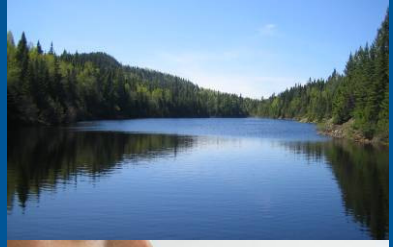
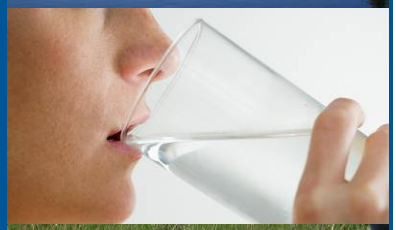






Real-Time Water Quality Deployment Report

Rattling Brook Network

September 16th to October 13th, 2010

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
St. John's, NL, A1B 4J6 Canada

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General

- Department of Environment and Conservation staff monitors the real-time web pages consistently.
- An emergency trip was made during the previous deployment period in August to switch out S/n 44604 due to a problem with the turbidity sensor. Since the instrument was received from repair and ready for deployment on September 15th, it was decided to deploy it then rather than wait for the next day when the other two stations were deployed.
- On September 21st, Hurricane Igor struck eastern Newfoundland. The Long Harbour construction site was closed due to poor conditions. The Rattling Brook network did not experience any significant damage. A few fallen trees were encountered, especially near the below Plant Discharge station where one tree was found to be partially leaning on the hut. A request will be made to have the tree removed to prevent damage.
- The following is a discussion of significant water quality related events at Rattling Brook Big Pond, below Bridge and below Plant Discharge stations for the deployment period ranging from September 16th to October 13th – a period of 27 days (28 for below Bridge).

Maintenance and Calibration of Instrument

- 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.
  - Upon deployment, a QA/QC Sonde is temporarily deployed along side the Field Sonde. Values for temperature and dissolved oxygen are compared between the two instruments. A grab sample is taken to compare with the Field Sonde for specific conductivity, pH and turbidity parameters. Based on the degree of difference between parameters recorded by the Field Sonde, QAQC Sonde and grab sample a qualitative statement is made on the data quality in Table 1 upon Deployment.
  - At the end of a deployment period, readings are taken in the water body from the Field Sonde 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 in Table 1 upon Removal.

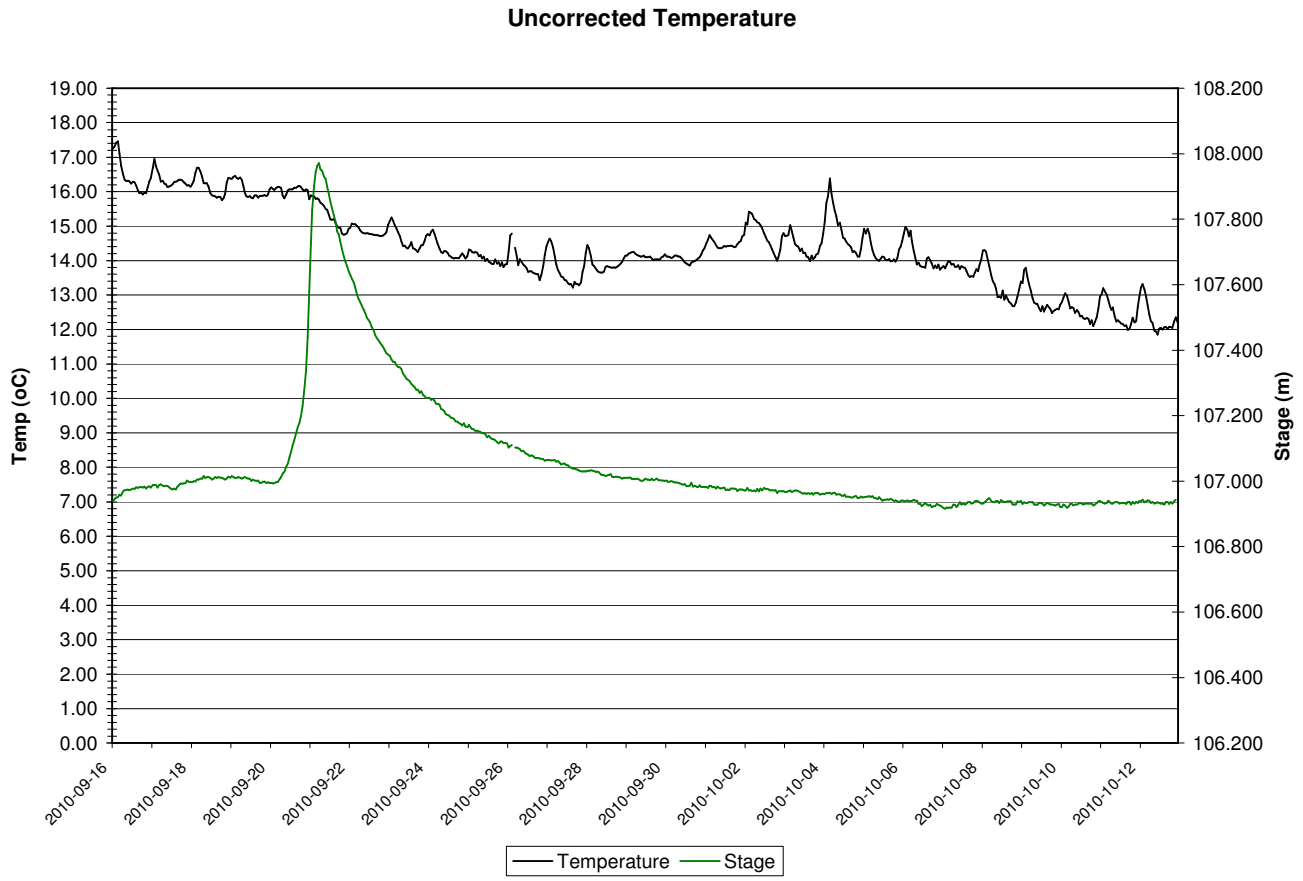
Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Rattling Brook Big Pond	September 16, 2010	Deployment	Excellent	Excellent	Excellent	Excellent	Excellent
	October 13, 2010	Removal	Excellent	Excellent	Excellent	Excellent	Excellent
Rattling Brook below Bridge	September 16, 2010	Deployment	Excellent	Fair	Good	Excellent	Excellent
	October 13, 2010	Removal	Excellent	Good	Excellent	Excellent	Excellent
Rattling Brook below Plant Discharge	September 16, 2010	Deployment	Fair	Good	Good	Excellent	Excellent
	October 13, 2010	Removal	Excellent	Fair	Excellent	Good	Excellent

- pH and Specific Conductivity at Rattling Brook below Bridge were ranked as 'Fair' and 'Good', respectively, during deployment. In an instrument-to-instrument comparison during removal, pH and Specific Conductivity were ranked as 'Good' and 'Excellent'. Since it is generally accepted that the quality of data should go down over the duration of the deployment period and not improve, it is reasonable to believe that some problem with the grab sample taken at deployment resulted in an under-ranking of pH and Specific Conductivity values.
- A similar problem was found with the instrument at below Plant Discharge. Efforts will be made to determine if this is indeed an instrument problem.

Data Interpretation

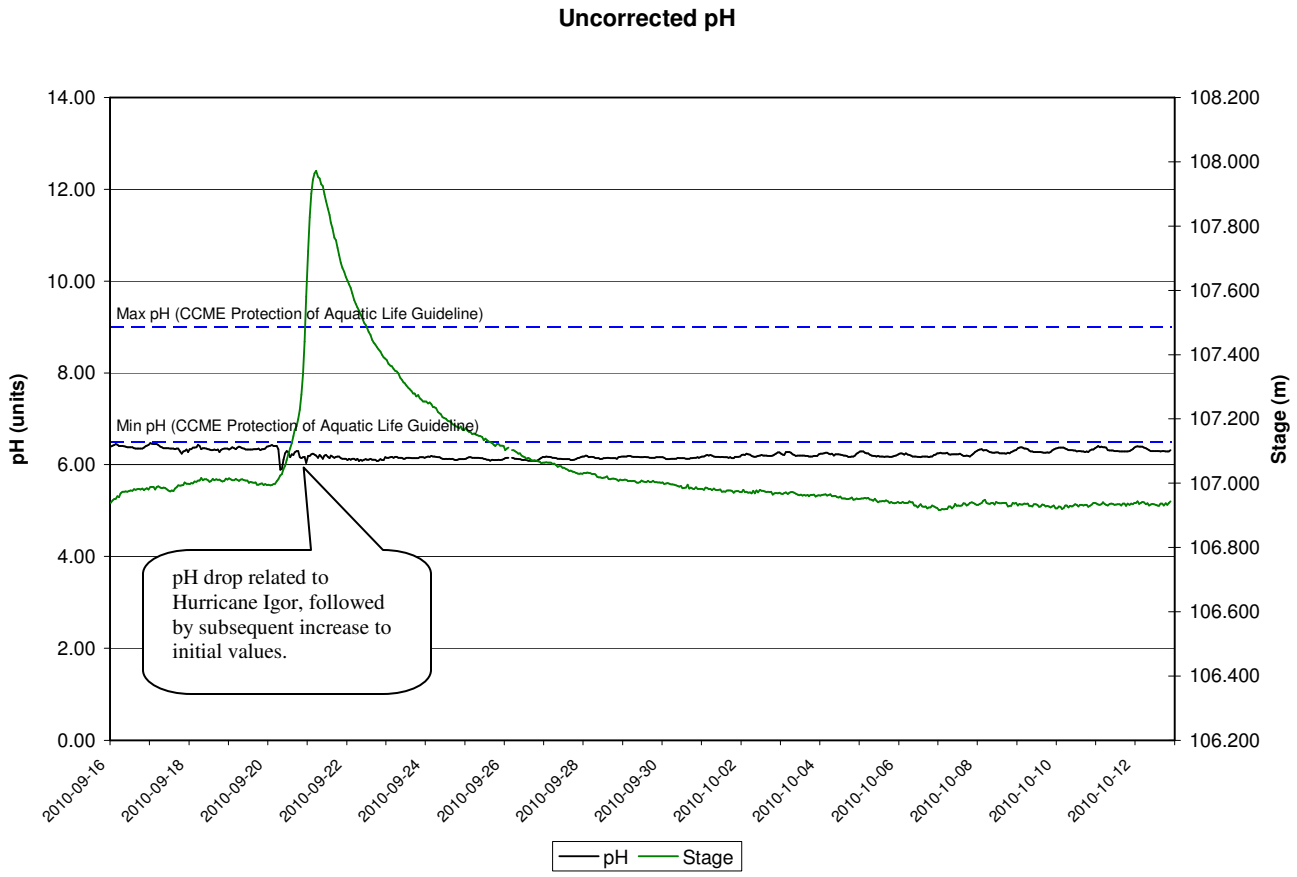
- No correction was made to Water temperature for this deployment period since the data correction criterion was not exceeded.
- Water temperature was found to range from 17.46 to 11.85^{o}C for this month's deployment. The maximum value occurred on September 16th at 3:30 pm while the minimum was recorded on October 12th at 10:30 pm. During these days, the mean air temperature was 16 and 10^{o}C, respectively.
- On September 21st, during hurricane Igor, a stage level increase of about 80 cm began a week-long decline in water temperature. Following this declining trend, a slight warming trend was recorded, ending the Igor induced flux in water quality at Rattling Brook Big Pond.
- A distinct downward trend in temperature is observed as summer progressed into fall.

Figure 1: Water Temperature at Rattling Brook Big Pond from September 16 to October 13, 2010



- No correction was made to pH during this deployment period since the total error did not exceed the data correction criterion.
- pH at Rattling Brook Big Pond exhibited a more-or-less net zero change in values over the deployment period. A dip in recorded values was observed during Igor, however, pH slowly regained its initial levels towards the end of deployment on October 13th.
- pH values ranged from 5.89 to 6.47 during this month. All values were found to be below the CCME Guideline for the Protection of Aquatic Life. This is considered to be natural conditions for this system.

Figure 2: pH at Rattling Brook Big Pond from September 16 to October 13, 2010



- No correction was made to Specific Conductivity – the data provided below is raw.
- Specific conductivity ranged from 39.7 to 34.1 µS/cm for this deployment period with a notable downward trend, especially following hurricane Igor.

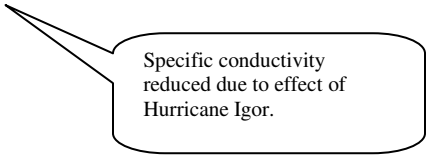
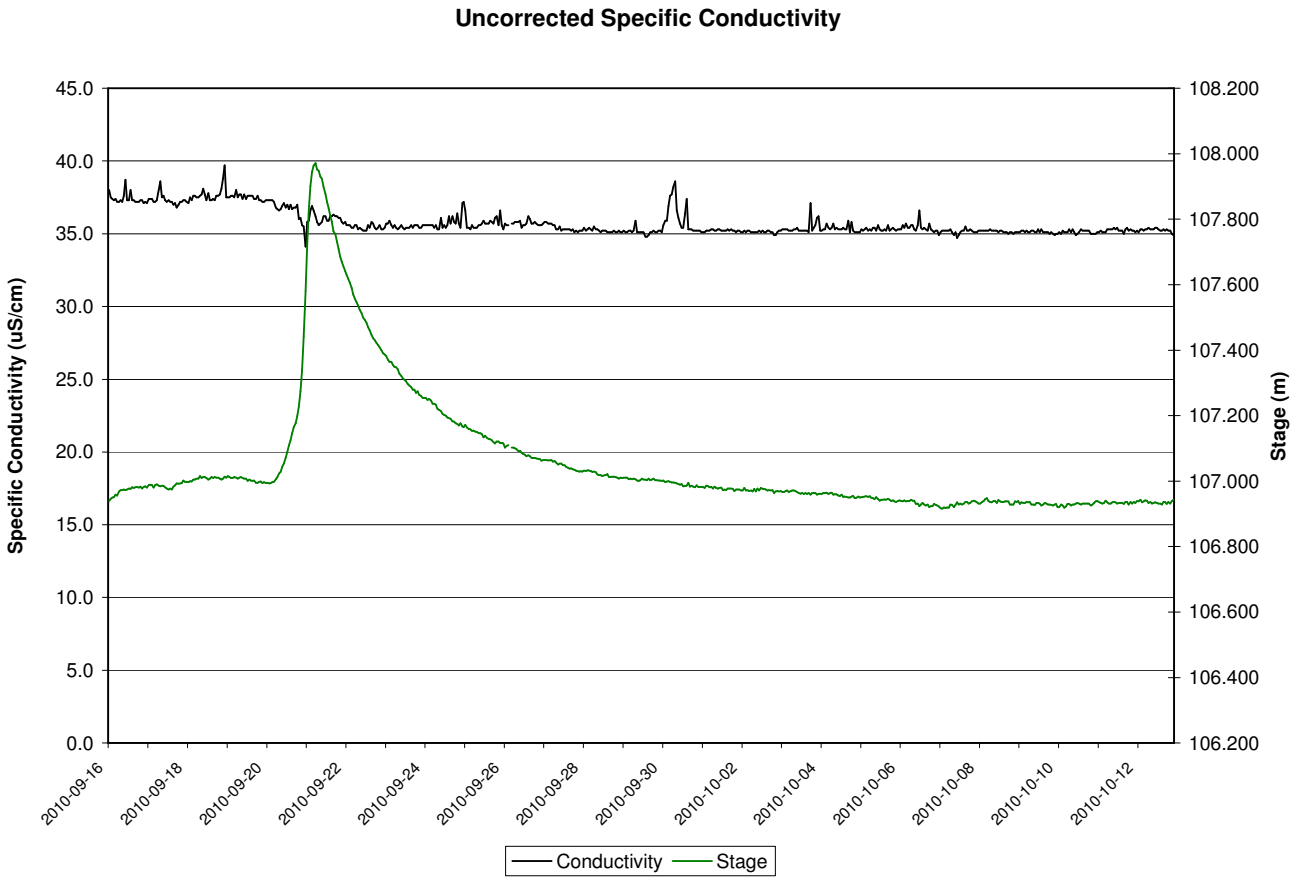
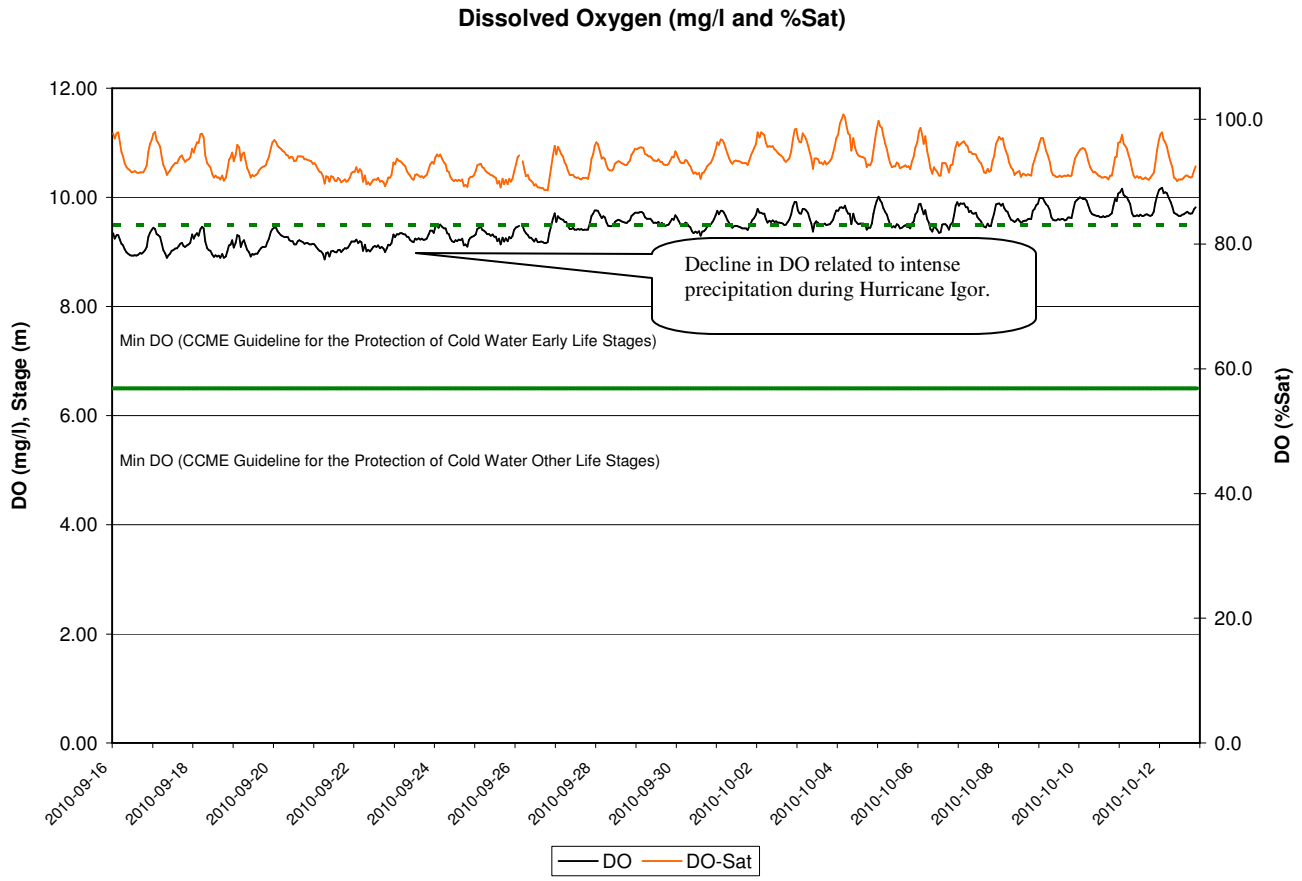


Figure 3: Specific Conductivity at Rattling Brook Big Pond from September 16 to October 13, 2010



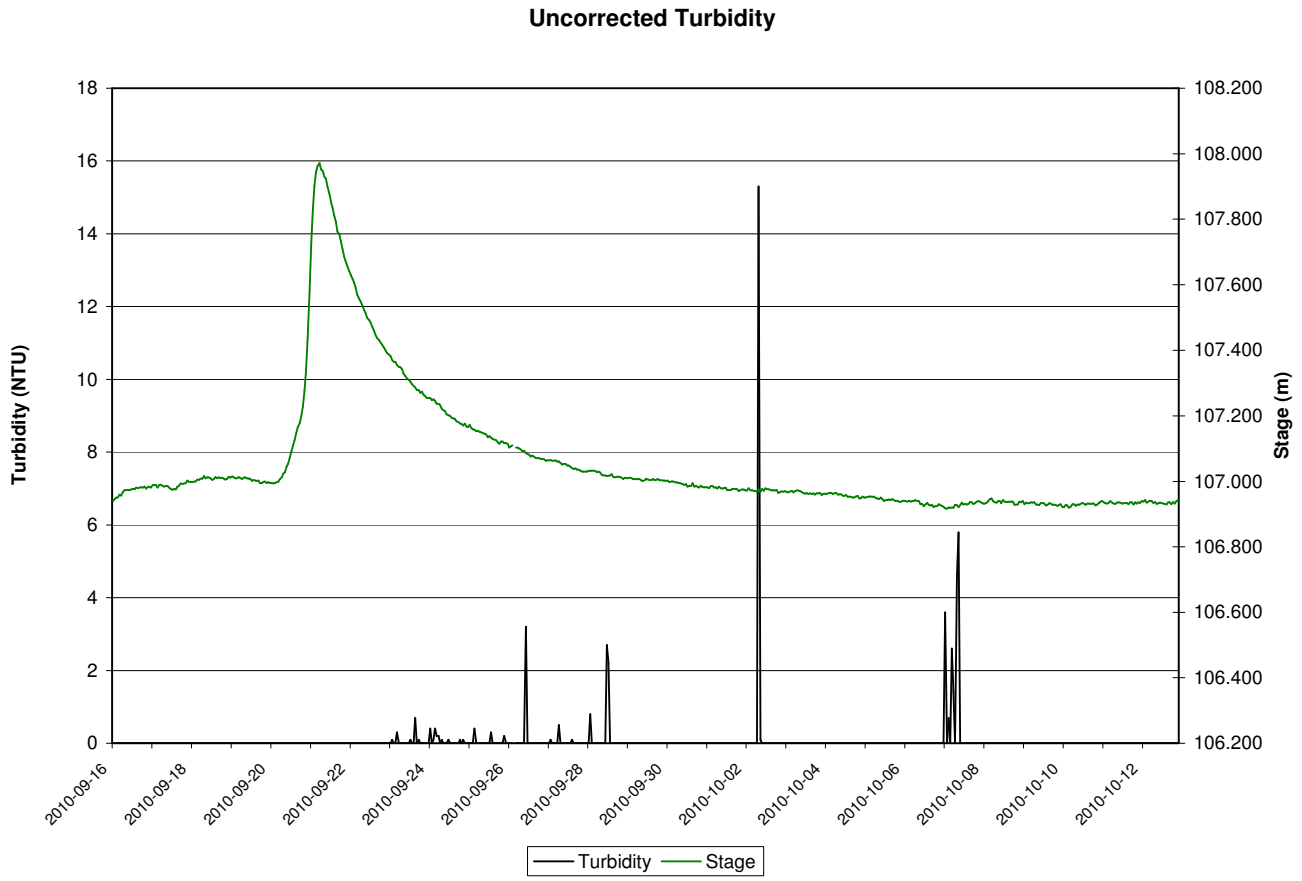
- Dissolved oxygen saturation was not corrected for this deployment period since the total error was a minimal 0.5%.
- Dissolved Oxygen saturation at Rattling Brook Big Pond ranged from 88.6 to 100.8% for this deployment period and showed no particular trend in either direction.
- In terms of the concentration of Dissolved Oxygen, however, a noticeable upward trend is observed as air temperature continued to cool into the fall season. The concentration of DO ranged from 8.86 to 10.18 mg/l with a median value of 9.48 mg/l.
- All values for DO were greater than the minimum CCME guideline of 6.5 mg/l for the protection of Early Life Stage cold water biota with many records exceeding the minimum CCME guideline of 9.5 for the protection of Other Life Stage cold water biota.

Figure 4: Dissolved Oxygen at Rattling Brook Big Pond from September 16 to October 13, 2010



- Turbidity was not corrected during this deployment period due to the low Total Error of 0.8 NTU.
- Values recorded during this deployment period are low with a range of 0.0 to 15.3 NTU. The median value is 0.0 NTU, indicating that more than half of the readings are turbidity-free.
- Interestingly, at Rattling Brook Big Pond station there was no turbidity event recorded during the hurricane, unlike the below Bridge and below Plant Discharge stations.

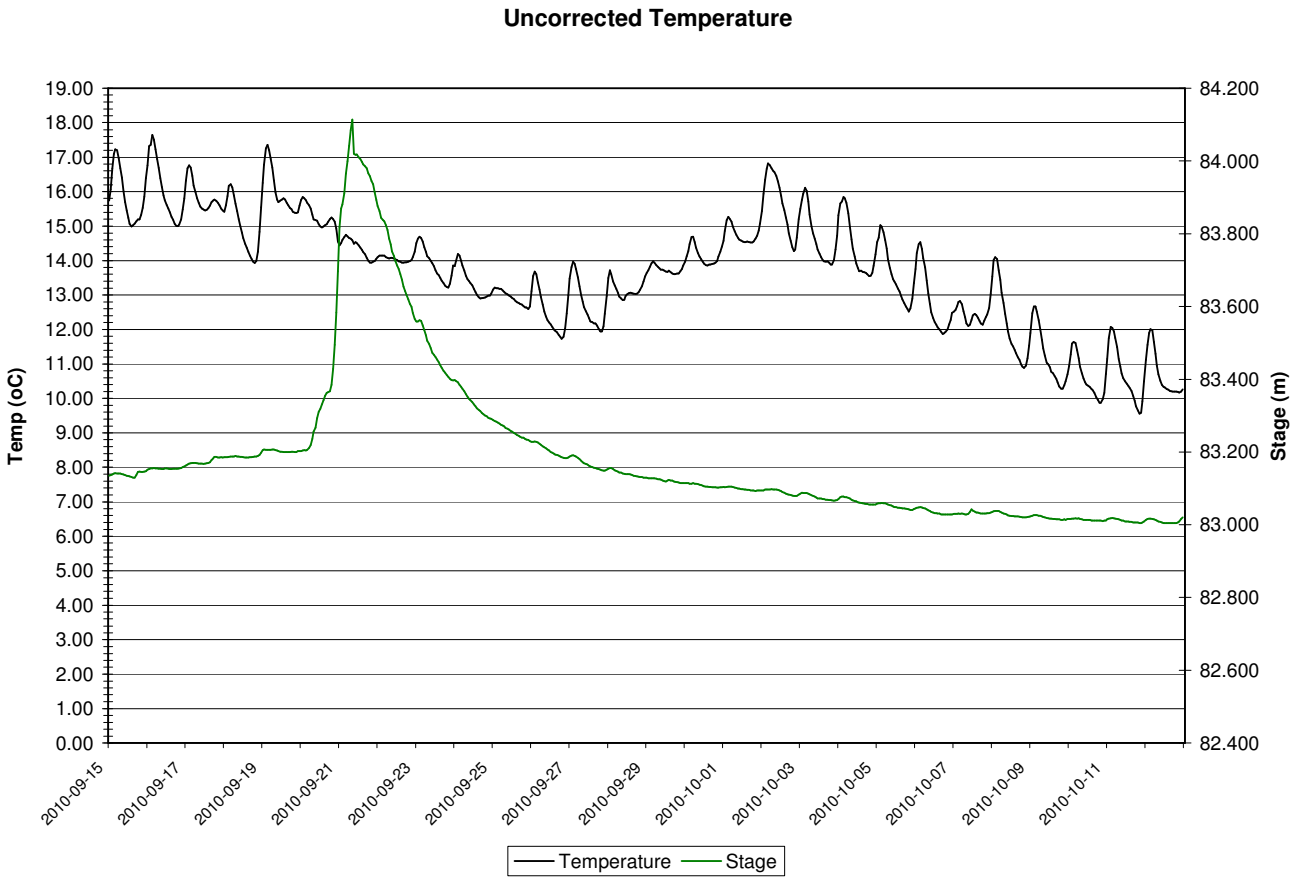
Figure 5: Turbidity at Rattling Brook Big Pond from September 16 to October 13, 2010



Rattling Brook below Bridge

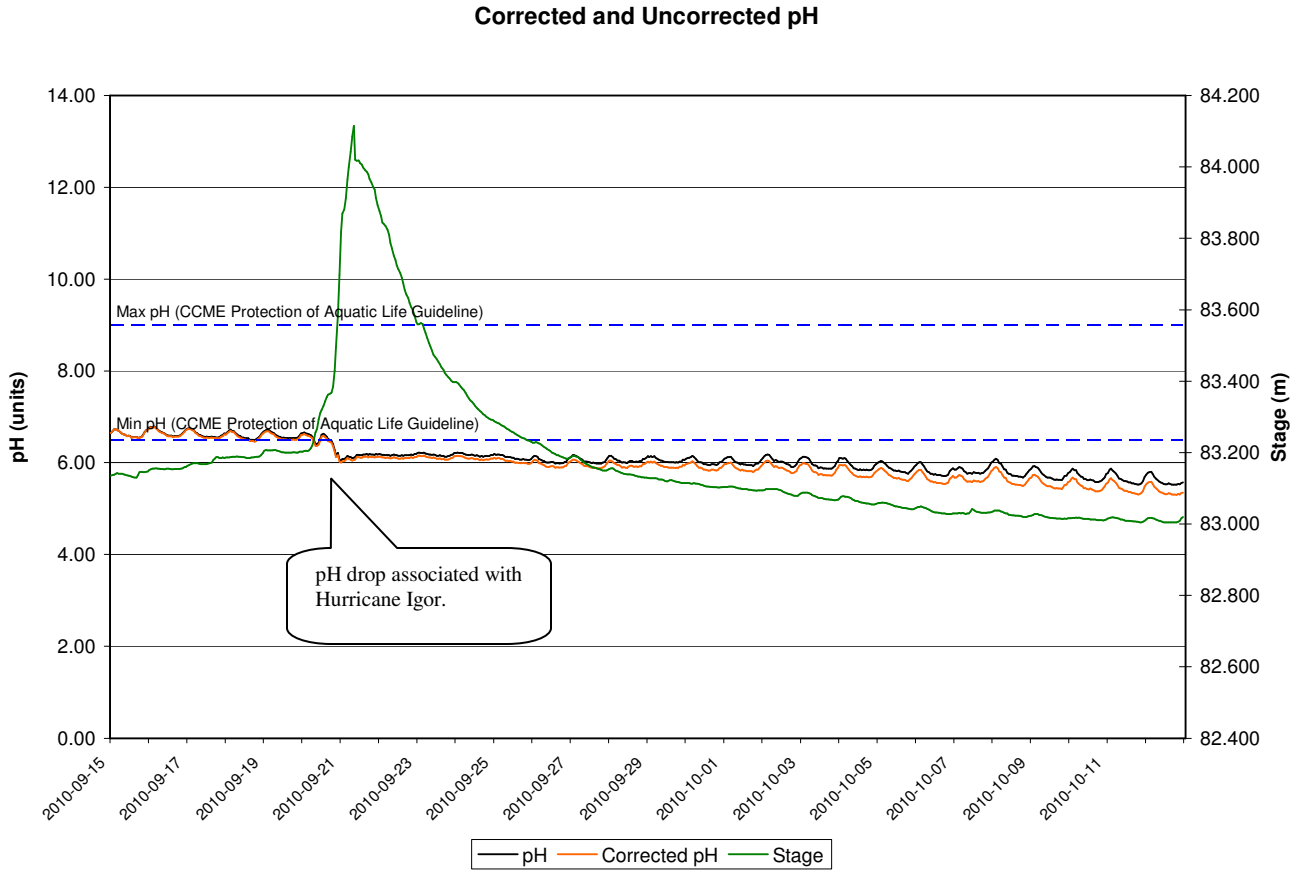
- Water temperature was not corrected during this deployment period since the Total Error did not exceed the data correction criterion.
- A bimodal trend is shown in the figure below. A cooling trend is observed from September 15th to September 27th, followed by a brief warming trend until October 2nd, and then another cooling trend lasting for the duration of the deployment.
- Water temperature at below Bridge station ranged from 17.64 to 9.56^{o}C. A depression of diurnal temperature cycling is observed during Igor, however, the cooling trend is otherwise undisturbed.

Figure 6: Water Temperature at Rattling Brook below Bridge from September 15 to October 13, 2010



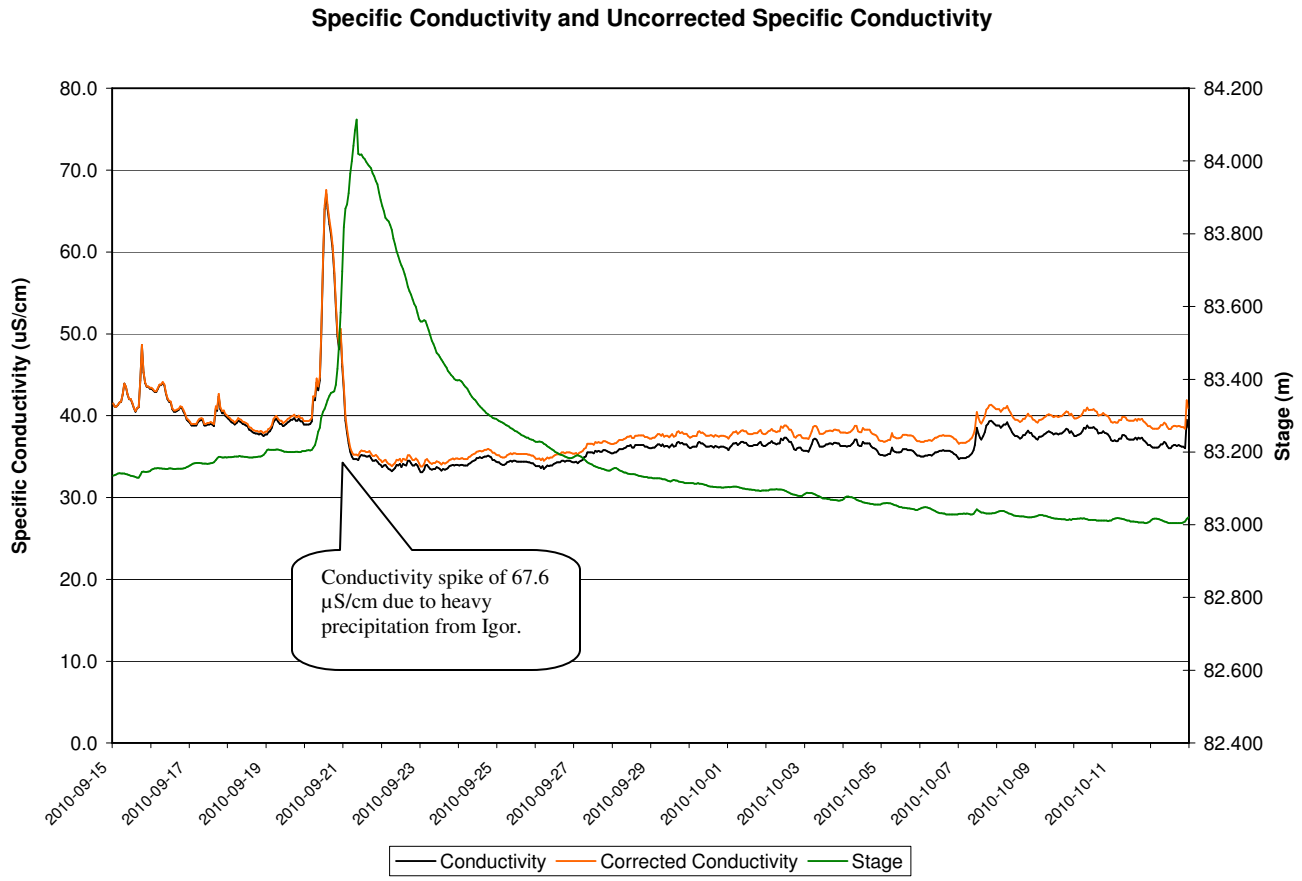
- A correction of -0.22 units was applied to the pH record for this deployment period.
- At the beginning of this deployment, pH values hovered near the expected 6.5 mark. During the onset of Igor, however, a near-instantaneous 0.5 unit drop was recorded that trended downwards until the end of deployment. While a drop in pH is expected during heavy precipitation (rain is somewhat acidic), this gradual decline in pH to a low of 5.3 is unusual and hints of a sensor malfunction more than an actual water quality event. pH at the downstream station did not show this trend, but instead recorded a marginal upward trend.

Figure 7: pH at Rattling Brook below Bridge from September 15 to October 13, 2010



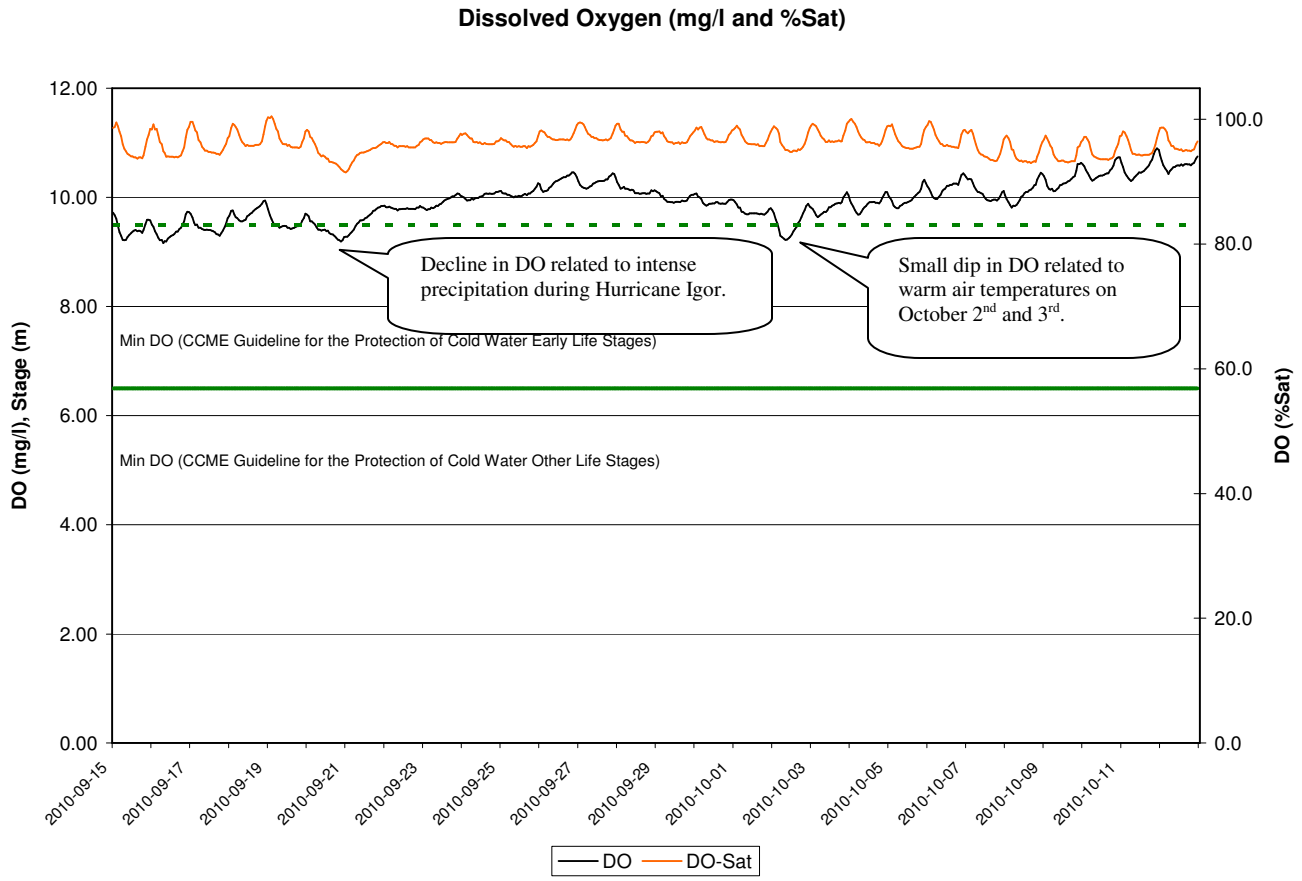
- A correction of 2.40 µS/cm was applied to specific conductivity for this deployment period.
- Corrected Specific Conductivity ranged from 33.8 to 67.6 µS/cm for this deployment period with a median value of 37.9 µS/cm.
- A maximum value of 67.1 µS/cm was recorded during the Igor storm event. Such a high peak is the result of significant overland flow carrying charged-ion laden silt and soil into the stream channel. A concurrent spike in turbidity is also recorded, indicating that this is the case.

Figure 8: Specific Conductivity at Rattling Brook below Bridge from September 15 to October 13, 2010



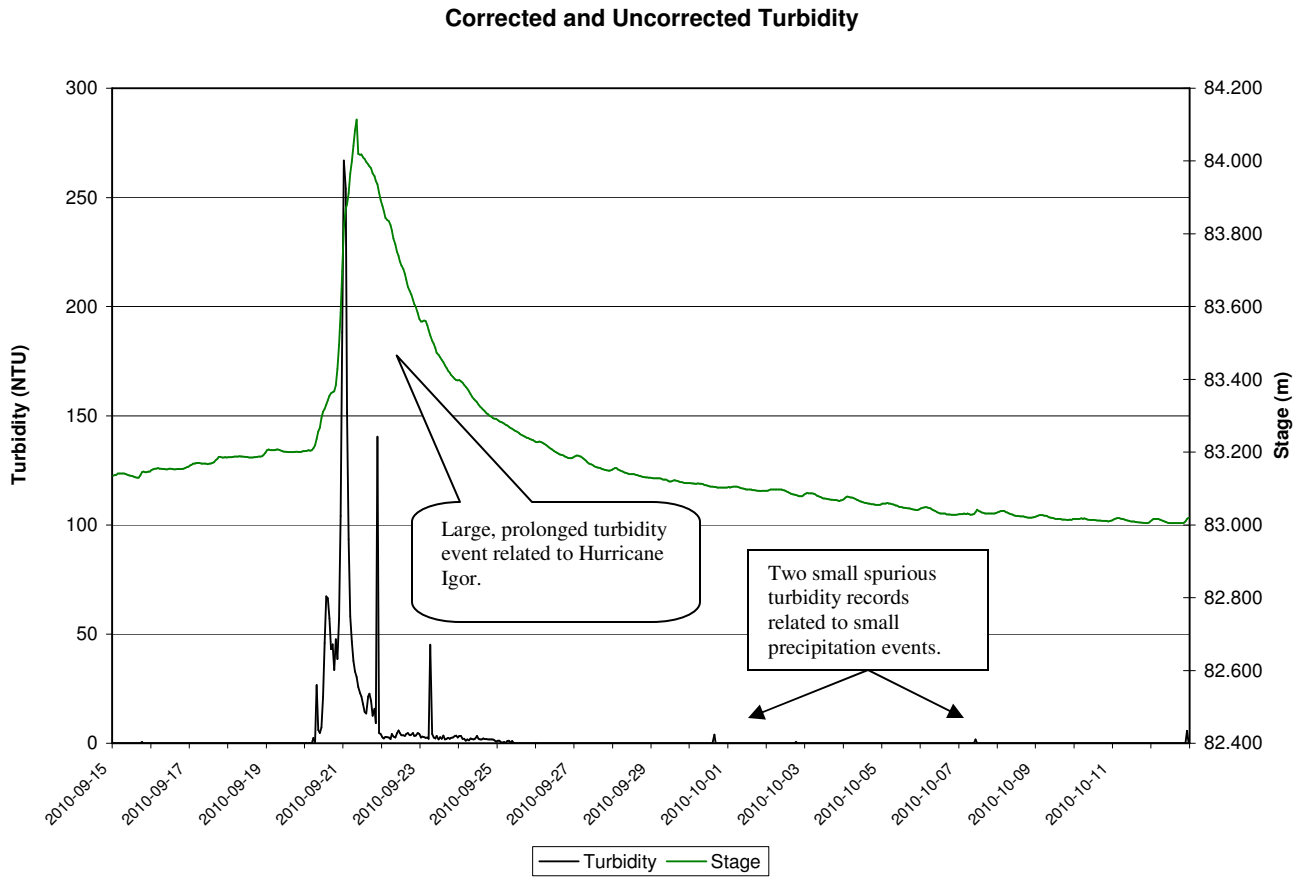
- A Total Error of 0.90% did not warrant a correction to Dissolved Oxygen for this deployment period at Rattling Brook below Bridge station.
- Saturation of DO ranged from 91.5 to 100.5% with no major up or downward trends.
- DO concentration ranged from 9.16 to 10.90 mg/l in an upward trend related to declining water temperatures.
- All values were found to be greater than the CCME minimum guideline of 6.5 mg/l for the protection of Early Life Stage cold water biota. Many values in the latter half of the deployment were recorded as greater than the guideline minimum of 9.5 mg/l for the protection of Other Life Stage cold water biota.
-

Figure 9: Dissolved Oxygen at Rattling Brook below Bridge from September 15 to October 13, 2010



- No correction was made to turbidity during this deployment period since the Total Error did not exceed the data correction criterion.
- For most of this deployment period, the turbidity was very low with two minor instances of turbidity outside of the large Igor-related turbidity event.
- Turbidity ranged from 0.0 to 266.9 NTU for the whole deployment with a median value of 0.0 NTU, despite Igor's influence.
- The subsidence of the prolonged turbidity event coincides with the declining storm-induced stage level. Turbidity did not finally return to normal until water levels reached pre-storm levels.

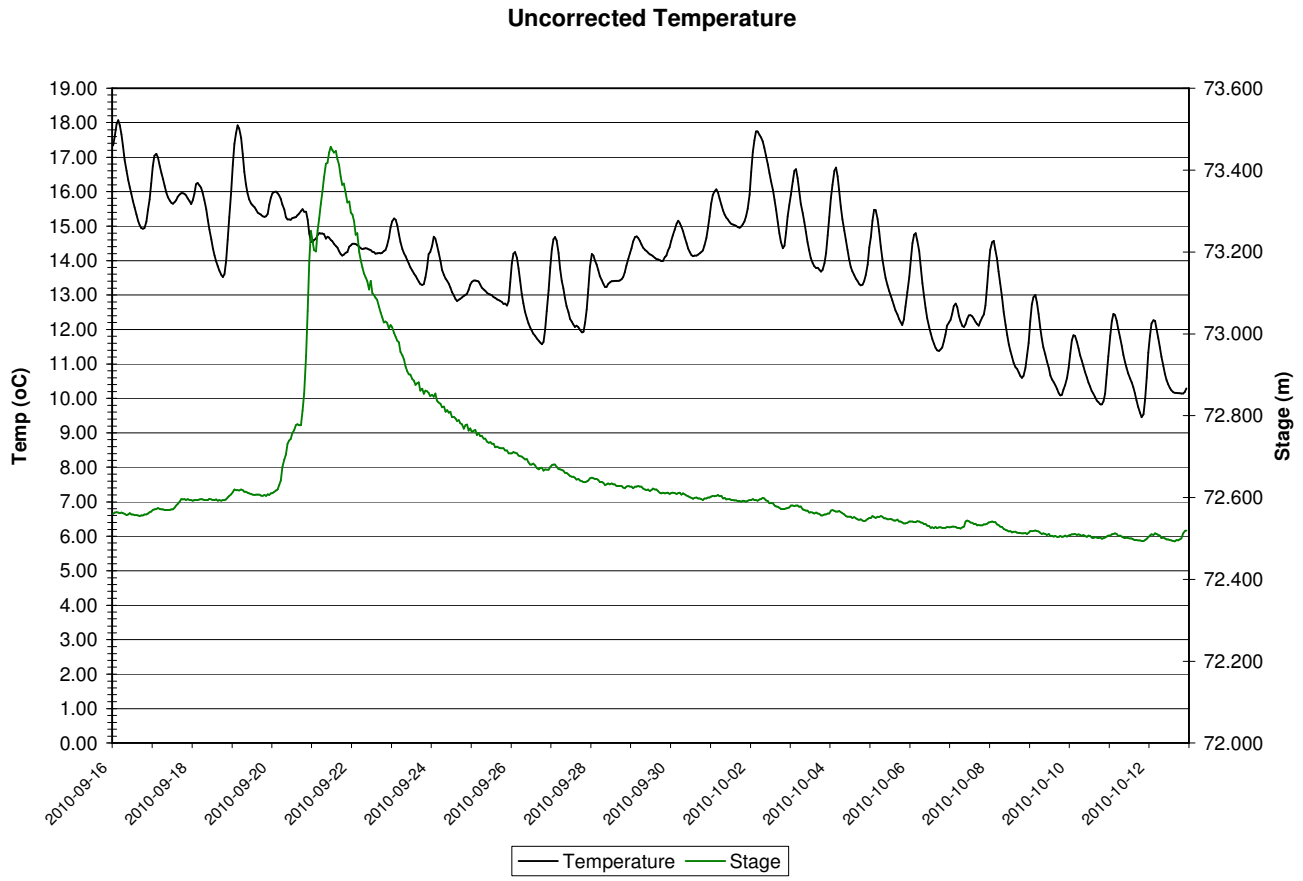
Figure 10: Turbidity at Rattling Brook below Bridge from September 15 to October 13, 2010



Rattling Brook below Plant Discharge

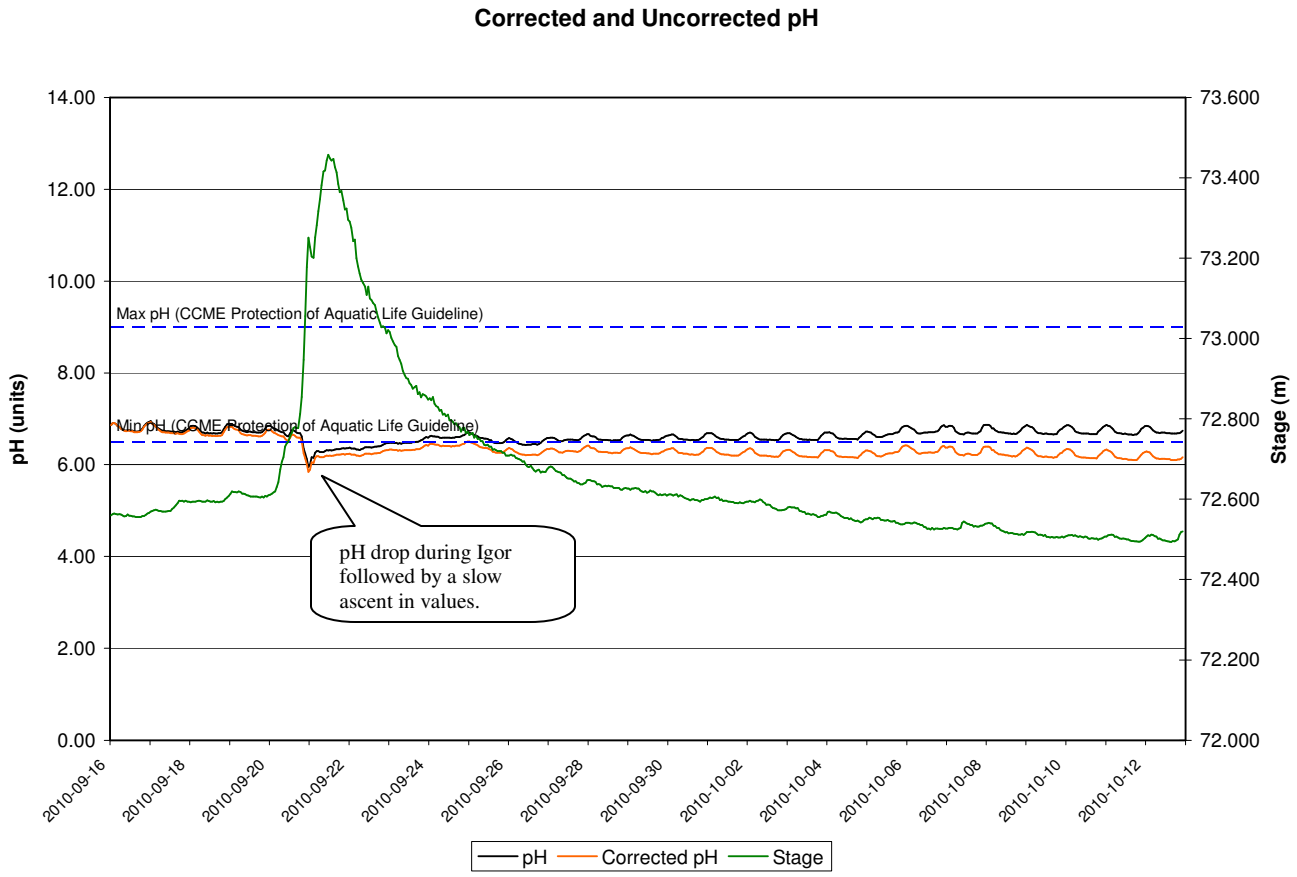
- No temperature correction was required for this deployment due to a small Total Error value.
- A bimodal trend similar to that observed at below Bridge station was recorded at below Plant Discharge station. A falling trend at the beginning of the deployment met with a brief warming trend that fell once again. The warming trend is associated with a period of mil temperatures with sequentially warmer average daily temperatures from September 25th to October 3rd.
- The range in water temperature recorded is from 18.07 to 9.46^{o}C.

Figure 11: Water Temperature at Rattling Brook below Plant Discharge from September 16 to October 13, 2010



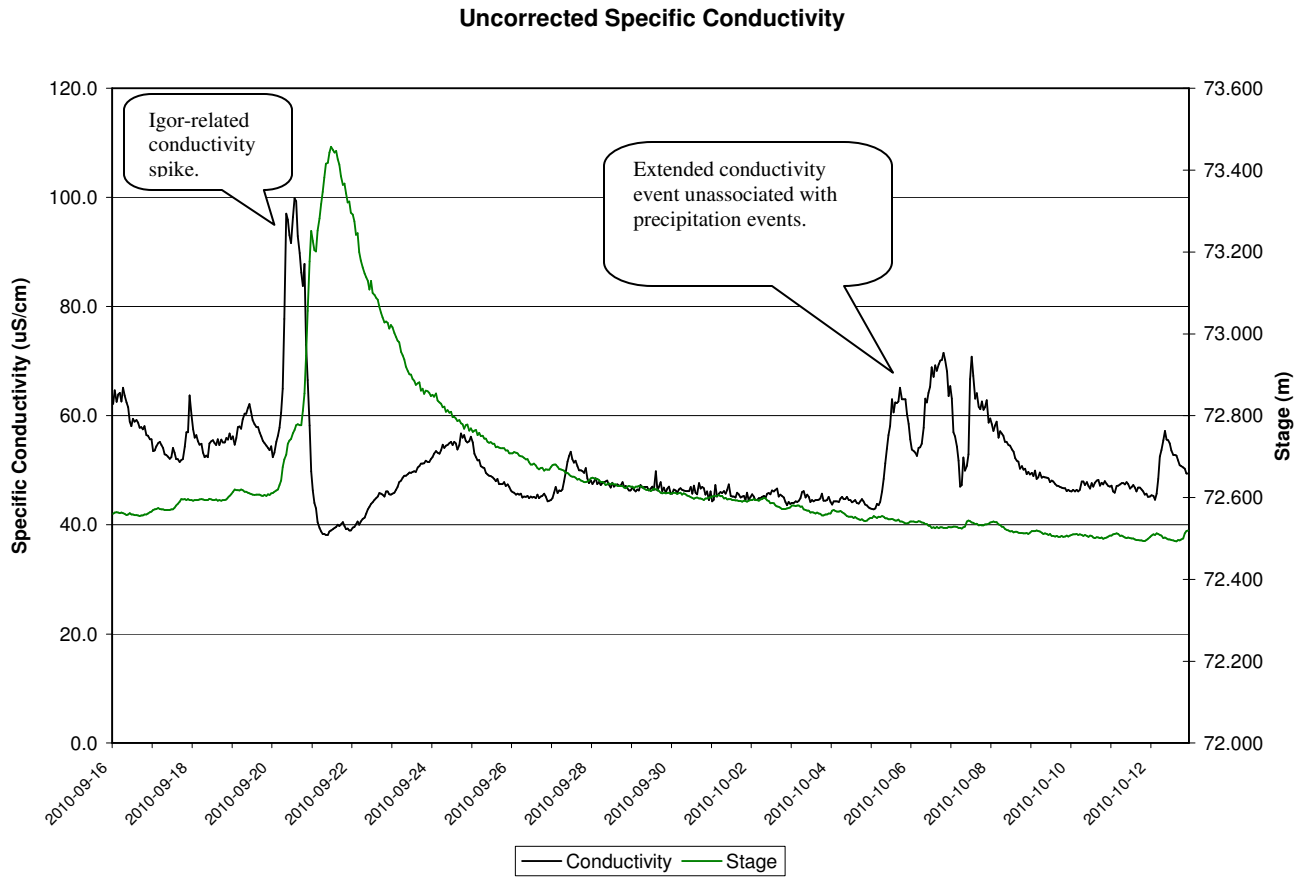
- Total Error exceeded the data correction for pH resulting in a correction of -0.58 units being applied to the record for this deployment.
- Initially, pH was above the minimum CCME Guideline value of 6.5 but fell below by almost a full unit from 6.76 to 5.84 on September 21st, during Hurricane Igor. A prolonged and slight recovering trend ensued for the duration of the deployment. The median corrected pH value for this time period was 6.28.

Figure 12: pH at Rattling Brook below Plant Discharge from September 16 to October 13, 2010



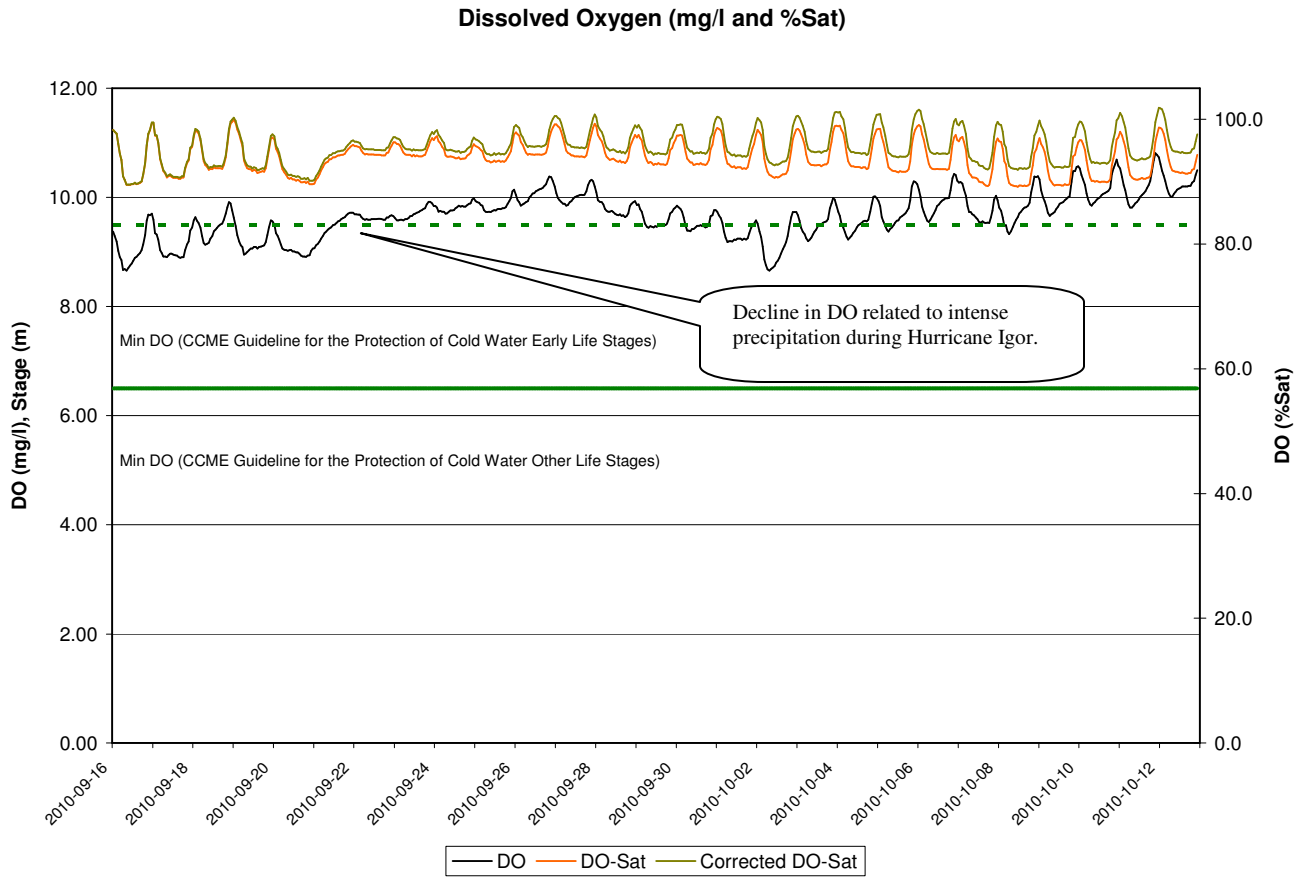
- Specific Conductivity was uncorrected for this deployment period and the raw data is presented below.
- Conductivity values were highly variable for this deployment and much more so than those recorded at below Bridge station. Conductivity ranged from 38.1 to 99.8 µS/cm with a median value of 47.9 µS/cm.
- A very large spike occurred during Hurricane Igor which was likely associated with stream bank erosion and siltation from extreme storm flow. Upon visitation to this station on October 13th, it was noted that shrubs and portions of the bank were completely obliterated and some trees were across the river upstream. In addition, large rocks and boulders were shifted and more were released that were previously embedded in the bank away from the normal stream channel.
- A prolonged conductivity event began on October 5th at 6:30 pm during a period with no precipitation. This pattern was not observed upstream at below Bridge station, suggesting that the even may be related to construction work in the area. Interestingly, no significant turbidity spikes (greater than normal) were recorded.

Figure 13: Specific Conductivity at Rattling Brook below Plant Discharge from September 16 to October 13, 2010



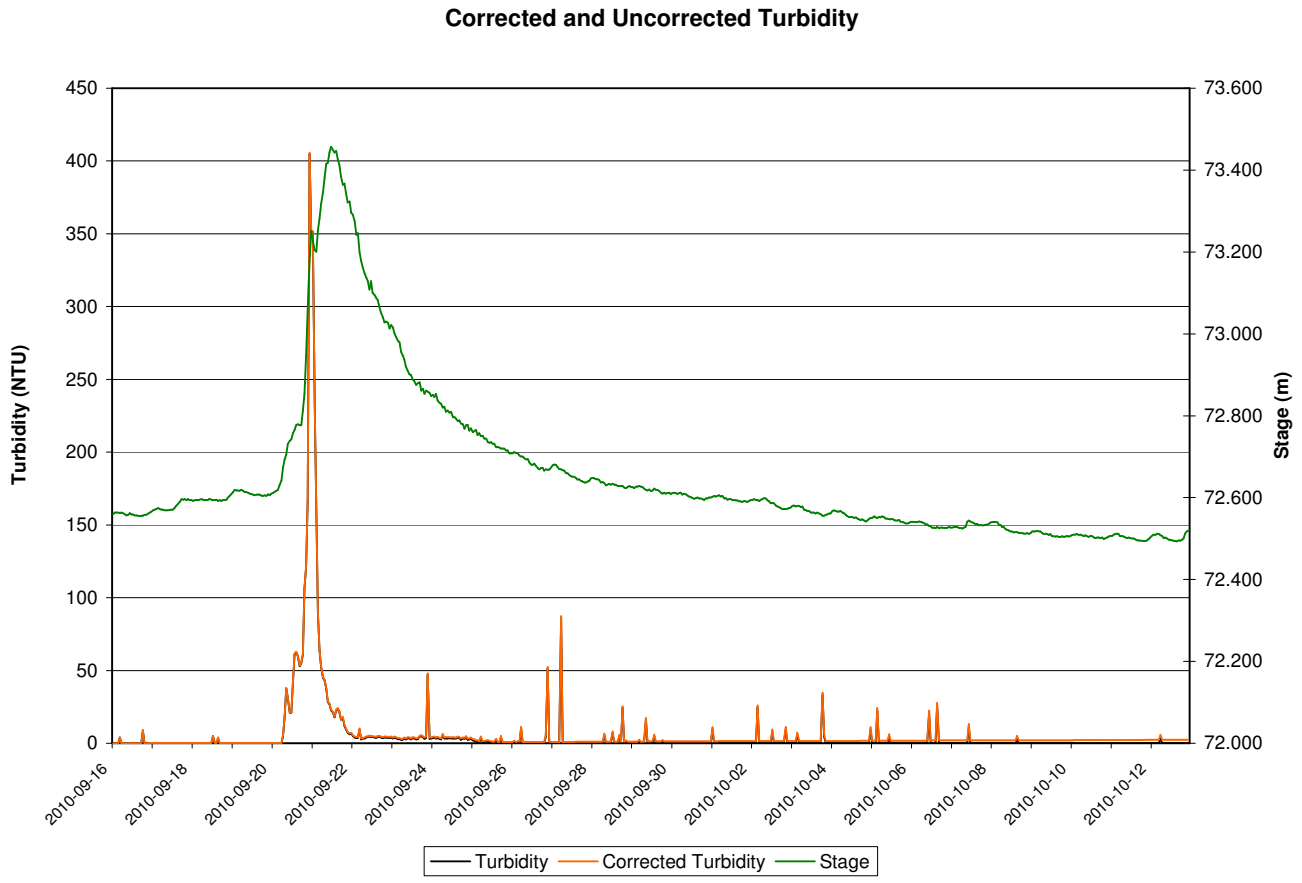
- A correction of 3.30% was applied to Dissolved Oxygen for this deployment period.
- Dissolved Oxygen saturation ranged from 89.5 to 101.9% with a median value of 95.03%. No major trend was observed up or down, however and interruption in the day-to-day cycling of saturation was noted in relation to heavy precipitation and flow during Igor.
- A bi-modal trend, inverse to that of water temperature, was noted during this deployment. A rising concentration of DO met with a short period of decline mid-deployment, followed again by rising DO levels.
- The concentration of DO ranged from 8.66 to 10.81 mg/l for this deployment period with a median of 9.67 mg/l. All values were greater than the minimum CCME guideline of 6.5 mg/l for the protection of Early Life Stage cold water biota with some records recorded as greater than the minimum value of 9.5 for the protection of Early Life Stage cold water biota.
- A depression in diurnal DO cycling is apparent following Igor due to large water volumes.

Figure 14: Dissolved Oxygen at Rattling Brook below Plant Discharge from September 16 to October 13, 2010



- A correction of 2.45 NTU was incorporated into the turbidity readings for this deployment.
- Corrected turbidity values ranged from 0.0 to 405.4 NTU with a median value of 1.79 NTU. As expected, the maximum value was attained during Igor, but prior to the peak streamflow. This indicates that the primary surge of turbidity was flushed quickly. It is also notable that the relationship between the scale of the storm and the resulting duration of turbidity is not intuitive. Given the size of the storm, one may expect that turbidity would be elevated for an extended period of time.
- A multitude of small spikes are recorded in turbidity for the remainder of the deployment. This may be due to instability in the banks along Rattling Brook releasing silt periodically as they begin to restabilize.

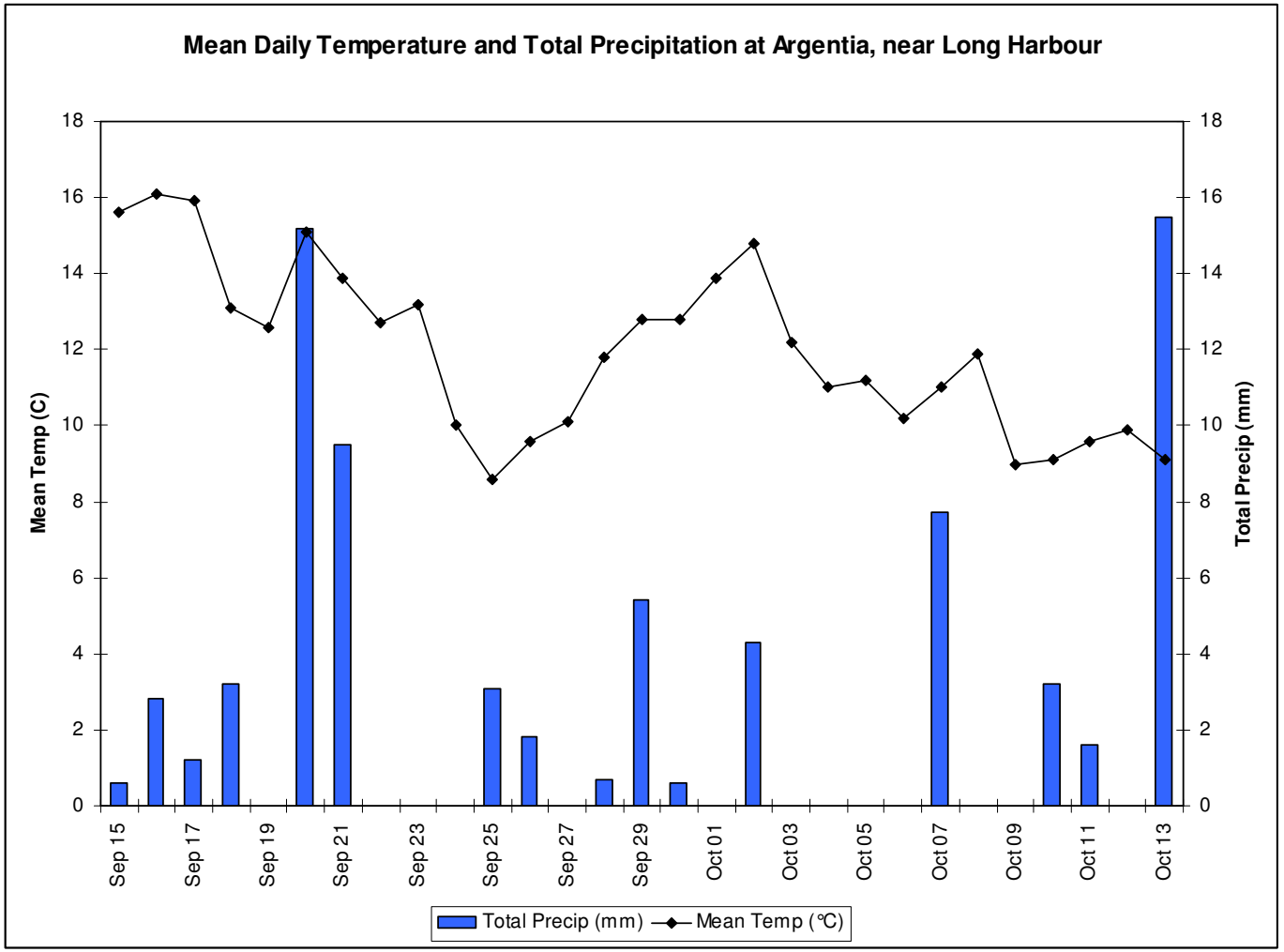
Figure 15: Turbidity at Rattling Brook below Plant Discharge from September 16 to October 13, 2010



Conclusions

- No major damage to huts or equipment was found in the aftermath of Hurricane Igor. All stations performed exceptionally and there were no major outages.
- Streambank erosion and fallen trees had the potential to cause damage to antennae and huts but proactive measures undertaken by Vale staff to remove fallen trees ensured that damage was avoided.
- Vale is to be commended in their institution of stormwater handling systems and settling ponds. Without the presence of these structures, erosion and siltation or Rattling Brook could have been much worse.

Appendix



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