Severe Wind Hazard Preliminary Assessment

Tropical Cyclone Nathan, Far North QLD, Australia

March 20th, 2015

(Courtesy NASA)

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Rev. 0

About the International Wind Hazard Damage Assessment Group

This report was prepared from onsite and media-sourced content by the engineering faculty and students at Cyclone Testing Station (James Cook University), the University of Florida, and the University of Queensland. The study compliments experimental research at these institutions seeking to characterize extreme wind events and their impact on buildings. The purpose of the report is to provide a preliminary engineering assessment of severe weather events, within the first 24 to 48 hours. As a result, much of the information is necessarily collated from immediately available sources (i.e. social media, local news outlets, weather agencies, etc.).

The International Wind Hazard Damage Assessment Group was originally created by Dr. David Prevatt at the University of Florida and expanded to Australia in 2014 through Dr. Daniel Smith and the Cyclone Testing Station at James Cook University. Central to its objectives, is training university students and personnel in novel forensic engineering and techniques for post-hazard damage surveys and data collection. The team has surveyed damage after severe wind events throughout Australia and the U.S. and continuously monitors severe wind events worldwide.

Please visit https://www.jcu.edu.au/cts/ and http://windhazard.davidoprevatt.com for additional information, and for access to previous rapid assessment damage reports. Questions and comments on any aspects of our work are most welcome. Please direct your enquiries to Dr. Daniel Smith (daniel.smith8@jcu.edu.au) at the Cyclone Testing Station or NSF Graduate Research Fellow and Ph.D. student, Mr. David B. Roueche (david.roueche@ufl.edu) at the University of Florida.

The authors gratefully acknowledge the Cyclone Testing Station (CTS) partners and benefactors (https://www.jcu.edu.au/cts/benefactors-links/benefactors-and-sponors), including the Bushfire and Natural Hazards Cooperative Research Centre, in additional to the National Science Foundation (NSF) for financial support of this study under NSF research grant 1150975. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Bushfire and Natural Hazards Cooperative Research Centre, other CTS partners, or the National Science Foundation.

Special thanks to the Queensland Fire and Emergency Services (QFES), Cook Shire Council, State Emergency Services (SES), and the Australian Bureau of Meteorology for their willingness to assist our research efforts. Our work would not be possible without their contributions.

BACKGROUND

At 4:48 PM (Australian Eastern Standard Time) on Tuesday, 17 March 2015, the Australian Government Bureau of Meteorology (BoM) issued a four day outlook for the Far North Queensland Coast in relation to TC Nathan. Coastal and island communities between Cape Melville and Cardwell were warned of the potential for destructive winds, storm tide, and heavy rainfall to develop from Thursday evening (Figure 1).

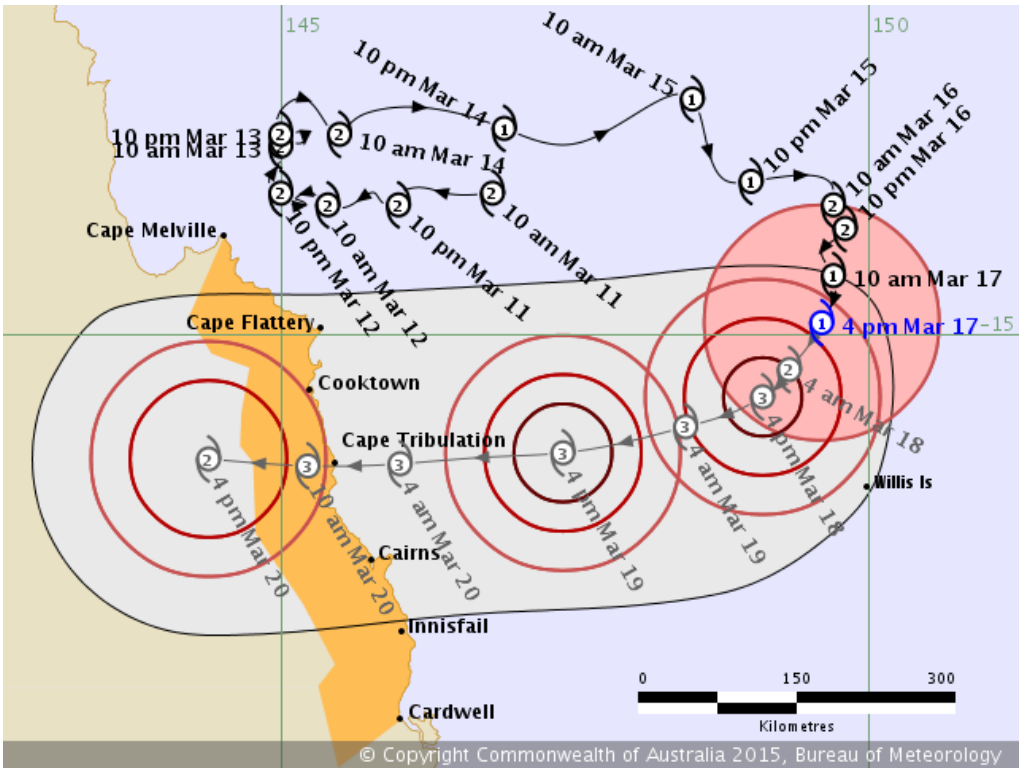


Figure 1. The Australia Bureau of Meteorology severe weather outlook issued at 4:48 PM AEST on 17 March, 2015.

The BoM's outlook for 19 March as of 3:53 PM, as TC Nathan approached landfall, is provided in Figure 2. The westerly moving system was expected to affect Cape Flattery, Cooktown, Cape Tribulation, etc.

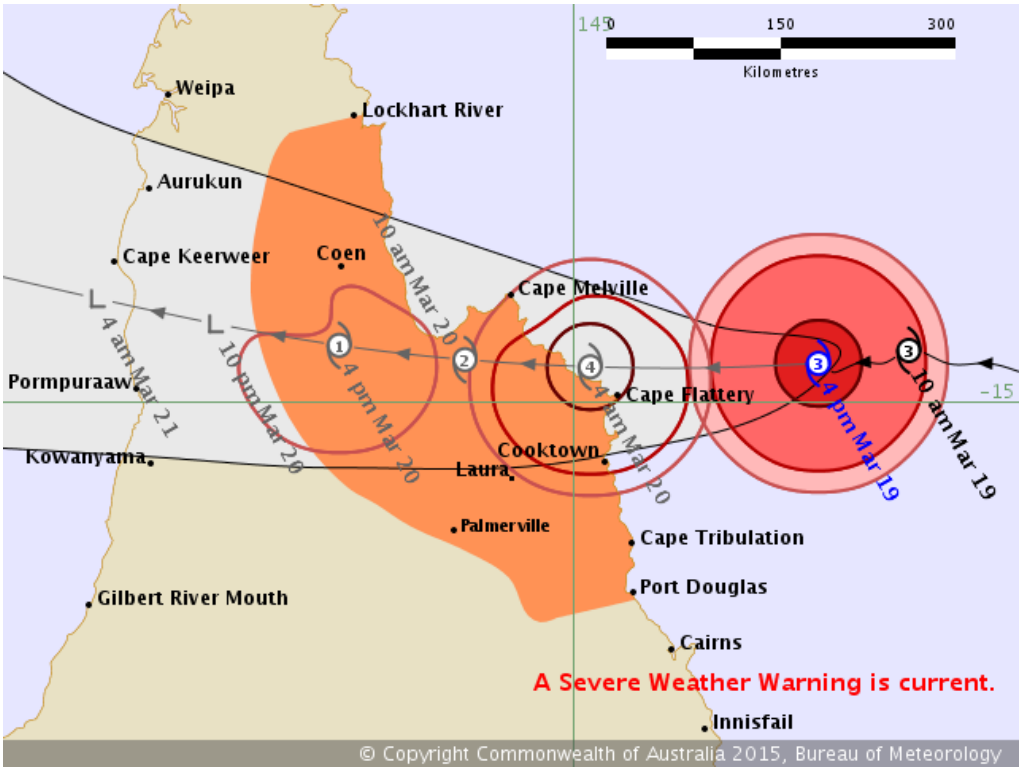


Figure 2. The Australia Bureau of Meteorology severe weather outlook approaching TC Nathan landfall (issued at 3:53 PM on 19 March, 2015).

The affected region (i.e. Cape Flattery, Cooktown, etc.) is in wind Region C (within 50 km of the coast) as defined in AS 1170.2 and shown in Figure 3 with regional design gust wind speed in standard conditions for typical (Importance Level 2) buildings of 248 km/h (69 m/s, 154 mph). Residential structures designed in QLD since the mid-1980s typically meet the design (ultimate) wind speed. Hence the recorded peak gust in the cyclone near landfall was ~65% (based on Cape Flattery AWS max V3,600) of the design ultimate wind speed for residential buildings in that location (allowing for the conversion of 3 second gusts to design wind speeds).

Table 1. Ultimate design regional wind speeds by region for 1/500 annual probability (appropriate for housing and other Importance Level 2 structures)

Regions	V_u (m/s)(mph) AS 1170.2:1989	V_{500} (m/s)(mph) AS/NZS 1170.2:2002	V_{500} (m/s)(mph) AS/NZS 1170.2:2012
A	50 (112)	45 (101)	45 (101)
B	60 (134)	57 (128)	57 (128)
C	70 (157)	69 (154)	69 (154)
D	85 (190)	88 (197)	88 (197)

(Source: Australian Standard AS 1170.2:1989 to AS/NZS 1170.2:2012)

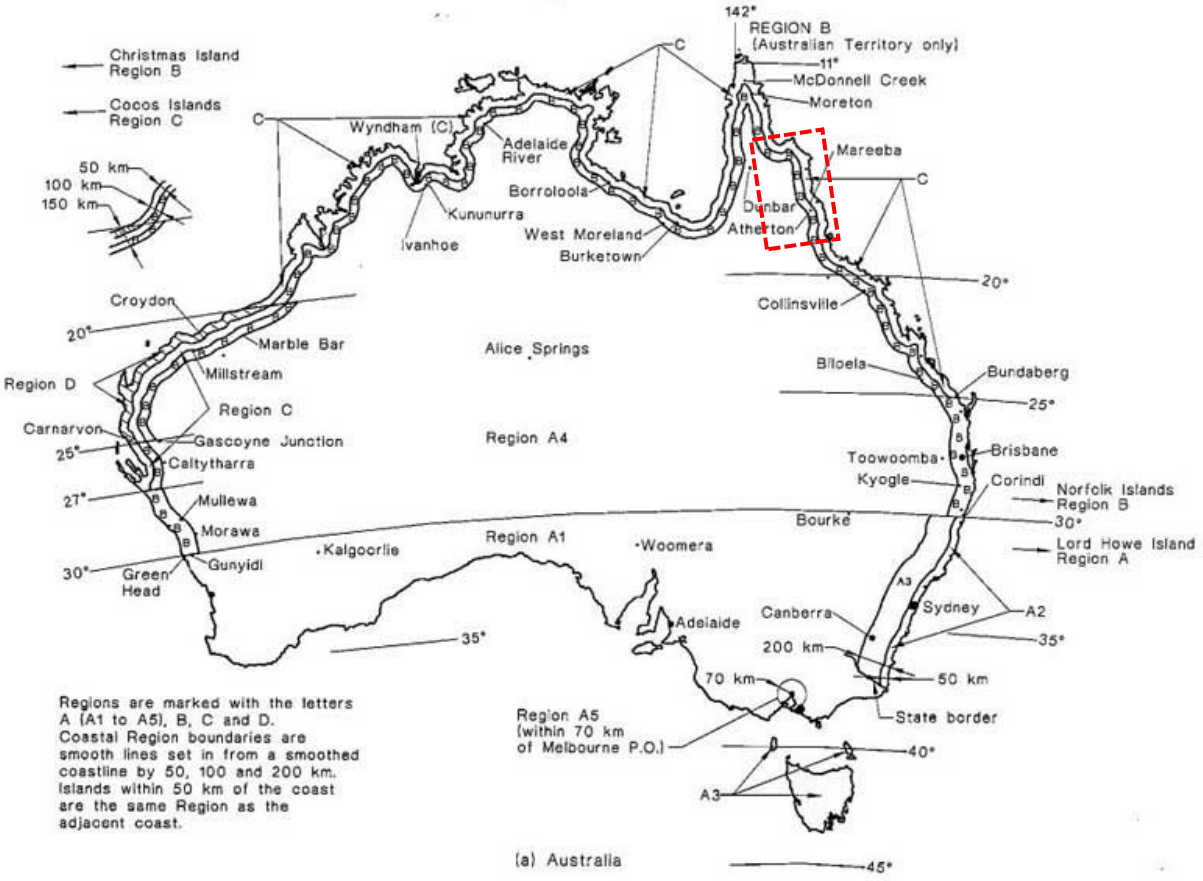


Figure 3. Design wind speeds for Australia based upon AS 1170.2 (2002). The region impacted by Tropical Cyclone Nathan (highlighted by the rectangle) has a design wind speed of 69 m/s (248 km/h, V0.2) in Region C.

STORM TRACK AND INTENSITY

Figure 4 shows the track of TC Nathan based upon advisories from the Australian Bureau of Meteorology (BoM). Times are given in Australian Eastern Standard Time (AEST), which is 10 hours ahead of UTC. It should be noted that the Category designations are from the BoM. The scales are summarized in Table 2. Note that the Australian classification uses 10-minute sustained (mean) as opposed to the 1-minute sustained (mean) used by the Saffir-Simpson Scale in the U.S.. Therefore, the 3-second peak gust speeds (used by both scales) should be used for comparison purposes.

Table 2. 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**

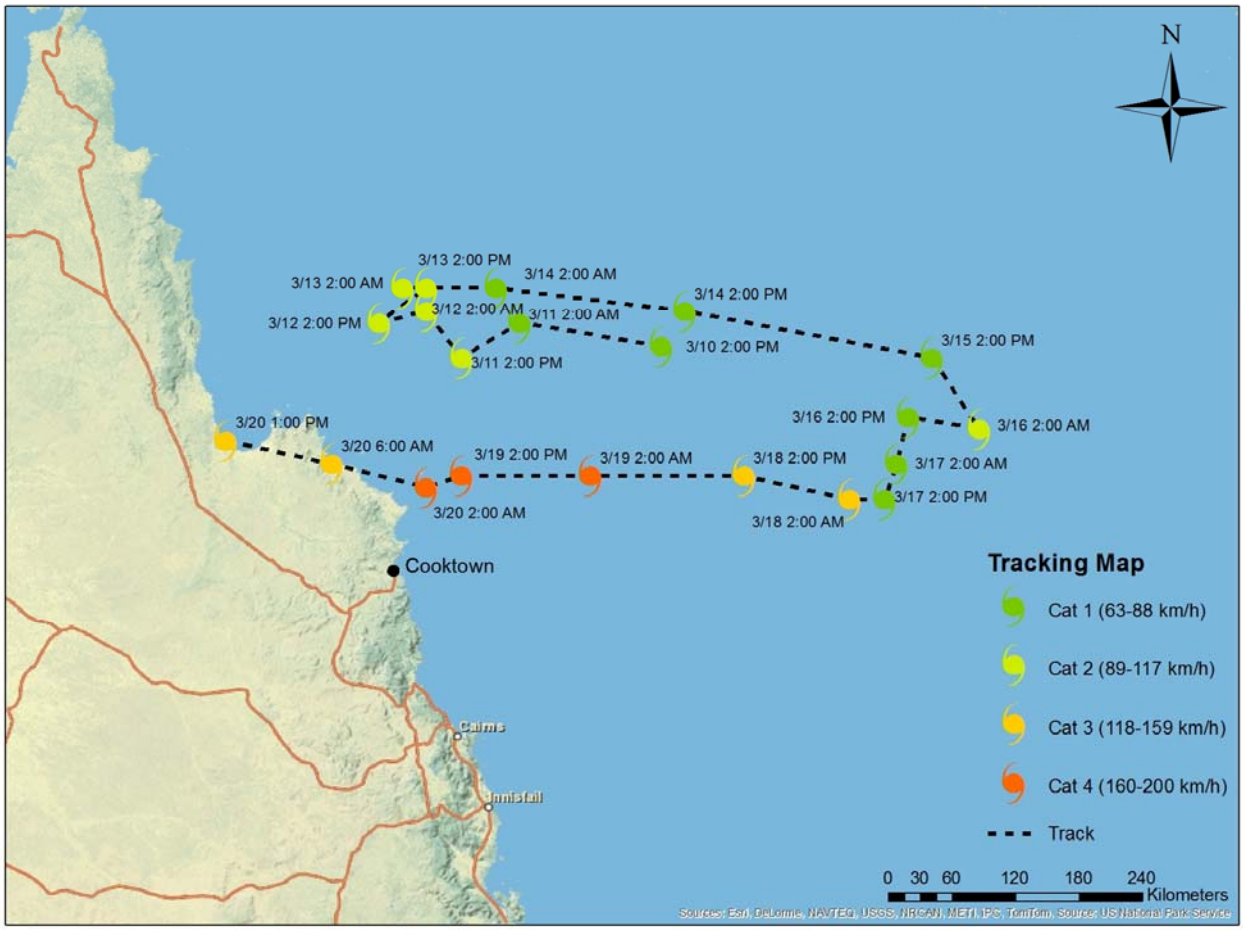


Figure 4. Tracking map for Tropical Cyclone Nathan as of 1 PM (AEST) 20 March based upon advisories from the Australian Bureau of Meteorology. Times are in Australian Eastern Standard Time (+10 UTC). The legend shows cyclone categories with 10-minute sustained wind speeds (See Table 1 for 3 second gust speeds). (Note at the time of this report TC Nathan was continuing beyond this path into the Gulf of Carpentaria)

WIND AND PRESSURE DATA

This section includes preliminary analysis of wind and pressure data from the Cyclone Testing Station's SWIRLnet (Surface Weather Information Relay and Logging network) portable anemometers and the BoM automatic weather stations in the affected regions of Far North Queensland. The CTS team deployed six anemometers (henceforth referred to as Towers 1 to 6) in the Cooktown region. However, only Towers 1-5 were configured for real time data transfer

and therefore the data from Tower 6 is not included in this preliminary analysis. All towers (except Tower 6 currently) record data locally at 10 Hz and send 10 minute summary files to an FTP (file transfer protocol) site via mobile internet networking cards. Due to the concentration of population and road conditions to the North, all towers were deployed in the Cooktown area. BoM automatic weather station data near TC Nathan landfall (Bougainville and Cape Flattery) and in Cooktown are also discussed in relation to SWIRLnet data.

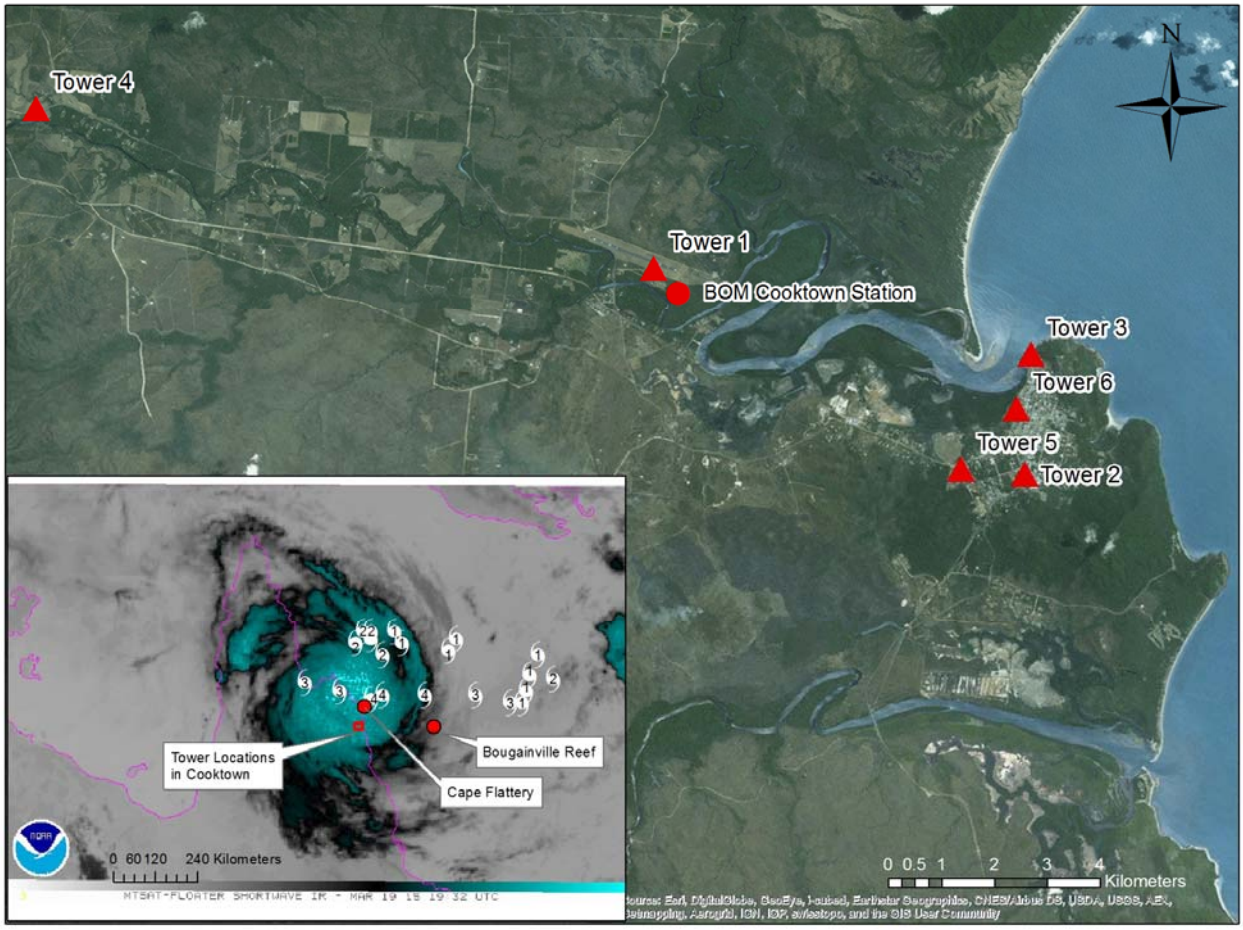


Figure 5. SWIRLnet and BoM weather station locations in Cooktown and North of Cooktown relative to satellite imagery of TC Nathan (Courtesy NASA).

Bullet Point Summary of Data

- It is interesting that the maximum recorded velocity was observed at Tower 2 given that it is located in more suburban terrain than Towers 3 or 5, but the timing and direction of gust indicate that the maximum at this location has occurred more towards the backside of the storm (i.e. the storm has moved West of Cooktown) than either Towers 3 or 5.

- The wind speed trace for Tower 2 is interesting in that the maximum has occurred during quite a large excursion from what would be typical (i.e. it probably has a large gust factor). It will be interesting to see if there has been significant rainfall during this period and whether this could be a convective gust.

- Tower 3 gusts may have been affected by the hill to its Southeast. This is roughly where the direction the maximum gust has come from. The wind direction is pretty consistently around SE to S until the wind speed rapidly dies off and the directions begin to fluctuate. This may be caused by the influence of the hill.

- Tower 4, recording the lowest maximum gust, is in line with what would be expected as the storm moves on land and both the storm itself decays and friction possibly starts slowing winds down more than in Cooktown itself.

- Measured atmospheric pressure was similar for all towers. Tower 1 and the Cooktown AWS also match well.

- Note that the AIMS Lizard Island anemometer was offline. This station would have seen the eye passage just prior to landfall and measured the highest gust during TC ITA.

Table 3. Wind, pressure, and measurement site information for SWIRLnet and BoM weather stations during TC Nathan

Site	Max V3,600 [m/s]	Direction (°)	Time [20/3]	Tower height [m]	Approx. upwind terrain category @ max gust	P [hPa]
Tower 1	21.5	128	3:46	3	2	1004
Tower 2	26.8	318	2:44	3	2.5-3	1002
Tower 3	21.1	158	1:43	3	2-2.5	1005
Tower 4	18.4	114	2:17	3	2-2.5	1001
Tower 5	20.3	153	2:11	3	2	1004
Bougainville Reef (BoM)	30.8	112	14:00 [19/3]	10	1.5	1002
Cape Flattery (BoM)	44.7	135	2:30	10	2	990
Cooktown (BoM)	23.6	112	3:30	10	2	1005

Comparison between BoM AWS at 10 m and Tower 1 at 3 m

- Very similar direction recorded at both heights during maximum intensity of storm. This is expected.

- Predominantly the 10 m V3,600 is larger than at 3 m, but there are times when it is not. This is probably not unexpected simply due to the randomness of the wind. This may warrant further investigation to determine the possible cause of these lower level excursions.

- Ratio of max V3,600 between 3 m and 10 m (V@3/V@10) is 0.91. $M_{z,cat}$ (terrain category/height multiplier per AS/NZS 1170.2) for Terrain Category 2 at 3 m is also 0.91. (Note: AS/NZS 1170.2 uses V0.2,600)

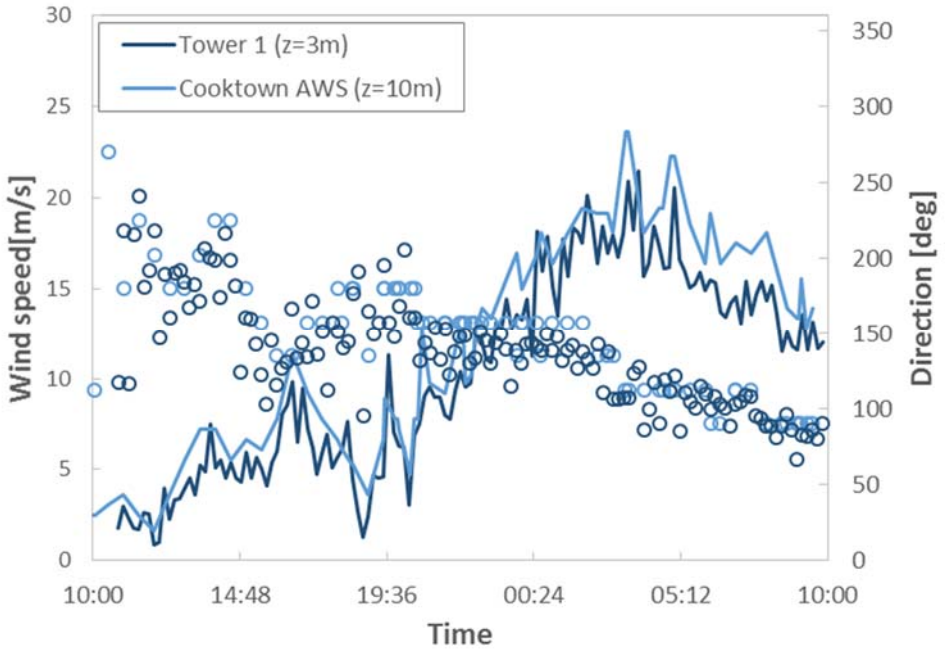


Figure 6. SWIRLnet anemometer Tower 1 (3 m height) and Cooktown Bureau of Meteorology (10 m height) automatic weather station maximum 3-second gust (V3,600) wind speed solid line) and direction (open dots) from 10 AM (AEST) Thursday 19 2015 to 10 AM Friday 19 2015 during TC Nathan. (Note: these weather stations were located within ~20 m of each other at the Cooktown Airport)

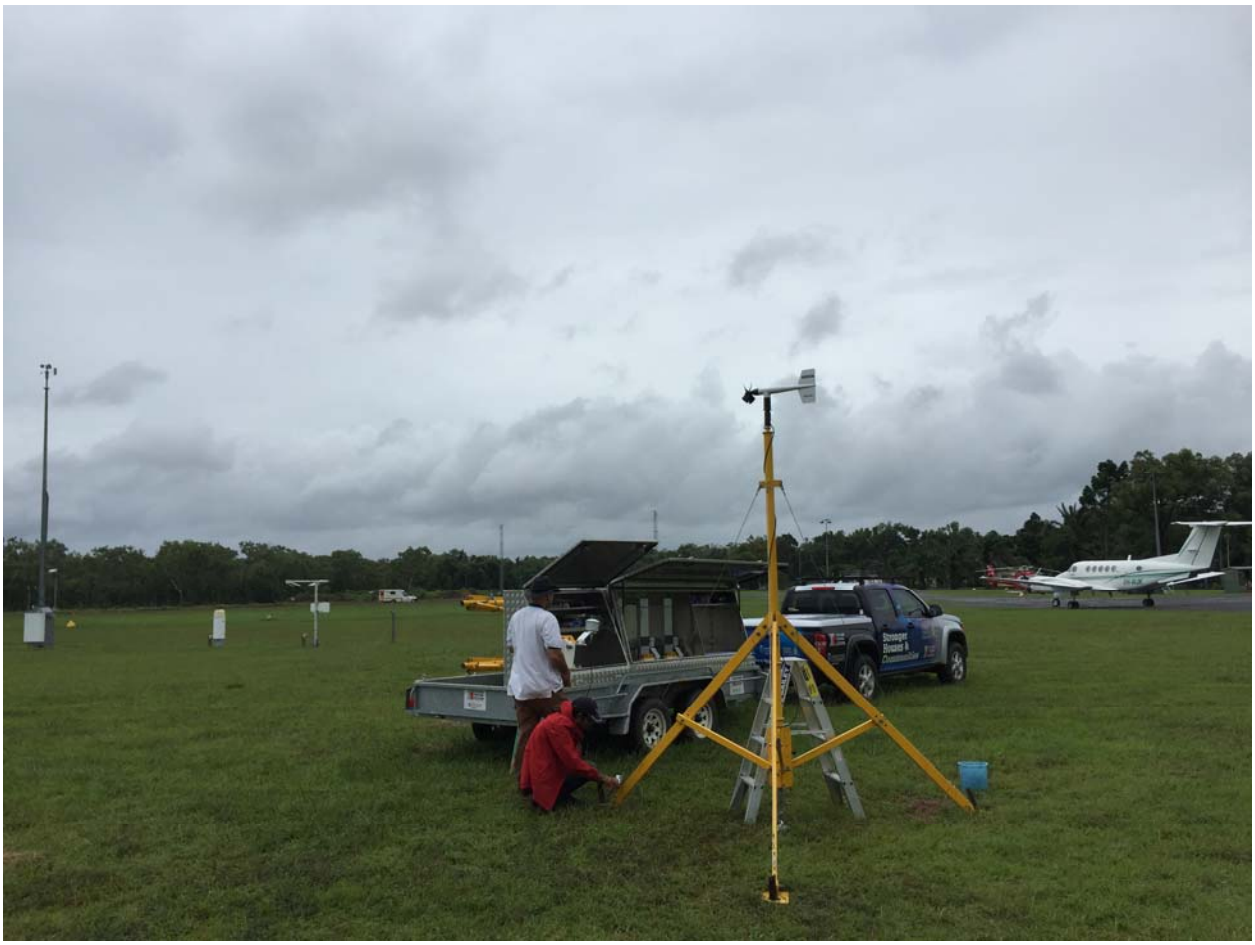


Figure 7. SWIRLnet anemometer Tower 1 (3 m height) and Cooktown Bureau of Meteorology (10 m height) automatic weather station (left hand side of figure) at the Cooktown Airport during TC Nathan.

SWIRLnet Observations

Figures 8-12 provide summarized time-history data for the SWIRLnet anemometer Towers 1-5. This is raw data which has yet to be fully analysed and validated by the CTS. The more detailed analysis of the SWIRLnet data may involve correction for calibration factors of each instrument and the surrounding exposure conditions.

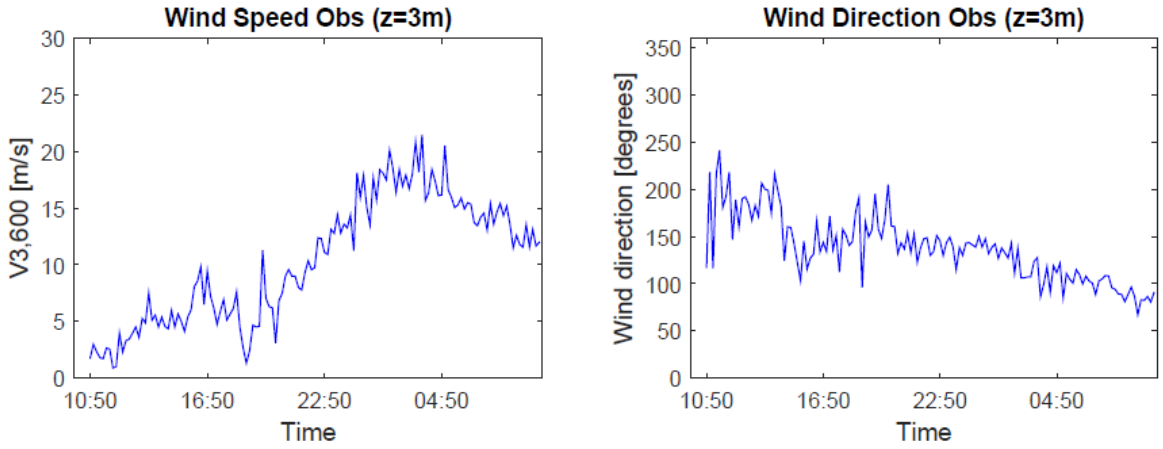


Figure 8. Wind speed (V3,600) and direction measurements from SWIRLnet Tower 1 (located at the Cooktown Airport) beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

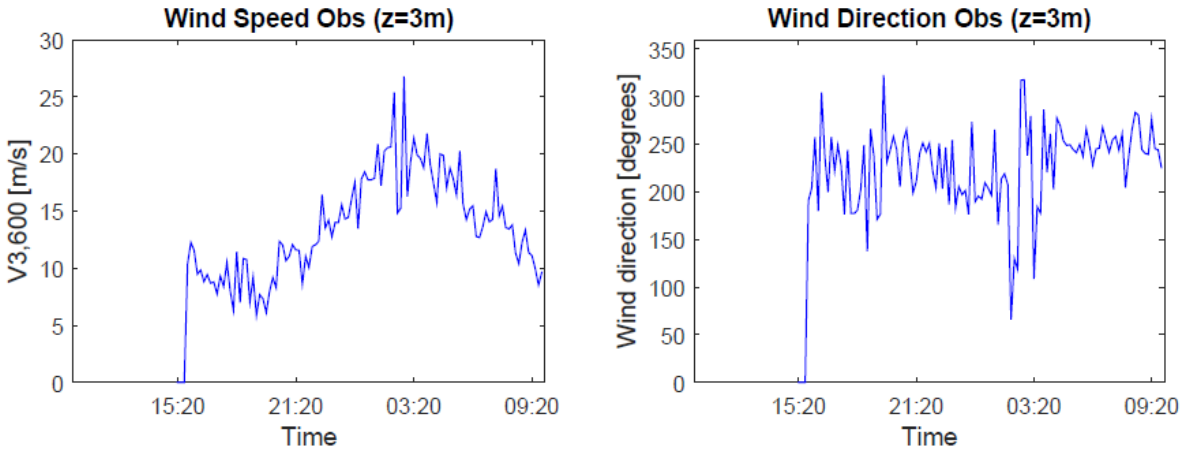


Figure 9. Wind speed (V3,600) and direction measurements from SWIRLnet Tower 2 (located near the Cooktown Community Center) beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

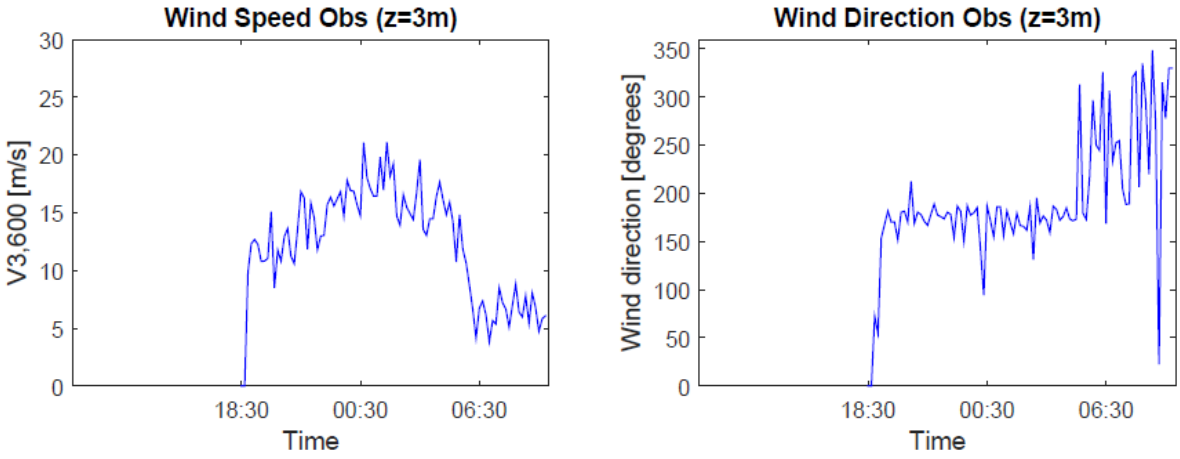


Figure 10. Wind speed (V3,600) and direction measurements from SWIRLnet Tower 3 (located on Charlotte Street near the Cooktown jetty) beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

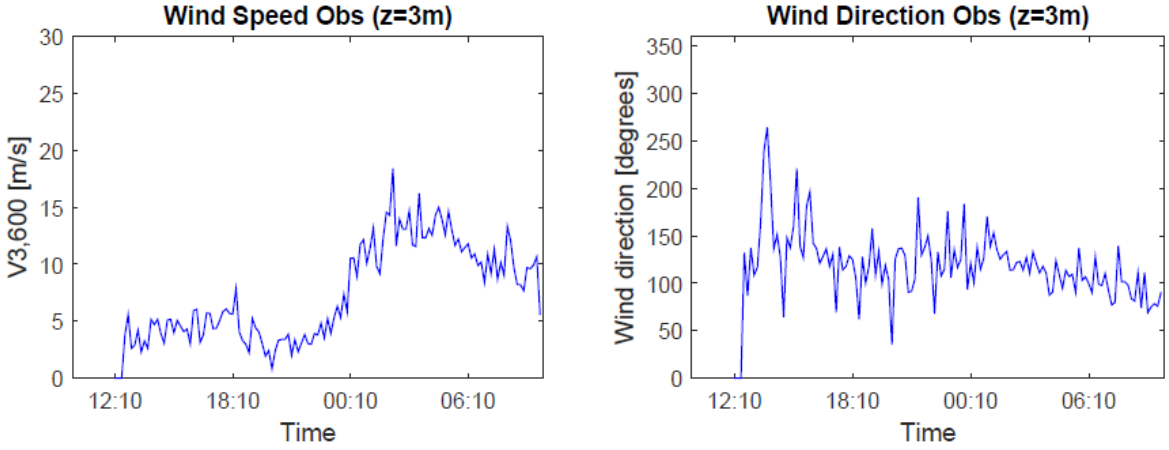


Figure 11. Wind speed (V3,600) and direction measurements from SWIRLnet Tower 4 (located West of Cooktown on private land) beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

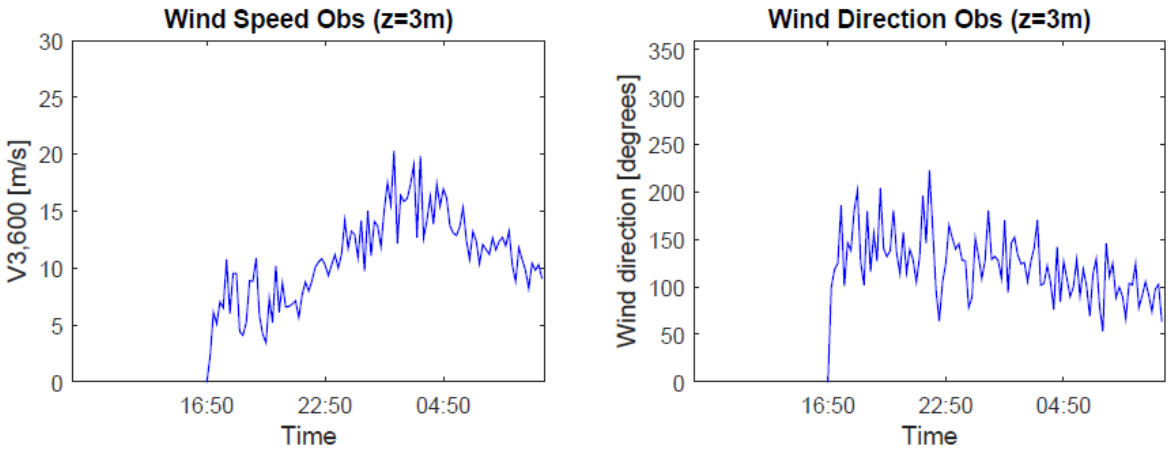


Figure 12. Wind speed (V3,600) and direction measurements from SWIRLnet Tower 5 (located adjacent to Cooktown racetrack) beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

Australian Bureau of Meteorology Observations

Figures 13-15 provide summarized time-history data for the BoM automatic weather stations (AWS) located at Bougainville Reef, Cape Flattery, and Cooktown. This is raw data and has yet to be confirmed by the Bureau of Meteorology. Their more detailed analysis of the AWS data may involve correction for calibration factors of each instrument and establishing whether the reported data may have been truncated or corrupted for any reason.

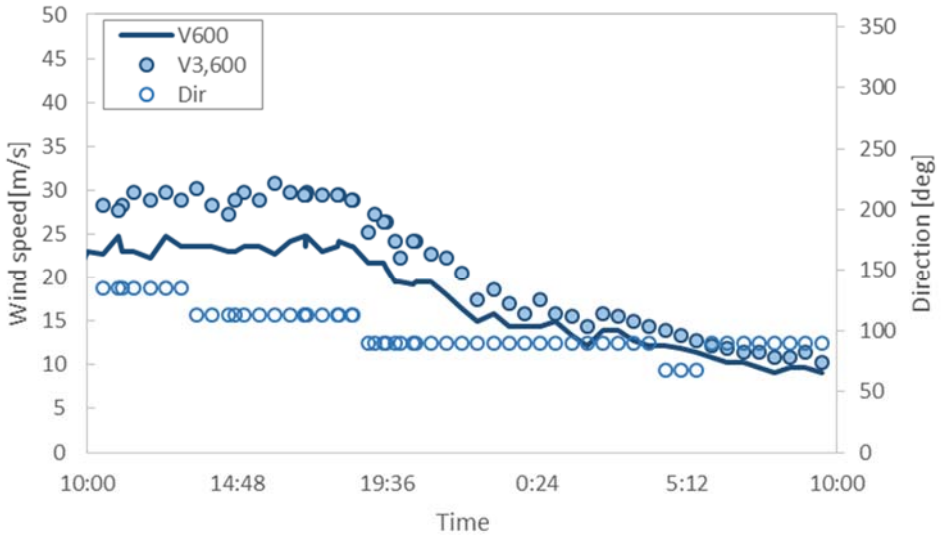


Figure 13. Wind speed and direction measurements from the Bougainville Reef automatic weather station beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

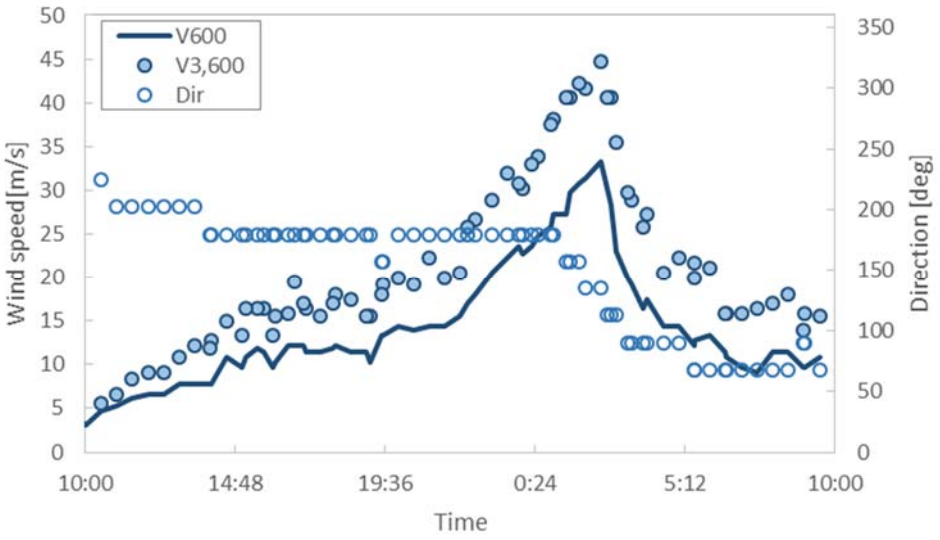


Figure 14. Wind speed and direction measurements from the Cape Flattery automatic weather station beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

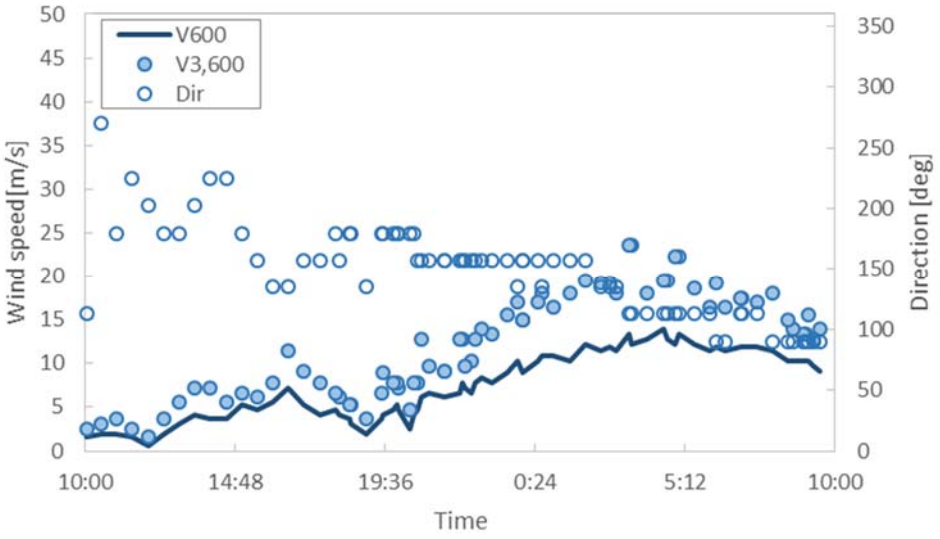


Figure 15. Wind speed and direction measurements from the Cooktown automatic weather station beginning 10 AM (AEST) Thursday 19 March and ending at 10 AM (AEST) Friday 20 March.

OBSERVED DAMAGE

Minimal damage was observed in Cooktown, although several instances of damage to ancillary items such as fences and television antennae was noted. Debris from vegetation was also minimal, with most trees retaining foliage and small amounts of branches on the streets. One instance of damage to a house due to tree fall was confirmed by the QFES. Additionally, no storm tide damage was observed.

The only observed severely damaged from wind loads building was a work/storage shed that failed. Wind speeds measured in the area were well below the anticipated design wind speed for this location. This building also experienced a roofing failure in Cyclone Ita and there was evidence of re-roofing. Initial indications suggest that aspects of the current roofing system may not have conformed to manufacturer's recommendations.

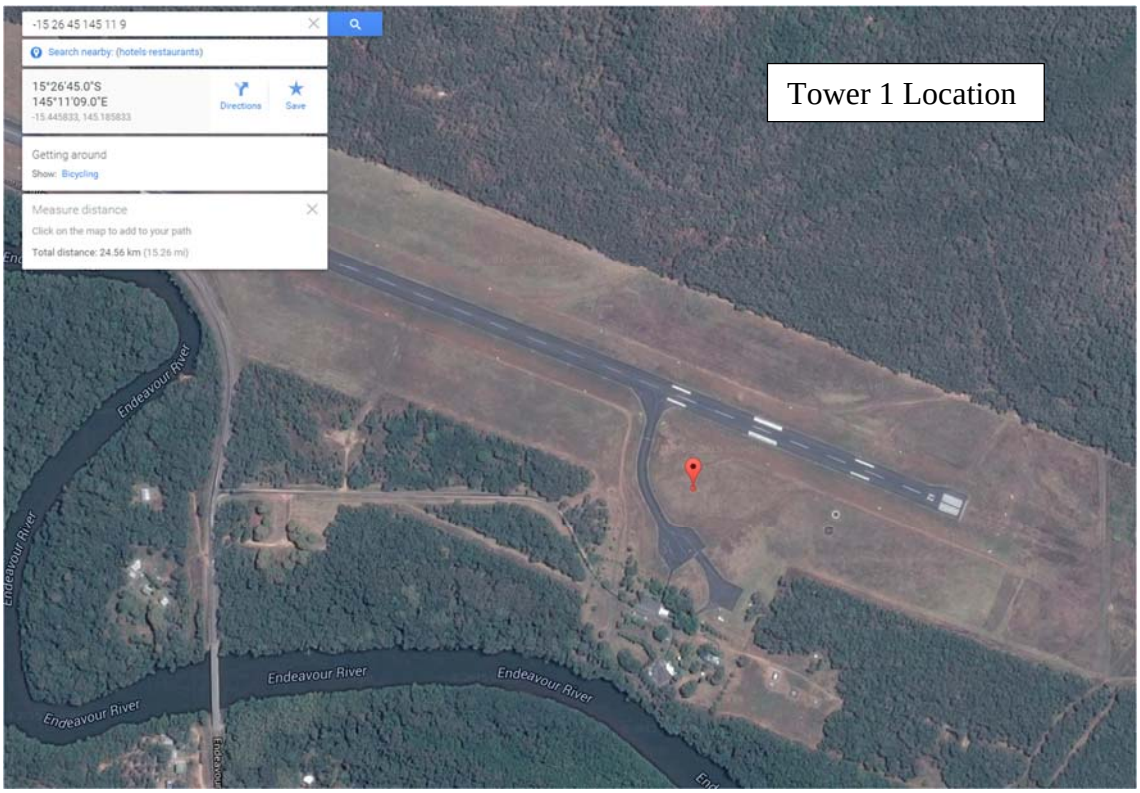
The QFES provided preliminary reports on damage in other more remote locations that were closer to the eye of the cyclone: No severe damage was observed in Cape Flattery, with some minor damage to shade sails. Lizard Island was more severely affected by the cyclone, with the total destruction of newly constructed resort unit at lockup stage and damage due to water ingress in other resort units.

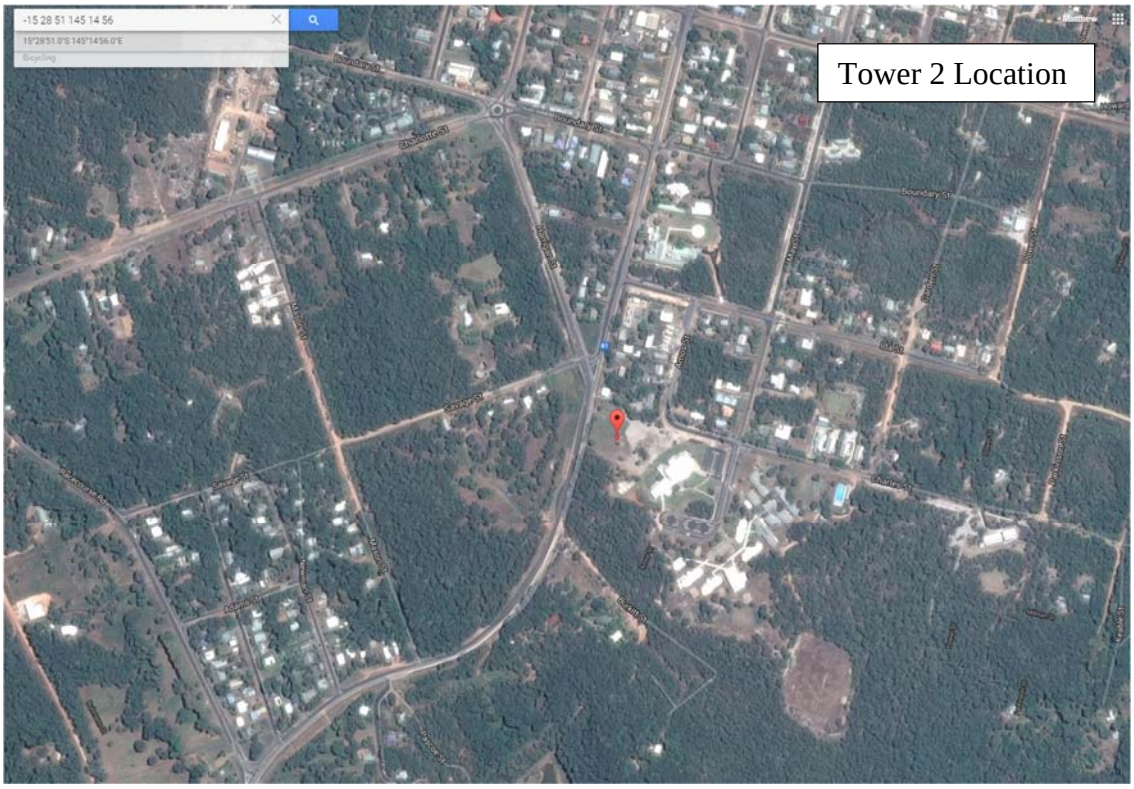
Figure 16. Wind damage to metal roof cladding and battens in Cooktown (Note: roller door was damaged during TC Nathan approach to coast in previous week)

Figure 17. Interior view of metal roof cladding damage to portal structure (see Figure 16)

Figure 18. Metal roof cladding removed from wind uplift and blown across street (Note: cladding from the structure in the previous figure)

Appendix


Tower 1 Location
-15 26 45 145 11 9
Search nearby: (hotels restaurants)
15°26'45.0"S
145°11'09.0"E
Directions
Save
Getting around
Show: Bicycling
Measure distance
Click on the map to add to your path
Total distance: 24.56 km (15.26 mi)
Endeavour River
Endeavour River
Endeavour River
Endeavour River
Endeavour River


Tower 2 Location
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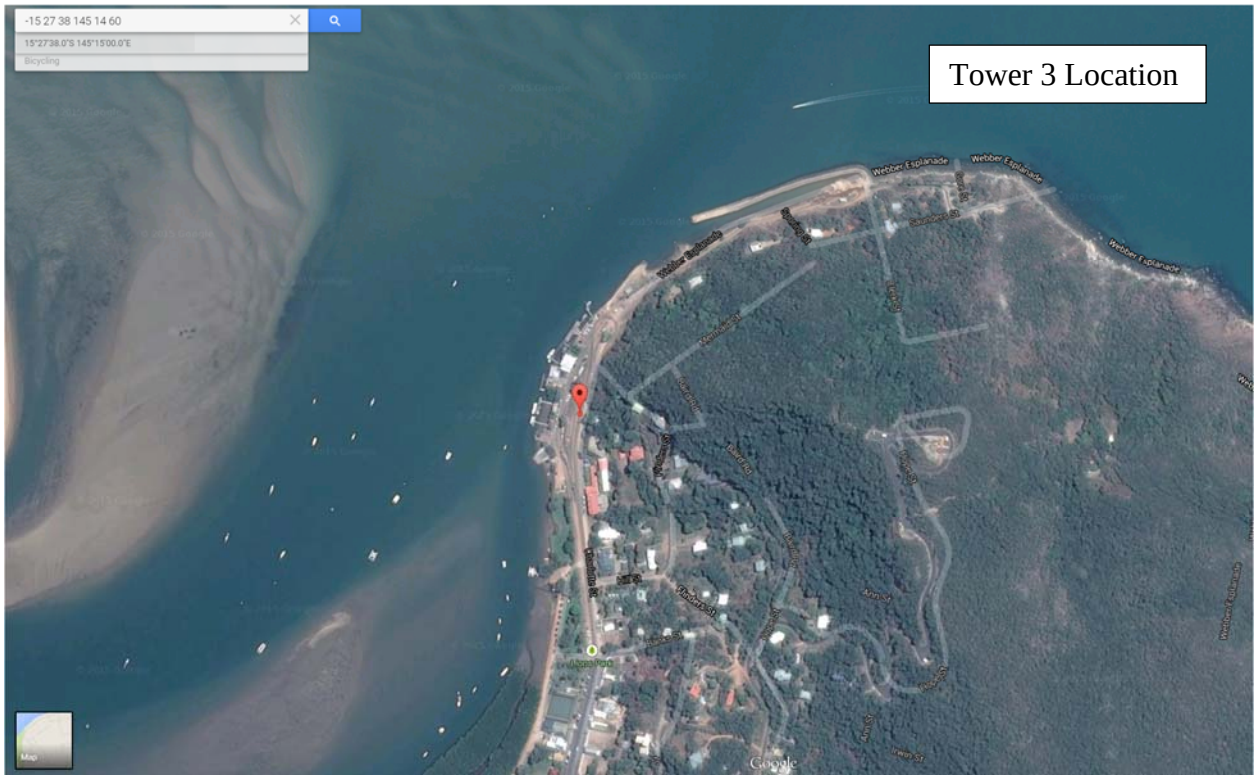
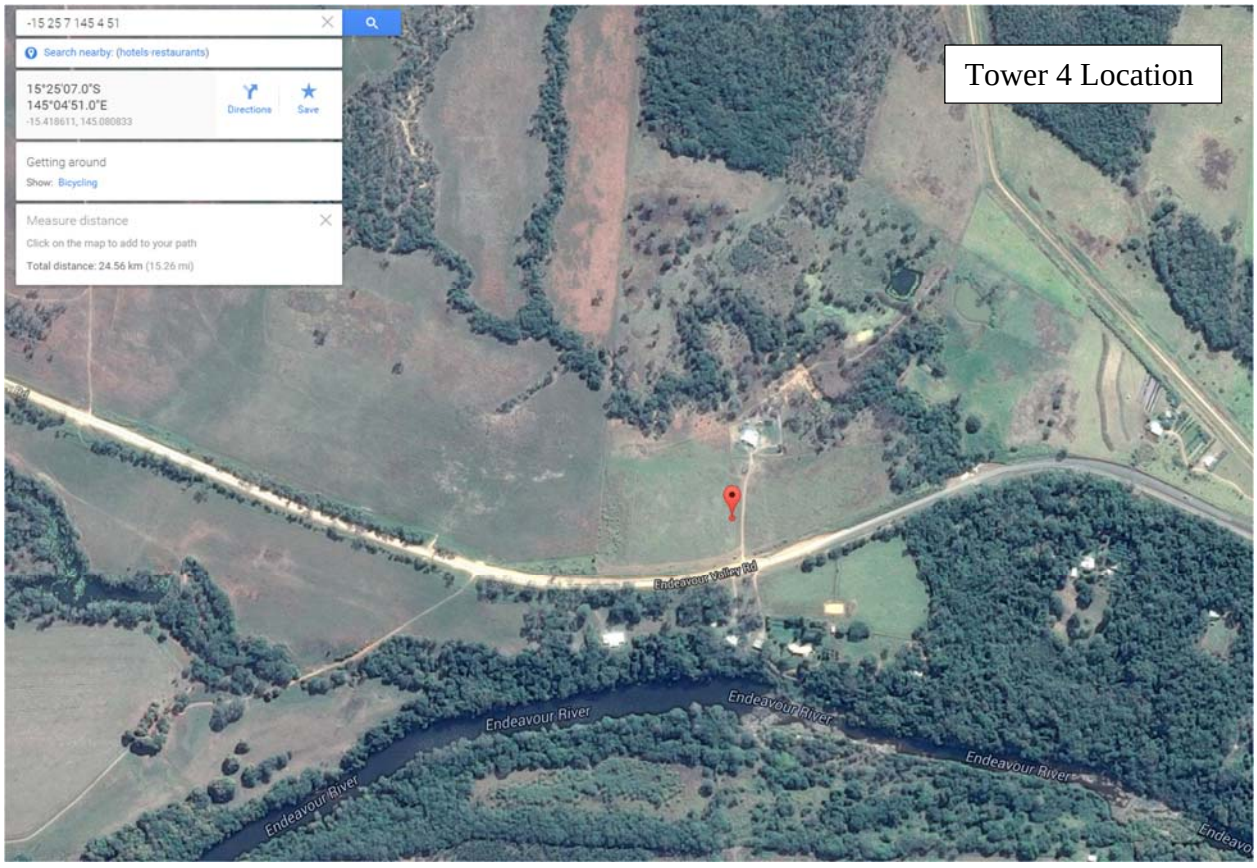
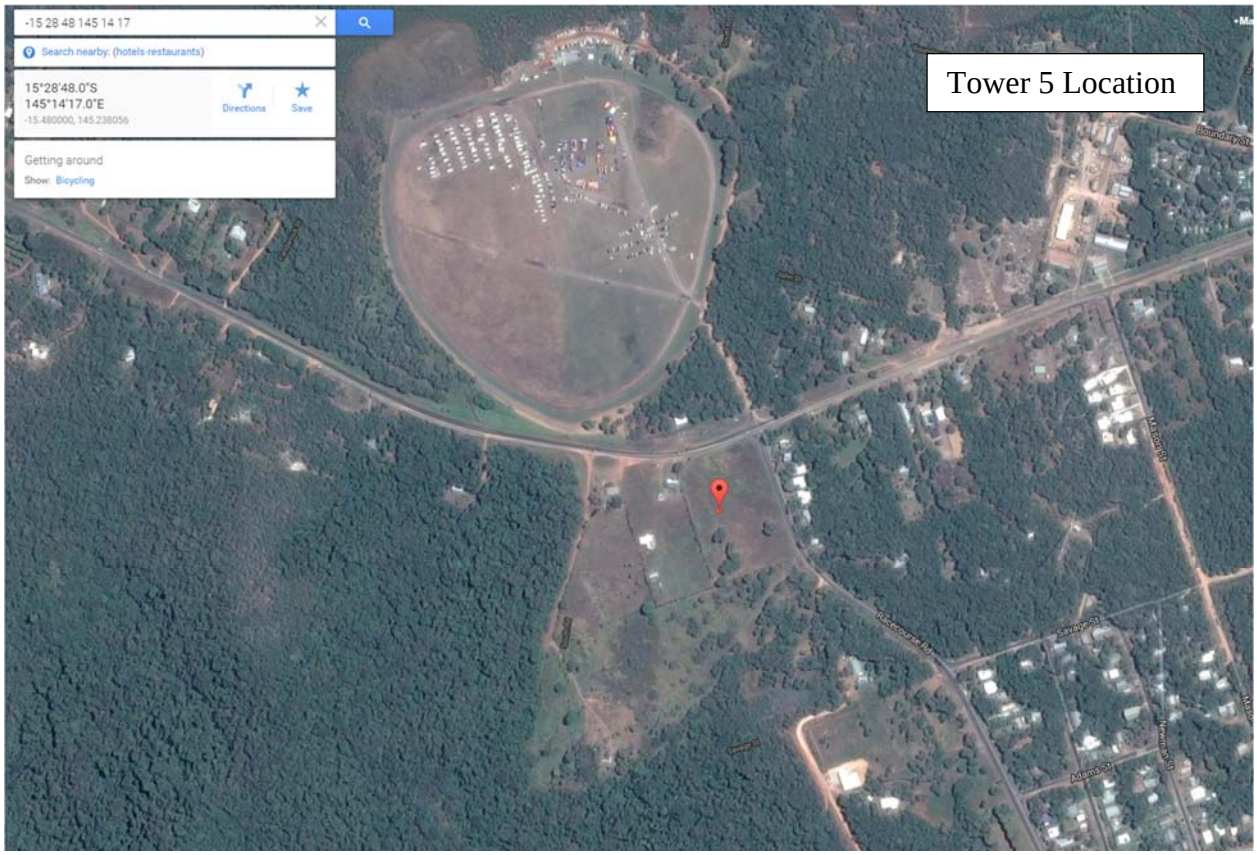
Boundary St
Charlotte St


-15 27 38 145 14 60
15°27'38.0"S 145°15'00.0"E
Bicycling
Tower 3 Location
Webber Esplanade
Google


-15 25 7 145 4 51
Search nearby: (hotels·restaurants)
15°25'07.0"S
145°04'51.0"E
-15.418611, 145.080833
Directions
Save
Getting around
Show: Bicycling
Measure distance
Click on the map to add to your path
Total distance: 24.56 km (15.26 mi)
Tower 4 Location
Endeavour Valley Rd
Endeavour River
Endeavour River
Endeavour River
Endeavour River


-15 28 48 145 14 17
Search nearby: (hotels·restaurants)
15°28'48.0"S
145°14'17.0"E
-15.480000, 145.238056
Directions
Save
Getting around
Show: Bicycling
Tower 5 Location