

## CASE STUDY: Tropical Cyclone Althea, 1971

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*Althea* crossed the coast just north of Townsville with a 106 knot gust being reported at the Townsville Met Office. There were three deaths in Townsville and damage costs in the Townsville region reached 50 million 1971 dollars. Many houses were damaged or destroyed (including 200 Housing Commission homes) by the winds. On Magnetic Island 90% of the houses were damaged or destroyed. Two tornadoes damaged trees and houses at Bowen. There was a major flood in the Burdekin but coastal floods were short lived. A 2.9 m storm surge was recorded in Townsville Harbour; however the maximum storm surge of 3.66m was to the north at Toolakea. This storm surge occurred at low tide; however the surge and large waves caused extensive damage along the Strand and at Cape Pallarenda.

Archived Plan Position Indicator (PPI) radar reflectivity photographs showing rain areas associated with tropical cyclone *Althea* while it approached the coast have been hand traced, as the originals cannot be reproduced clearly. A series of three of these PPI Displays are presented in Figure 1 covering the period from 2108 UTC 23 December 1971 to 2302 UTC 23 December 1971. These showed a circular band of precipitation lying through Townsville before landfall. This feature at the time was considered to be the eyewall of the cyclone and that the anemometer at Townsville Airport recorded the maximum winds associated with *Althea*. At 2209 UTC 23 December 1971 (Figure 1) the centre of *Althea* was near its closest approach to the Townsville Airport Meteorological Office. Around this time the anemometer there recorded the strongest winds (Figure 2) and the lowest mean sea level pressure of 971.5 hPa was registered. This was the lowest pressure observed near *Althea* as no barometer readings were taken in the eye. The peak wind gust was 106knots ( $53 \text{ ms}^{-1}$ ) from the east-southeast and the maximum wind speed averaged over 10 minutes was 75knots ( $37 \text{ ms}^{-1}$ ) see (the anemograph in Figure 2). Note the extreme turbulence from the fluctuations in wind direction during the period of maximum winds. East-southeast winds at Townsville Airport flow over the top of Castle Hill (300m) placing the anemometer (Figure 3) in a high frictional zone for winds in this direction. Therefore the anemometer likely recorded a wind significantly less than would be recorded over the ocean in the same part of the storm.

The database currently has *Althea* with a central pressure of 952 hPa at landfall, which for such medium sized cyclones, corresponds to a high end category 3 storm. In determining this central pressure, the radius of maximum wind ( $R_m$ ) was assumed to be 32 km. When the airport registered the lowest mean sea level pressure of 971.5 hPa the centre of the cyclone was 32 km away. The central pressure ( $P_c$ ) was then calculated from the formulae:  $-(971.5 - P_c) / (\text{environment pressure} - P_c) = \exp(-R_m/32)$ . For an environmental pressure of 1010 hPa, this resulted in a central pressure of 952hPa.

From aircraft observations of Atlantic hurricanes Willoughby (1990) described the concentric eye cycle of Hurricane *Diana*. Examining the PPI patterns of *Althea* reveal a similar cycle to

which *Diana* underwent. From Figure 1 the inner eye of *Althea* kept its identity as it passed Townsville and was still visible though clearly dissipating when it was overland near Rollingstone (lower panel Figure 1). Over the two-hour period covered by Figure 1 the outer radar ring can be seen to have contracted from a diameter of 55 km to 39 km. At landfall the outer convective ring of *Althea* was probably at the point of supplanting the inner eye cloud ring. Toolakea lay under this contracting outer cloud ring and was most likely near the region of maximum winds. Toolakea is where a beach survey team found evidence of the highest storm surge as *Althea* came ashore Hopley (1972, 1974). From this evidence we believe the anemometer at Townsville Aerodrome never experienced the maximum winds associated with *Althea* and the 10-minute average wind over the ocean probably exceeded 45 m/s in the maximum wind zone. This would make *Althea* a category 4 cyclone under the Australian classification.

Additionally the James Cook University Field examination (Bureau of Meteorology 1975) determined the maximum wind gust in the Townsville region was 116 knots at Picnic Bay on Magnetic Island. From Figure 4 the intense inner eye was located well to the northwest of Magnetic Island and the Island was under the outer eyewall, which subsequently shrunk and became the main eyewall. This meant that this outer eye wall would most certainly have had stronger winds associated with it later as it shrunk. From Figures 1 and 4 the maximum winds at Townsville occurred outside of this eyewall region when it became the maximum wind zone. Also as noted earlier, the erratic direction of the winds there during the strongest winds when the anemometer was downwind of the nearby Castle Hill helping reduce the anemometer wind speeds.

The mean sea level analyses (Figure 5) of *Althea* approaching landfall show that it was a medium sized storm with gales extending well to the south on its southern side where it was interacting with the sub-tropical ridge. The Townsville area suffered massive coastal wave damage and in Figure 6 we show a mean sea level analysis in the relative open water inside the section of the Great Barrier Reef east of Townsville. Obviously there is enough open water for some ocean wave energy to enter this area as well as enough open water to produce a fetch long enough to add to this energy. Figure 6 shows storm surge survey heights (Hopley 1972, 1974) and the location of Toolakea where the peak surge was located in a site removed from wave effects. Note how the debris levels in Townsville just outside the harbour were much higher than the tide gauge heights in the harbour illustrating how waves add to the water levels. The waves from *Althea* caused massive coastal erosion in the Townsville area (Figure 7). Note that the very severe erosion (Hopley 1974) extended up to Toolakea where the maximum onshore winds occurred. Note also the very severe erosion caused by southwest winds in the Palm Island Group. This coastal zone is termed a low energy coastline because it is very rarely exposed to any wave energy and consequently when it is exposed to waves it is extremely vulnerable to erosion. This was also where the maximum southwest winds would be expected from our analysis above.

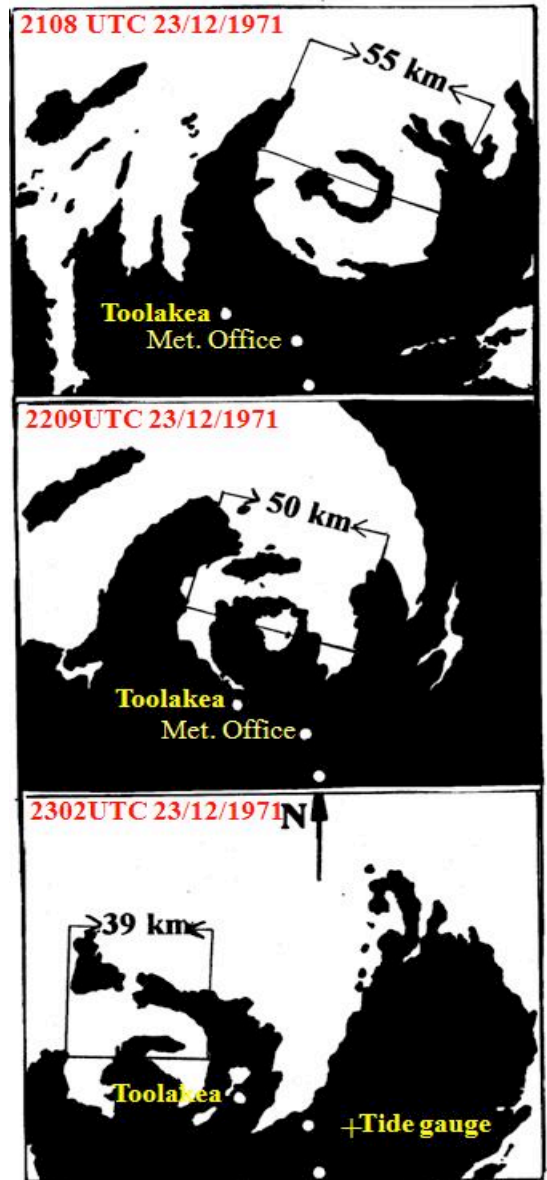
The data from the Townsville tide gauge (Figure 8) shows a storm surge of 2.9 metres at that location just after low tide. Obviously with the huge impact the storm surge and waves had at Townsville if *Althea* had arrived near high tide a potential disaster would have occurred with possibly many lives lost.

### **Satellite observations**

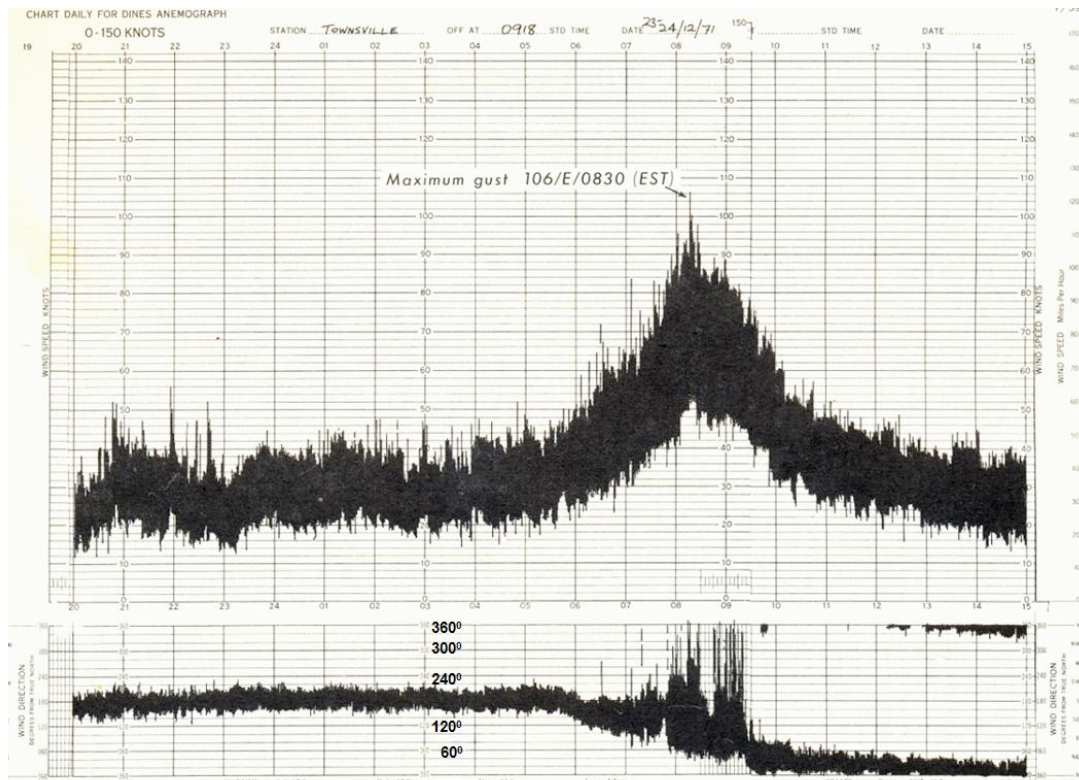
From Bureau of Meteorology 1975, the first hint of an eye came from the satellite observation at 2307UTC 21 December 1971. The next available imagery was at 2358UTC 22

December 1971, which is around the time of the MSL analyses in the left panel of Figure 5. By then it had a ragged eye and the analysis at the time suggested a maximum 10 minute mean wind of 80 knots. The next available image was at landfall though the storm was at the edge of the photograph. Comments at the time indicated that although a clear eye was evident, the photograph did not do the cyclone justice. This appears to indicate that *Althea* was intensifying all the way up to landfall and the concentric eye wall cycle it was undergoing at landfall appears to support this. These cycles are thought to be associated with only the most severe cyclones.

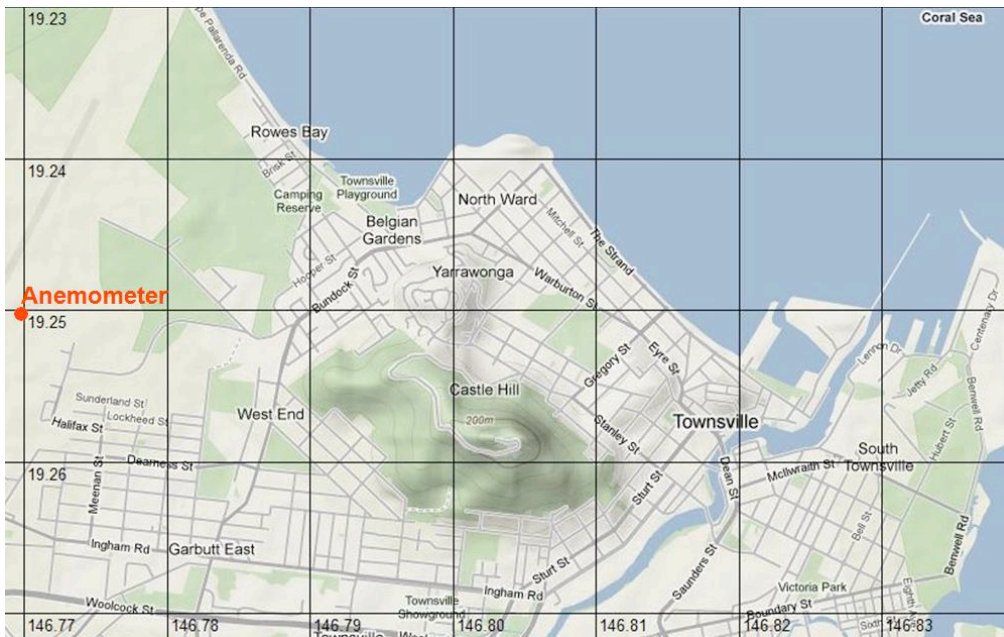
**Figure 1** Rain echo distributions of tropical cyclone *Althea* (dark region) at 2108 UTC 23 December 1971 (top ), 2209 UTC 23 December 1971 (centre) and 2302 UTC 23 December 1971 (lower panel). The small open circles at the bottom of each panel mark the location of Toolakea (left), Townsville Meteorological Office (centre) and the radar (lower right). The location of the Townsville Harbour tide gauge is marked in the bottom panel.



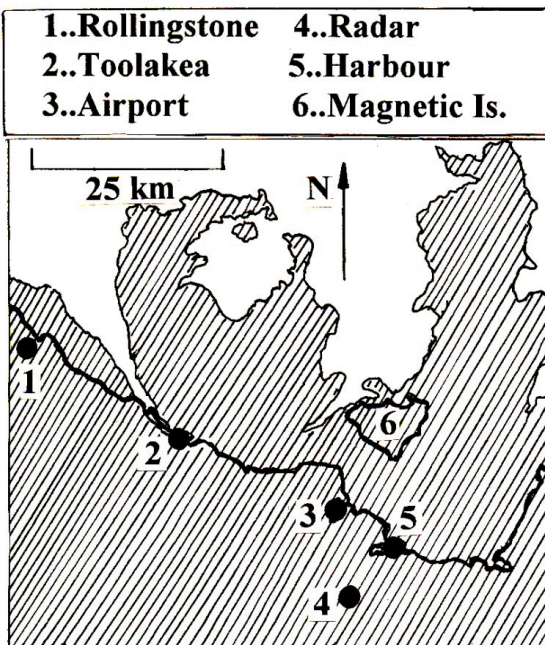
**Figure 2** Townsville anemograph for *Althea*.





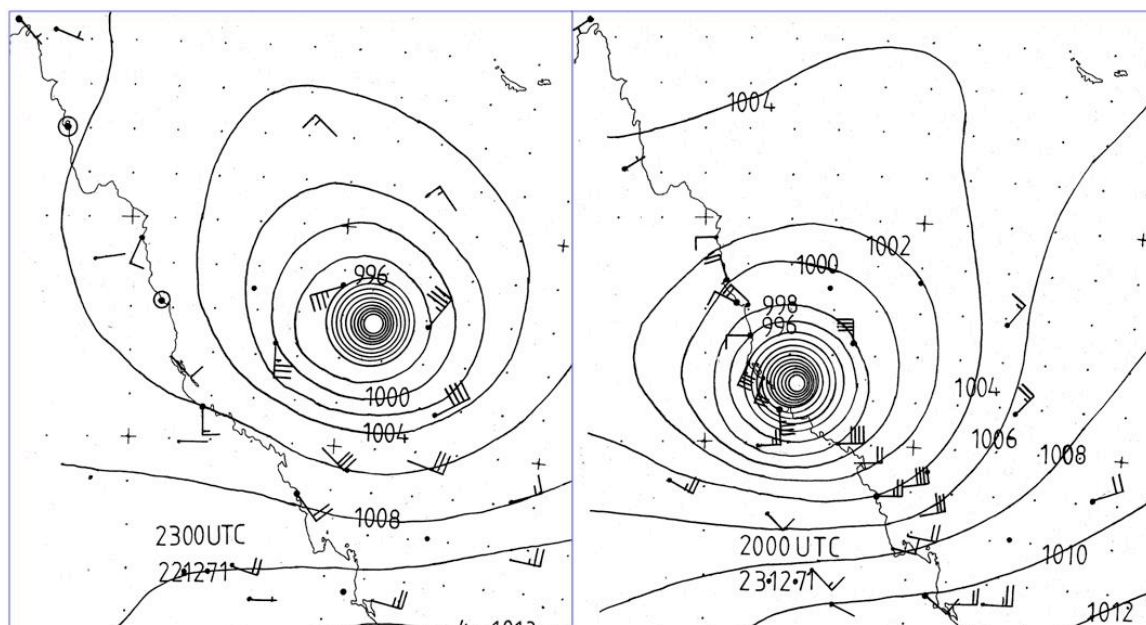


**Figure 3** The location of the anemometer at Townsville with respect to Castle Hill.

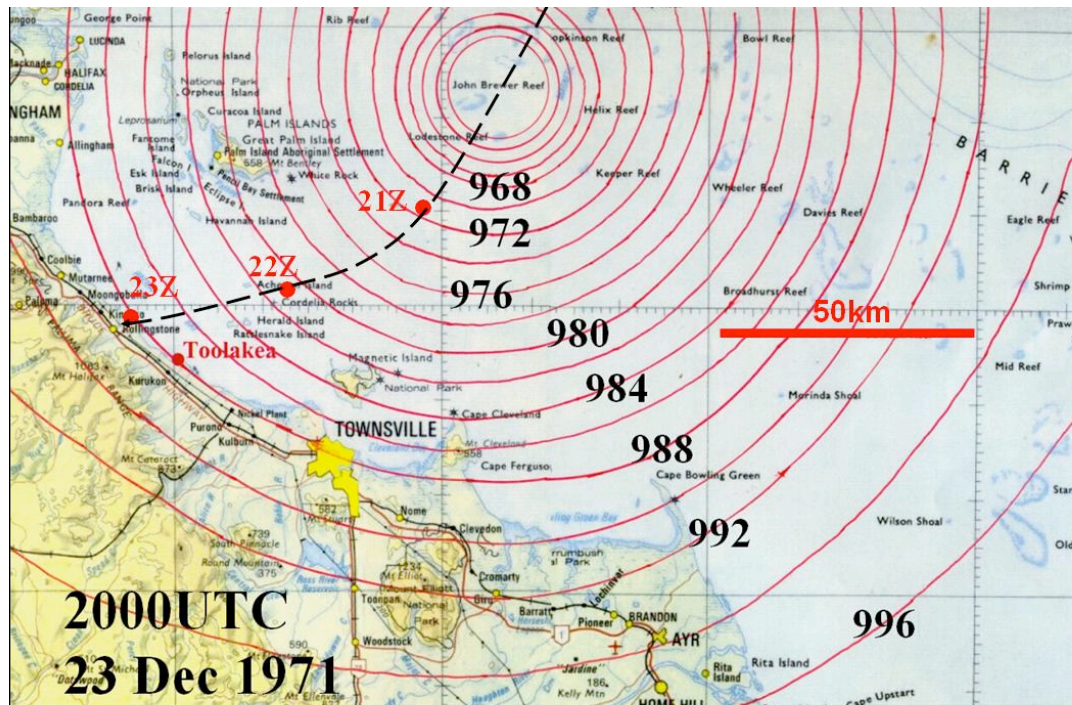


**Figure 4** showing the radar eye 2209UTC (precipitation hatched) of *Althea* in relation To Magnetic Island.

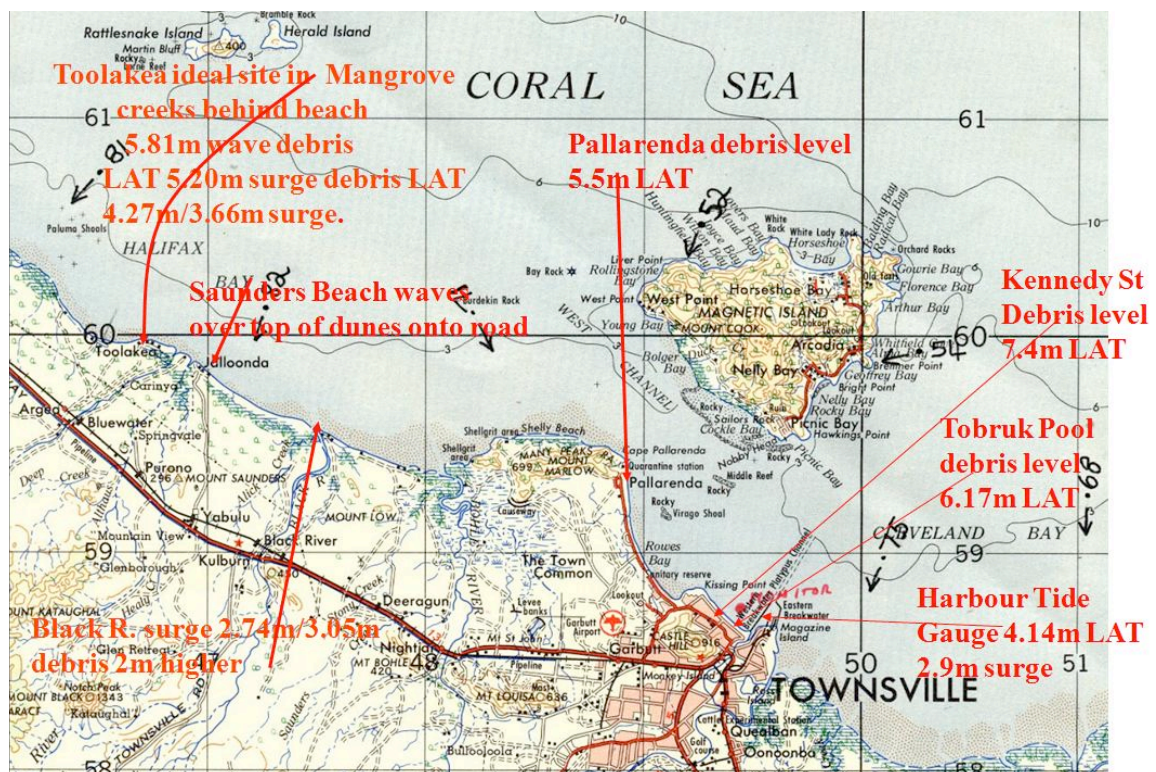
**Figure 5** The mean sea level analyses of *Althea* leading up to landfall.







**Figure 6** The mean sea level analysis of tropical cyclone Althea at 2000UTC 23 December 1971 in relation to the Great Barrier Reef. Subsequent hourly positions for *Althea* are also marked.



**Figure 7** Salt water inundation levels around the Townsville area associated with tropical cyclone *Althea*. LAT refers to the lowest astronomical tide datum level.



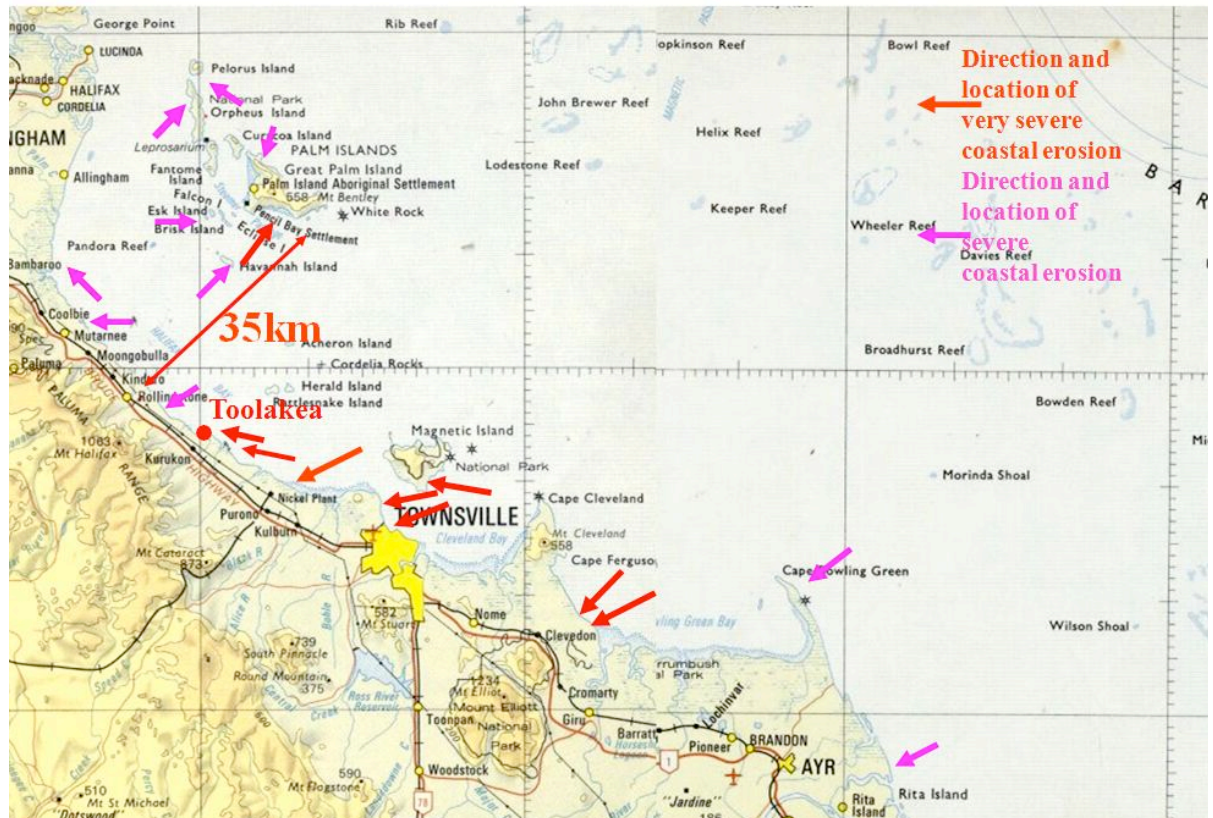


Figure 8 Coastal erosion around Townsville by waves driven by *Althea*.

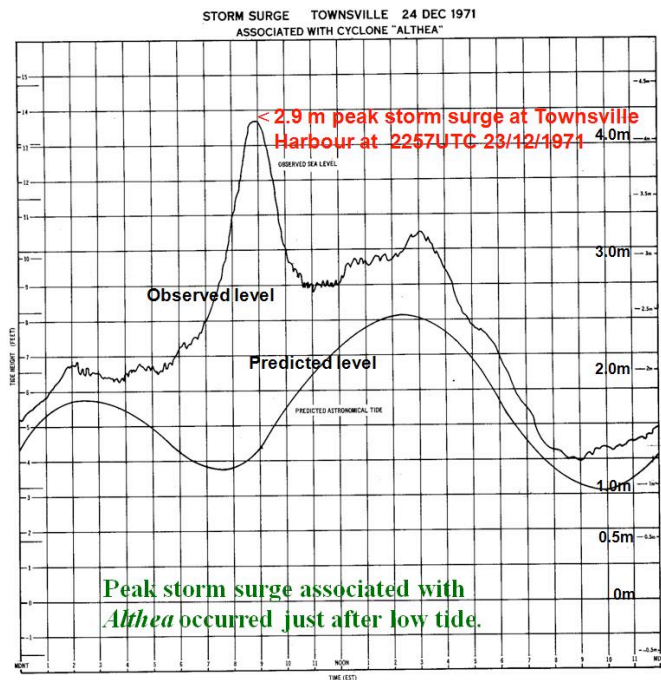


Figure 9 Townsville Harbour tide gauge.