Real-Time Water Quality Deployment Report

Voisey's Bay Network

August 31 to
September 27, 2011

Newfoundland Labrador

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

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Contents

General

- 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, Tributary to Lower Reid Brook, Lower Reid Brook and Camp Pond Brook.
- On August 31, 2011, 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 28 days. Instruments were removed for cleaning and calibration by Vale Environment staff on September 27.

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 deployed from August 31 to September 27, 2011 are summarized in Table 2.

Table 2: Comparison rankings for Voisey's Bay Network stations, August 31– September 27, 2011

Station Voisey's Bay	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Upper Reid Brook	Aug 31, 2011	Deployment	Good	Good	Excellent	Poor	n/a*
	Sep 27, 2011	Removal	Excellent	Poor	Excellent	Fair	n/a*
Tributary to Lower Reid Brook	Aug 31, 2011	Deployment	Good	Fair	Excellent	n/a†	n/a*
	Sep 27, 2011	Removal	Good	Poor	Excellent	n/a†	n/a*
Lower Reid Brook	Aug 31, 2011	Deployment	Excellent	Excellent	Good	Good	n/a*
	Sep 27, 2011	Removal	Excellent	Fair	Good	Excellent	n/a*
Camp Pond Brook	Aug 31, 2011	Deployment	Excellent	Fair	Excellent	Excellent	n/a*
	Sep 27, 2011	Removal	Excellent	Fair	Excellent	Fair	n/a*

* QAQC comparison rankings were not available due to the absence of a turbidity sensor on either the field or QAQC instrument.

† QAQC comparison readings were not available for dissolved oxygen because the display was not working on the handheld unit.

- At the station at Upper Reid Brook, temperature, pH, specific conductivity all ranked either 'good' or 'excellent' at deployment, while dissolved oxygen ranked 'poor'. The field instrument read a value of 11.60mg/l while the QAQC instrument read a value of 9.90mg/l, a difference of 1.70mg/l. This disparity may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. No turbidity comparison rankings are available because the field instrument at this station is not equipped with a turbidity sensor.
- At removal, temperature and specific conductivity both ranked 'excellent' while pH ranked 'poor' and dissolved oxygen ranked 'fair'. For pH, the field instrument read a value of 6.49 and the QAQC instrument read a value of 5.15, a difference of 1.34. The QAQC instrument read low pH values throughout the day at all stations, leading to 'fair' or 'poor' readings at all stations for pH. For dissolved oxygen, the field instrument read 11.72mg/l while the QAQC instrument read a value of 11.15mg/l. Both of these disparities may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. No comparison rankings for turbidity are available because the field instrument was not equipped with a turbidity sensor.
- At the station on the Tributary to Lower Reid Brook, temperature and specific conductivity ranked 'good' and 'excellent' respectively while pH ranked 'fair'. The field instrument read a value of 5.93 and the QAQC instrument read a value of 6.69, a difference of 0.69. This discrepancy is likely due to the time required for stabilization at deployment. At the time of the first transmission from the station following deployment (approximately 1 hour later) read a value of 6.61 which when compared to the QAQC value yields an 'excellent' ranking. Dissolved oxygen was not ranked because a reading from the QAQC instrument was unavailable on the hand held field PC at the time of deployment. The dissolved oxygen sensor was in good working condition when deployed. The first transmission of data from the station after deployment

reports a dissolved oxygen value of 10.67mg/l which when compared to the QAQC instrument reading of 11.19mg/l, yields a 'fair' ranking. No comparison rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.

- At removal, temperature and specific conductivity ranked 'good' and 'excellent' respectively while pH ranked 'poor'. The field instrument read a value of 6.84 while the QAQC instrument read a value of 5.67, a difference of 1.17. The QAQC instrument read low pH values throughout the day at all stations, leading to 'fair' or 'poor' readings at all stations for pH. This disparity may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. Dissolved oxygen was not ranked because a reading from the QAQC instrument continued to be unavailable on the hand held field PC at the time of removal. The dissolved oxygen sensor was in good working condition when deployed and throughout the deployment period reported reasonable values. The last transmission of data from the station before removal reports a dissolved oxygen value of 11.85mg/l which when compared to the QAQC instrument reading of 12.31mg/l yields a 'good' ranking. No comparison rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.
- At the station on Lower Reid Brook below the tributary, temperature, pH, specific conductivity, and dissolved oxygen all ranked either 'good' or 'excellent' at deployment. No comparison rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.
- At removal, temperature, specific conductivity and dissolved oxygen all ranked either 'good' or 'excellent' while pH ranked 'fair'. The field instrument read a value of 7.18 while the QAQC instrument read a value of 6.62, a difference of 0.56. The QAQC instrument read low pH values throughout the day at all stations, leading to 'fair' or 'poor' readings at all stations for pH. This disparity may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. No comparison rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.
- At the station on Camp Pond Brook, temperature, specific conductivity and dissolved oxygen all ranked 'excellent' at deployment while pH ranked 'fair'. The field instrument read a value of 5.81 while the QAQC instrument read a value of 6.41, a difference of 0.60. This discrepancy is likely due to the time required for stabilization at deployment similar to tributary to lower Reid. At the time of the first transmission from the station following deployment (approximately 1 hour later) the instrument read a value of 6.68 which when compared to the QAQC value yields a 'good' ranking. No comparison rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.
- At removal, temperature and specific conductivity both ranked 'excellent' while pH and dissolved oxygen both ranked 'fair'. For pH, the field instrument read a value of 6.73 while the QAQC instrument read a value of 6.03, a difference 0.70. The QAQC instrument read low pH values throughout the day at all stations, leading to 'fair' or 'poor' readings at all stations for pH. For dissolved oxygen, the field instrument read a value of 10.99mg/l and the QAQC instrument read a value of 11.69mg/l, a difference of 0.70mg/l. Both of these disparities may in part be caused by the insufficient time for the instrument to stabilize or the difference between the positions of the field and QAQC instruments. No comparison rankings for turbidity are available because the QAQC instrument was not equipped with a turbidity sensor.

Data Interpretation

- The following graphs and discussion illustrate significant water quality-related events from August 31 to September 27 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.

Upper Reid Brook (Outlet from Reid Pond)

- Water temperature ranged from 7.43 ^{o}C to 14.40^{o}C during the deployment period (Figure 1).
- Water temperature is decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 2). Water temperature fluctuates diurnally.

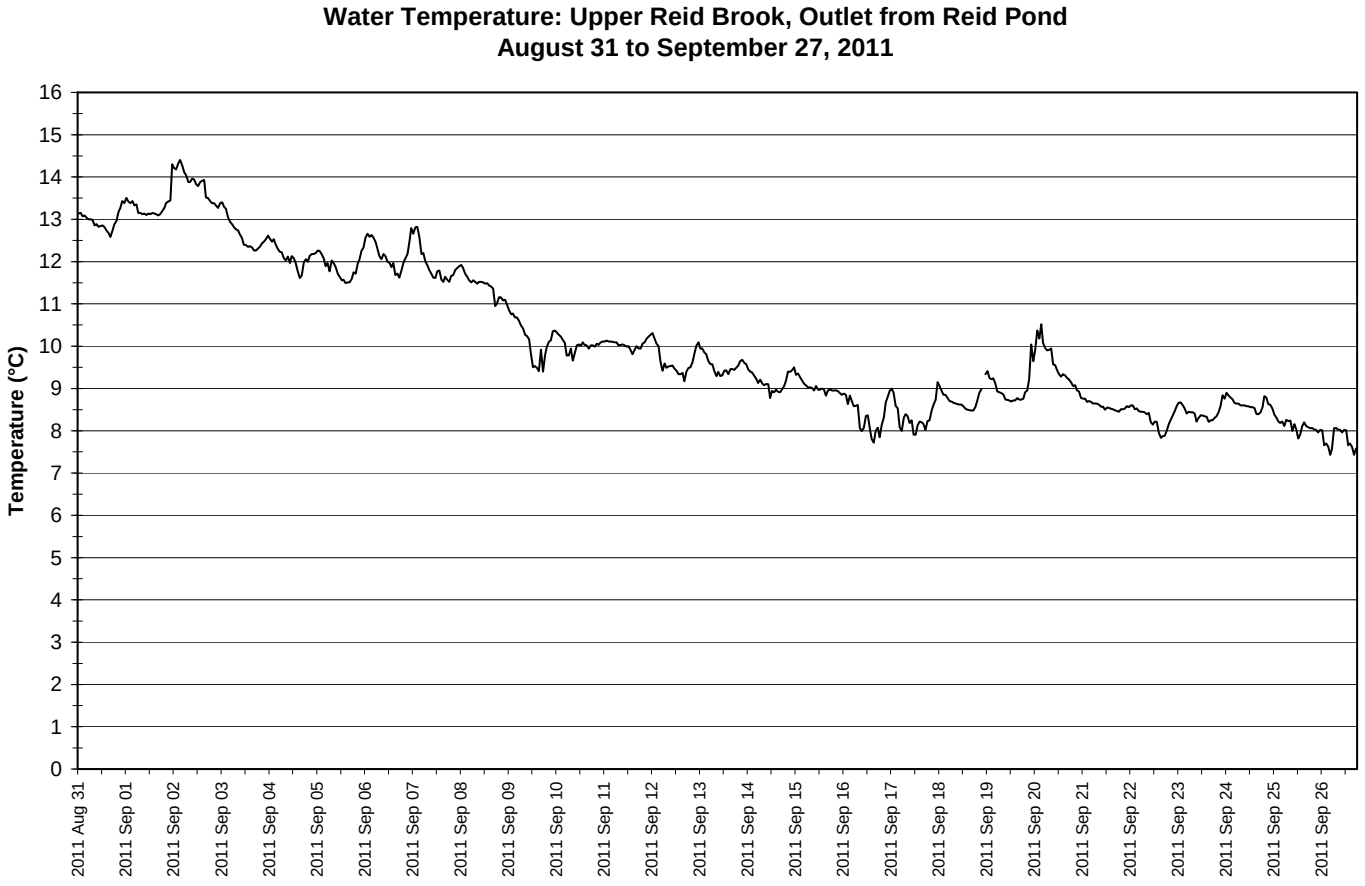

Figure 1: Water temperature at Upper Reid Brook

- Average daily air and water temperatures are generally decreasing throughout the deployment period (Figure 2). Average daily air temperatures do increase on occasion throughout the month of September and each time are reflected in slight increases in water temperature. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

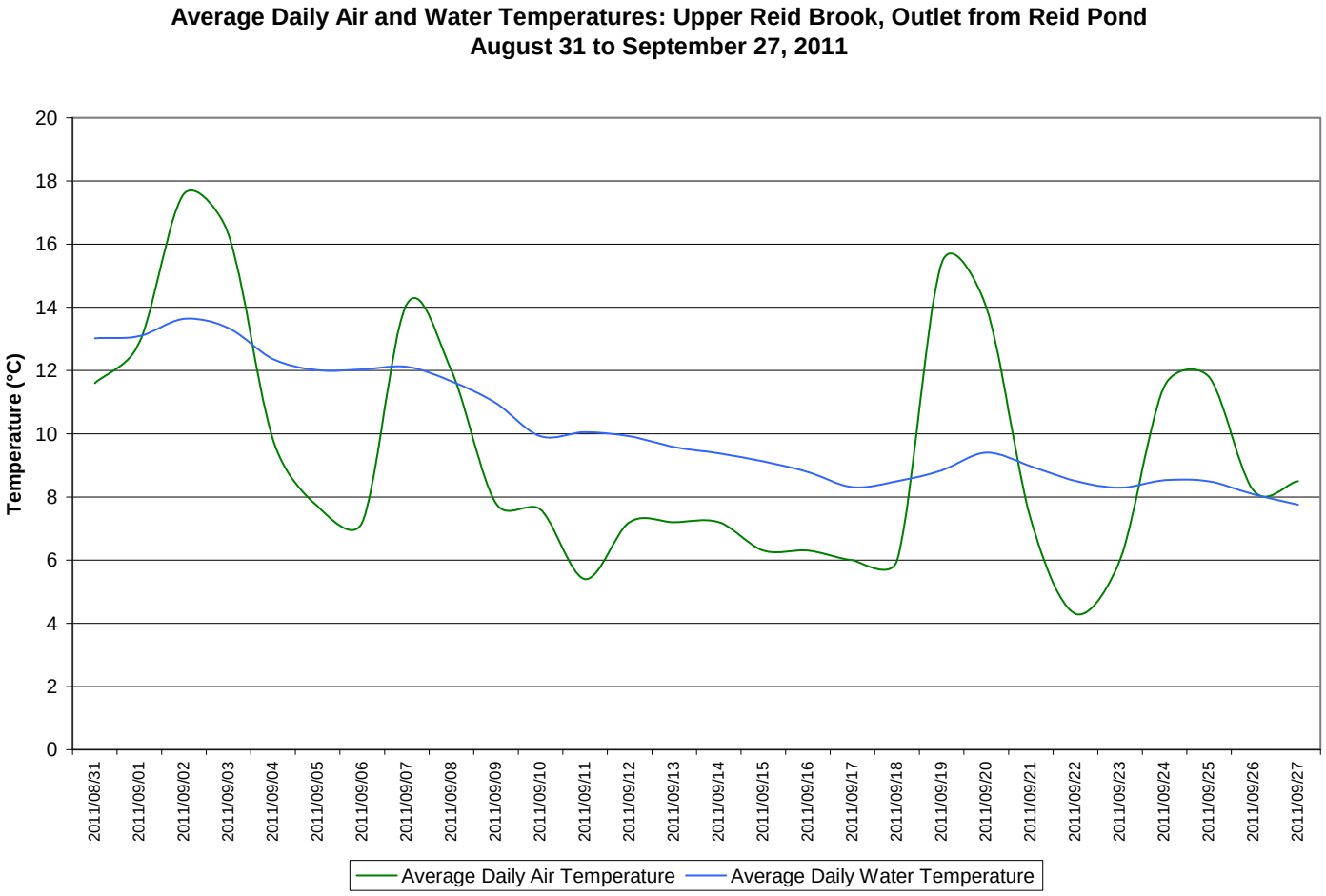

Figure 2: Average daily air and water temperatures at Upper Reid Brook

(weather data recorded at Nain)

- pH ranged between 6.42 and 6.81 pH units (Figure 3).
- pH values are decreasing slightly over the deployment period. When the instrument was deployed, pH comparison values ranked 'good'. At removal, the ranking was downgraded to 'poor' and was attributed to the QAQC instrument having insufficient time to stabilize.
- All values recorded during the first ten days of the deployment period are above the minimum CCME Guideline for the Protection of Aquatic Life (> 6.5 pH units). After this time, pH values drift and stay just below this guideline. Average and median pH values are >6.5 pH units.

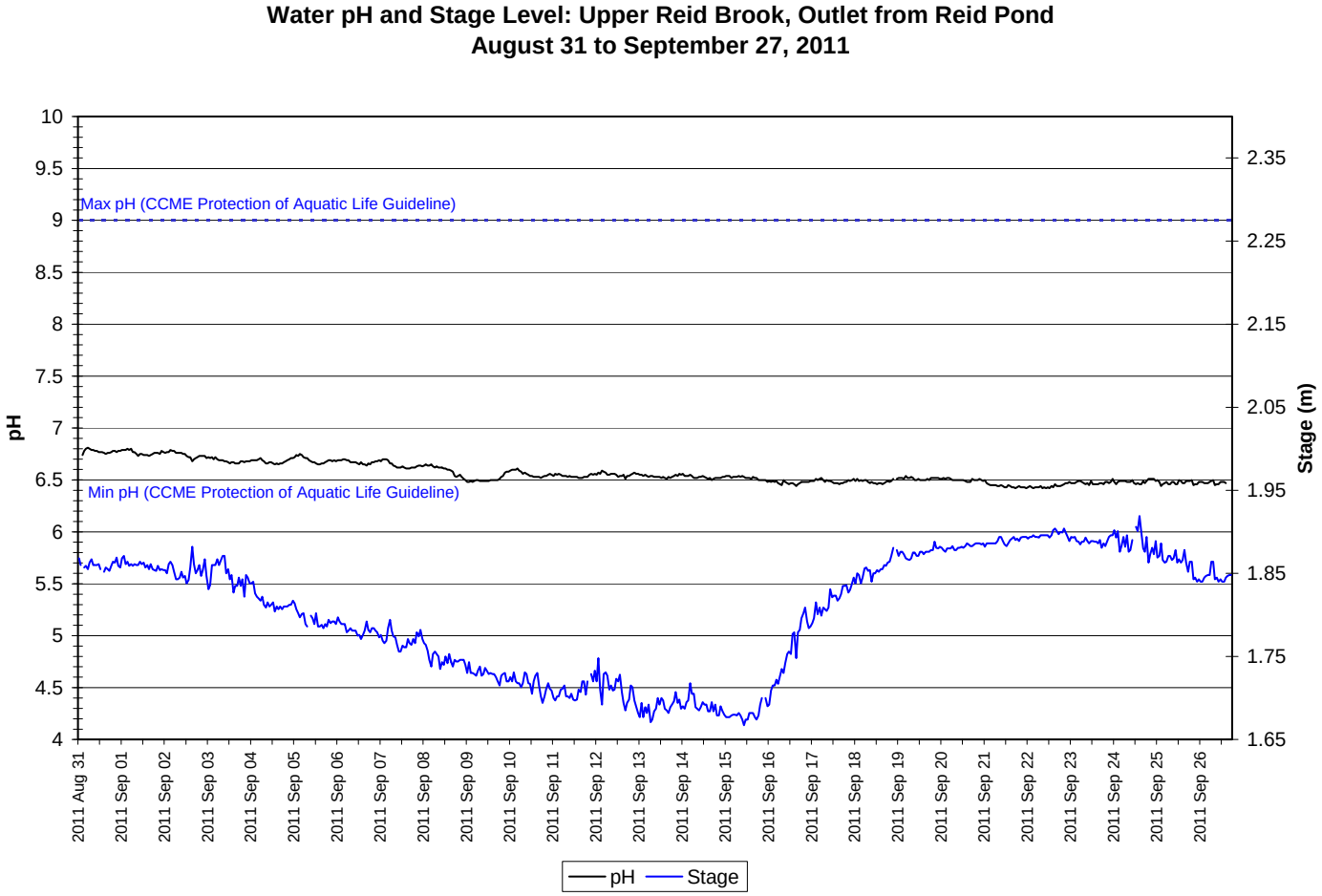

Figure 3: pH and stage level at Upper Reid Brook

- Specific conductivity ranged from 10.2µS/cm to 10.5µS/cm during the deployment period (Figure 4).
- Specific conductance remains very low and extremely stable throughout the deployment period with minimal fluctuation (±0.3µS/cm) regardless of the changing water level. This trend is expected as the flow from this station is directly from a stable lake environment.

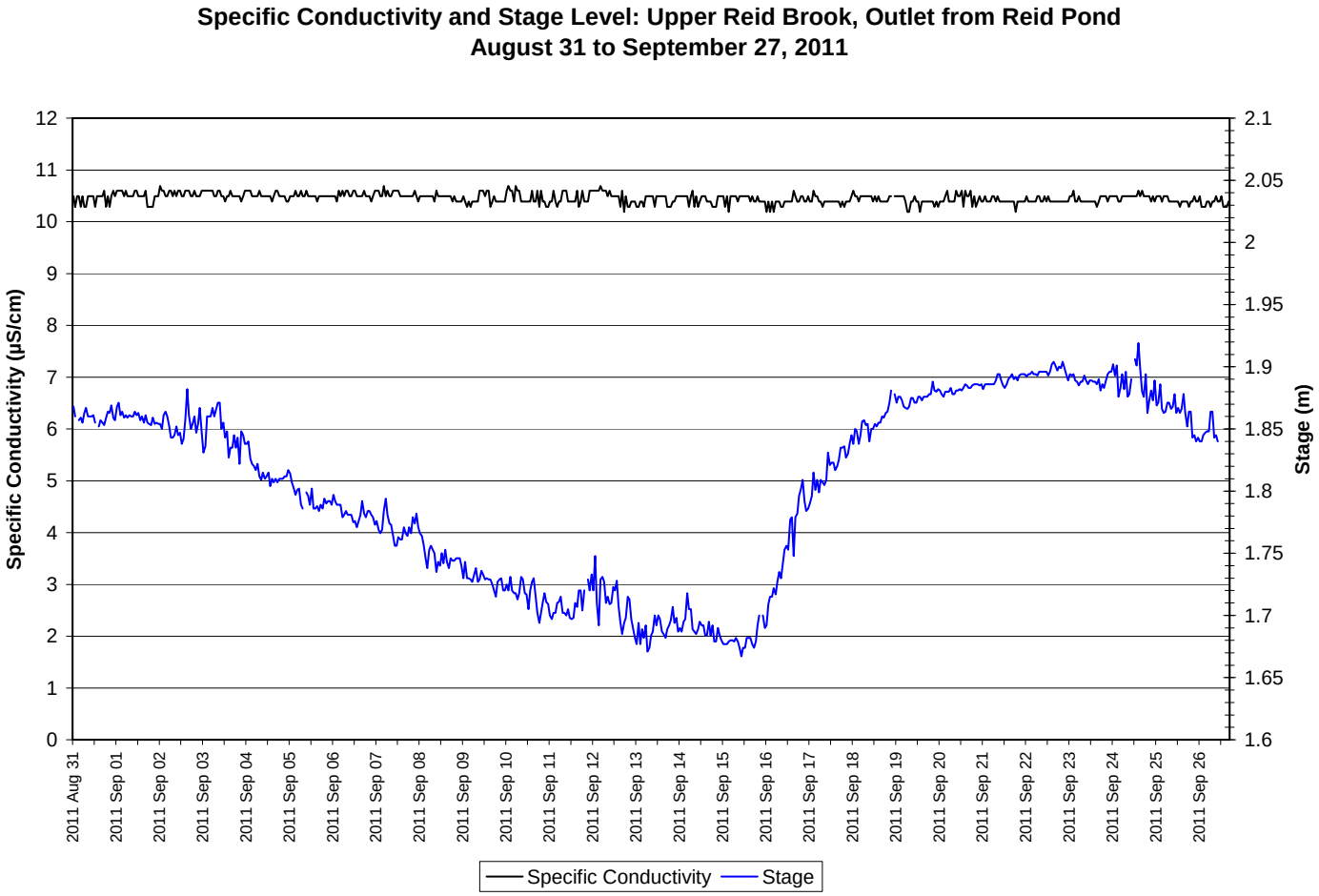

Figure 4: Specific conductivity and stage level at Upper Reid Brook

- Dissolved oxygen content ranged between 10.31mg/L and 11.87mg/L. The saturation of dissolved oxygen ranged from 96.0% to 105.7% (Figure 5).
- All values were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l and Early Life Stages of 9.5 mg/l during the deployment period. The guidelines are indicated in blue on Figure 5.
- Dissolved oxygen content is increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures in the fall season (Figure 1 & 2).

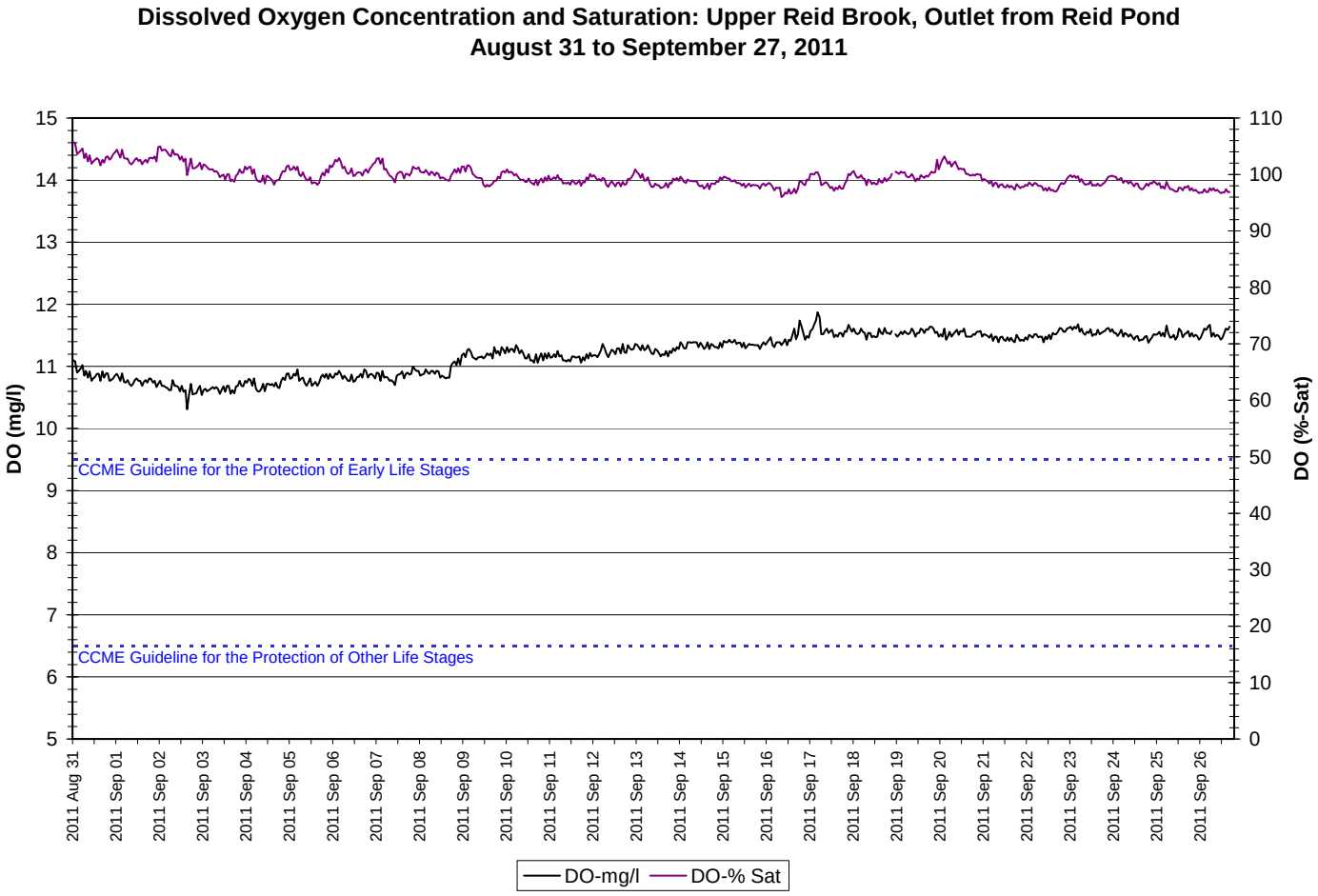

Figure 5: Dissolved oxygen and percent saturation at Upper Reid Brook

- The instrument deployed at Upper Reid Brook is a replacement instrument provided by the Department of Environment and Conservation. The Minisonde 4a, Special Edition, features a temperature, specific conductivity, Clark cell dissolved oxygen and pH sensors. This instrument is not equipped with a turbidity sensor therefore no turbidity data is available for discussion at this station.

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 6). Stage is generally decreasing for the first half of the deployment period. Stage level increases significantly after a large rainfall on September 16 (>35mm). Stage level remains high for the rest of the deployment period. Precipitation events are infrequent and are typically low in magnitude with the exception of the September 16 rainfall event.

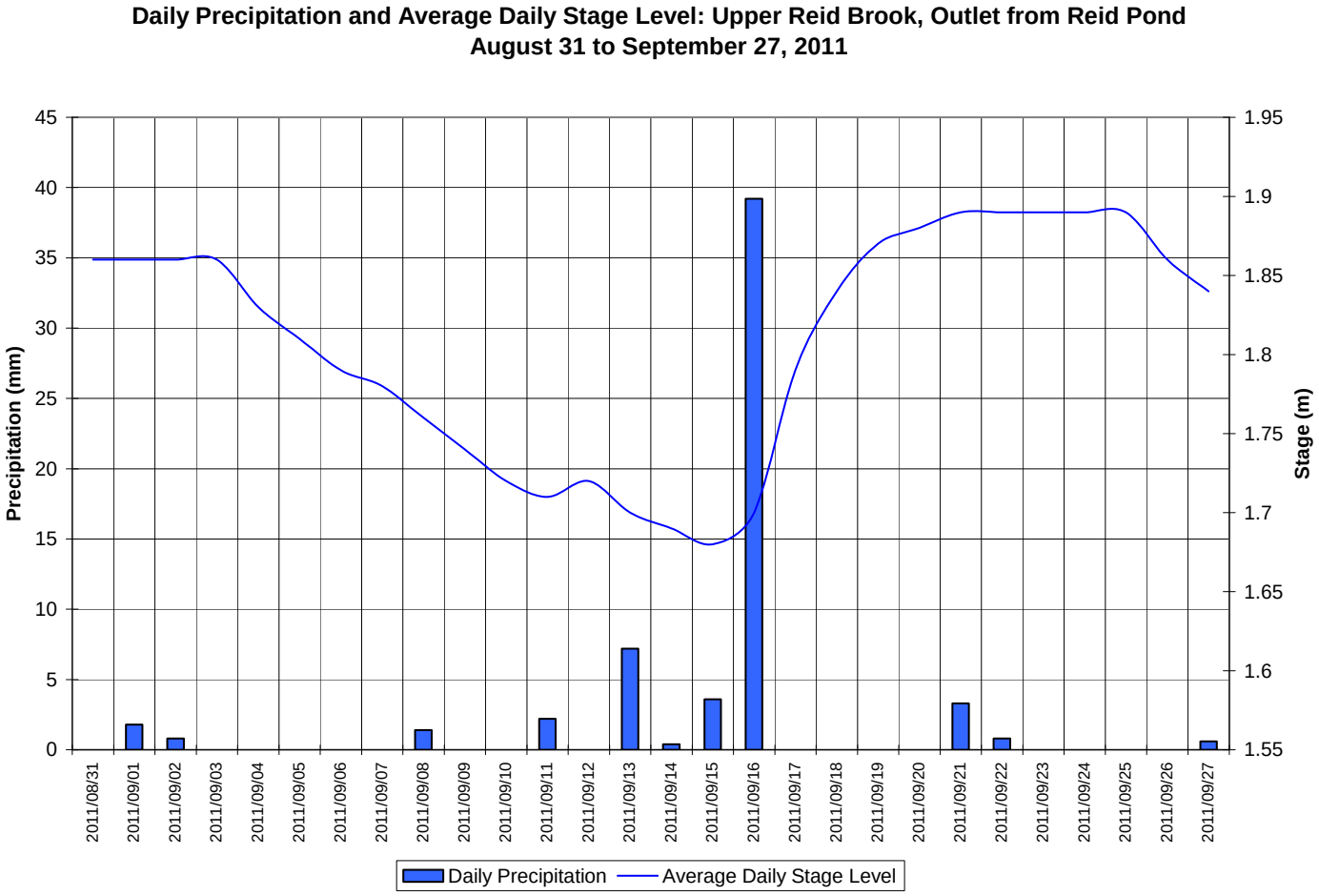

Figure 6: Daily precipitation and average daily stage level at Upper Reid Brook

(weather data recorded at Nain)

Tributary to Lower Reid Brook

- Water temperature ranged from 4.00 °C to 13.40°C during the deployment period (Figure 7).
- Water temperature is generally decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 8). Water temperature fluctuates diurnally.

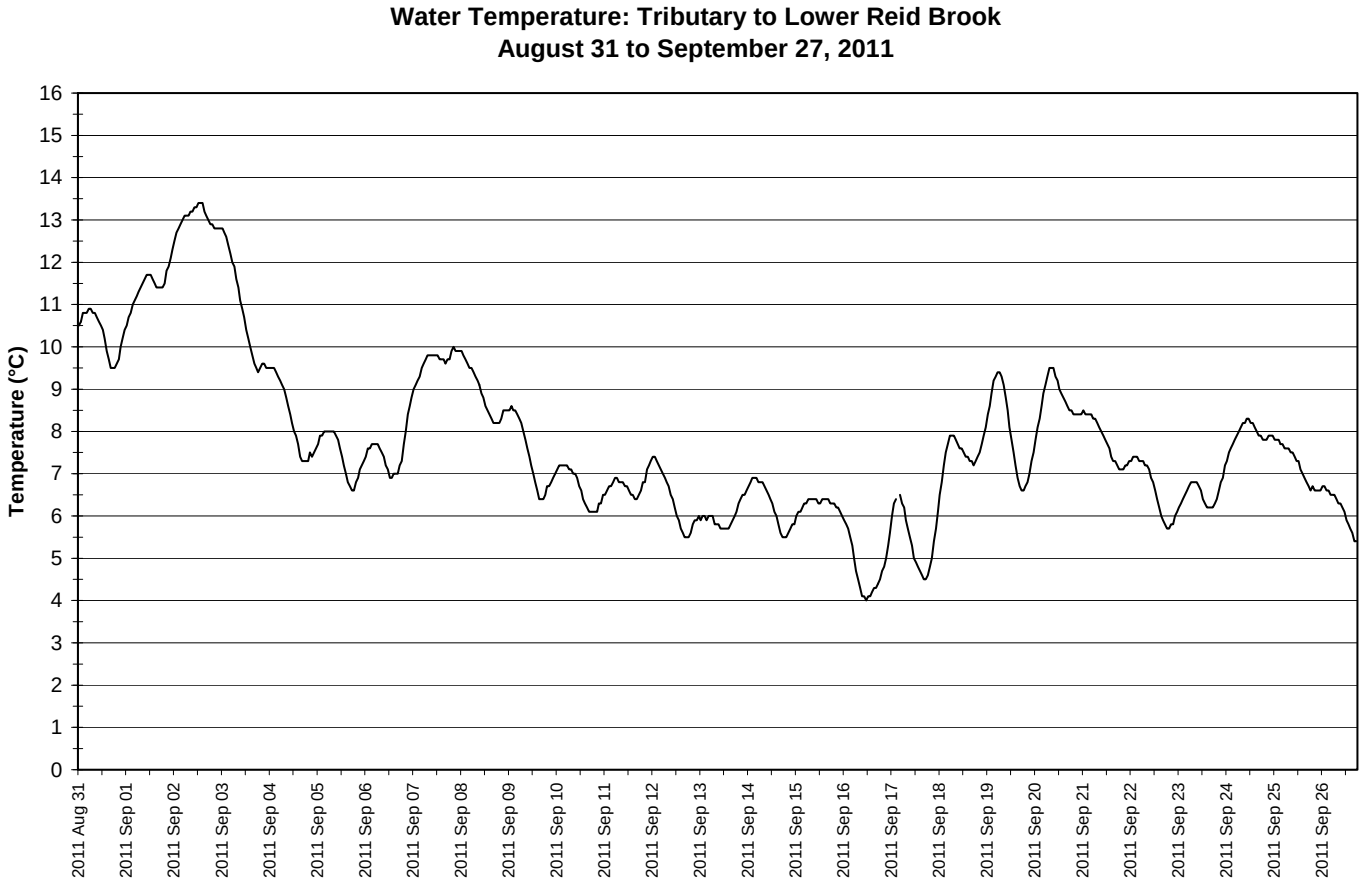

Figure 7: Water temperature at Tributary to Lower Reid Brook

- Average daily air and water temperatures are generally decreasing throughout the deployment period (Figure 8). Average daily air temperatures do increase on occasion throughout the month of September and each time are reflected in slight increases in water temperature. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

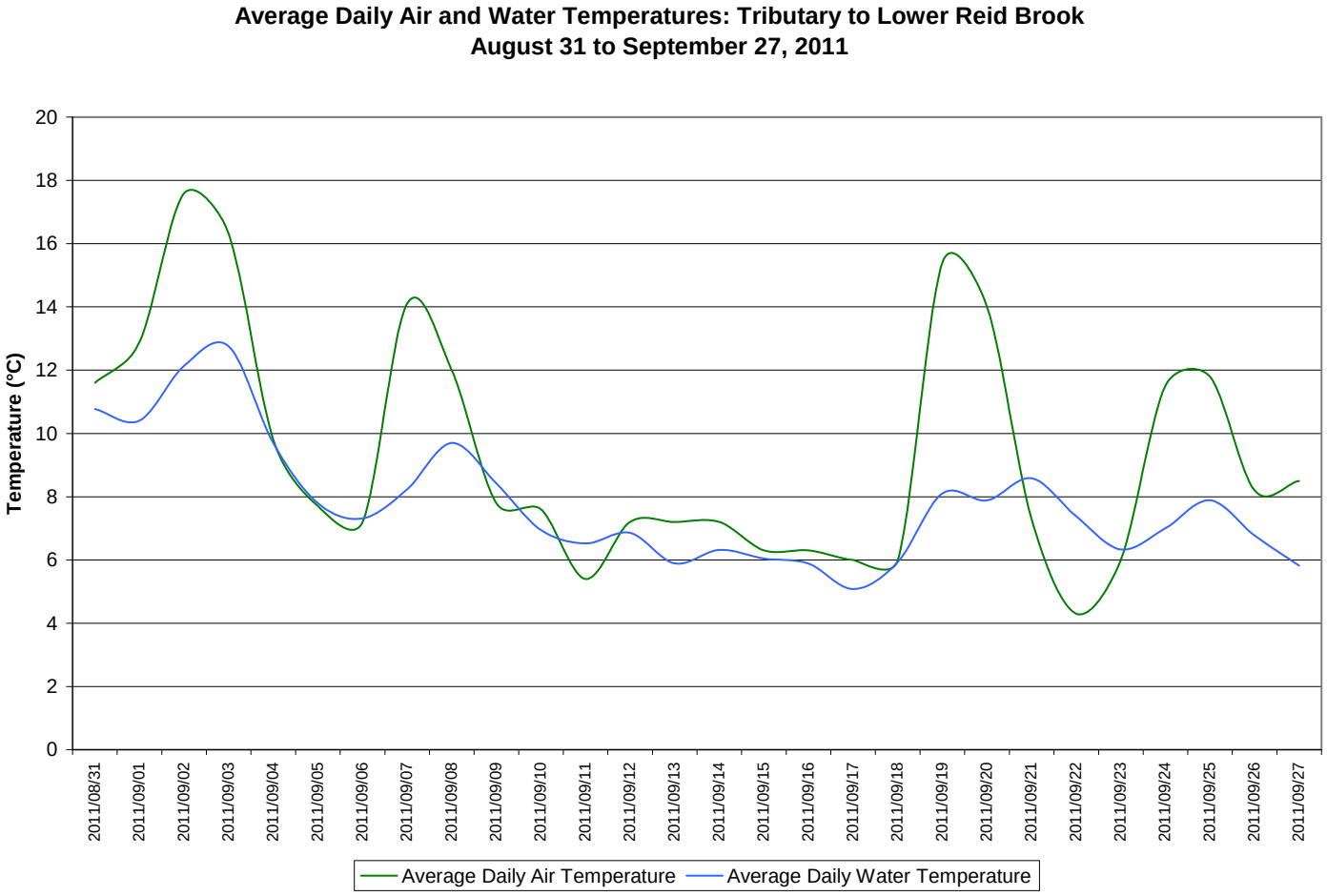

Figure 8: Average daily air and water temperatures at Tributary to Lower Reid Brook (weather data recorded at Nain)

- pH ranged between 6.24 and 7.09 pH units (Figure 9).
- pH values are increasing slightly throughout the first 17 days of the deployment period before decreasing rapidly over a number of hours to as low at 6.24 pH units. After this decrease, pH gradually increases and recovers over a number of days before stabilizing for the remainder of the deployment period.
- Stage is included on Figure 9 to show the relationship between water level and pH. As stage decreases slightly during the first half of the deployment period, pH is increasing gradually. The sharp and rapid decrease in pH on September 17 corresponds with a significant increase in stage (indicated by red arrows on Figure 9). A rainfall event >35mm was recorded by Environment Canada the day before in the nearby community of Nain. Specific conductivity is also affected by this increase in stage (Figure 10).
- Generally, all values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 9) with the exception of the decrease on September 17 lasting until September 18.

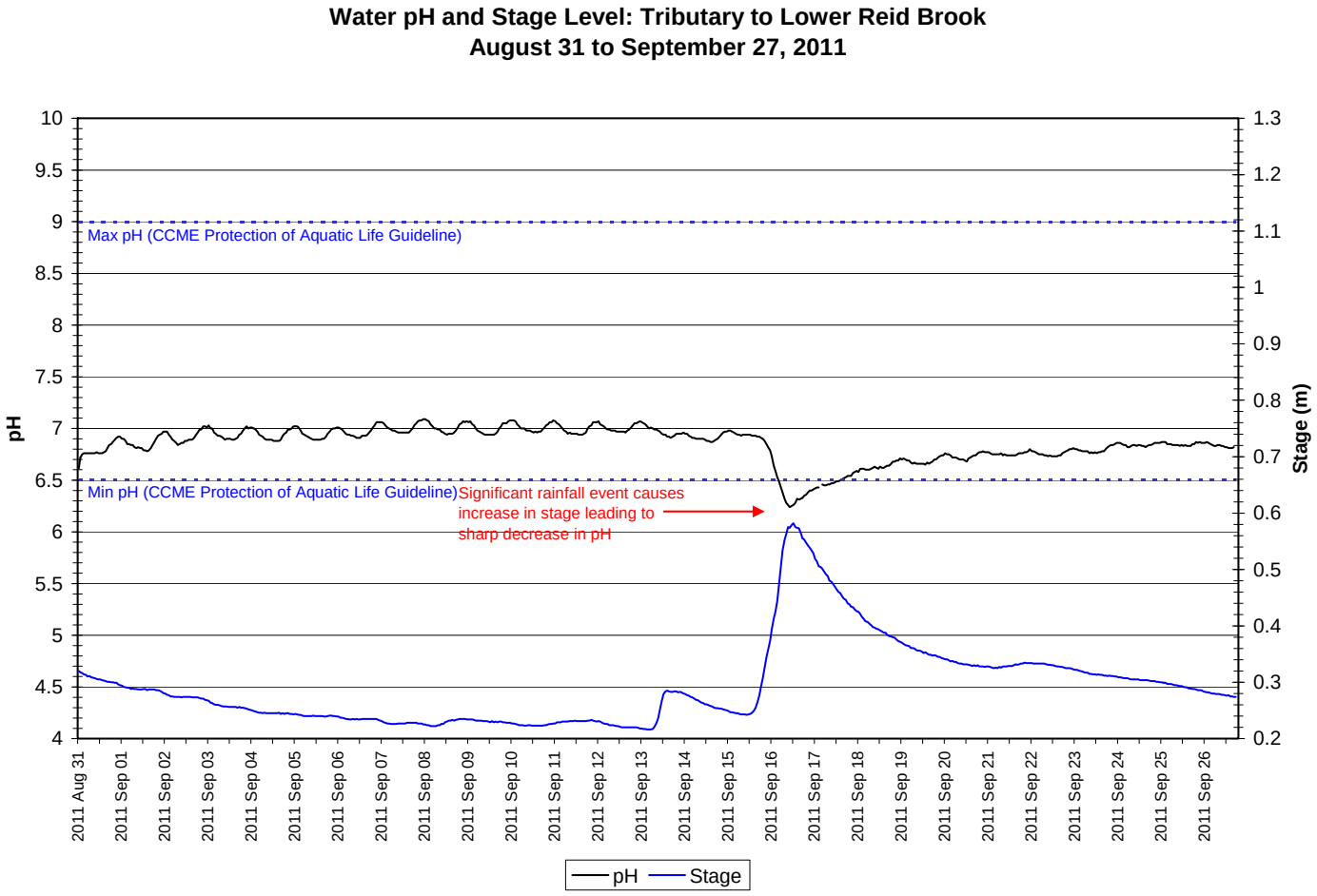

Figure 9: pH and stage level at Tributary to Lower Reid Brook

- Specific conductivity ranged between 19.8µS/cm and 36.8µS/cm and fluctuates throughout the deployment period (Figure 10).
- Stage is included in Figure 10 to illustrate the inverse relationship between conductivity and water level. Generally, stage is decreasing throughout the first half of the deployment period before increasing slightly on September 13 and then again significantly on September 17, following a heavy rainfall event. As stage increases slightly on September 13, specific conductivity decreases slightly. On September 17, the large increase in stage causes a very sharp decrease in specific conductivity. A decrease in pH is also noticeable in the data (Figure 9). As stage increases, specific conductivity generally decreases due to the dilution of dissolved solids in the water column. Inversely, as stage decreases, specific conductivity increases as the concentration of dissolved solids increases.

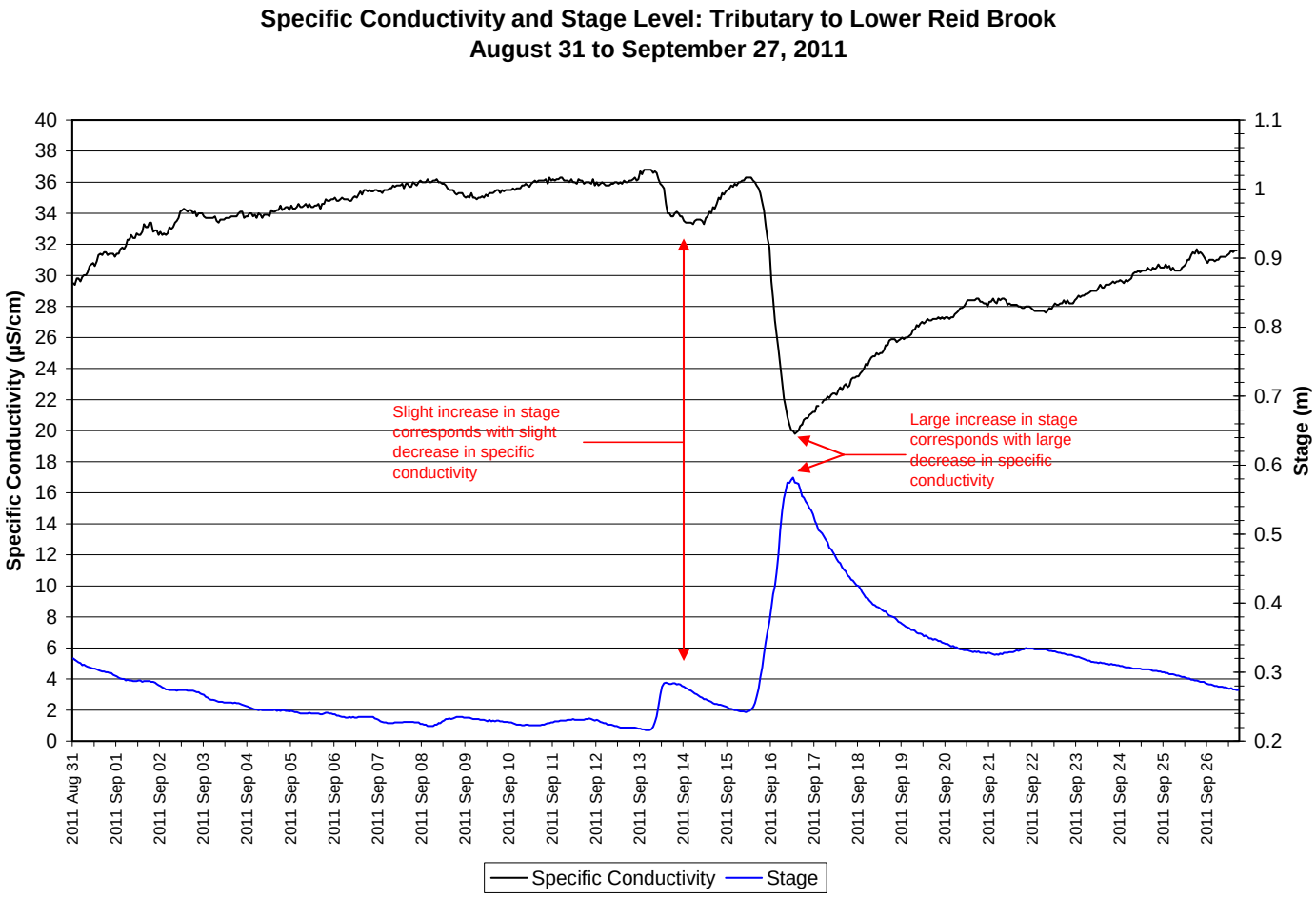

Figure 10: Specific conductivity and stage level at Tributary to Lower Reid Brook

- Dissolved oxygen content ranged between 9.52g/L and 12.19mg/L. The saturation of dissolved oxygen ranged from 90.5% to 96.7% (Figure 11).
- All values were above both the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l and Early Life Stages value of 9.5 mg/l. The guidelines are indicated in blue on Figure 11.
- Dissolved oxygen content is generally increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures in the fall season (Figure 7 & 8).

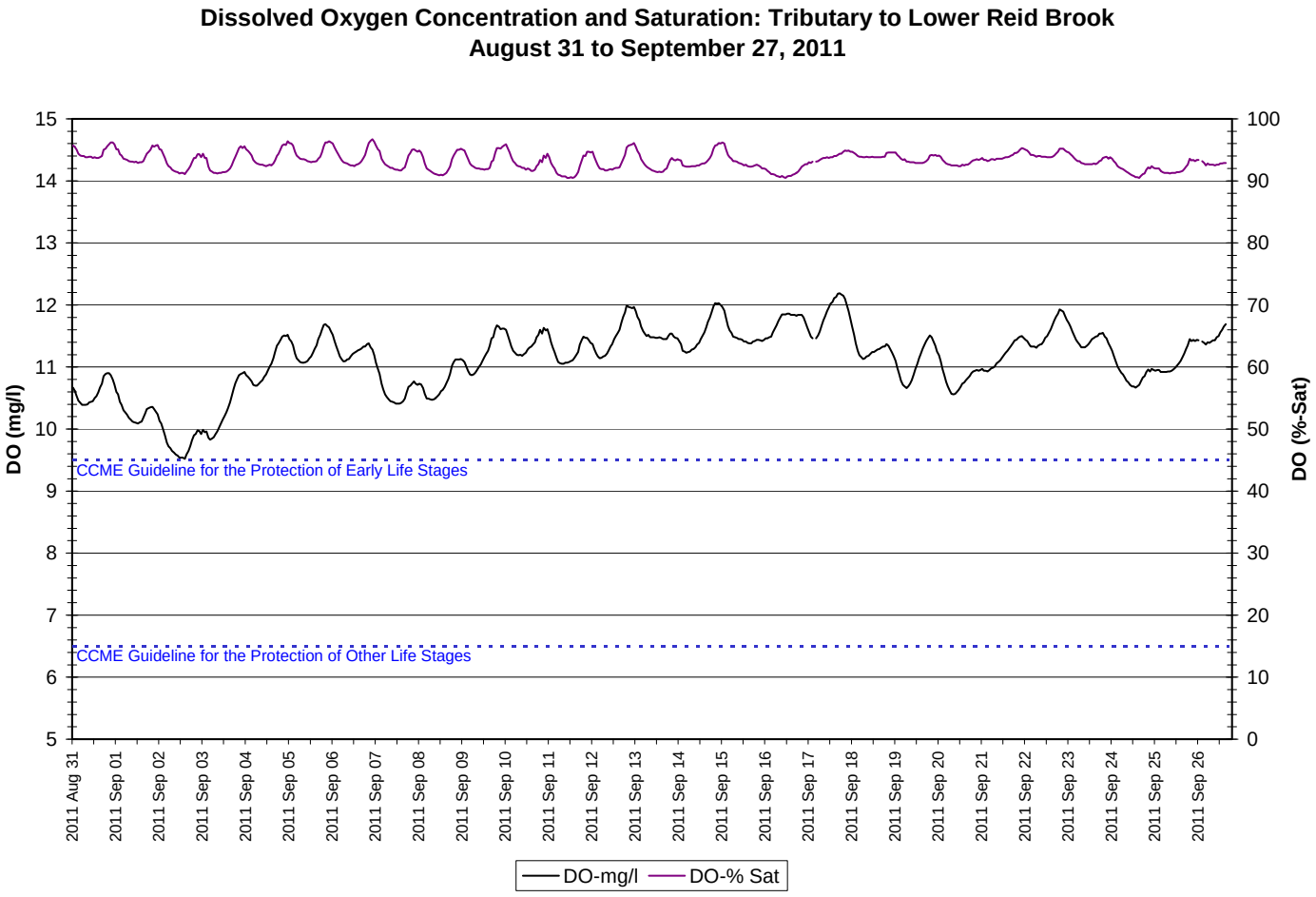

Figure 11: Dissolved oxygen and percent saturation at Tributary to Lower Reid Brook

- Turbidity remained at 0NTU for the entire deployment period (Figure 12).
- The turbidity sensor on the Tributary to Lower Reid Brook instrument (s/n 44175) was not functioning at full capacity during the deployment period. The wiper on the instrument no longer cleans the turbidity window on the sensor prior to the taking reading.
- During cleaning and calibration on August 31 after removal, the turbidity sensor was unresponsive and did not recalibrate indicating that the sensor no longer worked. The instrument was returned to the river and a note placed on the online graph indicating the turbidity sensor was not functional. Data collected during this time period is invalid and will be removed from the data set for future use.

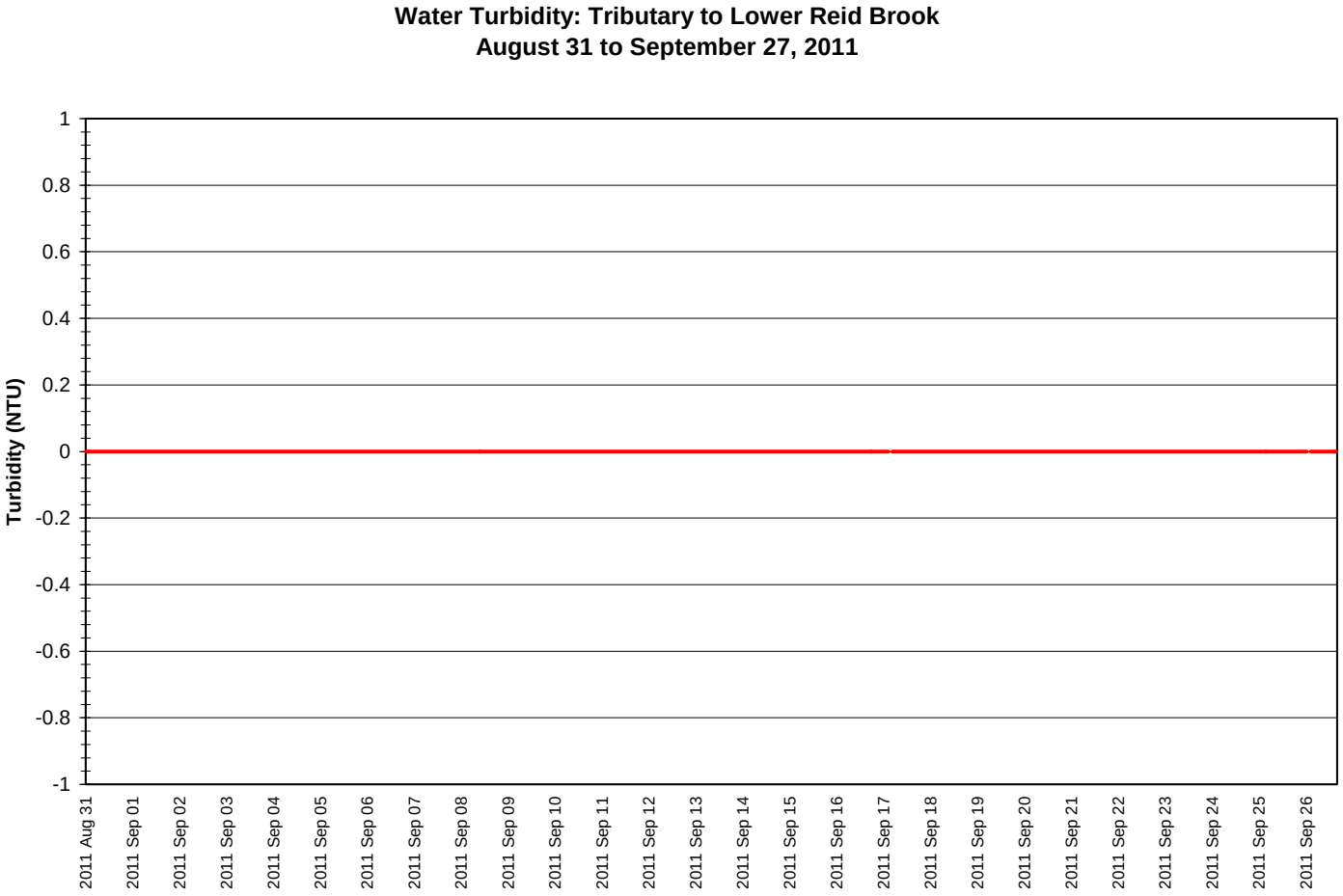

Figure 12: Turbidity at Tributary to Lower Reid Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 13). Stage is generally decreasing throughout the first half of the deployment period while rainfall events are infrequent and low in magnitude. There is a small increase in stage on September 14 following a small rainfall event on September 13. On September 17, there is a large increase in stage following a significant rainfall event (>35mm) on the previous day. Stage decreases gradually for the remainder of the deployment period.

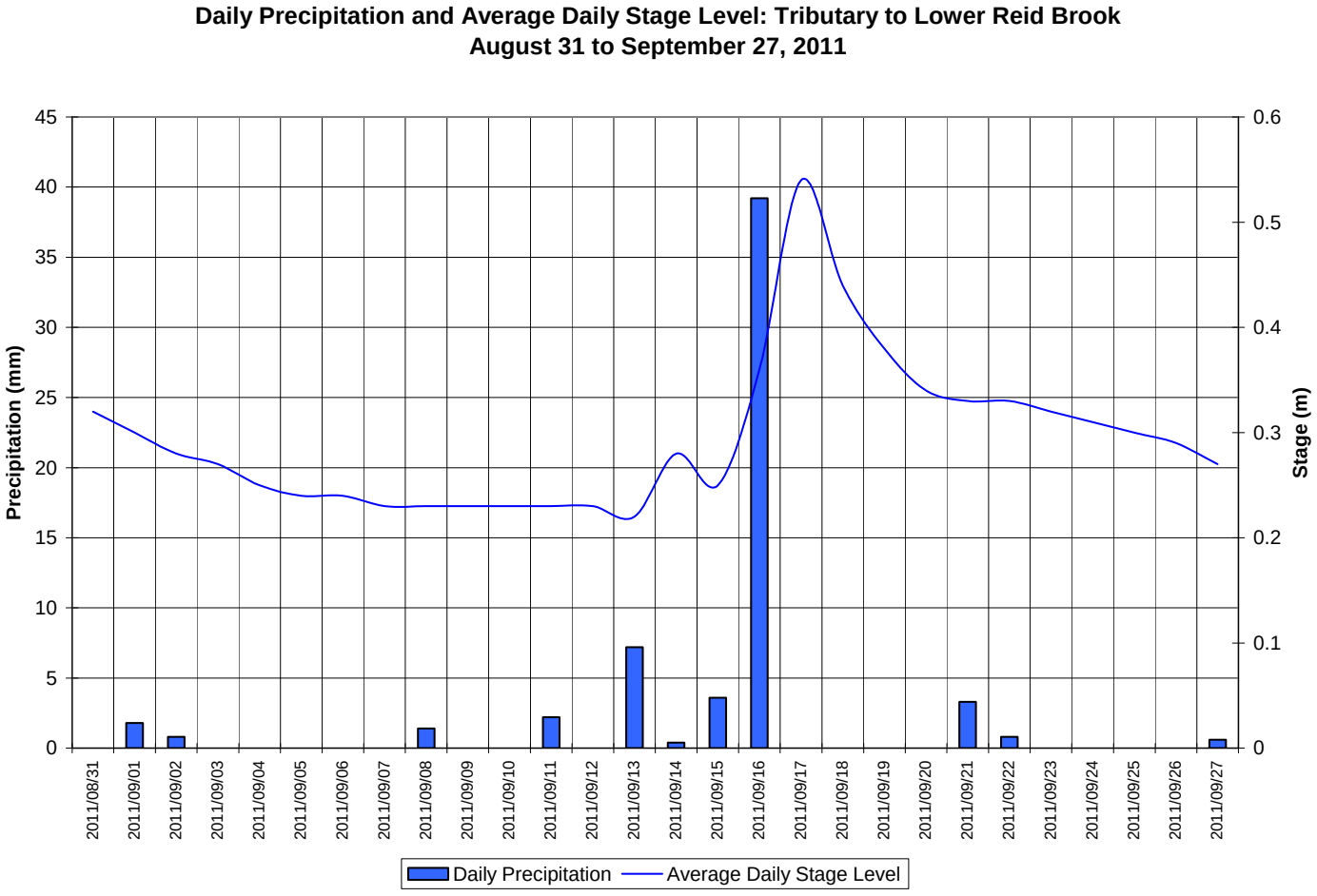

Figure 13: Average Daily Stage and Daily Precipitation at Tributary to Lower Reid Brook

Lower Reid Brook

- Water temperature ranged from 3.88 °C to 14.31°C during the deployment period (Figure 15).
- Water temperature is generally decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 16). Water temperature fluctuates diurnally.

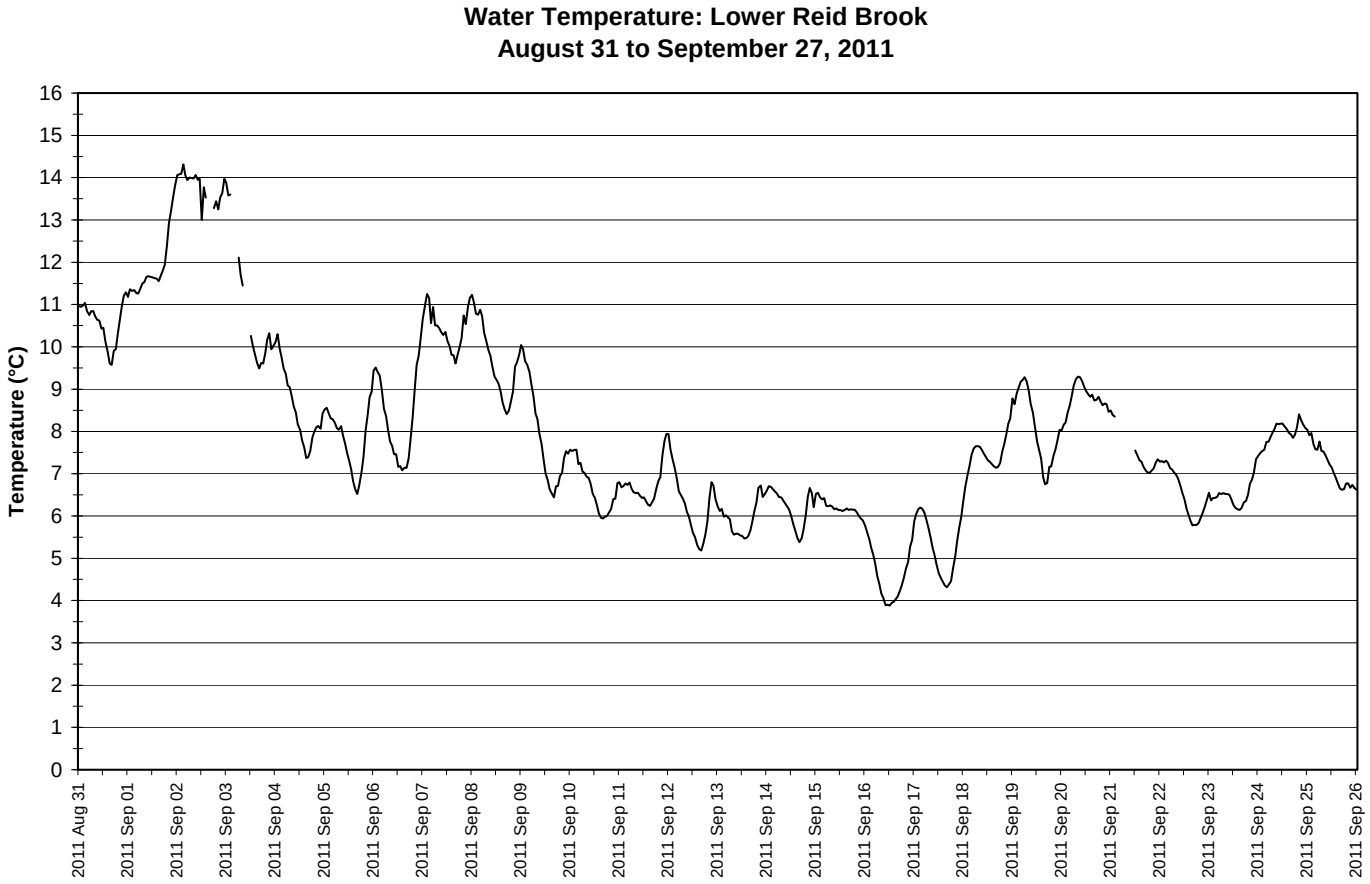

Figure 15: Water temperature at Lower Reid Brook

- Average daily air and water temperatures are generally decreasing throughout the deployment period (Figure 16). Average daily air temperatures do increase on occasion throughout the month of September and each time are reflected in slight increases in water temperature. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

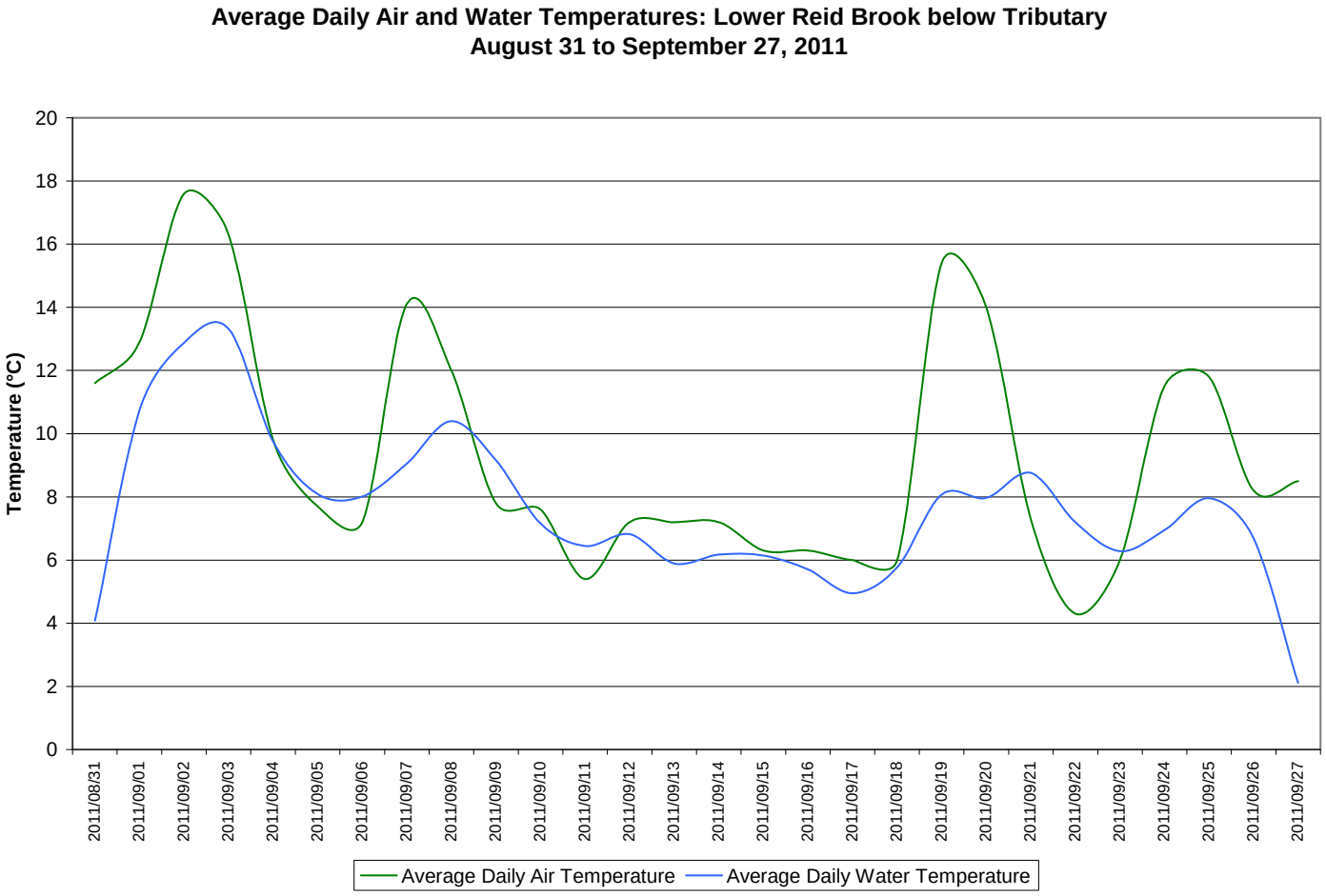

Figure 16: Average daily air and water temperatures at Lower Reid Brook

(weather data recorded at Nain)

- pH ranged between 6.62 and 7.37 pH units (Figure 17).
- pH values are stable with daily fluctuations throughout the first 17 days of the deployment period before decreasing rapidly over a number of hours to as low at 6.62 pH units. After this decrease, pH gradually increases and recovers over a number of days before stabilizing for the remainder of the deployment period.
- Stage is included on Figure 17 to show the relationship between water level and pH. The sharp and rapid decrease in pH on September 17 corresponds with a significant increase in stage (indicated by red arrows on Figure 17). A rainfall event >35mm was recorded by Environment Canada the day before in the nearby community of Nain. Specific conductivity is also affected by this increase in stage (Figure 18).
- All values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 9).

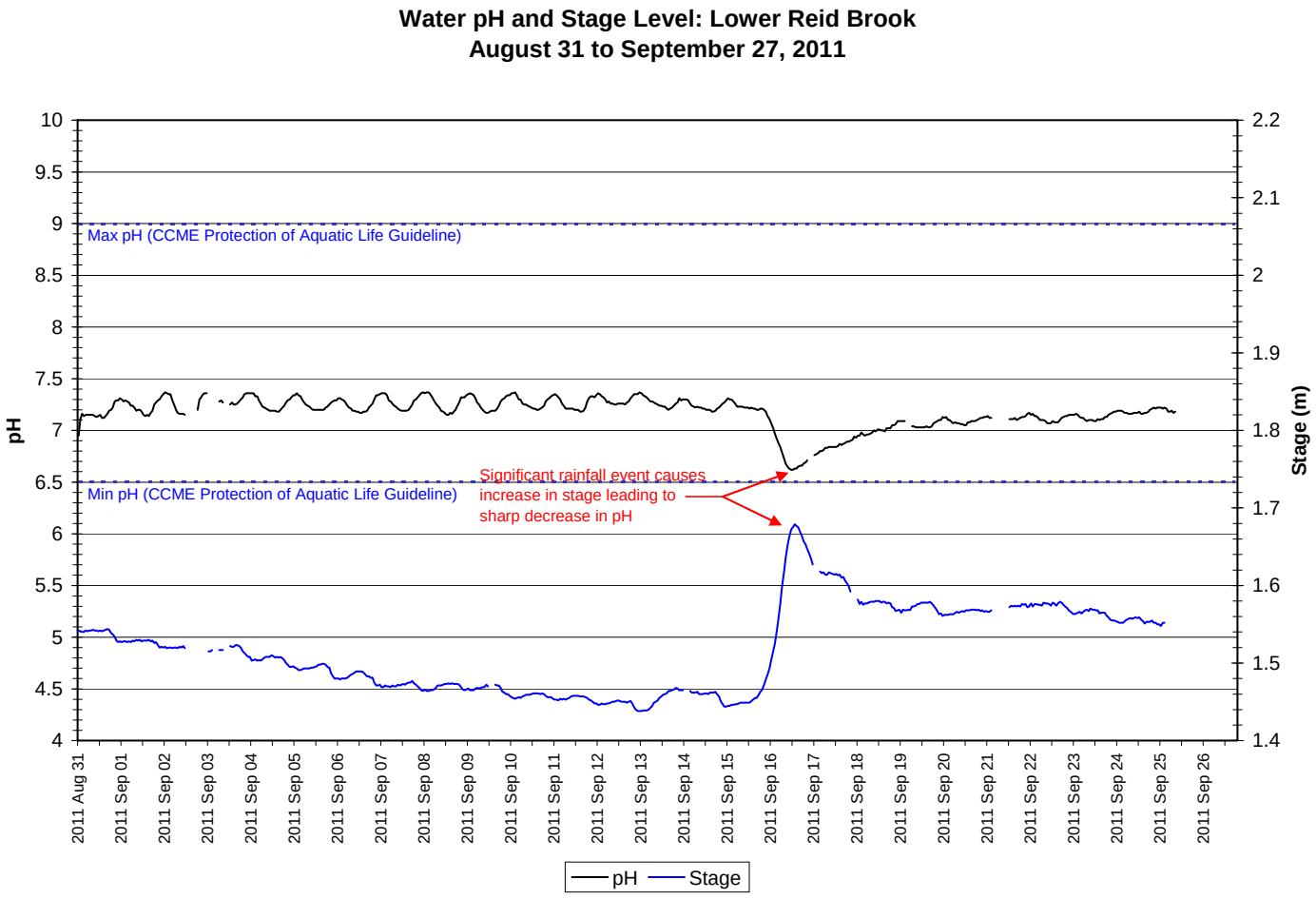

Figure 17: pH and stage level at Lower Reid Brook

- Specific conductivity ranged between 25.0 and 39.0µS/cm (Figure 18). Due to a programming error at this station, specific conductivity is only recorded to zero decimal places.
- Stage is included in Figure 18 to illustrate the inverse relationship between conductivity and water level. Generally, stage is decreasing throughout the first half of the deployment period before increasing sharply following a heavy rainfall event on September 16. On September 17, a large increase in stage causes a very sharp decrease in specific conductivity. A decrease in pH is also noticeable in the data (Figure 17). As stage increases, specific conductivity generally decreases due to the dilution of dissolved solids in the water column. Inversely, as stage decreases, specific conductivity increases as the concentration of dissolved solids increases.

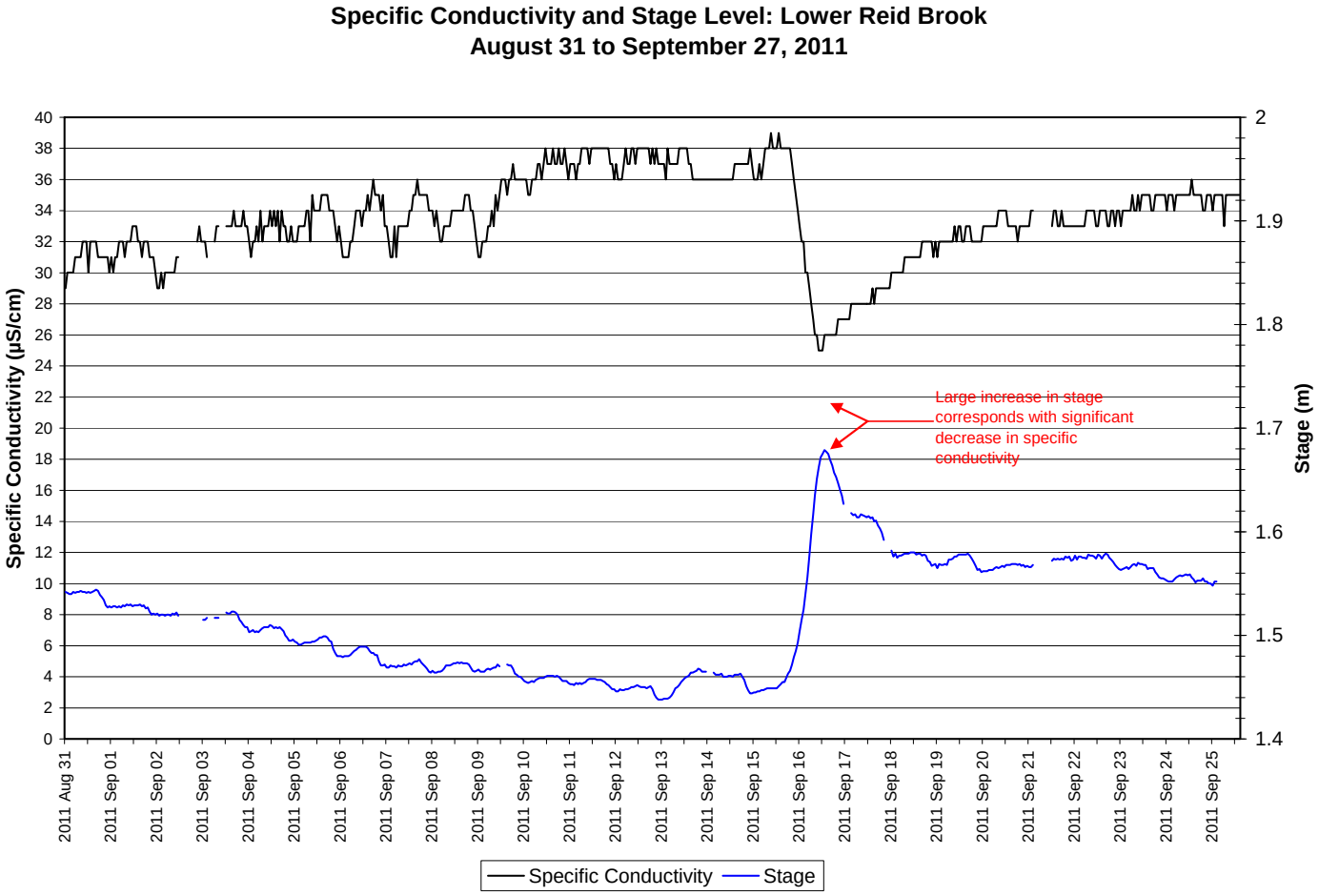

Figure 18: Specific conductivity and stage level at Lower Reid Brook

- During the July 21 to August 30 deployment period, the dissolved oxygen sensor was not working correctly and the inaccurate data collected for dissolved oxygen and percent saturation during that time has been removed from the data set. Oddly, during calibration and maintenance of the same instrument on August 31, the dissolved oxygen sensor calibrated successfully. Data collected during the deployment period between August 31 and September 27 appears to be accurate and typical of the station at this time of year.
- Dissolved oxygen content ranged between 9.17g/L and 11.76mg/L. The saturation of dissolved oxygen ranged from 82.6% to 99.6% (Figure 19).
- All values were above the minimum CCME Guideline for the Protection of Cold Water Biota at Other Life Stages of 6.5 mg/l. Most values were above the CCME Guideline for the Protection of Cold Water Biota at Early Life Stages value of 9.5 mg/l. The guidelines are indicated in blue on Figure 19.
- Dissolved oxygen content is fluctuating throughout the deployment period and increases slightly. This trend is expected given the cooling air and water temperatures in the fall season (Figure 15 & 16).

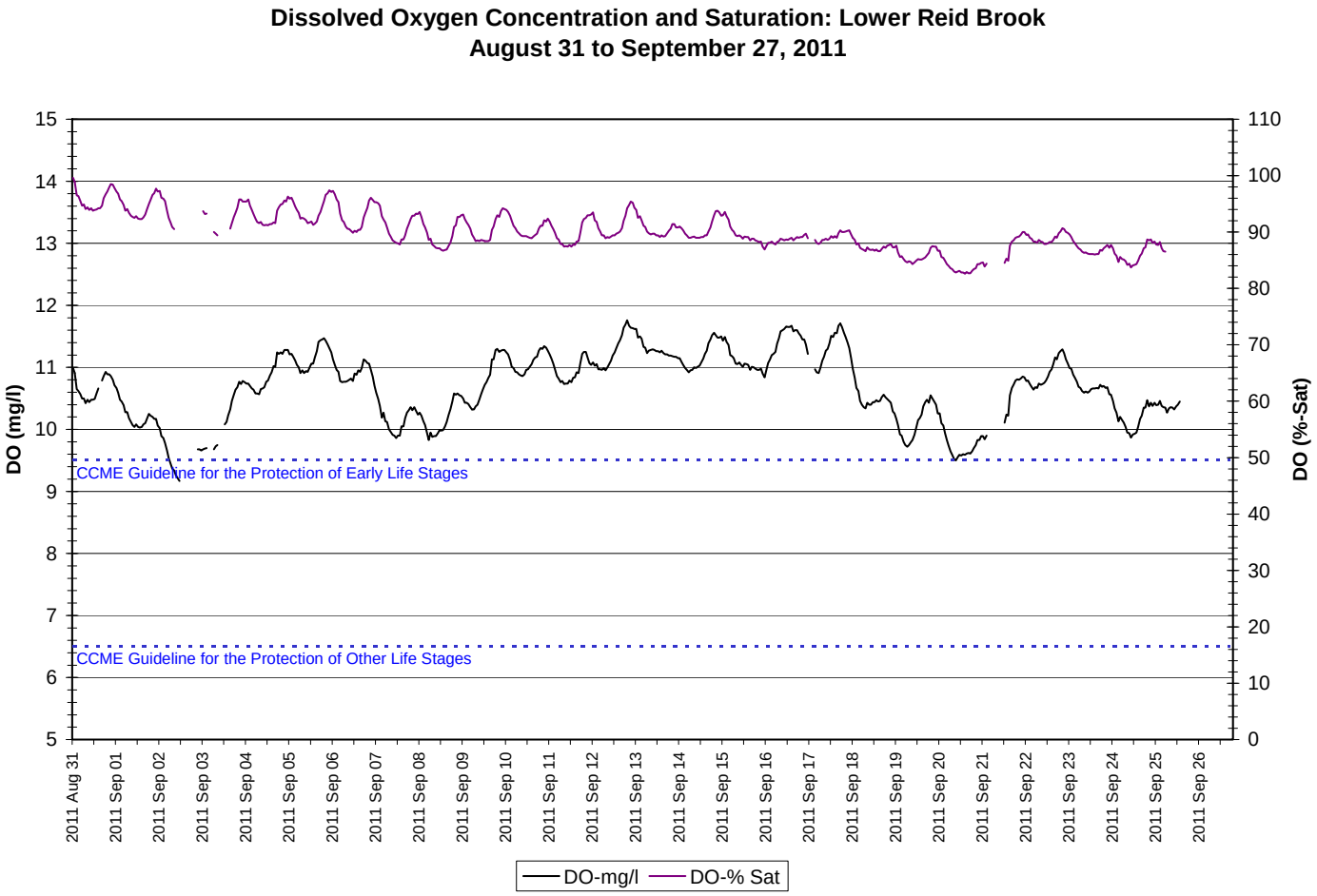

Figure 19: Dissolved oxygen and percent saturation at Lower Reid Brook

- During the July 21 to August 30 deployment period, the turbidity sensor was not working correctly and the inaccurate data collected during that time has been removed from the data set. During calibration and maintenance on August 31, the turbidity sensor calibrated successfully however the wiper and brush failed to rotate. A similar issue has been encountered with the instrument at the Tributary to Lower Reid Brook station and has caused inaccurate data values. Data collected during the deployment period between August 31 and September 27 appears to be compromised from the sensor failure and will be removed from the data set for future use. The inaccurate data values are depicted below in Figure 20.
- Turbidity values ranged from 0.0NTU to 104.0NTU. The consistent fluctuation between high turbidity (>50NTU) and no turbidity (0NTU) is not typical of this station. The turbidity sensor will be inspected upon removal and will likely need to be replaced before the 2012 deployment season.

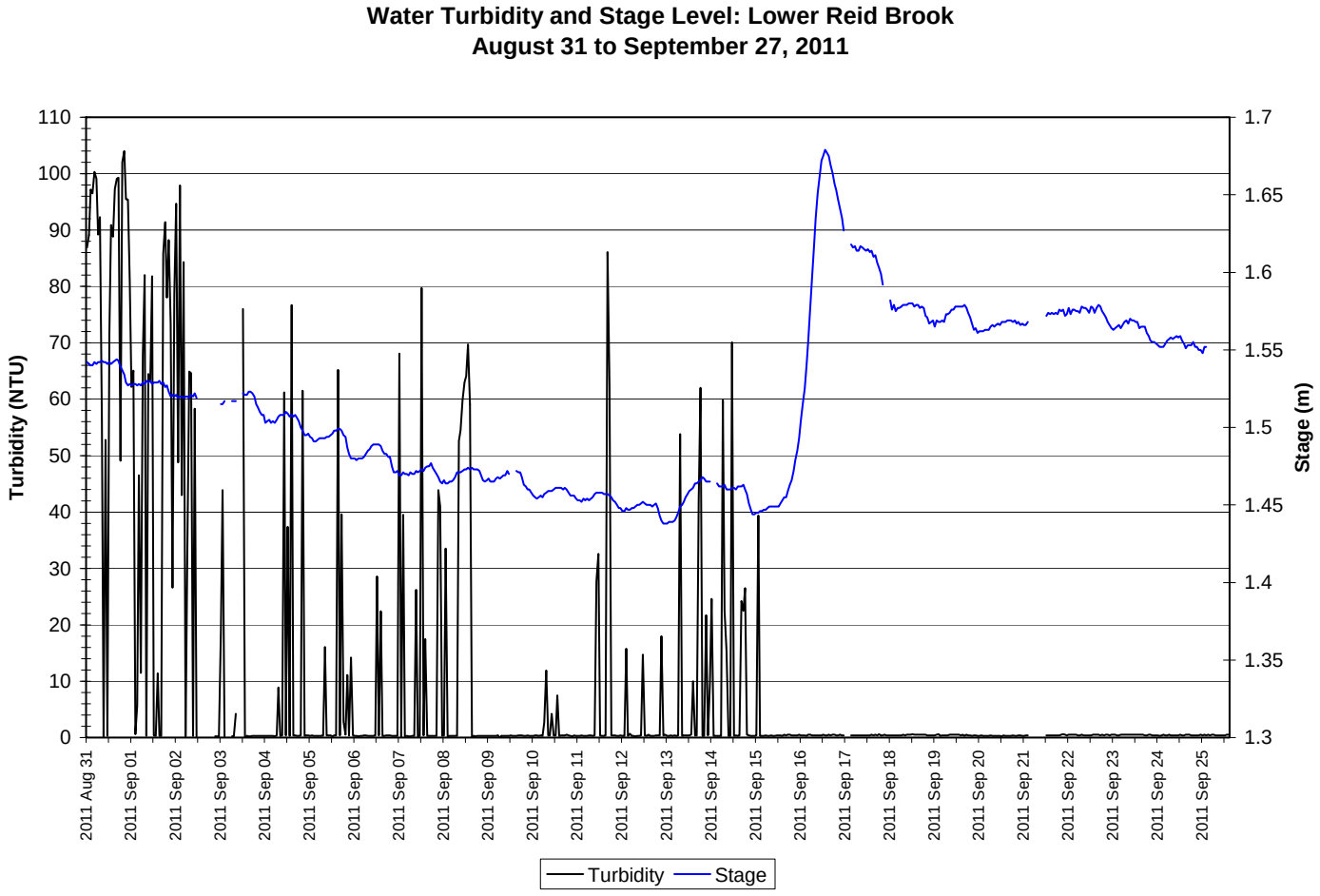

Figure 20: Turbidity and stage level at Lower Reid Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 21). Stage is generally decreasing throughout the first half of the deployment period while rainfall events are infrequent and low in magnitude. On September 17, there is a large increase in stage following a significant rainfall event (>35mm) on the previous day. Stage decreases gradually for the remainder of the deployment period.

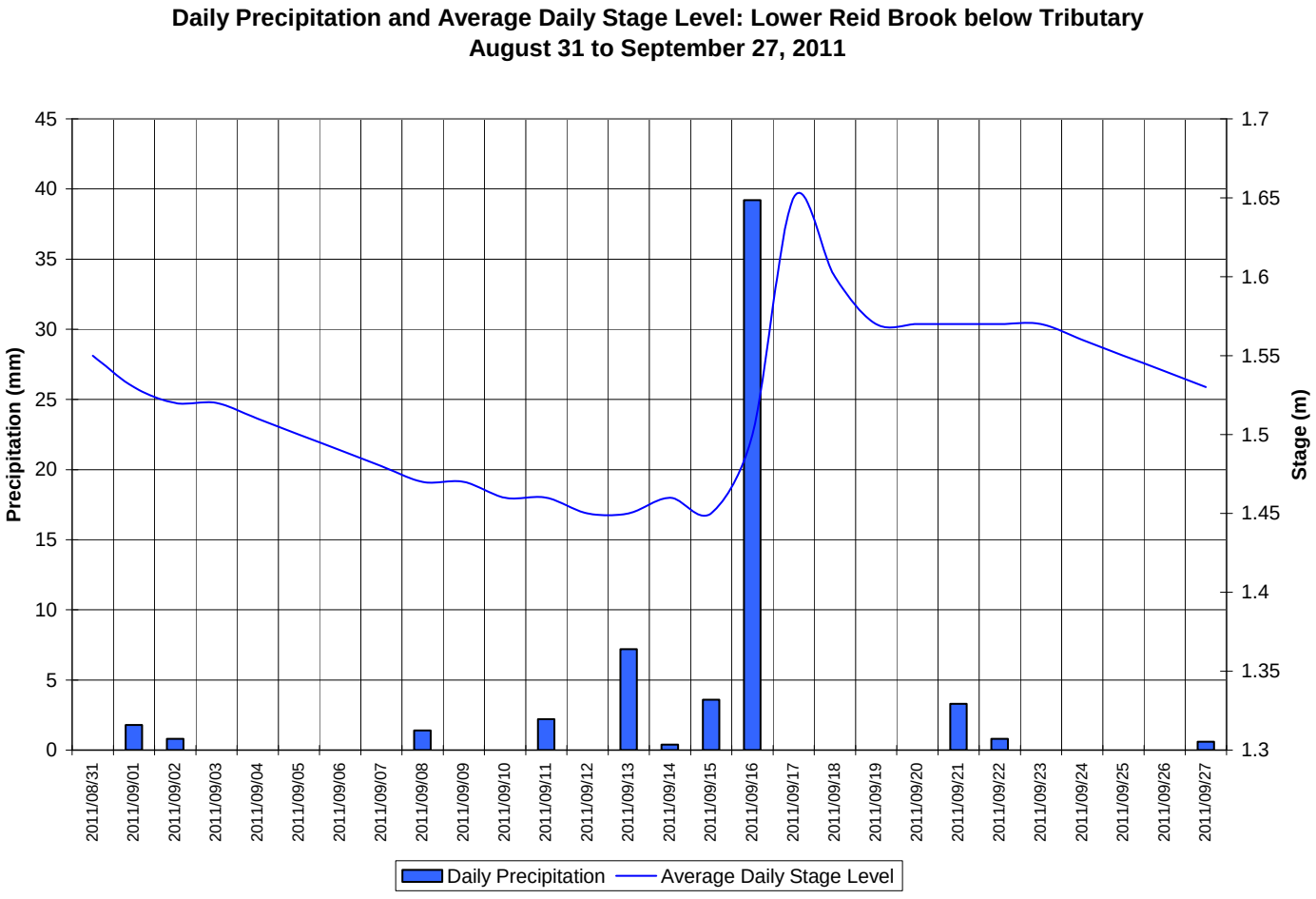

Figure 21: Daily precipitation and average daily stage level at Lower Reid Brook

(weather data recorded at Nain)

Camp Pond Brook

- Water temperature ranged from 3.70 °C to 17.40°C during the deployment period (Figure 22).
- Water temperature is generally decreasing throughout the deployment period. This trend is expected given the cooling ambient air temperatures in the fall season (Figure 23). Water temperature fluctuates diurnally.

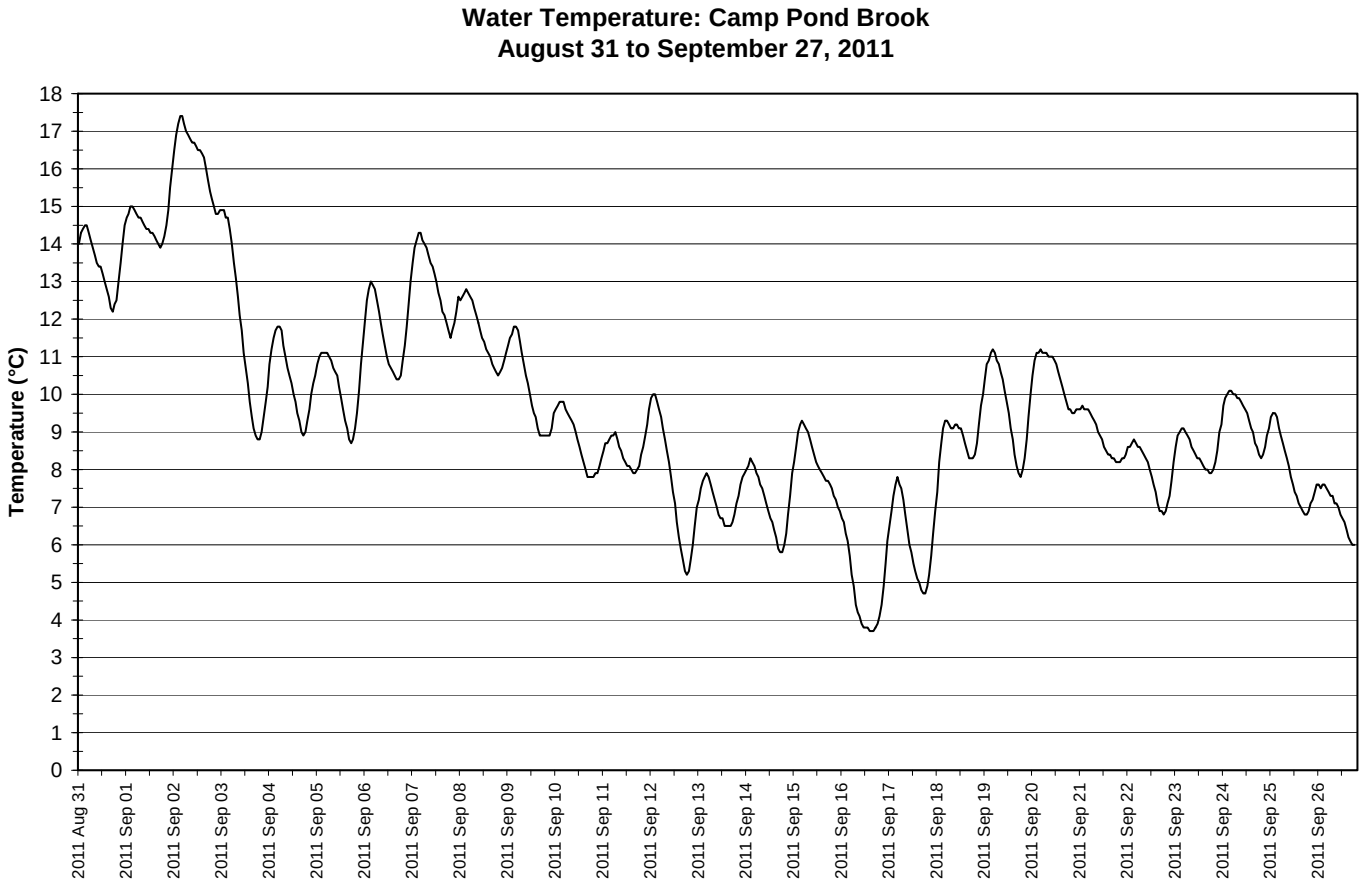

Figure 22: Water temperature at Camp Pond Brook

- Average daily air and water temperatures are generally decreasing throughout the deployment period (Figure 23). Average daily air temperatures do increase on occasion throughout the month of September and each time are reflected in slight increases in water temperature. Air temperatures generally increase and decrease faster while water temperatures increase and decrease more slowly over time.

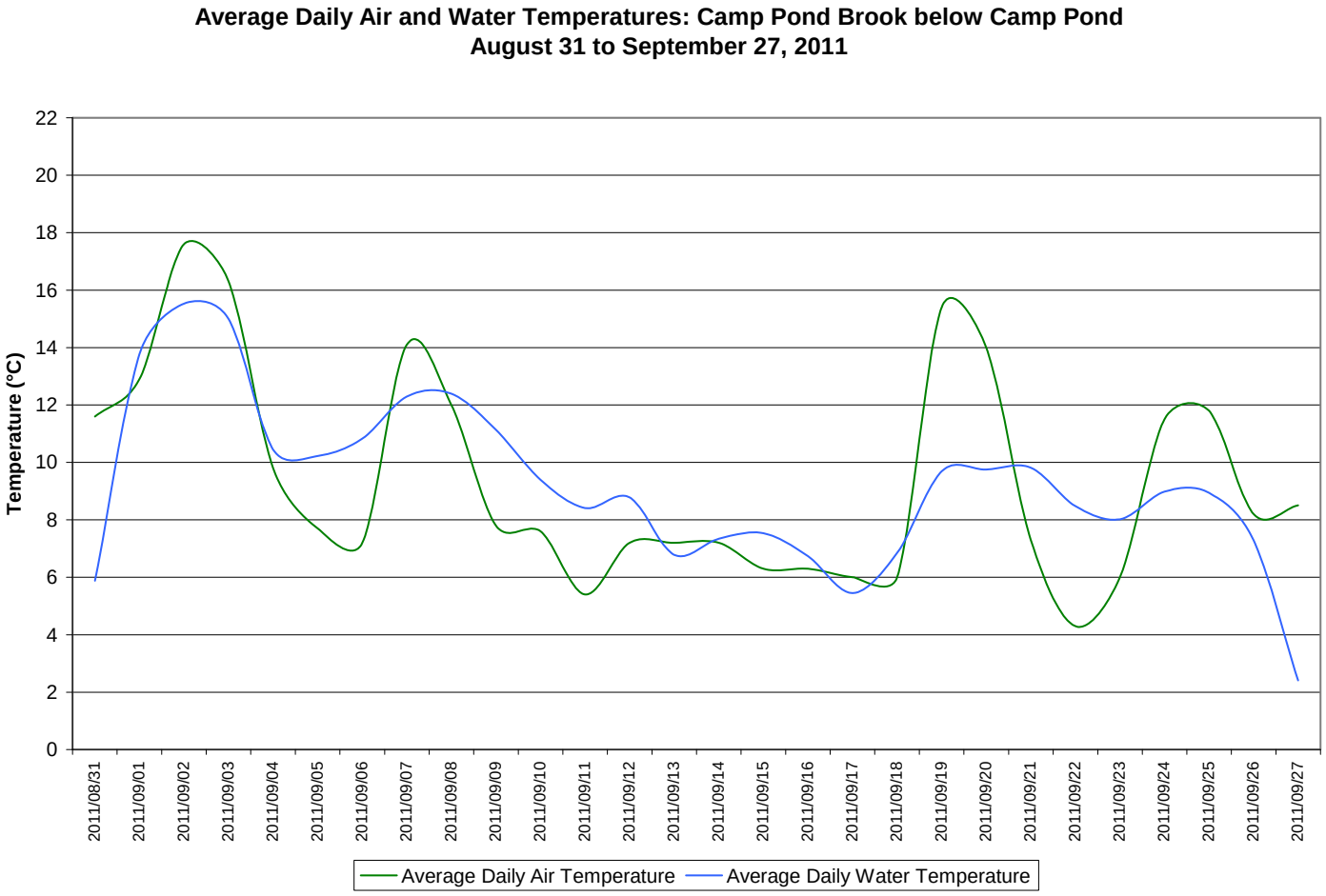

Figure 23: Average daily air and water temperatures at Camp Pond Brook

(weather data recorded at Nain)

- pH ranged between 6.50 and 6.97 pH units (Figure 24).
- pH values are stable with daily fluctuations throughout the first 17 days of the deployment period before decreasing slightly over a number of hours to as low at 6.5 pH units. After this decrease, pH gradually increases and recovers over a number of days before stabilizing for the remainder of the deployment period.
- Stage is included on Figure 24 to show the relationship between water level and pH. The decrease in pH on September 17 corresponds with a significant increase in stage (indicated by red arrows on Figure 24). A rainfall event >35mm was recorded by Environment Canada the day before in the nearby community of Nain. Specific conductivity is also affected by this increase in stage (Figure 25).
- All values are within the recommended range for pH as suggested by the CCME Guidelines for the Protection of Aquatic Life (indicated in blue on Figure 24).

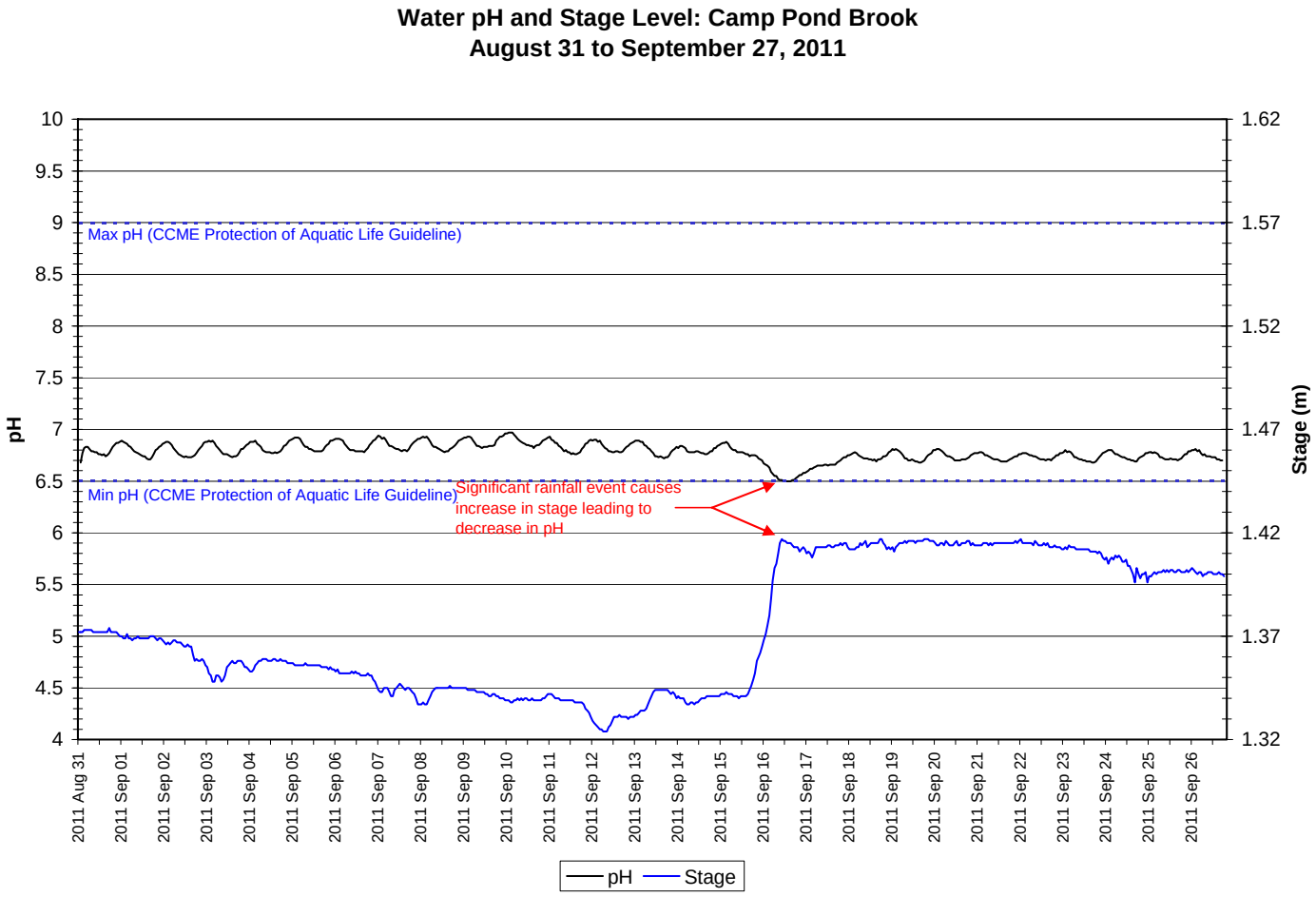

Figure 24: pH and stage level at Camp Pond Brook

- Specific conductivity ranged from 30.6µS/cm to 57.6µS/cm during the deployment period (Figure 25).
- Stage is included in Figure 25 to illustrate the inverse relationship between conductivity and water level. Generally, stage is decreasing throughout the first half of the deployment. Stage increases significantly following a heavy rainfall event on September 16. On September 17, a large increase in stage causes a very sharp increase in specific conductivity (indicated by the red arrows in Figure 25). A decrease in pH is also noticeable in the data (Figure 24).
- Precipitation input and stage level increase typically cause a decrease in the specific conductivity of the water by diluting the concentrations of dissolved solids present in the water column, however, in these instances, there is an increase in specific conductivity following the increase in stage. This pattern has been experienced at this station in the past.

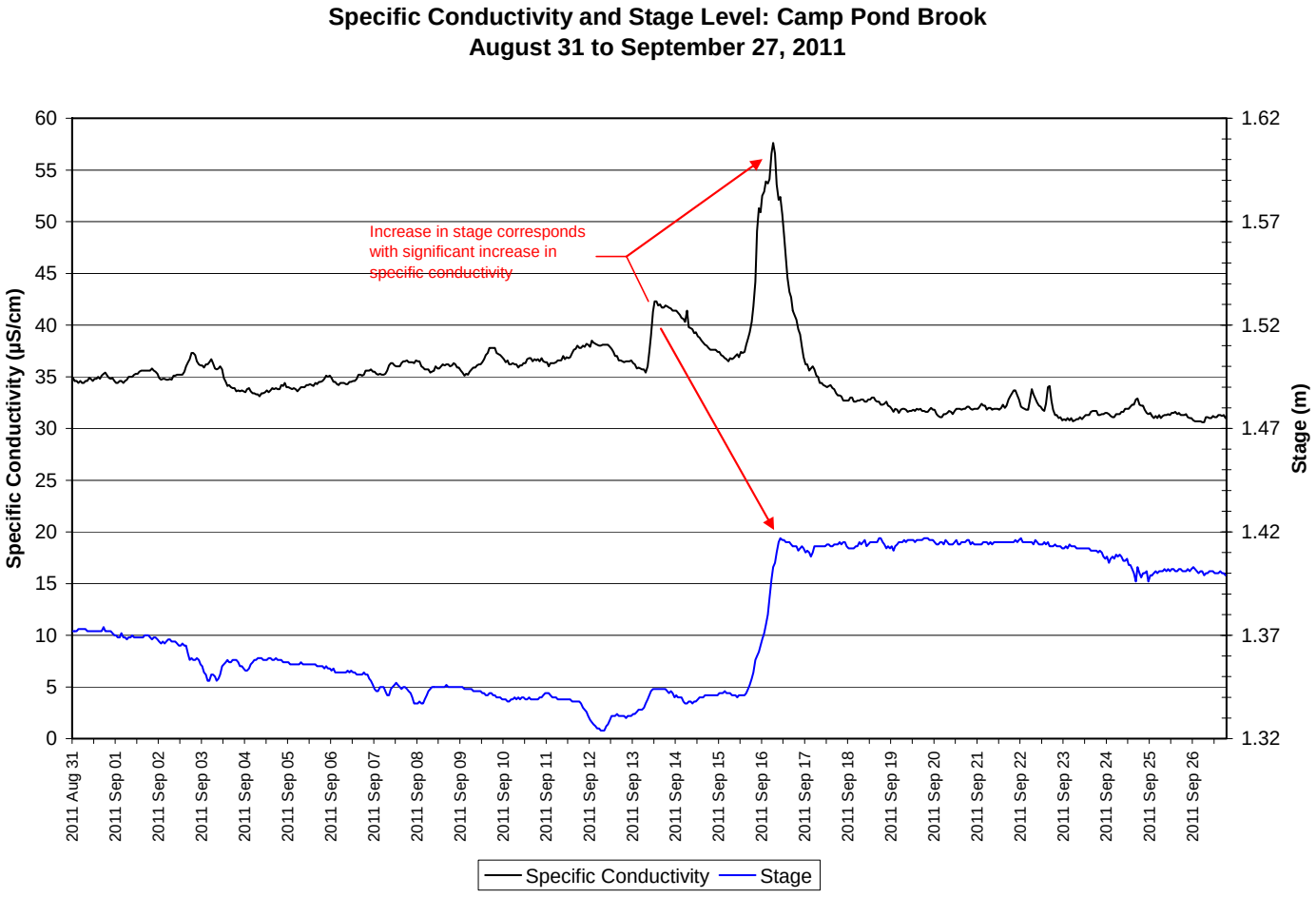

Figure 25: Specific conductivity and stage level at Camp Pond Brook

- Dissolved oxygen content ranged between 7.85mg/L and 12.32mg/L. The saturation of dissolved oxygen ranged from 74.6% to 104.3% (Figure 26).
- In several instances, DO and percent saturation dropped significantly to values as low as 20.0% and 3.00mg/L respectively. These outlying values are not included in the range and have been removed from the data set. The reason for the sporadic sensor readings is unknown at this time. The sensor will be examined carefully during the next calibration and will likely need to be replaced prior to the 2012 deployment season.
- All values were above the minimum CCME Guideline for the Protection of Other Life Stage Cold Water Biota of 6.5 mg/l while most of the values were below the minimum CCME Guideline for the Protection of Early Life Stage Cold Water Biota value of 9.5 mg/l in the first two weeks of the deployment period. In the latter half of the deployment period, dissolved oxygen content increased and remained above 9.5mg/l.
- Dissolved oxygen content is generally increasing throughout the deployment period. This trend is expected given the cooling air and water temperatures in the fall season (Figure 22 and 23).

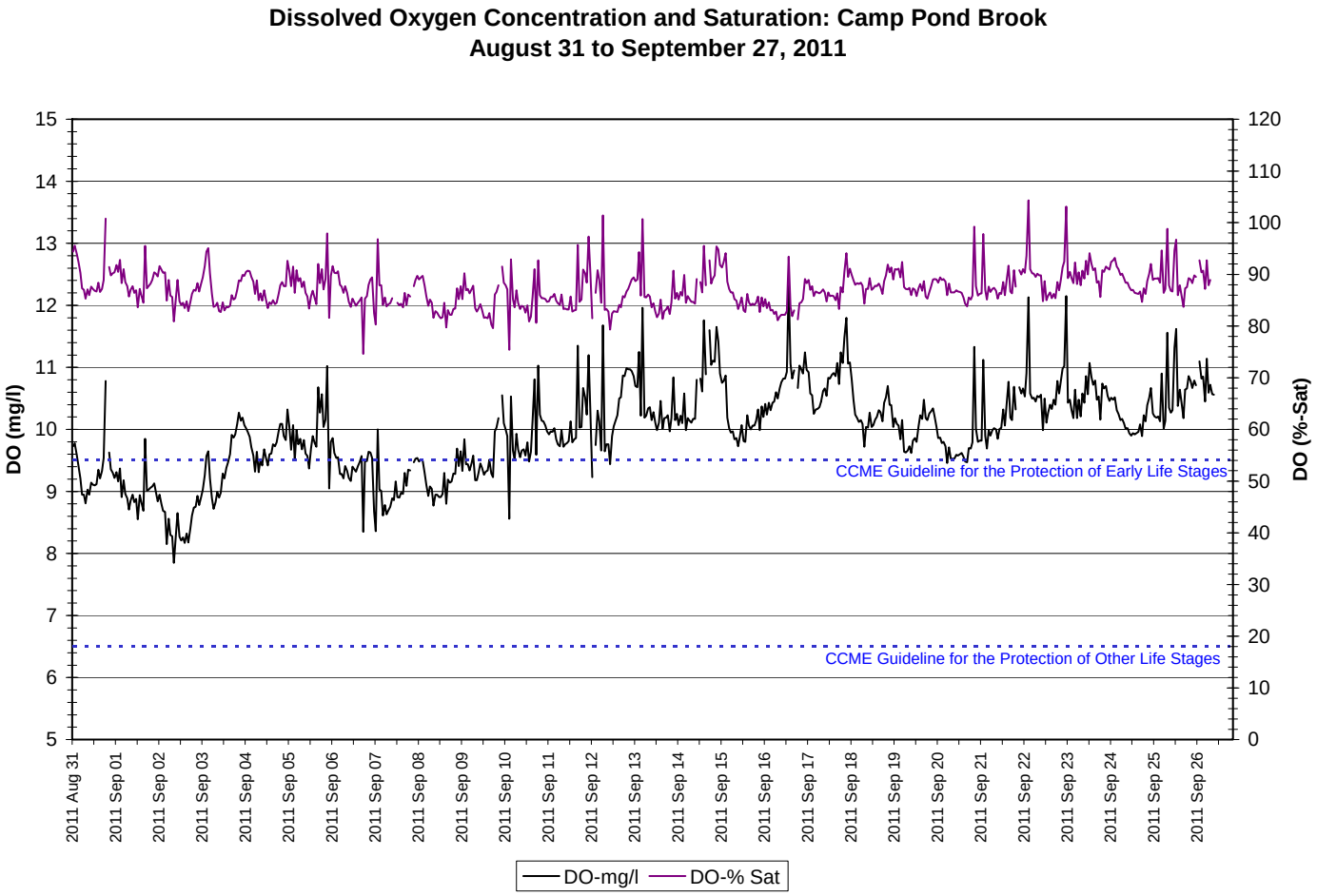

Figure 26: Dissolved oxygen and percent saturation at Camp Pond Brook

- A range of 0.0NTU to 65.1NTU was recorded for turbidity for this deployment period (Figure 27). A median value of 14.9 NTU indicates there is a consistent natural background turbidity value at this station.
- There is typically a natural turbidity value at this station however for this deployment period, the turbidity values are much higher than expected. The pattern seen in the turbidity values is not unusual though. Turbidity values are increasing over a number of days and then decrease gradually over time. There is a decrease in turbidity following the heavy rainfall event on September 16. This is unusual as normally turbidity will increase after rainfall events.
- There is a chance debris (sand, leaves etc.) may have accumulated in the sensor guard which would affect the sensors ability to read turbidity measurements. The reason for these increases remains unknown.

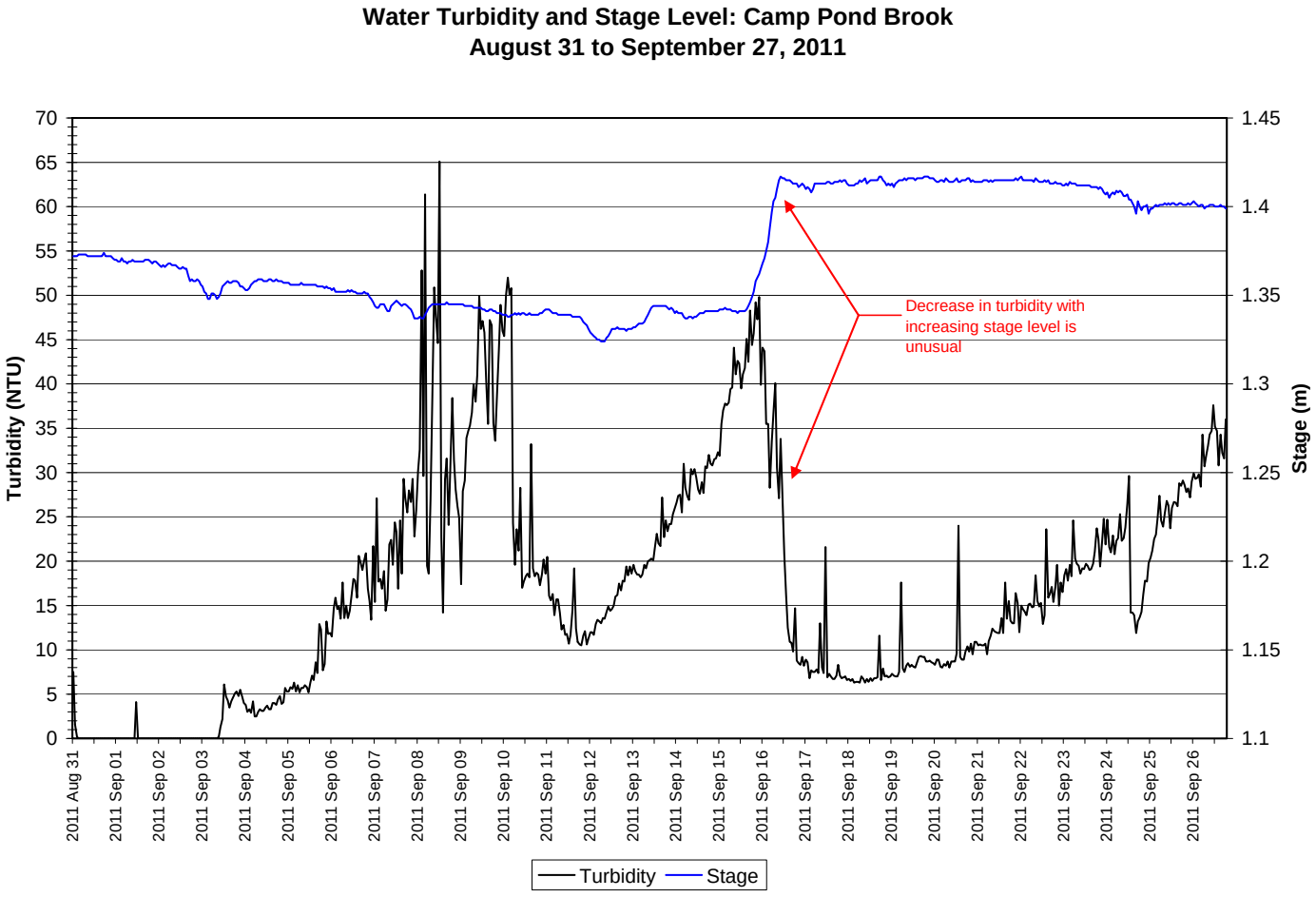

Figure 27: Turbidity and stage level at Camp Pond Brook

- Stage and precipitation are graphed below to show the relationship between rainfall and water level (Figure 28). Stage is generally decreasing throughout the first half of the deployment period while rainfall events are infrequent and low in magnitude. On September 17, there is a large increase in stage following a significant rainfall event (>35mm) on the previous day. Stage remains high for the last week of the deployment period.

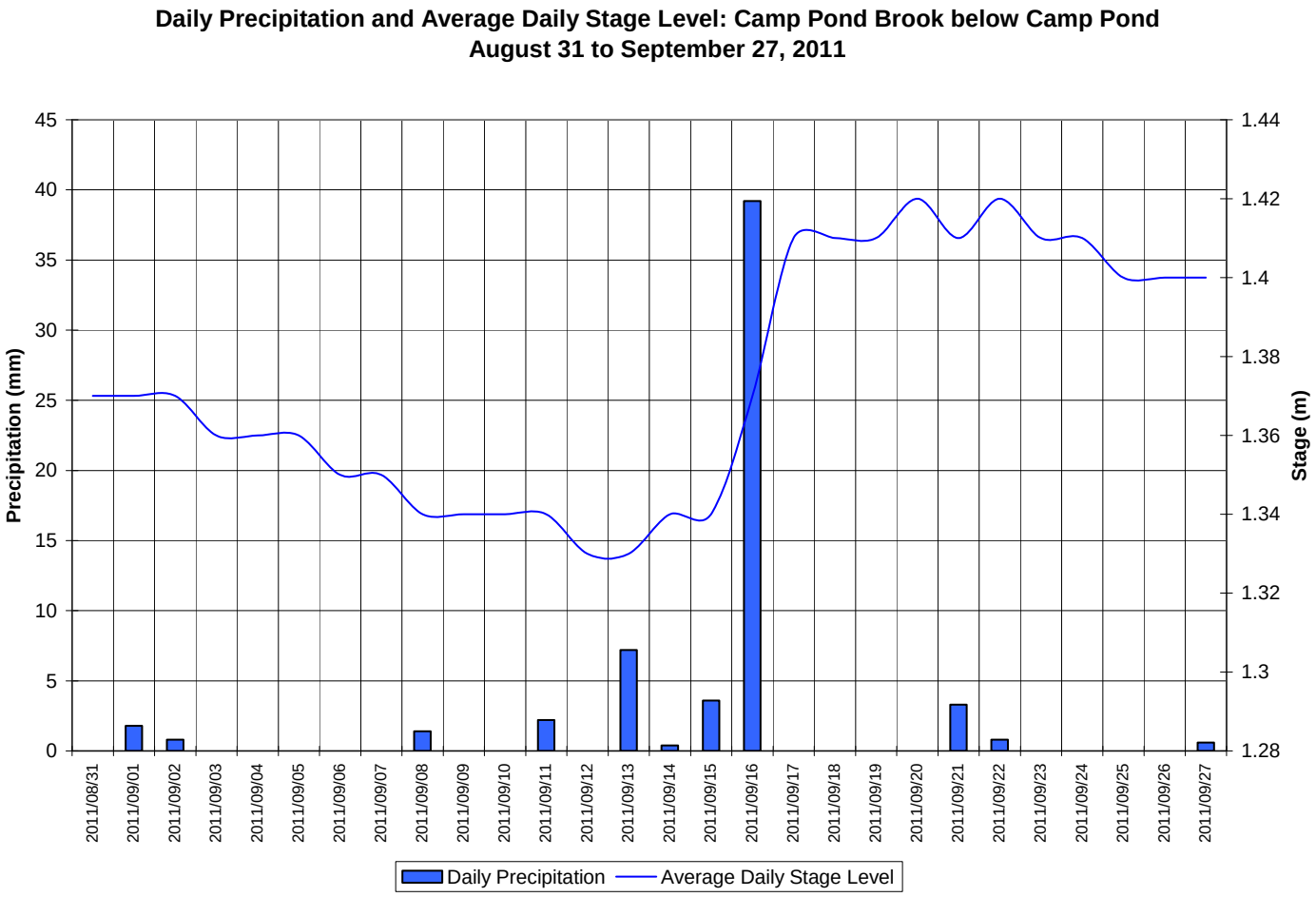

Figure 28: Daily precipitation and average daily stage level at Camp Pond Brook

(weather data recorded at Nain)

Conclusions

- Instruments at water quality monitoring stations in the Voisey's Bay Network were deployed from August 31 to September 27, 2011.

Summary by Station

- At Upper Reid Brook, a replacement instrument loaned to Vale by ENVC was deployed on August 31. This instrument features no turbidity sensor or battery pack therefore there is no turbidity data or option for a back up log file. Temperature decreased throughout the deployment period. There were minimal daily fluctuations in pH and values appeared to drift in the decreasing trend. Specific conductivity was extremely stable for the entire deployment period. Dissolved oxygen increased in response to the cooling air and water temperatures. Stage levels dropped for the first 2 weeks of the deployment before increasing significantly after a heavy rainfall on September 16. Stage remained high for the remainder of the deployment. Turbidity is not recorded at this station.
- At Tributary to Lower Reid Brook, the turbidity wiper and cleaning brush is not working. When the instrument was removed and calibrated at the end of August, the turbidity sensor was unresponsive. Turbidity remained at 0NTU for the entire deployment period. The data collected during this time is invalid and has been removed from the data set for future use. Other parameters were satisfactory; temperature decreased steadily, pH was generally stable and decreased sharply only when stage increased following a significant rainfall event. Specific conductivity showed a clear inverse relationship with stage level as well. Dissolved oxygen increased in response to the cooling air and water temperatures. Stage levels dropped for the first 2 weeks of the deployment before increasing significantly after a heavy rainfall on September 16. Stage gradually decreased for the remainder of the deployment.
- At Lower Reid Brook, temperature also decreased throughout the deployment period. pH values dropped rapidly when stage levels increased following a rainfall event. Specific conductivity also showed a clear inverse relationship with changes in water level. The dissolved oxygen sensor (previously non-functional) calibrated successfully and recorded typical values for this station with increasing values in response to cooling air and water temperatures. The turbidity sensor is not working correctly and the inaccurate values have been removed from the dataset. Stage levels dropped for the first 2 weeks of the deployment before increasing significantly after a heavy rainfall on September 16. Stage gradually decreased for the remainder of the deployment.
- At Camp Pond Brook, water temperatures decreased while dissolved oxygen values increased slightly throughout the deployment period. pH values were stable and decreased sharply when stage levels rose following a heavy rainfall event. Specific conductivity did not portray a typical inverse relationship with stage level. Instead of seeing specific conductivity decrease with increasing stage, specific conductivity increased following the significant rise in stage on September 17. Turbidity averaged around 16NTU, which is high for this station. Stage levels dropped for the first 2 weeks of the deployment before increasing significantly after a heavy rainfall on September 16. Stage remained high for the remainder of the deployment.

Summary by Parameter

- Temperature ranged from 4°C to 15°C at stations at Tributary to Lower Reid Brook, Lower Reid Brook, and Camp Pond Brook. At Upper Reid Brook, water temperatures were on average the warmest across the network for this deployment period, ranging between 7°C and 14°C. Temperature decreased at all stations throughout the deployment period due to the cooling ambient air temperatures in the fall season. All stations experienced diurnal fluctuations in water temperature.
- pH values typically averaged between 6.56 to 7.18 pH units across the network. Average values recorded were within the recommended range as stated by the CCME Guideline for the Protection of Aquatic Life. At stations at Tributary to Lower Reid Brook, Lower Reid Brook, and Camp Pond Brook, an increase in stage level following a heavy rainfall event caused the pH levels to drop suddenly. pH values increased again following this event.
- At Tributary to Lower Reid Brook, Lower Reid Brook and Camp Pond Brook stations, specific conductivity averaged between 32µS/cm and 35µS/cm. Values at Upper Reid Brook were considerably lower averaging 10.5µS/cm. These lower values are expected from this pristine station at the outflow from Reid Pond. Values at this station tend not to fluctuate a lot even with changing stage levels. At Tributary to Lower Reid and Lower Reid Stations, specific conductivity displayed a clear inverse relationship with stage level, with values decreasing when stage level increased on September 17. At Camp Pond Brook, an atypical trend was found when specific conductivity increased sharply when the stage level increased.
- Dissolved oxygen levels were satisfactory across the network averaging between 9.95mg/l and 11.12mg/l. All values recorded were above the minimum CCME Guideline for the Protection of Aquatic Life at Other Life Stages (6.5mg/l). Most values recorded were above the minimum CCME Guideline for the Protection of Aquatic Life at Early Life Stages of 9.5mg/l. Dissolved oxygen trends displayed a clear inverse relationship with water temperature and were increasing throughout the deployment period.
- Turbidity values are inaccurate for the station at Tributary to Lower Reid Brook and Lower Reid Brook due to sensor failure. Values recorded at Camp Pond Brook were greater than normal, averaging around 16NTU. An unusual occurrence where turbidity values decreased following a heavy rainfall event was also evident. There is no turbidity sensor on the instrument at Upper Reid Brook.
- Stage decreased for the first 2 weeks of the deployment period at all 4 stations while precipitation events were infrequent and low in magnitude. On September 16, a significant rainfall event (>35mm) caused a sharp increase in stage at all stations. Water levels at the station on Upper Reid Brook and Camp Pond Brook remained high for the rest of the deployment period while stage levels at Tributary to Lower Reid Brook and Lower Reid Brook gradually decreased.

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Appendix 1

Daily Precipitation and Average Daily Air Temperature: Nain, NL
August 31 to September 27, 2011