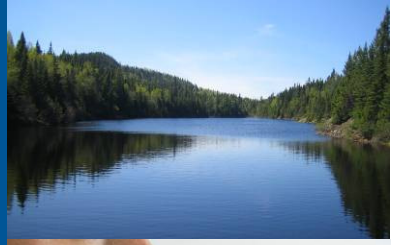
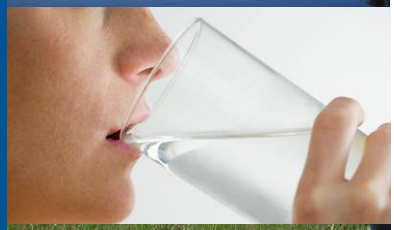






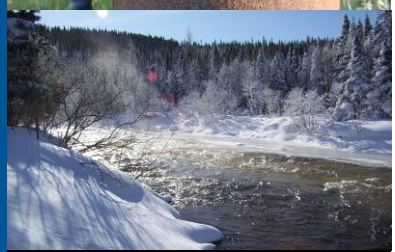

Real Time Water Quality Report
VALE, Voisey's Bay Stations

Deployment Period 2010-06-05 to 2010-07-20

2010-08-08

Newfoundland Labrador

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

Real Time Water Quality Monthly Report for VALE Newfoundland and Labrador Ltd. June & July 2010

General

- On June 5, 2010 VALE environmental staff deployed the 4 DataSondes® following the proper procedures.
- The real-time data (and subsequently the water quality graphs) logged, transmitted and graphed successfully for all four stations over the deployment period.
- Water Resources Management Division (WRMD) staff monitors the real-time web page on a daily basis.
- This report interprets the real-time data collected over the deployment period from June 5 until the instruments were removed on July 20 for calibration/cleaning before being redeployed.

Maintenance and Calibration of Instrumentation

- After being cleaned and freshly calibrated the **DataSondes®** were installed on June 5, 2010, and remained deployed continuously until July 20, 2010, a 46 day period. On July 20, 2010, the instrument was checked *in situ* against a freshly calibrated **MiniSonde®** to verify that it was functioning properly, and had no significant drift.

Quality Assurance / Quality Control (QAQC) Measures

- As part of the QAQC (Quality Assurance/Quality Control) protocol, 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. See **Table 1**.

Table 1: Ranking limits for Parameters

	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

- Upon deployment, a QAQC **MiniSonde®** is temporarily deployed along side the Field **DataSonde®**. Values for temperature, pH, dissolved oxygen, specific conductance and turbidity are compared between the two instruments. Based on the difference between parameters recorded by the Field **DataSonde®** and the QAQC **MiniSonde®** a qualitative statement is made on the data quality upon deployment.
- At the end of a deployment period, readings are taken in the water body from the Field **DataSonde®** before and after a thorough cleaning in order to assess the degree of biofouling. During calibration in the laboratory, an assessment of calibration drift is made and the two error values are combined to give Total Error (T_e). If T_e exceeds a predetermined data correction criterion, a correction based on T_e is applied to the dataset using linear interpolation. Based on the value for T_e, a qualitative statement is also made on the data quality upon removal.
- The rankings at the beginning and end of the deployment period are shown in **Table 2** for the Voisey's Bay Stations.

- During the scheduled visit of **Reid Brook at Outlet of Reid Pond** station, the data was ranked at installation and removal. Due to the absence of a turbidity probe on the QAQC **MiniSonde®** there is no ranking for turbidity. During installation most parameters ranked within the applicable ranges of *Good* and *Excellent*. The pH reading ranked as *Poor* at installation and *Excellent* at removal. The poor ranking was in reference to the QAQC **MiniSonde®** reading. The pH probe requires considerable time to stabilize when first placed in the water body, it is likely that the QAQC instrument did not stabilize before the reading was taken. Dissolved oxygen ranked as *Excellent* at installation and *Fair* at removal. This result may be a reflection of the performance of the Clark cell dissolved oxygen probe on the instrument.

- There were no major events or disruptions to the maintenance check of **Tributary to Lower Reid Brook** during the deployment period or the scheduled site visit. Due to the absence of a turbidity probe on the QAQC **MiniSonde®** there is no ranking for turbidity. The parameters all ranked within *Excellent* to *Good* for both deployment and removal.

- During the scheduled visit of **Lower Reid Brook below Tributary** station, the data was ranked at installation and removal. Due to the absence of a turbidity probe on the QAQC **MiniSonde®** there is no ranking for turbidity. During installation parameters ranked within the applicable ranges of *Good*, and E*xcellent*. Dissolved oxygen reading ranked as *Marginal* and then as *Poor* at removal. This result may be a reflection of the performance of the Clark cell sensor on the instrument during the deployment period.

- There were no major events or disruptions to the maintenance check of **Camp Pond Brook below Camp Pond** station, during the deployment period or the scheduled site visit. The data was ranked at installation and removal. Due to the absence of a turbidity probe on the QAQC **MiniSonde®** there is no ranking for turbidity. During installation parameters ranked within the applicable ranges of *Good*, and E*xcellent*. Dissolved oxygen reading ranked as *Marginal* at removal. This result may be a reflection of the performance of the Clark cell sensor on the instrument during the deployment period.

- It should be noted that the temperature sensor on any sonde 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 sonde the entire sonde 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.

- 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. Where appropriate, corrected data for water quality parameters are indicated.

Table 2: QAQC Data Comparison Rankings for deployment between June 5 and July 20, 2010

Station	Date	Action	Instrument Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Reid Brook Outlet (40644)	**June 5/10**	**Installation**	Good	Poor	Excellent	Excellent	n/a
	July 20/10	**Removal**	Good	Excellent	Excellent	Fair	n/a
Lower Reid Brook (40643)	**June 5/10**	**Installation**	Good	Excellent	Excellent	Marginal	n/a
	July 20/10	**Removal**	Excellent	Fair	Good	Poor	n/a
Tributary to Lower Reid Brook (44175)	**June 5/10**	**Installation**	Good	Excellent	Excellent	Excellent	n/a
	July 20/10	**Removal**	Good	Excellent	Excellent	Good	n/a
Camp Pond Brook (40642)	**June 5/10**	**Installation**	Excellent	Good	Good	Good	n/a
	July 20/10	**Removal**	Excellent	Good	Good	Marginal	n/a

DATA INTERPRETATION

- Due to technical difficulties connecting to the instrument, before and after cleaning values could not be taken of the Field **DataSonde®** at Reid Brook at outlet of Reid Pond. This affects the ability to calculate for biofouling drift on this instrument, hence there are no corrections applied to the Reid Brook at Outlet of Reid Pond data for biofouling. There were values to calculate the presence of calibration drift.

REID BROOK AT OUTLET OF REID POND (UPPER REID BROOK)

TEMPERATURE

The water temperature (**Figure 1**) ranged from a minimum of 1.53 ˚C to a maximum of 13.81˚C.

- The water temperature ranges depict a steady increase in water temperature from June onward, as air temperature increases.
- Around June 28, temperature data transmissions are intermittent for a period of days. Following this period, temperature data becomes erratic fluctuating as much as 7°C in an hour. Temperature values are irregular for the remainder of the deployment period. These are unusual readings for water temperature.
- At the Environment Canada Station in Nain, nearly 80mm of precipitation was recorded between June 23 and 26. This event corresponds with a significant increase in stage and stream-flow at the Upper Reid Brook station. The erratic temperature readings occur after this stage and stream flow increase and suggest that this event had a significant impact on the instrument. Free flowing silt and sediment may have covered the probe and caused the inaccurate readings.
- Data recorded between July 2 and July 20 is not accurate.

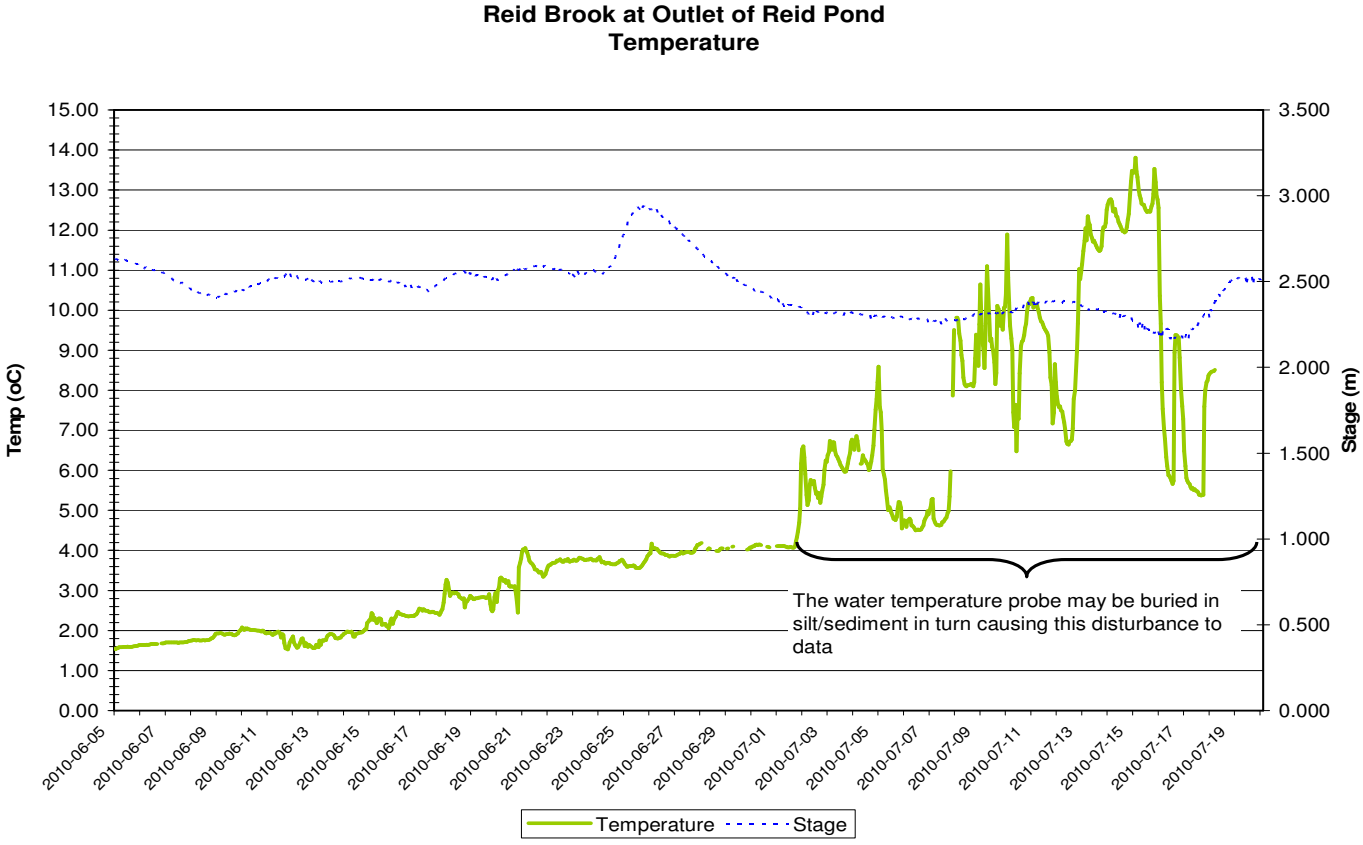

Figure 1: Water Temperature at Reid Brook at Outlet of Reid Pond

pH

- Throughout the deployment period pH values (**Figure 2**) ranged from a minimum of 6.28 to a maximum of 6.71.
- The pH values can be compared to the CCME *Protection for Aquatic Life Guidelines.* For Reid Brook Outlet the pH values sit slightly below the recommended range (6.5 – 9.0) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. This is not unusual as the background pH for Reid Brook Outlet is historically at the lower end of the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.
- There is a slight increase in the pH levels around July 4, 2010. This may be in relation to a precipitation event. Rain water is slightly acidic (~ pH 6.5) and may influence the pH levels at that time.

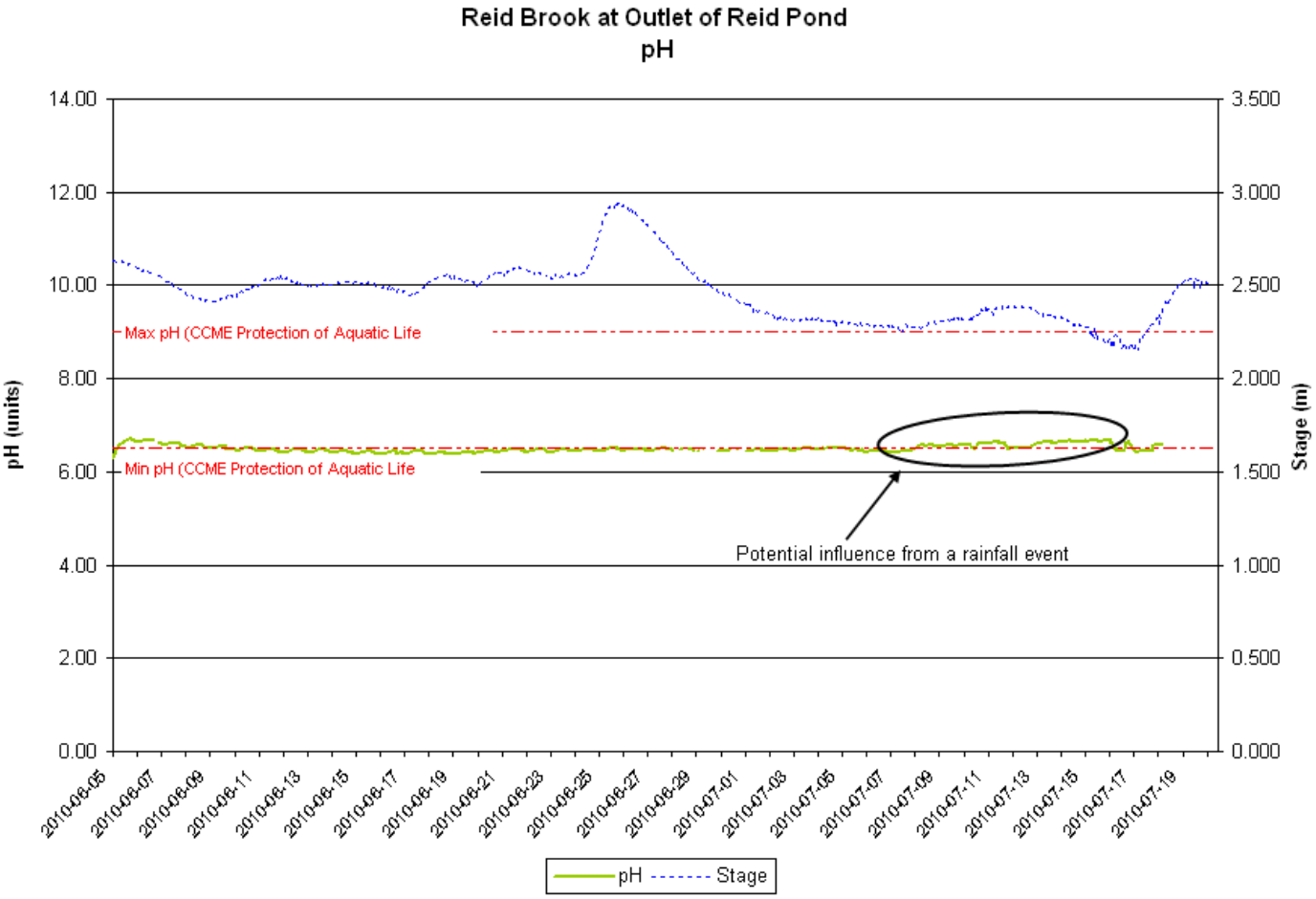

Figure 2: pH values at Reid Brook at Outlet of Reid Pond

SPECIFIC CONDUCTIVITY

- The specific conductivity **(Figure 3)** ranged from a minimum of 8.0 µS/cm to a maximum of 10.1 µS/cm over the deployment period.
- Specific Conductivity levels decrease slightly over the deployment period, however, remain stable and without significant fluctuation.
- There is no apparent correlation between specific conductivity and stage during this deployment period.

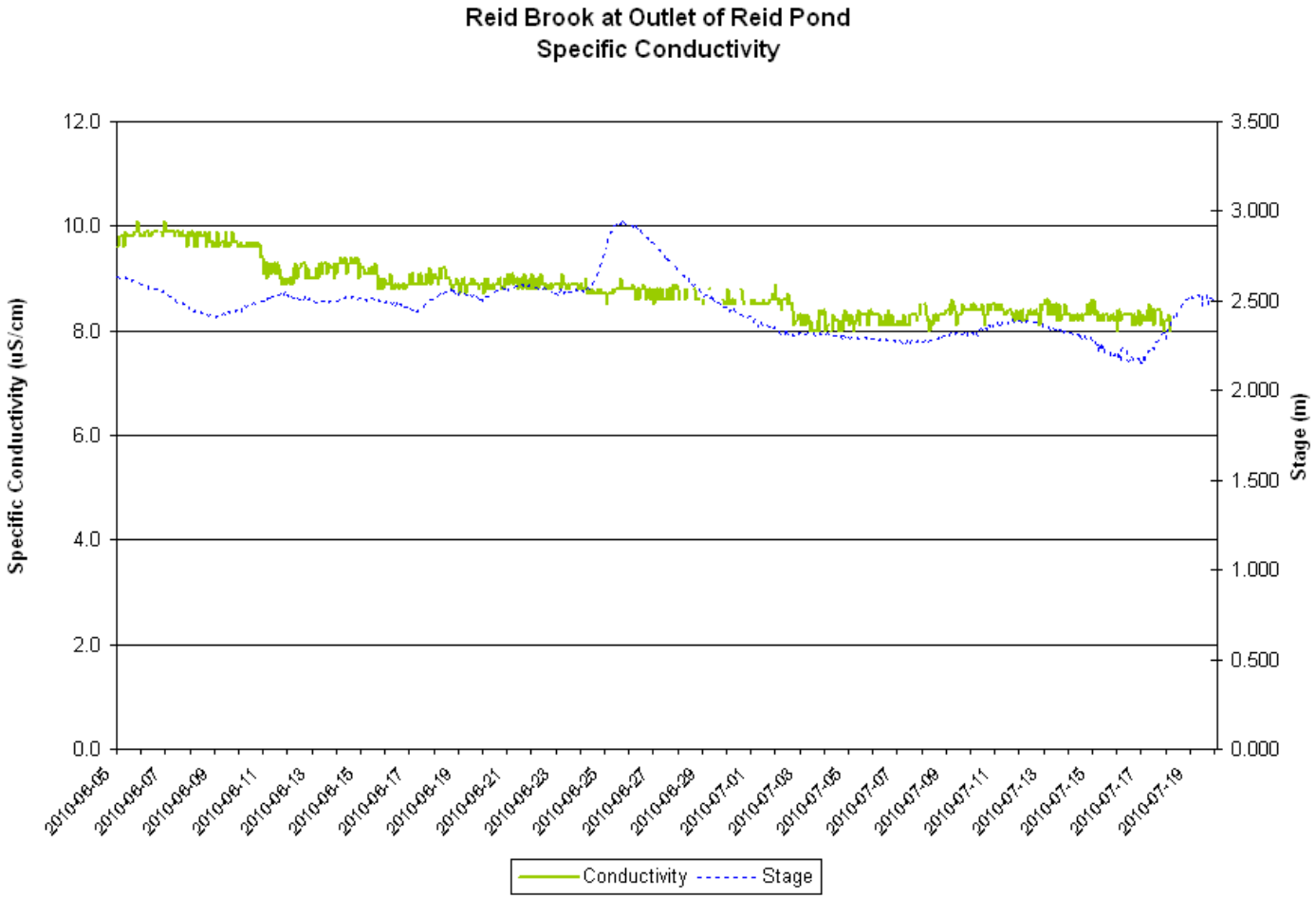

Figure 3: Specific Conductivity Values at Reid Brook at Outlet of Reid Pond

DISSOLVED OXYGEN

- The dissolved oxygen (DO), values ranged from a minimum of 9.29 mg/L to a maximum of 13.22 mg/L over the deployment period (**Figure 4**).
- Throughout the deployment period, most DO values were within the limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L and Cold Water/Other Life Stages – above 6.5 mg/L).
- The same precipitation event (80mm from June 23-26) which caused significant increases in stage and stream flow also significantly affected the DO sensor. Similar patterns between erratic temperature and DO data are evident. Immediately following the rainfall event, data transmissions are intermittent and then data becomes irregular. The sensors capability to accurately measure the water conditions is compromised following this disturbance.
- Data recorded between July 2 and the end of the deployment period, July 20, is not accurate.

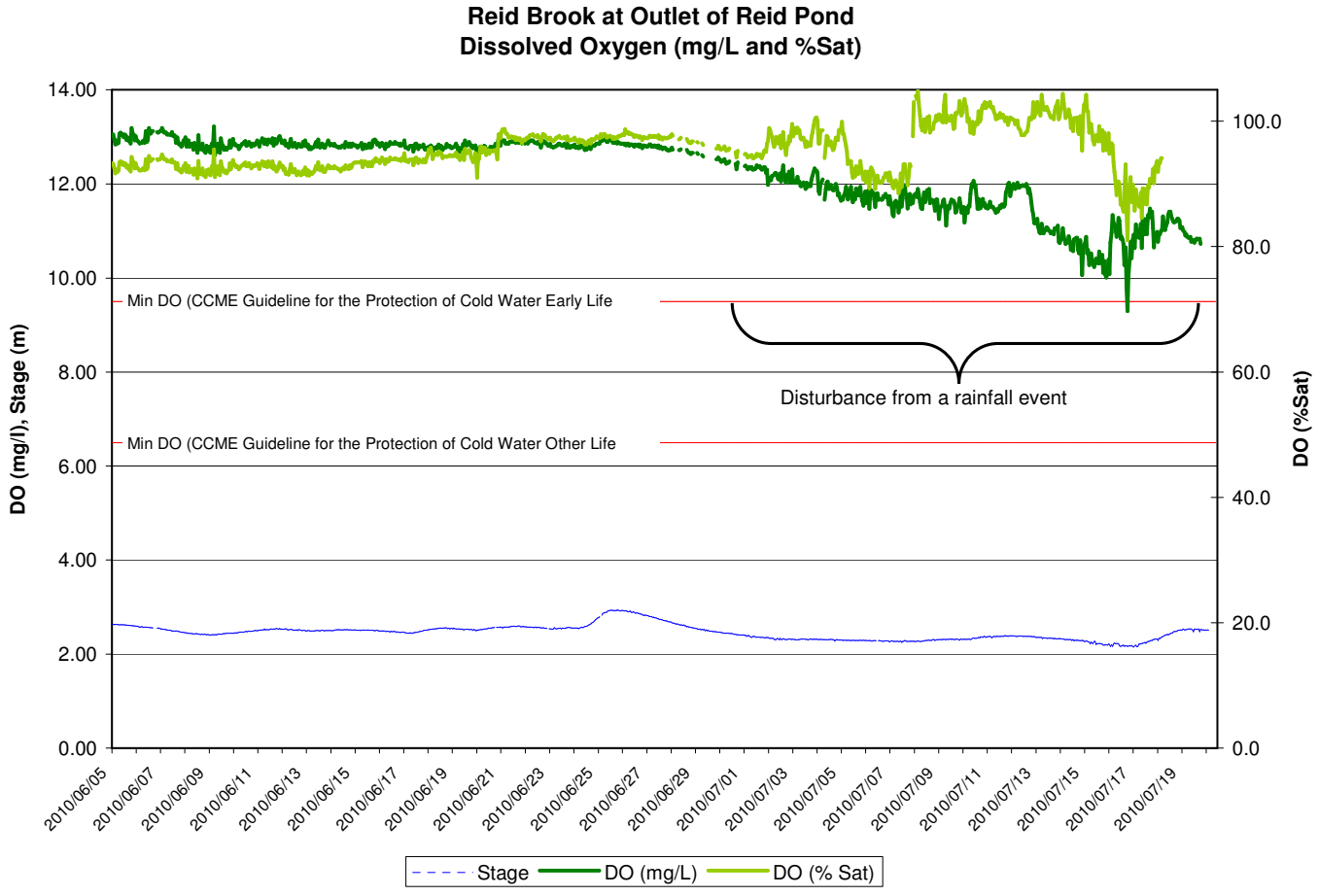

Figure 4: Dissolved Oxygen (mg/L & % Sat) at Reid Brook at Outlet of Reid Pond

TURBIDITY

- The turbidity values ranged from a minimum of 0.00 NTU to a maximum of 3000 NTU over the deployment period (**Figure 5a and b**). Turbidity is displayed in Figure 5a and b at two different scales in order to illustrate the different events that took place during the deployment period.
- The reading of 3000 NTU occurred on July 9, 2010, a reading of 3000 NTU is often identified as an error reading from the turbidity sensor (Figure 5a). This reading can result from floating debris or the self cleaning wiper blocking the sensor window during that exact time a reading is being taken.
- The turbidity sensor capability was also affected by the significant rainfall event that occurred between June 23 and 26. Following this event, turbidity started to increase to ~290 NTU over the period of a couple of days at this station (Figure 5b).
- From July 3, 2010 onwards toward the end of the deployment period there are fluctuating turbidity readings. These readings can be a result of silt and sediment interfering with the working of the sensor. After precipitation, streams continue to be influenced by runoff, and in turn the turbidity levels take several days to settle and stabilize.
- Upper Reid Brook station is typically clean and clear with no turbidity events. Data recorded during this deployment period is extremely unusual suggesting almost with certainty that the turbidity sensor was affected by the stage and stream flow increases.
- Data recorded between June 27 and July 20 is not accurate.

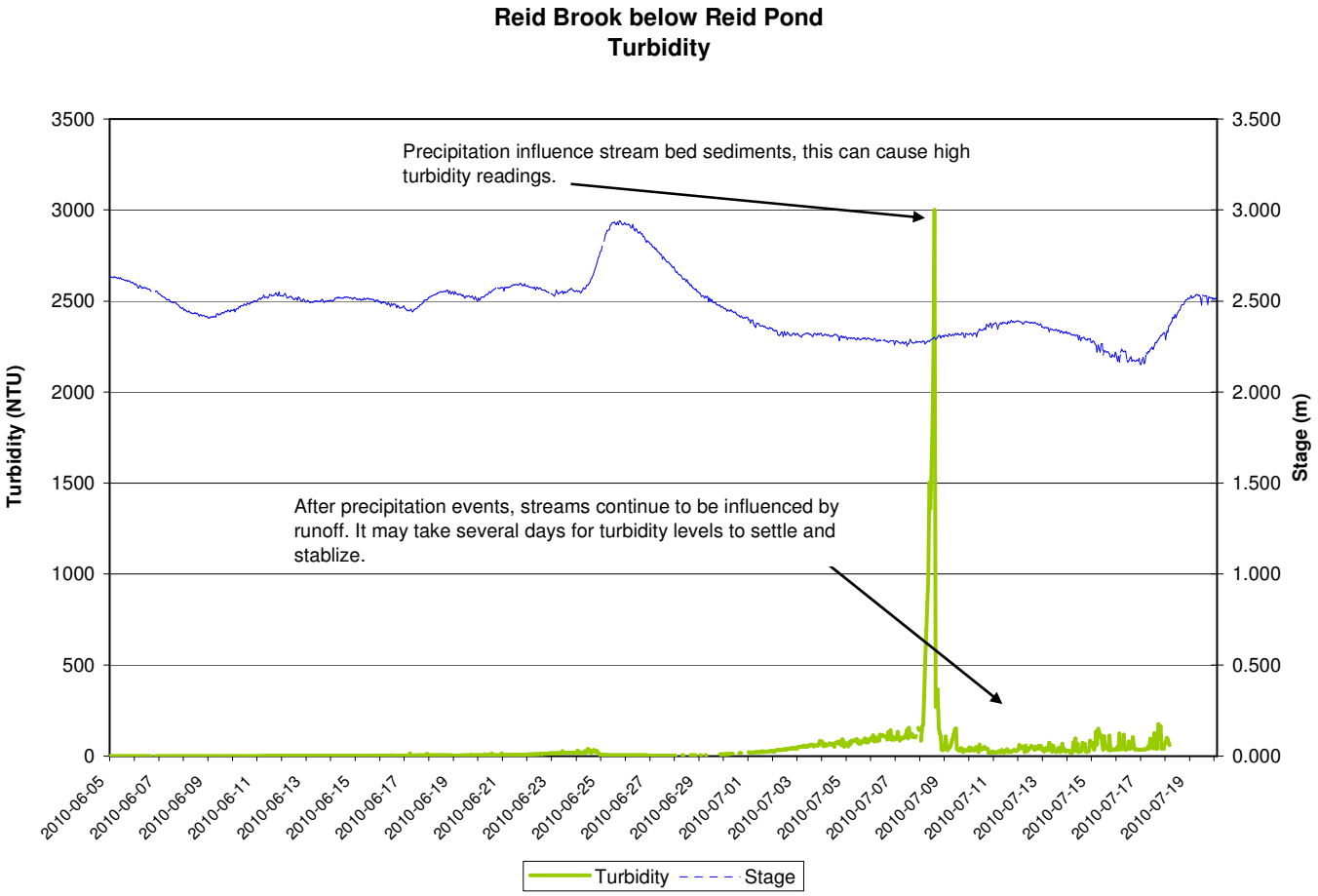

Figure 5a: Turbidity Values for Reid Brook at Outlet of Reid Pond up to 3500NTU.

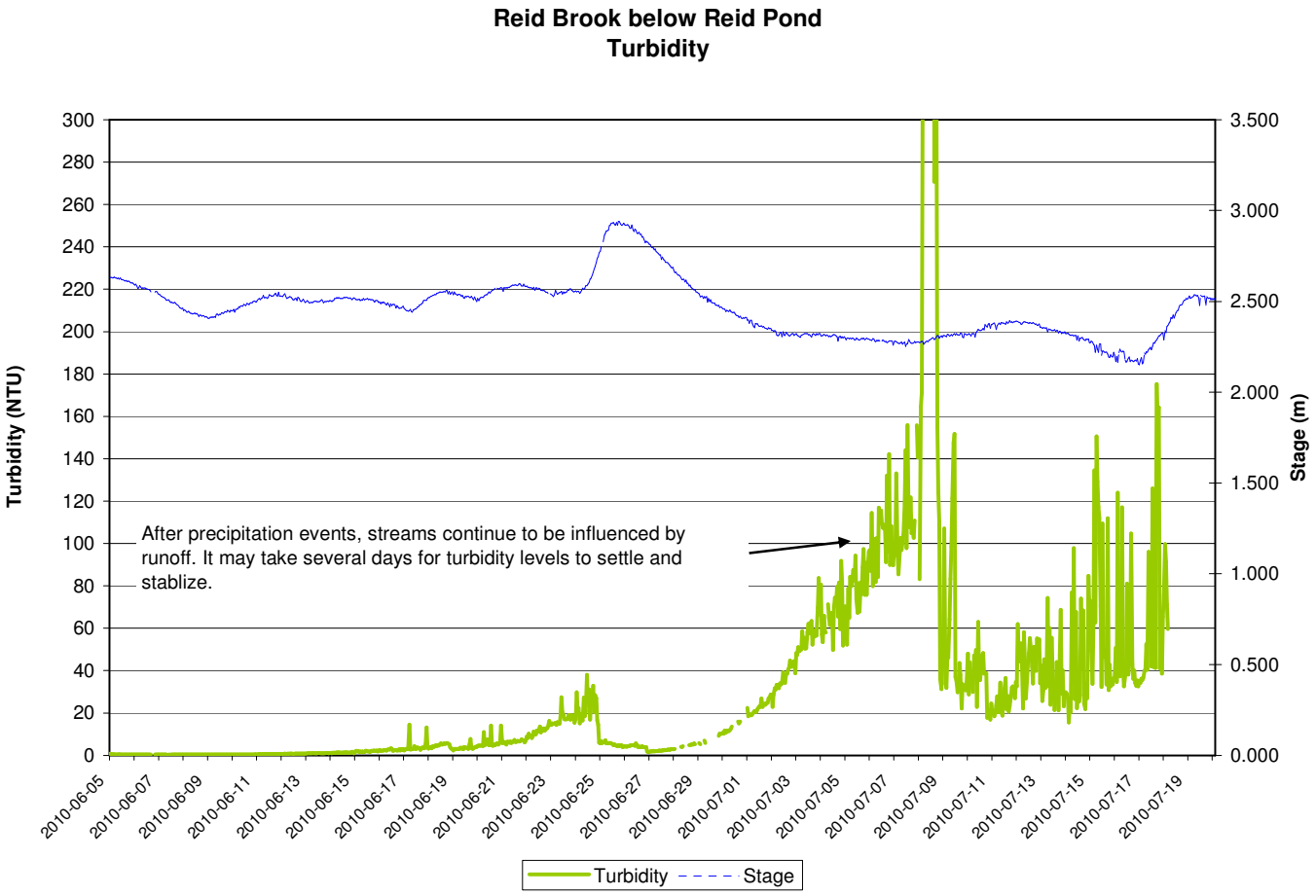

Figure 5b: Turbidity Values for Reid Brook at Outlet of Reid Pond up to 300NTU.

STAGE AND STREAM FLOW

- The stage (**Figure 6)** or water level ranged from a minimum of 2.151 m to a maximum of 2.941 m.
- The stream flow ranged from minimum of 5.72 m³/s to a maximum of 25.7 m³/s.
- There is an increase in levels for stage and stream flow, June 25-27, 2010 indicate an increase in stage to ~2.8 m with an increase in stream flow to ~25 m³/s.
- On June 23 to June 26, 2010 there was a significant precipitation event. This event corresponds with the erratic measurements from the temperature, DO and turbidity sensors at the Upper Reid Brook station. Stage increased just over 0.5m and stream flow increased over 60%. This event likely caused significant disruption in the stream bed under the sensor and could have caused it to become buried for the remainder of the deployment period.
- Other significant precipitation events are clearly depicted on Figure 6 on July 9, 2010 and at the end of the deployment period on July 16 to July 19, 2010.

PRECIPITATION

- The closest recorded rainfall to Reid Brook at Outlet to Reid Pond is at a weather station in Nain. This station is monitored by Environment Canada, and the data is available at http://climate.weatheroffice.gc.ca/climateData/dailydata_e.html?Prov=XX&timeframe=2&StationID=10813&Day=1&Month=6&Year=2010&cmdB1=Go
- The precipitation (**Figure 6)** ranged from a minimum of 0.0 mm to a maximum of 43.6 mm.
- Nain had two substantial rainfall events, the first on June 24, 2010 to 43.6mm and the second on July 17, 2010 to 31.2mm. After both events there is evidence of change in stage and stream flow.

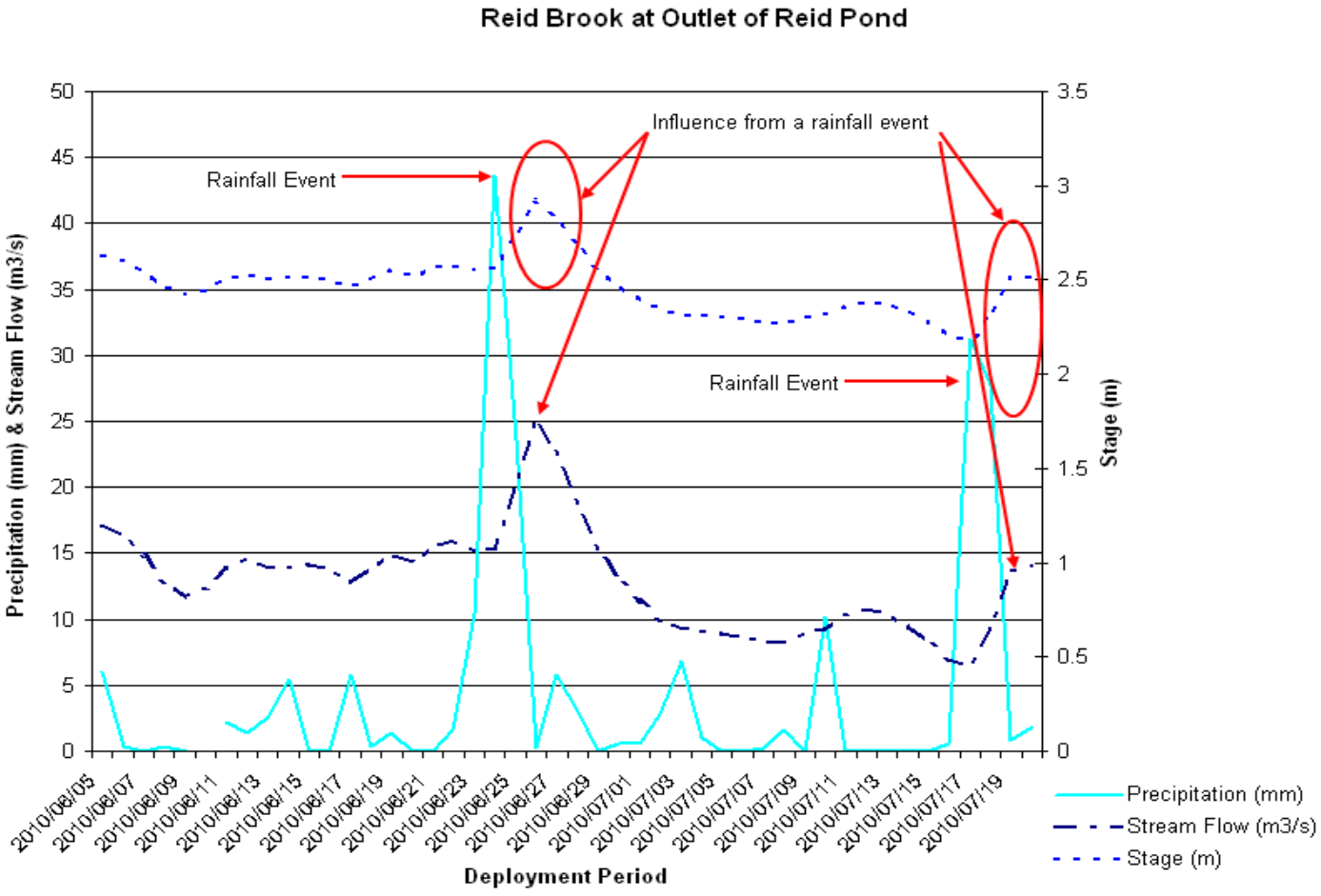

Figure 6: Reid Brook at Outlet of Reid Pond stream flow and stage

CONCLUSION

The water quality monitoring instrument was deployed at the station at Reid Brook at Outlet of Reid Pond between June 5 and July 20, 2010. During this deployment period, several water quality events were recorded at Reid Brook at Outlet of Reid Pond Station, these events were mainly associated with precipitation. A significant precipitation event occurring over three days in late June is likely the cause of disturbance to the stream bed environment that caused erratic measurements for temperature, DO and turbidity. These erratic measurements lasted the duration of the deployment period until the sonde was removed on July 20 for maintenance and calibration. Data collected during this time for these parameters is not accurate. Specific conductivity and pH data did not seem to be affected long term by this disturbance and it is likely a result of the sonde buried in sediment after the rainfall event. Typical seasonal patterns are evident in specific conductivity, pH and stage.

Throughout the deployment period, most dissolved oxygen values remained within acceptable limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L) and (Cold Water/Other Life Stages – above 6.5 mg/L). For Reid Brook Outlet the pH values sit slightly below the recommended range (6.5 – 9.0) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. This is not unusual as the background pH for Reid Brook Outlet is historically at the lower end of the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

DATA INTERPRETATION

- There were no technical difficulties with the instrument at Tributary to Lower Reid Brook.

TRIBUTARY TO LOWER REID BROOK

TEMPERATURE

- The water temperature (**Figure 7**) ranged from a minimum of 1.90 ˚C to a maximum of 18.10˚C.
- The water temperature ranges are depicting the steady increase in water temperature from June onward, as air temperature increases.
- There is evidence of a drop in temperature on June 25, 2010; the temperature increases again on July 1, 2010. This same occurrence was evident in the temperature readings for Reid Brook at outlet of Reid Pond (Figure 1). When compared to that of the stage level it is possible that the changes in temperature at those times are related to a rainfall event.
- Temperature in open waters during the summers can exceed 15˚C during the day and may drop to as low as 5˚C during the night. This diurnal cycling of temperature is a natural process which will also have an effect on other parameters.

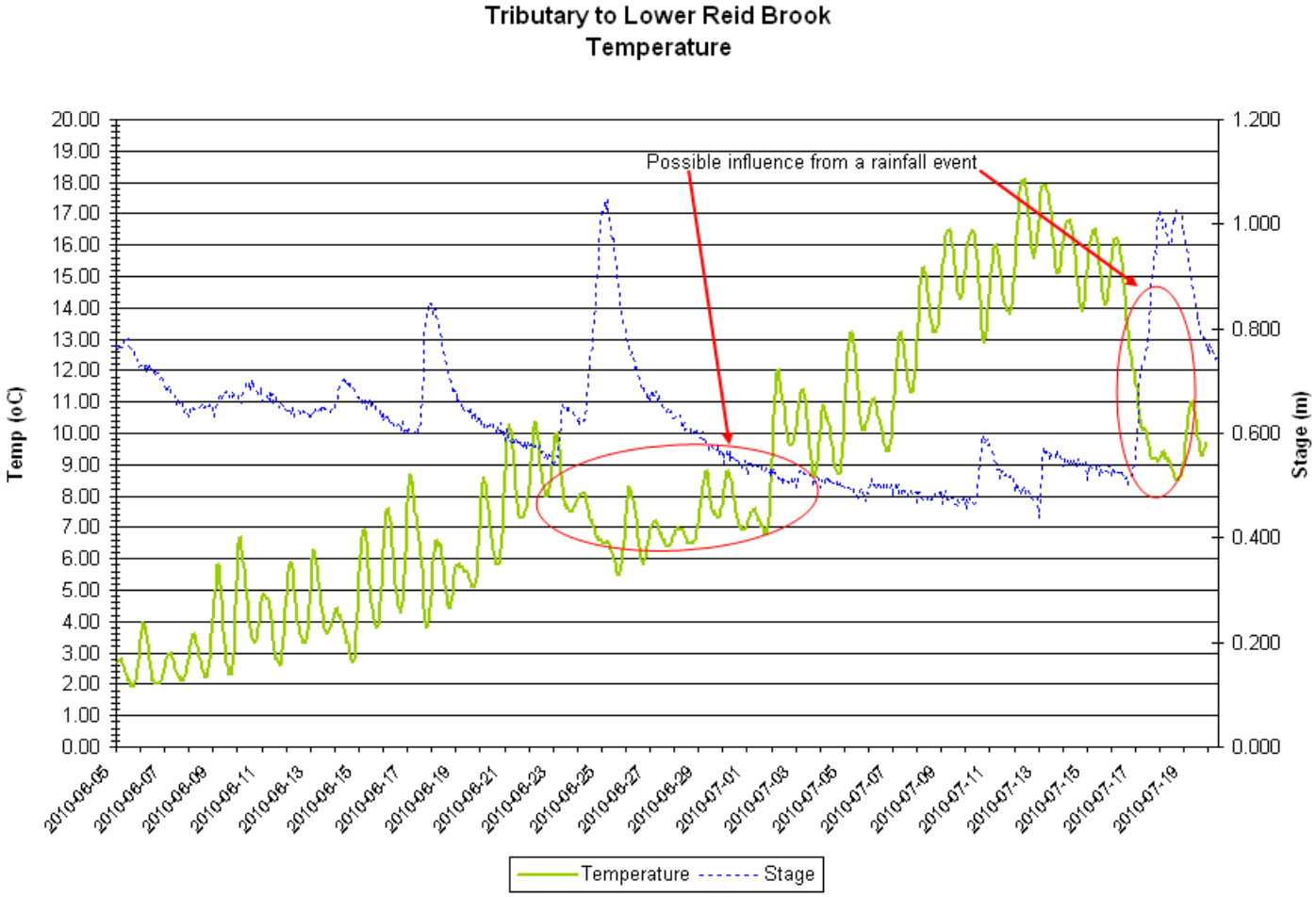

Figure 7: Water Temperature at Tributary to Lower Reid Brook

pH

- Throughout the deployment period pH values (**Figure 8**) ranged from a minimum of 5.55 to a maximum of 6.81.
- The pH values can be compared to the CCME *Protection for Aquatic Life Guideline.* For Tributary to Lower Reid Brook the pH values sit slightly below the recommended range (6.5 – 9.0) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. This is not unusual as the background pH for Tributary to Lower Reid Brook, is historically at the lower end of the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.
- There is a slight decrease in the pH levels on June 18, June 26 and July 17, 2010. It appears as though each slight decrease in pH may be in relation to a precipitation event. Rain water is slightly acidic (~ pH 6.5) and may influence the pH levels during those times.

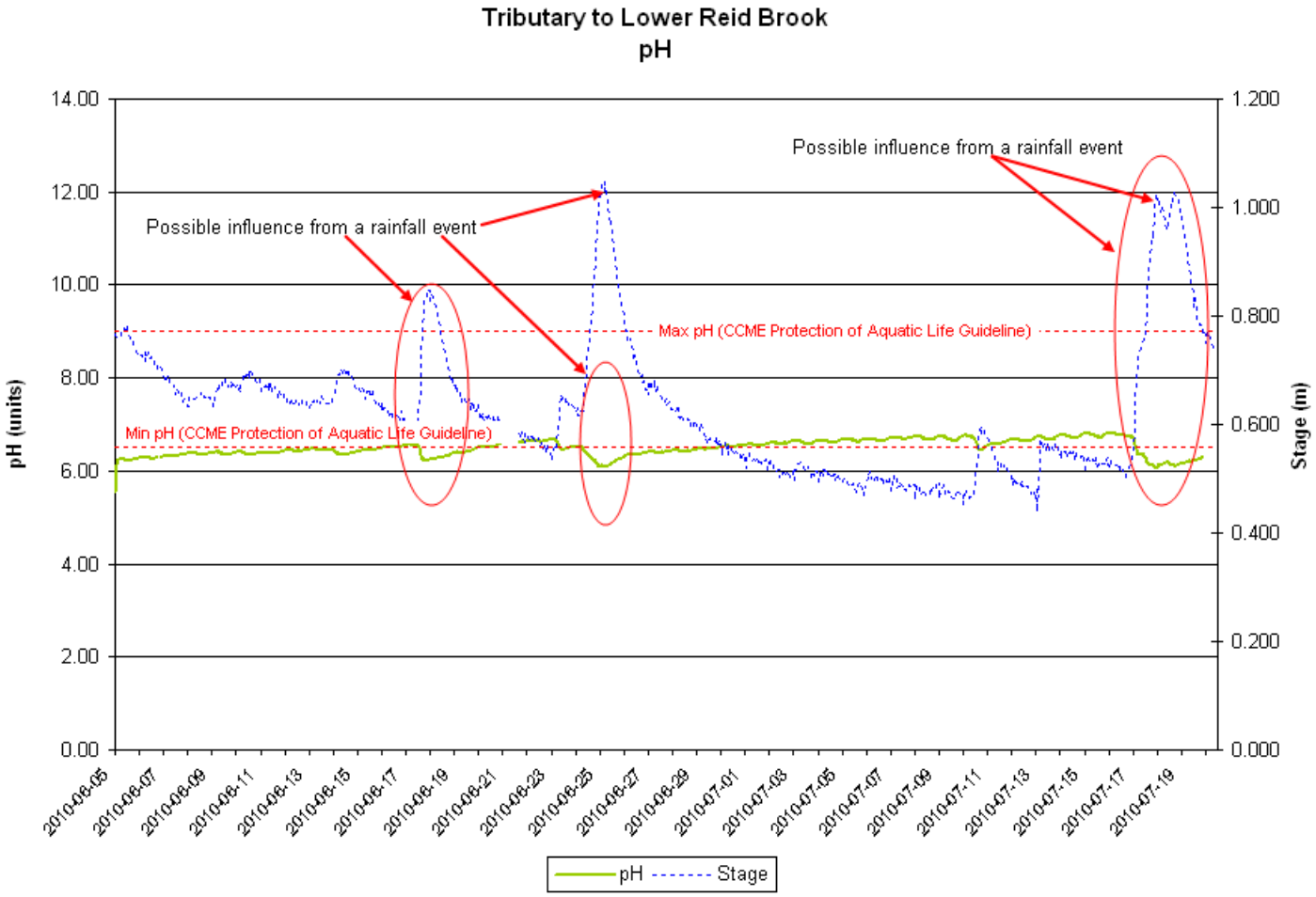

Figure 8: pH values at Tributary to Lower Reid Brook

SPECIFIC CONDUCTIVITY

- The specific conductivity **(Figure 9)** ranged from a minimum of 7.1 µS/cm to a maximum of 24.9 µS/cm over the deployment period.
- There appears to be a correlation between specific conductivity and stage. There are three events on June 18, June 25 and July 17-19, 2010, where stage increases and conductivity drops.
- The drop in conductivity is not uncommon as precipitation events have the ability to lower conductance values during or after rainfall or periods of snow fall due to dilution.

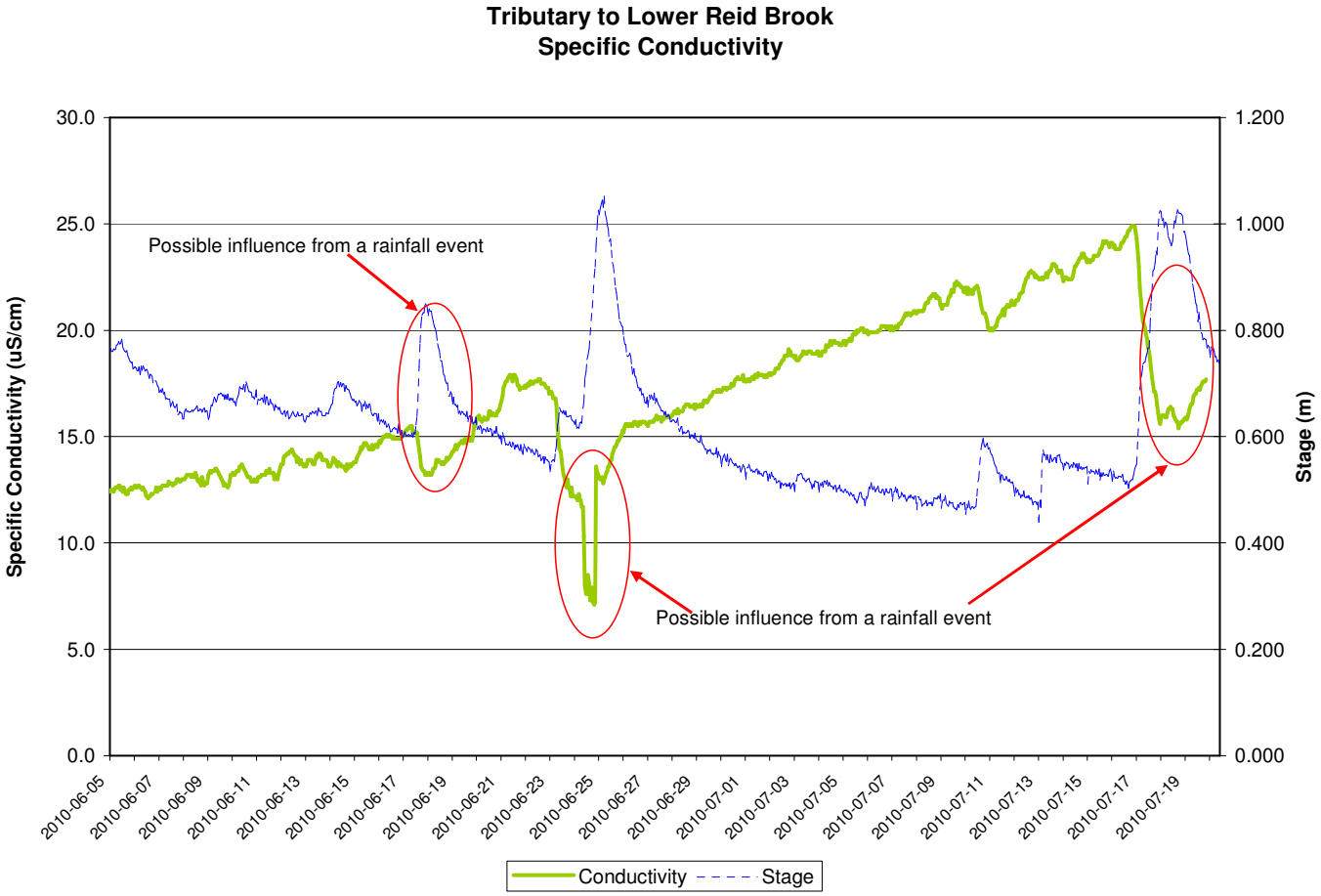

Figure 9: Specific Conductivity Values at Tributary to Lower Reid Brook

DISSOLVED OXYGEN

- The dissolved oxygen (DO), values ranged from a minimum of 9.19 mg/L to a maximum of 13.43 mg/L over the deployment period (**Figure 10**).
- Throughout the deployment period, the majority of DO values were within the limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L and Cold Water/Other Life Stages – above 6.5 mg/L).
- There was a small drop on July 11, 2010 to below the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L. Dissolved oxygen content is inversely related to water temperature. The drop below the guideline corresponds with the warmest water temperatures during the deployment period (~18°C).
- There is evidence of influence from possible rainfall events in the DO (mg/L) values at Tributary to Lower Reid Brook; these are highlighted on Figure 10, around June 25 – 29 and July 16-19, 2010.

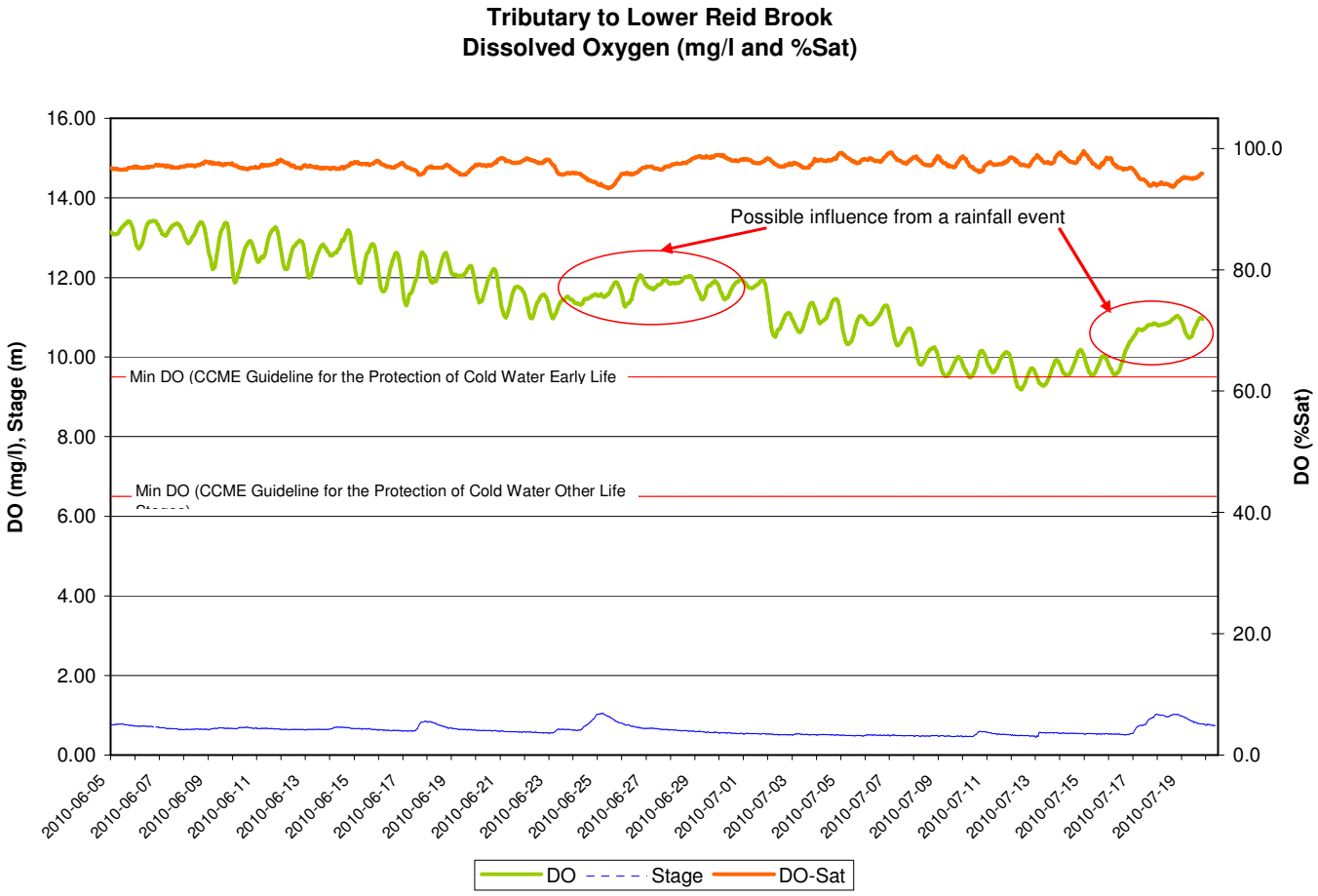

Figure 10: Dissolved Oxygen (mg/L & % Sat) at Tributary to Lower Reid Brook

TURBIDITY

- The turbidity values ranged from a minimum of 0.00 NTU to a maximum of 48.6 NTU over the deployment period (**Figure 11**).
- The turbidity events throughout the deployment period coincide with several increases in stage.
- Rainfall likely increased the stage levels during this period. Rainfall can also disturb the sediment and silt naturally present in a water body, which in turn influences turbidity levels.

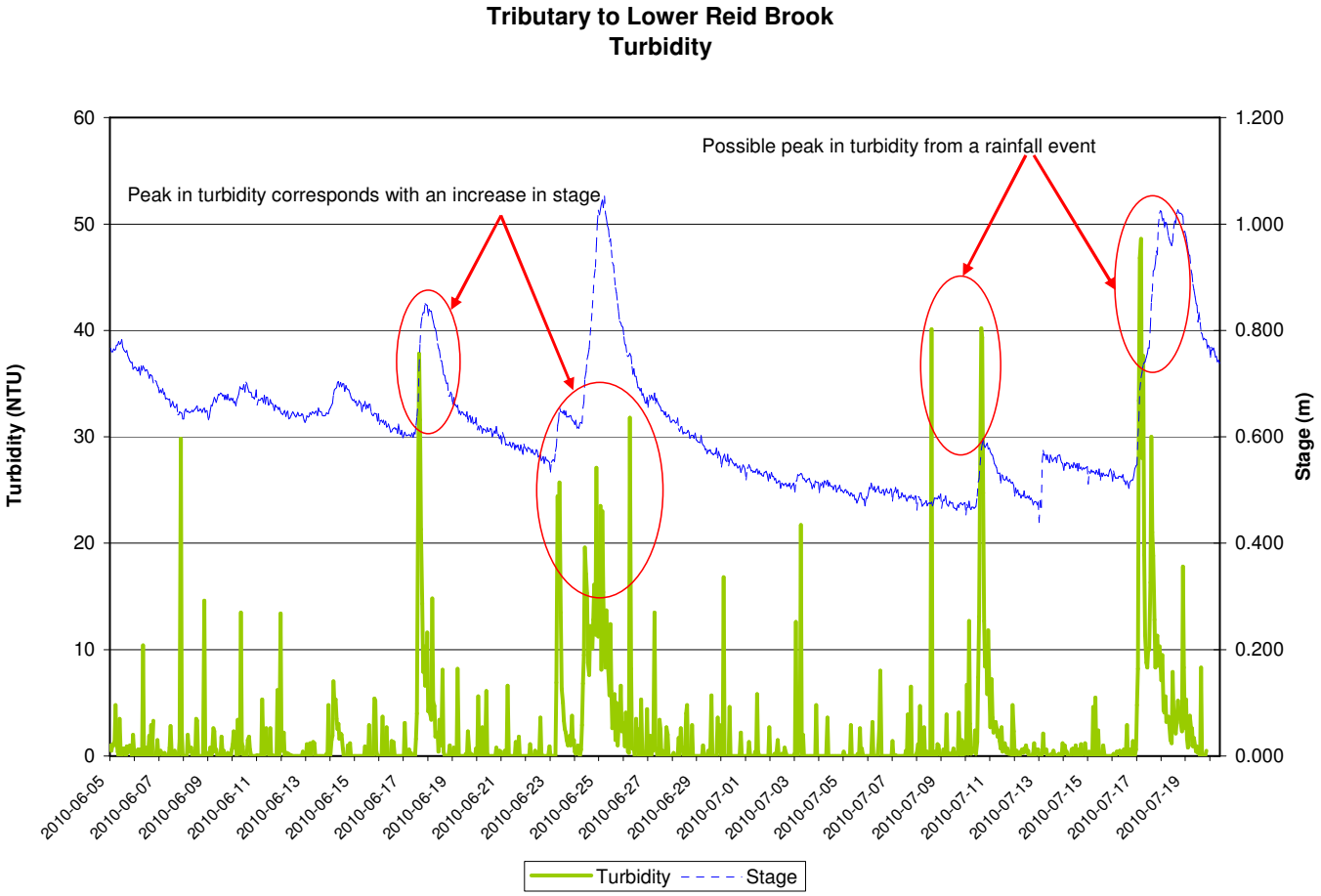

Figure 11: Turbidity Values for Tributary to Lower Reid Brook

STAGE AND STREAM FLOW

- The stage (**Figure 12)** or water level ranged from a minimum of 0.439 m to a maximum of 1.052 m.
- There was no data for stream flow.
- There is an increase in levels for stage on June 17-19, 2010, June 23 -27, 2010 and again on July 17-19, 2010. These events coincide with an increase in precipitation events recorded in the region.
- The high stage periods are due to precipitation events throughout the deployment period.

PRECIPITATION

- The closest recorded rainfall to Tributary to Lower Reid Brook is at a weather station in Nain. This station is monitored by Environment Canada, and the data is available at http://climate.weatheroffice.gc.ca/climateData/dailydata_e.html?Prov=XX&timeframe=2&StationID=10813&Day=1&Month=6&Year=2010&cmdB1=Go
- The precipitation (**Figure 12)** ranged from a minimum of 0.0 mm to a maximum of 43.6 mm.
- Nain had two substantial rainfall events, the first on June 24, 2010 to 43.6mm and the second on July 17, 2010 to 31.2mm. After both events there is evidence of change in stage and stream flow.

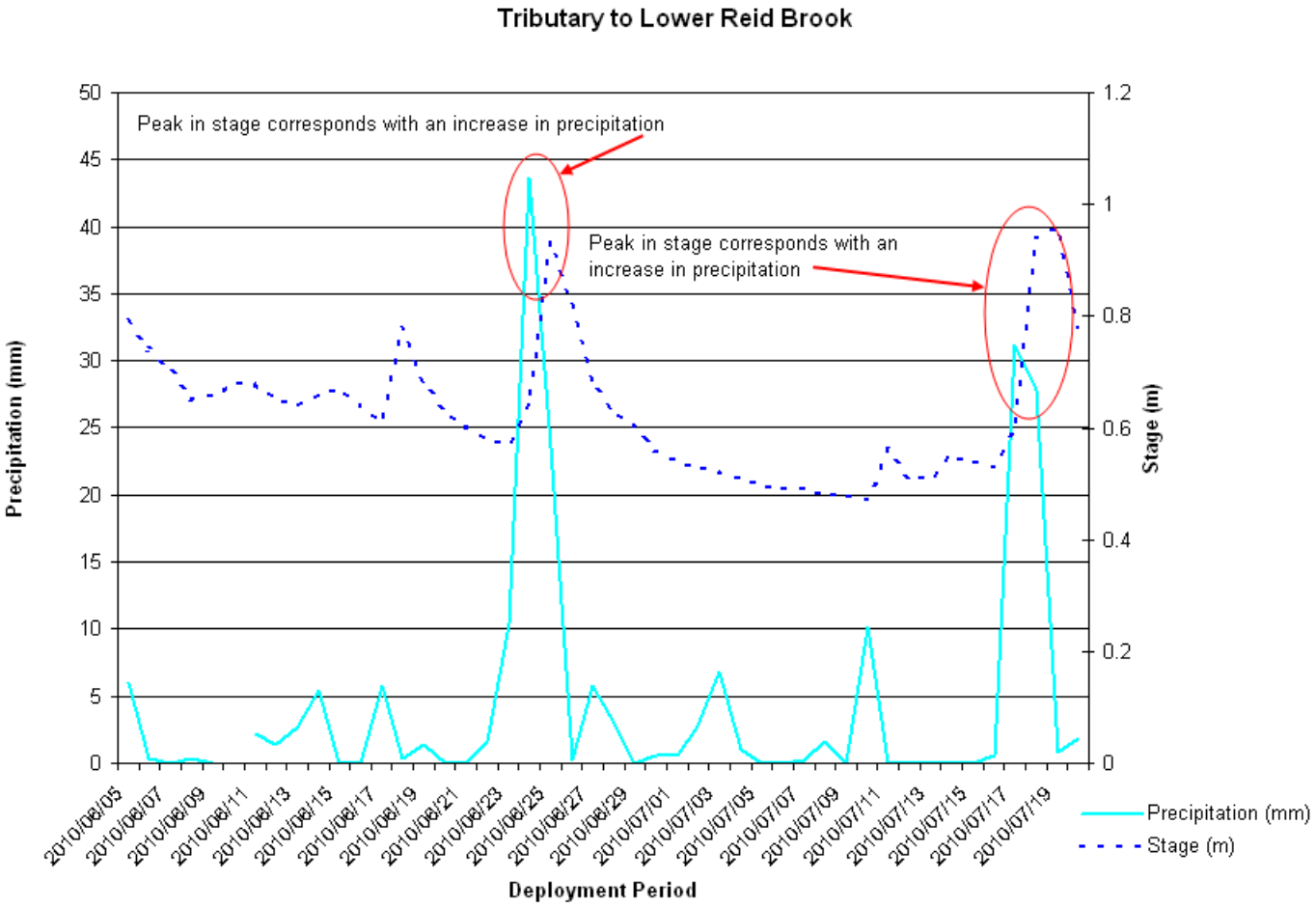

Figure 12: Tributary to Lower Reid Brook precipitation and stage

CONCLUSION

The water quality monitoring instrument was deployed at the station at Tributary to Lower Reid Brook between June 5 and July 20, 2010. There was an indication of possible rainfall occurrences throughout this deployment period. Precipitation may be the source of events on the graphs for water temperature, pH, dissolved oxygen and turbidity. Typical seasonal patterns are still evident in temperature, dissolved oxygen and stage.

Throughout the deployment period, almost all dissolved oxygen values were within the limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L and Cold Water/Other Life Stages – above 6.5 mg/L). For Tributary to Lower Reid Brook the pH values sit slightly below the recommended range (6.5 – 9.0) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. This is not unusual as the background pH for Tributary to Lower Reid Brook is historically at the lower end of the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

DATA INTERPRETATION

- Due to technical difficulties connecting to the instrument, before and after cleaning values could not be taken from the Field **DataSonde®** at Lower Reid below Tributary. This affects the ability to calculate for biofouling drift on this instrument, hence there are no corrections applied to the Lower Reid below Tributary data for biofouling. There were values to calculate the presence of calibration drift.

LOWER REID BELOW TRIBUTARY

TEMPERATURE

- The water temperature (**Figure 13**) ranged from a minimum of 1.75 ˚C to a maximum of 16.15˚C.
- The water temperature ranges are depicting the steady increase in water temperature from June onward, as air temperature increases.
- From July 16, 2010 to July 17, 2010 the water temperature drops significantly from ~15˚C down to ~ 8˚C. The change in water temperature corresponds with a precipitation event recorded in the region at this time.

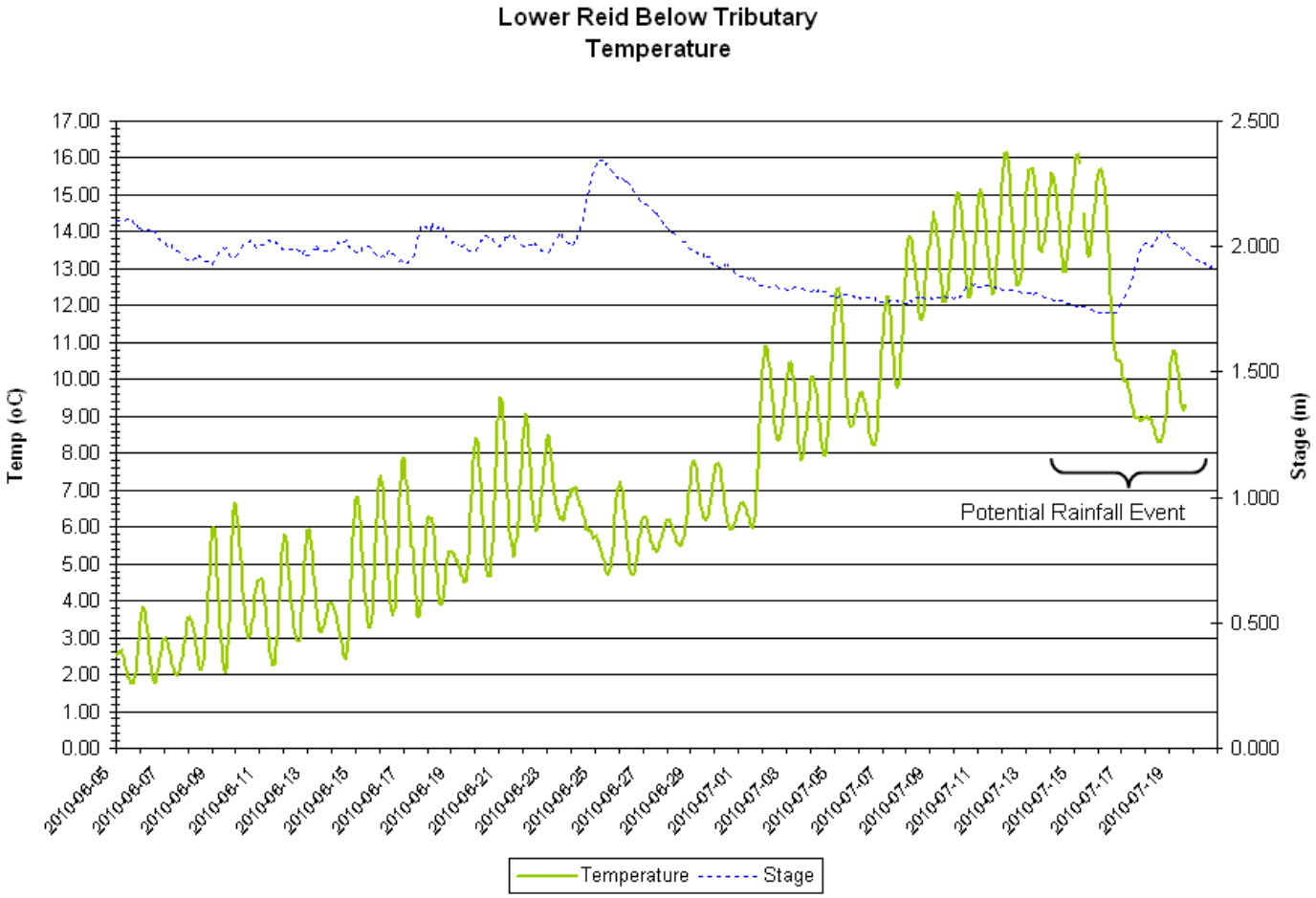

Figure 13: Water Temperature at Lower Reid below Tributary

pH

- Throughout the deployment period pH values (**Figure 14**) ranged from a minimum of 6.06 to a maximum of 7.09.
- The pH values can be compared to the CCME *Protection for Aquatic Life Guideline.* For Lower Reid Below Tributary the pH values sit slightly above the lower recommended range (6.5) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. This is not unusual as the background pH for Lower Reid Below Tributary is historically at the lower end of the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.
- There is a slight decrease in the pH levels around June 29, 2010. This may be in relation to a precipitation event. Rain water is slightly acidic (~ pH 6.5) and may influence the pH levels at that time.

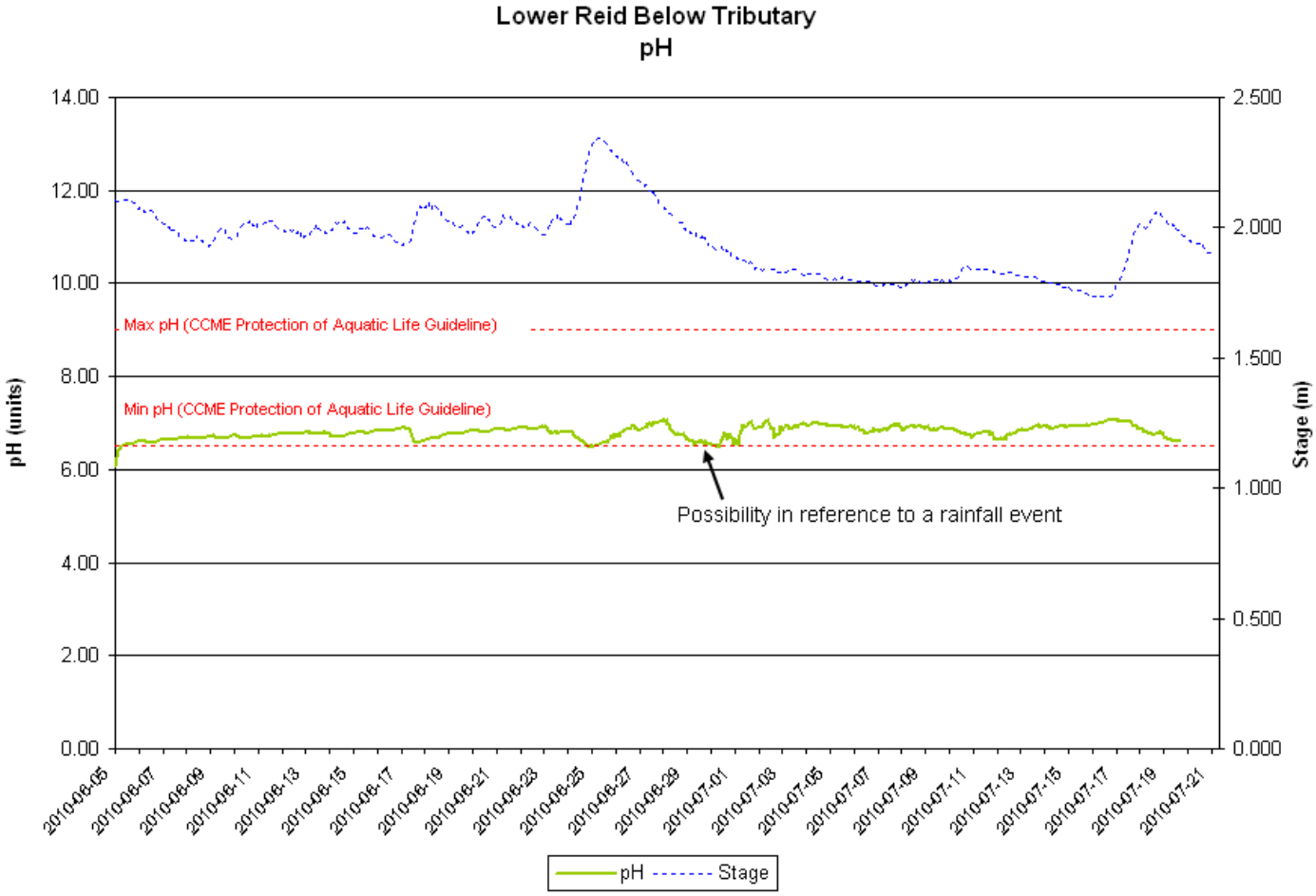

Figure 14: pH values at Lower Reid below Tributary

SPECIFIC CONDUCTIVITY

- The specific conductivity **(Figure 15)** ranged from a minimum of 9.0 µS/cm to a maximum of 29.0 µS/cm over the deployment period.
- Specific Conductivity remained reasonably constant during the deployment month in the range of 10 µS/cm of 17 µS/cm, except for one event on July 9, 2010 where the conductance level peaked to ~29 µS/cm. This event only lasted for one measurement (1 hour).
- As stage increases, specific conductivity usually increases. This is caused by dilution from rain water in the waterbody.

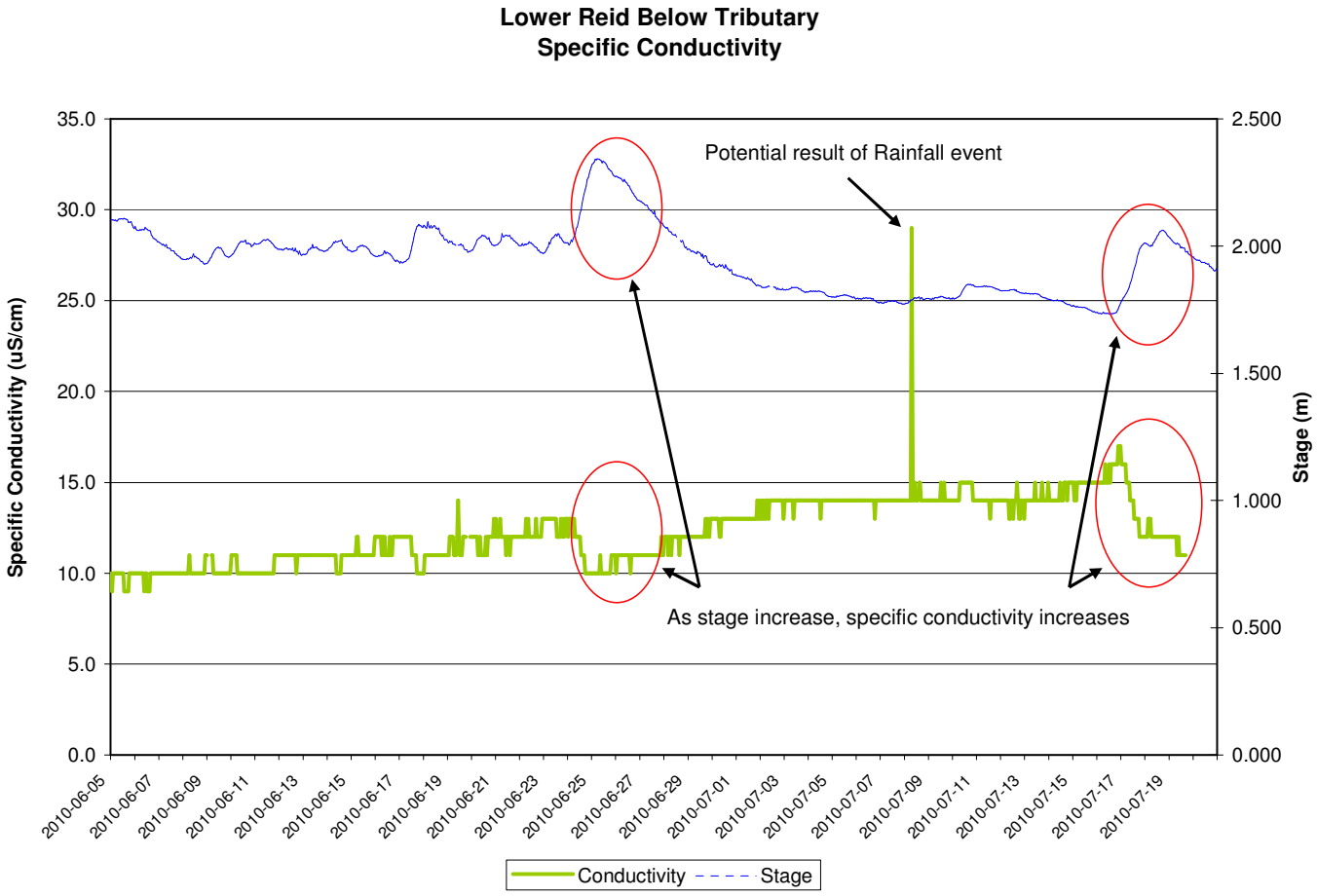

Figure 15: Specific Conductivity Values at Lower Reid below Tributary

DISSOLVED OXYGEN

- The dissolved oxygen (DO), values ranged from a minimum of 4.27 mg/L to a maximum of 14.50 mg/L over the deployment period (**Figure 16**).
- Over a period of three days, June 23-26, nearly 80mm of precipitation was recorded in the region. This precipitation event had significant effects on the stage level and stream flow. Immediately following this event, DO values begin to steadily decrease to very low levels (4.27mg/L). A similar situation was experienced at the station at Reid Pond Outlet (Figure 4). It is likely that this increase in stage and stream flow caused significant disturbance to the stream bed and caused the sonde to be at least partially buried for the remainder of the deployment period. DO values for the rest of the deployment period are inaccurate.
- Up until this rainfall event (~June 26), all DO values recorded were above the lower limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L and Cold Water/Other Life Stages – above 6.5 mg/L).

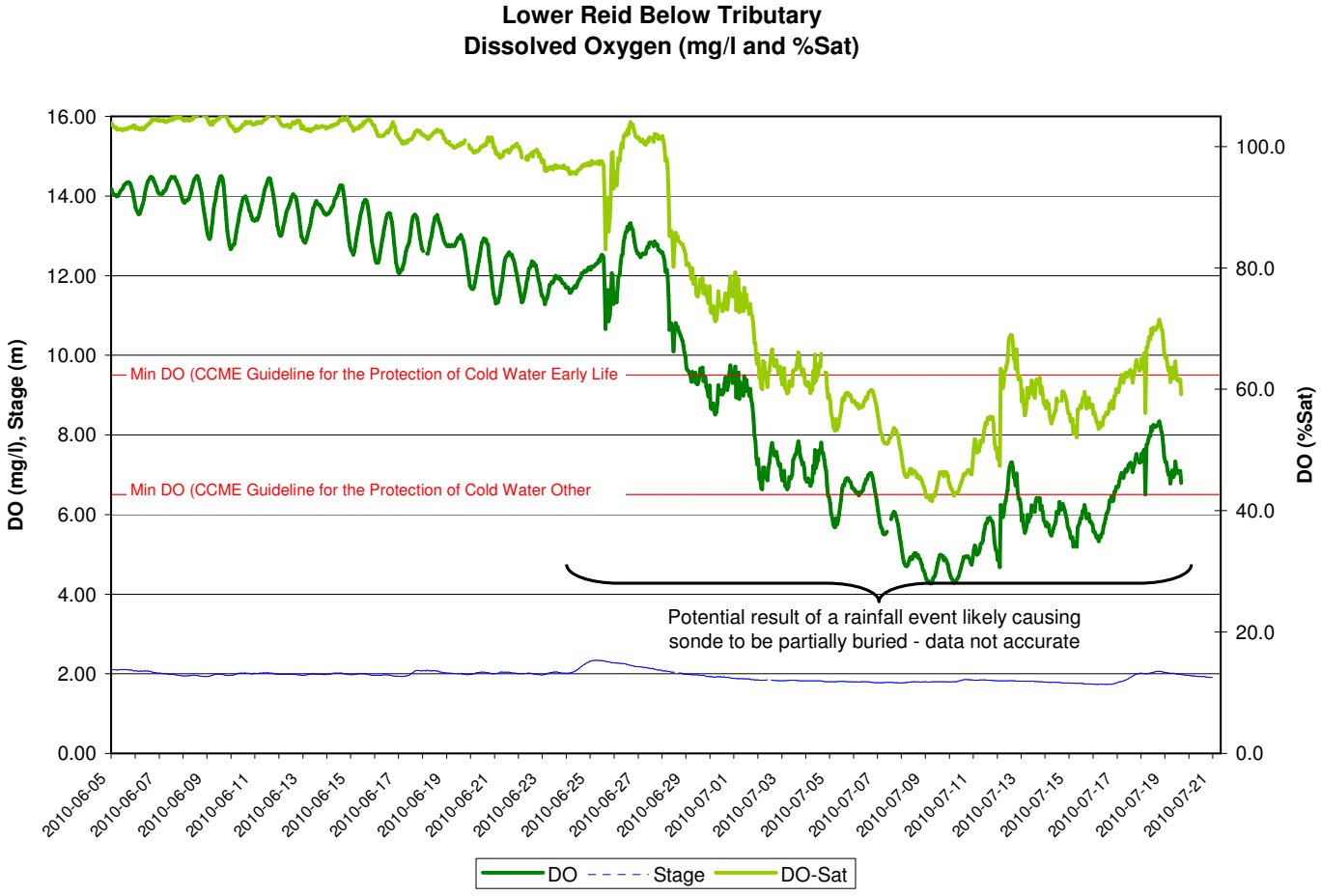

Figure 16: Dissolved Oxygen (mg/L & % Sat) at Lower Reid below Tributary

TURBIDITY

- The turbidity values ranged from a minimum of 3.1 NTU to a maximum of 3000 NTU over the deployment period (**Figure 17**).
- Similar to the turbidity values at Upper Reid Brook station (Figure 5), following a significant rainfall event which caused stage and stream flow to increase considerably, it is likely the sonde became at least partially buried for the remainder of the deployment period. Turbidity readings from June 26 to July 20 are erratic and do not represent the typical conditions at the Lower Reid Brook station. In addition, this station is very sandy and is prone to being affected by the stream bed material after a disturbance. Upon removal, there was a considerable about of sand and debris within the sensor guard.
- The reading of 3000 NTU occurred on June 27 -28, 2010 and July 7, 2010. A value of 3000 NTU is often identified as an error reading from the turbidity sensor. This value can result from debris blocking the sensor windows.
- Data recorded between June 26 and July 20 is not accurate.

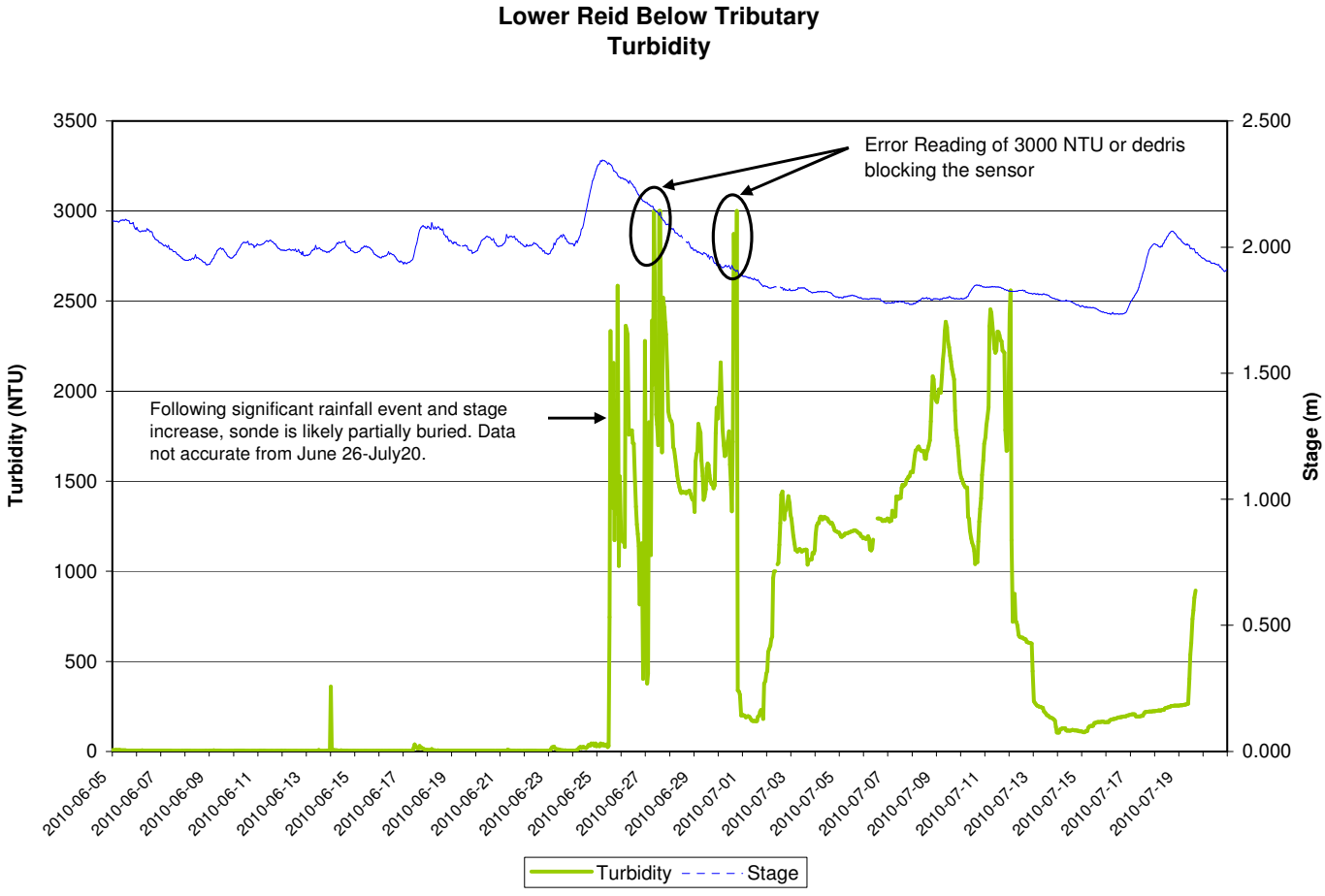

Figure 17: Turbidity Values for Lower Reid below Tributary

STAGE AND STREAM FLOW

- Stage can be defined as the height of the surface of a river or other fluctuating body of water above a set point. The set point is the bottom axis of this graph.
- The stage (**Figure 18)** or water level ranged from a minimum of 1.733 m to a maximum of 2.344 m.
- The stream flow ranged from minimum of 9.85 m³/s to a maximum of 41.1 m³/s.
- On June 23 – 26th, 2010 there was a precipitation event recorded in the region of nearly 80 mm, this in turn influenced an increase in stage of 0.35m and a nearly 60% increase in stream flow to ~40 m³/s.
- It could be assumed that the high flows periods during the deployment are due to the precipitation events that occurred.

PRECIPITATION

- The closest recorded rainfall to Lower Reid below Tributary is at a weather station in Nain. This station is monitored by Environment Canada, and the data is available at http://climate.weatheroffice.gc.ca/climateData/dailydata_e.html?Prov=XX&timeframe=2&StationID=10813&Day=1&Month=6&Year=2010&cmdB1=Go
- The precipitation (**Figure 18)** ranged from a minimum of 0.0 mm to a maximum of 43.6 mm.
- Nain had two substantial rainfall events, the first on June 24, 2010 to 43.6mm and the second on July 17, 2010 to 31.2mm. After both events there is evidence of change in stage and stream flow.

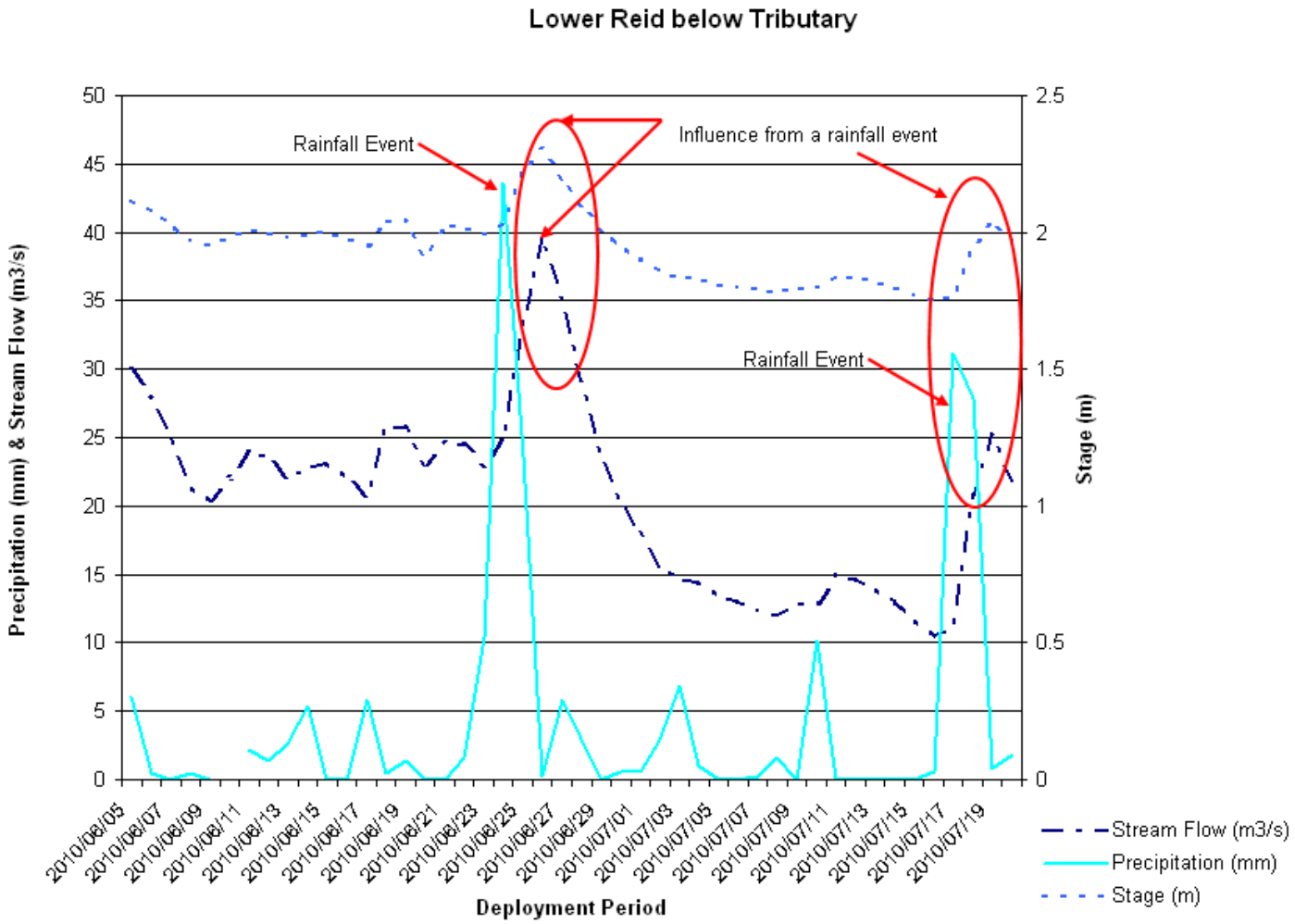

Figure 18: Lower Reid below Tributary stream flow and stage

CONCLUSION

The water quality monitoring instrument was deployed at the station at Lower Reid Brook below Tributary between June 5 and July 20, 2010. During this deployment period, several water quality events were recorded at Lower Reid Brook below Tributary Station and these events were mainly associated with precipitation. A significant precipitation event occurring over three days in late June is likely the cause of disturbance to the stream bed environment that caused erratic measurements for DO and turbidity. This pattern was also seen at the station upstream at Reid Brook at Outlet to Reid Pond. These erratic measurements lasted the duration of the deployment period until the sonde was removed on July 20 for maintenance and calibration. Data collected during this time for these parameters is not accurate. Temperature, specific conductivity and pH data so not seem to be affected long term by this disturbance and is likely a result of how the sonde was buried in sediment after the high flow event. Typical seasonal patterns are evident in temperature, specific conductivity, pH and stage.

Throughout the deployment period up until the precipitation event that caused disturbance to the DO values on June 26, all dissolved oxygen values remained within acceptable limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L and Cold Water/Other Life Stages – above 6.5 mg/L).

DATA INTERPRETATION

- Due to technical difficulties connecting to the instrument, before and after cleaning values could not be taken of the Field **DataSonde®** at Camp Pond Brook below Camp Pond. This affects the ability to calculate for biofouling drift on this instrument, hence there are no corrections applied to the Camp Pond Brook below Camp Pond data for biofouling. There were values to calculate the presence of calibration drift.

CAMP POND BROOK BELOW CAMP POND

TEMPERATURE

- The water temperature (**Figure 19**) ranged from a minimum of 2.90 ˚C to a maximum of 20.50˚C.
- The water temperature ranges are depicting the steady increase in water temperature from June onward, as air temperature increases. The water temperature at this station reflects the water temperature events indicated previously at Lower Reid below Tributary station.
- From July 15, 2010 to July 17, 2010 the water temperature drops from ~20˚C down to ~ 11˚C.
- The change in water temperature may be explained by a precipitation event at this time. This decrease in temperature is also clearly evident at the stations on Lower Reid below Tributary and Tributary to Lower Reid Brook. This decrease corresponds with a rainfall event over July 17 to 19 recorded in the region.

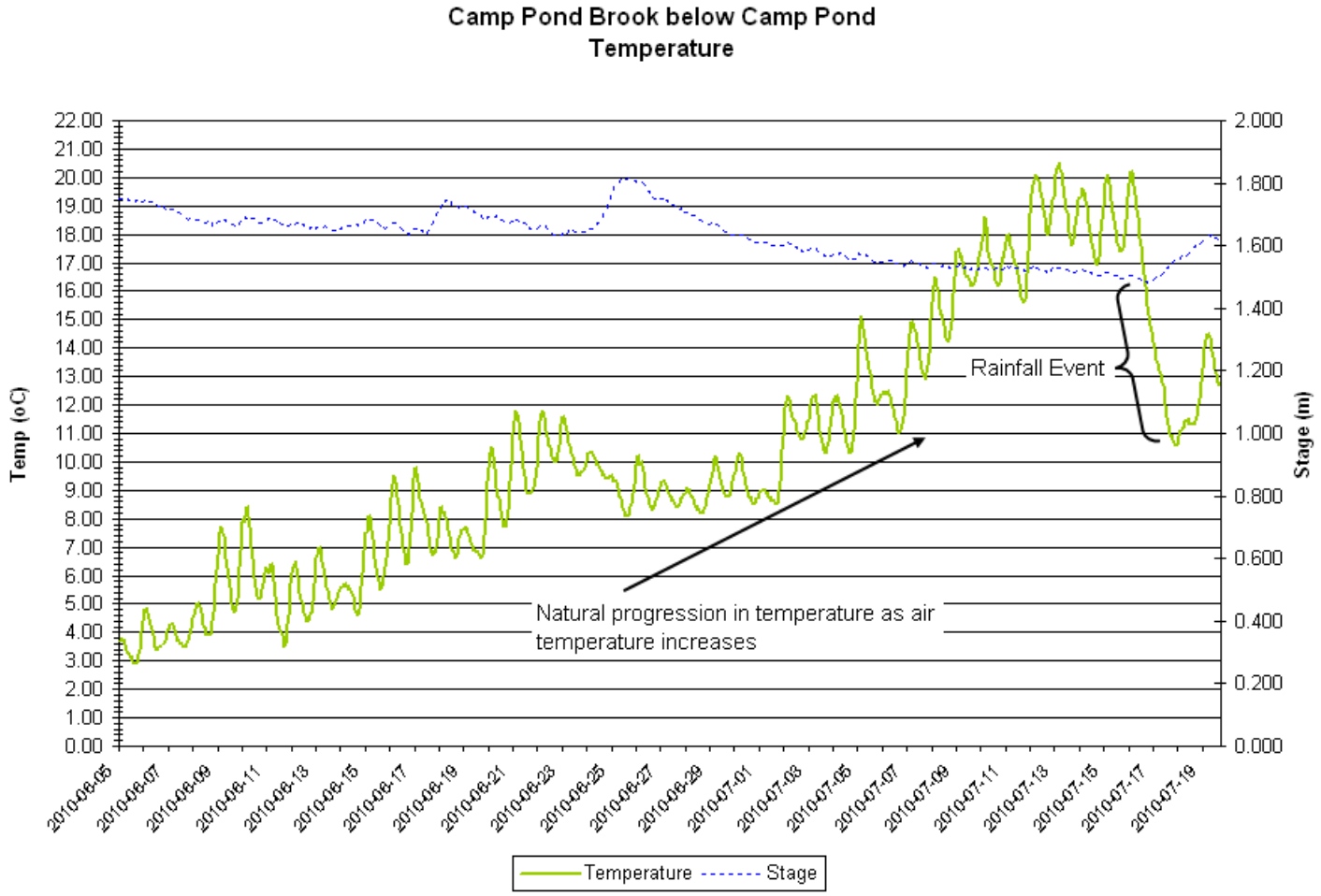

Figure 19: Water Temperature at Camp Pond Brook below Camp Pond

pH

- Throughout the deployment period pH values (**Figure 20**) ranged from a minimum of 6.24 to a maximum of 6.95.
- The pH values can be compared to the CCME *Protection for Aquatic Life Guideline.* For Camp Pond Brook below Camp Pond the pH values sit slightly above the lower recommended range (6.5) for the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. This is not unusual as the background pH for Camp Pond Brook below Camp Pond is historically at the lower end of the CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life*.

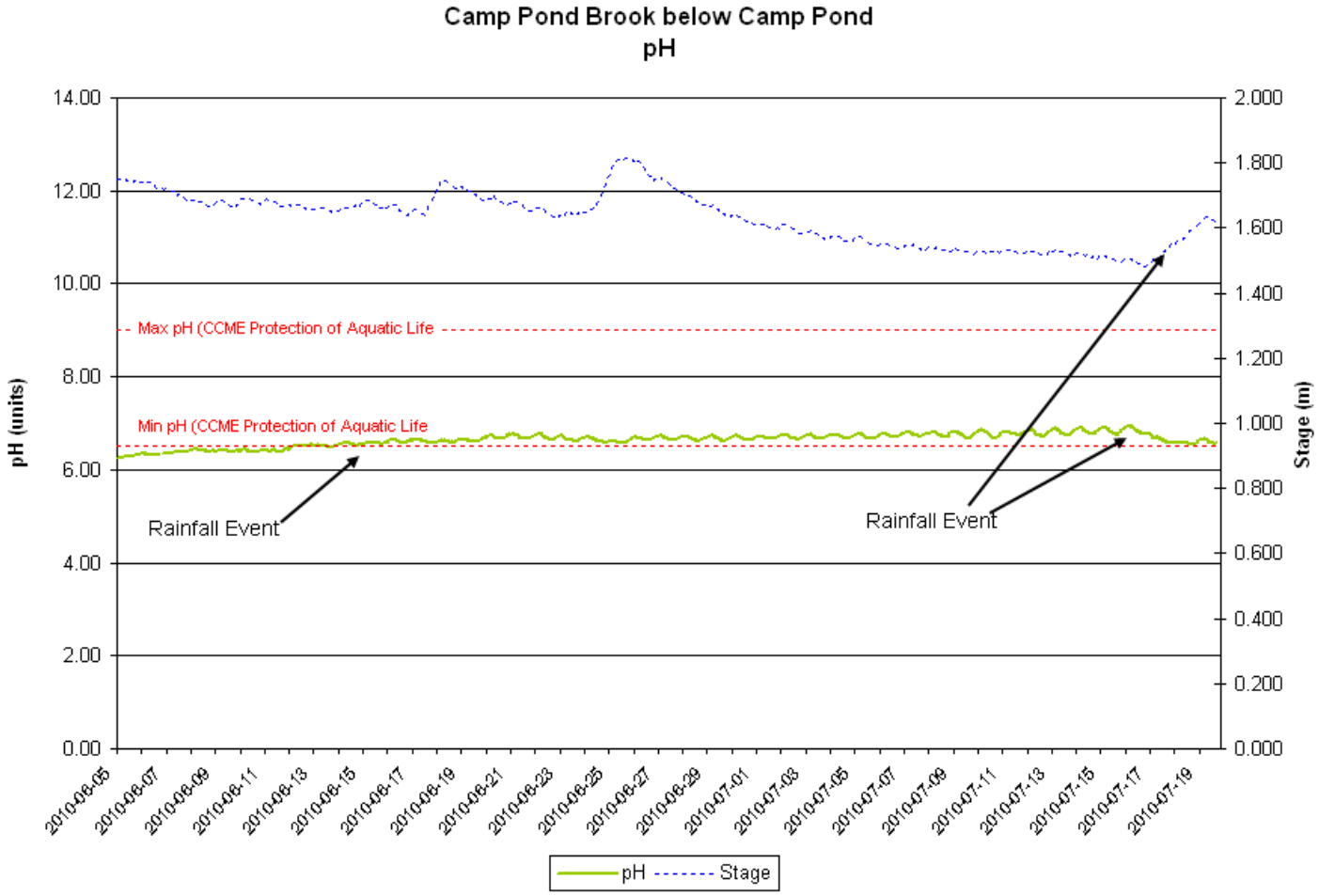

Figure 20: pH values at Camp Pond Brook below Camp Pond

SPECIFIC CONDUCTIVITY

- The specific conductivity **(Figure 21)** ranged from a minimum of 11.4 µS/cm to a maximum of 25.8 µS/cm over the deployment period.
- Specific Conductivity remained reasonably constant during the deployment month between the ranges of 11 µS/cm of 20 µS/cm. There were several events that the conductance level peaked, one event on June 23, 2010, one on July 7-11, 2010 and a prominent event on July 17, 2010; these events correspond with precipitation events in the area. This was similar evidence in the specific conductance values at Lower Reid below Tributary station.

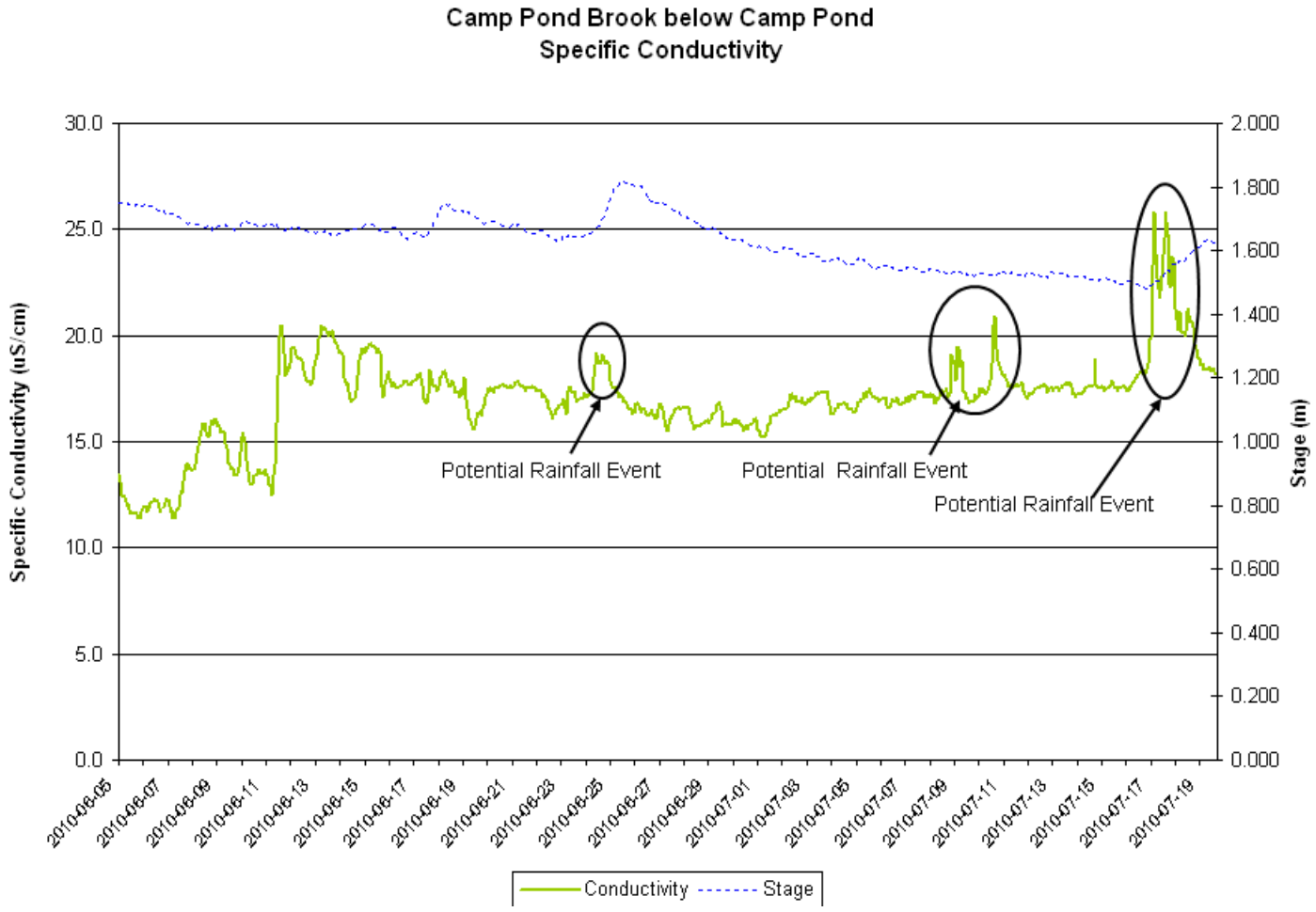

Figure 21: Specific Conductivity Values at Camp Pond Brook below Camp Pond

DISSOLVED OXYGEN

- The dissolved oxygen (DO mg/L), values ranged from a minimum of 7.83 mg/L to a maximum of 12.89 mg/L over the deployment period (**Figure 22**).
- On June 30, 2010 the DO values (mg/L) dropped below the limits recommended by CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L).
- DO sensor is a temperature dependent sensor; therefore the erratic readings that are evident on the temperature graph (Figure 19) can also be noted on the DO graph below. Water temperature is inversely related to DO content. The low DO values correspond with the warmest water temperatures recorded during the deployment period.
- The DO values at Camp Pond do resemble similar events on those dates that occurred at Reid Pond Outlet and Lower Reid below Tributary, which can indicate an influence from a rain fall event. Data during this period should be used with caution.

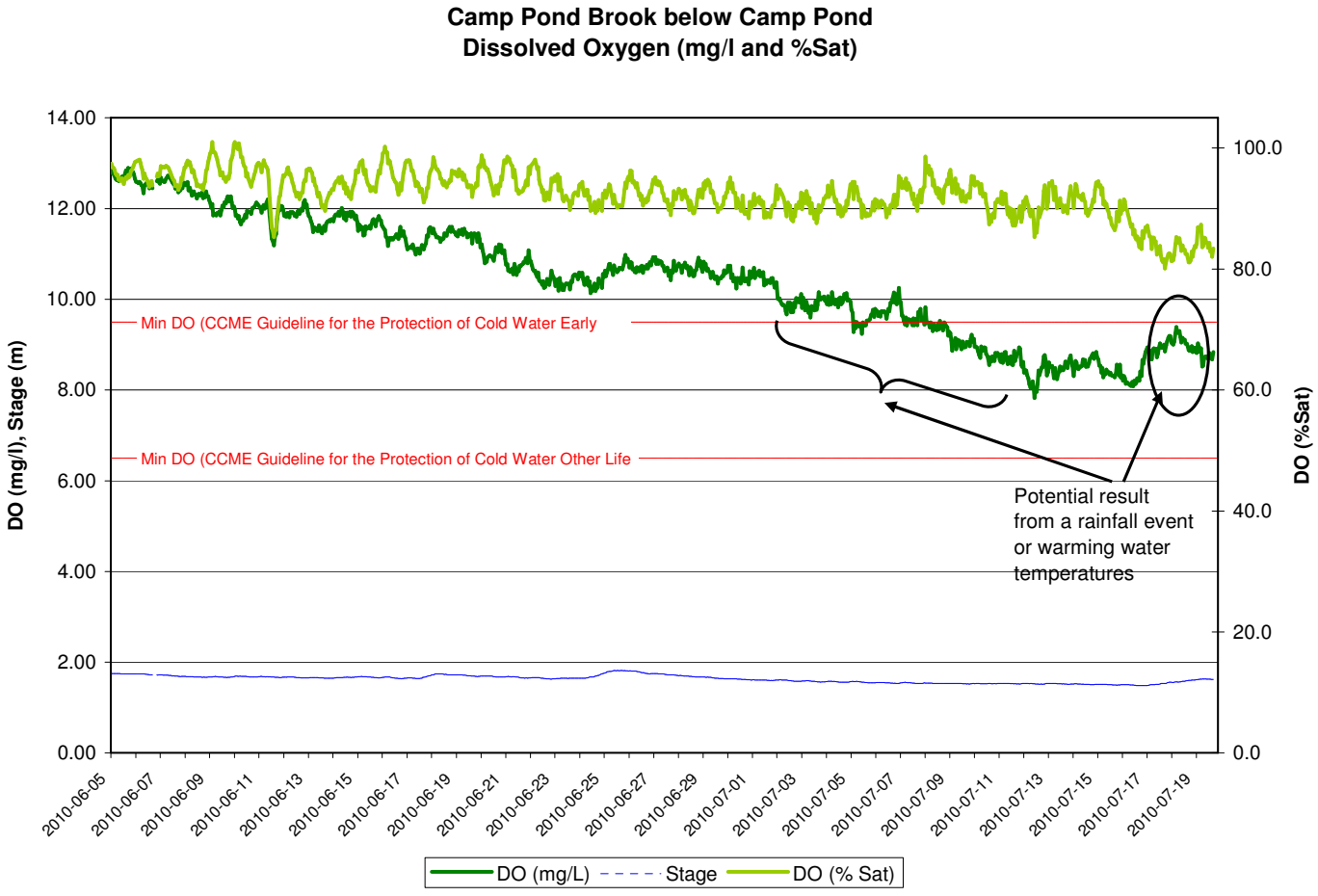

Figure 22: Dissolved Oxygen (mg/L & % Sat) at Camp Pond Brook below Camp Pond

TURBIDITY

- The turbidity values ranged from a minimum of 1.0 NTU to a maximum of 41.8 NTU over the deployment period (**Figure 23**).
- Stage displays variation in Camp Pond Brook water levels which correspond with precipitation events recorded in the region. There is also some variation in the turbidity values throughout this deployment month as well. However even though the peaks rise to ~ 25 NTU the values return to ~ 5 NTU and lower within a couple of hours. This is a typical trend for the station at Camp Pond Brook.
- On July 17, 2010 turbidity peaks to ~ 43 NTU settles around 25 NTU before returning to below 10 NTU, this occurred over a couple of days and also corresponds with a rainfall event in the area.

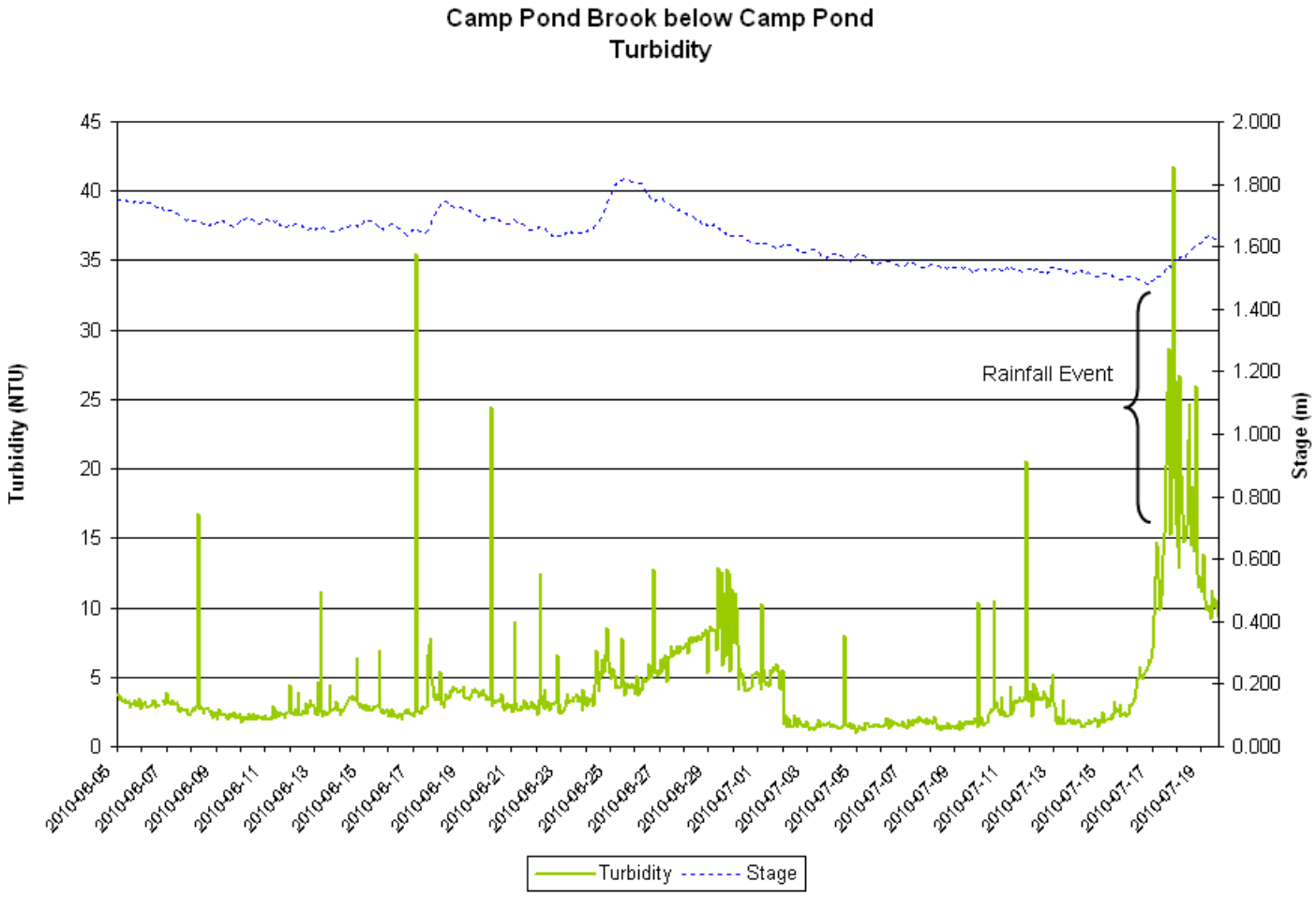

Figure 23: Turbidity Values for Camp Pond Brook below Camp Pond

STAGE AND STREAM FLOW

- Stage can be defined as the height of the surface of a river or other fluctuating body of water above a set point. The set point is the bottom axis of this graph.
- The stage (**Figure 24**) or water level ranged from a minimum of 1.481 m to a maximum of 1.817 m.
- The stream flow ranged from minimum of 0.743 m³/s to a maximum of 3.92 m³/s.
- On June 23 to June 26, 2010 there was a significant precipitation event. This event results in an increase in water level of 0.2m and an increase of flow of over 90%.
- Other precipitation events occur on July 9, 2010 and at the end of the deployment period from July 16 to July 19, 2010 which influenced several of the readings for turbidity, dissolved oxygen and temperature.

PRECIPITATION

- The closest recorded rainfall to Camp Pond Brook below Camp Pond is at a weather station in Nain. This station is monitored by Environment Canada, and the data is available at http://climate.weatheroffice.gc.ca/climateData/dailydata_e.html?Prov=XX&timeframe=2&StationID=10813&Day=1&Month=6&Year=2010&cmdB1=Go
- The precipitation (**Figure 24**) ranged from a minimum of 0.0 mm to a maximum of 43.6 mm.
- Nain had two substantial rainfall events, the first on June 24, 2010 to 43.6mm and the second on July 17, 2010 to 31.2mm. After both events there is evidence of change in stage and stream flow.

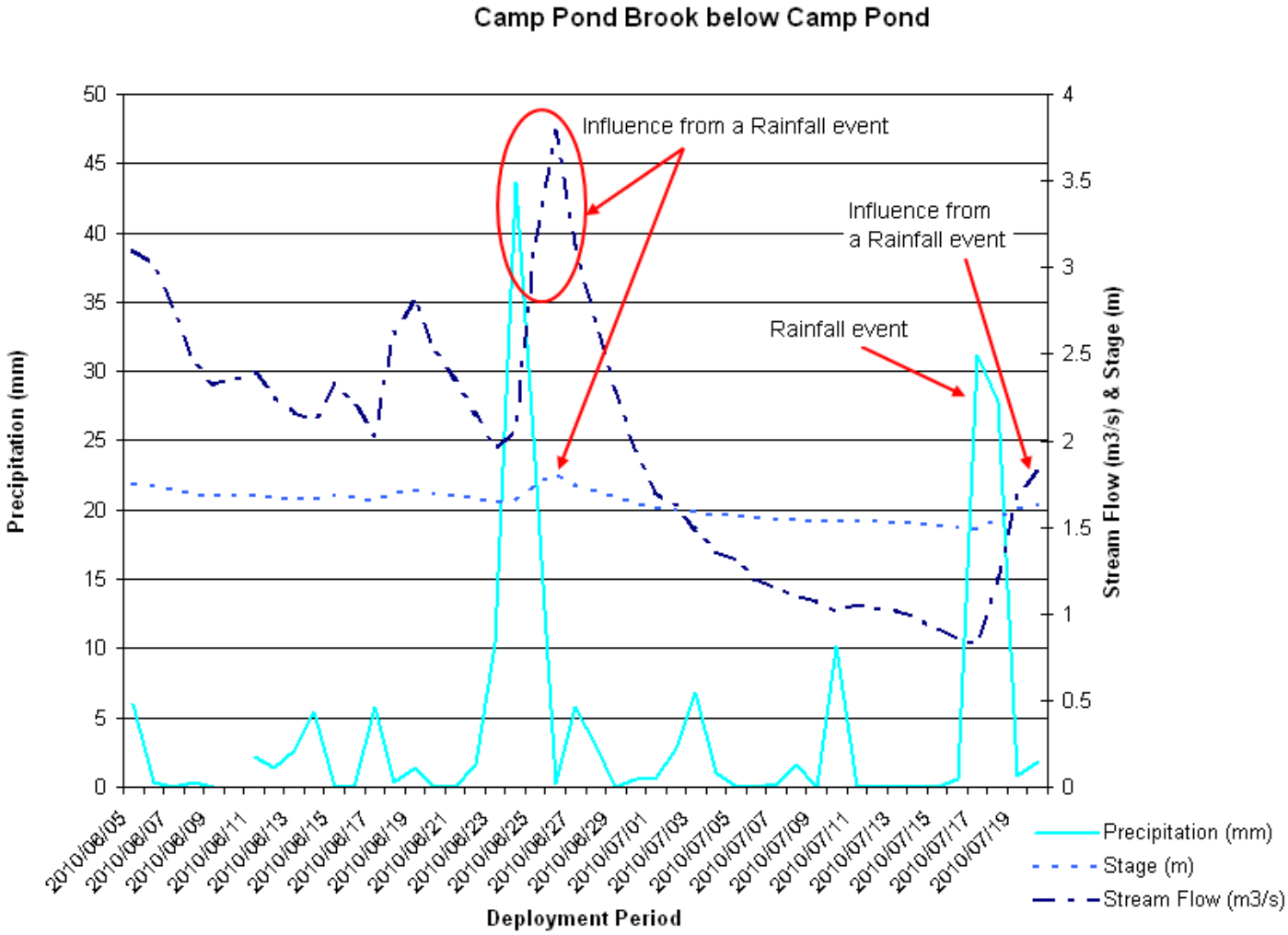

Figure 24: Camp Pond Brook below Camp Pond Tributary stream flow and stage.

CONCLUSION

The water quality monitoring instrument was deployed at the station at Camp Pond Brook below Camp Pond Tributary between June 5 and July 20, 2010. There was an indication of rainfall occurrences throughout this deployment periods. Precipitation may be the source of the events on the graphs for water temperature, pH, conductance, dissolved oxygen and turbidity. Typical seasonal patterns are still evident in temperature, dissolved oxygen and stage.

On June 30, 2010 the dissolved oxygen values (mg/L) dropped below the limits recommended by *CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life* (Cold Water/Early Life Stages – above 9.5 mg/L). The DO values at Camp Pond do resemble similar events on those dates that occurred at Lower Reid below Tributary, which can indicate an influence from a rainfall event or high flow period. This period of low DO values also occurs when the water temperature is at its warmest for the deployment period and therefore could be considered a seasonal trend more so than an instrument error. DO data should be used with caution.

COMPARISONS BETWEEN STATIONS

Temperature

The temperature readings for all four stations at Voisey's Bay increase over the duration of the deployment period. Tributary to Lower Reid Brook, Lower Reid below Tributary and Camp Pond Brook below Camp Pond all have similar temperature performances. Reid Brook at outlet of Reid Pond has a slightly different temperature graph; after a large rainfall event the readings become erratic and jumpy. This may have been contributed to the sensor end of the instrument becoming buried in sand or silt on the Brook floor. All station graphs for temperature portray the same precipitation events on June 23 to June 26, on July 9, 2010 and another at the end of the deployment period from July 16 to July 19. These events influenced and adjusted the readings which are evident on all station graphs.

pH

Over the course of the deployment period the pH values did not deviate too far from the minimum CCME guideline for all Voisey's Bay stations. There is potential of a precipitation event influencing pH values in Tributary to Lower Reid Brook and Lower Reid below Tributary. When stage increased the pH values drop, this is apparent on Figure 14 and Figure 8 for June 25, 2010 and July 17, 2010.
Camp Pond Brook below Camp Pond and Reid Brook at outlet of Reid Pond do not show any significant changes during the deployment period, both stations pH values remain constant.

Specific Conductance

Specific Conductance can be directly influenced by precipitation; rainfall has the affect of lowering conductance values during or after precipitation events. The control station of Reid Brook at outlet of Reid Pond Specific Conductance graph did not display any changes due to rainfall – pH remained steady throughout. The three other stations, Camp Pond Brook below Camp Pond, Lower Reid below Tributary and Tributary to Lower Reid Brook have similar specific conductivity events on June 25 -27 and July 17 -19, 2010 where the values drop slightly corresponding with an increase in stage.

Dissolved Oxygen

Due to Dissolved Oxygen (DO) being a temperature-dependent sensor, one can expect a relationship between the DO values and temperature values corresponding with each station. The irregular DO readings for Reid Brook at outlet of Reid Pond do correspond with the erratic temperature readings from July 5 – July 19, 2010 at that station, which may be a result of the sonde being buried in sand. Lower Reid below Tributary indicates erroneous values for this deployment period. The performance of the DO probe can be linked to the rainfall events. Influence from the rainfall and runoff have caused the DO readings to become erratic. The readings displayed on the DO graph are questionable; for at deployment (of the instrument) the DO ranked as marginal, indicating that initially the probe was not performing to full capacity At the two other stations the DO readings are steady; though there is a slight decrease in the DO (mg/L) during the overall deployment period, this is not unusual as temperature increases as it reflects the summer months.

Turbidity

All Voisey's Bay stations show turbidity events during the deployment period. The turbidity readings for Lower Reid below Tributary station did increase to a value as high as 3000 NTU, however 3000 NTU generally is identified as an error reading for the sonde, caused by a piece of debris (i.e. leaf, soil) blocking the sensor windows. The 3000 NTU can also occur if the sonde becomes buried in a sandy river bottom. The turbidity events at Lower Reid below Tributary correspond with turbidity events recorded at the Reid Brook below Reid Pond station. There is one large event on July 9, 2010 and then for the remainder of the deployment period the turbidity remains higher than normal. This is highly uncharacteristic for this station. Tributary to Lower Reid Brook has turbidity readings that fluctuate during the deployment period; there are several larger turbidity events toward the end of the deployment period however nothing over 50 NTU. Camp Pond Brook below Camp Pond also has fluctuating turbidity values, with one main event toward the end of the deployment period; this may be a result of runoff after a rainfall event. These are typical turbidity trends for both Tributary to Lower Reid Brook and Camp Pond Brook Stations.

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