Tropical Cyclone Narelle: Insights on resilience

Understanding damage, vulnerabilities and future risk to buildings in Wind Regions D, C, B2 and A

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Australian Government

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We acknowledge the Traditional Custodians across all the lands on which we live and work, and we pay our respects to Elders both past, present and emerging. We recognise that these lands and waters have always been places of teaching, research and learning.

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Executive summary

Severe Tropical Cyclone Narelle crossed the coast of Queensland on Cape York Peninsula, Northern Territory in east Arnhem Land and Western Australia near Coral Bay in the Gascoyne region. The main region of damage investigated in this report is the western Pilbara and Gascoyne regions including Exmouth, Learmonth, Coral Bay, Carnarvon and Gascoyne Junction in Western Australia. Through this area, the peak recorded and estimated wind gusts were around 60% to 70% of the design wind speed for Importance Level 2 buildings. This meant that wind loads were around 35% to 50% of the ultimate design wind loads for buildings in the area of the field investigation.

Despite the relatively low wind speeds, some new buildings and some old buildings experienced damage. Damage from rainwater ingress was more common than structural damage. The investigation showed that the extent of water damage to buildings could be severe for even small holes through which the leakage is driven. Water came through any type of structural damage including verandas and flashings, but also through flashings and windows where there was no structural damage.

In some older buildings, damage to structural elements was caused by corrosion or rot in structural elements. This was particularly the case for exposed elements such as verandas.

A few buildings experienced failure because of high internal pressures, and one building had significant damage from the combination of storm surge and wave action which impacted the walls of the building.

The investigation in the agricultural areas of the Gascoyne also highlighted concerns with the performance of agricultural shade structures.

The investigation highlighted damage to both ground-mounted and roof top solar PV systems even though wind loads were between 35% and 50% of the wind actions for Importance Level 2 buildings. Solar panels that became wind-borne debris caused damage to other buildings and in some cases travelled over 1 kilometre.

The report makes recommendations about:

- maintenance of buildings
- selection of corrosion resistant materials for structural elements in coastal environments
- design and construction of buildings in cyclone regions
- fixing of solar PV panels.

Introduction

This report investigates damage to buildings caused by Severe Tropical Cyclone Narelle that crossed the Western Australian coast south of Coral Bay Friday 27th March 2026 at around 1pm as a category 3 severe tropical cyclone. It had previously been classed as a category 4 event as it approached North West Cape near Exmouth.

The field investigation commenced on Sunday 29 March 2026. It focused on the areas of Exmouth, Learmonth, Coral Bay, Carnarvon and Gascoyne Junction. It was supported by damage assessments undertaken by DFES staff.

The field deployment aligns with Natural Hazard Research Australia's research priorities focused on improving community resilience to extreme weather events through evidence-based building design and construction practices.

Research approach

The CTS monitored the passage of Tropical Cyclone Narelle through Queensland Northern Territory and Western Australia maintaining contact with emergency services personnel to establish the damage reported in each jurisdiction.

The CTS along with the Western Australia Department of LGIRS deployed two teams to investigate damage based out of Exmouth and Carnarvon. The northwest coastal highway was cut between Carnarvon and Coral Bay which prevented the two teams from meeting up. The field investigations commenced on Sunday 29 March 2026 and the site work was completed on Thursday 2 April 2026. The teams focused on areas affected by wind, rainfall and coastal processes.

Field observations included photographic documentation, inspection of structural elements and assessments of water ingress and damage to building envelopes. Wind speed data from Bureau of Meteorology Automatic Weather Stations (AWS) were analysed and corrected for terrain and topography to benchmark building performance against relevant standards. This data was augmented with information from simple structures such as road signs (windicators) and a numerical model of the cyclone winds to derive a wind field for the event.

The study aimed to identify recurrent vulnerabilities and contribute to the evidence base supporting improved building codes, construction practice and community preparedness in cyclonic regions.

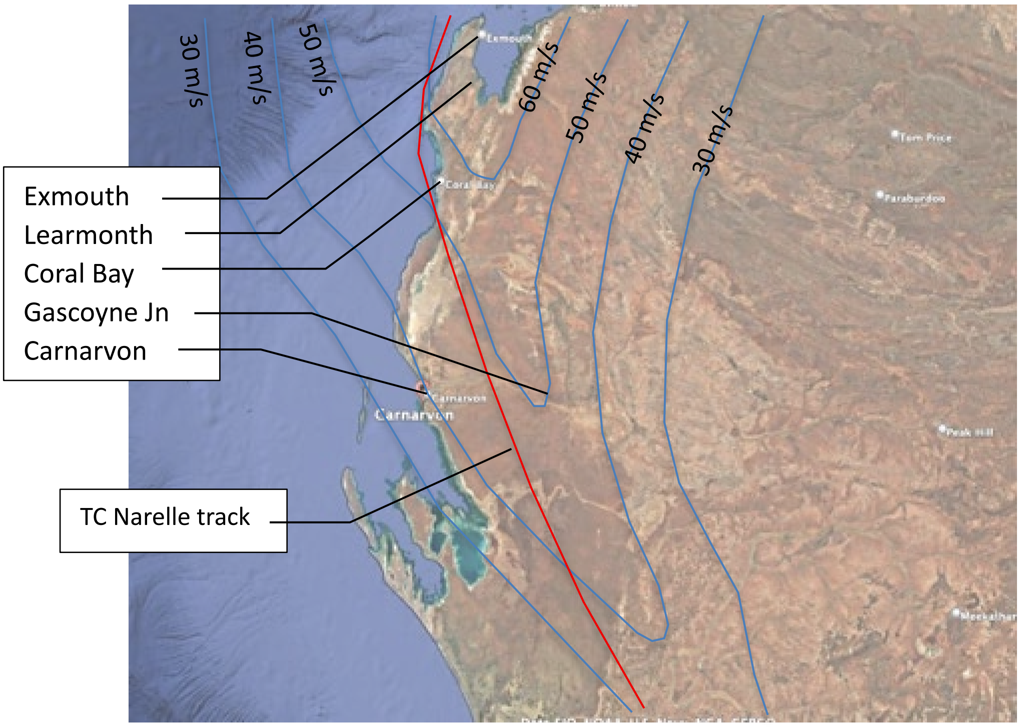
Wind field

Data from Bureau of Meteorology AWS was analysed to estimate peak gust wind fields near the track of Tropical Cyclone Narelle in Queensland, Northern Territory and Western Australia. The work involved adjusting wind speeds for terrain and topography so that the output was equivalent to standard conditions of flat land with open terrain. The reported gust wind speed records from the AWS were all 3 second gust wind speeds, while the Australian wind loading Standard AS/NZS 1170.2 uses 0.2 second wind gust speeds, so the data was converted to 0.2 second gusts. This enabled it to be compared directly with the design wind speeds tabulated in AS/NZS 1170.2. A table shows the peak wind gusts recorded by each AWS or estimated from windicators or the numerical model of the cyclone in each community. The table also shows the peak gust wind speed as a percentage of the design wind velocity for Importance Level 2 structures (such as houses).

Refer to CTS Technical Report Technical Report 72 *TC Narelle, Queensland, Northern Territory and Western Australia: Damage to Buildings* for detail on the conversion of the wind gust data and development of the wind field maps for each of the three crossing points.

Station	**peak 0.2 s gust (m/s)**	**peak 3 s gust (km/h)**	**Bearing**	**Date and time**	**Region**	**%V_{IL2}**	**Source**
Cape Flattery, Q	25.0	80	135	19/3 20:00	C	38%	AWS
Cooktown, Q	21.5	69	135	19/3 23:45	C	33%	AWS
Lockhart River, Q	38.0	121	315	20/3 09:26	C	58%	AWS
Coen,Q	(33)	(104)			C	(50%)	model
Sherger, Q	22.1	70	337.5	20/3 16:00	C	33%	AWS
Weipa, Q	34.0	109	315	20/3 17:00	C	52%	AWS
Kowanyama, Q	16.2	52	135	20/3 16:30	C	25%	AWS
Gove, NT	30.6	98	292.5	21/3 23:00	C	46%	AWS
Groote Eylandt, NT	26.8	85	112.5	22/3 01:19	C	41%	AWS
Ngukurr, NT	22.4	71	112.5	22/3 09:30	B	39%	AWS
Bulman, NT	17.8	57	225	22/3 07:11	A	40%	AWS
Central Arnhem, NT	24.3	78	315	22/3 16:00	A	54%	AWS
Jabiru, NT	18.0	57	315	22/3 17:00	B	32%	AWS
Tindal, NT	24.3	78	112.5	22/3 20:12	A	54%	AWS
Mt Bundy S, NT	18.6	59	315	22/3 18:26	B	33%	AWS
Douglas River, NT	24.2	77	0	23/3 02:30	A	54%	AWS
Wadeye, NT	21.7	68	202.5	23/3 02:30	C	33%	AWS
Kununurra, WA	20.3	65	112.5	23/3 14:30	B	36%	AWS
Wyndham, WA	19.7	63	90	23/3 20:38	C	30%	AWS
Kalumburu, WA	15.6	50	0	24/3 11:06	C	24%	AWS
Koolan Island, WA	27.0	86	0	25/3 05:28	C	41%	AWS
Lombadina, WA	23.0	73	0	25/3 01:30	C	35%	AWS
Broome, WA	23.7	76	90	25/3 03:11	C	36%	AWS
Rowley Shoals, WA	40.6	134	0	25/3 18:19	C	61%	AWS
Bedout Island, WA	42.0	139	45	26/3 08:22	D	49%	AWS
Port Hedland, WA	30.0	96	45	26/3 10:13	D	35%	AWS
Karratha, WA	38.1	122	90	26/3 14:50	D	45%	AWS
Onslow, WA	47.8	153	45	27/3 01:30	D	56%	AWS
Exmouth, WA	(60)	(191)			D	(70%)	Windicators
Learmonth, WA	60.2	193	67.5	27/3 06:22	D	71%	AWS
Coral Bay, WA	(50)	(158)			D	(60%)	Windicators
Gascoyne Jn, WA	(51)	(161)			A		Windicators
Carnarvon, WA	41.5	133	112.5	27/3 15:40	C	63%	AWS
Geraldton, WA	27.2	87	45	26/3 10:44	B	48%	AWS

There was minimal reported structural damage to communities in Queensland and Northern Territory, so no damage investigation was undertaken in those regions. However, there was structural damage in the region where Tropical Cyclone Narelle crossed the Western Australia coastline. The wind field in that investigation area is shown below.

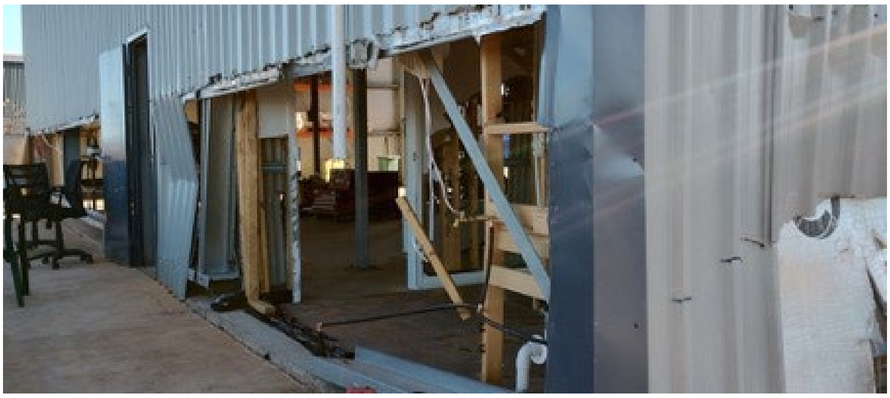


0.2 second wind gusts (Compatible with AS/NZS 1170.2)

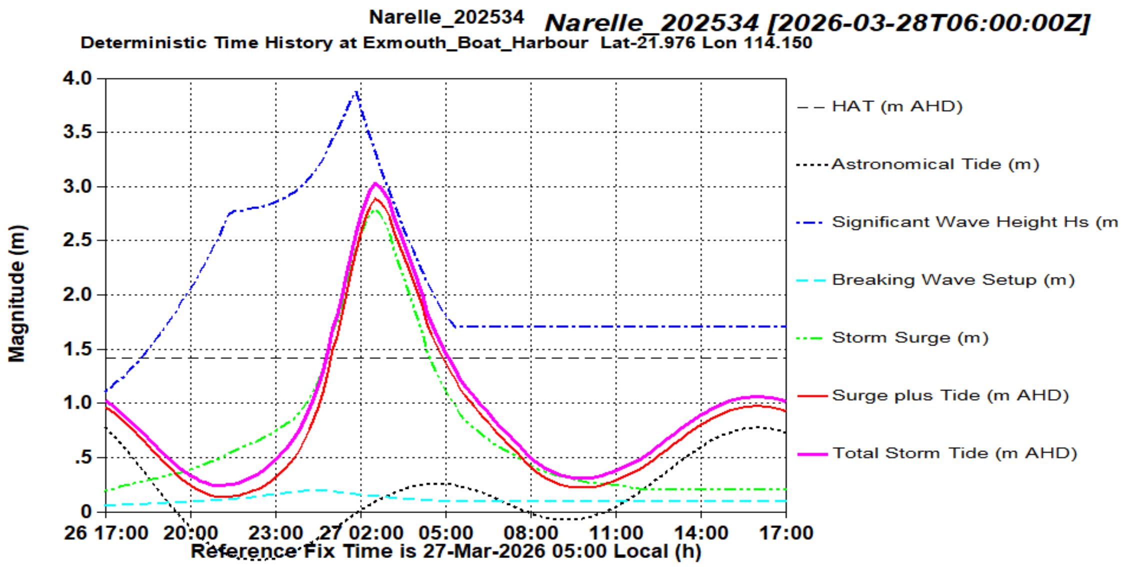
The estimated wind speeds in the inspected region were between 60% and 70% of the design wind speed for houses. Wind loads are calculated from wind pressures that are based on the square of the wind speed, so the loads that the buildings in this area had to resist are less than 50% of the required design load the building components).

Storm tide measurements

There were significant storm tide effects in Exmouth Gulf. They were a combination of storm tide and wave action. The data from the tide gauge at Exmouth showed that the storm tide there was 3 metres. This correlated well with the modelling from SEAtide which is shown below. It indicates that storm tide peaked at 3 metres Australian Height Datum (AHD) and at the same time the most significant waves in the Gulf were around 3.8 metres. The combination of wave action and storm tide height broke over the sea wall at the Exmouth Marina. This damaged the sea wall and several buildings.



Wave and storm tide damage to a building at Exmouth wharf



SEA Tide modelling of storm tide at Exmouth

A combination of wave action and a higher storm tide further south in the Gulf near Learmonth caused the water to overtop the dunes and break into the land near Learmonth airport. The water washed over the runway, taxiways and carparks and damaged the road between Exmouth and Learmonth. Having travelled over 2 kilometres inland to reach the airport, the effects of waves were minimal. Damage caused by storm tide at the airport was due to inundation. Storm tide did not damage the airport terminal.

Storm tide mark on fence and damage in a carpark at Learmonth airport

Refer to [CTS Technical Report 72](#) for more detail on the analysis of water height data.

Damage from wind effects

In the investigation area, there were a number of buildings that had experienced wind damage.

Wind-borne debris

Trees and branches impacted building, and there were a number of cases in which building components struck buildings and caused damage.

Windborne debris in Exmouth, piece of timber, section of complete roof, solar panels

Screens and debris protection that can absorb the energy of a piece of timber cannot protect against heavier items such as portions of a roof or solar panels shown in the Figure above. The only effective way of preventing roof loss after a debris strike is to design the building to be able to cope with the high internal pressure following creation of a large opening by wind-borne debris.

Internal pressure

Some buildings failed because of internal pressure following breakage of windward wall envelope elements.

A large, enclosed shed lost two sliding doors off one side when the wind was blowing parallel to the ridge, and the doors were sucked out by the sidewall negative pressure. After the wind direction changed by 90°, the very large opening was on the windward wall, and the internal pressure damaged the roof and blew out the ends of the building. It is shown below in the left photo.

The right photos below show a building in which the vent shown allowed pressurisation of the roof space above the ceiling and this positive pressure above the ceiling caused it to be pushed into the building.

Damage following internal pressure

Damage to houses from failed verandas

The inspection investigated 12 buildings in which verandas had failed. In nearly all cases, the reason for the failure when the wind loads were around 50% of the design wind loads for the region was deterioration of connections or the veranda posts.

Deterioration of metal components at ground level was common. Metal posts corroded where they contacted either the ground or concrete. Some timber posts supported on stirrups also failed because of either rot in the timber or corrosion of the stirrup. Loss of the integrity of the posts enabled the whole veranda to fold back at the eaves line. This damaged the wall and the roof behind the veranda. Where the veranda completely separated from the house, it became significant wind-borne debris. The following photo shows ground-line elements of verandas that had deteriorated.

Deterioration of veranda posts at ground line that led to veranda loss

Deterioration of connections in the veranda also caused damage to the veranda with creation of more debris. Corrosion of connections within the veranda are illustrated below.

Deterioration of other elements in verandas

All structural elements in verandas are exposed to the elements so resilience can be improved by selecting the appropriate corrosion resistance levels for metal elements in verandas. Continued maintenance should include replacing elements that have corroded or rotted. Painting elements that have been compromised by loss of competent material to corrosion or rot will not restore their structural function.

Roof damage

Roof damage was observed on some new buildings and some older buildings. The wind actions in Regions C and D were around 50% or less of the design wind actions. Damage in these areas was caused by:

- deterioration of roof fixings
- use of nails in batten to rafter connections
- errors in installation of roof tie downs
- poor fastening of flashings.

Roof damage to older buildings

Water damage to buildings

More buildings were damaged by water entry than were structurally damaged. The study observed the following main entry points for water:

- through the roof
- through closed windows and doors.

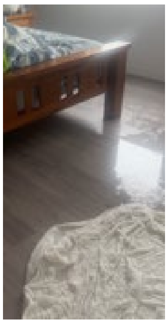
Water entering through the roof

Where flashings had lifted or were ineffective, water had direct access to the roof space. Likewise, where verandas had been lost, the fascia or the roof was damaged. This allowed water into the roof space. In these cases, ceilings collapsed onto building contents as shown below.

Ceiling loss following damage to a veranda

Relatively minor levels of cladding damage produced significant levels of ceiling loss. The photo above shows ceiling loss over nearly the whole room after a fascia had been removed during the loss of a veranda.

In addition to water entering the roof space where there had been some damage to cladding, water entered the roof space through the roof as wind-driven rain being forced under flashings or through minor gaps in the roof cladding. This included wind forcing water up box gutters away from the rain head or up valley gutters to enter the roof space at the top of the valley. The photos below show rain being blown over the top of a roof, water falling freely from the ceiling under a valley gutter and ceiling loss under a box gutter.



Rainwater passing up a roof slope, water falling from the top of a valley gutter and ceiling loss under a box gutter

Water entering through closed windows

There were reports that during the event, water entered buildings through closed windows and ran down the inside of the walls onto floor coverings. It entered through weep holes which had the appearance of water bubbling up through the window tracks. Under normal operation, any water that gets to the inside of a window drops into the sill where it is drained to the outside through weepholes. Under high winds, there is a strong pressure differential from the outside to the inside across the window. This can prevent water from draining out of the sill and drive water through the weep holes from the outside.

It also seeped around the window frame through the gap between the window frame and the building. In this case, it ran down the inside of the window and around the window and onto the floor.

Water can also enter through window seals, and through gaps around moving parts.

Significant volumes of water came under this bifold door as there was no seal

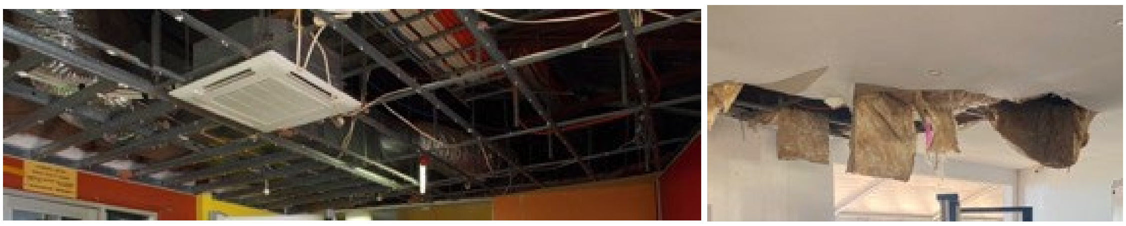
Consequences of water entry

Water inside the building damages floor coverings, contents and, in some cases, can cause damage to wall and ceiling linings. A number of buildings that had been damaged in 2015 during Tropical Cyclone Olwyn (Boughton et al., 2015) were checked for their performance after Tropical Cyclone Narelle. The wind speeds were similar in these two events. The figures below show a number of buildings that experienced nearly identical damage in the two events. This indicates that in repairing the building after Tropical Cyclone Olwyn, only the obvious damage was repaired without addressing the point of entry of the water. In each of these pairs of photos damage after Tropical Cyclone Olwyn is shown on the left and damage after Tropical Cyclone Narelle is shown on the right.

Damage to a flashing that caused ceiling loss inside the building

Bowing of lightweight sliding door causing water entry

Ceiling loss behind ineffective apron flashing



Ceiling loss under a vent in the roof space

Other structures

Agricultural shade cloth structures

In the area around the Gascoyne River, there are a number of plantations that use irrigation to grow a range of crops. The efficiency of these plantations is enhanced by shade cloth structures that protect crops and significantly reduce irrigation demand. These structures contribute to the resilience of the agricultural enterprises by limiting the exposure to variations between seasons.

Both agricultural shade cloth structures and shade sails for protection of people from sun, survived where they were removed as shown below.


Survival of shade structures where they were rolled up or removed

Where the shade cloth was not stowed, then there was significant damage to the structure so that it was no longer functional. Other methods must be investigated to make these structures resilient.


Damage to agricultural shade structures where they were not taken down prior to the event

Solar panels

For Exmouth, even though the wind loads were around 50% of the design wind loads for Importance Level 2 structures, there was still some damage to both ground-mounted and roof-mounted solar panels.

Ground-mounted panels failed by wind pressure causing either failure of the glass or crazing of the glass. In some cases, the camps anchoring the panels to the support structure failed by either loosening of the clamp or fatigue of the metal in the solar panel chassis.

Failure of ground-mounted solar panels, by failure of the glass and loosening of clamps

Roof-mounted panels also separated from the mounting systems by movement or failure of clamps. One panel was found 1.2 kilometres from its original position and other panels caused debris impacts into nearby structures.

Clamp failures allowed panels to move on the roof and be blown off the roof

Recommendations

The following recommendations have been drawn from the detailed investigations of buildings in the Exmouth, Coral Bay and Carnarvon regions coupled with similar findings from multiple CTS damage investigations in Western Australia, Northern Territory and Queensland.

Maintenance

Functionality of buildings may be compromised if all elements of the building including verandas are not in good condition. Replace any elements that have deteriorated. Undertake more frequent maintenance of tie downs in coastal environments.

Design and construction

All structures in the cyclone regions (B2, C and D) including sheds need to be designed to resist high internal pressures.

It is difficult to design buildings to resist waves on top of storm tide. Rather than building to resist wave action, it is better to avoid building in storm tide risk areas. Because of the risk to life of storm tide actions on occupied buildings, all buildings in storm tide areas should be evacuated.

In coastal areas, specify all exposed fasteners including cladding fasteners and connections to roof-mounted attachments with appropriate corrosion protection for their environment.

Further research is required on preservation of agricultural shade structures in high winds.

Wind-driven rain

AS 1562.1 requires flashing to be fixed to each face of the building with screws at closer centres than 500 millimetres. Fixings for any roof attachments should be designed to resist the appropriate wind actions.

Apron flashings, box gutters and valley gutters are all potential sources of wind-driven rainwater entry above the ceiling. If they cannot be avoided, they should be well sealed to prevent water from being blown over the edge of the gutter up under the roof. Profiled closed cell foam can assist in sealing these under the roof sheeting.

Windows and glass doors that do not comply with current Australian Standards are too flexible to keep out wind-driven rain. Even those that do comply with Australian Standards offer more effective prevention of water entry if the weepholes are protected.

In repairing elements damaged by water, it is important to not only fix the damaged linings, but also to address the point of water entry so that future events do not cause the same problem.

PV (and other attachments)

PV systems must be designed to resist the same wind actions as nearby structures. Select an appropriate importance level for solar panel installations based on expectation of functionality after severe events. Specify and install panels and support systems with appropriate wind ratings for the site.

Metal components of the support system should be tested for strength under repeated load and unload cycles.

Further reading

Boughton, G., Henderson, D., Ingham, S., Smith, B., McAulay, J., and Harper, B. (2026) "TC Narelle, Queensland, NT and WA – Damage to Buildings", Technical Report 72, Cyclone Testing Station, James Cook University. https://www.jcu.edu.au/__data/assets/pdf_file/0011/2336834/Technical-Report-72-TC-Narelle-v1.pdf

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