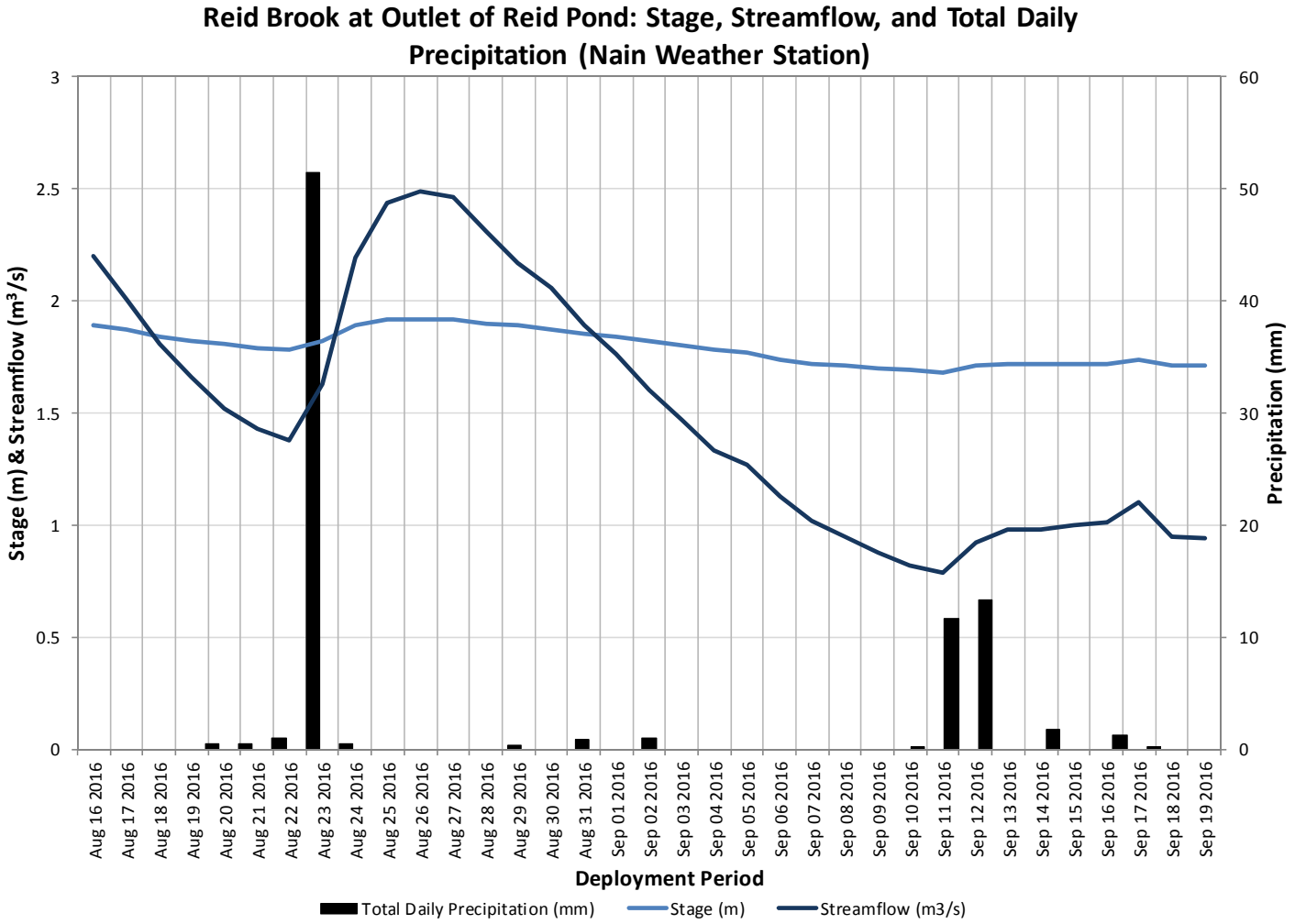


**Figure 8: Daily Stage and Streamflow data from Reid Brook at Outlet of Reid Pond and Total Daily Precipitation from Nain, Labrador Weather Station**

## Camp Pond Brook below Camp Pond

### Water Temperature

Water temperature ranged from 4.44°C to 19.38°C during this deployment period (Figure 9).

The water temperature at this station displays diurnal variations of the temperature. There is a significant peak in water temperature and air temperature on September 5th 2016. These increases coincide with a dip in stage level which may be a result natural evaporation as the air temperatures increase (Figure 10).

This stream is sensitive to changes in the ambient air temperature and fluctuates considerably depending on the weather and time of day. This station typically has the highest water temperatures and greatest fluctuations when compared to the other stations in the network.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

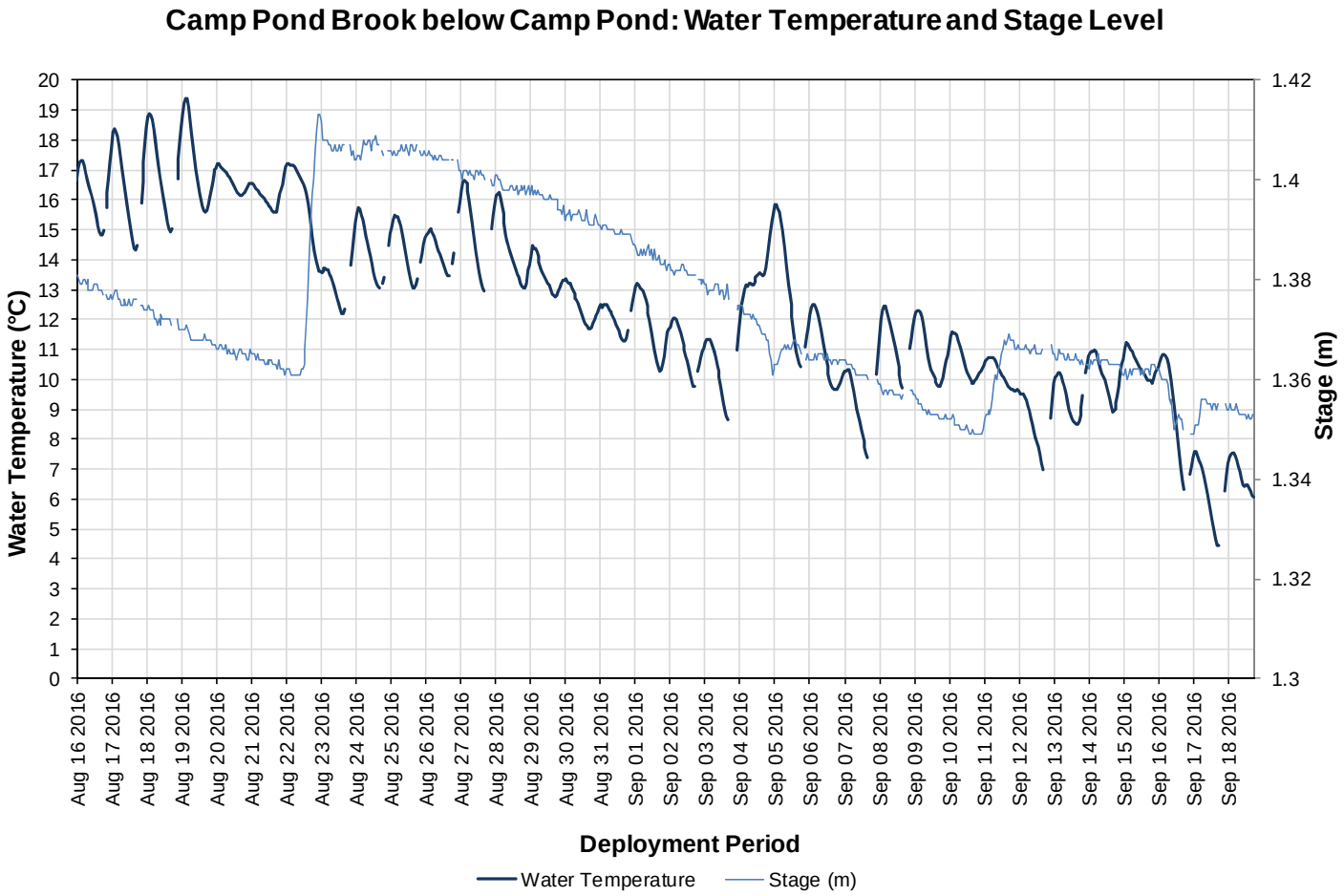


**Figure 9: Water Temperature & Stage Level at Camp Pond Brook below Camp Pond**

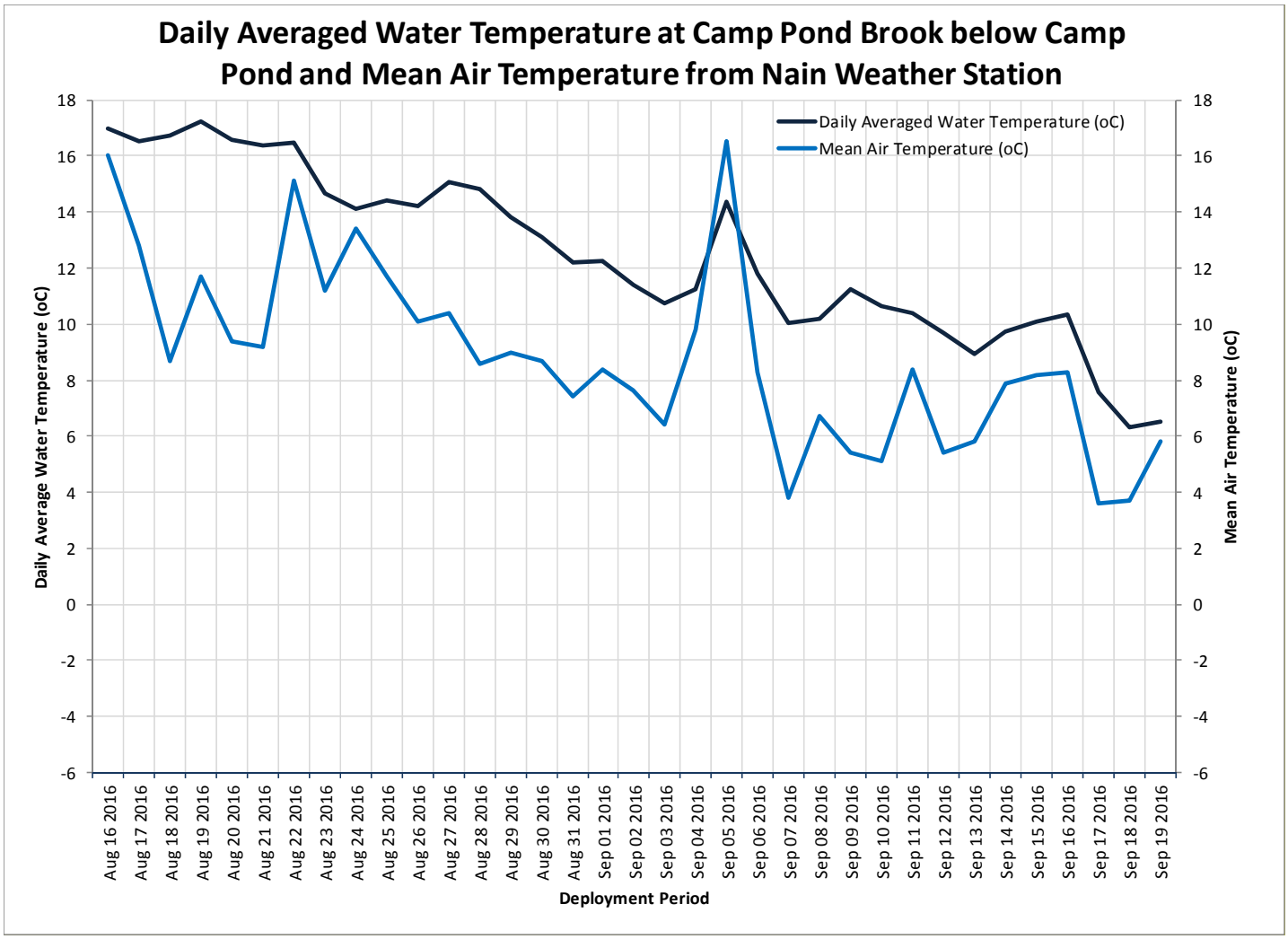


**Figure 10: Daily Averaged Water Temperature at Camp Pond Brook below Camp Pond & Mean Air Temperature from Nain Weather Station.**

**pH**

Throughout the deployment period, pH values ranged between 6.54 pH units and 7.00 pH units (Figure 11).

The pH levels are consistent during the deployment. The pH data remains within the Guideline for Protection of Aquatic Life. The Canadian Council of Ministers of the Environment (CCME) guidelines are just a basis by which to compare any dramatic change in the pH data within a dataset. Every brook is different with its own natural baseline conditions.

Natural events such as rainfall and snow melt will alter the pH of a brook for a period of time. This is evident on Figure 11, on August 23rd 2016. The pH levels will decrease slightly for a short period of time during and after high stage levels. This is a natural process.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

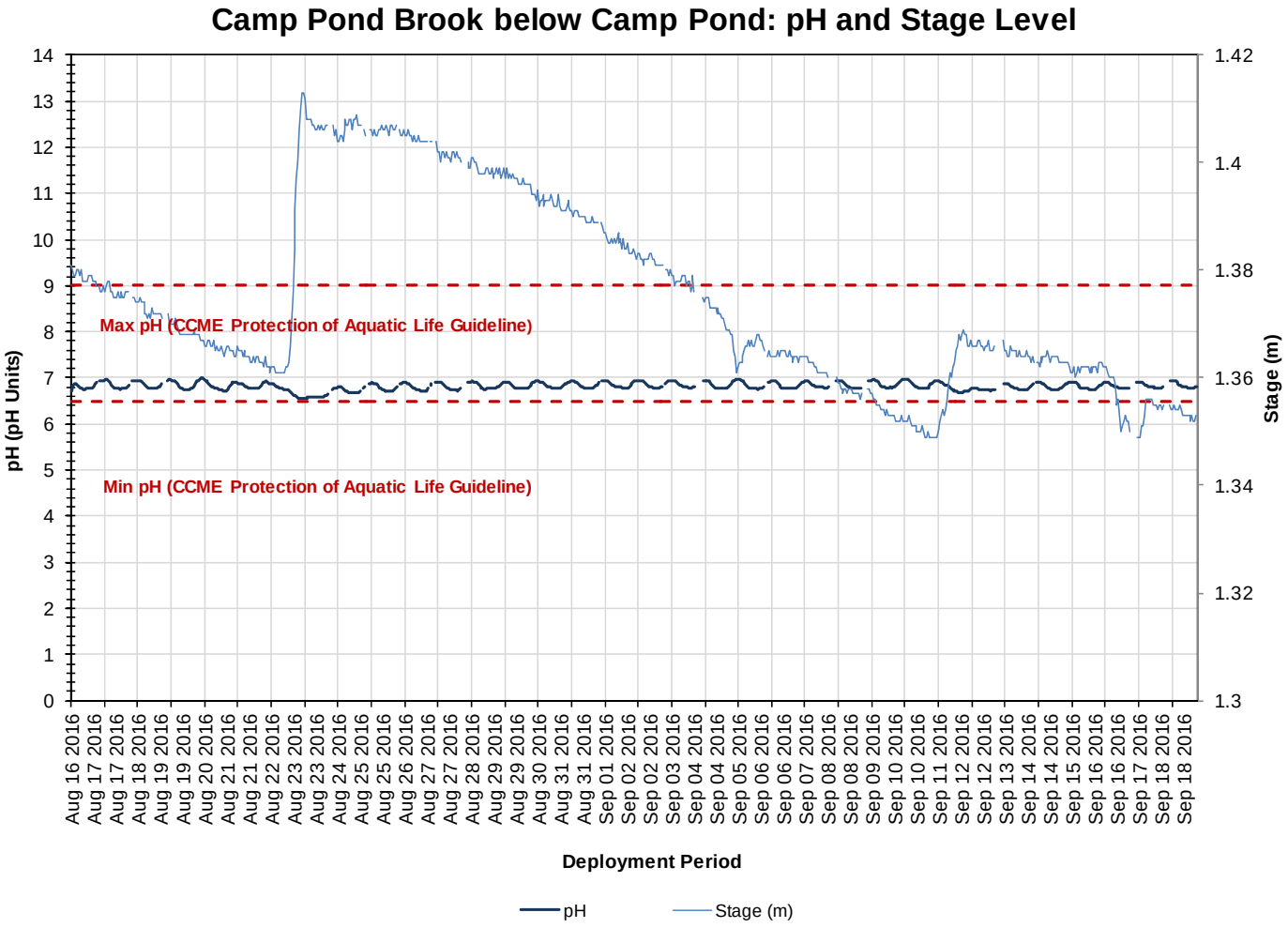


**Figure 11: pH & Stage Level at Camp Pond Brook below Camp Pond**

**Specific Conductivity**

Specific conductivity ranges from 36.3µS/cm to 64.0 µS/cm with a median of 38.8 µS/cm (Figure 12).

At this site the specific conductivity increases with stage level increases (Figure 12). The specific conductivity of the water increases as there is an increase in the concentration of dissolved solids present in the water column.

This is evident on Figure 12, on August 23rd and September 11th, 2016 when the stage and conductivity values both increase for a short period of time. The increase in specific conductivity is likely from runoff from the nearby roadway. This site is located close to a frequently used main road and disturbed dust, particles and dissolved substances can be flushed into this brook.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

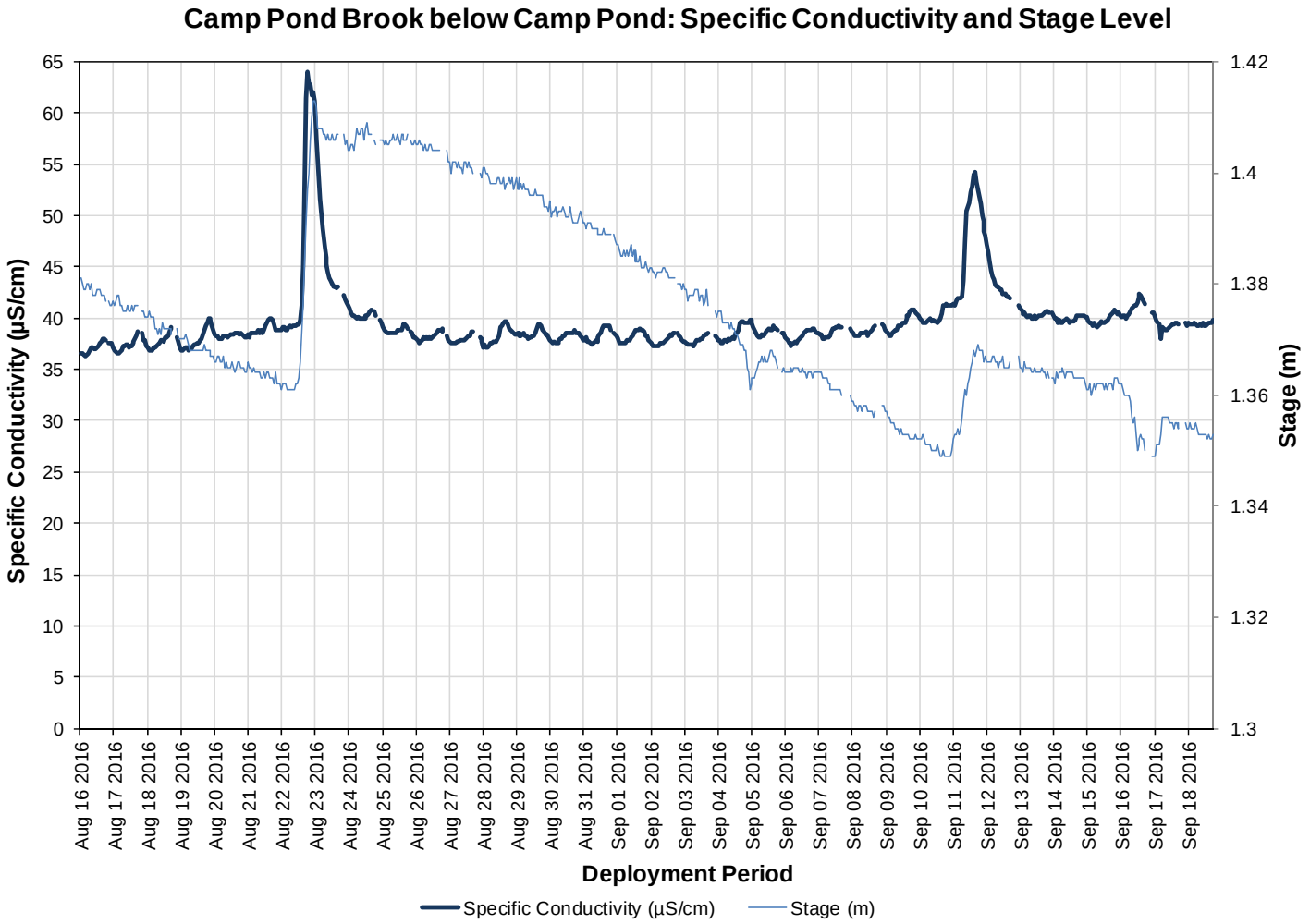


**Figure 12: Specific Conductivity & Stage at Camp Pond Brook below Camp Pond**

### Dissolved Oxygen (mg/L & % Saturation)

Dissolved oxygen content ranges between 8.75mg/l and 11.9mg/l during the deployment period. The saturation of dissolved oxygen ranges from 87.9% to 102.0% (Figure 13). 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 concentration dipped below the CCME guideline of 9.5mg/L at the beginning of this deployment. There were also higher water temperatures at that time (Figure 9). This is expected as water temperature directly influences the level of dissolved oxygen present in the water column.

Dissolved oxygen data is consistent with the changes in water temperatures that would be occurring during the summer weather.

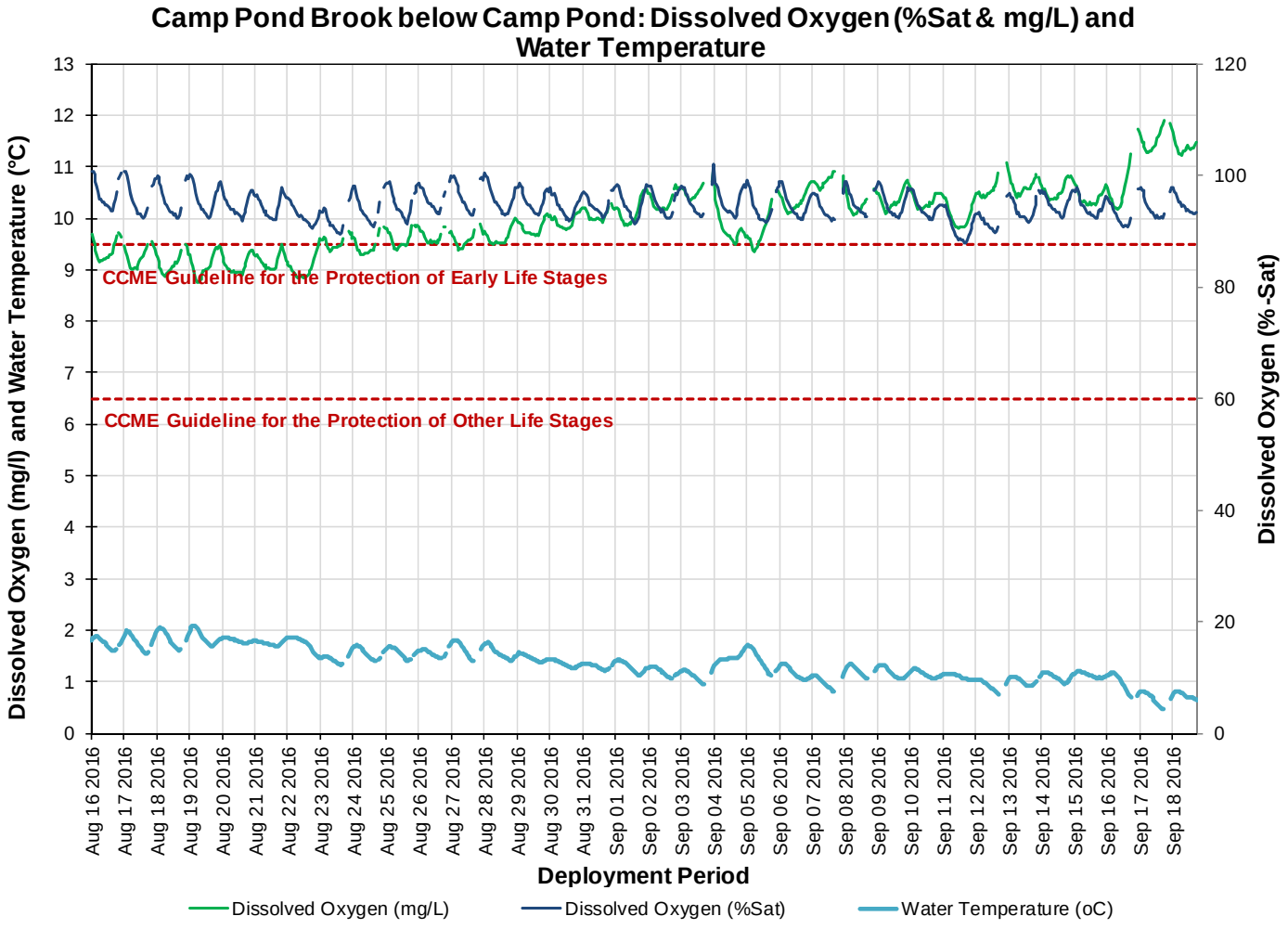


**Figure 13: Dissolved Oxygen & Water Temperature at Camp Pond Brook below Camp Pond**

**Turbidity**

Across the deployment period the turbidity ranges from 0.0NTU to 0.7NTU, with a median value of 0.0NTU (Figure 14). A median value of 0.0 NTU indicates there is very little natural background turbidity at this station during this deployment period.

The one turbidity spike during this deployment period is low. This type of turbidity change could be caused by anything in the water body (bubbles, drifting of algae or sunlight scattering). The graph below indicates the turbidity event was likely a result of the stage level increase from significant rainfall. These factors likely increased the amount of material in the water body for a short period of time.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

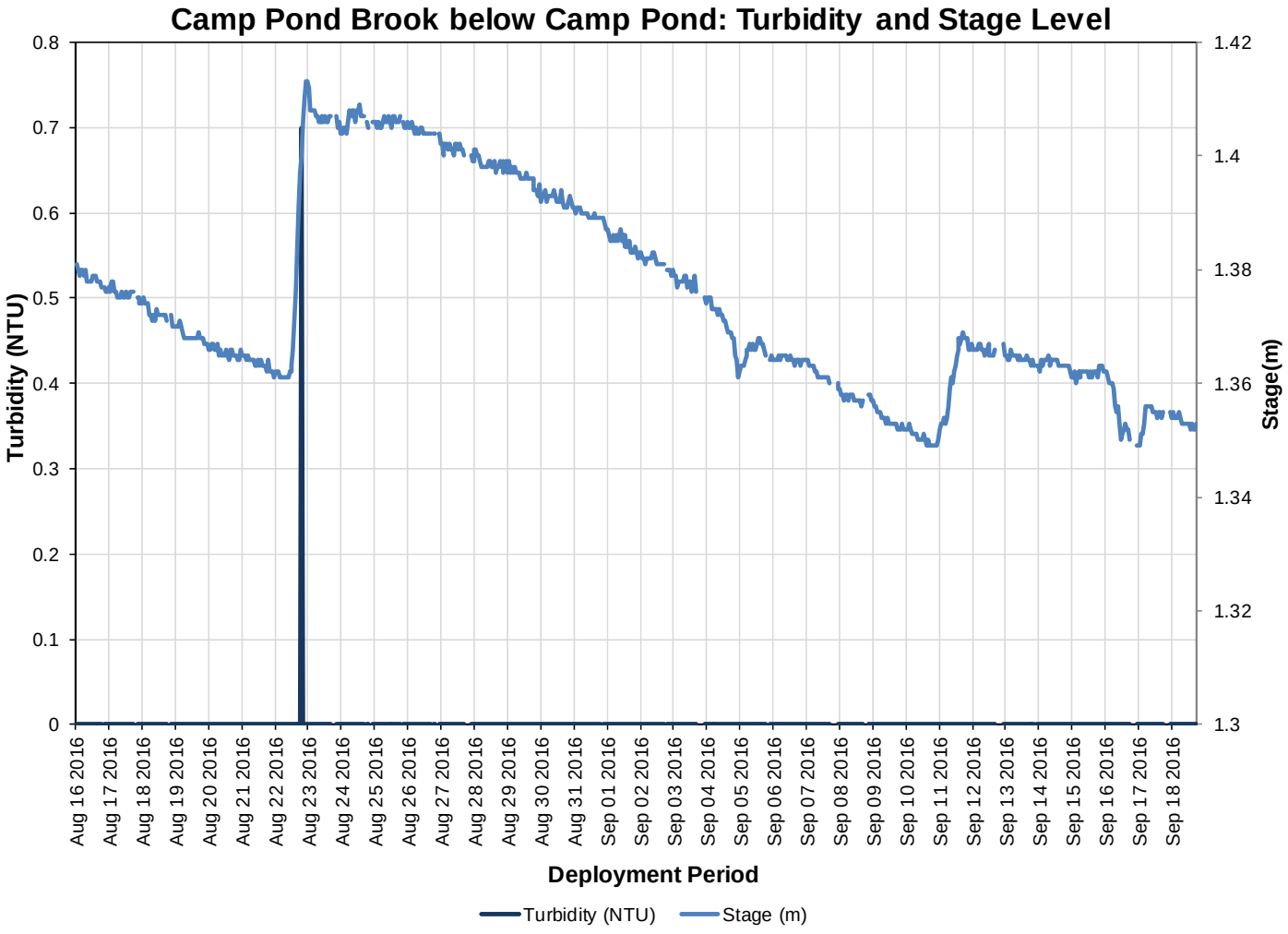


**Figure 14: Turbidity & Stage Level at Camp Pond Brook below Camp Pond**

### Stage, Streamflow and Precipitation

WSC (Environment and Climate Change Canada) is responsible for QAQC of water quantity data (stage and flow). Corrected data can be obtained upon request. During the deployment period, the stage values ranged from 1.35m to 1.41m. Streamflow had a minimum amount of 0.17$m^3$/s and a maximum flow of 0.36$m^3$/s.

Precipitation data was obtained from the Environment Canada weather station at Nain. The weather station is 30 km northeast of Voisey's Bay (Figure 15). Precipitation occurs on 17 days during the deployment period and amounts are small in magnitude, with the largest on August 23rd, 2016 accumulating 51.4 mm of precipitation.

Daily averaged stage, daily averaged streamflow and total precipitation are graphed below to show the relationship between rainfall and water level (Figure 15). These factors can influence changes in water quality parameters.

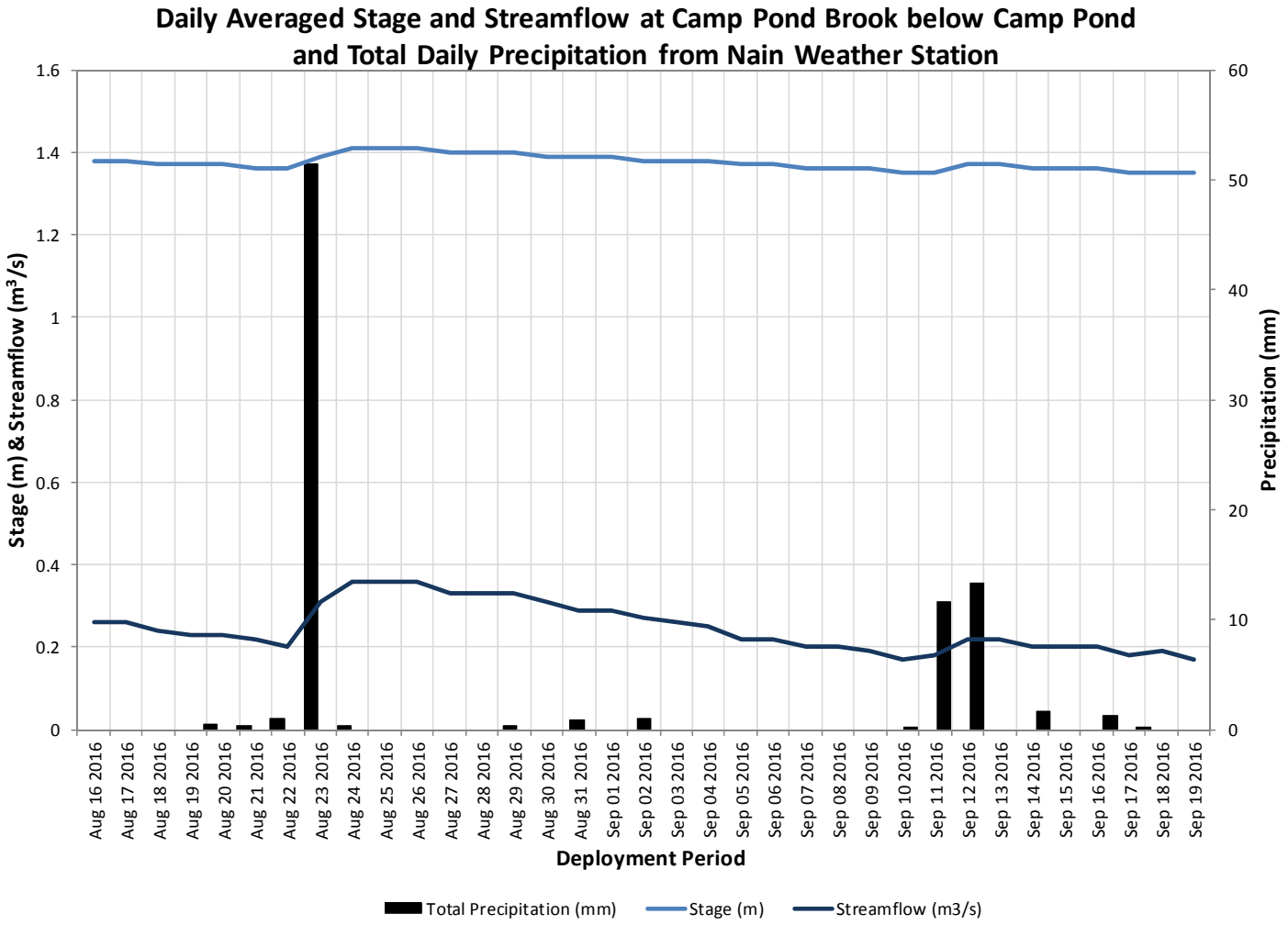


**Figure 15: Daily averaged stage, daily averaged streamflow at Camp Pond Brook below Camp Pond and Total Daily Precipitation (Nain, Labrador Weather Station)**

## Reid Brook below Tributary

### Water Temperature

Water temperature ranges from 3.67 °C to 15.65 °C, with a median value of 9.91 °C (Figure 16).

The water temperature at this station displays diurnal variations of the temperature. There is a spike in water temperature on September 4th, 5th and 6th, 2016 which corresponds with a decrease in the stage level. The increase in water temperature was likely a result of evaporation at this time of year (Figure 17).

This graph displays the relationship between stage decrease and water temperature increase. Temperature is influenced by the lower stage level and increases slightly for a short period of time.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

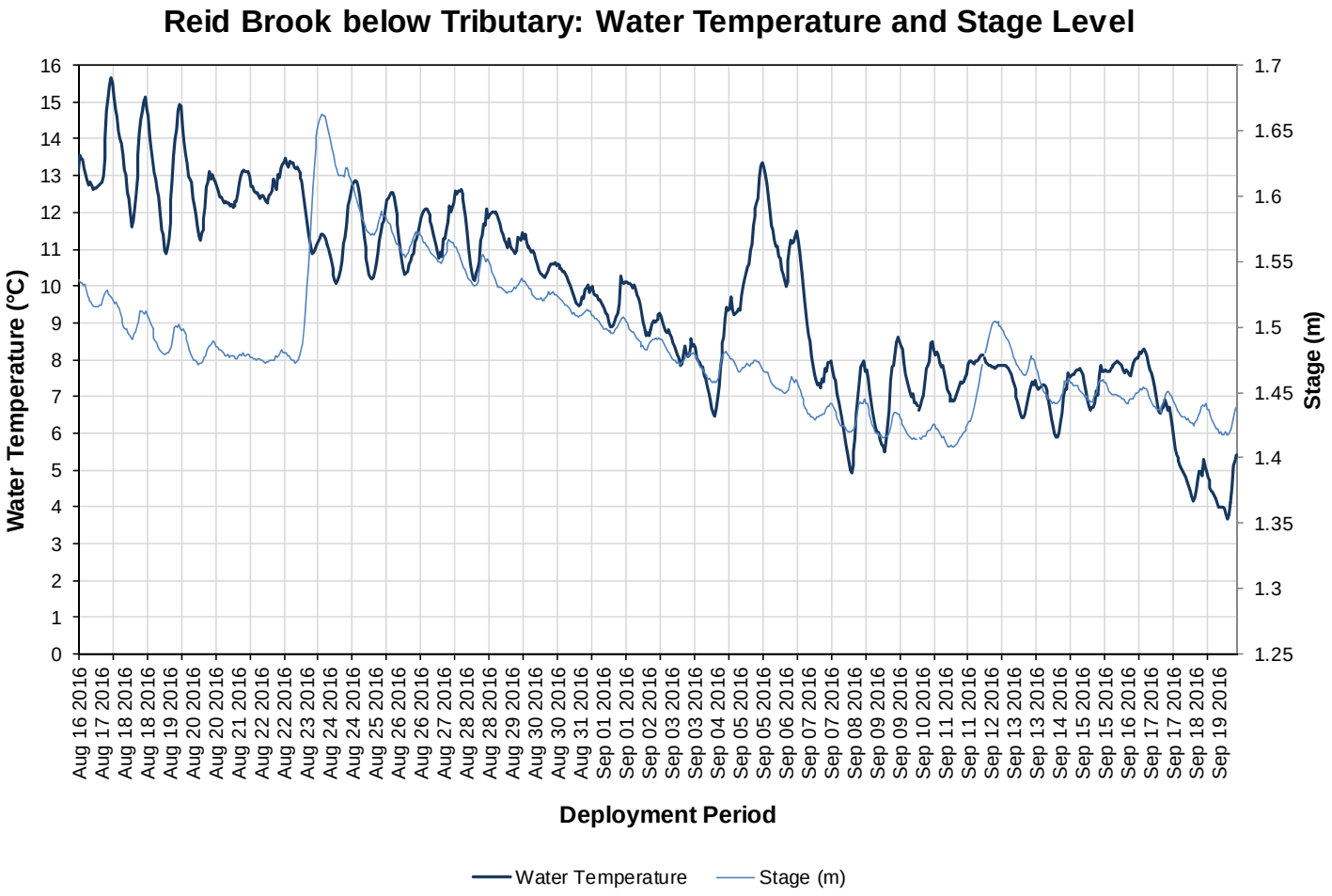


**Figure 16: Water Temperature & Stage Level at Reid Brook below Tributary**

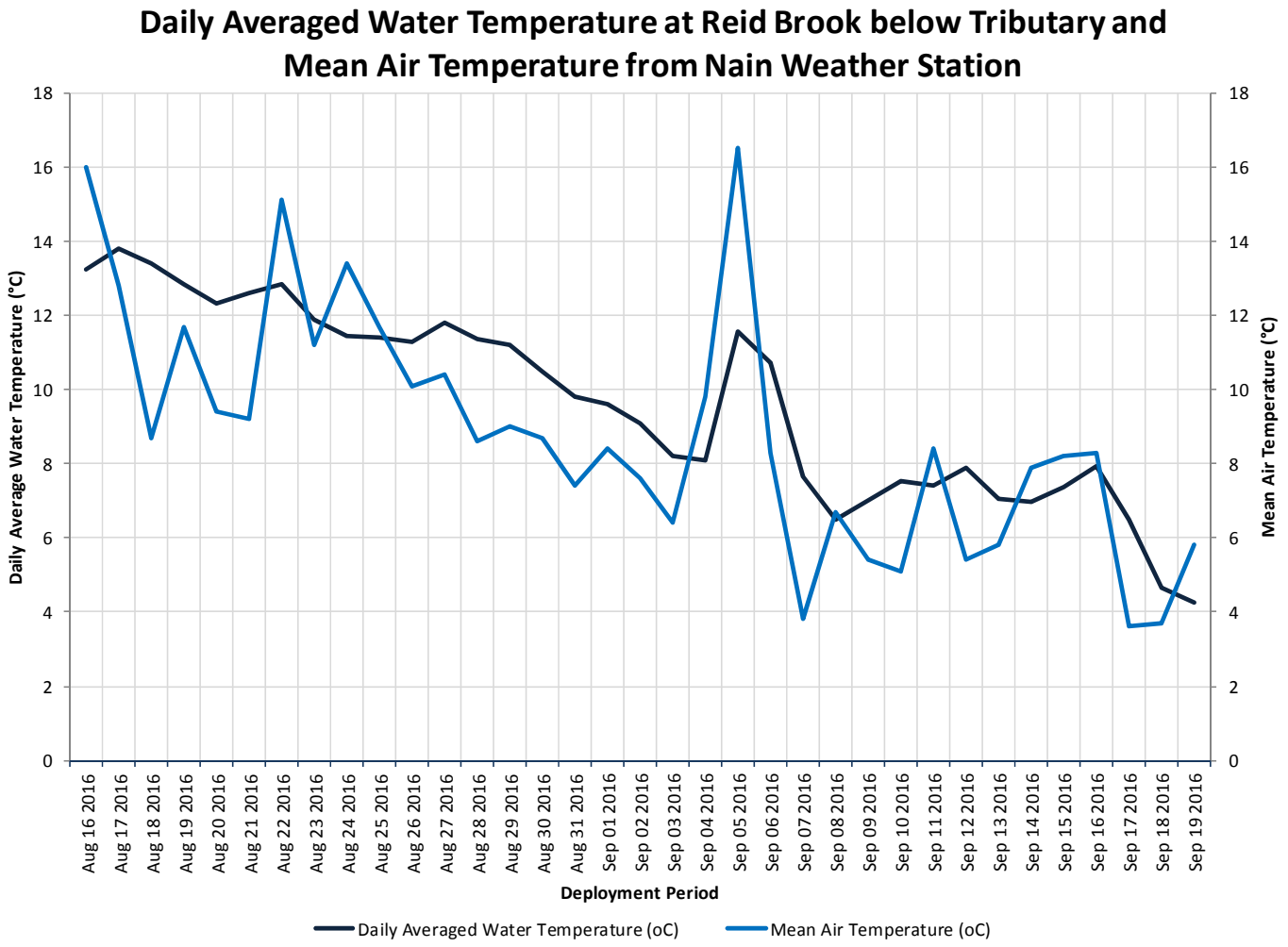


**Figure 17: Daily Averaged Water Temperature at Reid Brook below Tributary and Mean Air Temperature from Nain Weather Station**

**pH**

During this deployment this station had a pH range from 6.91 to 7.58 pH units, with a median value of 7.38 (Figure 18).

The pH data remains within the CCME guidelines for aquatic life. During stage increases pH levels will dip slightly. The stage increases are likely a result of precipitation and the addition of rain water cause the water to become slightly more acidic therefore the pH drops. Overall the pH levels at this station are consistent.

The Canadian Council of Ministers of the Environment (CCME) guidelines are just a basis by which to compare any dramatic change in the pH data within a dataset. Every brook is different with its own natural baseline.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

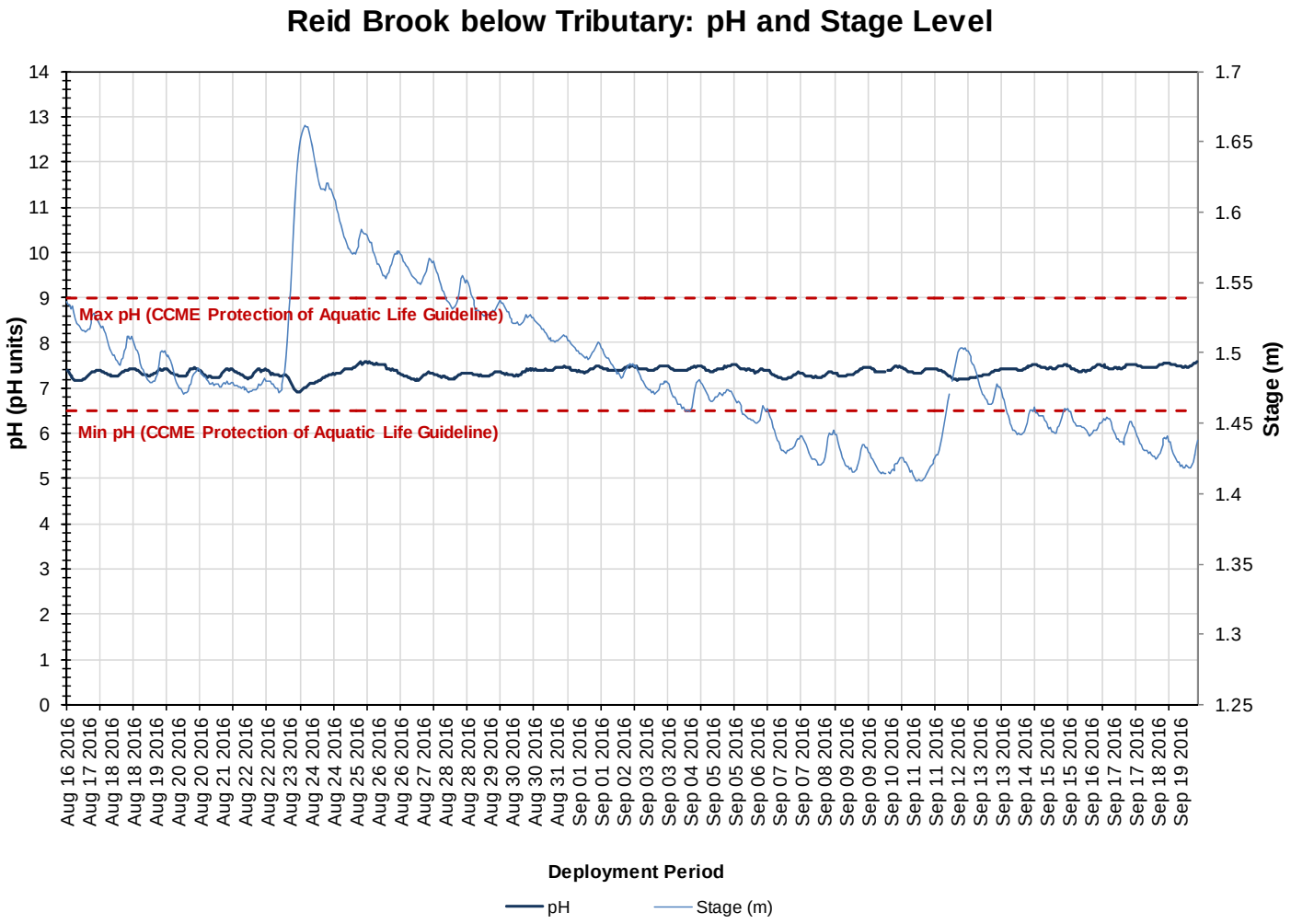


**Figure 18: pH & Stage at Reid Brook below Tributary**

**Specific Conductivity**

Specific conductivity ranges from 27.8µS/cm to 40.5µS/cm with a median of 34.7µS/cm. (Figure 19).

As stage level increases, the specific conductivity of the water decreases likely a result of the higher volume of water flushing the dissolved solids through the brook. This relationship is evident on August 22nd and September 12th 2016 for a short period of time (Figure 19).

Over the deployment period the conductivity levels are gradually increasing. This is to be expected as the water level drop slightly due to the warmer air temperature and less precipitation occurring at this time of year. This trend is typically experienced at this site (Figure 19).

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

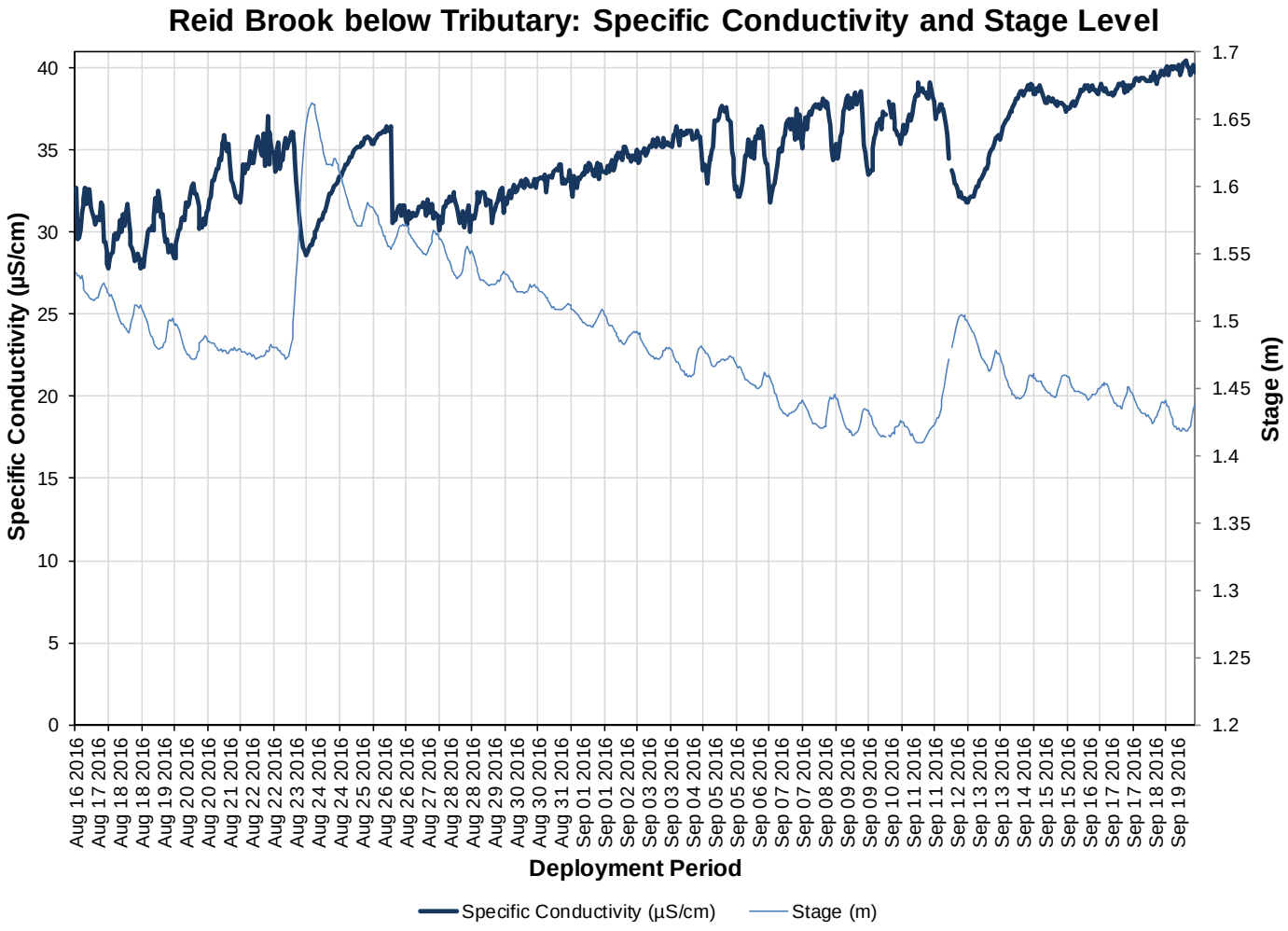


**Figure 19: Specific Conductivity & Stage at Reid Brook below Tributary**

### Dissolved Oxygen

Dissolved oxygen content ranges between 9.81mg/l and 12.81mg/l during the deployment period. The saturation of dissolved oxygen ranges from 92.6% to 103.9% (Figure 20). 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 (Figure 20).

During this deployment the dissolved oxygen concentration remained above the CCME guideline of 9.5mg/L. The dissolved oxygen levels were reasonably consistent; there were small dips in dissolved oxygen that correspond with changes in water temperature at the same time.

Toward the end of the deployment the dissolved oxygen concentration increases, this change is reflected in the drop in water temperature for the same time frame. The lower temperature allows for more dissolved oxygen to be present in the water body.

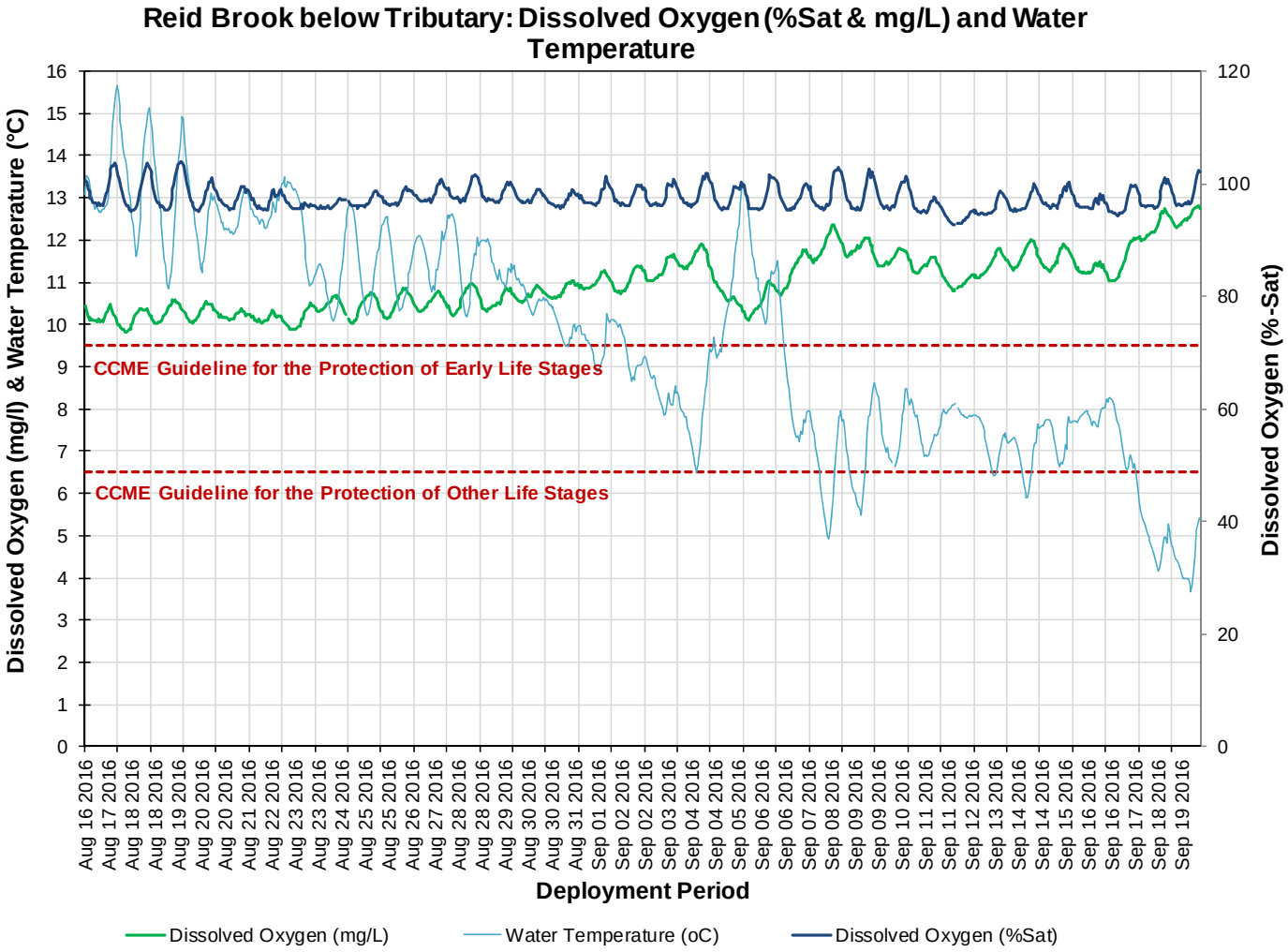


**Figure 20: Dissolved Oxygen (%Sat & mg/L) and Water Temperature at Reid Brook below Tributary**

**Turbidity**

Turbidity ranges from 0.0 NTU to 64.5 NTU during the deployment period, with a median value of 0.0NTU (Figure 21).

A median value of 0.0 NTU indicates there is very little natural background turbidity. There were a few low - medium turbidity events at this station throughout the deployment. The turbidity spikes correlate with an increase in stage level and likely a result of precipitation causing the mixing of solids in the water column (Figure 21).

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

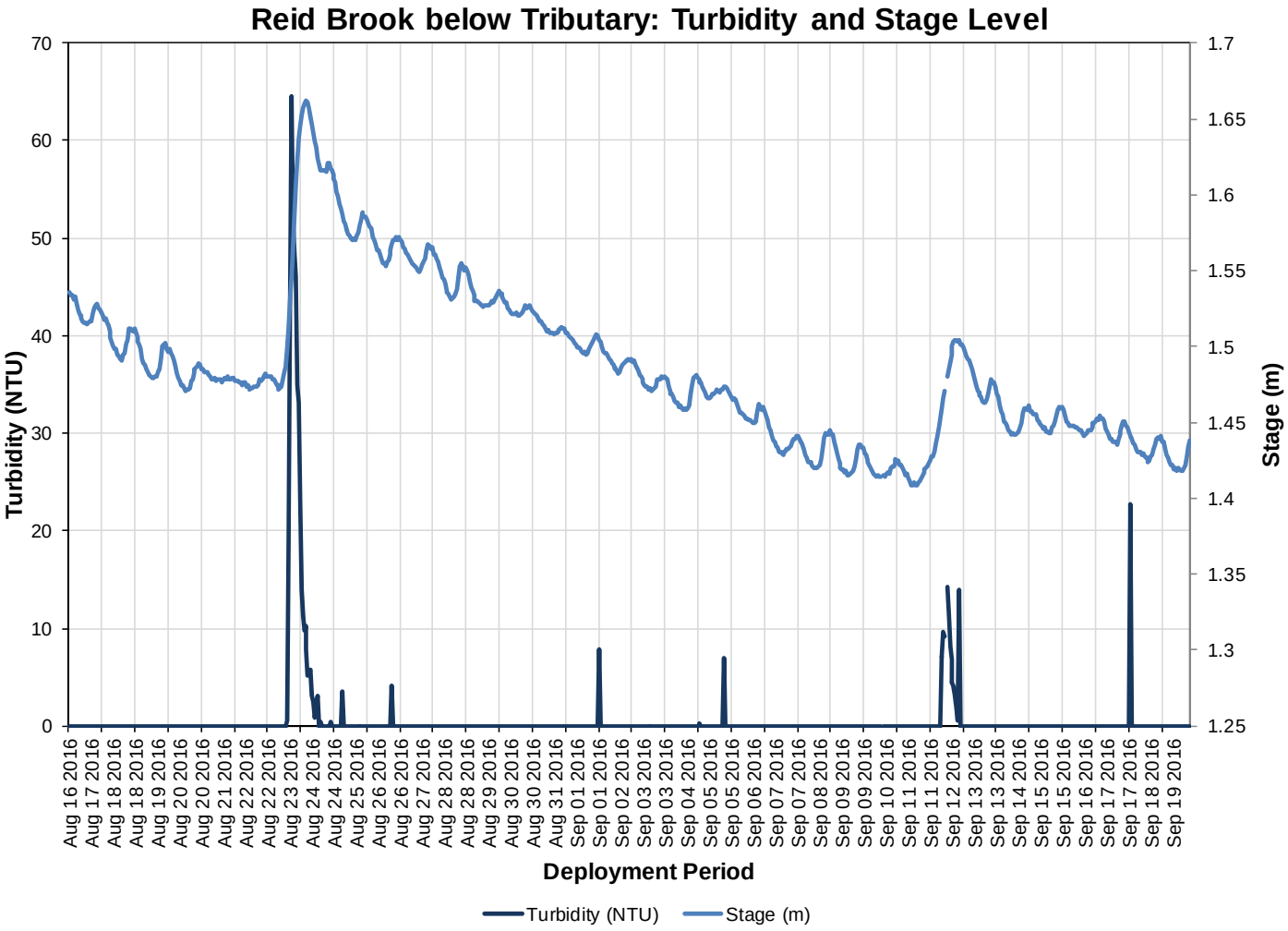


**Figure 21: Turbidity and Stage Level at Reid Brook below Tributary**

### Stage, Streamflow and Precipitation

Stage, streamflow and precipitation are graphed below to show the relationship between rainfall and water level (Figure 22). It is evident that the peaks in stage (m) and streamflow ($m^3/s$) data are a result of precipitation.

Precipitation data was obtained from the Environment Canada weather station at Nain. The weather station is 30 km northeast of Voisey's Bay. Precipitation occurs on 12 days during the deployment period and amounts are small in magnitude, with the exception of the largest on August 23rd, 2016 with 51.4 mm of rain.

During the deployment period, the stage values ranged from 1.41m to 1.66m. Streamflow had a minimum amount of $1.04m^3/s$ and a maximum flow of $6.46m^3/s$.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

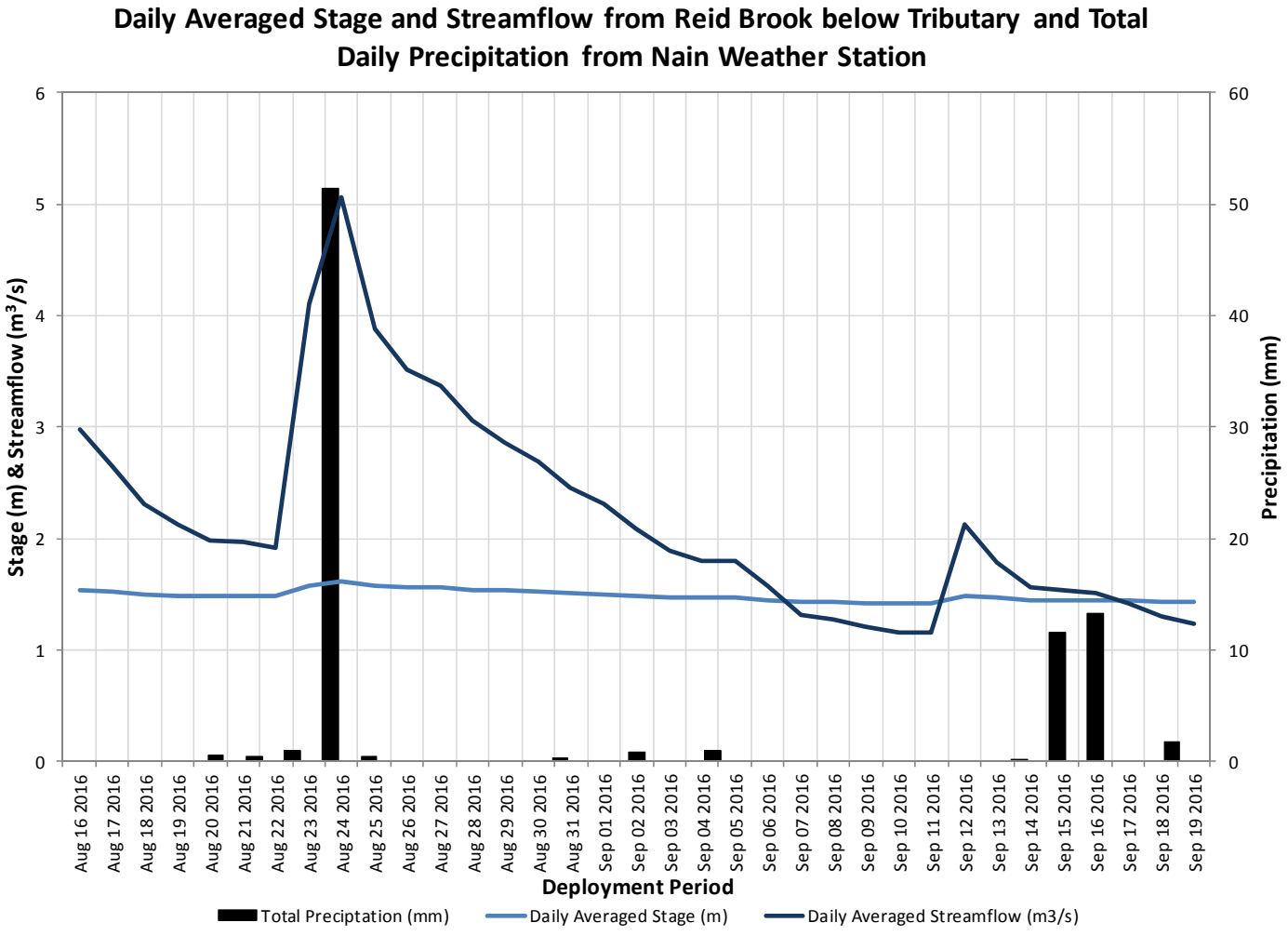


**Figure 22: Daily averaged stage and Daily averaged streamflow at Reid Brook below Tributary and Total Daily Precipitation from Nain, Labrador Weather Station**

## Tributary to Reid Brook

### Water Temperature

Water temperature ranges from 3.60 °C to 12.90 °C, with a median value of 9.50°C (Figure 23).

Streams and brooks are sensitive to changes in the ambient air temperature, thus water temperature will fluctuate considerably depending on the weather and the time of day (Figure 24). This is evident at this station with the low dips in water temperature during the higher stage increases. It is likely that there was a rainfall event at this time.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

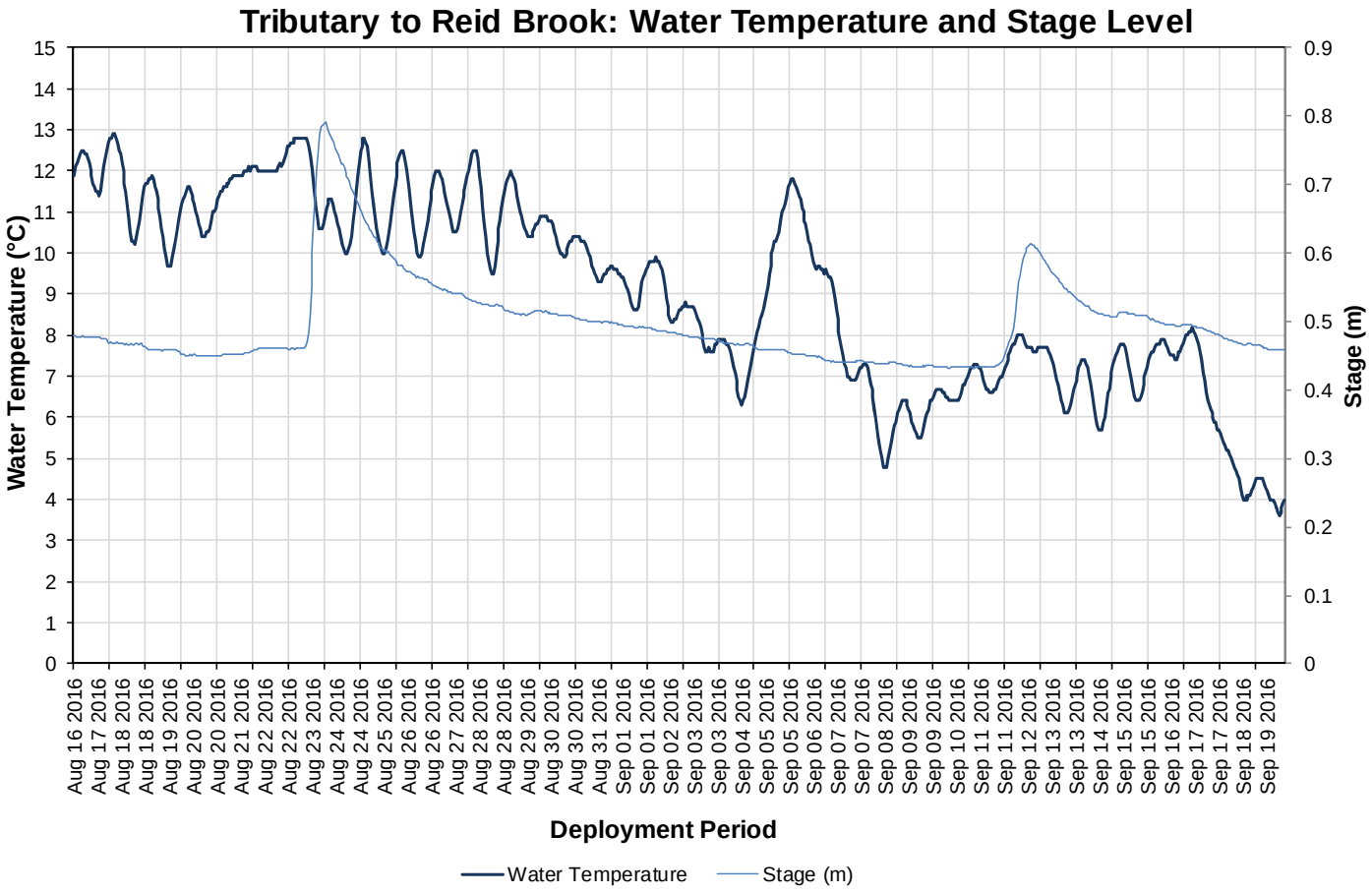


**Figure 23: Water Temperature and Stage at Tributary to Reid Brook**

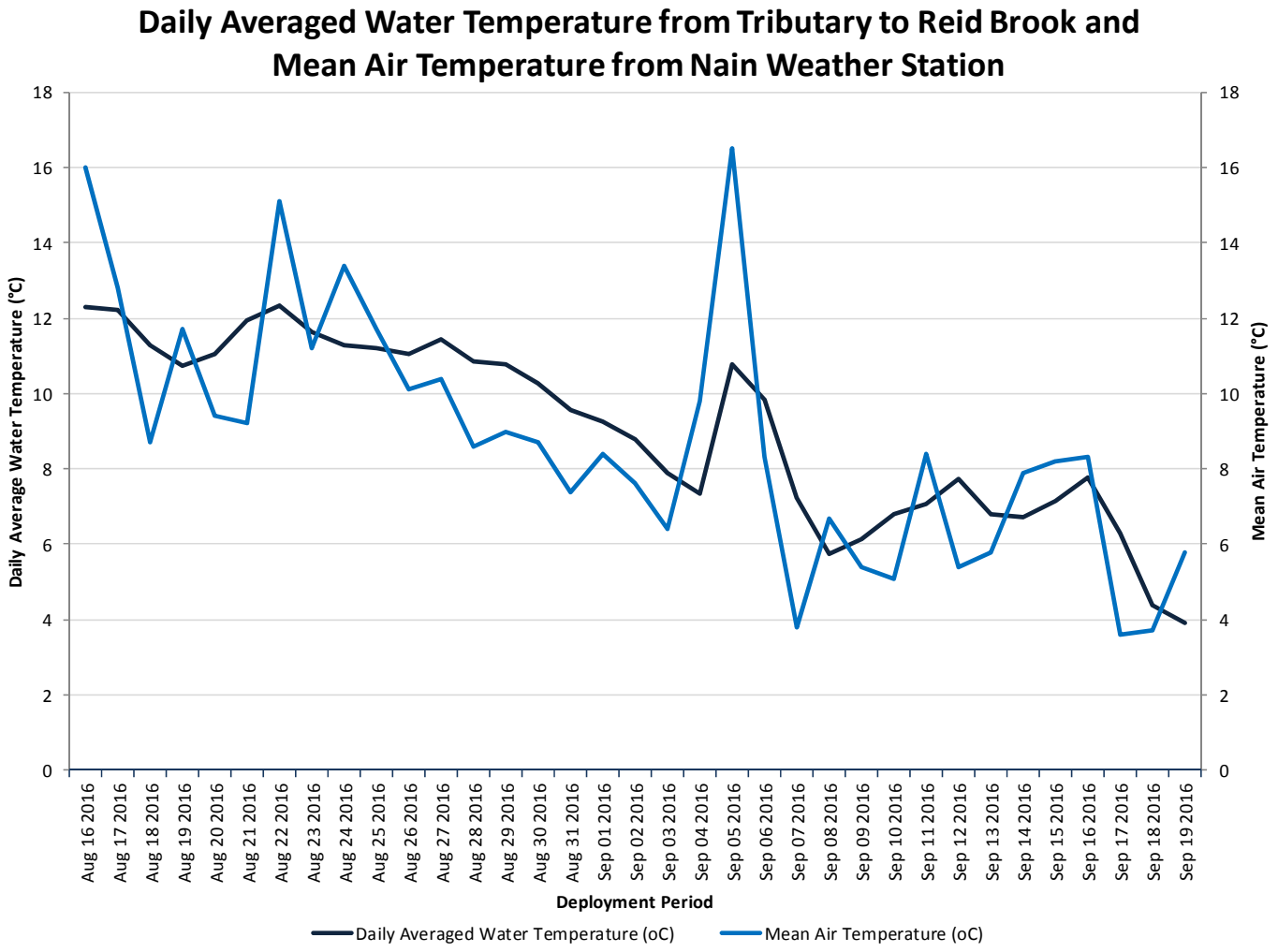


**Figure 24: Daily Average Water Temperature at Tributary to Reid Brook and Mean Air Temperature from Nain Weather Station.**

**pH**

Over the deployment period the pH values ranged from 6.08 to 7.04 pH units, with a median value of 6.74 (Figure 25).

The pH values stayed within the CCME guidelines expect during the high stage events. Stage increases can indicate a rainfall event, and rainfall will influence the pH values to decrease for a short period of time (Figure 25). This is evident on Figure 25 on the dates August 23rd and September 11th and 12th 2016.

The CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams are different and have natural baseline conditions.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

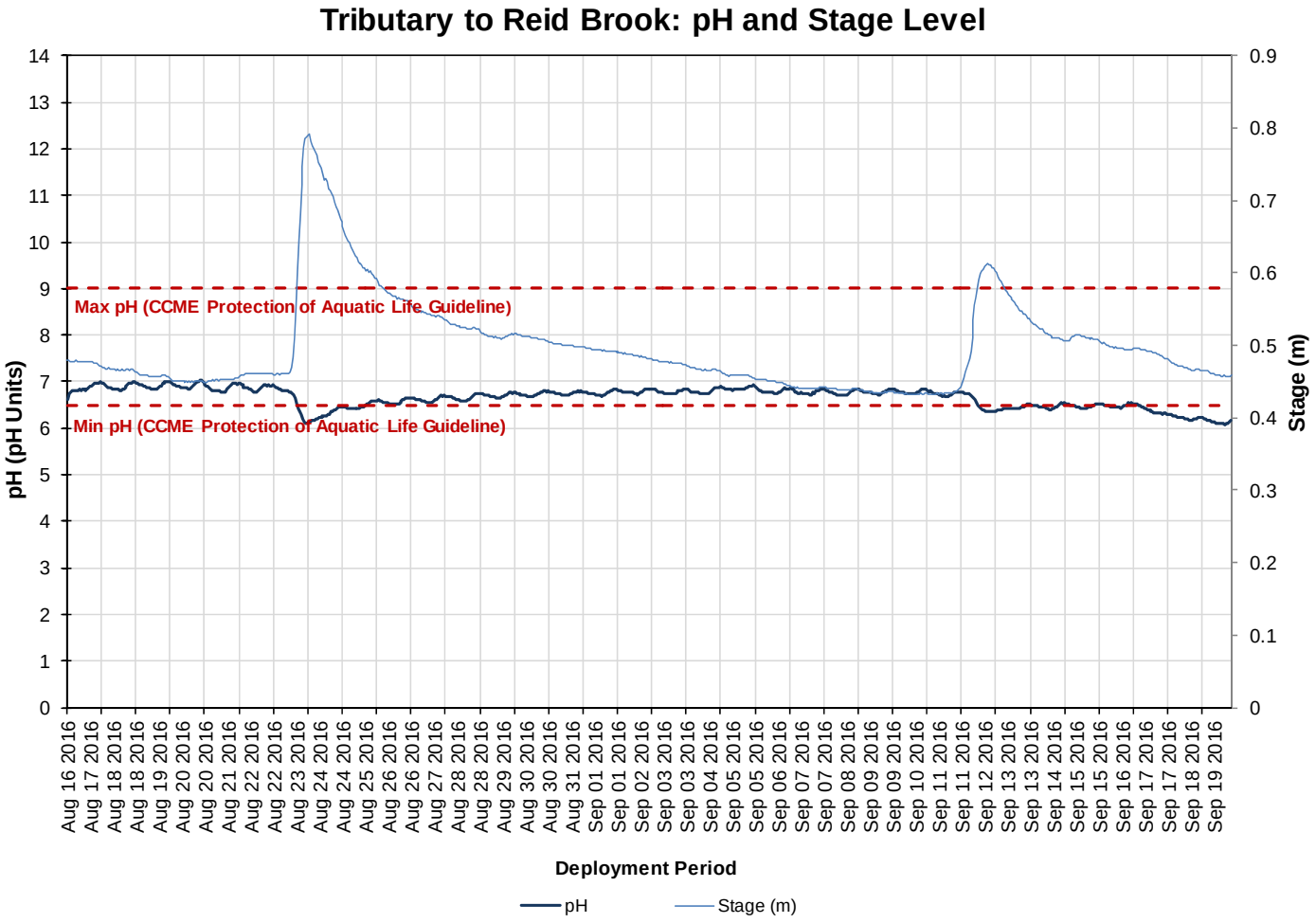


**Figure 25: pH & Stage Level at Tributary to Reid Brook**

**Specific Conductivity**

Specific conductivity ranges from 25.2µS/cm to 41.2µS/cm with a median of 36.8µS/cm. (Figure 26).

The relationship between specific conductance and stage is inversed. When stage level rises, the specific conductance level drops in response as the increased amount of water in the river system dilutes the solids that are present (Figure 26).

The large dips in specific conductivity on August 23rd and September 12th, 2016 were likely a result of rainfall.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

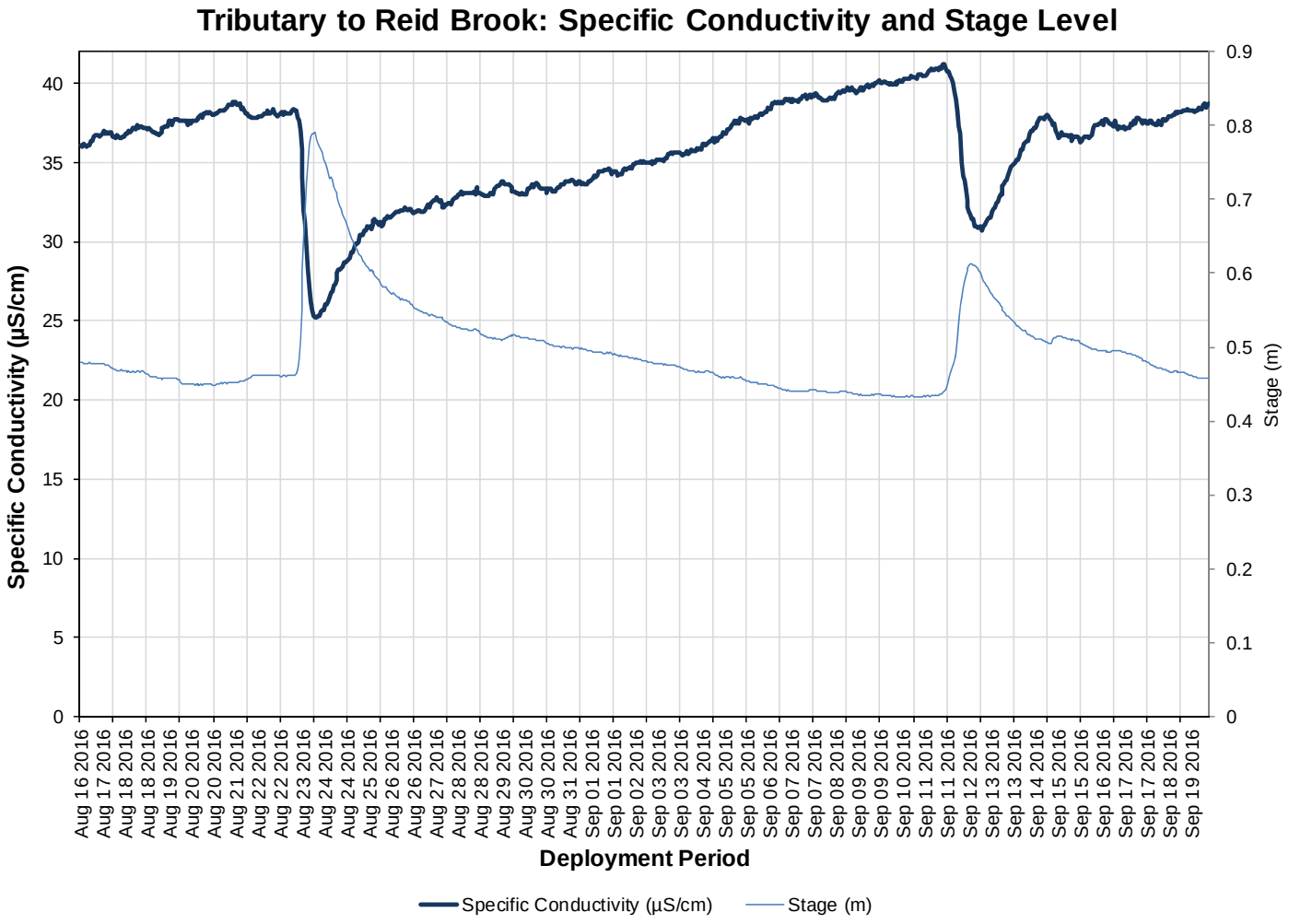


**Figure 26: Specific Conductivity & Stage at Tributary to Reid Brook**

### Dissolved Oxygen

Dissolved oxygen content ranges between 9.97mg/l and 12.85mg/l during the deployment period. The saturation of dissolved oxygen ranges from 92.8% to 100.4% (Figure 27). 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 dissolved oxygen data levels remained above the CCME guidelines for the protection of early/other life stages (Figure 27). The larger dip in the dissolved oxygen concentration (mg/L) on September 5$^{th}$ corresponds with a spike in the water temperature.

Dissolved oxygen data also displays a diurnal pattern as the data is displayed. During nightfall the dissolved oxygen levels are higher, the cooler temperatures allow for more DO to be stored in the water column. During the day time the water temperatures are higher so there is less DO in the water column. During the day time aquatic organisms will also be using the dissolved oxygen present.

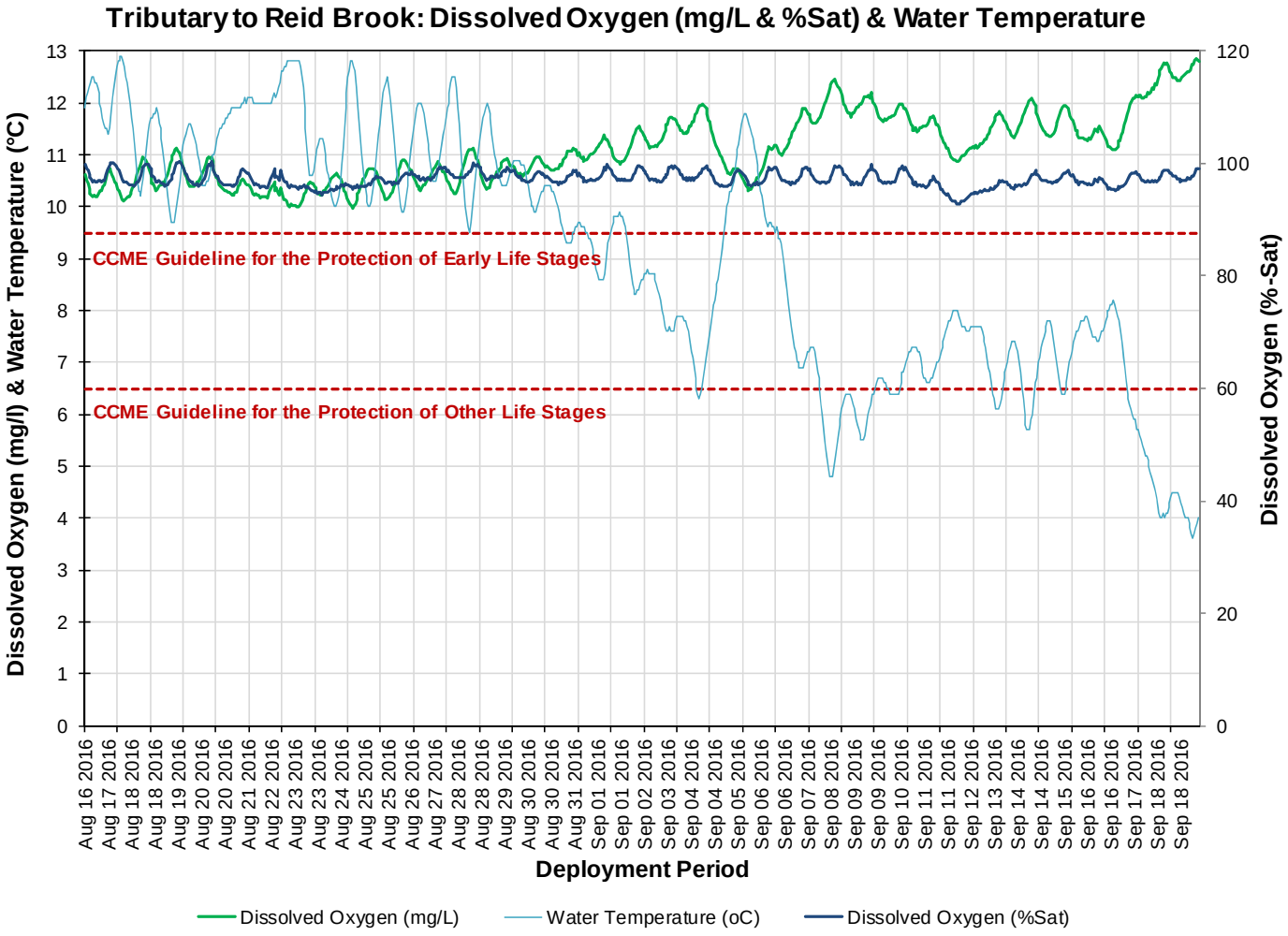


**Figure 27: Dissolved Oxygen & Water Temperature at Tributary to Reid Brook**

**Turbidity**

Turbidity ranges from 0.0 NTU to 100.2 NTU during the deployment period, with a median value of 0.0NTU (Figure 28). 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 medium turbidity events at this station throughout the deployment. The turbidity events correlate with an increase in stage level, likely a result of rainfall. The increase in water volume can stir up solids and materials in the water column (Figure 28).

This particular site has sandy-clay like bottom to the brook. This material is easily disturbed during rainfall events or large increases in stage.

Please note the stage data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC.

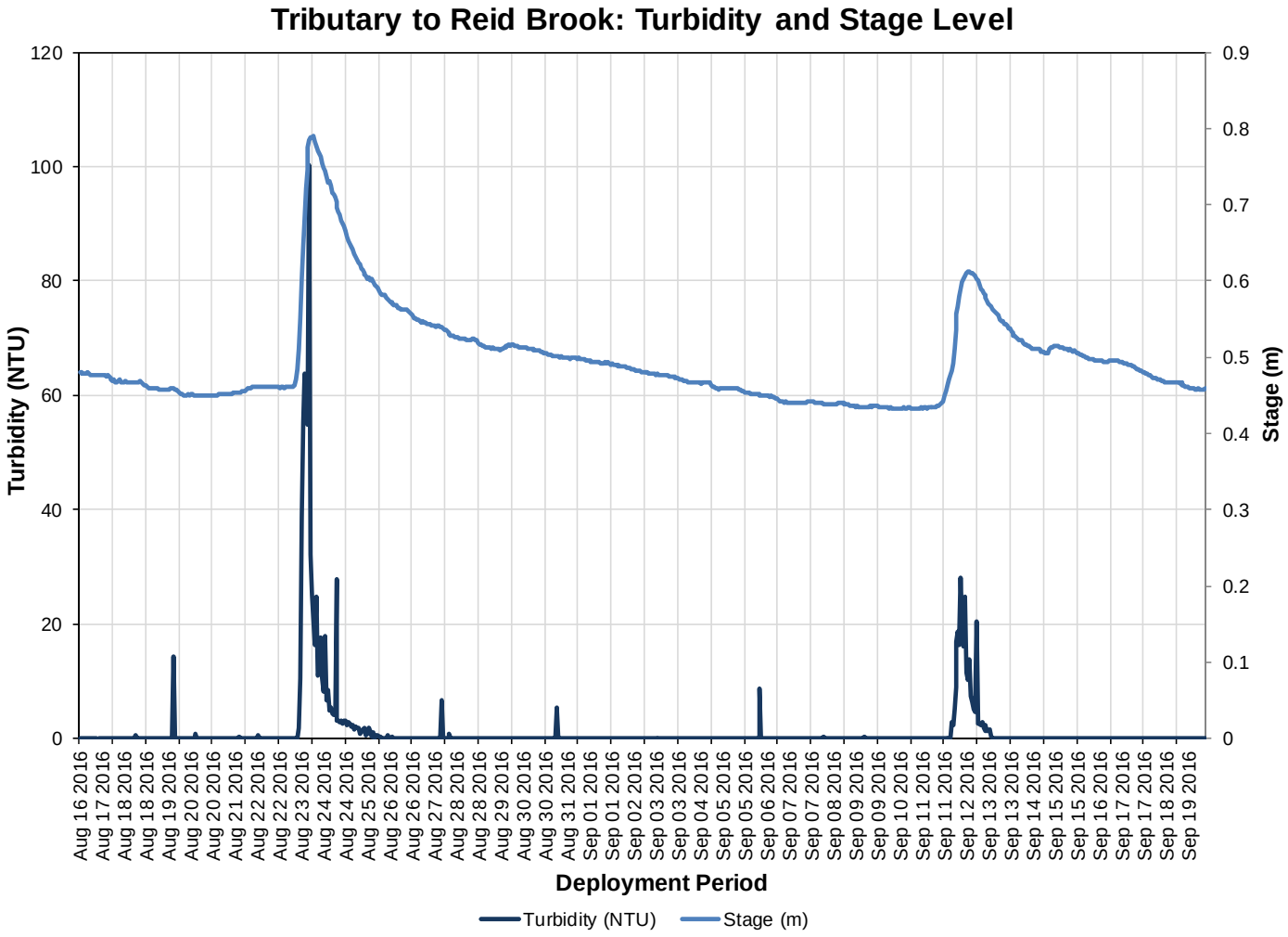


**Figure 28: Turbidity & Stage at Tributary to Reid Brook**

### Stage, Streamflow, and Precipitation

Please note the stage and streamflow data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data. Corrected data can be obtained upon request to WSC. Precipitation data was obtained from the Environment Canada weather station at Nain. The weather station is 30 km northeast of Voisey's Bay (Figure 29).

Precipitation occurs on 12 days during the deployment period and amounts are relatively small in magnitude, the largest rainfall occurs on August 23rd, 2016 with a total of 51.4mm

During the deployment period, the stage values ranged from 0.43m to 0.79m. Streamflow had a minimum amount of 0.10$m^3$/s and a maximum flow of 1.41$m^3$/s.

Daily averaged stage, streamflow and total precipitation are graphed below to show the relationship between rainfall and water level (Figure 29). It is evident that the peaks in stage (m) and streamflow data are a result of precipitation.

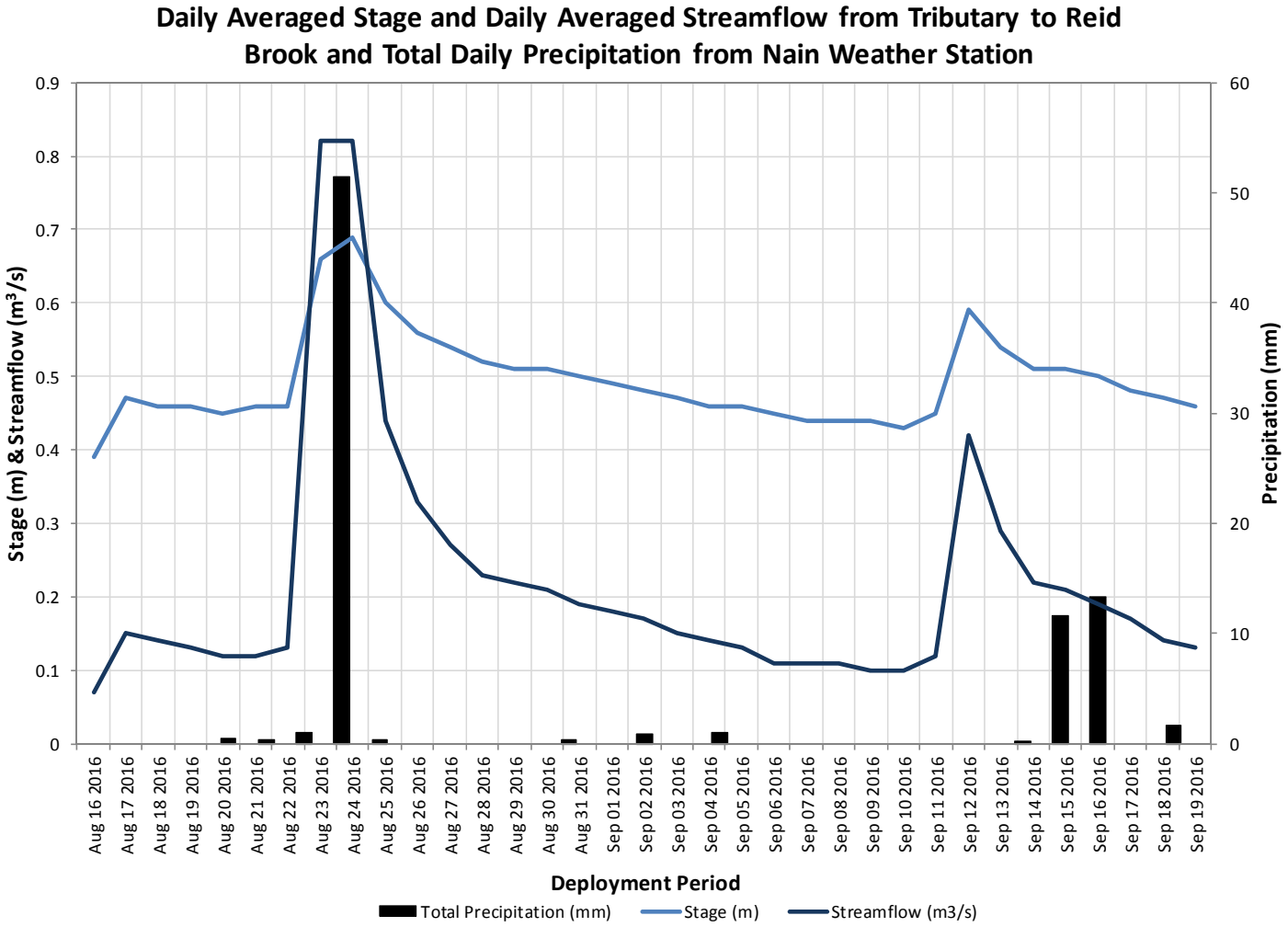


**Figure 29: Daily Averaged Stage and Streamflow at Tributary to Reid Brook and Total Daily Precipitation (Nain, Labrador Weather Station)**

## Conclusions

The overall water temperatures across all stations were within a minimum of 3.6°C found at Tributary to Reid Brook and a maximum of 19.38°C recorded at Camp Pond Brook below Camp Pond. Camp Pond Brook had the highest water temperature maximum from the previous deployment season. Overall the water temperature was decreasing across the network of stations as the air temperatures start to cool. 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 as these sites are brooks with continuously moving water. Reid Brook at Outlet of Reid Pond is a pond that has a larger surface area and is deeper. Ponds and lakes take a longer time to adjust to the ambient air temperature.

The pH values for this deployment ranged between a minimum of 6.08 pH units at Reid Brook below Reid Pond and Tributary to Reid Brook and a maximum of 7.58 pH units at Reid Brook below Tributary site. Throughout this season the pH at all of the stations was reasonably consistent. There were dips below the CCME guideline for the protection of aquatic life cycles; however the CCME guideline provides a basis by which to judge the overall health of the brook. Naturally, all streams are different and have varying ranges of normal. When there were changes in the pH values it was during high stage events, likely from rainfall.

The overall specific conductivity across all stations were within a minimum of 11.3 µS/cm at Reid Brook at Outlet of Reid Pond and a maximum value of 64 µS/cm at Camp Pond Brook below Camp Pond. These two stations also had the lowest conductivity minimum and highest conductivity maximum from the July to August 2016 deployment. Conductivity values at Reid Brook at Outlet of Reid Pond were the lowest across deployment when compared to the other stations. Camp Pond Brook below Camp Pond maintains the highest median at 38.7µS/cm, however this is to be expected with Camp Pond Brook being closer to the mine site and has an increased potential for roadway runoff and other anthropogenic influences.

Dissolved oxygen levels for the deployment period ranged between a minimum of 8.75 mg/l at Camp Pond Brook below Camp Pond and a maximum of 12.85 mg/l found at Tributary to Reid Pond. Camp Pond Brook below Camp Pond also had the highest DO mg/L maximum from the July to August 2016 deployment season. Dissolved oxygen is lower at this time of year and varies diurnally as water temperature is greatly affected by ambient air temperature.

Turbidity levels for the four real-time stations ranged within a minimum of 0.0 NTU from all stations and a maximum of 100.2 NTU at Tributary to Reid Brook. Tributary to Reid Brook site has sandy-clay like bottom to the brook. This material is easily disturbed during rainfall events or large increases in stage. It is likely the cause of why this brook has the highest maximum turbidity data for this deployment.

Overall the changes in the water quality for this deployment can be explained by natural events. Camp Pond Brook below Camp Pond does have the potential for anthropogenic influences as the site is the closest to the inhabited area. It is important to note that during a change (a decrease or increase) in the water quality the change only occurs for a short period of time and the water quality parameters do return to the original state.

# APPENDIX A: Comparison Graphs

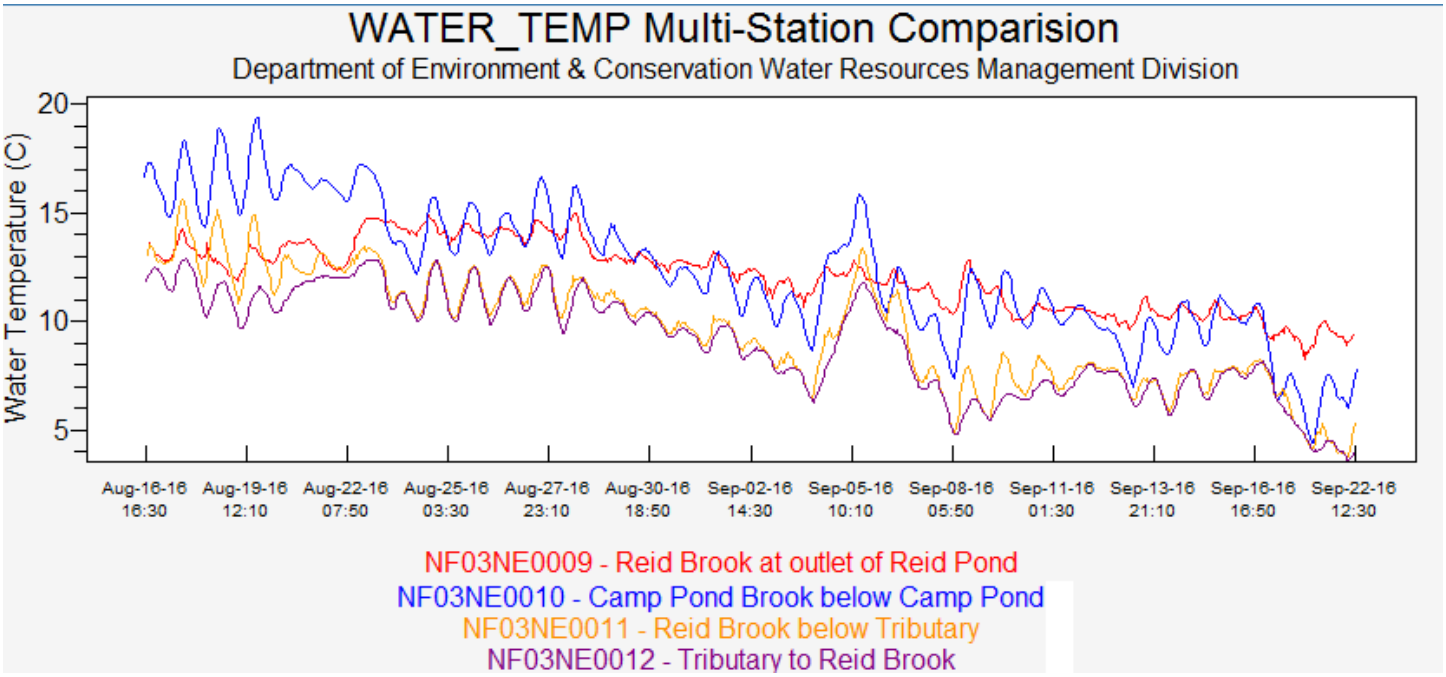


**Figure A1: Comparison of Water Temperature at the Real-Time Stations in Voisey's Bay**

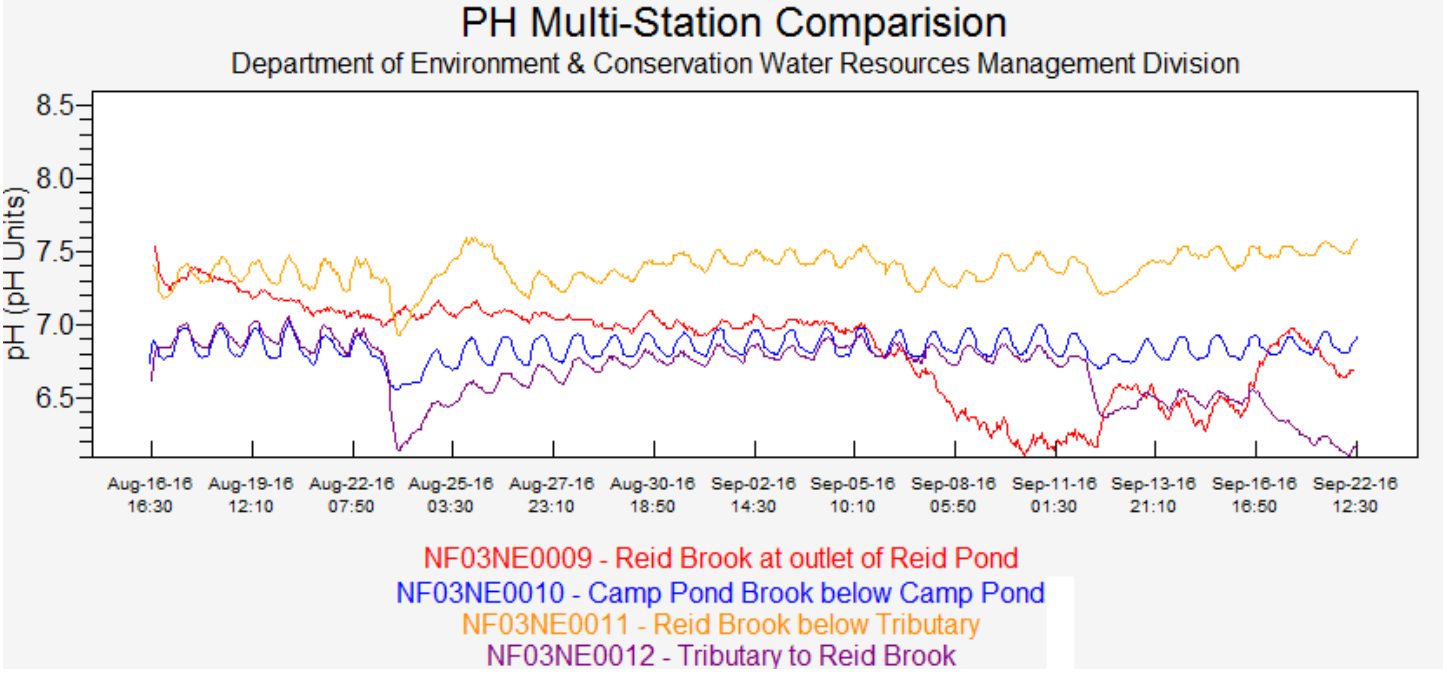


**Figure A2: Comparison of pH at the Real-Time Stations in Voisey's Bay**

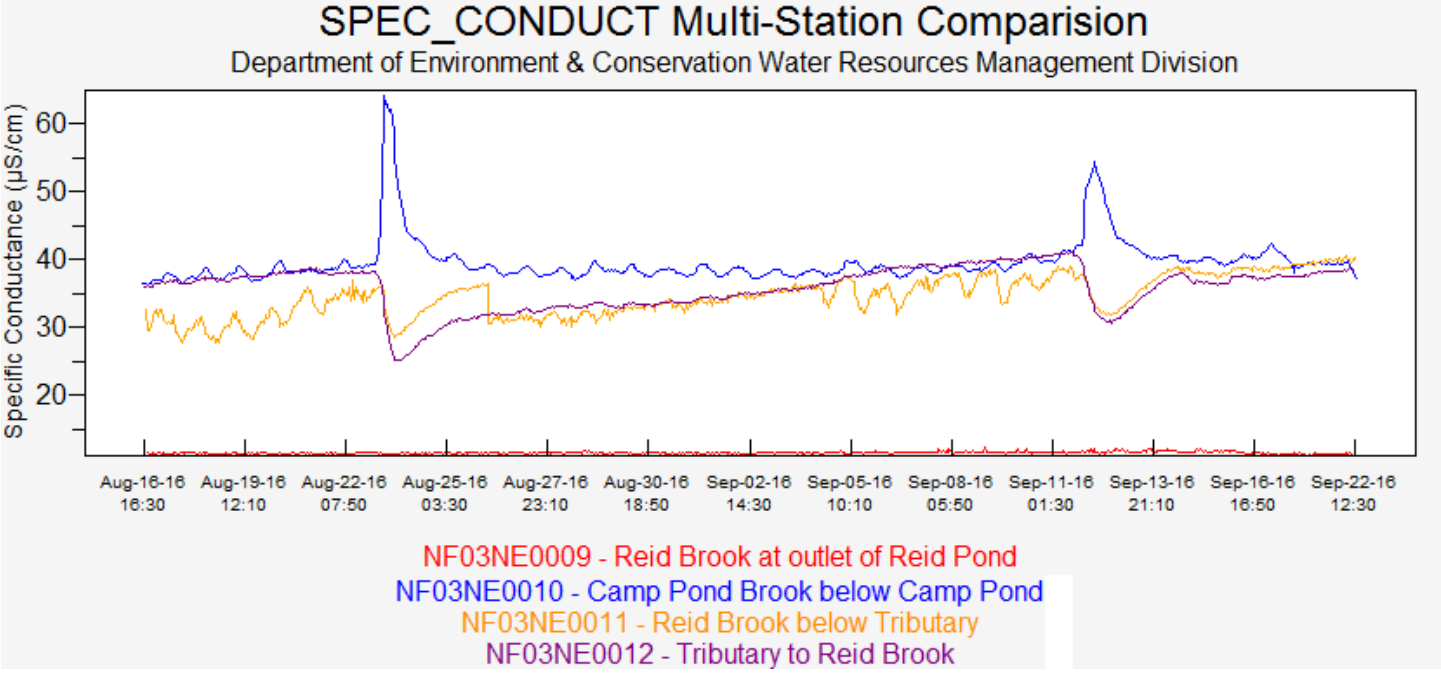


**Figure A3: Comparison of Conductivity at the Real-Time Stations in Voisey's Bay**

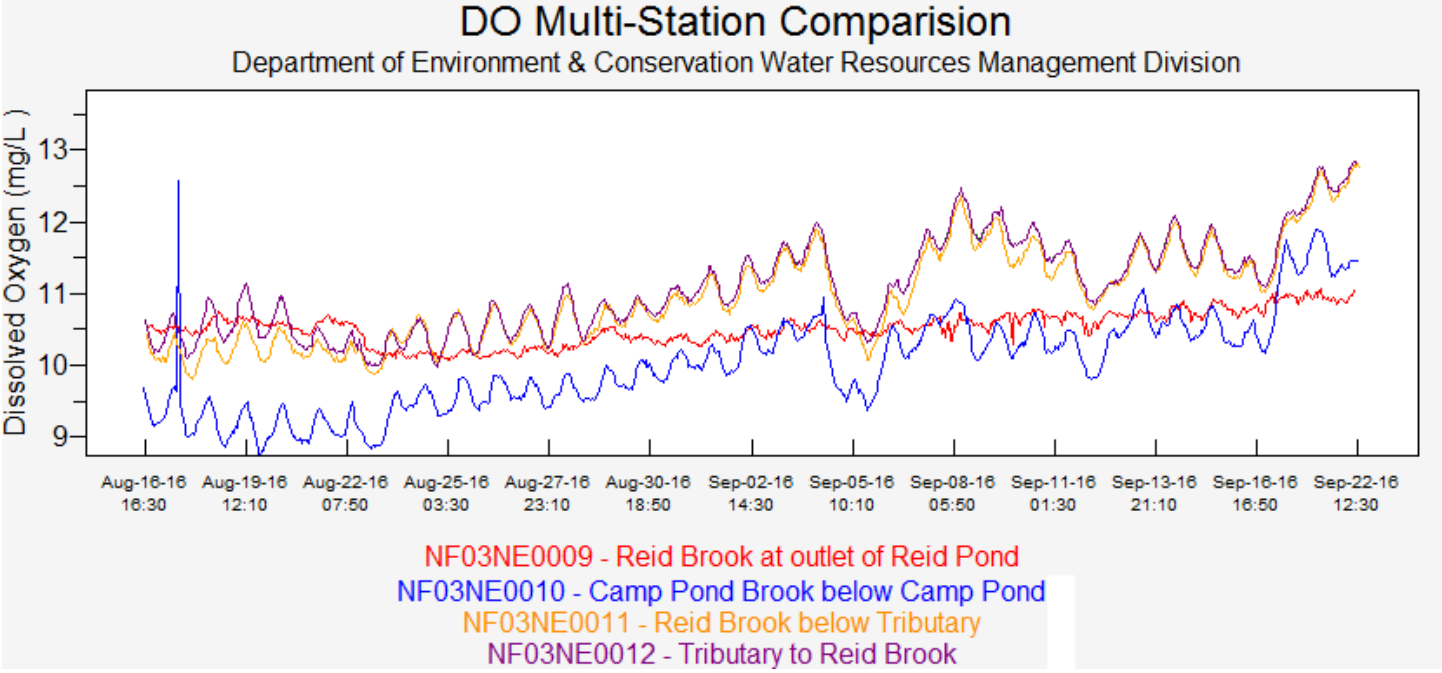


**Figure A4: Comparison of Dissolved Oxygen (mg/L) at the Real-Time Stations in Voisey's Bay**

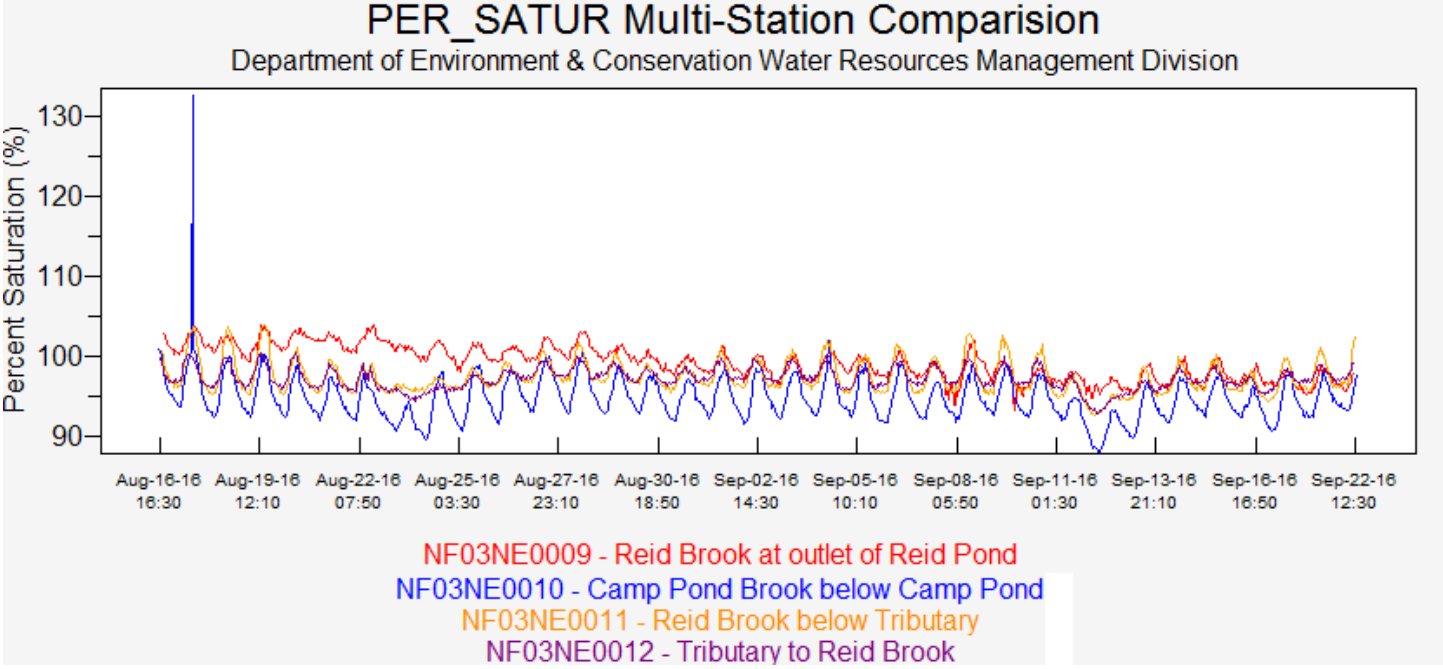


**Figure A5: Comparison of Dissolved Oxygen (%Sat) at the Real-Time Stations in Voisey's Bay**

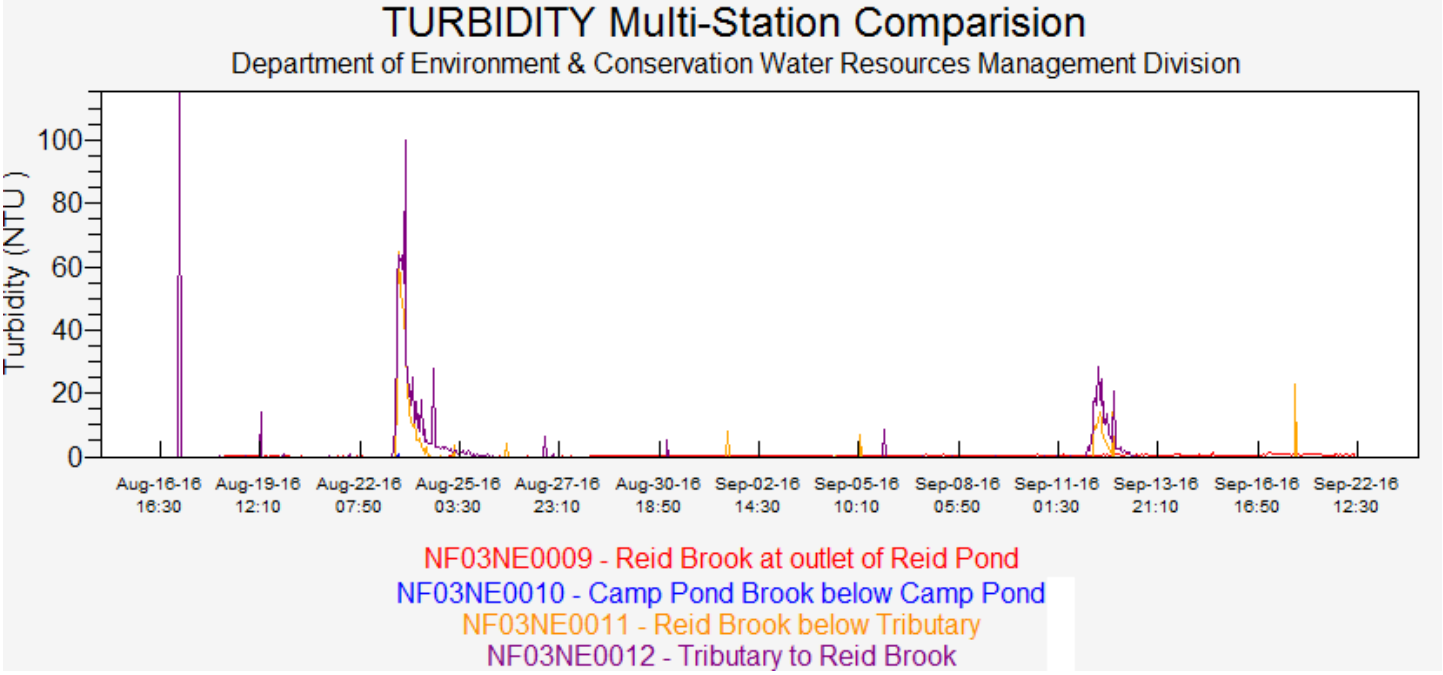


**Figure A6: Comparison of Turbidity at the Real-Time Stations in Voisey's Bay. (The circled Reid Brook below Tributary turbidity data was removed for the report).**

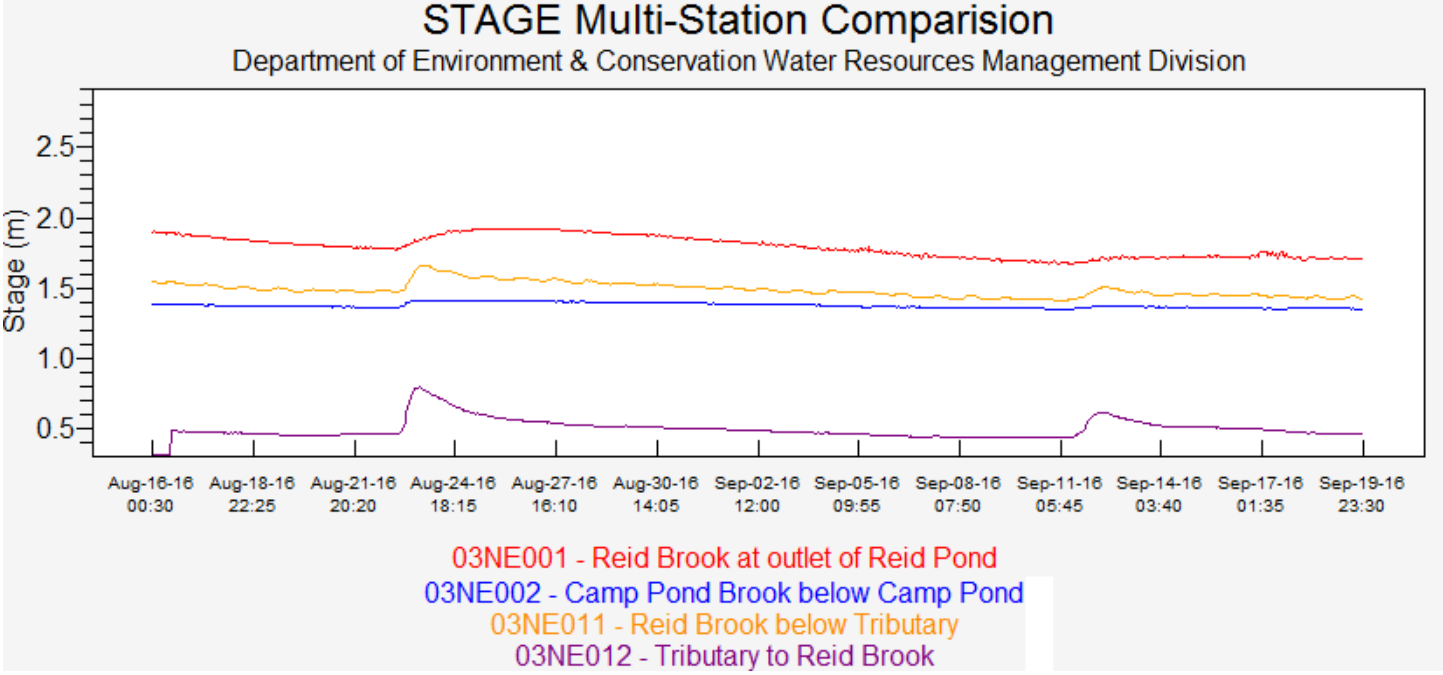


**Figure A7: Comparison of Stage (m) at the Real-Time Stations in Voisey's Bay. Please note the stage and streamflow data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.**

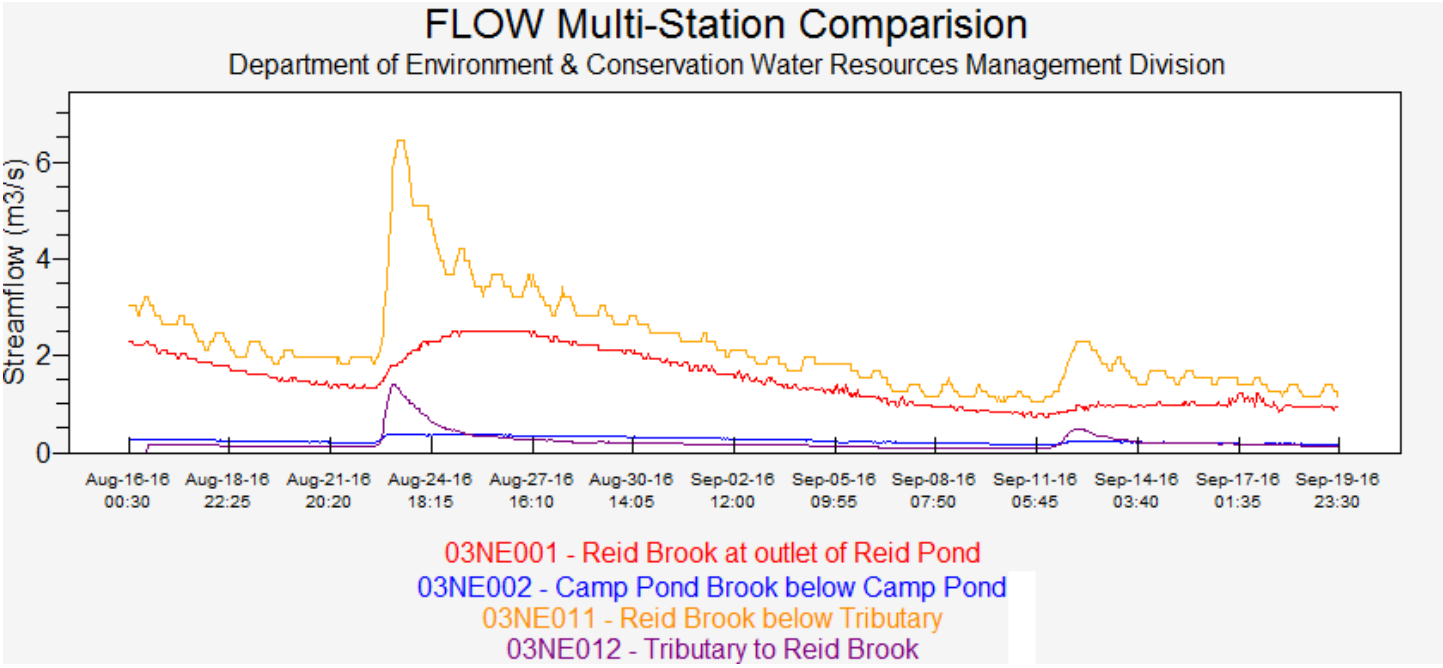


**Figure A8: Comparison Flow ($m^3/s$) at the Real-Time Stations in Voisey's Bay. Please note the stage and streamflow data on the graph below, is raw data. It has not been corrected for backwater effect. WSC is responsible for QA/QC of water quantity data.**

# APPENDIX B: Water Parameter Description

**Dissolved Oxygen**: The amount of Dissolved Oxygen (DO) (mg/l or % saturation) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (CCME 2014).

**Flow:** Flow (m3/s) is a measure of how quickly a volume of water is displaced in streams, rivers, and other channels.

**pH:** pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of $CO_2$ (CCME 2014).

**Specific conductivity:** Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25°C. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Swanson and Baldwin 1965).

**Stage:** Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

**Temperature:** Essential to the measurement of most water quality parameters, temperature (°C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (OTT Hydromet 2017).

**Total Dissolved Solids:** Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (CCME 2014; Swanson and Baldwin 1965).

**Turbidity:** Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Sadar, 2017).

# APPENDIX C: Water Parameter Description

Maxxam Job #: B6I0658
Report Date: 2016/09/09

Department of Environment & Conservation
Your P.O. #: 215062145-2

| Sample Details/Parameters | Result | RDL | UNITS | MU | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| CYH417 Reid Brook @ Outlet to Reid Pond | | | | | | | | |
| Sampling Date 2016/08/16 18:00 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2016-6408-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Calculated TDS | 8.0 | 1.0 | mg/L | N/A | 2016/09/08 | 2016/09/08 | | 4634209 |
| Hardness (CaCO3) | 4.6 | 1.0 | mg/L | N/A | 2016/08/30 | 2016/08/30 | | 4634202 |
| **Inorganics** | | | | | | | | |
| Dissolved Chloride (Cl) | <1.0 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | DRM | 4648813 |
| Conductivity | 12 | 1.0 | uS/cm | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636077 |
| Nitrite (N) | <0.010 | 0.010 | mg/L | N/A | 2016/09/08 | 2016/09/08 | C_N | 4648807 |
| Nitrate (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/08 | 2016/09/08 | C_N | 4648807 |
| Nitrate + Nitrite (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/08 | 2016/09/08 | C_N | 4648807 |
| Bromide (Br-) | <1.0 | 1.0 | mg/L | N/A | 2016/08/27 | 2016/08/27 | FD | 4637053 |
| Total Alkalinity (Total as CaCO3) | 5.3 | 5.0 | mg/L | N/A | 2016/08/31 | 2016/08/31 | NRG | 4642146 |
| Total Ammonia-N | <0.050 | 0.050 | mg/L | N/A | 2016/09/07 | 2016/09/07 | COP | 4648408 |
| Colour | 9.1 | 5.0 | TCU | N/A | 2016/09/01 | 2016/09/01 | NRG | 4642149 |
| Dissolved Fluoride (F-) | <0.10 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636078 |
| Total Kjeldahl Nitrogen (TKN) | <0.10 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/30 | AAY | 4639630 |
| Dissolved Organic Carbon (C) | 1.5 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639132 |
| Total Organic Carbon (C) | 1.7 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639130 |
| Orthophosphate (P) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648817 |
| pH | 6.84 | N/A | pH | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636076 |
| Total Phosphorus | <0.004 | 0.004 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SNR | 4638896 |
| Dissolved Sulphate (SO4) | <1.0 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648818 |
| Turbidity | 0.11 | 0.10 | NTU | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636118 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | <0.000013 | 0.000013 | mg/L | N/A | 2016/08/25 | 2016/08/26 | ARS | 4634839 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | 0.049 | 0.0050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Antimony (Sb) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Arsenic (As) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Barium (Ba) | 0.0022 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Boron (B) | <0.050 | 0.050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Cadmium (Cd) | <0.000010 | 0.000010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Calcium (Ca) | 1.4 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Chromium (Cr) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Copper (Cu) | <0.0020 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Iron (Fe) | <0.050 | 0.050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Lead (Pb) | <0.00050 | 0.00050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Magnesium (Mg) | 0.28 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Manganese (Mn) | <0.0020 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Nickel (Ni) | <0.0020 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Potassium (K) | <0.10 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Selenium (Se) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Sodium (Na) | 0.79 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Strontium (Sr) | 0.0048 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Uranium (U) | <0.00010 | 0.00010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Zinc (Zn) | <0.0050 | 0.0050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |



Maxxam Analytics International Corporation o/a Maxxam Analytics 200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel: 902-420-0203 Toll-free: 800-565-7227 Fax: 902-420-8612 www.maxxamanalytics.com

Maxxam Job #: B6I0658
Report Date: 2016/09/09

Department of Environment & Conservation
Your P.O. #: 215062145-2

| Sample Details/Parameters | Result | RDL | UNITS | MU | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| CYH418 Camp Pond Brook | | | | | | | | |
| Sampling Date 2016/08/16 16:40 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2016-6409-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Calculated TDS | 22 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | | 4634209 |
| Hardness (CaCO3) | 12 | 1.0 | mg/L | N/A | 2016/08/30 | 2016/08/30 | | 4634202 |
| **Inorganics** | | | | | | | | |
| Dissolved Chloride (Cl) | 2.0 | 1.0 | mg/L | +/- <RDL | 2016/09/07 | 2016/09/07 | DRM | 4648794 |
| Conductivity | 34 | 1.0 | uS/cm | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636077 |
| Nitrite (N) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Nitrate (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Nitrate + Nitrite (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Bromide (Br-) | <1.0 | 1.0 | mg/L | N/A | 2016/08/27 | 2016/08/27 | FD | 4637053 |
| Total Alkalinity (Total as CaCO3) | 11 | 5.0 | mg/L | N/A | 2016/08/31 | 2016/08/31 | NRG | 4642146 |
| Total Ammonia-N | <0.050 | 0.050 | mg/L | N/A | 2016/09/07 | 2016/09/07 | COP | 4648408 |
| Colour | 24 | 5.0 | TCU | N/A | 2016/09/01 | 2016/09/01 | NRG | 4642149 |
| Dissolved Fluoride (F-) | <0.10 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636078 |
| Total Kjeldahl Nitrogen (TKN) | 0.13 | 0.10 | mg/L | +/- <RDL | 2016/08/26 | 2016/08/29 | AAY | 4637200 |
| Dissolved Organic Carbon (C) | 3.1 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639132 |
| Total Organic Carbon (C) | 3.2 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639130 |
| Orthophosphate (P) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648796 |
| pH | 7.04 | N/A | pH | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636076 |
| Total Phosphorus | 0.005 | 0.004 | mg/L | +/- 0.004 | 2016/08/29 | 2016/08/29 | SNR | 4638896 |
| Dissolved Sulphate (SO4) | 4.2 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648798 |
| Turbidity | 0.86 | 0.10 | NTU | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636118 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | <0.000013 | 0.000013 | mg/L | N/A | 2016/08/25 | 2016/08/26 | ARS | 4634839 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | 0.081 | 0.0050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Antimony (Sb) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Arsenic (As) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Barium (Ba) | 0.0054 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Boron (B) | <0.050 | 0.050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Cadmium (Cd) | <0.000010 | 0.000010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Calcium (Ca) | 3.3 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Chromium (Cr) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Copper (Cu) | 0.0033 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Iron (Fe) | 0.19 | 0.050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Lead (Pb) | <0.00050 | 0.00050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Magnesium (Mg) | 0.98 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Manganese (Mn) | 0.0064 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Nickel (Ni) | 0.021 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Potassium (K) | 0.53 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Selenium (Se) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Sodium (Na) | 2.2 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Strontium (Sr) | 0.018 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Uranium (U) | <0.00010 | 0.00010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |
| Total Zinc (Zn) | <0.0050 | 0.0050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638597 |



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Maxxam Job #: B6I0658
Report Date: 2016/09/09

Department of Environment & Conservation
Your P.O. #: 215062145-2

| Sample Details/Parameters | Result | RDL | UNITS | MU | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| CYH419 Tributary to Lower Reid Brook | | | | | | | | |
| Sampling Date 2016/08/16 16:43 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2016-6410-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Calculated TDS | 27 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | | 4634209 |
| Hardness (CaCO3) | 13 | 1.0 | mg/L | N/A | 2016/08/30 | 2016/08/30 | | 4634202 |
| **Inorganics** | | | | | | | | |
| Dissolved Chloride (Cl) | 2.0 | 1.0 | mg/L | +/- <RDL | 2016/09/07 | 2016/09/07 | DRM | 4648794 |
| Conductivity | 34 | 1.0 | uS/cm | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636077 |
| Nitrite (N) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Nitrate (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Nitrate + Nitrite (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Bromide (Br-) | <1.0 | 1.0 | mg/L | N/A | 2016/08/27 | 2016/08/27 | FD | 4637053 |
| Total Alkalinity (Total as CaCO3) | 12 | 5.0 | mg/L | N/A | 2016/08/31 | 2016/08/31 | NRG | 4642146 |
| Total Ammonia-N | <0.050 | 0.050 | mg/L | N/A | 2016/09/07 | 2016/09/07 | COP | 4648408 |
| Colour | 39 | 5.0 | TCU | N/A | 2016/09/01 | 2016/09/01 | NRG | 4642149 |
| Dissolved Fluoride (F-) | 0.11 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636078 |
| Total Kjeldahl Nitrogen (TKN) | 0.12 | 0.10 | mg/L | +/- <RDL | 2016/08/26 | 2016/08/29 | AAY | 4637200 |
| Dissolved Organic Carbon (C) | 3.9 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639132 |
| Total Organic Carbon (C) | 3.9 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639130 |
| Orthophosphate (P) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648796 |
| pH | 7.11 | N/A | pH | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636076 |
| Total Phosphorus | 0.005 | 0.004 | mg/L | +/- 0.004 | 2016/08/29 | 2016/08/29 | SNR | 4638896 |
| Dissolved Sulphate (SO4) | 2.3 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648798 |
| Turbidity | 0.99 | 0.10 | NTU | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636117 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | <0.000013 | 0.000013 | mg/L | N/A | 2016/08/25 | 2016/08/26 | ARS | 4634839 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | 0.092 | 0.0050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Antimony (Sb) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Arsenic (As) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Barium (Ba) | 0.0053 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Boron (B) | <0.050 | 0.050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Cadmium (Cd) | <0.000010 | 0.000010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Calcium (Ca) | 3.3 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Chromium (Cr) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Copper (Cu) | <0.0020 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Iron (Fe) | 0.43 | 0.050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Lead (Pb) | <0.00050 | 0.00050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Magnesium (Mg) | 1.1 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Manganese (Mn) | 0.0060 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Nickel (Ni) | 0.0064 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Potassium (K) | 0.41 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Selenium (Se) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Sodium (Na) | 2.7 | 0.10 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Strontium (Sr) | 0.018 | 0.0020 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Uranium (U) | <0.00010 | 0.00010 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |
| Total Zinc (Zn) | <0.0050 | 0.0050 | mg/L | N/A | 2016/08/29 | 2016/08/29 | BAN | 4638593 |



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Maxxam Job #: B6I0658
Report Date: 2016/09/09

Department of Environment & Conservation
Your P.O. #: 215062145-2

| Sample Details/Parameters | Result | RDL | UNITS | MU | Extracted | Analyzed | By | Batch |
|---|---|---|---|---|---|---|---|---|
| CYH420 Lower Reuid brook below Tributary | | | | | | | | |
| Sampling Date 2016/08/16 17:06 | | | | | | | | |
| Matrix W | | | | | | | | |
| Sample # 2016-6411-00-SI-SP | | | | | | | | |
| Registration # WS-S-0000 | | | | | | | | |
| **RESULTS OF ANALYSES OF WATER** | | | | | | | | |
| **Calculated Parameters** | | | | | | | | |
| Calculated TDS | 21 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | | 4634209 |
| Hardness (CaCO3) | 9.7 | 1.0 | mg/L | N/A | 2016/08/29 | 2016/08/29 | | 4634202 |
| **Inorganics** | | | | | | | | |
| Dissolved Chloride (Cl) | 1.7 | 1.0 | mg/L | +/- <RDL | 2016/09/07 | 2016/09/07 | DRM | 4648794 |
| Conductivity | 27 | 1.0 | uS/cm | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636077 |
| Nitrite (N) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Nitrate (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Nitrate + Nitrite (N) | <0.10 | 0.10 | mg/L | N/A | 2016/09/07 | 2016/09/07 | C_N | 4648806 |
| Bromide (Br-) | <1.0 | 1.0 | mg/L | N/A | 2016/08/27 | 2016/08/27 | FD | 4637053 |
| Total Alkalinity (Total as CaCO3) | 11 | 5.0 | mg/L | N/A | 2016/08/31 | 2016/08/31 | NRG | 4642146 |
| Total Ammonia-N | <0.050 | 0.050 | mg/L | N/A | 2016/09/07 | 2016/09/07 | COP | 4648408 |
| Colour | 25 | 5.0 | TCU | N/A | 2016/09/01 | 2016/09/01 | NRG | 4642149 |
| Dissolved Fluoride (F-) | <0.10 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636078 |
| Total Kjeldahl Nitrogen (TKN) | <0.10 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/29 | AAY | 4637200 |
| Dissolved Organic Carbon (C) | 2.9 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639132 |
| Total Organic Carbon (C) | 2.9 | 0.50 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SMT | 4639130 |
| Orthophosphate (P) | <0.010 | 0.010 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648796 |
| pH | 7.08 | N/A | pH | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636076 |
| Total Phosphorus | 0.004 | 0.004 | mg/L | N/A | 2016/08/29 | 2016/08/29 | SNR | 4638896 |
| Dissolved Sulphate (SO4) | 1.7 | 1.0 | mg/L | N/A | 2016/09/07 | 2016/09/07 | ADB | 4648798 |
| Turbidity | 0.62 | 0.10 | NTU | N/A | 2016/08/26 | 2016/08/26 | JMV | 4636118 |
| **MERCURY BY COLD VAPOUR AA (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Mercury (Hg) | <0.000013 | 0.000013 | mg/L | N/A | 2016/08/25 | 2016/08/26 | ARS | 4634839 |
| **ELEMENTS BY ICP/MS (WATER)** | | | | | | | | |
| **Metals** | | | | | | | | |
| Total Aluminum (Al) | 0.063 | 0.0050 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Antimony (Sb) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Arsenic (As) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Barium (Ba) | 0.0041 | 0.0010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Boron (B) | <0.050 | 0.050 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Cadmium (Cd) | <0.000010 | 0.000010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Calcium (Ca) | 2.6 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Chromium (Cr) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Copper (Cu) | <0.0020 | 0.0020 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Iron (Fe) | 0.23 | 0.050 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Lead (Pb) | <0.00050 | 0.00050 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Magnesium (Mg) | 0.76 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Manganese (Mn) | 0.0041 | 0.0020 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Nickel (Ni) | 0.0040 | 0.0020 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Potassium (K) | 0.34 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Selenium (Se) | <0.0010 | 0.0010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Sodium (Na) | 1.9 | 0.10 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Strontium (Sr) | 0.014 | 0.0020 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Uranium (U) | <0.00010 | 0.00010 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |
| Total Zinc (Zn) | <0.0050 | 0.0050 | mg/L | N/A | 2016/08/26 | 2016/08/27 | BAN | 4636306 |



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# References

Canadian Council of Ministers of the Environment. (2014) "Canadian water quality guidelines for the protection of aquatic life" Canadian Council of Ministers of the Environment. Retrieved from: http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html

Canadian Council of Ministers of the Environment. (2014) "Water Quality Guidelines for the Protection of Aquatic Life" Canadian Council of Ministers of the Environment. Retrieved from: http://st-ts.ccme.ca/en/index.html?chems=162&chapters=1

OTT Hydromet (2017) "Hydrolab" Retrieved from: http://www.ott.com/en-us/products/water-quality-2/hydrolab-ds5x-multiparameter-data-sonde-855/

Mike Sader (2017) "Turbidity Measurement: A Simple, Effective Indicator of Water Quality Change". OTT Hydromet. Retrieved from http://www.ott.com/en-us/products/download/turbidity-white-paper/

Swanson, H.A., and Baldwin, H.L., (1965) "A Primer on Water Quality" U.S. Geological Survey. Retrieved from: http://ga.water.usgs.gov/edu/characteristics.html