



Sector Building Resilience Under Fire

David Henderson
Chief Research Engineer at Cyclone
Testing Station, James Cook
University



Sector Building Resilience Under Fire

or

(Why are our buildings failing us?)

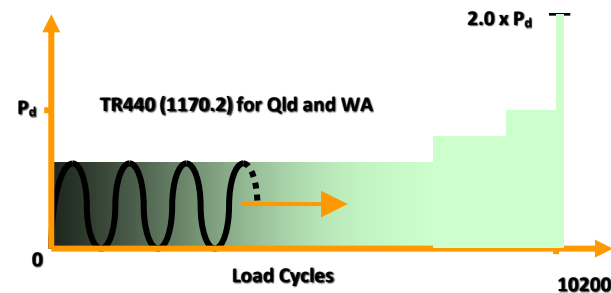
David.Henderson@jcu.edu.au

Content

- CTS
- NCC and Australian wind loading standard
- TC Seroja – Internal pressure
- TC Alfred – Wind driven rain
- TC Isla – PV
- Hail

CTS

- Founded in 1977
- Evaluating various building products from screws right up to whole houses
- Wind tunnel tests
- Damage investigations
- Vulnerability models





Cyclone Tracy (1974)



- Peak gust estimated 70m/s (250 km/h)
- 70-90% of housing destroyed
- Engineered structures performed better (in terms of structural robustness)

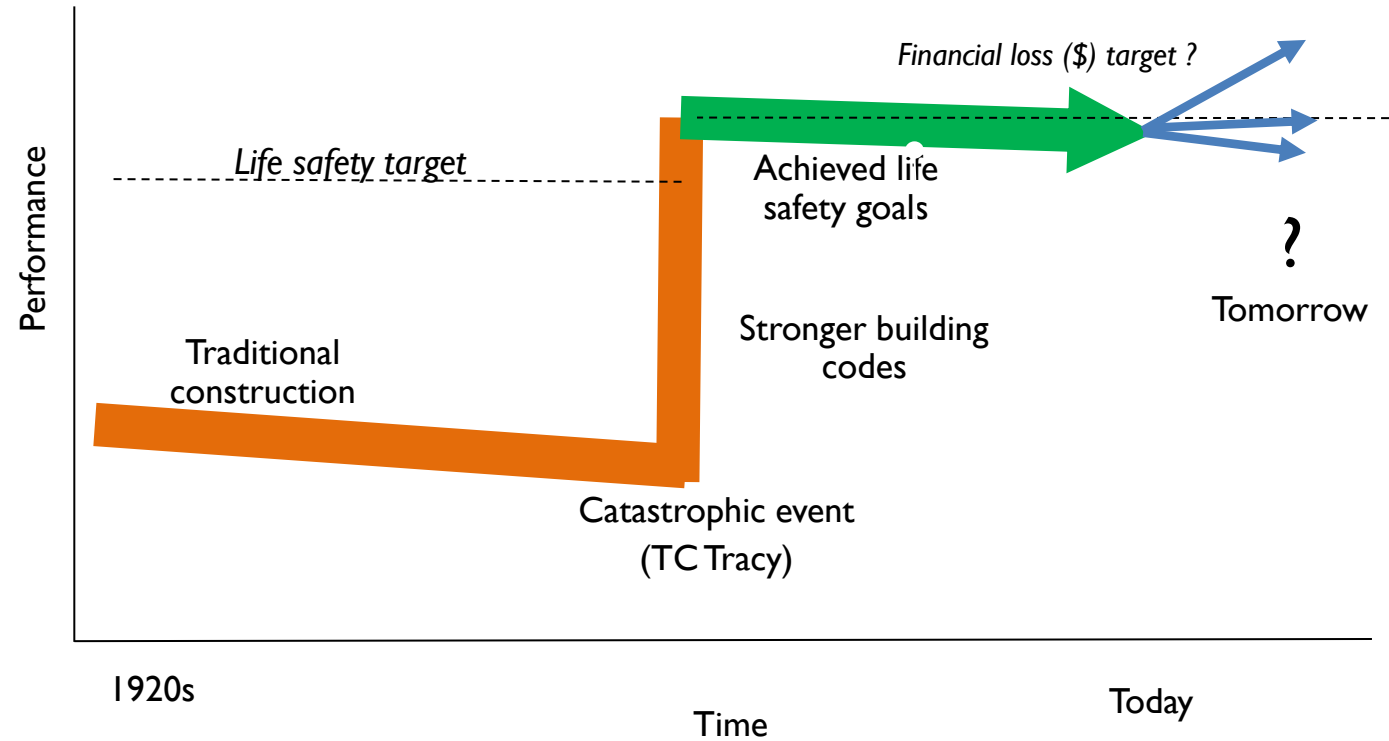


Queensland Home Building Code (1982)



BCA/NCC, Standards, TRADAC, Manufacturer load tables, etc.

Structural Performance



National Construction Code

BP1.1 Structural reliability

- (a) A building or structure, during construction and use, with appropriate degrees of reliability, must—
- (i) perform adequately under all reasonably expected design actions; and
 - (ii) withstand extreme or frequently repeated design actions; and
 - (iii) be designed to sustain local damage, with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage; and
 - (iv) avoid causing damage to *other properties*, by resisting the actions to which it may reasonably expect to be subjected.

Robustness

AS/NZS 1170.2:2021

Minimum design standards

NCC: Class 2 Importance level
 10% in 50 yrs prob of exceedance
 (1:500 Annual probability of exceedance)

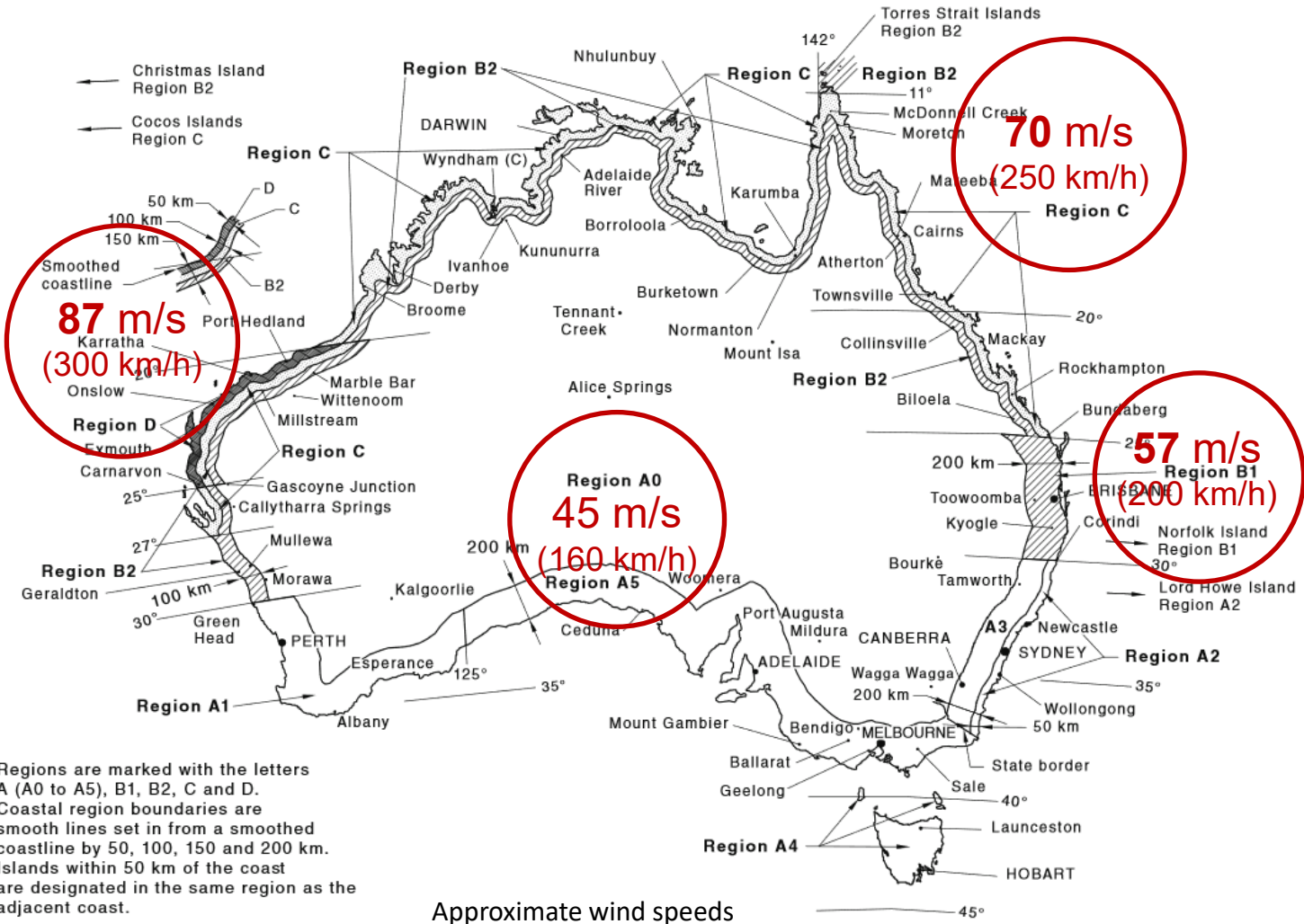
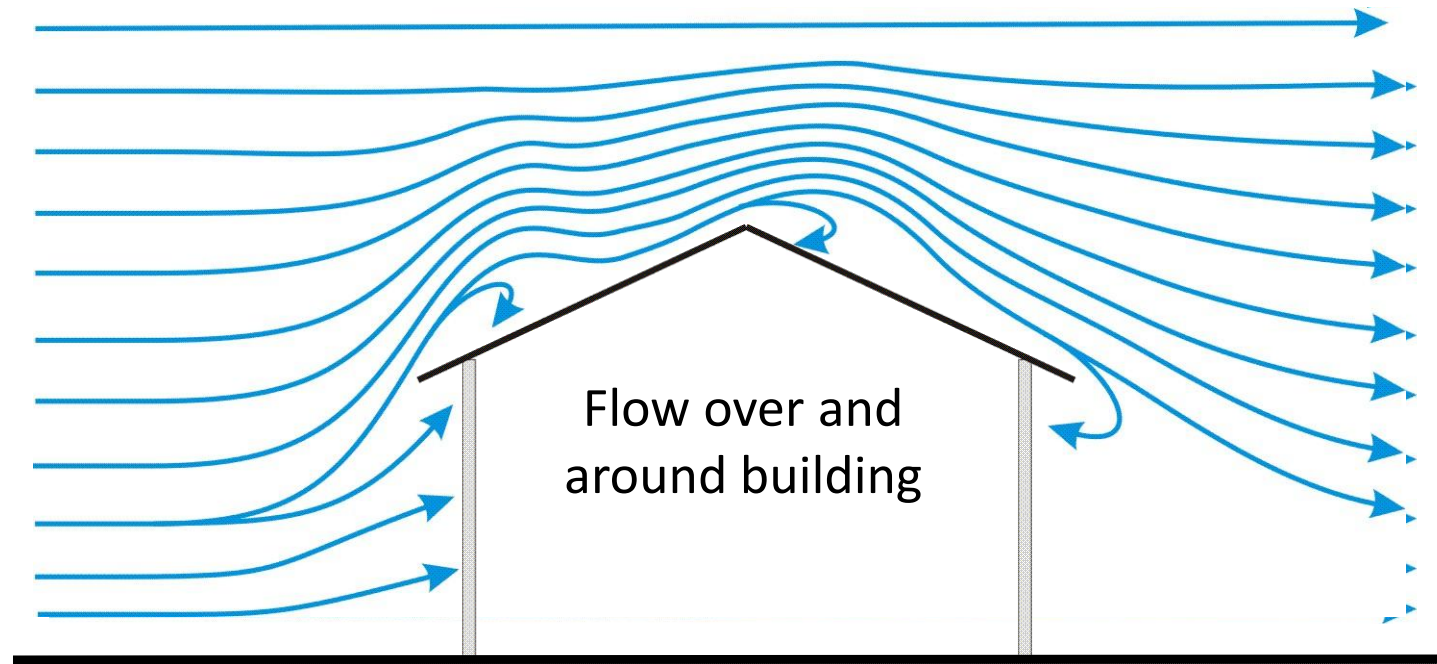


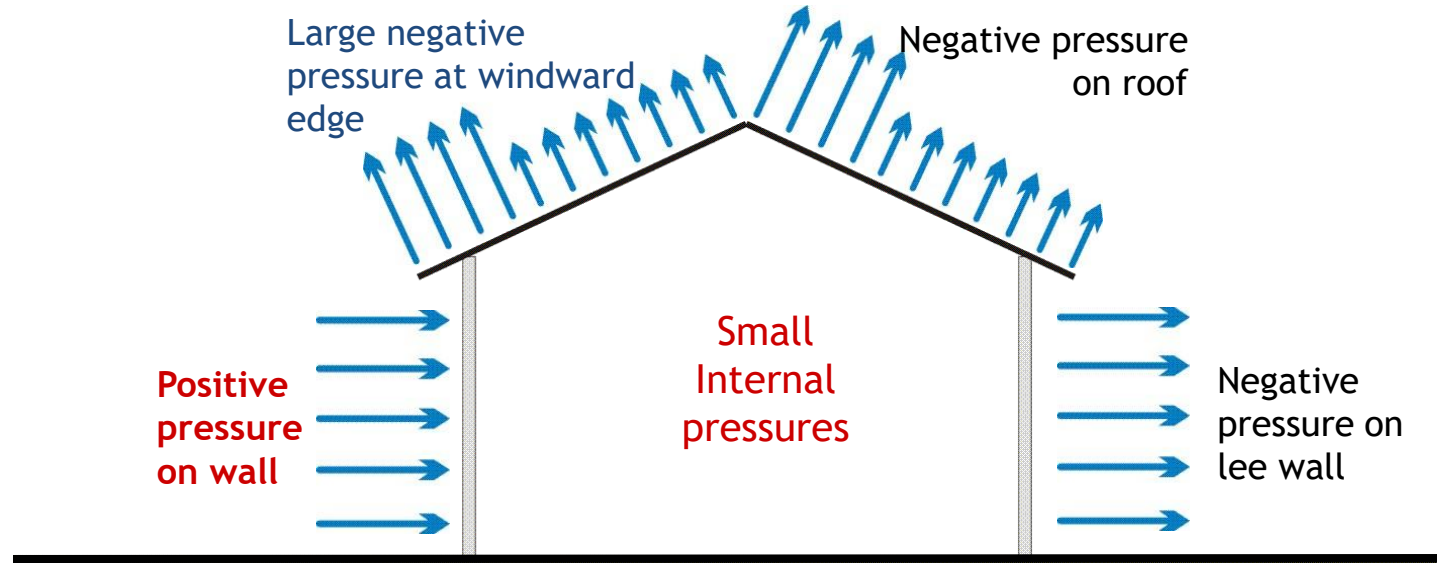
Figure 3.1(A) — Wind regions — Australia

Wind loads on building

Consider the forces caused by pressures induced by wind passing over structure

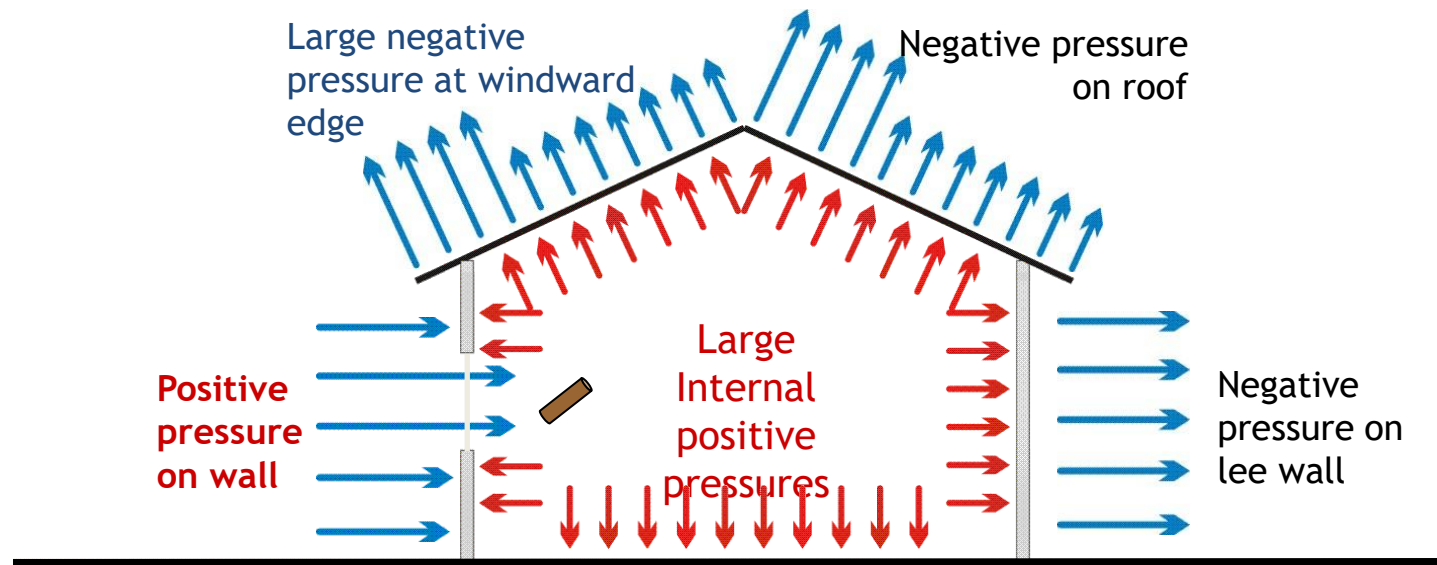


Wind loads on building



Wind loads on building

If an opening forms in the external envelope of the building
e.g. a window is broken or a door blows in...



Typically, designers only consider dominant opening for regions, C and D only

IBHS full scale wind tunnel



IBHS full scale wind tunnel



So... From different design criteria for internal pressure

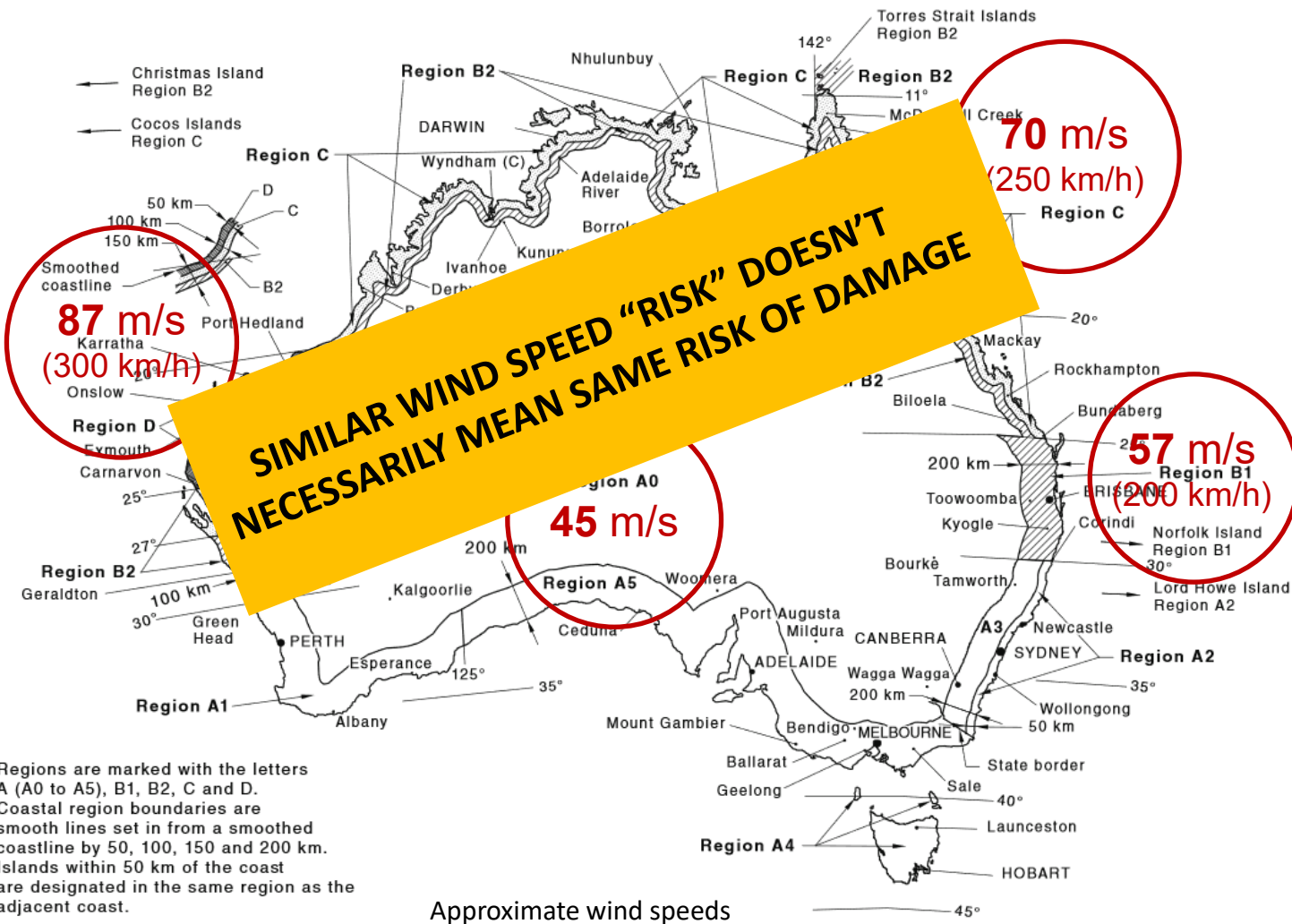


Figure 3.1(A) — Wind regions — Australia

AS/NZS 1170.2:2021

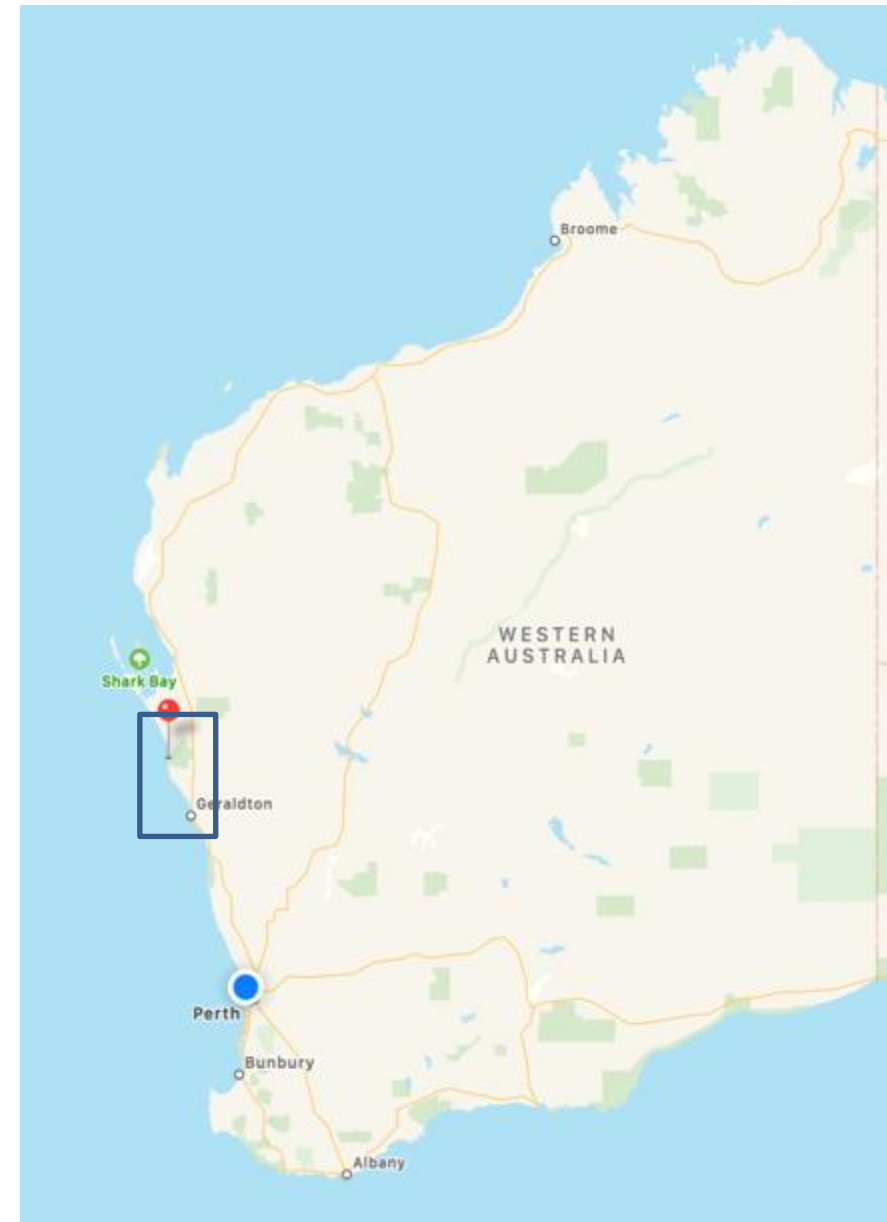
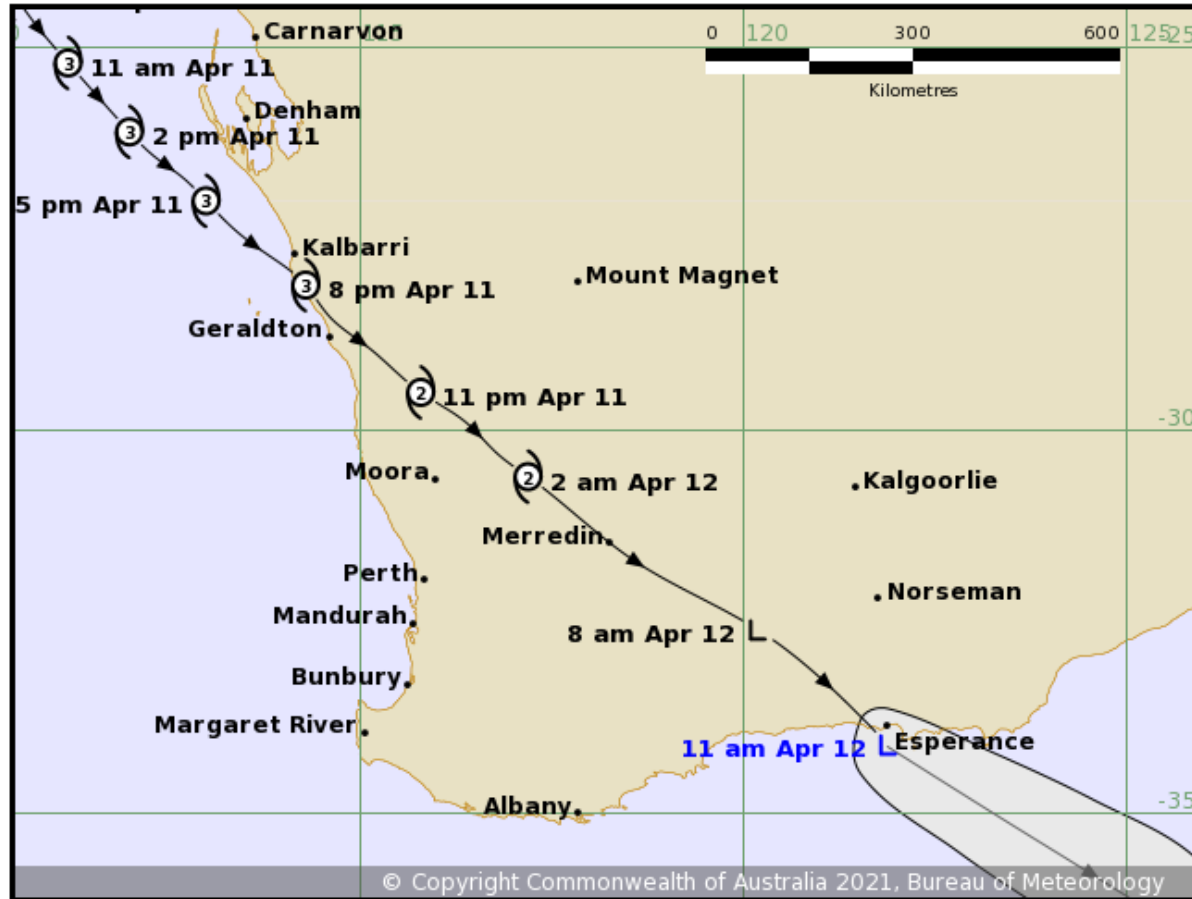
Minimum design standards

NCC: Class 2 Importance level
 10% in 50 yrs prob of exceedance
 (1:500 Annual probability of exceedance)

Track, affected area

Ex-Tropical Cyclone Seroja

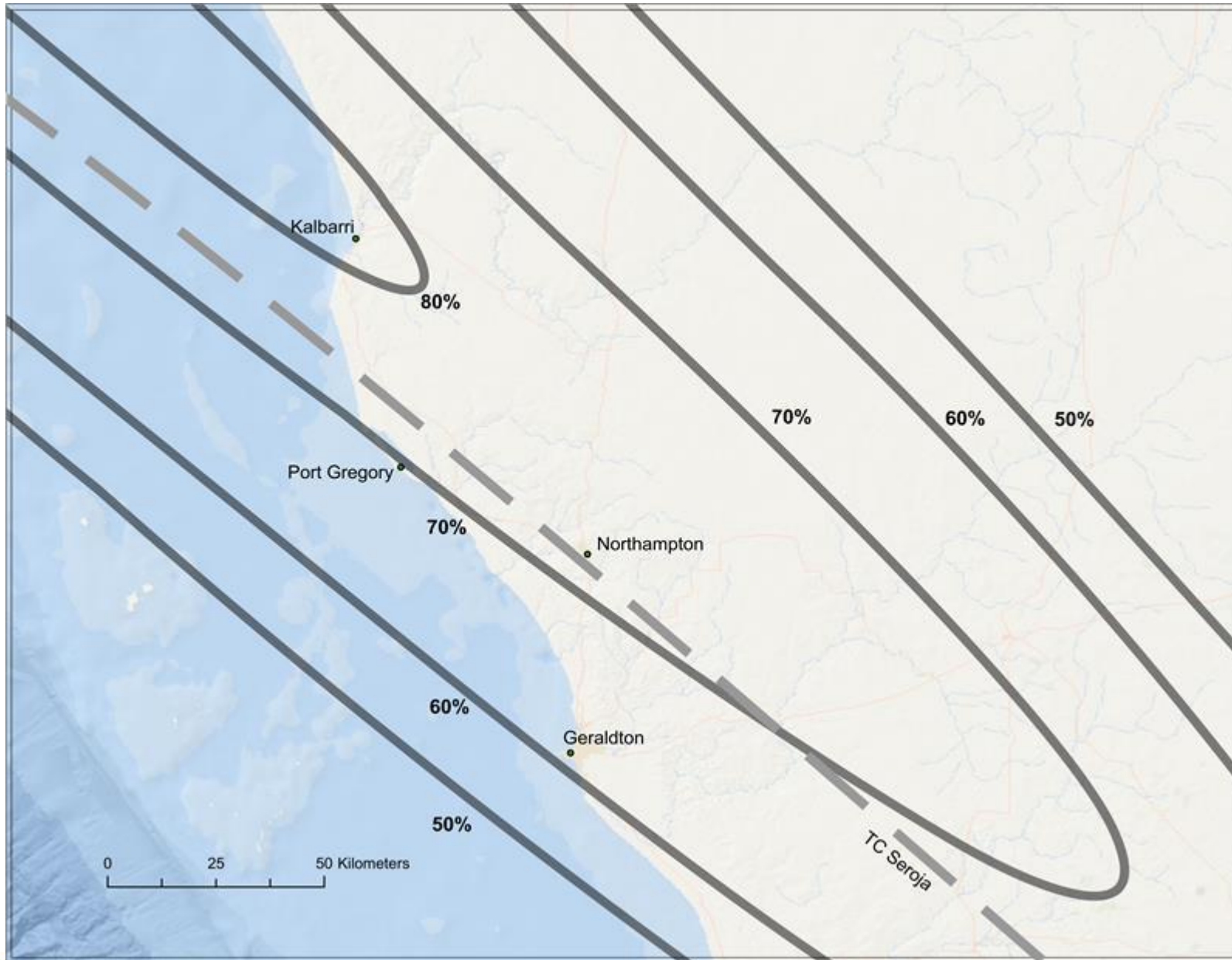
Issued at 11:33 am AWST Monday 12 April 2021. Refer to Tropical Cyclone Advice Number 29.



Why do damage surveys?

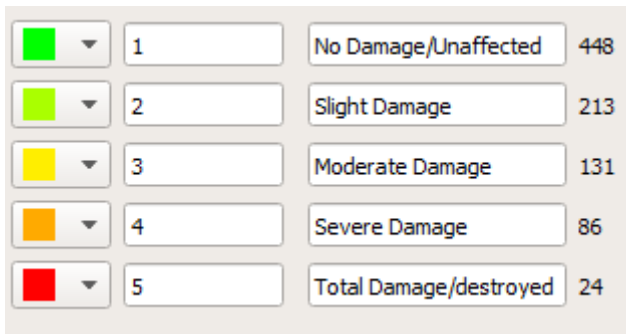
- Are our design standards appropriate?
- Was the design criteria (wind speed) exceeded?
- Correct implementation of design criteria?
- Appropriate materials?
- Adequate construction quality?





Kalbarri - DFES RDA data

Only damaged locations shown



Legend / Damage type	No of buildings	
No damage/Unaffected	448	50%
Slight damage	213	24%
Moderate damage	131	15%
Severe damage	86	10%
Total damage/destroyed	24	3%
Total	902	



Wind-borne debris



Wind-borne debris



Total roof loss and wall damage



Not robust and not resilient!

Changes to Code:



- Wind Region B2 cyclonic in AS 4055 and AS/NZS 1170.2 (amd 2024)

Now need to design assuming dominant opening (as well as wind rated garage doors and LHL for cladding)

Wind driven debris

- Small
 - Tiles
- Medium
 - Battens
 - Sheets
- Large
 - Roofs
 - Sheds
 - Big consequences



Wind driven debris test



Australian Standard Test (AS/NZS1170.2):

- 4 kg 100 x 50 mm timber travelling at > 28 m/s (100 km/h) (Region C house)

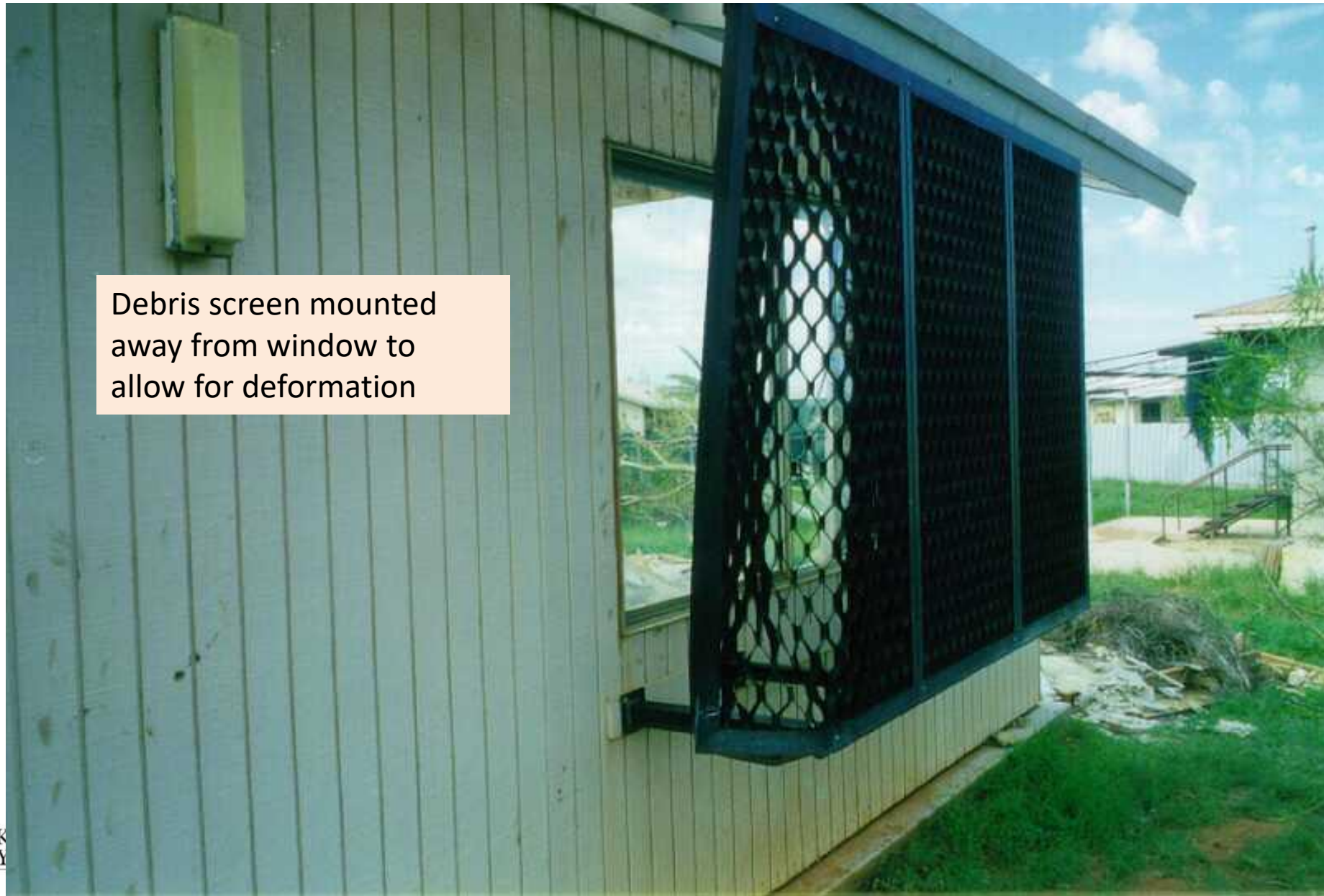
Wind driven debris test



Australian Standard Test (AS/NZS1170.2):

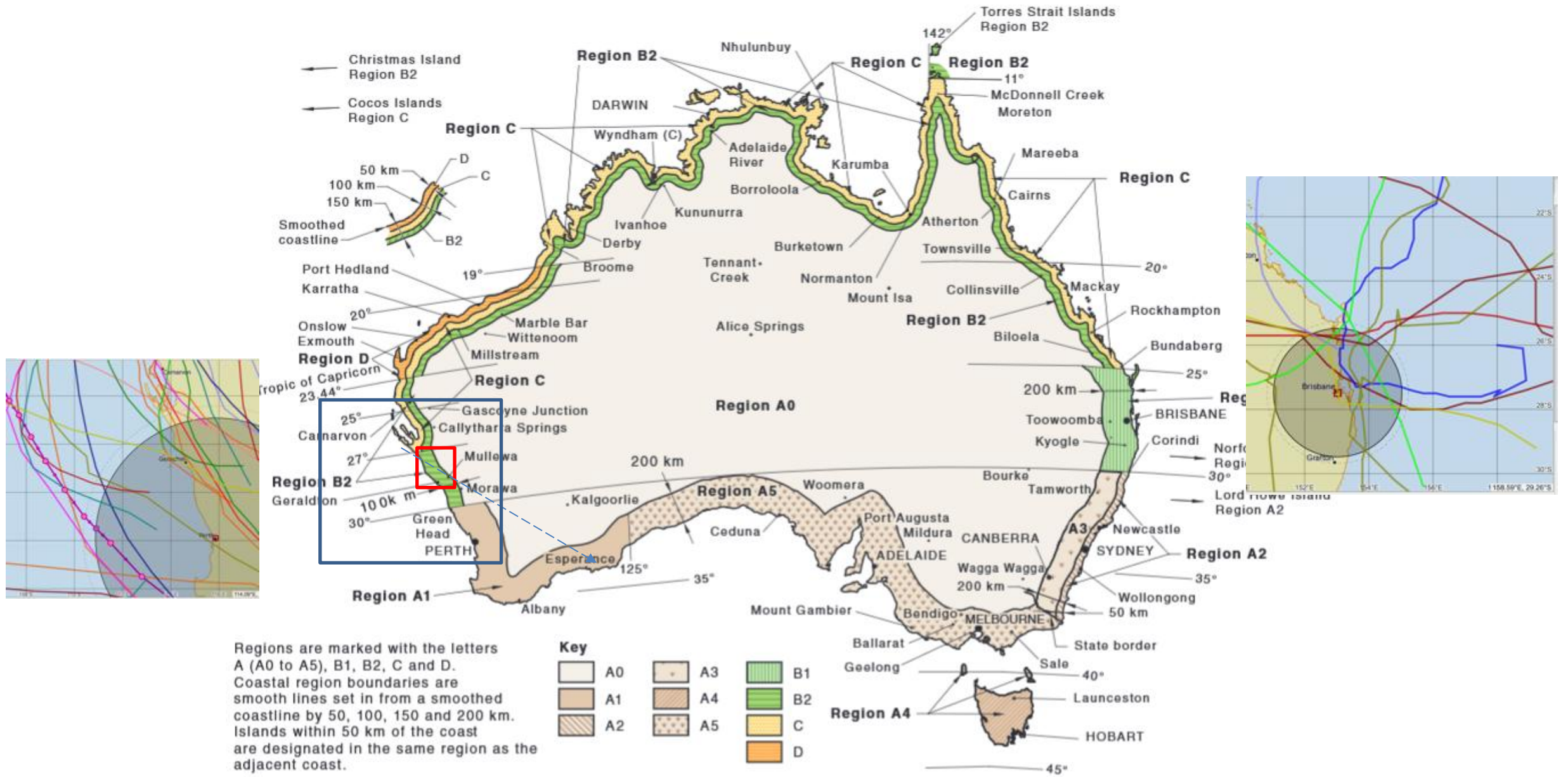
- 4 kg 100 x 50 mm timber travelling at > 28 m/s (100 km/h) (Region C house)

Cyclone Vance 1999



Debris screen mounted
away from window to
allow for deformation





Regions are marked with the letters A (A0 to A5), B1, B2, C and D. Coastal region boundaries are smooth lines set in from a smoothed coastline by 50, 100, 150 and 200 km. Islands within 50 km of the coast are designated in the same region as the adjacent coast.

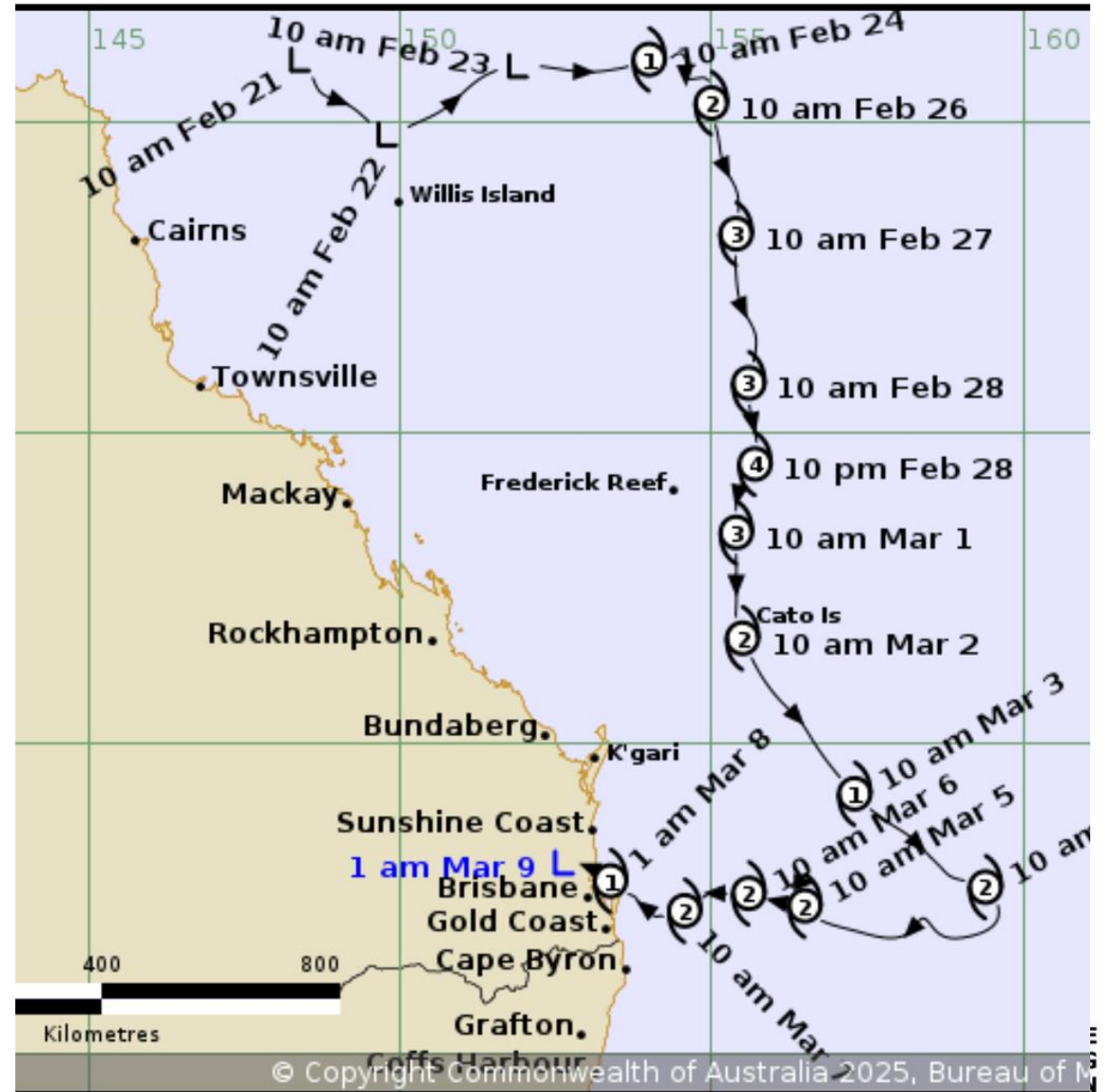
Key



am AEST Sunday 9 March 2025. No Tropical Cyclone Advice is current for this s

TC Alfred

Very wide
Slow moving
Lots of rain
Stalled as a Cat 1 in Moreton Bay
Crossed an ex-TC



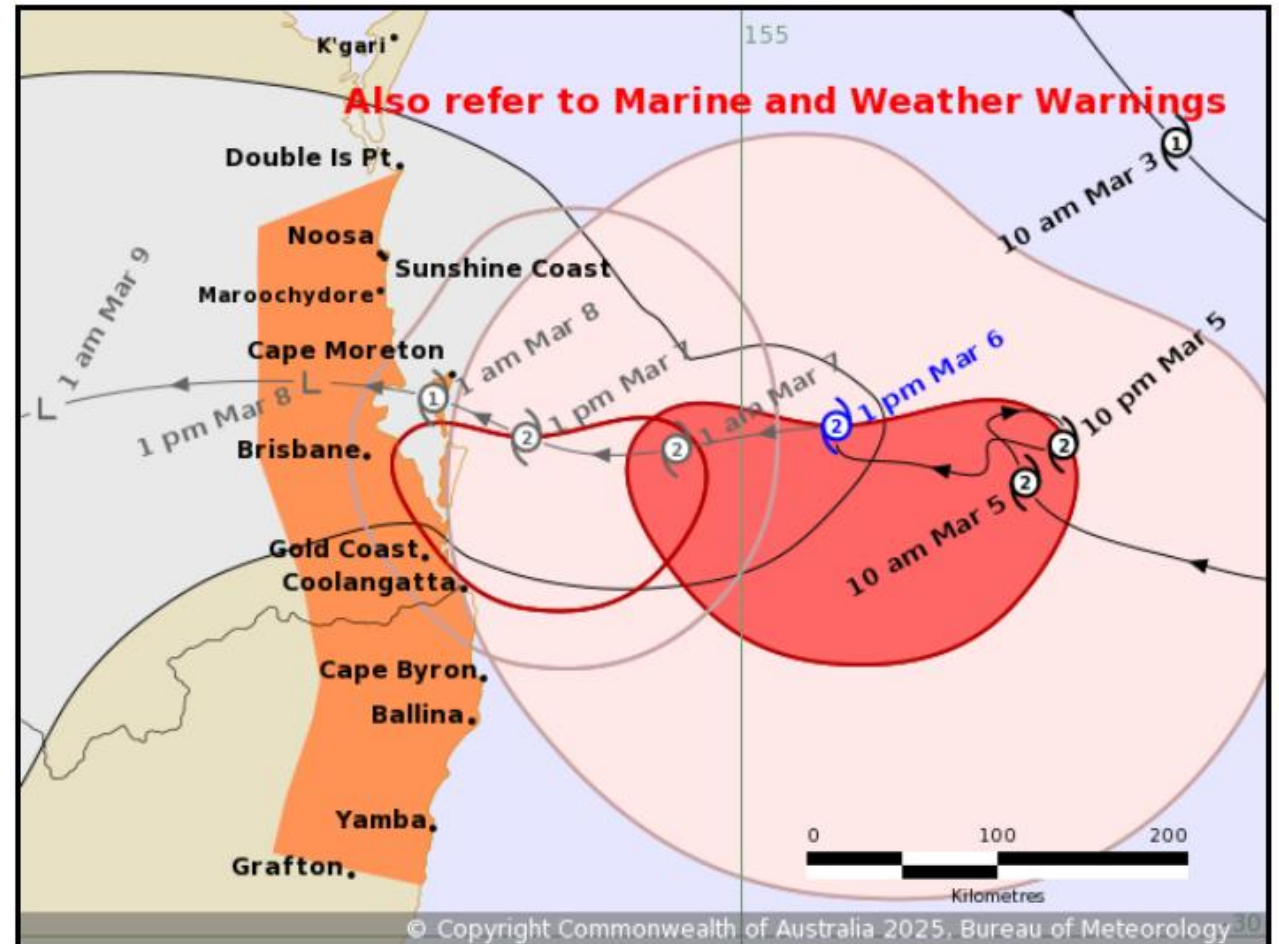
TC Alfred

During its journey West
Winds forecast: 140 to 150 km/h

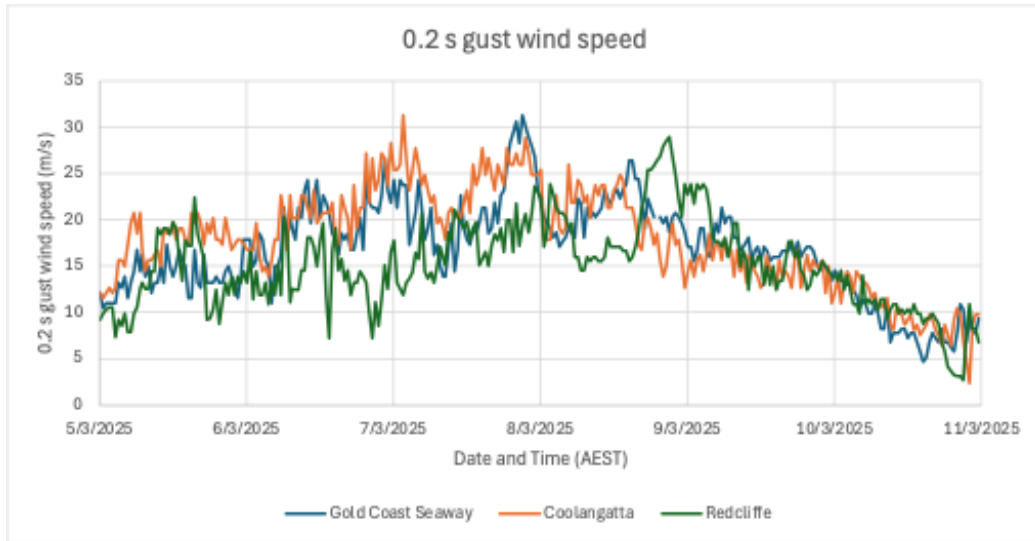
TROPICAL CYCLONE FORECAST TRACK MAP

Tropical Cyclone Alfred 22U

Issued at 1:33 pm AEST Thursday 6 March 2025. Refer to Tropical Cyclone Advice Number 21.



ex TC Alfred



Max gusts approx. 32 m/s (100 km/h)
Days of driving wind and rain



Figure 2-3 Wind field showing maximum 0.2 s gust wind speeds from reanalysis of anemometer data

100 km/h too low for:

- Lifting tiles
- Lifting wind-borne debris
- Blowing in garage doors



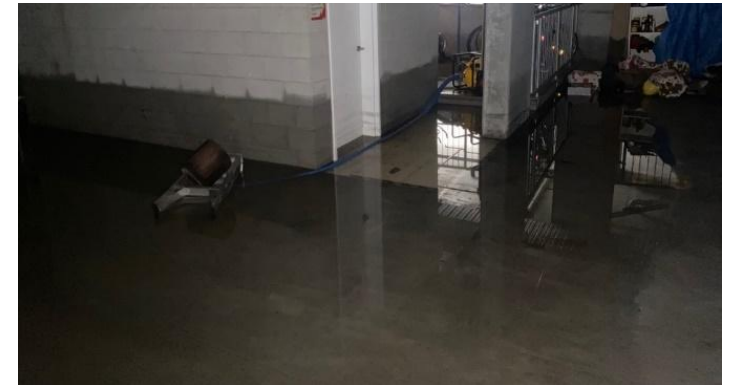
But found weak links

- Corrosion in steel
- Rot in timber
- Poor design
- Water ingress



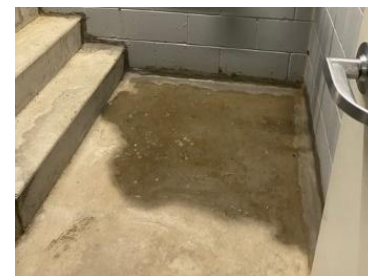
Contemporary Construction

- Very little structural damage
- **Lots of wind-driven rainwater ingress**
- **Balcony pavers**
- Failure of windows and podiums near ground level
- **Basements**
- **Internal pressures**



Water Ingress – ex TC Alfred

- Roofs – small leaks from wind-driven rain (buildings OK in rain if without wind)
- Walls – leakage through single leaf concrete blocks, flashings
- Windows – pressures above AS water penetration test pressures but lower than serviceability pressures



Basements and ground floors – ex TC Alfred

- Seepage on a good day is brown (corroded r/f)
- Water can take out power (switchboards, fire panels, meters, transformers)
- No power, no pumps
- Reliability of back-up power? (Lifts, pumps, emergency lighting, fire systems, ventilation)



Robustness and Resilience?

Goes beyond the current NCC in terms of Life Safety (*but must evacuate if in an evacuation zone*)

Let's define...

Resilience is about Maintaining Functionality

- The building (home, shop, school, etc.) is able to be mostly functional within a short time of being impacted from storm, flood etc.
- Minimize damage and therefore minimize displacement of people
- The community recovers quicker (and needs less external support)





Wind driven rain (WDR) ingress

In every cyclone or thunderstorm damage investigation report conducted by the CTS back to Cyclone Winifred mentions damage due to water ingress



- Extensive damage to Plasterboard linings
- Corrosion of framing elements
- Non structural elements
- Mold and bacteria
- Odour



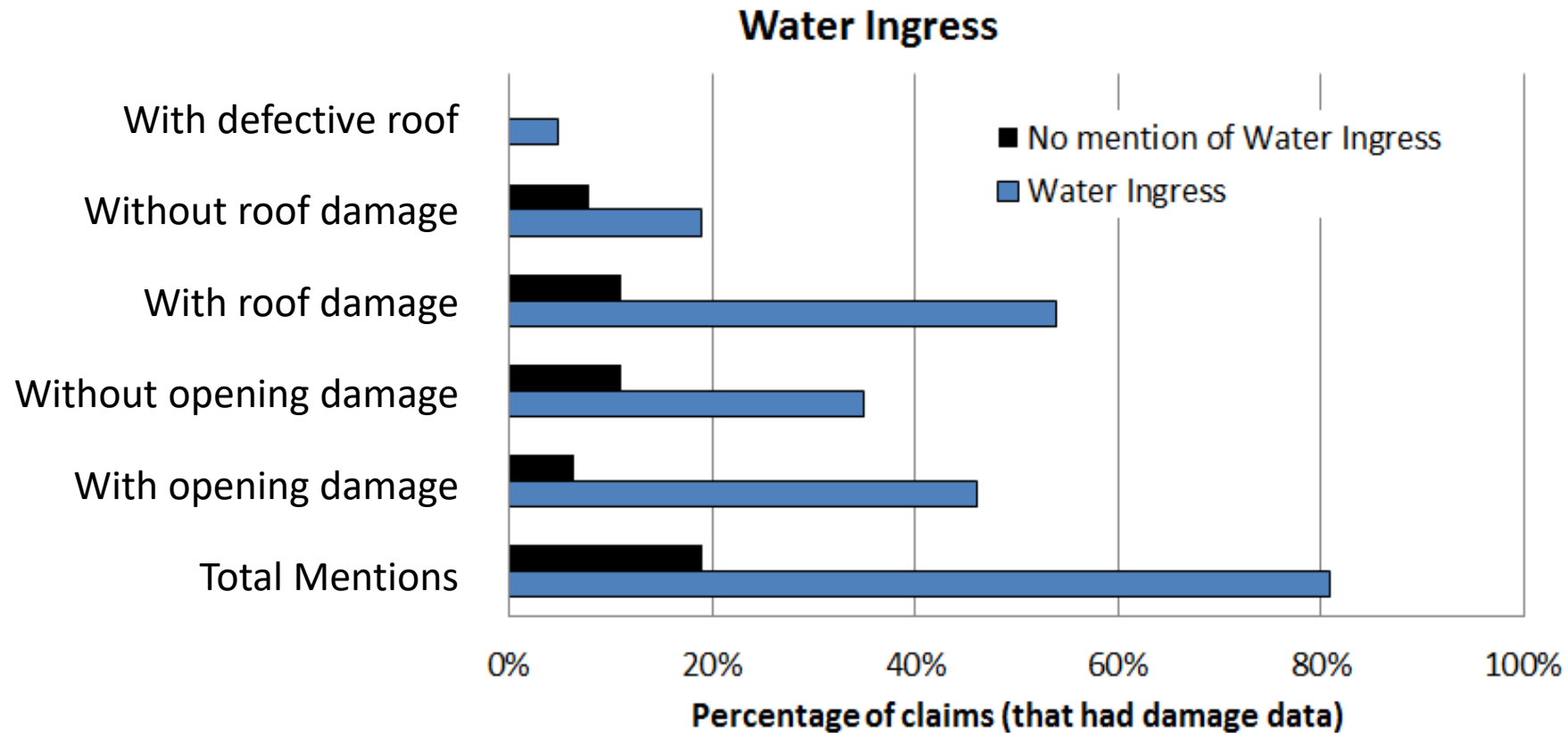
But don't need a hole in roof to let the water in



Due to low design test requirements (AS2047) for windows/doors water ingress and associated damage to house can be expected when heavy rain occurs with wind speeds greater than about 30 m/s.

Require levels of performance (ratings) that give the purchaser knowledge of the amount of “controlled” water to enter into the building

Text analysis of claims data for Strata buildings



CTS report TS899:

www.insurancecouncil.com.au/assets/report/Independent%20strata%20study.pdf

CTS Report TS948

www.insurancecouncil.com.au/assets/media_release/2014/July%202014/100714%20Report%20JCU%20Engineering%20Inspection%20Scheme.pdf

Resilience of PV systems



Impact from STC Ilsa (2023) in WA

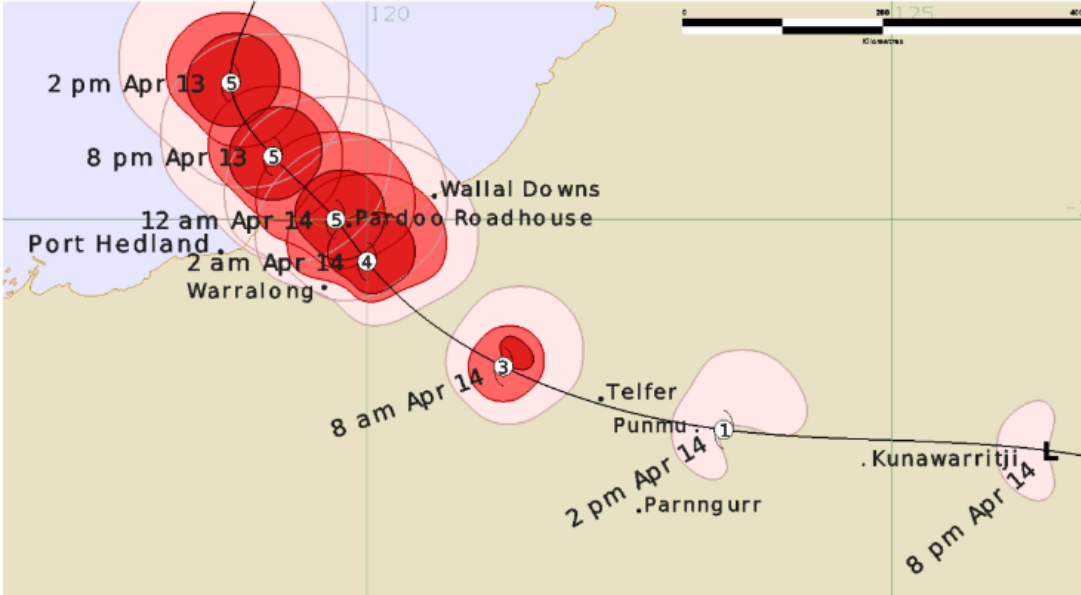


Figure 2-1 TC Ilsa track – Courtesy of BoM

How do PV survive in strong winds?

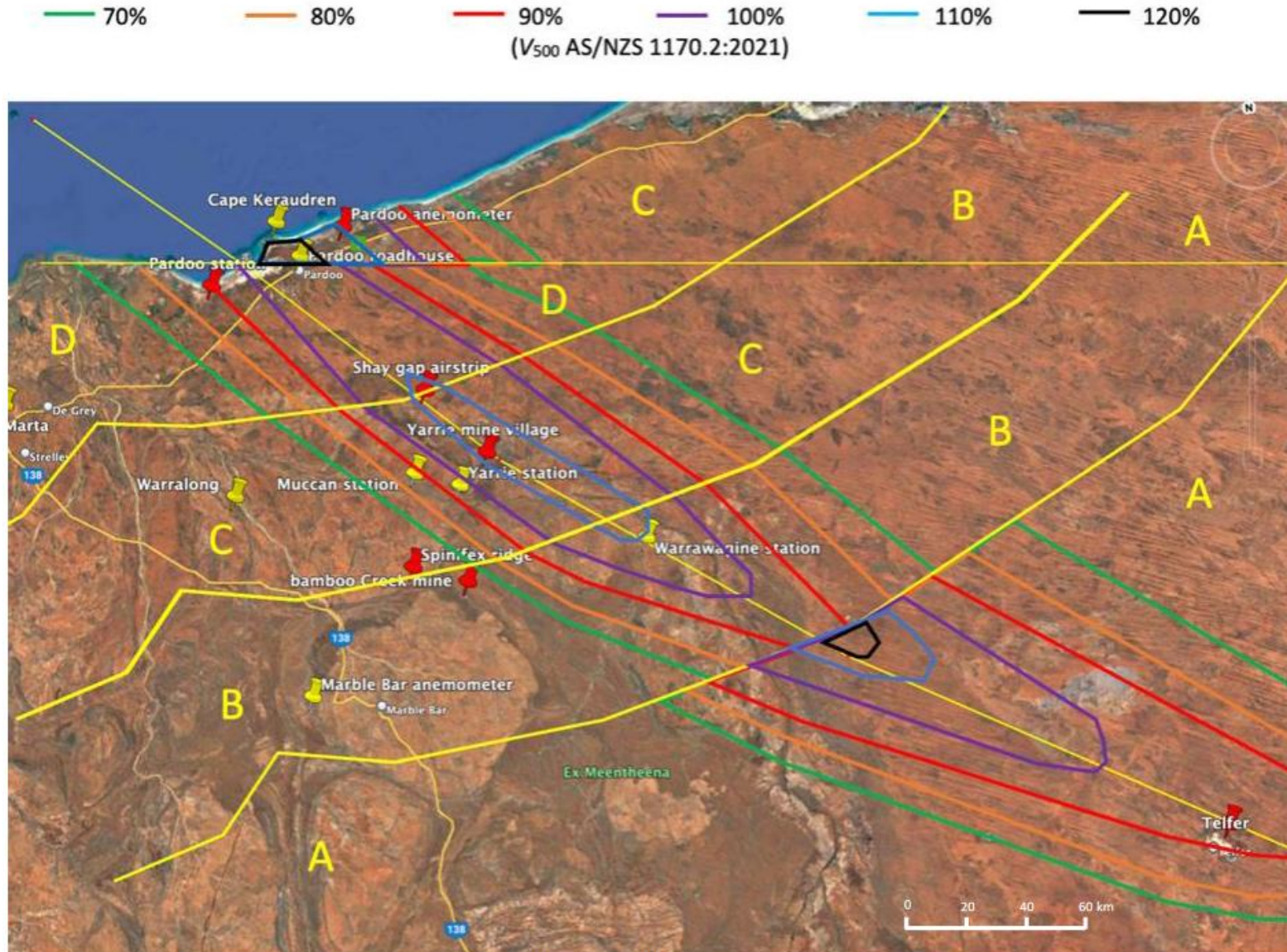


Figure 4-1 Percentage of design V_{500} experienced during TC Isla

2023 impact from
STC Ilsa in WA

How do PV survive in strong winds?



How do PV survive in strong winds?



What is the regulation for PV design?

Is there NCC design criteria?



CTS is advocating for appropriate design criteria to match the requirement (importance) of use.

Hail



<https://www.abc.net.au/news/2025-11-04/105966036>



<https://www.jcu.edu.au/cyclone-testing-station/reports/Technical-Report-60-Investigation-of-Damage-Brisbane-27-November-2014-Severe-Storm-Event.pdf>

Collaborative research project with Unimutual and TEFMA

Investigate the performance of building products to hail impacts

- Metal cladding
- Roof tiles
- Plastic roofing
- PV panels

Utilise damage data from Unimutal to compare with current hail test methods





Insurers recommend solar systems be switched off during a storm. (Reuters: Tim Wimborne/file photo)

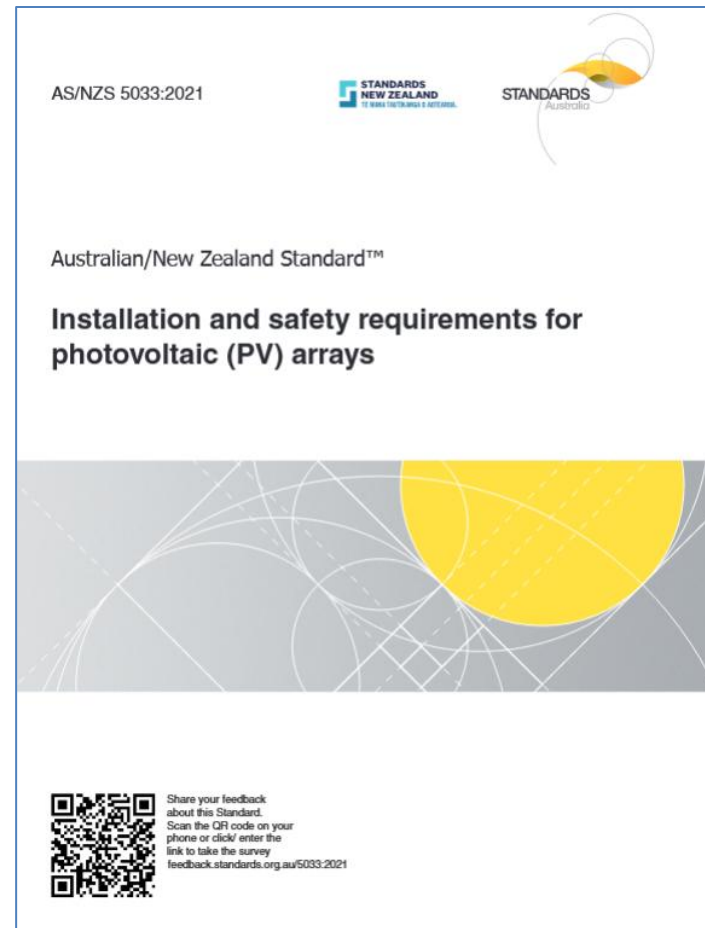
Solar panels must meet a national minimum standard that requires them to withstand the impact of a 2.5 centimetre hailstone.

Standards Australia chief development officer Adam Stingemore said Australia had adopted the international standard, which also allowed for testing of hail up to 7.5cm.

Mr Stingemore said changing the minimum requirement of hail resilience would need to be coordinated between Standards Australia, governments, communities and industry.

"Standards revisions generally run between three to five years at the international level and are very much based on data," he said.

"As conditions change, the standards change to meet those conditions."



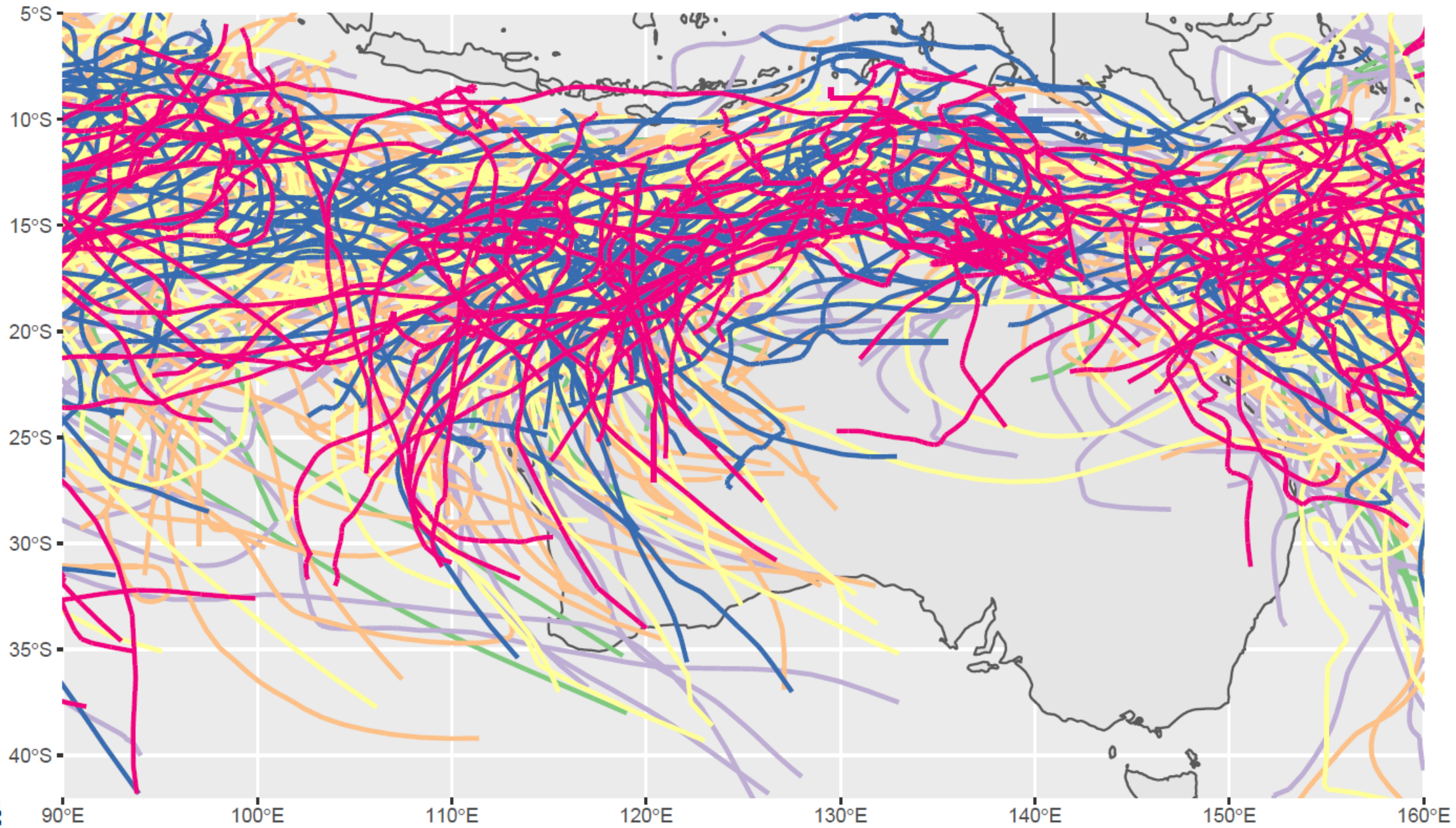
<https://www.abc.net.au/news/2025-11-13/solar-power-panel-damage-giant-hail-queensland/105992850>

To conclude...

- **Climate Change is happening at an increasing rate that is faster than we understand all the changes and implications**
- **Our Building Code and Standards are typically 10 to 20 years “old” in terms of current lessons learnt**
- **We cannot keep waiting to “react” to a damaging event to trigger code change**
- **We need to be keeping up with evolution of our building systems and accounting for new shapes, methods, products, climate**
- **As we start talking about 25 or 50 year horizons...**
- **Will we invest in resilient buildings and build beyond the minimum, or will building stock be the same as it is now?**

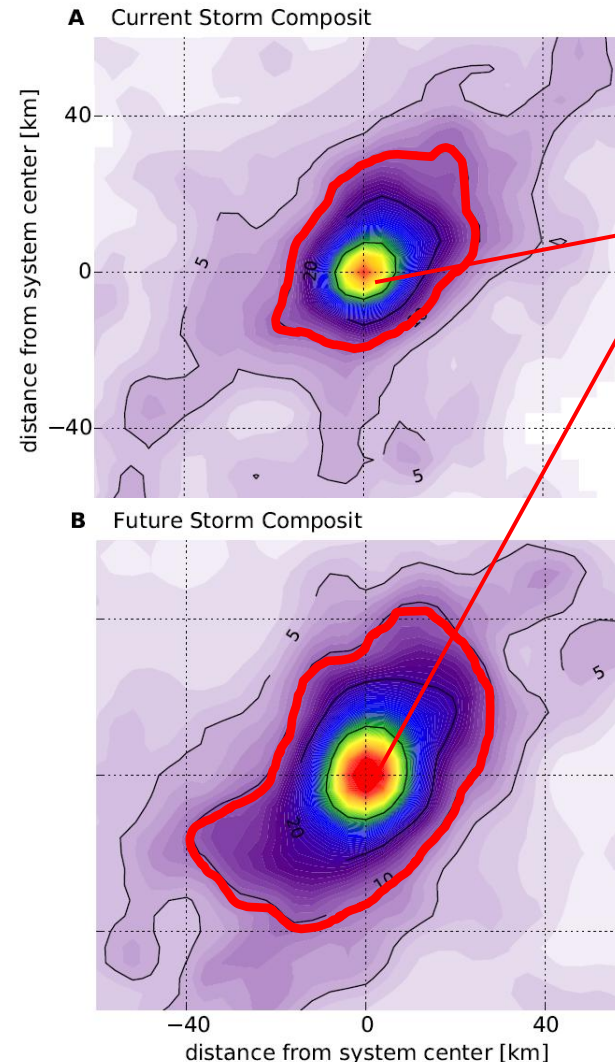
CTS supporters





Impact on Extreme Precipitation

- Under **static** conditions, warmer air holds more moisture (~7% per °C)
- **Additionally**, future storms will be bigger, last longer, have higher rain rates and are more vigorous
- Together this will lead to significant changes to extreme precipitation
- **Predictions:**
 - Both more extreme wet and dry events
 - Bigger, more severe systems
 - Frequency of extreme events increases



**Maximum
rain rate**

+30 %

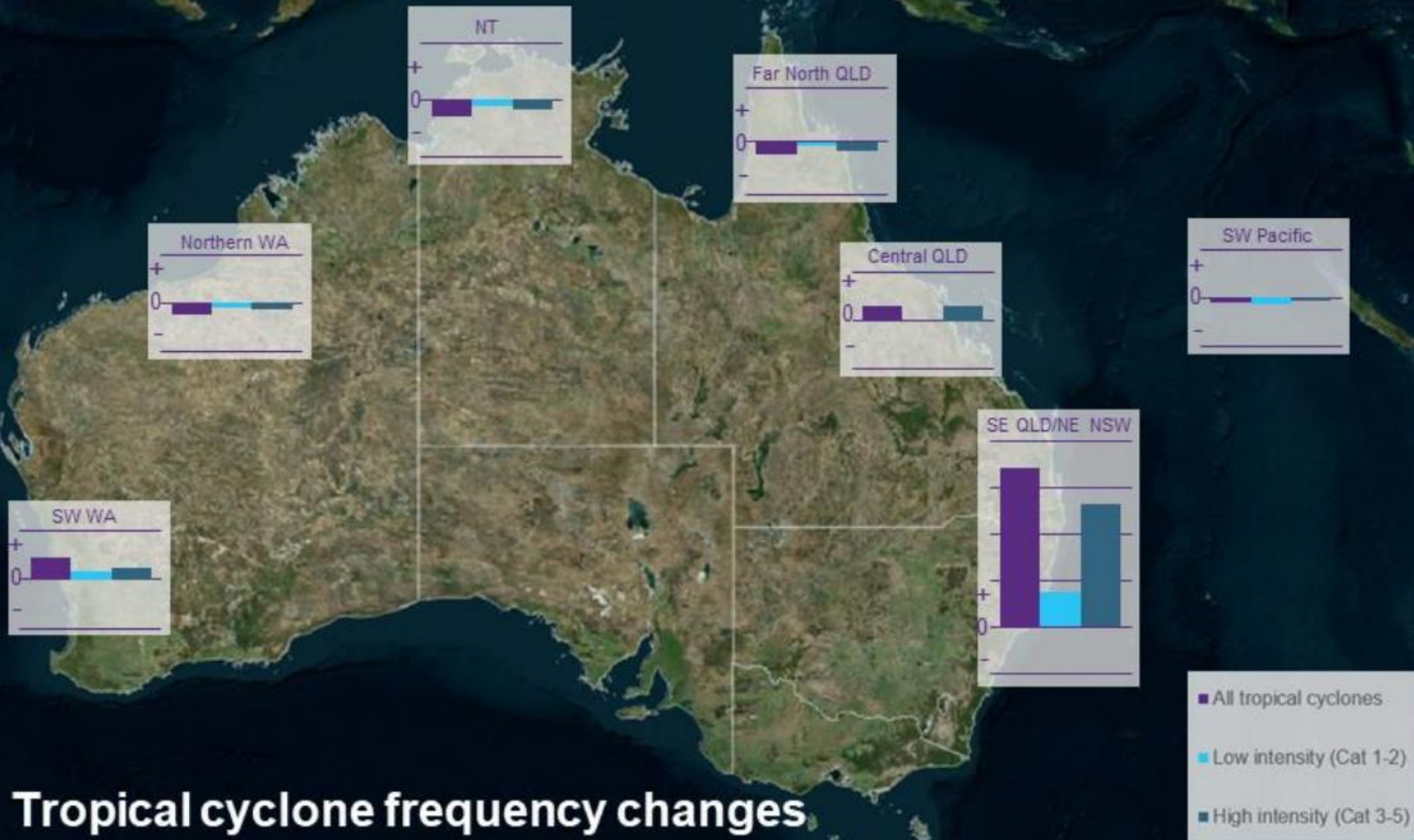
Area

+88 %

Rainfall Volume

+105 %

Tropical cyclone frequency changes in a warming world



5.3 Damaging Hail

Section Summary

In the November 2019 edition of this report, it was stated that large and giant hail risks should increase over central to south-eastern New South Wales, including the Australian Capital Territory, and the central to eastern parts of Victoria. New, independent research has strengthened these conclusions, and points to **further marked increases in hail risk over the south-east of Queensland and north-east of New South Wales**, which further exacerbates the multi-peril risks across this region.

Insurance Council of Australia data shows hailstorms are the most frequently occurring damaging weather phenomena in Australia. However, inhomogeneous historical data have hampered the identification of trends in the occurrence of large and giant hail events across Australia.

IAG analyses conducted in 2019 reveal crop losses for pea size hail and above. Motor claims commenced with hail in the 2-3cm range, with vulnerabilities varying with motor vehicle type and make. Building damage commenced with hail sizes of 4cm and above. Damage surveys indicate that Australian domestic properties can get cracked tiles and dented metal roofs (Parackal et al. 2014) when hail is approximately 5cm in diameter.

The most rigorous Australian hailstorm climatology and trend analysis to date was conducted by Soderholm and Warren (2020 – personal communications). Their analysis was based on 20 years of eastern Australian radar observations. Preliminary results show evidence of a substantial increase in the frequency of damaging hailstorms across the major urban areas of eastern Australia, extending from the Sunshine Coast in Queensland down beyond Wollongong in New South Wales. These studies also confirmed the existence of strong inter-annual variability linked at least in part to the ENSO (Soderholm et al. 2017).

There are emerging signs, backed-up by insurance claims records, that Melbourne may be experiencing an increase in damaging hail events. The rarity of large and particularly giant hail for cities such as Canberra, Perth and Adelaide makes the short available period of radar data inadequate to identify trends. However, historical insurance claims also identify an increasing trend of hail-related damage for these locations. Overall, insurance claims records indicate a southward extension of the primary hail risk regions of Australia.

<https://www.iag.com.au/content/dam/corporate-iag/iag-aus/au/en/documents/corporate/iag-severe-weather-changing-climate-edition-0920.pdf>