STORM SURGE ANALYSES FOR RIVERSDALE & PLACENCIA

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Storm surge calculations were done using **T**he **A**rbiter **o**f **S**torms (**TAOS**) computer model. TAOS is a PC based storm hazard model for assessing storm surge and wind hazards generated by tropical storms and hurricanes.

1. Frequency of Occurrence

Historical storm tracks were extracted from the TAOS database in order to find the frequency of occurrence of each class of tropical cyclones. The data presented in Table 1 include the amount of tropical cyclones passing within 30 nautical miles of both Placencia and Riversdale. It covers the period 1886 to 2005. (Storm categories are described in section 3.)

Table 1. Storm categories. year of occurrence , name and frequency.

Category	**Year**	**Frequency**	**Names**
Tropical depression	-	0	-
Tropical storm	1934,1941,1971,1974	4	Not named, not named, Laura, Fifi
Category 1	1945,1960,1961, 1969	4	Not named, Abby, Anna, Francella
Category 2	-	0	-
Category 3	-	0	-
Category 4	2001	1	Iris
Category 5	-	0	-

The most frequent categories of tropical cyclones impacting on the area of interest are those of tropical storm and category 1 strength systems.

Figure 1 below shows the 100-year return period for various storm surge heights for the country of Belize. For the Placencia/Riversdale area surge heights of 1-2 meters show a 100 year return period. The higher magnitude surges do not lie not within that 100 year recurrence interval.

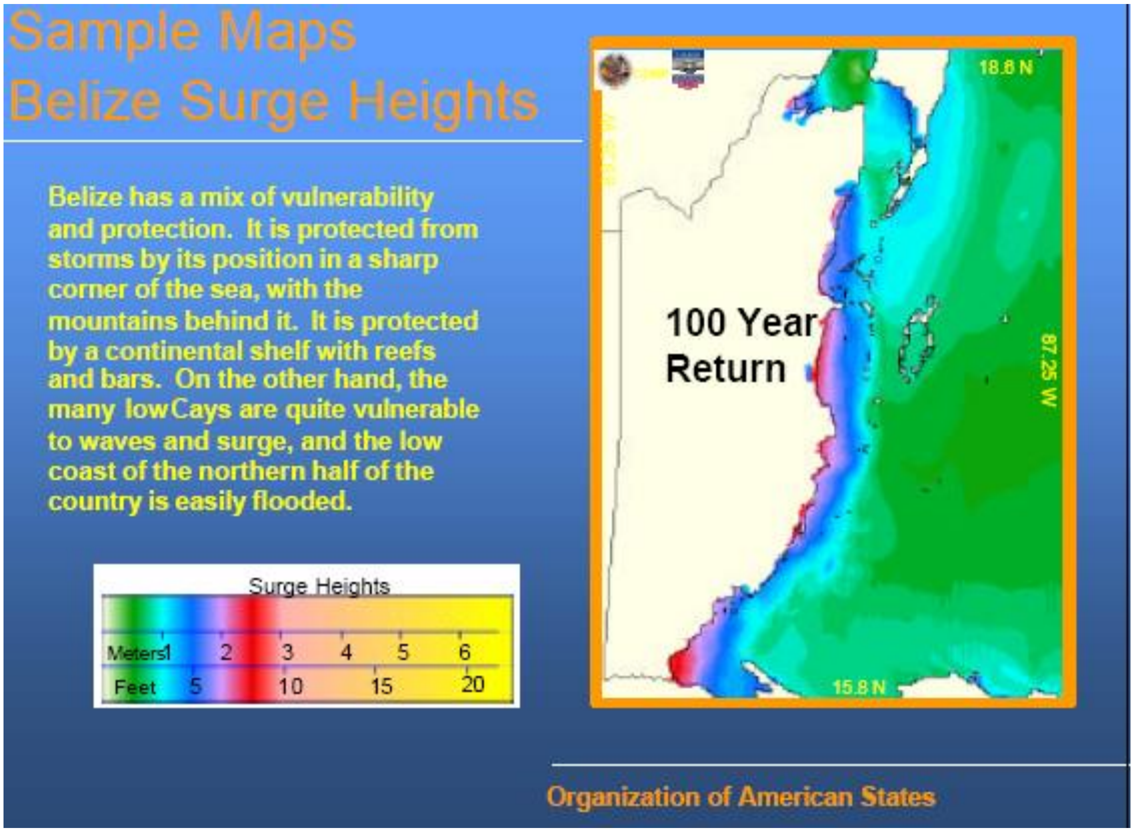

Figure 1. 100 year return period for various surge heights for Belize (*Courtesy Organization of Americam States (OAS)*)

2. <u>Terminology:</u>

- **Storm Surge**:- The increase in water levels resulting from the passage of a tropical cyclone. Usually understood to include pressure setup, wind setup, wave setup, and astronomical tide, although in common usage it can also include wave runup and even wave crest heights.

- **Pressure Setup**:- The increase in water level due to the lower atmospheric pressure in the interior of a tropical cyclone.

- **Wind Setup**:- the increase in water level due to the force of the wind on the water. The wind causes currents in the surface layer of the water. If the water cannot get away from a shallow area as quickly as it arrives, the water level rises.

- **Wave Setup**:- The increase in still water levels resulting from mass transport by breaking waves.

- **Wave Runup**:- The area where the inertia of breaking waves carries water up a beach.

- ❖ **Astronomical Tide:-** Contribution to total surge due to lunar and solar tidal forces. This effect is typically small in the Caribbean.

- ❖ **Wave Height**:- The height of waves from crest to trough.

3. <u>Methodology</u>

Simulations were done with hydrographs placed offshore Riversdale (Latitude 16.6º N, Longitude 88.3° W) and Placencia (Latitude 16.5º N, Longitude 88.36° W).. Each TAOS storm run includes the timing of the storm, and water levels as depicted in the hydrographs. Outputs generated by TAOS include astronomical tide and the non-linear interaction of this astronomical tide with the traditional storm effects such as wind, wave, and pressure setup.

The values are in terms of height above mean sea level (MSL). To use the outputs with any given vertical datum, determine the offset of that datum from mean sea level, and add or subtract that value from the TAOS outputs.

The actual accuracy of the storm surge calculations are dependent on many factors, but as a general guide for a given storm event 90% of computed surges on a shoreline will be within 0.3 meters of observed, and 99% within 0.6 meters of observed.

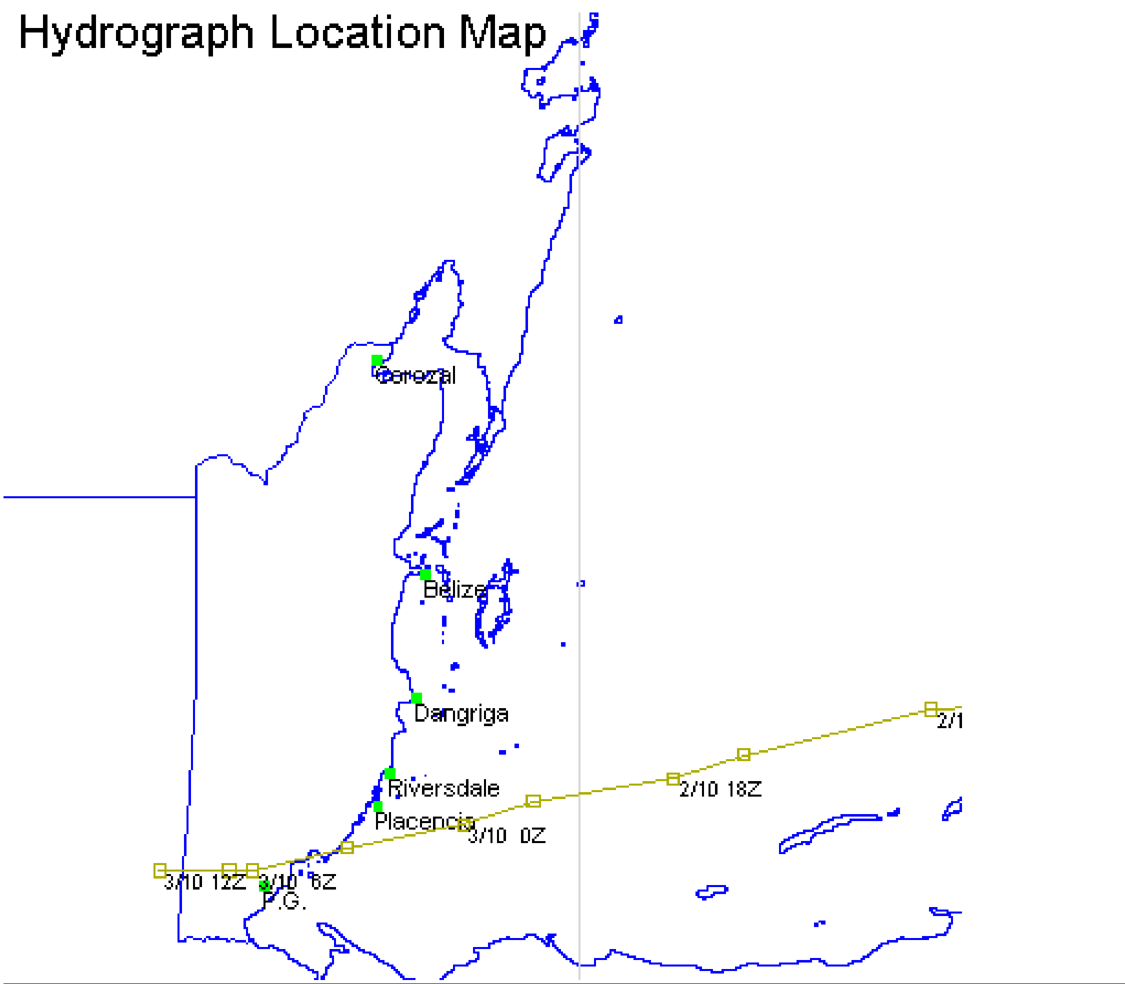

Figure 2. Hydrograph locations and track used in the simulation. (Times and dates were arbitrarily chosen)

Model runs used to compute storm surge and wave heights were done for all the following classifications:

i) tropical depression –sustained wind speeds less than 33 knots or 38 mph
ii) tropical storm – 34-63 kt (39-73 mph)
ii) All categories of hurricanes i.e Category 1- (64-82 kt or 74-95 mph)
Category 2 - (83-95 kt or 96-110 mph)
Category 3- (96-113 kt or 111-130 mph)
Category 4 - (114-135 kt or 131-155 mph)
Category 5 - (>135 kt or >155 mph)

All were set to follow the same track shown in Figure 2 above. With this track the strongest quadrant of the system is made to impact on both Placencia and Riversdale. Winds in the systems at landfall were also made to be near the upper end of each classification range.

4. Results

a. Tropical Depression (TD): A tropical depression was simulated to make landfall with speeds of 33 knots (38 mph).

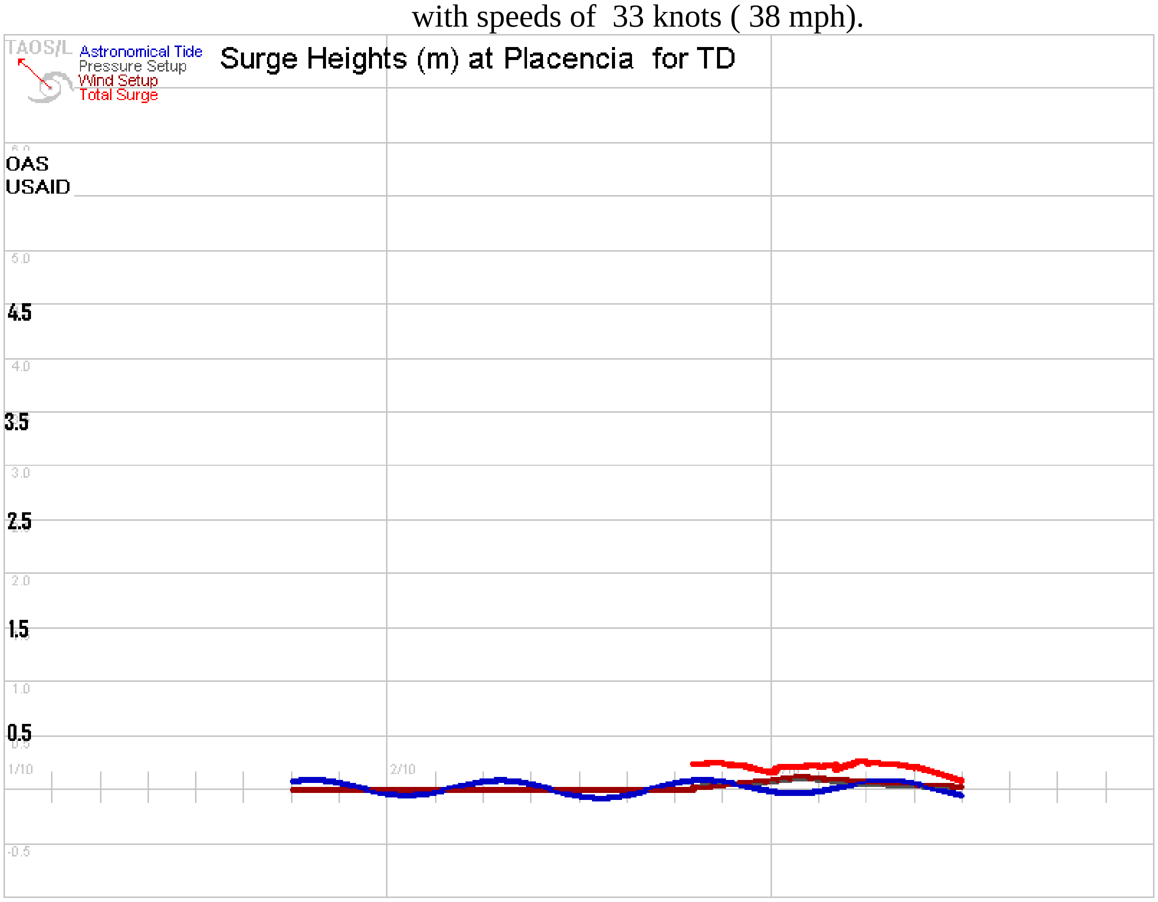

Figure 3. Surge computations for Placencia for a land falling tropical depression (Increments of time on the abscissa are 3 hours and are arbitrary dates and times.)

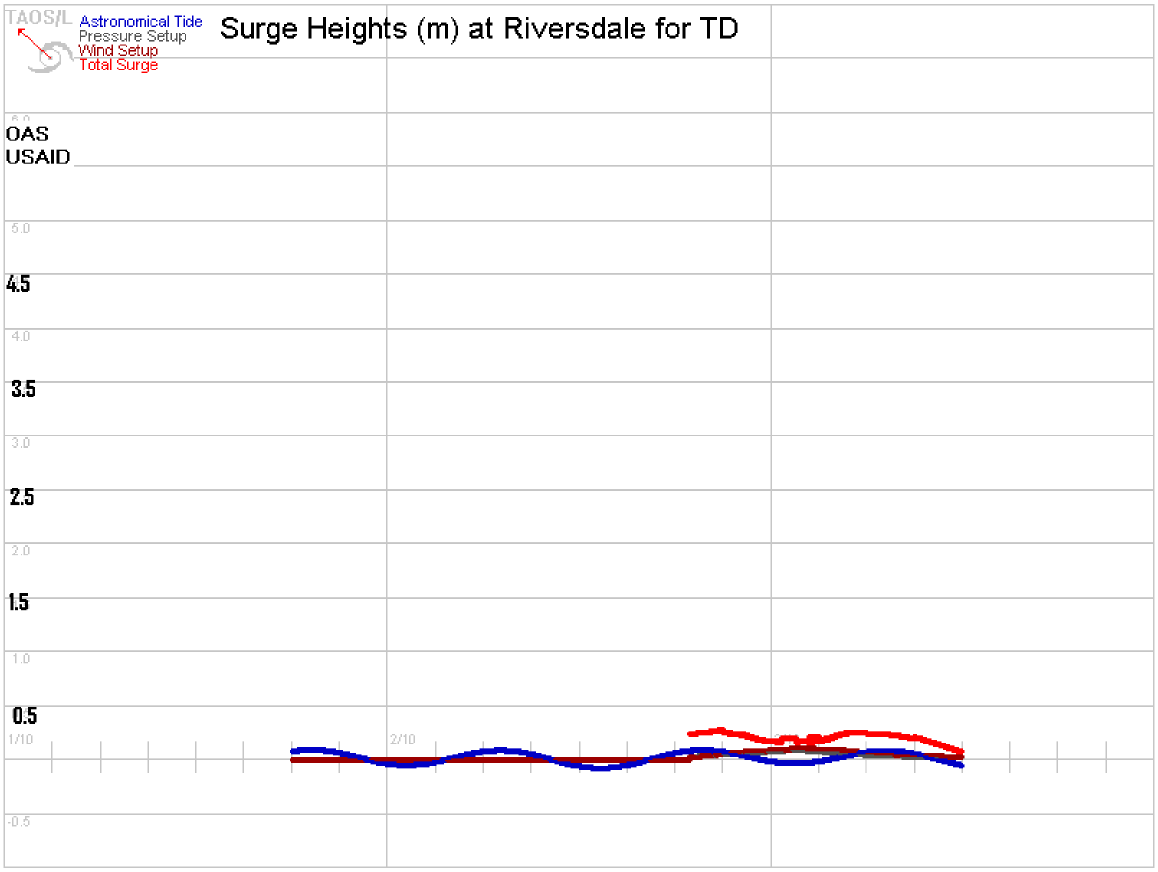

Figure 4. Surge computations for Riversdale for a land falling tropical depression.

As seen in both Figure 2 and 3 the difference in surge at Placencia and Riversdale is almost negligible. The maximum surge associated with a TD is 0.28 m (0.9 ft)

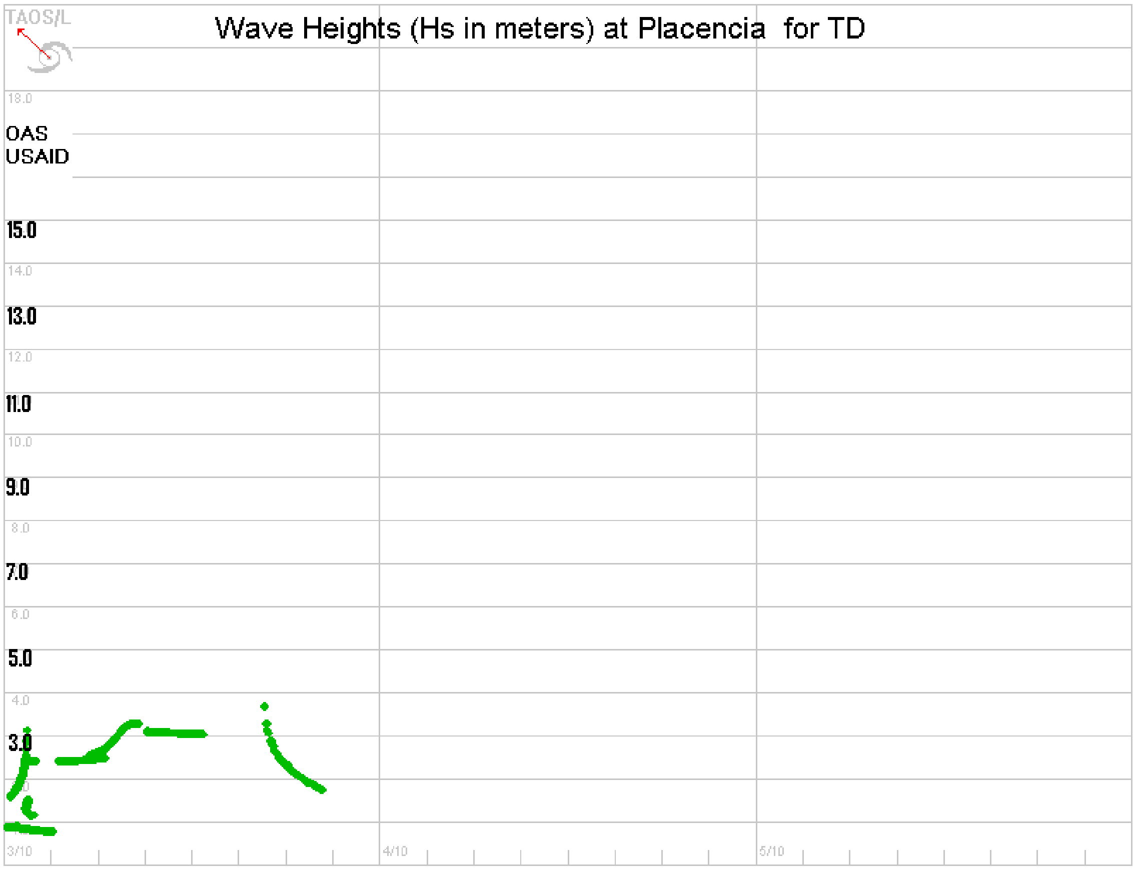

Figure 5. Wave heights (meters) offshore Placencia for a land falling tropical depression.

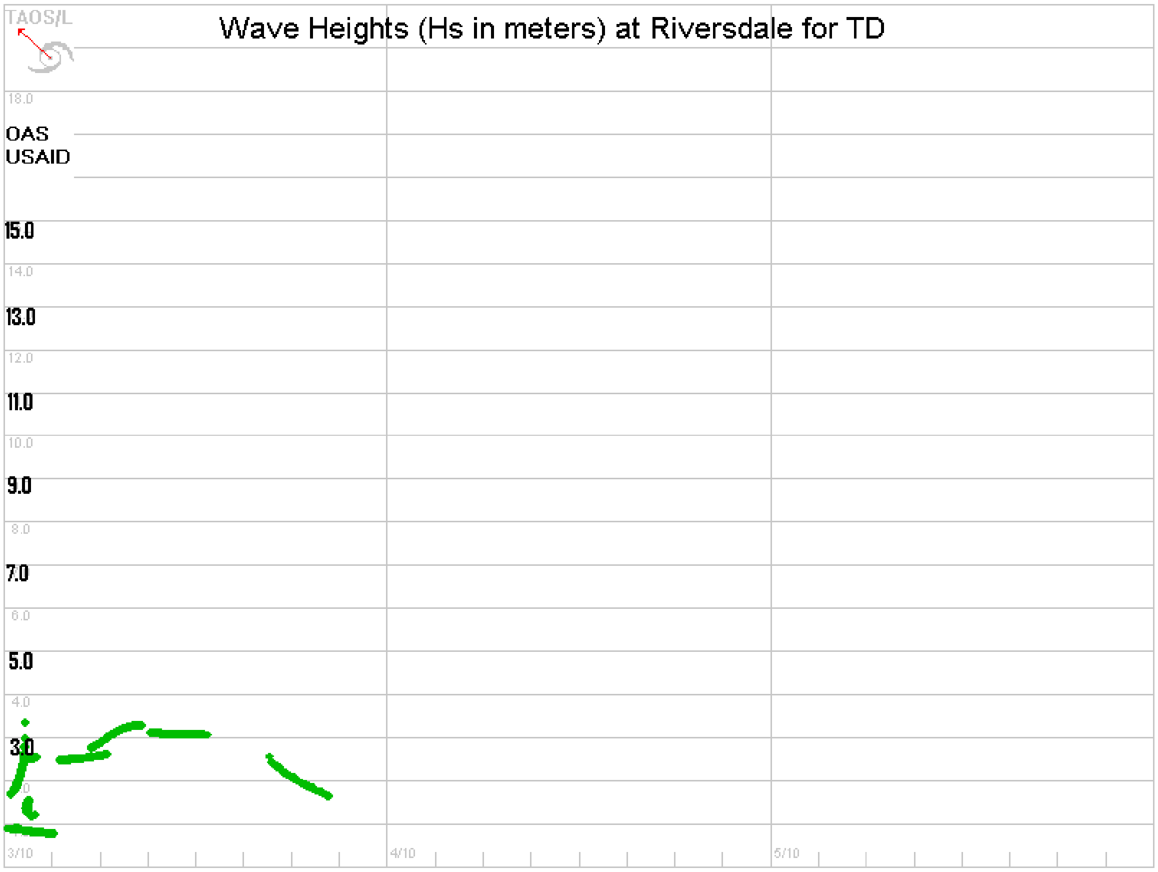

Figure 6. Wave heights (meters) offshore Riversdale for a land falling tropical depression.

Wave height differences between Placencia and Riversdale are not significantly different throughout all the simulations. Hence, only figures depicting wave heights from Riversdale will be subsequently presented in this document.

b. <u>Tropical Storm (TS):</u> In this part of the simulation a tropical storm made landfall with winds of 58 knots (67 mph)

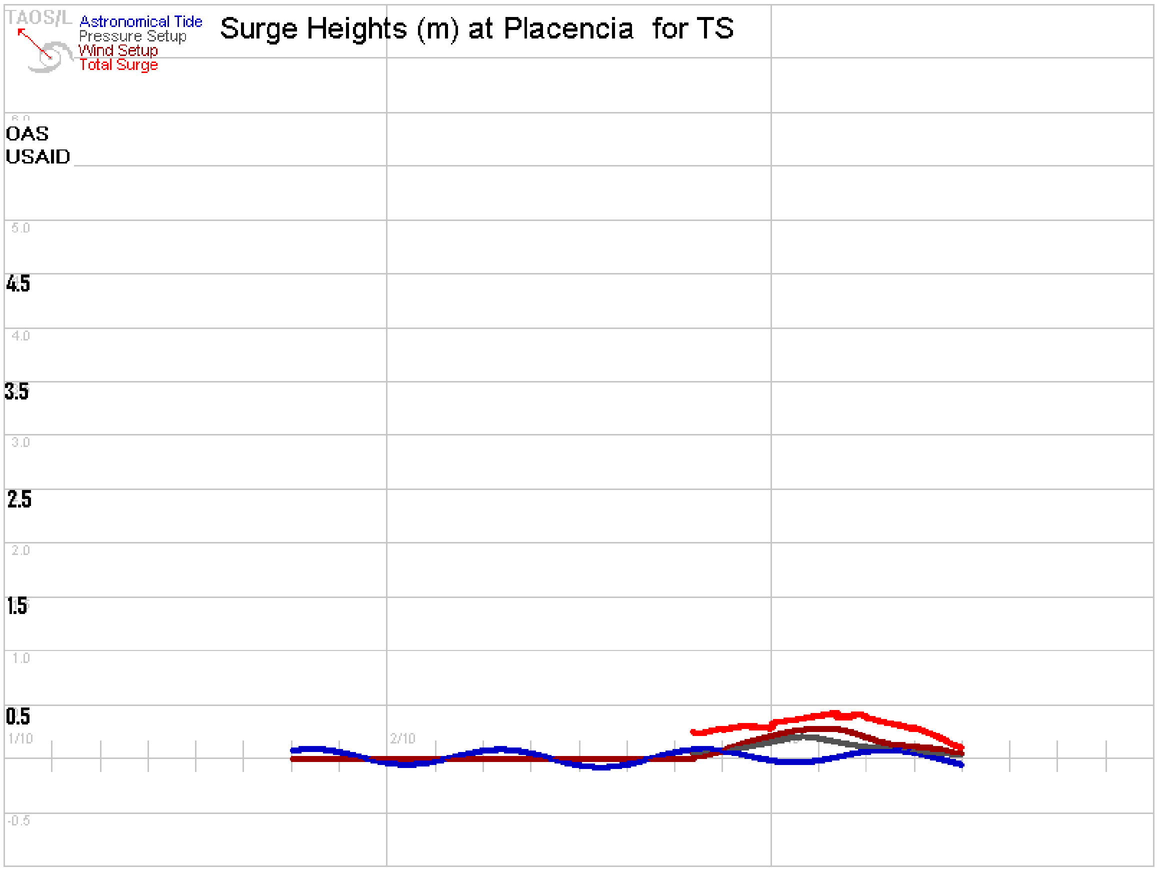

Figure 7. Storm surge at Placencia for a land falling tropical storm

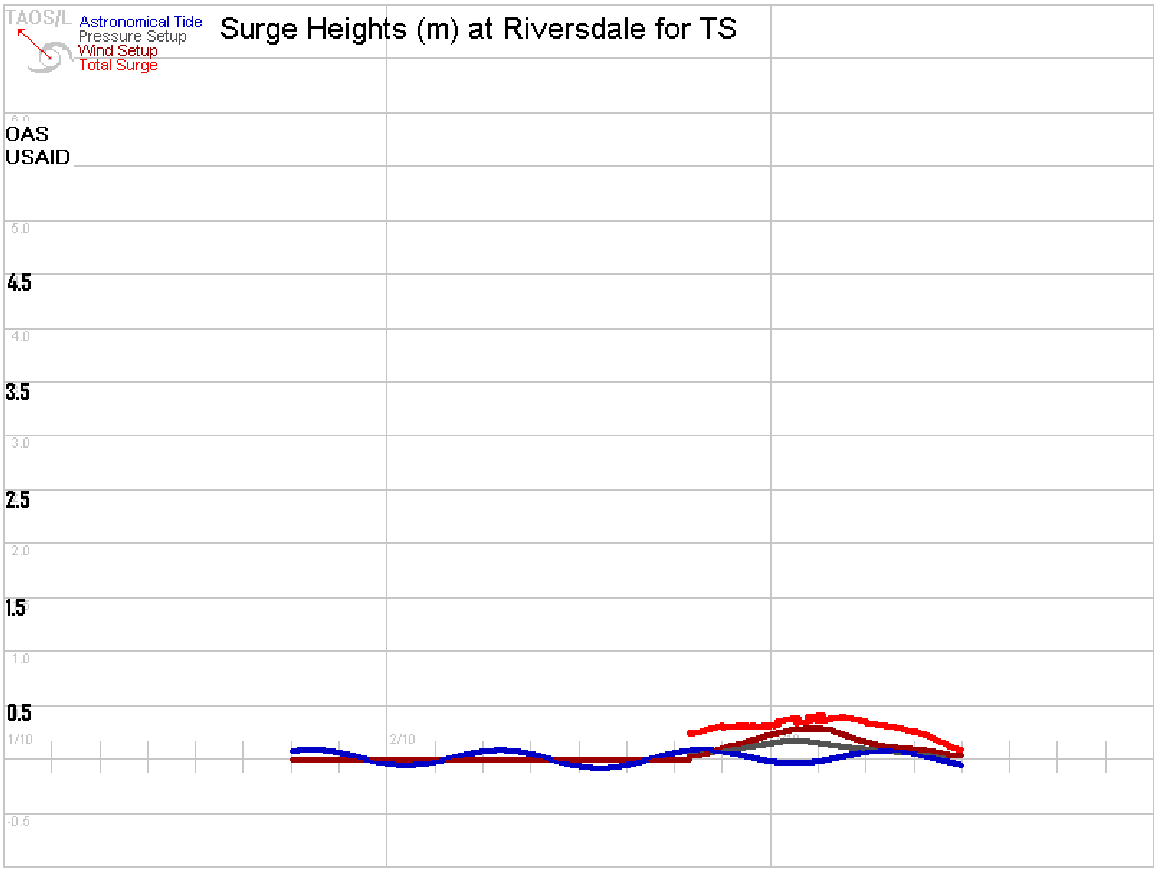

Figure 8. Storm surge at Riversdale for a land falling tropical storm

From Figures 7 and 8 computed storm surge for a TS at both Riversdale and Placencia is approximately 0.4m (1.3 ft)

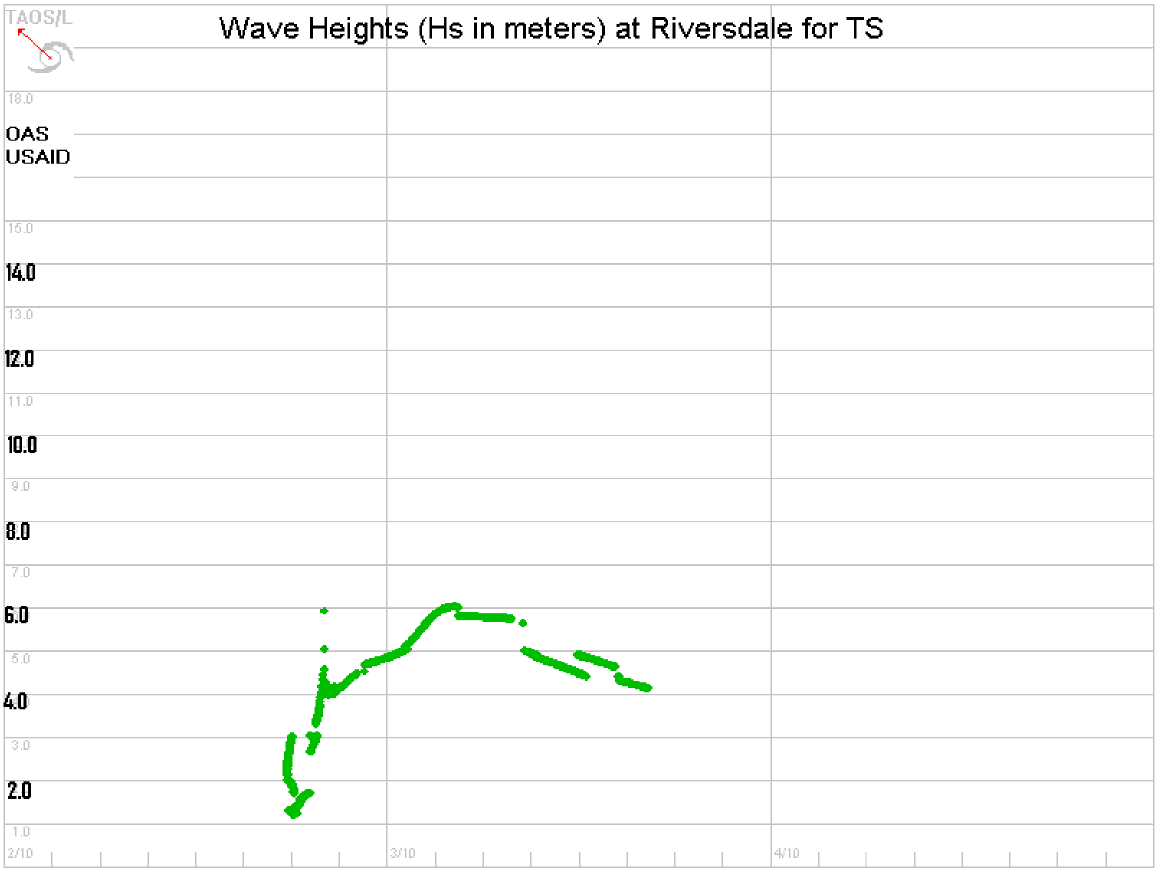

Figure 9. Wave heights offshore Riversdale for a land falling tropical storm.

c. **Hurricanes**

Category 1: This category 1 hurricane made landfall with winds of 80 kt (92 mph)

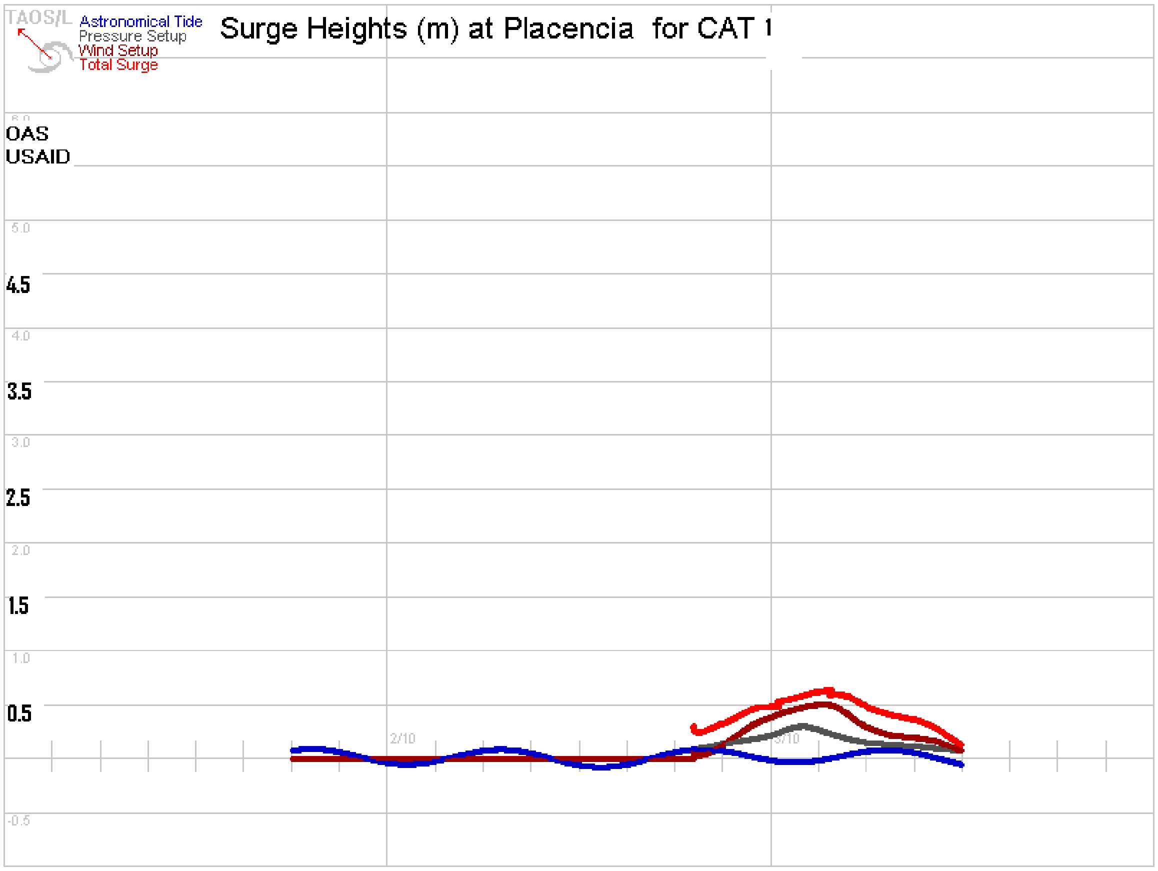

Figure 10. Storm surge (m) at Placencia for a category 1 hurricane.

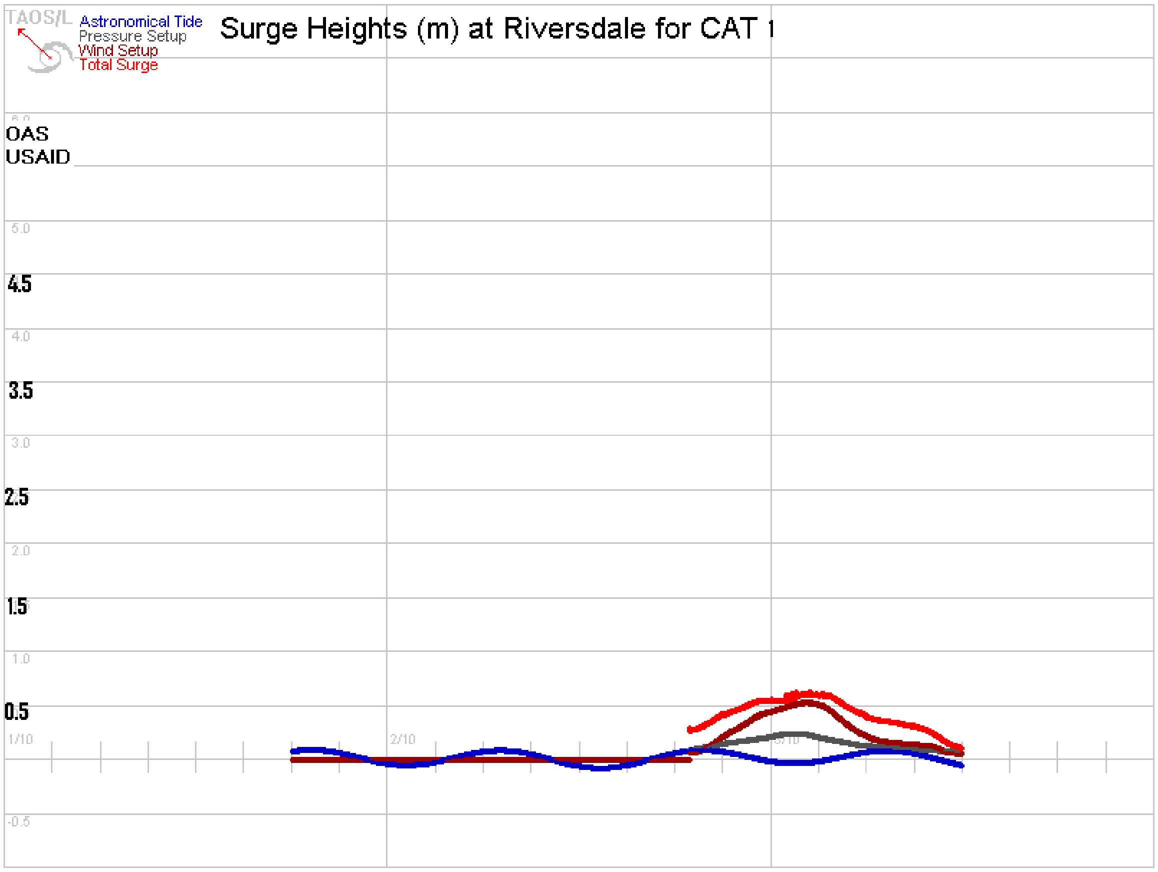

Figure 11. Storm surge at Riversdale for a category 1 hurricane.

From figures 10 and 11 storm surge estimates at Placencia and Riversdale for a Category 1 hurricane is approximately 0.6 m (2 ft)

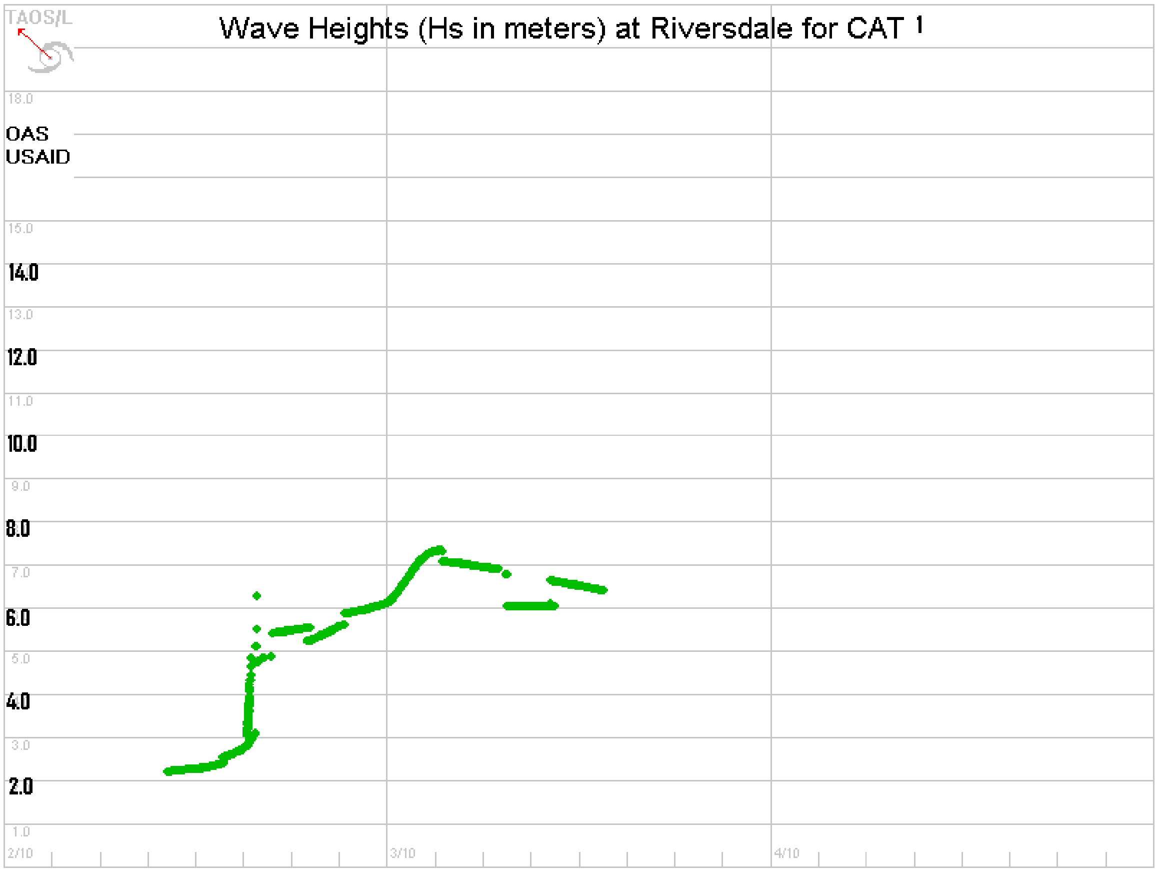

Figure 12. Wave height (m) offshore Riversdale for a category 1 hurricane.

Category 2: A hurricane was simulated to make landfall with wind speeds of 93 kt (107 mph)

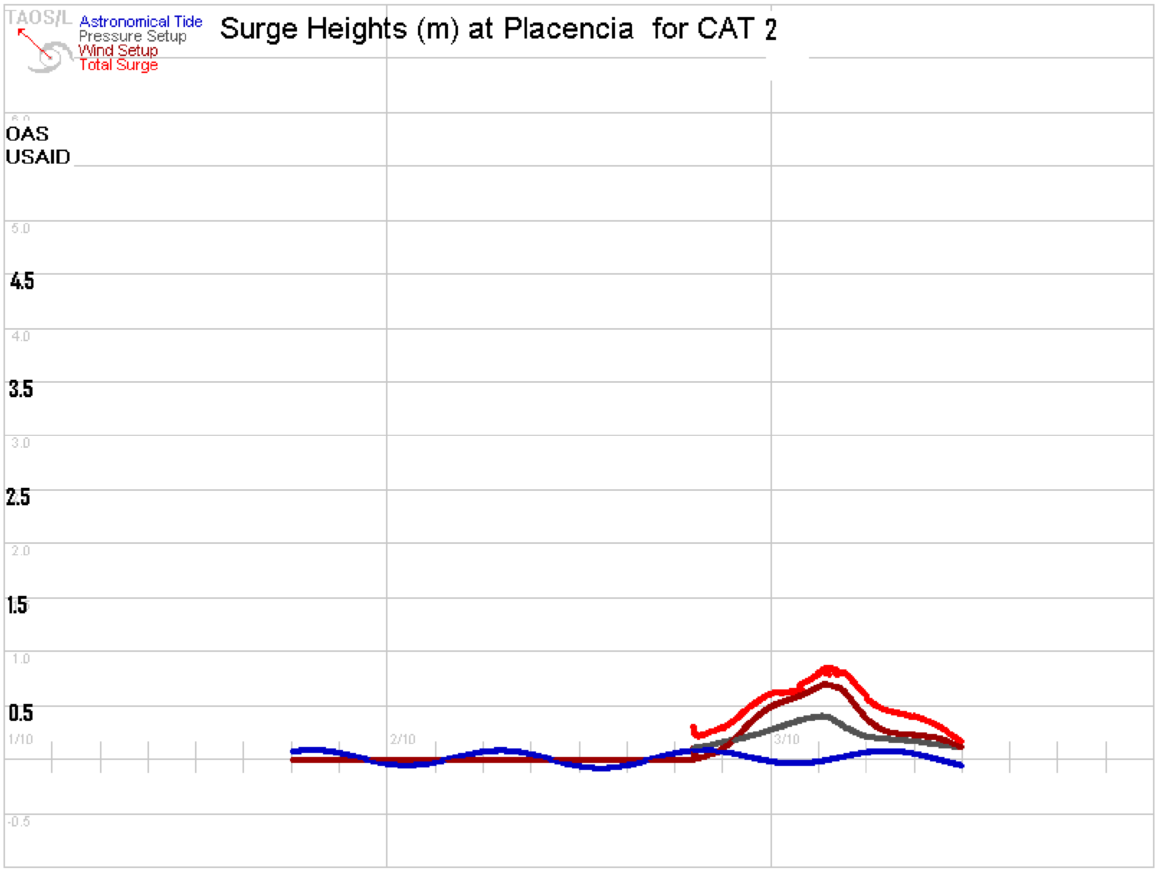

Figure 13. Surge heights (m) at Placencia for a category 2 hurricane.

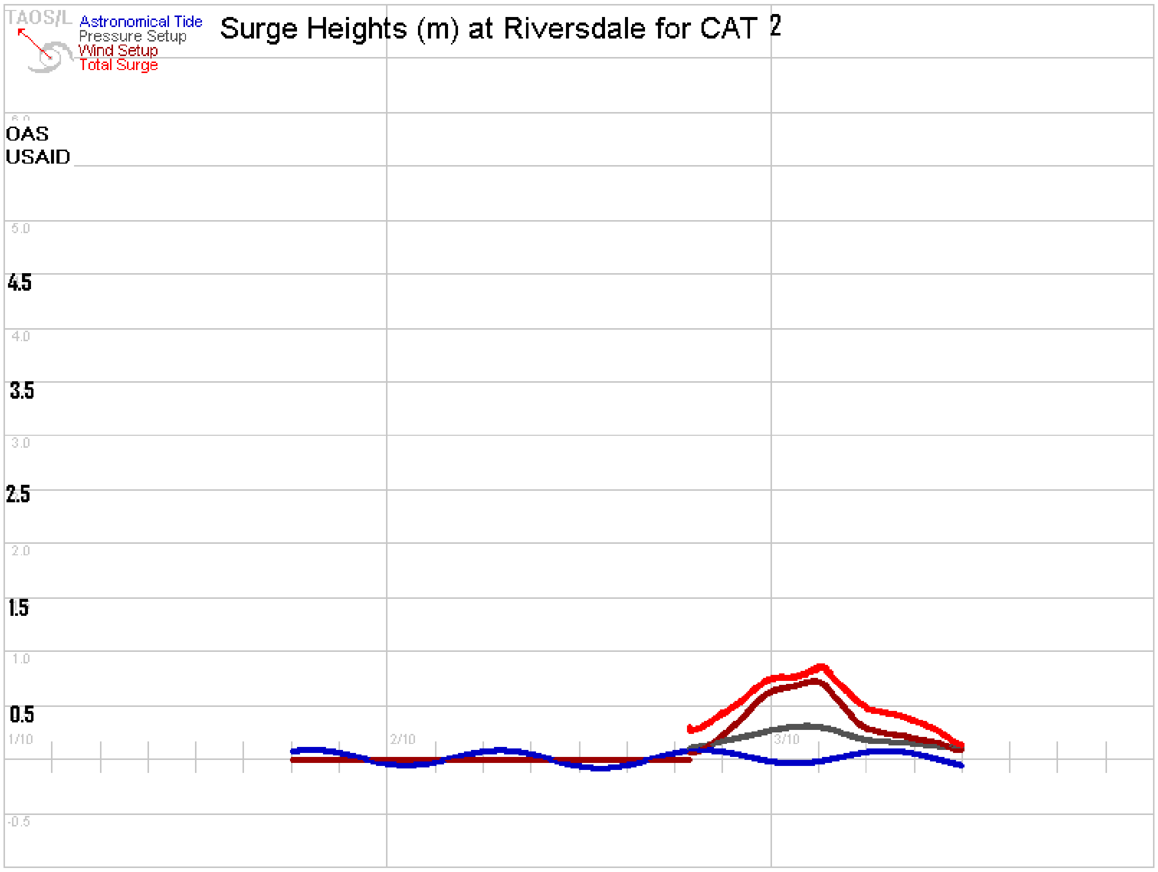

Figure 14. Surge heights (m) at Riversdale for a category 2 hurricane.

From figures 13 and 14 storm surge estimates at Placencia and Riversdale measures 0.8 m (2.6 ft).

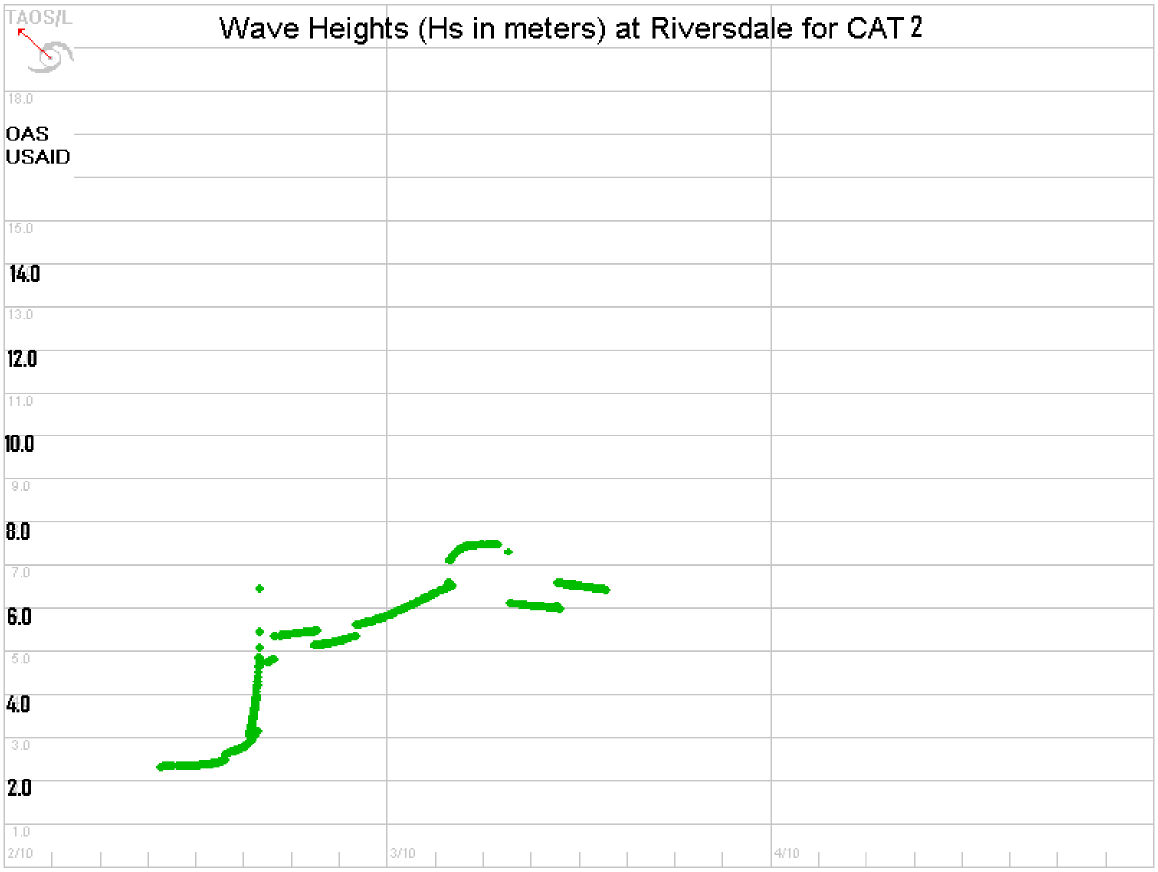

Figure 15. Wave heights (m) offshore Riversdale for a category 2 hurricane.

Category 3: A category 3 hurricane was simulated to make landfall with maximum sustained winds of 110 kt (127 mph)

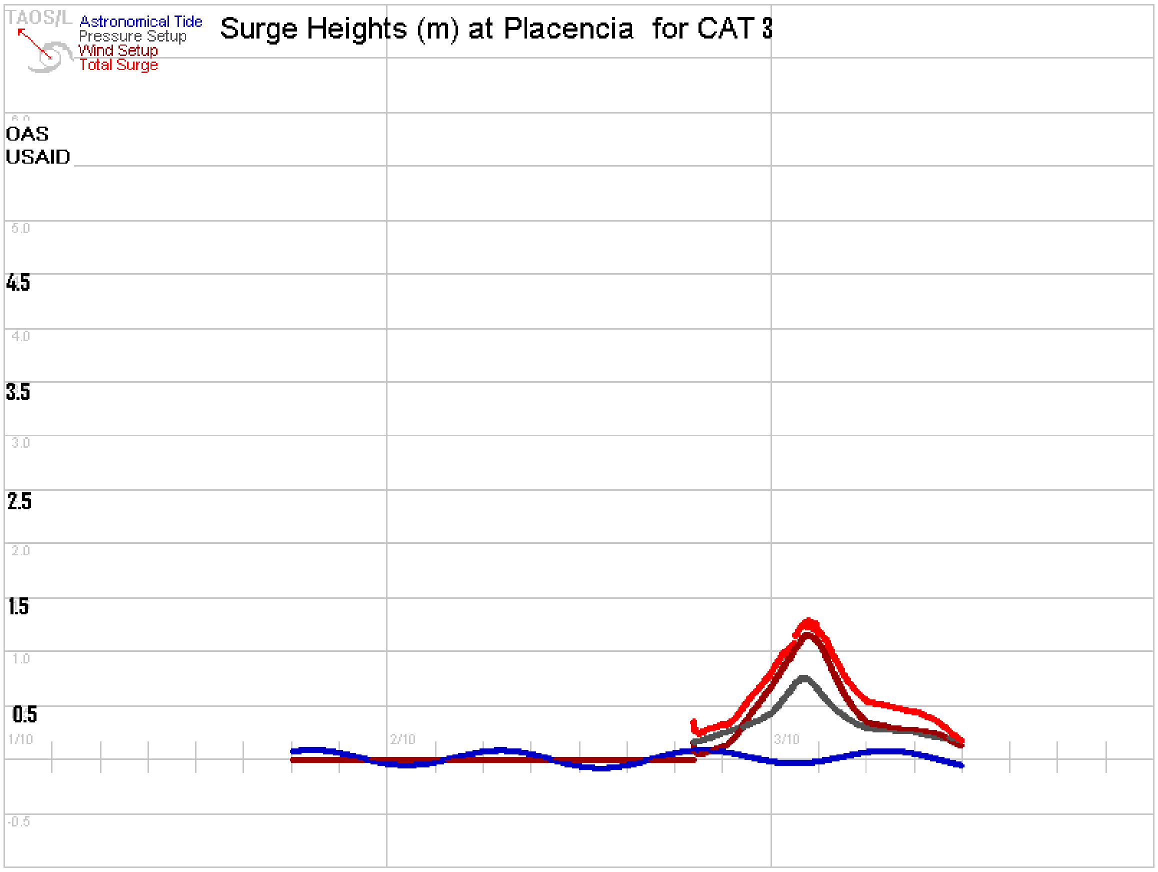

Figure 16. Storm surge heights (m) for a category 3 hurricane at Placencia.

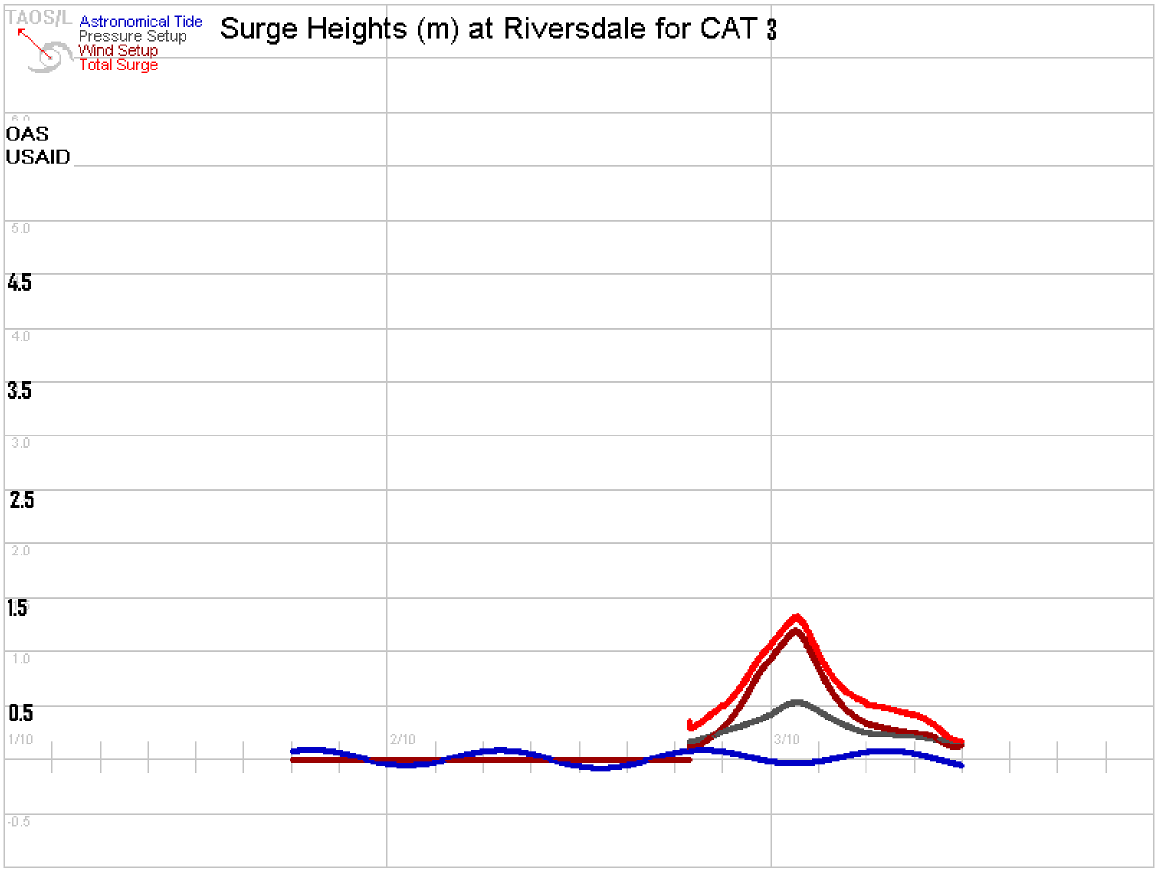

Figure 17. Storm surge (m) for a category 3 hurricane at Riversdale.

From the hydrographs in figures 16 and 17 the estimated surge heights for a category 3 hurricane at Placencia and Riversdale is 1.3 m (4.3 ft)

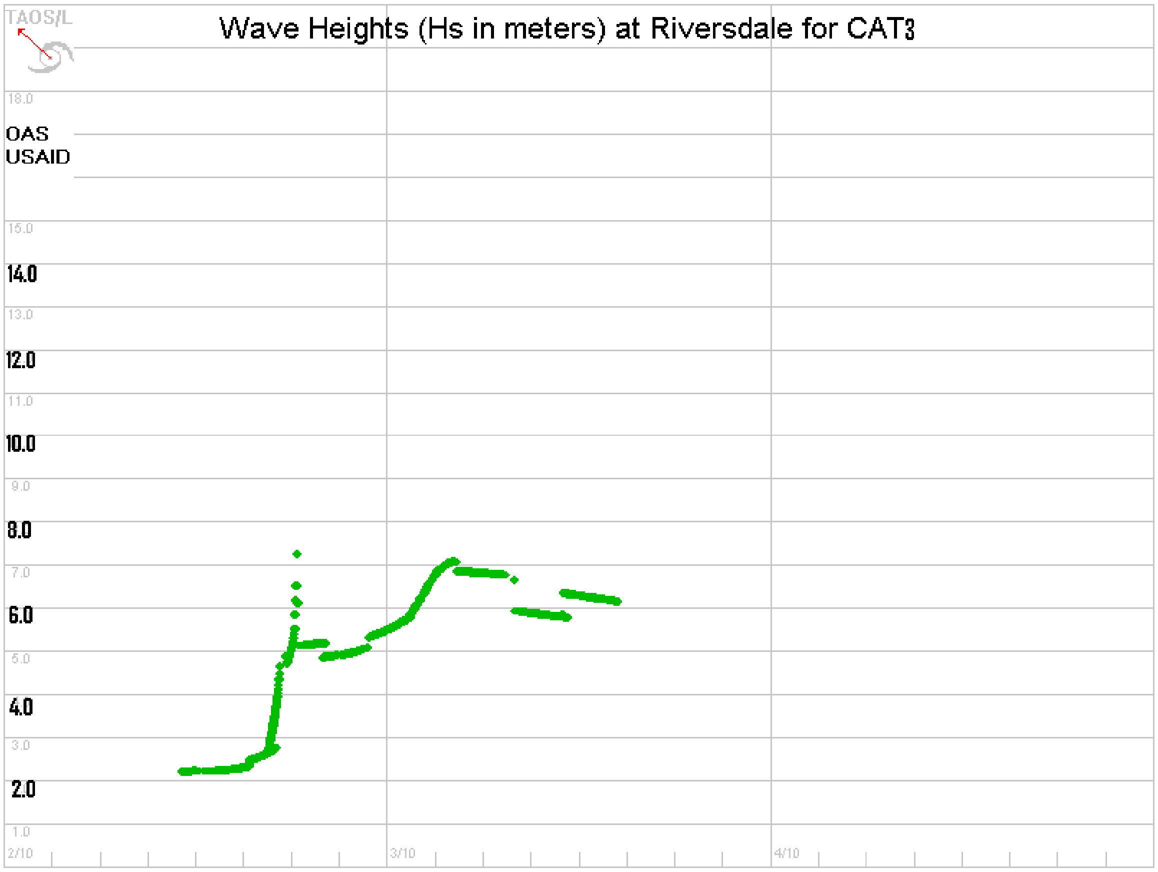

Figure 18. Wave heights (m) offshore Riversdale for a category 3 hurricane.

Category 4: This sequence involves a category 4 hurricane making landfall with speeds of 130 kt (150 mph)

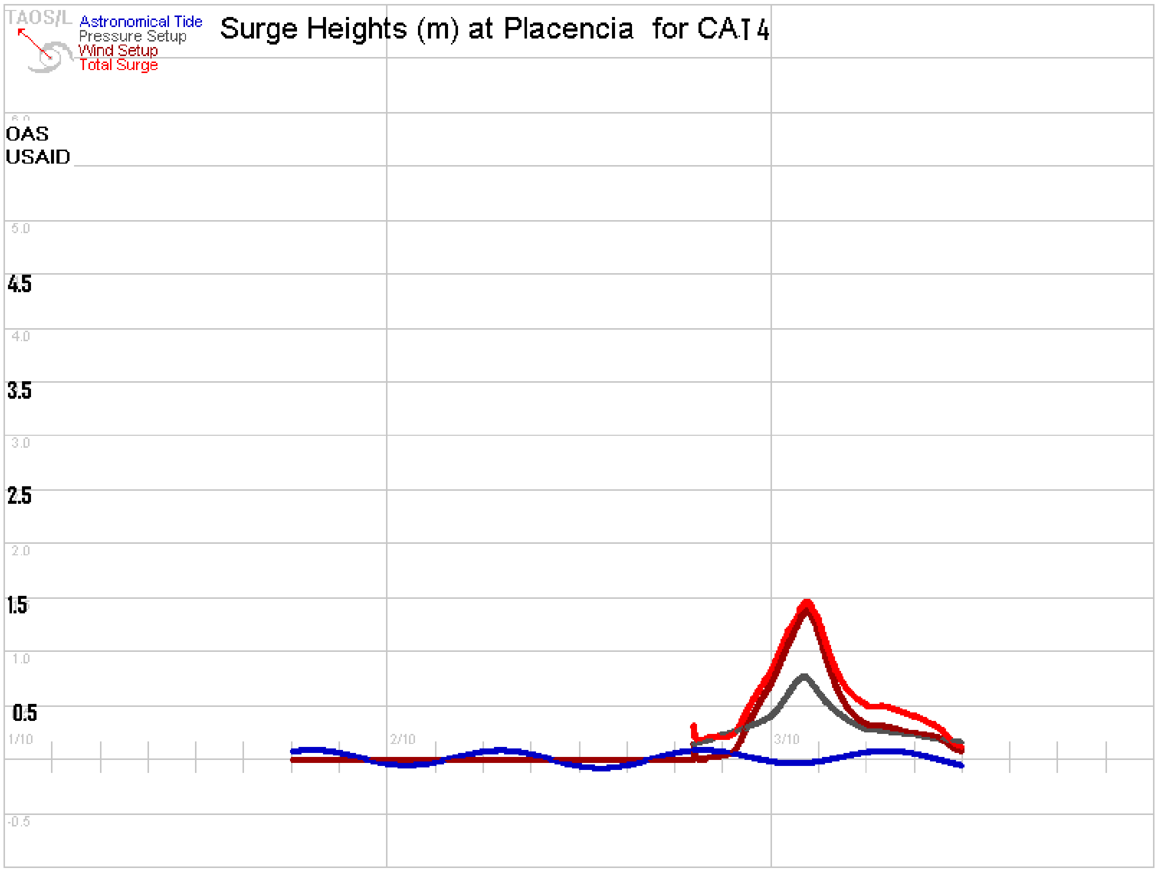

Figure 19. Storm surge (m) at Placencia for a category 4 hurricane.

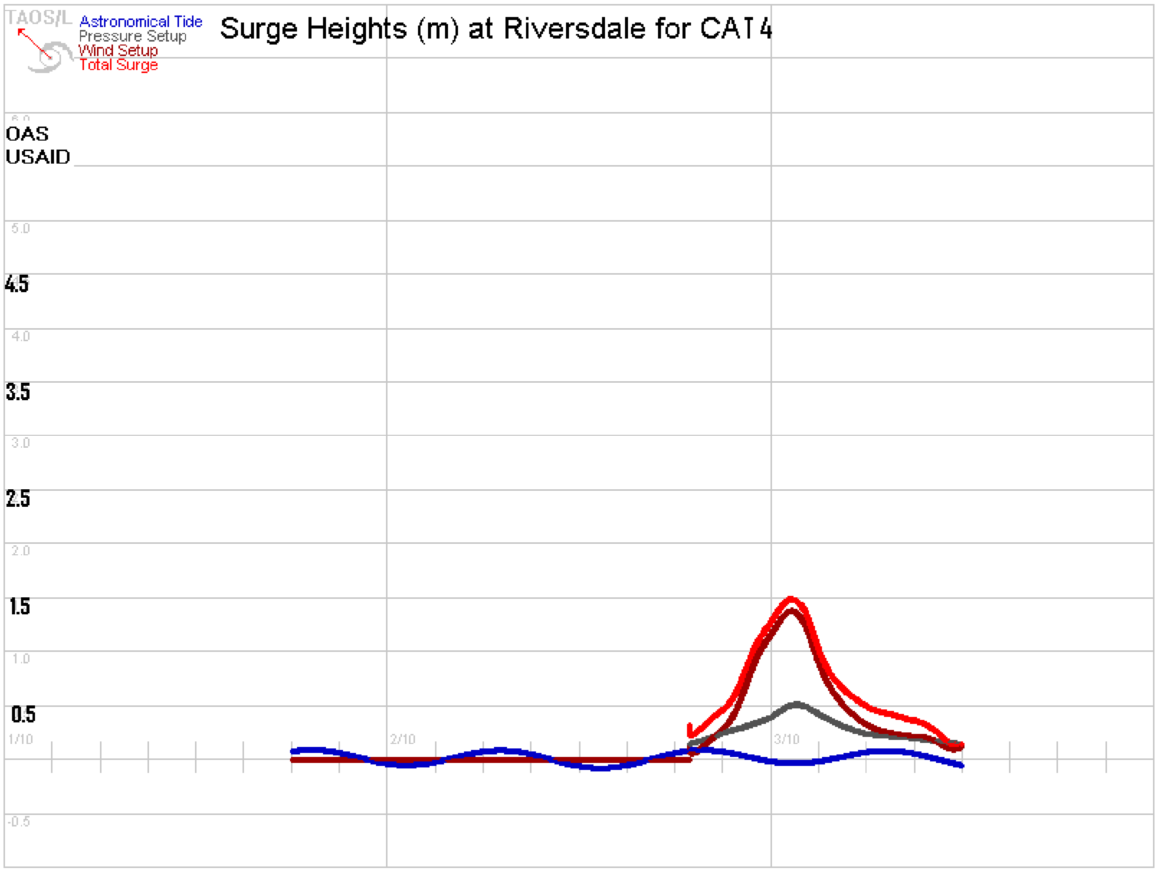

Figure 20. Storm surge (m) at Riversdale for a category 4 hurricane.

Average storm surge value for a category 4 hurricane for the Placencia/Riversdale area is 1.5 m (4.9 ft)

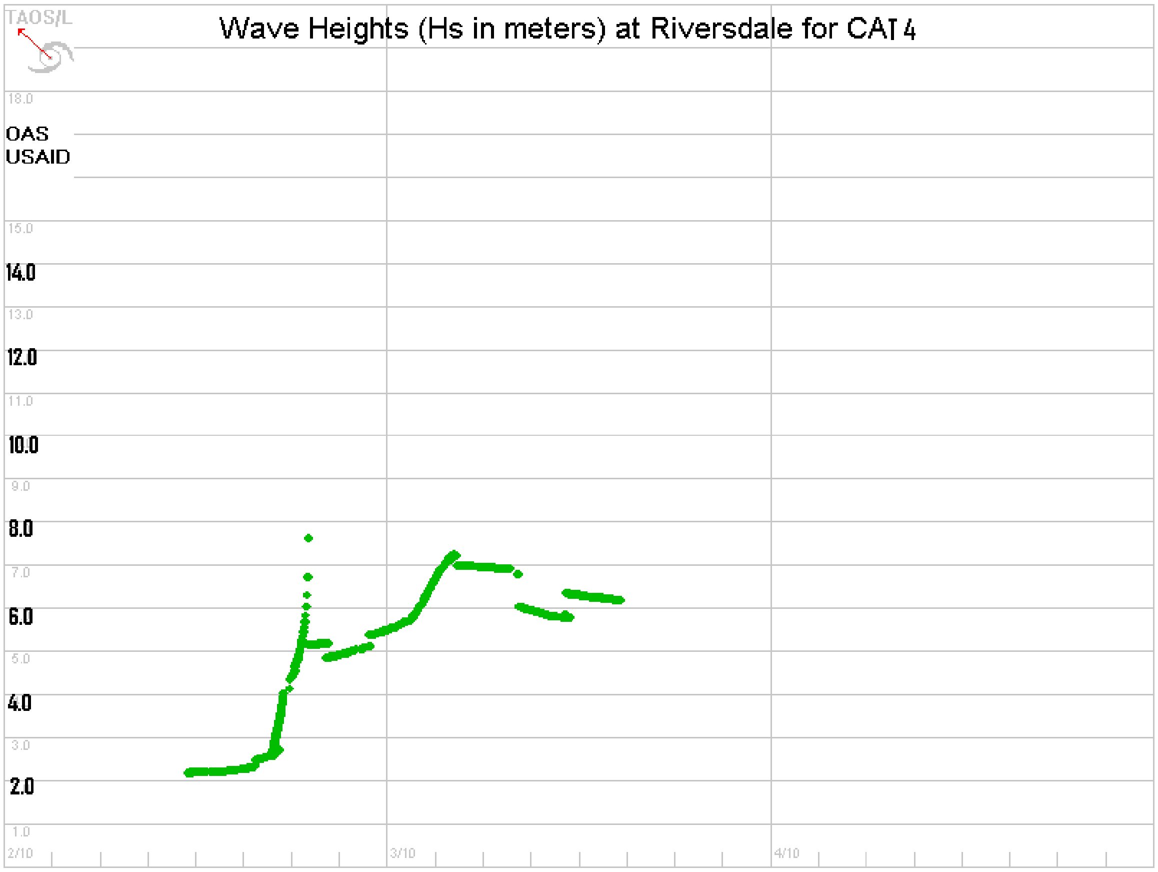

Figure 21. Wave heights (m) for offshore Riversdale.

Category 5: A category 5 hurricane was simulated to make landfall with maximum sustained winds of 150 kt (173 mph)

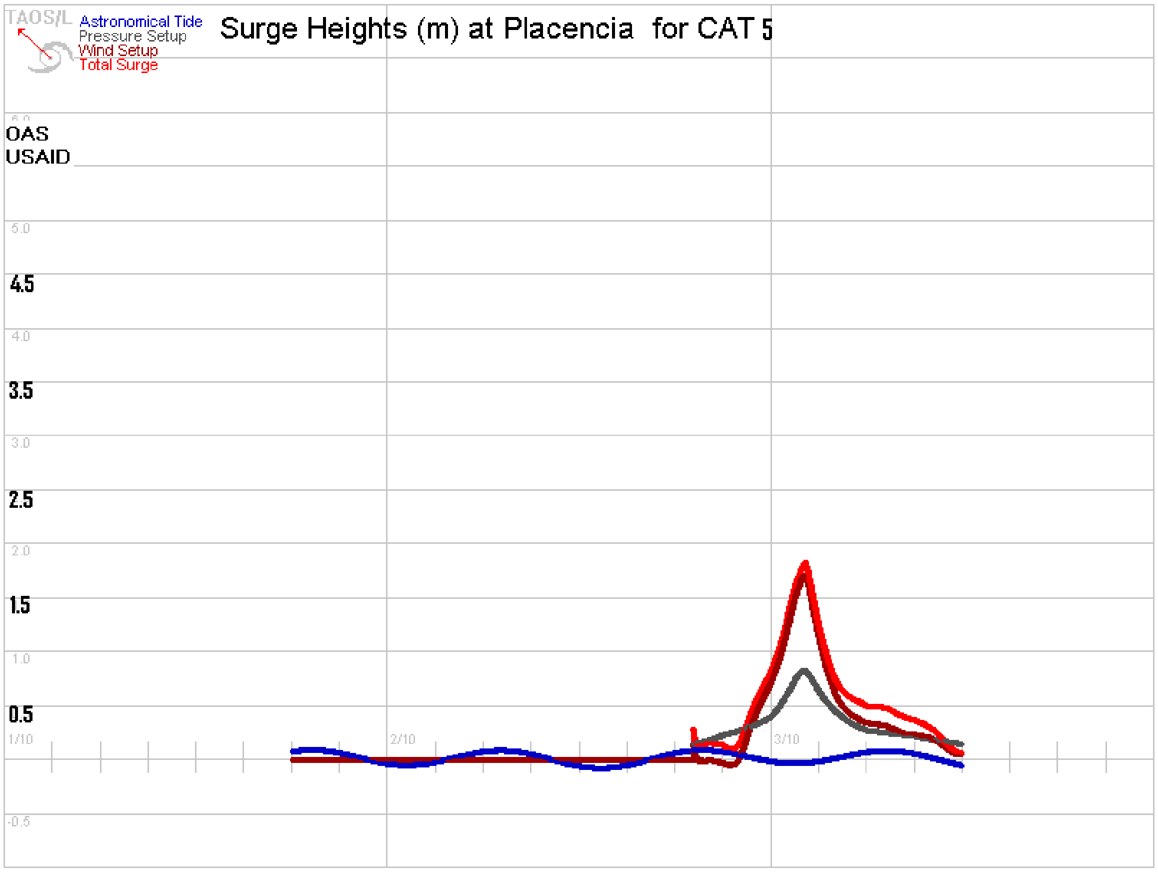

Figure 22. Storm surge (m) at Placencia for a category 5 hurricane

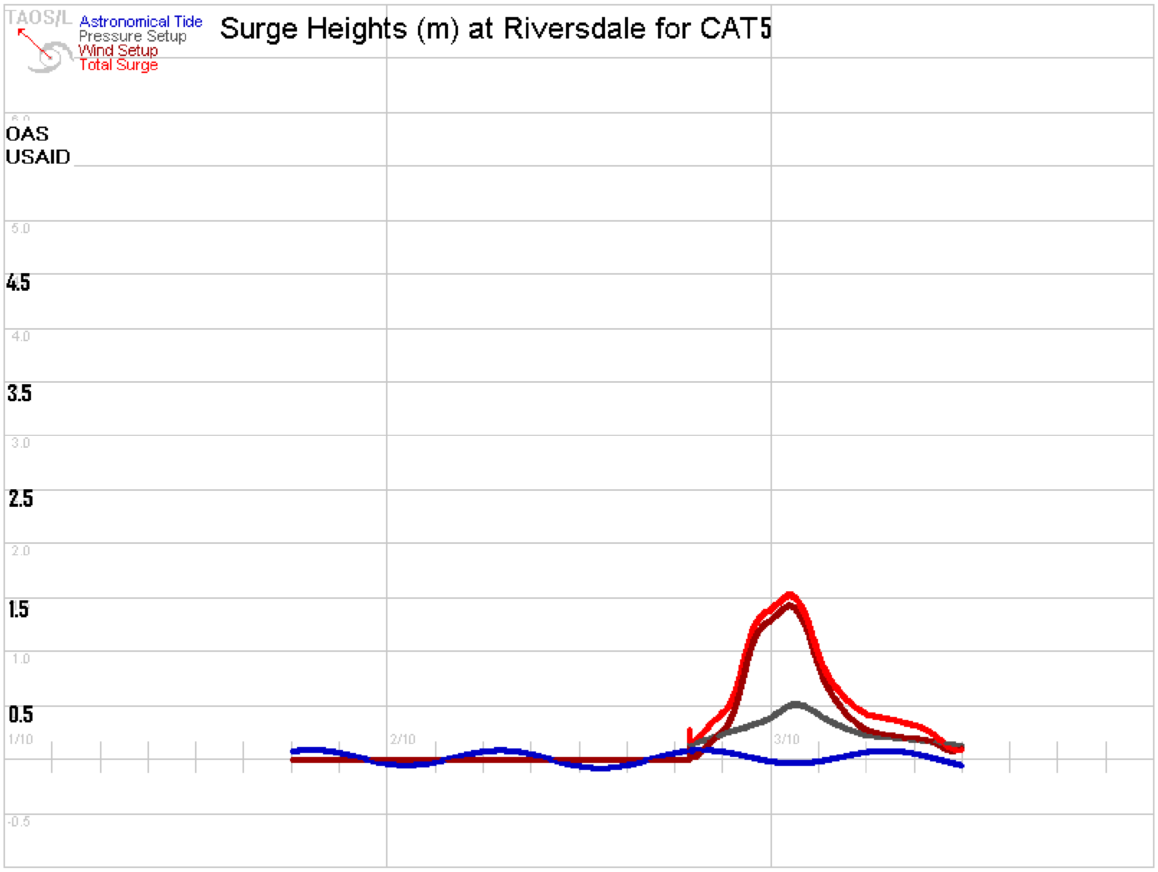

Figure 23. Storm surge values (m) art Riversdale for a category 5 hurricane.

The average storm surge values for Placencia and Riversdale range from 1.7 m (5.6 ft) and 1.5 m (4.9 ft) respectively.

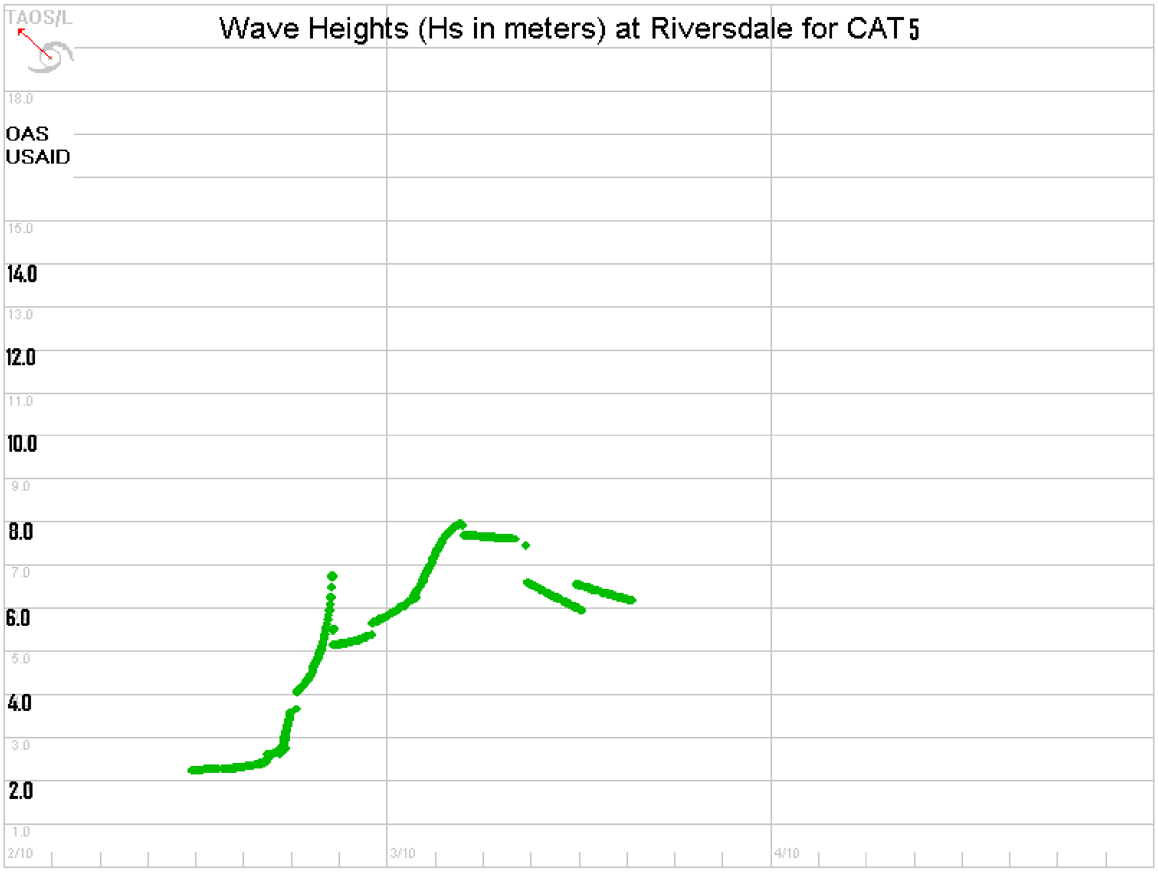

Figure 24. Wave heights (m) offshore Riversdale for a category 5 hurricane

Pointers:

1) Storm surge estimates in this document must be added/subtracted from surface contour datum to yield actual overland surge.
2) The slopes of the recession limbs in the hydrographs are gentler possibly due to the retention or storage capabilities of the Placencia lagoon.
3) Linearity between storm surge values for the different classifications should not be assumed.

END