CTS Preliminary Damage Assessment Report

Tropical Cyclone Marcia, Queensland Australia

February 20th, 2015

(Reference: The Australian)

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BACKGROUND

At 2:46 PM (Australian Eastern Standard Time) on Monday, 16 February 2015, the Australian Government Bureau of Meteorology (BOM) issued a three day outlook for the Coral Sea, noting that there was moderate potential for a tropical cyclone to develop by 19 February. The threat materialized when Tropical Storm Marcia formed at 7:00 PM on Thursday, 17 February, approximately 1000 km NE of Yeppoon in Queensland, and continued to strengthen as it moved South. The BOM issued a tropical cyclone warning for the coastal region of Queensland near Yeppoon and Rockhampton. The convective outlook included destructive winds and potential for flash floods. The BOM's outlook for 20 February as of 6 AM is provided in Figure 1. The southerly moving system was expected to affect towns as far as Mundubbera before downgrading to a tropical low bringing rain to Brisbane and the Gold Coast areas. On Friday, February 20, 2015 at 8:00 AM Tropical Cyclone Marcia crossed the Queensland coast North of Yeppoon at Shoalwater bay, estimated as a Category 5 cyclone (predicted wind speeds greater than 200 km/h (10-minute mean = V600)).

The wind speeds observed in Yeppoon and Rockhampton were lower than expected. The BOM anemometers recorded maximum wind speeds of 120 km/h (V600) with gusts (3-second peak = V3) up to 156 km/h at Yeppoon, and maximum wind speeds of 82 km/h (V600) with gusts up to 113 km/h (V3) at Rockhampton.

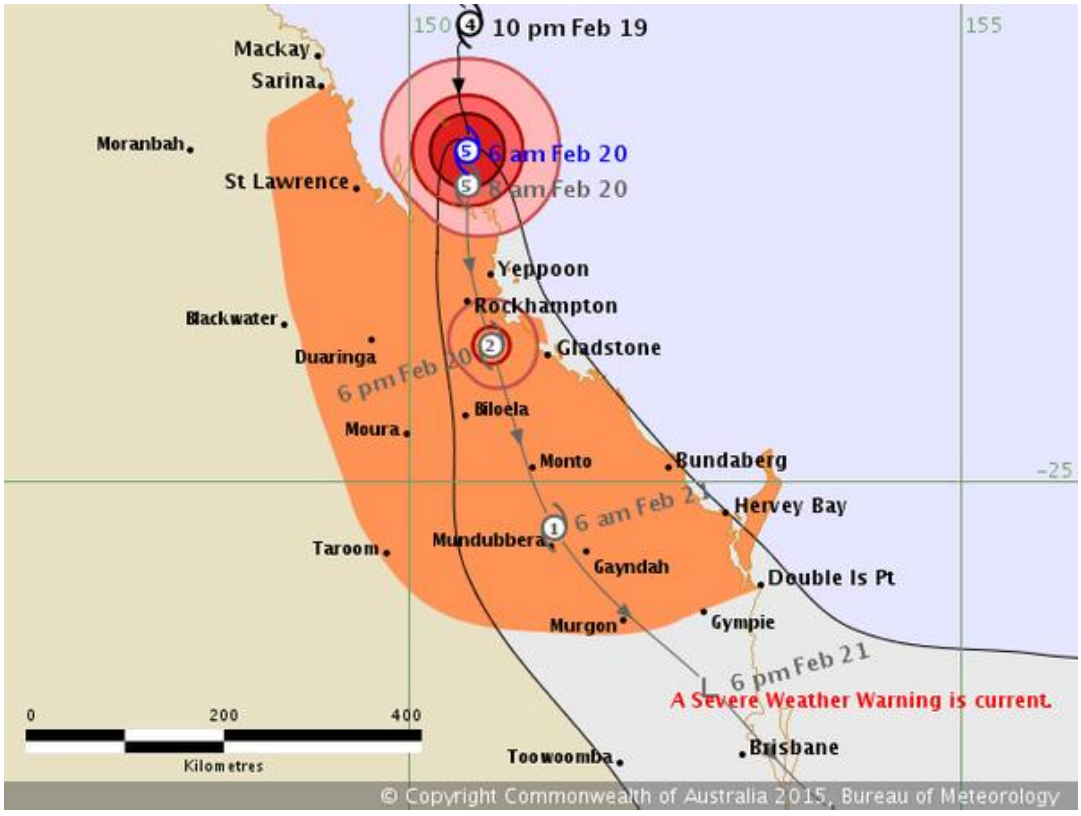

Figure 1. The Australia Bureau of Meteorology severe weather outlook as issued at 6 AM on 20 February, 2015. Times are in Australian Eastern Standard Time (+10 UTC).

The design wind speeds for Australia are defined in AS/NZS 1170.2 as shown in Figure 2. Residential structures designed in Queensland since the mid-1980s likely meet these design criteria. The coastal regions impacted by Tropical Cyclone Marcia have an ultimate design wind speed of 250 km/h (V0.2), well above the wind speeds recorded by the local weather stations (V600, V3).

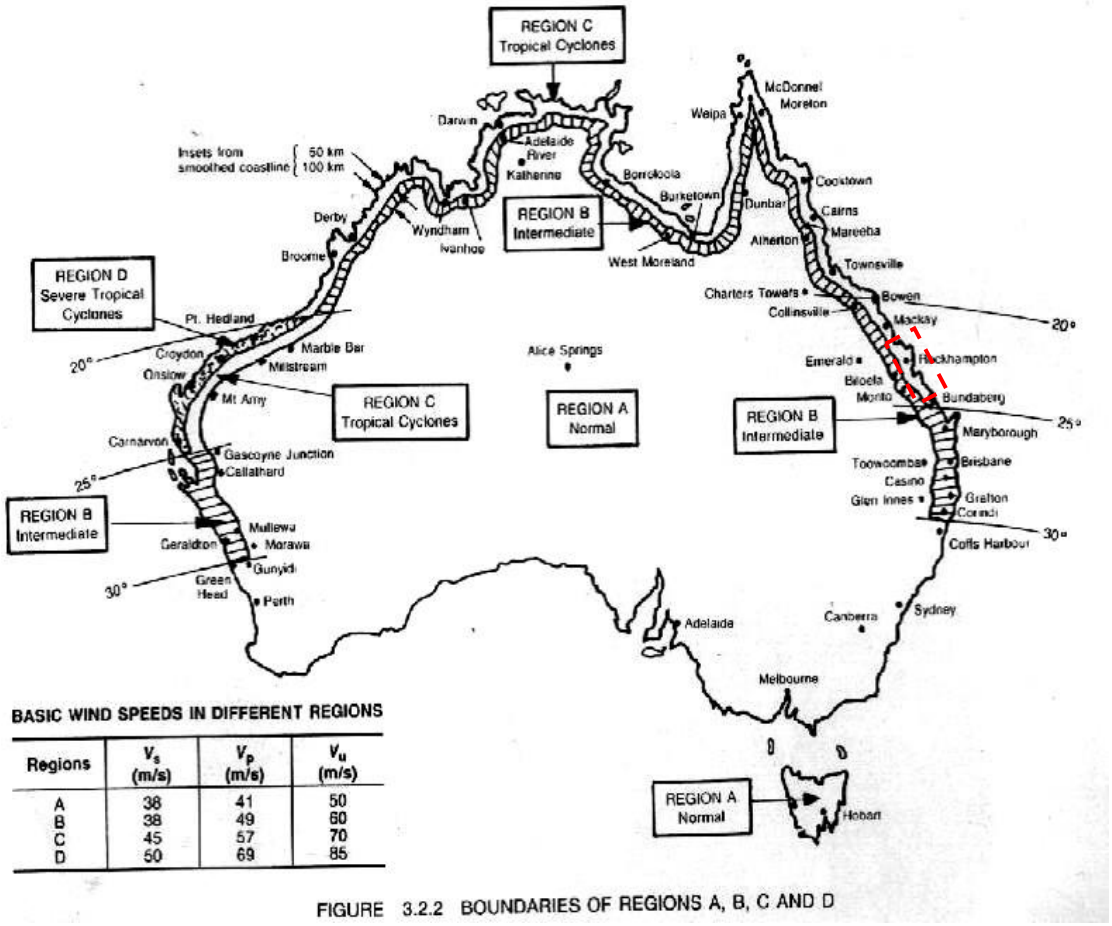

Figure 2. Design wind speeds for Australia based upon AS/NZS 1170.2 (1989). The region impacted by Tropical Cyclone Marcia (highlighted by the red rectangle) has a design wind speed of 69 m/s (250 km/h, V0.2).

TIMING OF STORM REPORTS

The timeline of Tropical Cyclone Marcia as it impacted the central Queensland coast is as follows (note all times are Australian Eastern Standard Time (AEST) (+10 UTC)).

February 20, 2015

08:00 AM – Tropical Cyclone Marcia made landfall North of Yeppoon near Shoalwater Bay as an estimated Category 5 cyclone, moving South.

12:00 PM – Tropical Cyclone Marcia passes West of Yeppoon generating a peak 3-sec (V3) gust wind speed of 156 km/h as it continues its southerly movement.

12:30 PM – Rockhampton sustains peak 3-sec gusts (V3) of 110 km/h.

02:00 PM – Tropical Cyclone Marcia downgraded to Category 3 (165-224 km/h, V3)

02:30 PM – The eye of Tropical Cyclone Marcia passes through Rockhampton continuing South South-East.

03:00 PM – Rockhampton weather station records gust wind speed (V3) of 113km/h

04:00 PM - Tropical Cyclone Marcia downgraded to Category 1 (91-125 km/h, V3)

February 21, 2015

2:00 AM – Tropical Cyclone Marcia becomes post-tropical with mean wind speeds (V600) of 55 km/h.

Figure 3 shows the track of Marcia based upon bulletins from the Australian Bureau of Meteorology (BOM).. It should be noted that the Category designations are from the BOM, and differ from the Saffir-Simpson Scale used in the United States. The scales are summarised in Table 1. Note that the Australian classification uses 10-minute sustained (mean) as opposed to the 1-minute sustained (mean) used by the Saffir-Simpson. Therefore the 3-second peak gust speeds (used by both scales) should be used for comparison purposes.

Table 1. Wind speed categories (in km/h) for Australian BOM and Saffir-Simpson Scale

Cyclone Category	Australia Bureau of Meteorology		Saffir-Simpson Scale	
	10-min Sustained	**3-sec Gust**	1-min Sustained	**3-sec Gust**
Category 1	63-88	**91-125**	119-153	**154-200**
Category 2	89-117	**125-164**	154-177	**201-230**
Category 3	118-159	**165-224**	178-209	**232-272**
Category 4	160-200	**225-279**	210-249	**273-325**
Category 5	>200	**>279**	≥250	**>325**

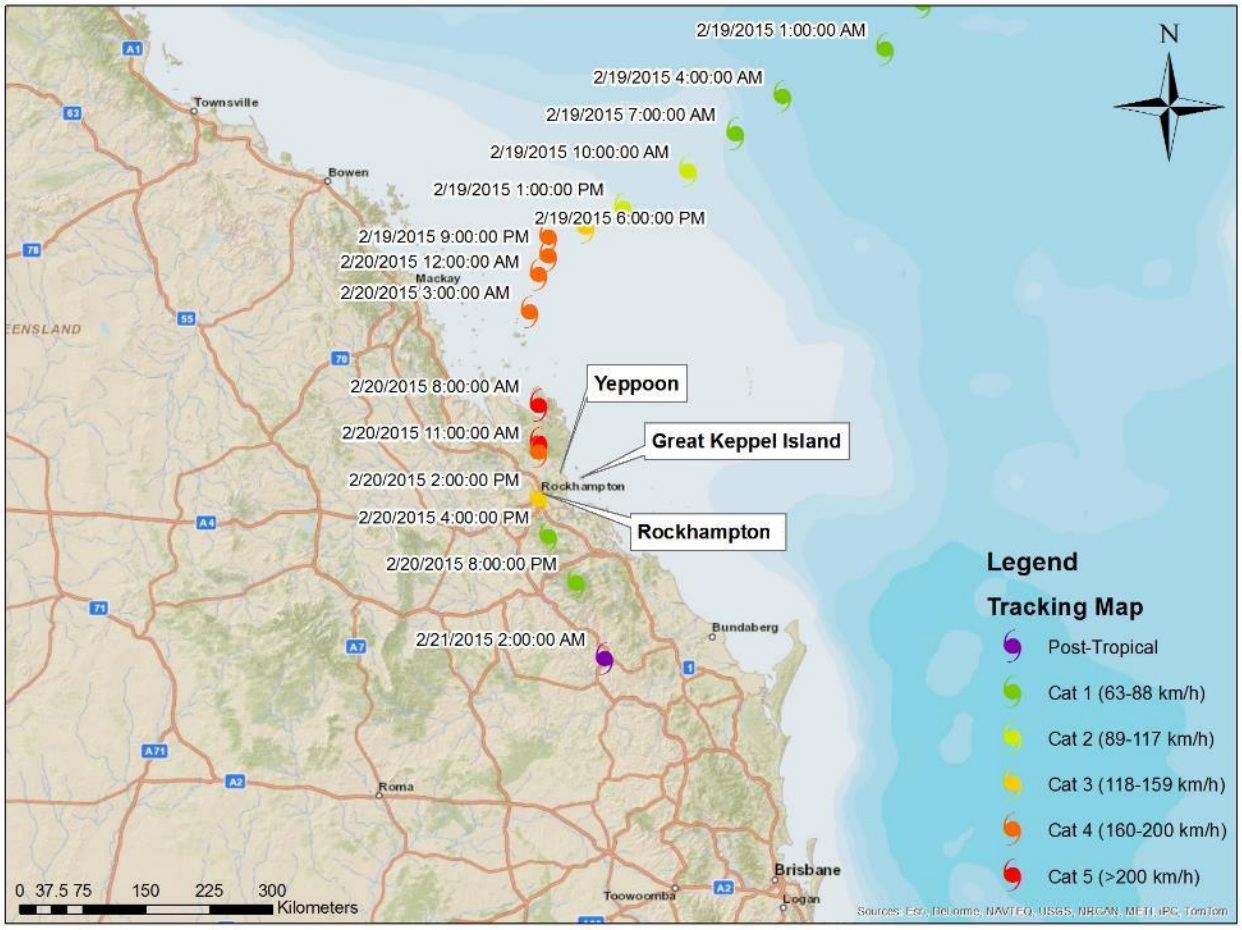

Figure 3. Tracking map for Tropical Cyclone Marcia based upon bulletins from the Australian Bureau of Meteorology. Times are in Australian Eastern Standard Time (+10 UTC). Cyclone categories refer to 10-minute sustained (V600) wind speeds.

OBSERVED DAMAGE

As of 8 AM February 21, media analysis suggested the most significant property damage occurred in the towns of Yeppoon, Rockhampton and Great Keppel Island. There was evidence of beach front erosion due to storm surge, uprooted trees, and downed power lines. Several houses suffered structural damage, particularly older properties (the damage was severe in some cases). There were no reports of injuries or fatalities.

Great Keppel Island

Great Keppel Island is located approximately 15 km from the town of Yeppoon off the Australian mainland. The island covers 14.5 km^2 and is sparsely populated, with the majority of the structures consisting of resorts and villas on the west side of the island. The island is known for its multiple beaches and hard coral reefs. Much of the damage to the island appears to have been caused by the storm surge, with reports and photos showing at least three properties with severe structural foundation failures due to rapid erosion. Figures 4 and 5 are examples.

Figure 4. Severe structural damage along the coast of Great Keppel Island due to the storm surge of Tropical Cyclone Marcia. Photos courtesy of 9News Brisbane.

Figure 5. Beach erosion in Great Keppel Island (Photo from Pierre Jayez)

Town of Yeppoon

Yeppoon is a town on the coast of Queensland with a population of 13,500. With its beaches and access to the barrier reefs, its industry is primarily driven by tourism. The eye of Cyclone Marcia passed approximately 16 km from the town around 12 PM on 20 February. Sustained wind speeds (V600) of 120 km/h and gusts (V3) of 156 km/h were recorded by the local Yeppoon weather station, which reflect a Category 2 cyclone. The time histories of the wind speed and direction are shown in Figure 6. The atmospheric pressure and temperature as Marcia passed by are shown in Figure 7.

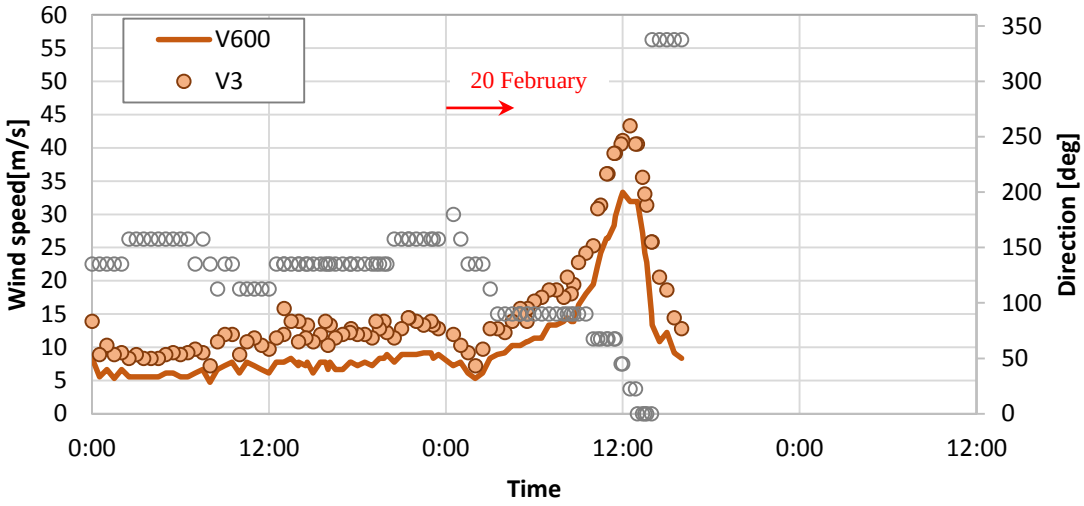

Figure 6. Wind speed and direction time histories from the weather station at Yeppoon. The single peak in the wind speed time history indicates the eye did not pass directly over the weather station.

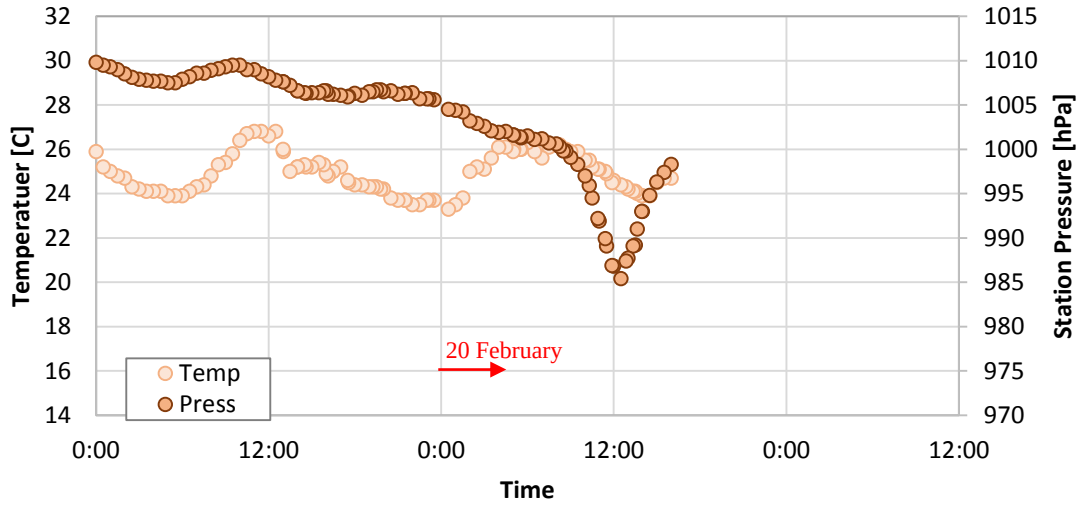

Figure 7. Temperature and atmospheric pressures recorded at the Yeppoon weather station during the passage of Tropical Cyclone Marcia.

No estimates of the total number of homes damaged is available at the time of this report, but the photos and videos that have emerged on social media and local news indicate significant structural damage has been suffered to some properties (mostly to older house construction). Figure 8 shows a roller door blown outward at Yeppoon Hotel, Figure 9 shows a home with roof batten and cladding damaged, Figures 10-11 show homes with a missing roof, and Figure 12 shows a home with the roof removed by the wind and exterior walls collapsed.

Figure 8. Roller doors blown outward at Yeppoon Hotel (Google Images)

Figure 9. Batten and cladding damage in Yeppoon (pre-1960's house) (ABC News)

Figure 10. Fibro house (est. pre-1970's) with missing roof in Yeppoon (ABC News)

Figure 11. Roof damage to a home in Yeppoon caused by Tropical Cyclone Marcia. Photo courtesy of 7News Brisbane.

Figure 12. Roof removed and exterior walls collapsed in a home in Yeppoon. (ABC News)

Town of Rockhampton

Rockhampton is a city and local government in Queensland with a population of 82,550 as of 2013. It is located 38 km Southwest of Yeppoon. Rockhampton has a significant number of governmental, community and major business offices for the coastal region of Queensland. The economy is primarily driven by the beef industry. The BOM categorised Tropical Cyclone Marcia as a Category 3 as it passed over Rockhampton. However, the maximum sustained wind speeds (V600) recorded by the local weather station were 82 km/h, with gusts (V3) of 113 km/h. The time histories of wind speed and direction are shown in Figure 13. The pressure and temperature are given in Figure 14.

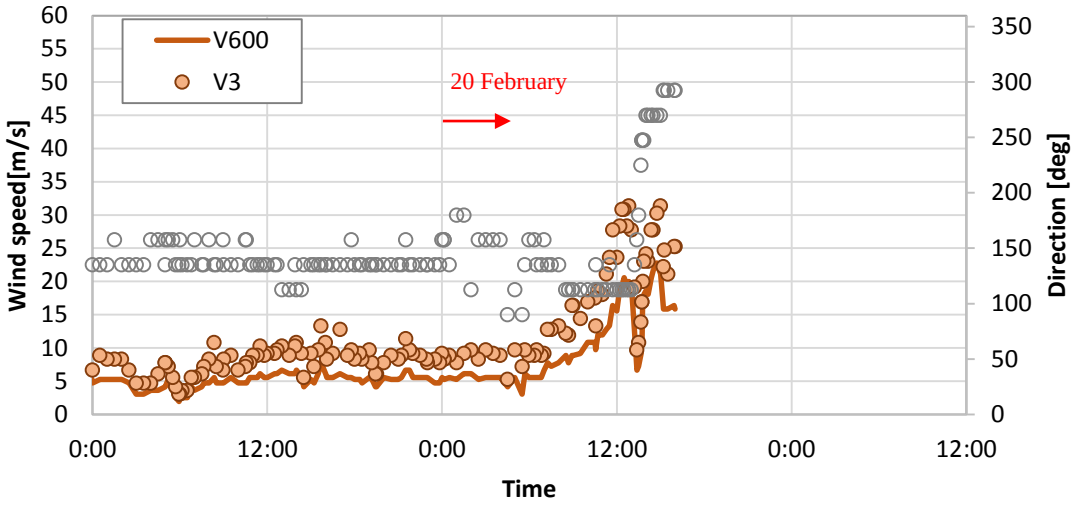

Figure 13. Wind speed and direction time histories recorded by the Rockhampton weather station. Note the two peaks in the wind speeds, indicating that the eye passed directly over the weather station.

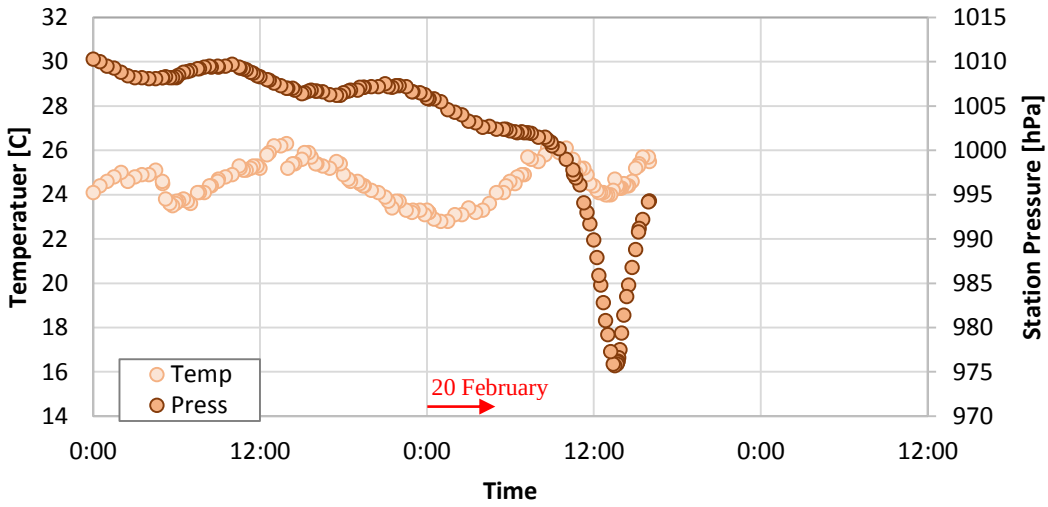

Figure 14. Temperature and static pressure during the passage of Tropical Cyclone Marcia. The sharp decrease and increase in pressure also indicates the passage of the eye over the weather station.

The intensity of Tropical Cyclone Marcia decreased as it moved inland. Wind speeds became less of a concern in comparison to the high rainfall rates and potential for flooding. Figure 15 shows the rainfall intensity during the passage of Tropical Cyclone Marcia, peaking at 30 mm/h just after passage of the eye.

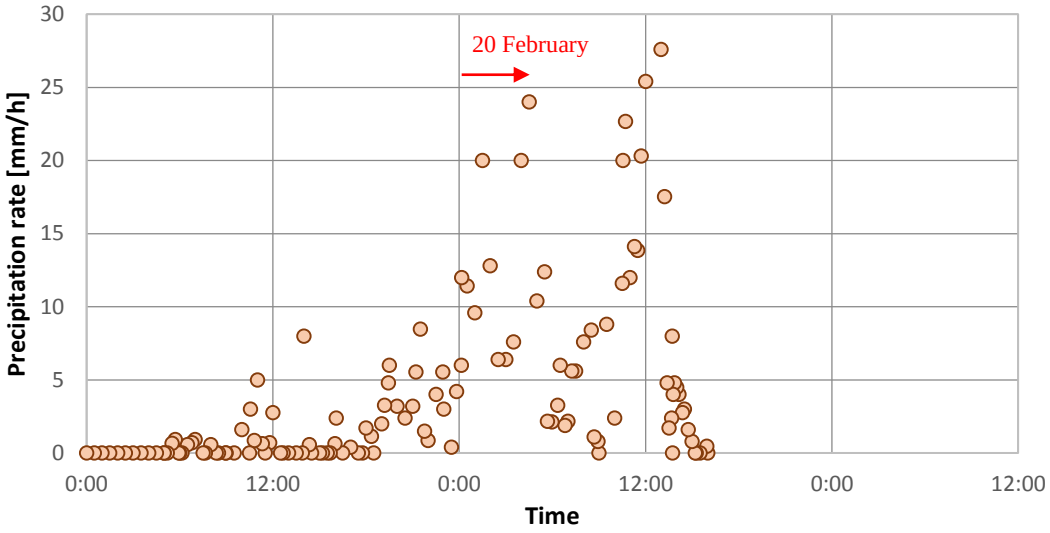

Figure 15. Rainfall intensity rates measured by the Rockhampton weather station as Tropical Cyclone Marcia passed directly over.

At the time of this report, the extent of the wind damage to Rockhampton is still being assessed. Figure 16 shows a local business with significant damage to the structure of the building. Apart from the structural damage, there were numerous reports of flooding and road closures.

Figure 16. Structural damage to local business in Rockhampton. Courtesy Louisa Rebgetz.

SUMMARY

Wind speeds of a Category 5 cyclone are in excess of 280 km/h (V3), and between 225-279 km/h (V3) for a Category 4. Tropical Cyclone Marcia crossed the coast in a relatively unpopulated section of the Queensland coast. The maximum Automatic Weather Station (AWS) wind speeds measured at Yeppoon during the event were up to 156 km/h (V3). The design wind speed for this region (region C cyclonic) is 69 m/s (250 km/h) (V0.2) (at 10m in open terrain) for a 500 year return period.

The winds recorded during Marcia were below the design wind speed. It is important that the wind speeds impacting the communities are determined so that: [1] assessments of building codes and standards can be made and [2] appropriate messages to the community on building performance can be articulated. A community that receives an over-represented wind speed report may have potential for complacency in preparation or building standards in the future. Further research is required to determine if this is an issue.

Despite less than design level wind speeds, significant structural damage was still observed during the cyclone event. From preliminary media images the majority of severe damage has occurred to older housing, with some cases of roof failure for retrofitted installation of new roof cladding on old roof structure. Despite wind damages, it is expected that widespread flooding (caused by the heavy rains, coastal erosion) and wind-driven rain (water ingress) are likely to be the main contributors to building/infrastructure losses in this event. The most recent report by the Queensland Police Station stated that preliminary reports indicated several hundred homes in Yeppoon and Rockhampton suffered structural damage.

The preliminary assessment in this report is made solely on the basis of photographs and details provided by online media outlets without field damage assessments. The purpose of this report is to present the scientific and engineering community with a brief overview of available information immediately following an event, when recovery decisions are critical.

Table 2. Wind speed and gust measurements by weather station

Station	Wind Speed (km/h)	Wind Gust (km/h)
Rockhampton	82	113
Yeppoon	120	156
Gladstone	59	82
Gladstone Airport	48	72
St Lawrence	28	43

(Source: http://www.bom.gov.au/qld/observations/qldall.shtml)

About the International Wind Hazard Damage Assessment Group

The International Wind Hazard Damage Assessment Group was originally created at the University of Florida and expanded to Australia in 2014 through the Cyclone Testing Station at James Cook University. Its mission is to train university students interested in building construction, engineering and architecture in the forensic engineering and techniques for post-hazard damage surveys and data collection. The team has surveyed damage after severe wind events throughout the U.S. and Australia and continuously monitors their prevalence worldwide.

Appendix A – Reference Content

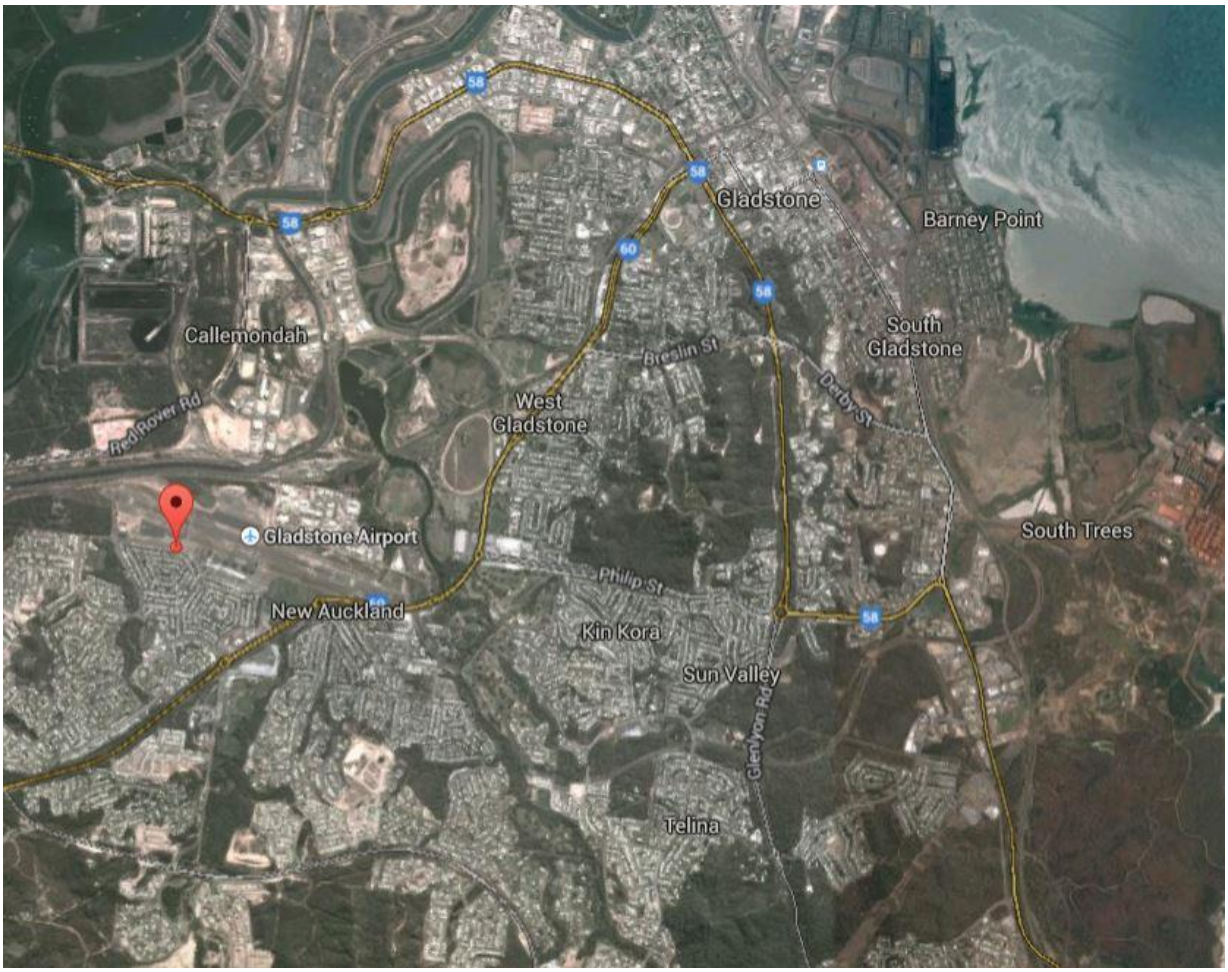

Figure A1. Gladstone Airport weather station location (Google Maps)

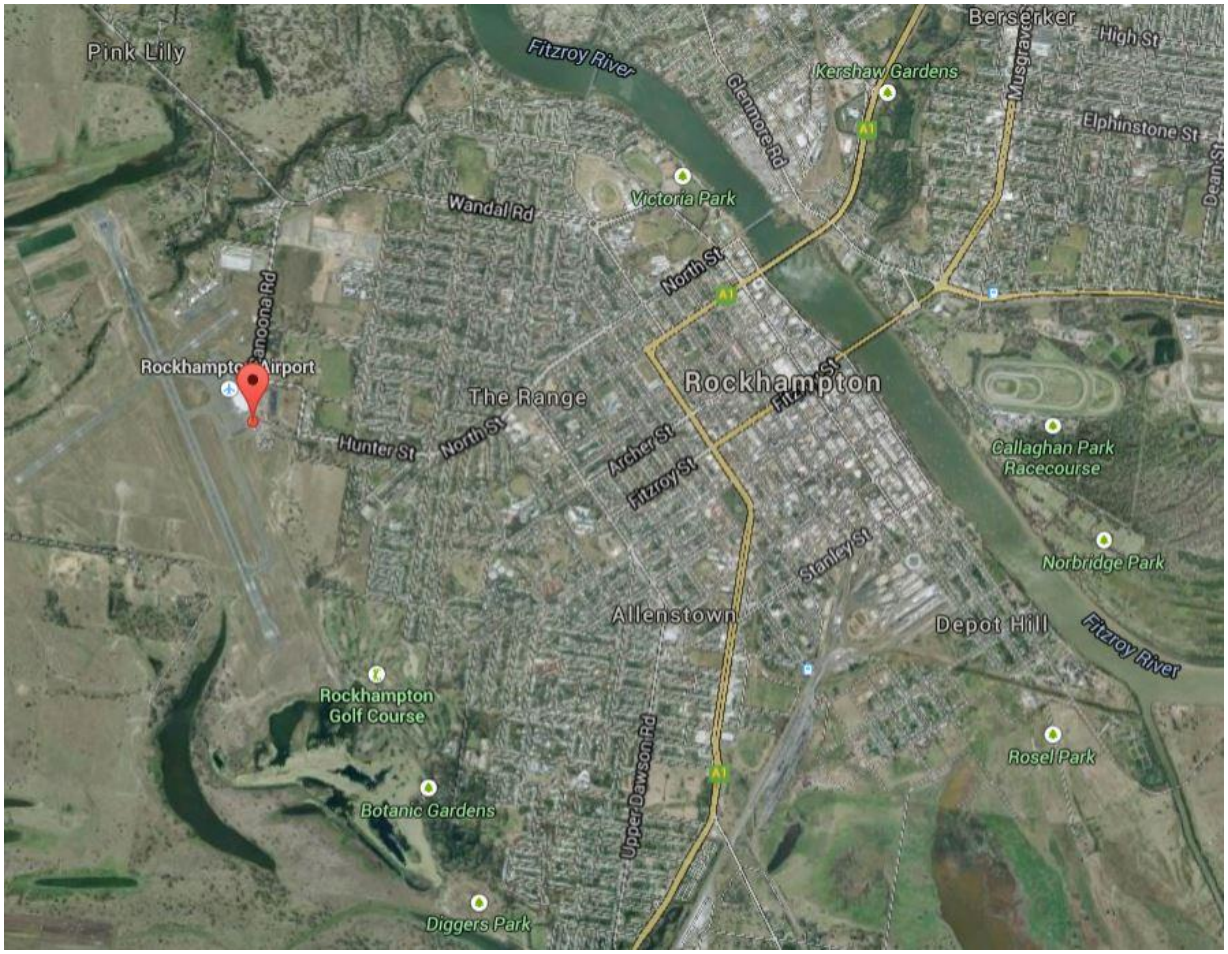

Figure A2. Rockhampton weather station location (Google Maps)

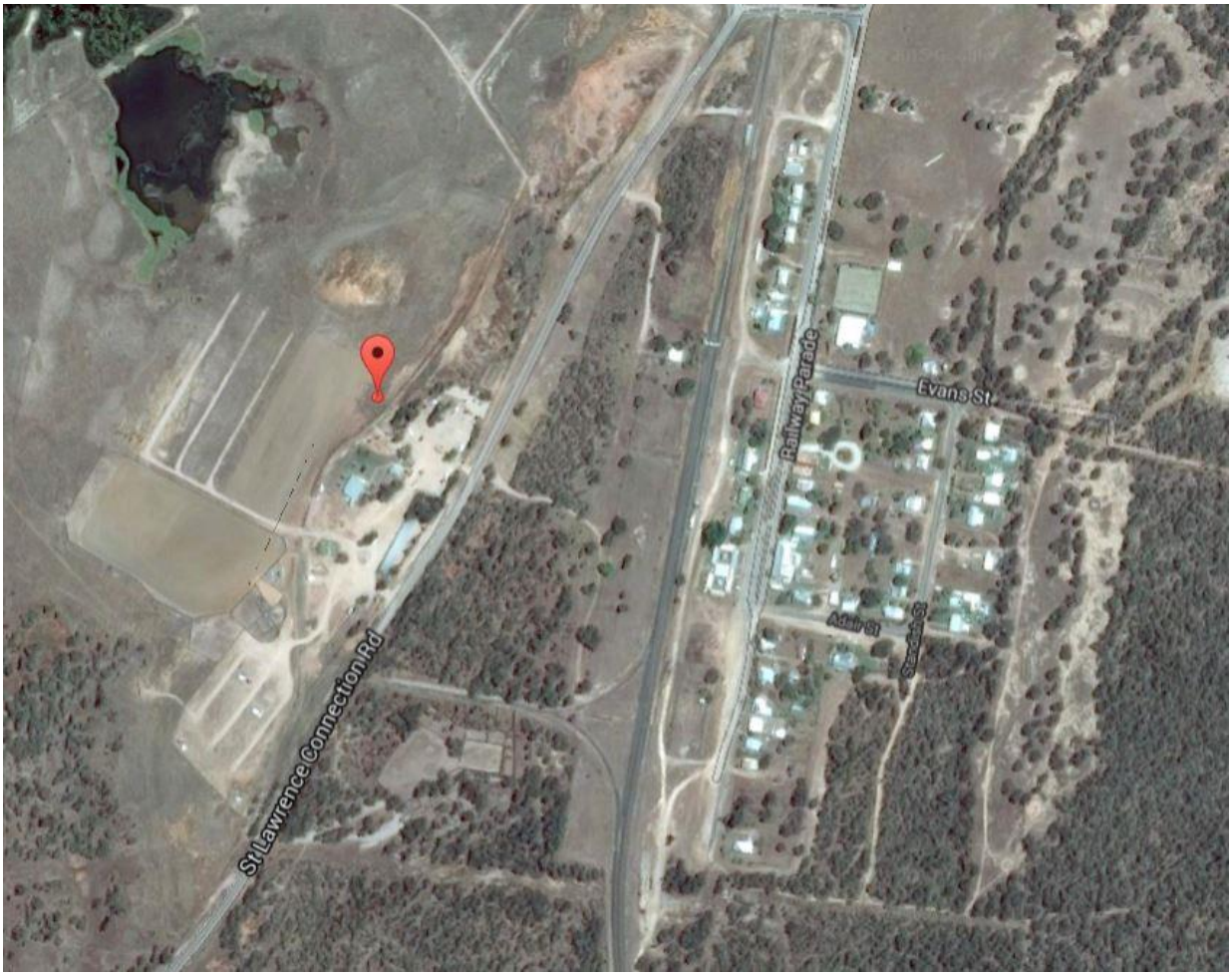

Figure A3. St. Lawrence weather station location (Google Maps)