Cairns Base Hospital - District Disaster Planning Committee

Cairns Base Hospital

Cyclone Resilience Study - Structural and Building Envelope

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Executive Summary

This report presents the findings of a high-level structural engineering assessment of the building assets on the Cairns Base Hospital Esplanade campus. The report alludes to other risks that need to be considered in a disaster planning process these are outside the scope of this assessment. These other risks may, once the planning process has been undertaken, result in conditions that would trigger action by the hospital well before the levels that would be expected to cause either building envelope or structural distress sufficient to cause action to be implemented.

The buildings on the Cairns Base Hospital Esplanade campus have been designed and constructed over a period spanning approximately 40 years. During this time, significant changes have been made to the design codes which are used by engineers. These changes are based (in part) on greater understanding of the interaction of weather events with buildings, improved knowledge and control of material manufacturing and general evolution in industry practice. This report compares the design standards in force at the time of construction of each building and presents the assessment against a common benchmark. The benchmark is the 2002 version of the Wind Code, which is the latest version to be used in the design of any of the buildings on campus (including the currently under-construction Block D).

A summary of key data from other disaster management plans (by Cairns Regional Council and Cairns Airport) is also included, as each of these may impact on the decision making process of the hospital.

Results for expected performance are separated into ***wind*** and ***storm surge***, as the two are not *necessarily* concurrent risks. Tabulated performance is presented for each risk and ***the two sets of tables should be referred to*** during the planning phase in advance of a cyclone.

The findings indicate that the ***main structure*** of any of the buildings on campus is unlikely to ever be threatened during a cyclonic event where the buildings may be occupied. This means that collapse (in whole or in part) of the main structures is not considered realistic. The ***building envelope*** however, could be at risk of localised damage during wind or storm surge events when occupation may be considered feasible or even preferred to the alternatives. Full details are presented in the accompanying tabulated data.

This report does not attempt to address the risks presented to building occupants or the continuity of service provision by the impact of cyclones. Rather it presents advice on the expected structural performance of the building assets during the range of cyclonic events. ***How these risks are translated into operational requirements are outside the scope of this report*** and no responsibility is undertaken by Arup or the individual authors for operational decisions made on the basis of the building risks presented in this report. Cyclones are natural events as as such have a degree of unpredictability. Codes of Practice are relied on by engineers to design safe and functional facilities for a given range of natural phenomenon. Such codes are based on statistical data and as such are not infallible.

Finally, the nature of large campuses is that changes to buildings and the functions they support are inevitable over time. Should any specific changes occur (either to the building fabric or the internal functions) it would be prudent to review this report in that context, to ensure it remains valid.

1 Introduction

The following report has been prepared for the District Disaster Planning Committee to use as a tool in the event of a cyclone approaching Cairns which may influence Cairns Base Hospital. The report looks at the expected structural performance of the buildings and how the building envelope may be expected to perform under a number of different conditions. **It is important to note that there may be other conditions or occurrences during an emergency that may trigger the need for action before the levels indicted by this study.**

We have used the Bureau of Metrology designated cyclone categories as the reference cyclone events. These categories are well known and understood by the community in Cairns and is the way that information regarding cyclones is usually broadcast. It is important to note that forecasts are just that – they provide an indication of what *may* happen. The decision for action for the hospital may have to occur several hours or even days before the forecasted arrival of an event and as such the decision can only be made based on the meteorological information being provided at that time.

The Cairns Base Hospital campus has a number of buildings of varying age and forms of construction. The building ages range from the early 1970s: Blocks A and B; through to the recently constructed: Block E; and under construction: Block D.

We have endeavoured to present our findings in a user-friendly way so that when people are under pressure they can quickly see the expected performance of the various facilities at the hospital and can undertake the appropriate actions. The document can also be used as a planning tool to allow the hospital to identify “at risk” areas and perhaps plan to re-locate sensitive operations to locations of expected lower risk as a pre-emptive measure.

This is a live document and should be considered likely to change over time as additional information comes to light or the hospital is used in different ways.

There is necessarily a lot of detail that sits behind the analysis. The report includes that detail to allow those who need a deeper understanding to interrogate the methodology and rationale behind the summarised information.

This report however has a principal aim of providing accurate information in a concise and easily understood form.

The following image shows the Cairns Base Hospital campus and the building which make up the campus.

Image 1 : Cairns Base Hospital campus.

2 Background

The following section provides some background information to the study and some essential information regarding the base data and assumptions that have been used for this study.

2.1 Limitations of this study

This study is limited by the available, documented information on the existing structures. We have not undertaken any invasive investigations of the existing buildings to determine the structural makeup of the components of the buildings. No ceilings or finishes were removed to observe concealed structural details. Only visual observations have been undertaken during a walk-through of the buildings assessed. No assessment of the condition of structural fixings, the condition of materials or the amount of maintenance throughout their life has been made.

We have not had access to any architectural drawings of the original Blocks A and B and there are no structural drawings available of these buildings apart from those related to the partial refurbishment of these blocks undertaken in the year 2000. This partial refurbishment related to the addition of links between the blocks and various extensions including provision of additional plant areas at roof level.

2.2 Engineering Design Standards

The structures at the Cairns Base Hospital campus have been constructed over a number of years. The oldest two buildings, Blocks A and B, were built in the early 1970s before much was known about the physical structure of cyclones and their interaction with buildings. The Australian Standard for wind forces that Block A and B would have been designed to was most likely *AS CA34, Part II – 1971 – SAA Loading Code Part II – Wind Forces.* This code was in use prior to the devastation of Darwin by Cyclone Tracy in 1974. Following Cyclone Tracy much work was done to understand wind forces in and around buildings and the design codes were soon upgraded. The wind loading codes that have been in force during the time of the Cairns Base Hospital campus have been:

- AS CA34.2 – 1971;
- AS1170.2 – 1973 (revised and redesignated);
- AS1170.2 – 1975 (second edition);
- AS1170.2 – 1981 (third edition);
- AS1170.2 – 1983 (fourth edition);
- AS1170.2 – 1989 (fifth edition);
- AS/NZS 1170.2 – 2002 (revised, amalgamated and redesignated);
- AS/NZS 1170.2 – 2011 (second edition) (no buildings on campus have been designed to the requirements of this Australian Standard, including the latest Block D. It is therefore not considered in this report).

The 1971 wind force code was a *permissible stress* design code and considered a particular wind force for each structure. The structural capacity of the elements used in the structure were then modified to reduce their capacity and provide a "factor of safety" to the applied loads. Later wind codes have progressed to considering an *ultimate* load, which is a load at which the structure would be expected to experience significant deflections that may make the structure unusable. While such behaviour is regarded as 'failure' by structural engineers, this term can be misleading to non-engineers. It ***does not*** mean that the structure would have collapsed, either partially or completely. It ***does*** mean that the structure is likely to be no longer safe to occupy and is likely to require significant remedial work to make it safe.

It is worth noting that larger structures (including those at the hospital) typically have many alternative load paths, structural redundancies, and residual stiffness even once the above-described deflections have occurred. These are not typically quantified in design due to their unpredictable nature. The design process is such that buildings will not reach this situation when used in accordance with their designed function.

We have included the above background to illustrate that the Cairns Base Hospital campus includes structures that have been designed and constructed using a number of different design principals over several decades. For this report it has been necessary to equate these parameters so that all structures can be compared on a reasonably equivalent basis. Adopting this common benchmark for design requirements, this report presents expected building performance data against cyclone forecast data issued by the Bureau of Metrology (BOM).

2.3 Bureau of Meteorology – Cyclone Categories

We have undertaken analysis of the various wind codes and compared these with the Cyclone Categories that people are familiar with. This analysis is contained in Table 1 below:

Table 1 : Bureau of Meteorology – Cyclone category wind speeds

	Gust Wind Speed Range for Category (km/hr)		Gust Wind Speed Range for Category (metres/sec)	
Cyclone Category	Lower	Upper	Lower	Upper
1	90	124	25.0	34.5
2	125	164	34.6	45.6
3	165	224	45.7	62.2
4	225	279	62.3	77.5
5	280	>280	77.6	>77.8

2.4 Building Design Wind Speeds

Table 2 details the wind speeds that are considered to have been used in the design of the various structures at the Cairns Base Hospital campus. These have been determined from the various wind loading codes that were in force at different times over the life of the campus. The various design wind speeds from each of the codes have been converted to a comparable current design wind speed to allow comparison with cyclone categories.

The following assumptions have been made for the purposes of this comparison:

- Buildings are located in Terrain Category 1 for serviceability limit state design and Terrain Category 2 for ultimate limit state design;
- Buildings using *permissible stress* design (1971 wind forces code) have used a 50 year return period wind speed. For Cairns this is 100 miles/hour, with a 1.15 factor for cyclonic areas, and a Terrain Category Multiplier of 1.1;
- Buildings using *ultimate limit state* design (2002 wind load code) have used a 1 in 1000 year cyclonic wind speed (i.e. Importance Level 3). For Cairns this is 70 metres/second, cyclone factor = 1.05, Terrain Category Multiplier = 1.0;
- All gust wind speeds are 3 second gust wind speeds, as measured and reported by BOM;
- Internal and external pressure coefficients have not changed significantly across the various codes over the years;
- Wind speeds are referenced to 10m height above the surface;

- The conversion from Permissible Wind Speed to Ultimate Wind Speed is calculated using $V_{Ult} = \sqrt{(V^2_{permissible} \times 1.5)}$.

Table 2 : Building Design Wind Speeds for the Main Structure

Wind Basis	**Max Design Gust Wind Speed**	**Percentage difference in max design gust wind *speed***	**Percentage difference in wind *force***	**BOM Cyclone Category**
Using 1971 wind forces converted to metres/second and to comparable Ultimate Limit State	68.85m/sec	Base	Base	Mid Category 4 (62.5 to 77.5m/sec)
Using 2002 wind forces in Ultimate Limit State	73.5m/sec	Base + 6.7%	Base + 14%	High Category 4 (62.5 to 77.5m/sec)

In addition to the basic wind speed that has been calculated above, *building envelopes* are exposed to *local pressure factors*. These local pressure factors are applied to small areas on the building envelope, typically close to the corners and edges of the structure. They can also affect areas away from the corners and edges as wind usually occurs in gusts that can affect a small, localised area of a building facade in any location on the building. Table 3 summarises the range of these pressure coefficients.

Table 3 : Range of Local Pressure Coefficients applied to buildings

Local Pressure Coefficients	**Negative pressure**	**Positive pressure**	**Associated Negative Pressure Coefficient for side walls**	**Associated Positive Pressure Coefficient for windward walls**
Local Pressure Coefficient using 1971 code	1.5	1.0	-0.7	+0.85
Local Pressure Coefficient using 2002 code	1.5 to 2.0	1.0 to 1.25	-0.65	+0.8

The nett effect of this difference in local pressure factors between the earlier and later wind codes is an increase of approximately 25% in the nett pressure coefficient influencing the smaller wall cladding elements. ***This means that those wall elements designed before the 2002 code was introduced are likely to be less resilient to localised wind gusts than more modern installations.***

The roofs have similar local pressure areas close to edges and ridges however comparison between the earlier and later wind loading codes indicates that the local pressure factor has remained the same over this period. External pressure coefficients for roofs have mostly remained similar except for negative pressure coefficients for tall buildings with relatively flat roofs.

As modern design codes require local pressure factors to be applied, the difference in these since the original designs were done means that a reduction in the likely envelope performance must be taken. Further detail is given in Section 5.2.1.

2.5 Storm surge

It is not the role of this report to provide predictions of the possible or likely storm surge levels. Instead, we have considered the likely structural impact on the campus buildings at various heights of storm surge.

The Bureau of Meteorology provides expected storm surge data in different ways at different times during the approach of a cyclone.

Cyclone Watch: During this period of time, which is typically ***between 24 and 48 hours*** in advance of wind impact on communities, BOM issue a *possible* storm surge height based on the highest astronomical tide (HAT). This is because the timing of the cyclone approaching land with respect to normal tide times is uncertain. ***These projections assume a worst case combination of the highest possible tide plus the forecast storm surge rise.***

Cyclone Warning: During this period of time, which is typically ***less than 24 hours*** in advance of predicted wind impact on communities, BOM issue a revised storm surge height which is based on the known normal tide behaviour at the time of the predicted landfall. For instance, if the cyclone is due to make landfall at low tide, then a forecast will adjust the overall maximum height to take account of this. While the overall storm surge height is unchanged, the impact is dramatically reduced because the tide is low. At this time, BOM issues storm surge advice based on the predicted normal tide height at the time of predicted landfall. BOM also relate this to HAT, so that the public have a meaningful reference point (most people can relate to a 'king tide' level (which is essentially HAT), which occurs twice per year, though there are periods of regular high tides which are very close to king tides).

Given the time required to facilitate evacuations, it can be seen from the forecasting methods above that evacuation and other preparation decisions are based upon a conservative assessment of the storm surge risk. It may be considered that this forecasting approach is intended to preserve life safety while a window of opportunity exists to move people to safer locations.

This report provides data on structural risk against forecast storm surge height measured against HAT. It is known that the ground floor of the main campus buildings are approximately 2.27m above HAT, therefore it is reasonable to consider the risk of building inundation exists at levels greater than this. **It is possible that HAT may change in the future due to general sea level rise** (see Appendix B)**.** This report should be updated when a published change to HAT is made. It is also understood that the actual HAT (1.78m AHD) is a rare event (occurring approximately once every 18-19 years), and that the *normal* high tide is up to 0.8m below this, though regular high tides can also be very close to actual HAT. A more rigourous assessment could be made by comparing the BOM forecast issued at the time with tide tables for the time of year in which the cyclone is occurring. This would provide a more realistic, yet still conservative estimate of the likely storm surge (conservative because it is still based on the unknown timing of the coastal impact at up to 48 hours away). This anomaly is not considered in this report as BOM forecast against HAT for a conservative approach, but it may be considered as an additional level of comfort, perhaps.

Storm surge forecasts do not include data on expected wave heights, which are above the surge heights quoted. Wave heights will vary between different cyclone characteristics. The impact of waves breaking on the shore and then buildings is almost impossible to predict accurately and is beyond the scope of this report. **For the sake of this report, we have allowed a wave zone of 0.5m above the forecast storm surge height in our assessment.** This value has been taken from the Parsons Brinkerhoff report dated May 2007, which in turn reviews earlier research. It is an estimate only and is based on a 1000 year return period (equivalent to the design of most of the hospital campus buildings).

For background information, there are two systems of measurement of height relevant here, AHD and HAT. AHD (Australian Height Datum) is used for surveying and is commonly the reference point used for building heights. Levels expressed in AHD may be seen on architectural or engineering drawings. AHD has no meaningful relationship to HAT (Highest Astronomical Tide) as HAT varies for different parts of the coast.

HAT is the highest level the tide will reach at a given point on the coastline under normal circumstances. For conversion between the two measurements, at the Cairns Base Hospital Esplanade site, HAT = 1.78m AHD. These figures are for information only and are not relevant to the assessments made by this report.

2.6 Other Information References

2.6.1 Cyclone Shelter Design Guidelines

The Queensland Government's Department of Public Works has prepared some "Design Guidelines for Queensland Public Cyclone Shelters", dated September 2006.

Within this document it is indicated that a 100km/h wind speed (3 sec gust) is the lock down wind speed for the public cyclone shelter and is deemed to be the speed beyond which it is unsafe to be outdoors.

This is used in the Queensland Storm Surge Warning system as the threshold wind speed before which all evacuations should be completed.

The Queensland Storm Surge Warning is intended to give a prediction of expected surge 12-24 hours before wind gusts of 100km/h are expected in the impact area so, it is presumed, appropriate action can be undertaken to evacuate if required before these conditions are expected to be reached. This timeframe should be compared to the timeframes given in Section 2.6, with respect to BOM predictions available for asset managers' use.

The Guidelines indicate that the annual probability of exceedence of the design wind event for ultimate limit states should be 1 in 10,000 (i.e. a 99.99% confidence level in relation to the wind speeds expected). For Cairns this would be a design gust wind speed of 306 km/hr (85 metres/second). This equates to a Category 5 cyclone. While it is not clearly stated that this is the upper limit a cyclone may reach, it seems a reasonable reference point for this report to place the design of the hospital buildings into context (an assessment of the maximum likely wind speeds which a Category 5 cyclone may produce is beyond the scope of this report). At wind speeds of this magnitude (not including local pressure factors), the force exerted on the same area of a building could easily be one third more than the design of the hospital structures has taken into account. It seems clear therefore, that if there were any consideration to upgrade to a Category 5 wind resilient structure, very significant upgrades would most likely be required to the base structure, and most certainly to the building envelope which can also experience the local pressures due to gusts described earlier.

Cairns Base Hospital is not considered a cyclone shelter however, and as we understand the situation, ***none of the campus buildings are considered to be a post-disaster facility*** as defined in the Building Code of Australia. The 'post-disaster' designation is important as it implies that the facility will be available for use immediately following a disaster. Structures in this category are designed for greater wind speeds (though not necessarily as high as a cyclone shelter might be).

2.6.2 Cairns Regional Council Disaster Management Plan

Cairns Regional Council (CRC) maintain a Local Disaster Management Plan (available from the Council website). This document describes the scenarios in which an evacuation order will be given.

The CRC plan clearly states that no evacuation order will be given by the Council on account of any forecast wind speed. Rather, an evacuation order will only be given if lives are considered to be at threat from storm surge (in developed areas). This evacuation order is not legally enforced (despite it being called a *mandatory* evacuation order) and while ***no exact timing*** is placed on it due to a large number of variables, Council would endeavour to allow sufficient time for *typical* residences and commercial premises to evacuate. Clearly the hospital is not a typical building with regard to an evacuation scenario and so may consider it appropriate to determine an appropriate time at which to put plans into place to evacuate or relocate people from at-risk areas.

CRC has produced storm tide evacuation maps (available on their website), which compare ground levels to the likelihood of inundation. The current version of these use red, orange and yellow colour codes to represent decreasing levels of risk. The hospital site is entirely within a red zone. CRC evacuation plans will issue evacuation instructions to red zones first. The map covering the hospital area is included in Appendix C.

CRC respond to the same BoM-issued information for the threat as the public see.

2.6.3 Cairns Airport Cyclone Plan

Cairns Airport maintains a Cyclone Plan which is available on their website. The plan requires the airport to keep Cairns Regional Council and the Queensland Police fully informed of the status of the airport.

The airport operates an 8 stage plan; those which may directly influence hospital evacuation decisions are shown in **bold**:

- Stage 1 commences when BOM issue a *cyclone watch* (24-48 hours until winds above 75km/h are expected).
- Stage 2 commences when BOM issues a *cyclone warning* (less than 24 hours until winds above 75km/h are expected).
- **Stage 3 is called when wind gusts greater than 100km/h are between 6-12 hours away. At this stage major airlines are encouraged to consider scheduling implications.**
- **Stage 4 begins when wind gusts greater than 100km/h are between 3-6 hours away. At this stage the airport begins a staged shutdown, during which all flight operations cease as soon as possible. When the last aircraft has departed, the airport declares a non-availability status.**
- Stage 5 sees no airport operations during strong winds.
- Stage 6 is when strong winds have passed but the all-clear has not yet been given.
- Stage 7 begins the re-activation of airport services, including the lifting of the non-availability status. Strong winds have passed but a *cyclone warning* may still exist.
- Stage 8 represents airport readiness to resume normal operations.

The airport cyclone plan (as publicly available) does not include preparations to deal with storm surge, but it does note that the lowest part of the levee wall is approximately 2.4m AHD (or approximately HAT +0.62m for comparison purposes at the hospital site). It is reasonable to assuming that a breach of the levee may restrict airport operations, but this would not occur until perhaps Stage 4 when the cyclone is getting close to the coast. By this time any decision to use the airport by the hospital may already have been made and any evacuations effected. The storm surge risk at the airport is therefore considered of little relevance *prior* to a cyclone.

Clearly a major storm surge would have an impact on ground level services at the airport, therefore some services may be unavailable immediately following a storm surge, at least until an inspection of the runway can be done and it deemed safe to use.

2.7 Design History for the Structures

As far as we are able to determine the buildings which are the subject of this study were constructed around the following dates:

MHU – 1998;

Block A – 1972 generally, with two additional links to Block B added in 2000;

Block B – 1972 generally, with two additional links to Block B added in 2000;

Block C – 1998 generally, though has been modified and extended over its life in various stages;

Block D – Under construction (2012);

Block E – 2011.

3 Building Construction

The following description of the building provides a summary of the salient parts of the building structure and fabric as we understand from our visual inspection and previous experience of the Cairns Base Hospital campus. Any dimensions noted are approximate.

3.1 Mental Health Unit (MHU)

The MHU block is generally a single-storey triangular building with a two-storey administration centre to part of the area.

The ground floor is raised above ground with a partial void below and sloped earth embankments to make up the internal courtyard level. The ground floor is at a level of approximately 4.05m AHD. The building sits on shallow pad footings, up to 500mm deep below existing external ground level.

The external walls include a combination of concrete panels, lightweight compressed fibre-cement on steel stud walls and laminated glass windows in aluminium frames (toughened in locations where patients may access). In some locations there are breaks in the external walls and steel fences with mesh panels provide ventilation to the internal courtyard.

3.2 Block A

Block A dates from the early 1970s and consists of a 4-storey reinforced insitu concrete frame and floors with infill cavity brick walls and steel and aluminium framed windows typically. Two links to Block B were added in approximately 2000 (including the area currently occupied by the JCU auditorium). Figure 1 shows a typical floor arrangement of Block A.

The ground floor is raised above ground with a void below. Due to access restrictions we are not aware of the full extent of the void, but assume it is throughout the sub-floor area with the exception of lift pits. The ground floor is at a level of approximately 4.05m AHD. Due to its height and weight, the building is assumed to sit on piled footings, though no details are available of these.

The lift and stair core is located in the middle of the long direction of the building but offset to one side outside of the main building structure. The stair and lift core to this central location have glass windows.

There are additional stair cores located at either end of the long direction of the building. These also have glazed windows.

The windows comprise the following types:

- original steel-framed windows with annealed (float) glass panes 5mm thick;
- aluminium-framed with internal jockey sash (probably for acoustic performance and dust control) and annealed (float) glass 6mm thick;
- aluminium-framed sliding sash and annealed (float) glass 6mm thick;

- aluminium-framed with asbestos cement or fibre cement sheet infill (thickness unknown).

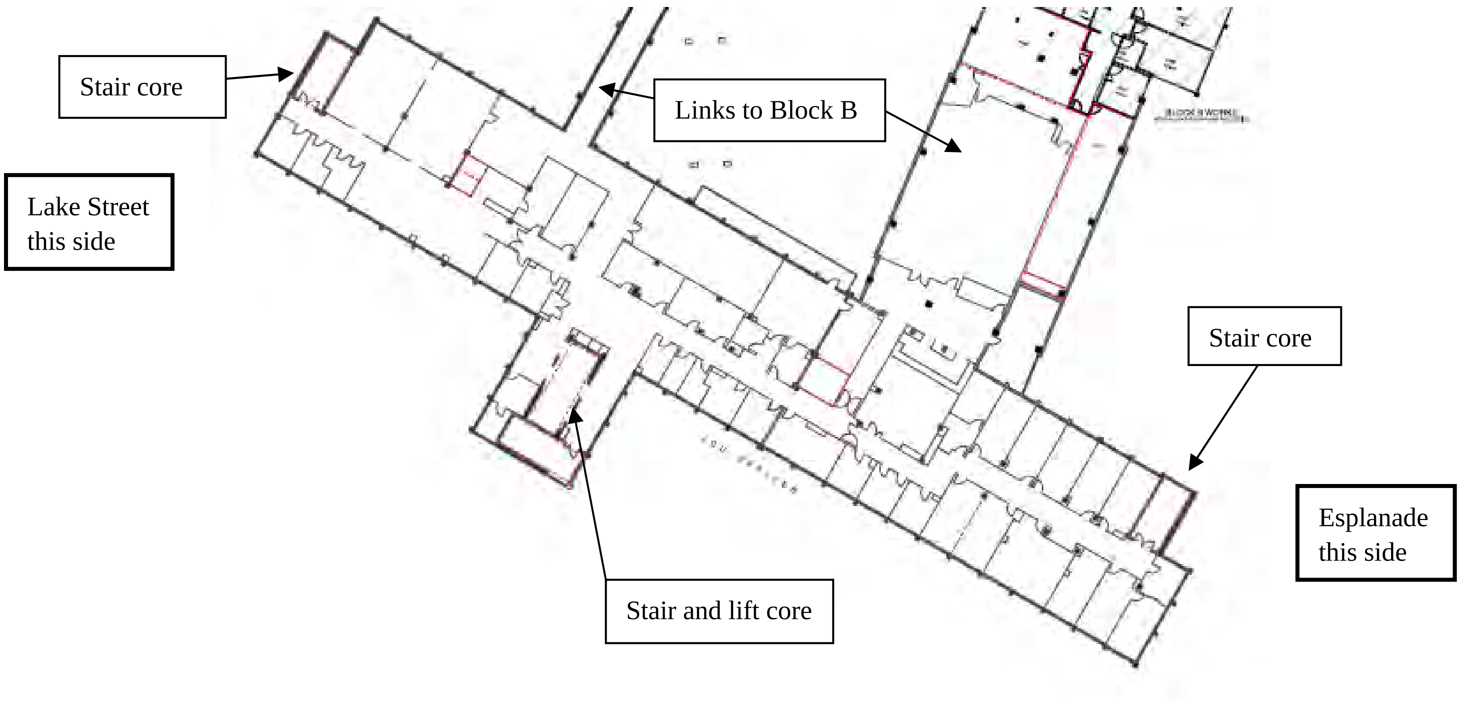
The roof appears to comprise two distinct types:

- Original aluminium profile sheeting typically on timber purlins at 900mm centres and screw-fixed with washers to every ridge. Steel rafters support the purlins. There is also a concrete slab directly below the main roof to the building (i.e. directly above level 4);
- New portal frame structure (1998 extension) with profiled Colorbond sheeting on steel purlins at 900mm centres and screw fixed with cyclone washers.

The following was noted in particular:

- Numerous roof-mounted extraction fans. These could be a potential path for water ingress during a cyclone and are reasonably exposed to storm debris, which may cause the fans to be damaged or even torn off, leaving a hole for ensuing damage to occur.
- Lift core located external to main structure with original steel-framed glass windows to lift lobby area. This older glass is not considered very resilient and therefore the use of these lifts may be more risky during a cyclone because of the risk of window damage.

Figure 1: General layout of a typical level in Block A (Level 2 shown).



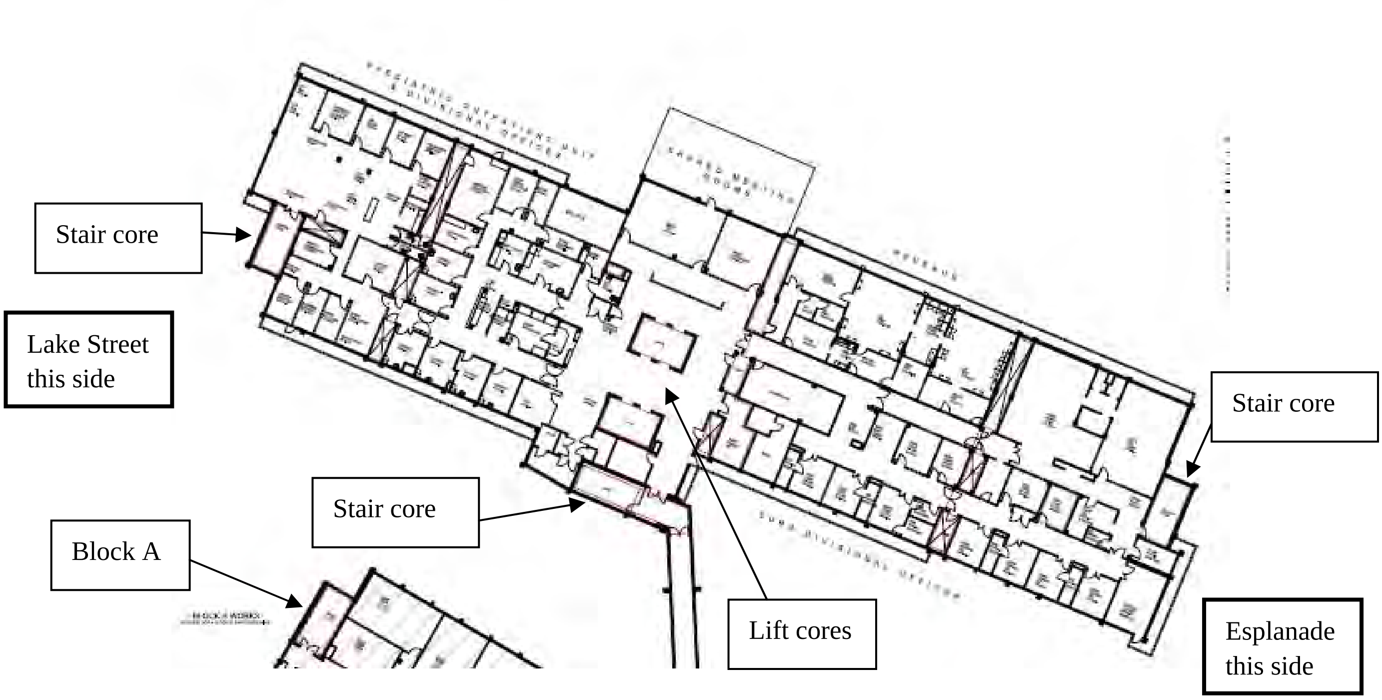
3.3 Block B

Block B is of similar construction to Block A with similar structural elements and building envelope elements, except that all glass is 6mm thick annealed (float). It has 6 storeys (the general layout is illustrated in Figure 2, below).

As Block A, the ground floor is raised above ground with a void below. Due to access restrictions we are not aware of the full extent of the void, but assume it is throughout the sub-floor area with the exception of lift pits. The ground floor is at a level of approximately 4.05m AHD. Due to its height and weight, the building is assumed to sit on piled footings, though no details are available of these.

The main layout difference between Block A and B is that Block B has its lift core within the main building. This results in the lift core being more protected from the elements.

Figure 2: General layout of a typical level in Block B (Level 3 shown).



3.4 Block C

Block C in its current form is a combination of various stages of building work from the 1970s to 2012. The envelope of the building consists of various combinations of glazing, solid brick or block, concrete and lightweight steel stud framing with compressed fibre-cement sheet or colorbond steel cladding. Plant areas typically include steel louvres.

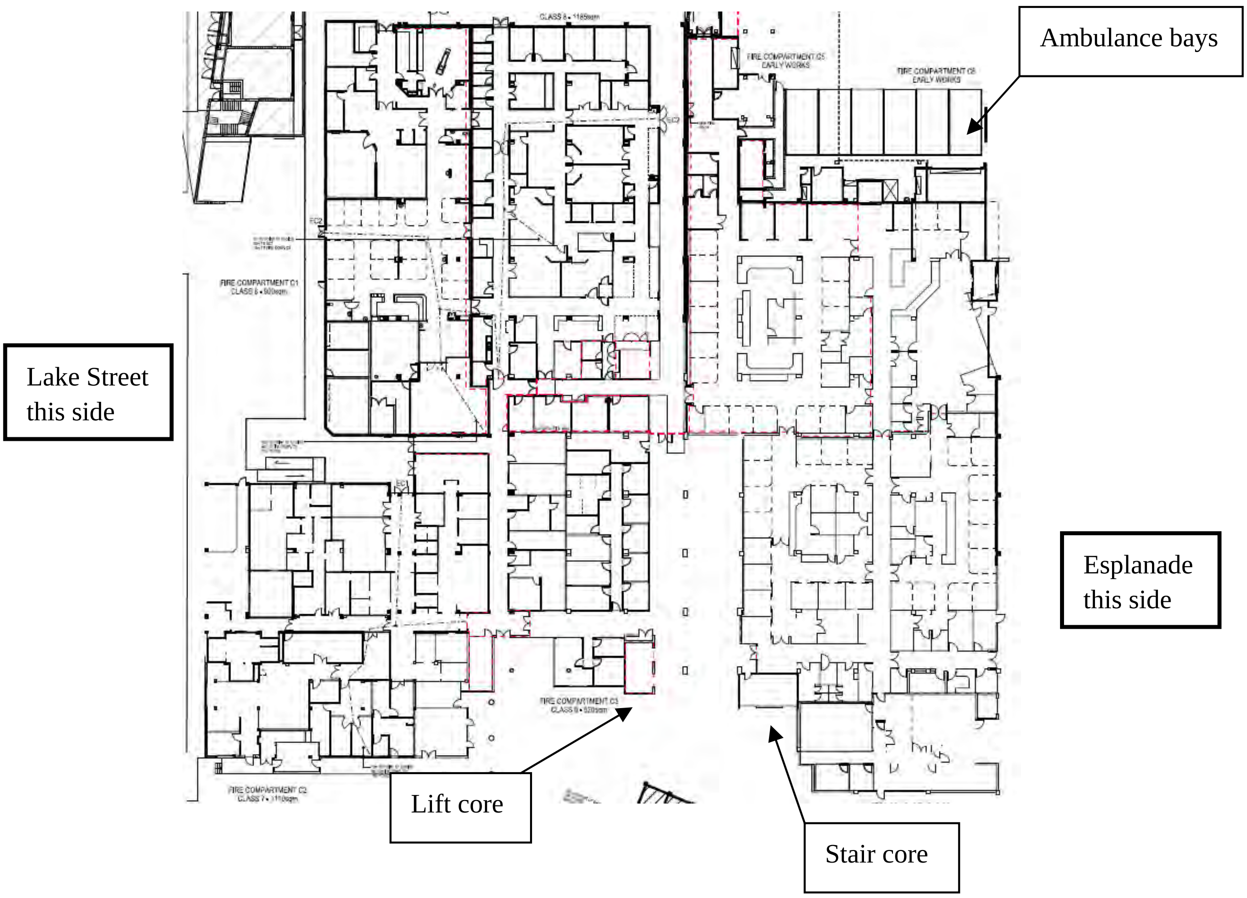
All floors, including the ground floor, are suspended reinforced concrete slabs.

Block C is a three-storey building, with plant rooms generally at level 3 which is a narrower floor plate than the levels below. The ground floor layout is shown in Figure 3, below.

The ground floor is raised above ground with a void below. A maintenance corridor exists below the building where the ground has been cut out to provide easier access, but otherwise the void is believed to be similar to those below Blocks A and B and hence is restricted access. The ground floor is at a level of approximately 4.05m AHD. The building sits on piled footings.

External walls are typically solid brick, block, or precast concrete. Some small areas of external wall are constructed of lightweight steel stud, clad with compressed fibre-cement sheet or colorbond steel sheeting. Glazed areas also exist within the external walls, on all main wall elevations. Plant areas (Level 3) include some areas of external wall which is louvered. Roof areas typically consist of profiled metal sheet roofing screw fixed to steel purlins supported on structural steel roof framing.

Figure 3: General layout of Block C at ground floor.



3.5 Block D

Block D is under construction at the time of writing; due for completion in 2013. It comprises a 3 level podium structure with a further 3 levels of clinical floors plus 2 levels of plant at the top. The layout at Level 1 is shown in Figure 4, below.

The main structure is a reinforced concrete frame with various lift and stair cores spaced around the floor plate. The building envelope comprises a combination of lightweight cladding including glazing, reinforced concrete walls and blockwork walls. Plant areas also include steel louvres. The roof is a traditional profiled metal deck.

All floors, including the ground floor, are suspended decks. The ground floor was built on an earth mound so no sub-floor void exists below this level as it does in other blocks. The ground floor is at a level of 4.05m AHD, to match the other existing blocks.

Figure 4: General layout of Block D at first floor.

3.6 Block E

Block E was completed in 2011. It comprises 8 levels of car park with clinical and support services on ground floor, first and second. The ground floor includes three radiation oncology bunkers, which are massive concrete shells with walls up to 2.5m thick in some places.

The main structure is a reinforced concrete frame with a lift core and several stair cores sapced around the floor plate. The building envelope comprises a combination of lightweight cladding including glazing, reinforced concrete walls and open louvres in the car park decks. Many of the glazed areas have external sunshading. The roof to the top car park level is an open-sided Aramax sheet. The full car park decks are entirely naturally ventilated with the louvres allowing air flow while minimising rain penetration under normal conditions.

The ground floor of Block E is lower than the other blocks by approximately 700mm. The general layout of Block E at Level 2 is shown in Figure 5, below.

Figure 5: General layout of Block E at second floor.

4 Risk Sources

There are many risk sources associated with the built environment. The following risks are considered in this study:

4.1 Wind

Typically for Cairns this is associated with extreme wind events such as tropical cyclones. High winds can also be produced by thunderstorms, but for the Cairns region these do not tend to govern the structural design.

4.2 Debris Impact

Debris in the external environment (on or off the hospital site) that becomes windborne during a cyclone can impact building envelope elements and cause damage. The number and location of such impacts would be very difficult to quantify.

4.3 Storm Surge

This risk is also usually associated with tropical cyclones. It is the result of persistent high winds pushing on a shallow open water surface, creating a 'piling up' of water at the coastline. Sea water levels are also raised by the low atmospheric pressure at the centre of cyclonic systems. Storm surge behaviour is by its nature unpredictable and is unique to each part of the coastline.

4.4 Other Risks

There are many other risks that are outside the scope of this study but ought to be considered in the overall risk assessment process. These may include:

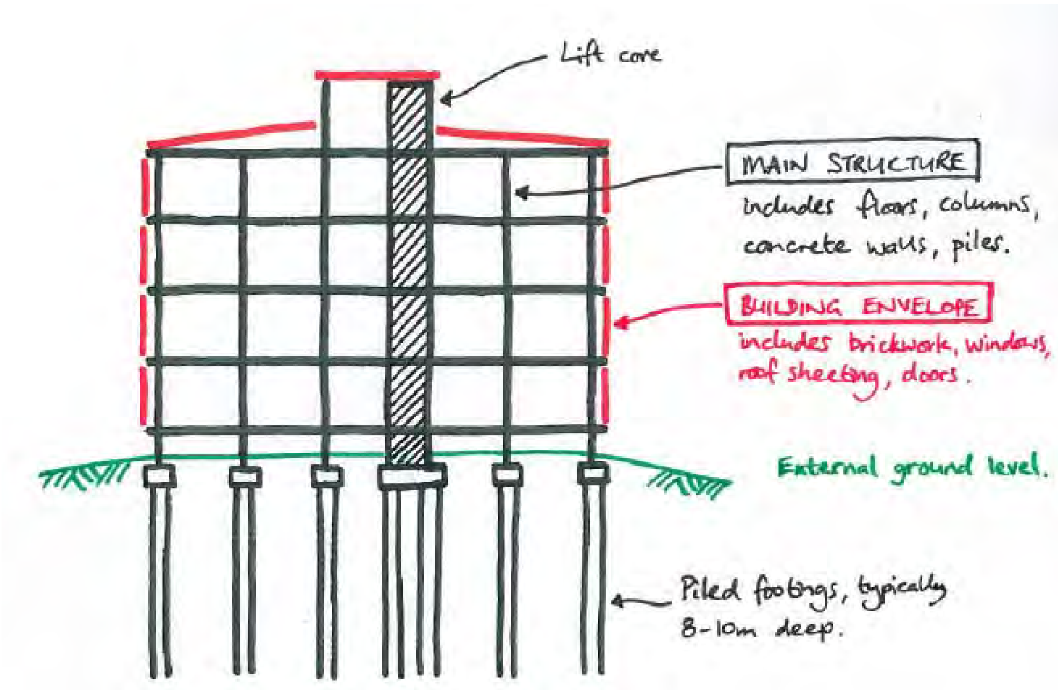
- Seismic;
- Blast;
- Impact not associated with wind events;
- Continuity of supply of consumables;
- Continuity of supply of essential services (water, electricity, gas, sewerage, communications, microwave links, mobile links, etc.);
- Access to and from the site;
- Evacuation routes;
- Condition of site to which to evacuate;
- Provision of downstream supply of assumed services and links (airport, road, transport etc);
- Malicious damage.

5 Risk Areas and Discussion

5.1 Main Structure

This section is concerned with the performance of the buildings as a whole and the performance of the main load-bearing elements such as the columns, beams, slabs, roof structure, core walls – the elements that transfer the loads to the ground and hold the building up. **There is an important distinction between the riskd to the *structure* and the *envelope*, the latter of which is discussed in section 5.2.** Figure 6 shows the fundamental difference.

Figure 6: Explanation of *Main Structure* and *Building Envelope*



5.1.1 Wind Loads

Based on our analysis of the likely design wind loads for the various structures that make up the Cairns Base Hospital campus, it is expected that the ***main structure*** of all buildings in the campus would have been designed to be structurally sufficient to a mid-to-high range Category 4 cyclone.

Structurally sufficient in this context would mean:

- that the structure would survive the event with minimal if any damage to its main load-bearing structural elements and would essentially appear as it now exists following the event;
- the structure would not have yielded or deflected to the point where it would not return to its original position or close to it;
- doors, windows, lifts etc would still operate once inspected and passed for water and debris damage;

- stairs would essentially be in their current condition.

With the various safety factors that exist in materials and the usual case that elements are not designed to their full capacity, it is expected that the ***main structure*** would be capable of resisting a low range Category 5 cyclone. To this level the structure would essentially perform as above. Without reliable engineering data on what was provided in the buildings (particularly Blocks A and B), the degree of 'over-provision' of structural capacity is impossible to accurately assess. This statement is therefore provided for some reassurance only – the summary (on which planning decisions should be made) does not consider it relevant.

Above a low Category 5 cyclone the structure *may* yield and deflect permanently though it is *not expected* that this would be to the point of collapse (refer to section 2.2). Due to building movement, doors may become unusable, windows may not open and lifts may not work due to lift shafts being slightly off vertical. Stairs between floors may be damaged and may not easily be utilised.

This is expected to be the case for all of the buildings which are the subject of this study.

It is also noted that the impact of a Category 5 cyclone in Cairns is without precedent in the modern era. The community-wide destruction expected would be very significant as no buildings (save the official cyclone shelters) have been purposely *designed* for these wind forces. There may be other community triggers for general evacuation which come to the fore should such a cyclone forecast be given.

5.1.2 Storm Surge

There are two principal aspects of storm surge to be considered in relation to structural performance; *inundation* and *wave action*.

Inundation is when the general rise of sea level causes water to seep in through the normal gaps within the building (including below doors and in through any drains, for example). Inundation is expected to be a gradual process and not like a tidal wave. Some service provision (including movement between the ground level links) may be able to continue if a small amount of water is present across the floor. Any level of inundation naturally makes movement more dangerous for personnel even if the building structure is quite safe in itself. This should be considered in any emergency plan, to minimise the risk of injuries to building occupants on potentially slippery floors.

As the majority of the buildings on campus have piled footings, inundation is unlikely to affect the main structural components or the stability of the buildings as a whole. The only building that does not have piled footings is the Mental Health Unit. Inundation may cause some scour around these shallow pad footings or localised softening of the ground. As only the perimeter pad footings are exposed in this way (the rest being below a built-up earth embankment), this is not considered a risk to the overall building structure.

Wave action (also known as wave set-up) has the potential to cause damage to the building envelope (discussed in Section 5.2.3), but the risk to the *overall structure* is considered minimal. The exact nature of wave action, particularly in a storm surge scenario, is unpredictable. Likely consequences of wave action include loss of or damage to parts of the building envelope. With the loss of the infill between the structural elements comes a reduction in the load applied to the buildings, as the water simply moves through the building with fewer obstructions. For this reason the impact of wave action on the *main structure* is considered minimal. The exception to this is if floating items become lodged against the main structural elements and these then apply loads to these main structural elements due to the area of the article exposed to waves (an extreme example may be a boat, pontoon or car). Even in this case, any damage to the main structure is expected to be localised rather than throughout.

5.2 Building Envelope

5.2.1 Wind Loads

Perhaps the greatest risk area that exists is the building envelope. A building envelope is typically designed for slightly higher wind loads than the main structural elements are design for. This is because wind is not uniform in its behaviour but gusts in small areas for short periods of time. These gusts usually act over an area that is smaller than a whole building hence cladding and wall elements are designed with local pressure factors considered which affect only small areas, perhaps the size of a typical window unit in many buildings.

On this basis and the earlier analysis of local pressure factors for wall and roof cladding it can be observed that for these localised wind loads the original infill wall elements may have been designed for approximately 25% less wind load than would be required now. This then puts into question the capacity of the following building envelope elements:

- the glass;
- the window framing ;
- the window framing connection to the structure;
- the other infill panels to the window framing (such as the asbestos cement/ fibre cement sheeting);
- cavity brick infill panels.

In addition there are concealed elements within the building envelope that can deteriorate over time such as brick ties between the leafs of the cavity brick walls, the fixings for the window frames to the structure. None of this can be checked on site without invasive measures. *It has therefore been assumed that all such elements are in sound condition and do not reduce the expected design performance of the facade elements currently seen on site.*

The above-noted 25% difference in wind load translates to a 15% reduction in design wind speed (as pressure is based on the *square* of the wind speed). ***Therefore the design gust wind speed for the older windows in Blocks A and B may be approximately 62.5m/sec (225km/h) which is at the boundary between Category 3 and 4 cyclone.*** Rather like the structural factors of safety discussed above, the glazing systems ought to have some built-in factors of safety, though without some physical testing it is not considered reasonable to extend the assumed performance from that described above.

Some elements of the building envelope may also fail at, or even below, their expected load where the original element restraint has deteriorated due to decay or corrosion, or original workmanship has reduced the capacity of the element to accept above design load. *For the purposes of this report it has been assumed that all such elements are in sound condition and do not reduce the expected design performance of the facade elements currently seen on site.*

Site measurements of some representative glass panels was undertaken as part of our scope. Back-calculations have been done for the thicknesses and types of glass found, to give expected performance levels.

5.2.2 Fatigue Effects

The Building Code of Australia defines testing criteria for roof systems (including sheeting, its direct support and all fixings) which reflect the possible slow passage of a cyclone overhead. These requirements (known as *low-high-low*) were introduced in 2007, though this does not mean that systems installed prior to this are at risk.

Slow moving cyclones have the potential to introduce a risk of fatigue into envelope fixings, due to the high number of wind gusts they subject the envelope to during the slow passage of the cyclone. This means that – in theory – a slow moving, lower category of cyclone may, in some instances for some properties, present a greater-than-might-be-expected risk of envelope failure when considering the maximum wind gust alone. The principal risk area for this scenario is the roof sheeting.

Blocks A and B both have the benefit of a concrete slab directly below the roof sheeting over all occupied areas. Other areas in these blocks have plant room levels above the occupied areas. In each case, the risk to occupant safety from the structural failure of the roof sheeting is considered minimal.

Block C has been the subject of a separate study, where some localised areas were found to be non-compliant with the low-high-low tests.

MHU is expected to have some similar localised areas of concern.

Blocks D and E were each designed after the requirements were introduced and therefore do not carry this risk.

5.2.3 Debris and Dominant Openings

One aspect of glass design that has changed significantly over the years is the design for impact resistance. It is recommended by the wind code that the building envelope design accounts for increased internal pressures caused by a *dominant opening* forming in the building envelope. This dominant opening is most commonly due to the breakage of one or more external windows (due to debris, for example) but may also be caused by an external door blowing open in the wind. By designing for a dominant opening, the risk of a cascading effect of a series of windows being blown out after the first one has failed is minimised. The later wind codes provide for this specifically, ***giving an option*** to adopt additional parameters for impact resistance of building envelope elements.

Adopting such impact loading criteria allows a designer to reduce the amount of internal pressure the windows are designed to, on the assumption that a dominant opening does not occur. In high wind regions such as Cairns, this can often lead to project savings on large buildings as the envelope construction required to resist the normal, high wind loads is often sufficiently resilient to resist the nominated debris test aswell, though this has to be proven by testing on the component parts. In areas of the building where the normal envelope construction is not sufficiently resilient, choosing to upgrade this has downstream benefits such as a reduction in the internal pressure coefficients and internal partition wall design loads.

The debris criteria in the 2002 Wind Code is:

Building envelope to be capable of resisting impact loading equivalent to a 4kg piece of timber of 100mm x 50mm cross-section, projected at 15 metres/second.

It should be noted that there is some ambiguity around the code clause in relation to debris impact resistance. In particular, the code does not define at what angle the projectile should strike the envelope, or at what location the projectile should strike the envelope or, and perhaps most importantly, what constitutes a failure of the envelope under the loading regime. It is also very clear ***that the above impact load does not cover all possible impacts***, such as a failed portion of roof from an adjacent building. Consideration of such risks is beyond the scope of this report.

The wind code suggests that debris resilience (if required by the project brief) should be considered for building heights up to 25 metres above ground, on the assumption that above this height very little flying debris is likely.

It is expected that any windows (in any building) with annealed (otherwise known as 'float') glass, would be susceptible to breakage by debris at the above design criteria. Testing methods have been developed by James Cook University's Cyclone Testing Station to validate the debris resilience of wind assemblies. As physical testing is beyond the scope of this report, it has been left that debris resilience remains a risk to all windows.

5.2.4 Storm Surge

Inundation is unlikely to affect building envelope components unless there is a difference in water level across a building envelope element which subjects the envelope to a hydrostatic load. As the buildings are not watertight, it is expected that the gradual water level rise due to storm surge would generally be equalised on each side of the building enevelope.

Wave action has energy and due to the density of water can have damaging effects on building envelope elements. It is likely that wave action would affect all walls that are exposed to the waves, i.e. ground level walls facing the Esplanade. Other walls to other elevations would be less at risk principally due to them being out of the direct line of the wave impacts.

Waves occur above the level of the storm surge, so they present a risk before inundation does. **For this reason, this report makes an allowance of 0.5m above a storm surge level for wave action to be considered a threat**. This value has been taken from the Parsons Brinkerhoff report dated May 2007, which in turn reviews earlier research. It is an estimate only and is based on a 1000 year return period (equivalent to the design of most of the hospital campus buildings).

Should a breach of the envelope occur, it is reasonable to assume that water trapped inside a building would cause significant damage to internal walls and possibly other external walls as the water looks for a route to escape. Having broken through one side of the building, the wave energy would be much dissipated due to the general roughness of the land and building surfaces over which it is passing.

While restricted to the most extreme end of the storm surge scale, it is conceivable that water with sufficient energy could effectively clear the contents of ground floor level, causing extensive damage to the lightweight internal fabric of the building. Should this situation arise, the water may eventually break through the building and flow more freely, thus relieving the load on the main structure. It is stressed that this would be a most extreme situation and there are likely to be other community triggers for general evacuation which come to the fore should such a storm surge forecast be given.

Clearly in the above scenario it would be expected that no-one would have cause to remain on the ground floor or indeed within the buildings generally.

6 Summary

It is important to recognise that the magnitude of a storm surge *impact* is not only related to the severity of a cyclone, but also to the timing of the approach of the cyclone in relation to normal tidal behaviour. For this reason, the results have been presented separately for wind and storm surge. Both parts of the results are relevant to decision making and should be considered alongside each other in response to forecasts from the Bureau of Meteorology or other appropriate authorities. The summarised details are presented in graphical format for ease of use in the planning process.

Performance is presented against the 'weakest link' in the building fabric. In all cases this is the building envelope rather than the main structure. If a portion of the building envelope cannot be considered resilient, then alternative arrangements may need to be made for continuity of service provision within that area of the building.

The assessment of debris resilience requires some physical testing to be carried out on elements of the envelope (glazing and fibre-cement cladding, for example). As this has not been done in the preparation of this report, it has been decided to omit detailed commentary on debris resilience from the report at this stage where the design approach or envelope materials are not known (i.e. for Blocks A, B and C).

Debris impact can occur in any category of cyclone and is more likely closer to ground level than it is higher up a building. Its impact on service provision is expected to be localised only. **In any given wind event the impact *location* on the building envelope and *the number of debris strikes* are beyond reasonable assessment in a report of this type.** For these reasons, the risk of debris strike is not included in this overall performance review.

6.1 Wind Resilience

6.1.1 Blocks A, B, C and MHU

Categories 1-3 inclusive: Expected to be resilient to all wind speeds in these categories of cyclone. Debris risk exists to glass and brittle cladding elements (e.g. fibre-cement sheeting).

Category 4: Risk of *localised* window or envelope failure at the building corners, but no risk of main structural failure. Debris risk exists to glass and brittle cladding elements (e.g. fibre-cement sheeting).

Category 5: Risk of failure of both the building envelope (more widespread than at Category 4) and excessive movement of the main structure to the point of causing discomfort for occupancy (particularly on higher floors) and possibly localised deflection causing the building to be unserviceable during and after the event. The risk of structural collapse of the main load-bearing elements is not considered realistic even at Category 5 wind speeds (to a reasonable assumed maximum as identified in the Public Cyclone Shelter Design Guidelines referenced earlier, given this category is theoretically unlimited).

6.1.2 Block D

Categories 1-3 inclusive: Expected to be resilient to all wind speeds in these categories of cyclone. Debris resilient envelope in accordance with AS1170.2 (2002) which will provide additional protection.

Category 4: Risk of *localised* window or envelope failure at *higher* wind speeds within this category, but no risk of main structural failure. Debris resilient envelope in accordance with AS1170.2 (2002), which will provide additional protection.

Category 5: Risk of failure of both the building envelope (more widespread than at Category 4) and excessive movement of the main structure to the point of causing discomfort for occupancy (particularly on higher floors) and possibly localised deflection causing the building to be unserviceable during and after the event. The risk of structural collapse of the main load-bearing elements is not considered realistic even at Category 5 wind speeds (to a reasonable assumed maximum as identified in the Public Cyclone Shelter Design Guidelines referenced earlier, given this category is theoretically unlimited).

6.1.3 Block E

Categories 1-3 inclusive: Expected to be resilient to all wind speeds in these categories of cyclone. Debris risk exists to glass and brittle cladding elements (e.g. fibre-cement sheeting) where not protected.

Category 4: Risk of *localised* window or envelope failure at *medium* wind speeds within this category, but no risk of main structural failure. Debris risk exists to glass and brittle cladding elements (e.g. fibre-cement sheeting).

Category 5: Risk of failure of both the building envelope (more widespread than at Category 4) and excessive movement of the main structure to the point of causing discomfort for occupancy (particularly on higher floors) and possibly localised deflection causing the building to be unserviceable during and after the event. The risk of structural collapse of the main load-bearing elements is not considered realistic even at Category 5 wind speeds (to a reasonable assumed maximum as identified in the Public Cyclone Shelter Design Guidelines referenced earlier, given this category is theoretically unlimited).

6.2 Storm Surge

Storm surge risks are presented against height above HAT, which is how BOM forecast in the period 24 to 48 hours prior to likely wind impact. Within 24 hours of wind impact, the forecast is revised to be presented relative to the expected tide at the time. Those reading the forecasts should pay particular attention to the distinction.

All buildings are taken to have a ground floor level of 4.05m AHD (equivalent to 2.27m above HAT). There are a few exceptions to this, including most notably Block E and the BEMS office to the rear of Block B, which are both lower.

As described above, an allowance of 0.5m has been made above storm surge forecasts for wave action, on the basis that waves pose a threat to the building envelope and hence occupants should not be in those areas at risk.

6.2.1 All Blocks *except* Block E

HAT plus anything less than 1.77m: All blocks would be expected to be resilient at this level of storm surge. Possibility of minor water ingress due to spray from waves.

HAT plus 1.77m to 2.27m: Risk of inundation to all buildings and wave action up to waist level of occupants if envelope is breached due to wave action.

HAT plus 2.27m to 2.42m: Inundation to all buildings at ground floor level up to approximately 150mm above ground floor. Probable envelope damage to all lightweight wall or window areas exposed to waves. Concrete ground floor walls (e.g. MHU) will resist collapse but ground floor wave-facing brickwork at risk of collapse.

HAT plus 2.42m to 6.38m: Significant inundation to all buildings at ground level. Significant envelope damage to all lightweight and brickwork walls, including probable loss of ground floor windows due to wave action. Probable extensive internal damage to non-structural walls. Main structure expected to perform adequately.

HAT plus 6.38m or more: Approximate first floor level. Threat of excessive movement of the main structure to the point of localised deflection causing the building to be unserviceable during and after the event.

6.2.2 Block E

HAT plus anything less than 1.52m: Expected to be resilient at this level of storm surge. Possible minor lapping of water at thresholds due to wind pushing water, which woudl just be starting to flood the immediate building surrounds.

HAT plus 1.52m to 1.67m: Likely inundation to Block E up to approximately 150mm. Unlikly to see significant wave action due to shallow depth of water.

HAT plus 1.67m to 6.72m: Significant inundation to Block E at ground level. Significant envelope damage to all lightweight walls, including probable loss of ground floor windows due to wave action. Probable extensive internal damage to non-structural walls. Main structure expected to perform adequately.

HAT plus 6.72m or more: Approximate first floor level. Threat of excessive movement of the main structure to the point of localised deflection causing the building to be unserviceable during and after the event.

7 Future Opportunities

This report considers only those buildings at the main hospital campus on the Esplanade/Lake Street. The investigation has been high level in its nature and could not reasonably consider every nuance of building construction quality nor ongoing maintenance regimes. No physical materials testing has been done in the preparation of this report and no condition inspection has been done to verify that any building elements are correctly fastened and in appropriate condition to resist the loads that might be expected during a cyclone.

In the preparation of the report, several opportunities have presented themselves; either due to the limitations of this report or through broader discussions with stakeholders. We would be pleased to discuss opportunities for any of the following if they are considered of value.

1. Physical testing of existing facade elements to validate wind and/or debris resilience.
2. Design of additional protection measures to windows (or other fragile facade elements) in certain areas may provide a greater degree of wind and/or debris resilience. This could increase the range of conditions for safe use of either critical areas or those areas inherently more at risk such as building corners. Such measures may be as simple as the replacement of some glazing.
3. Assessment of alternative facilities to provide data on the expected wind and/or storm surge resilience of evacuation locations, to ensure people are not moved from one at-risk location to another (which may be subject to different risks, or indeed not actually be as resilient as the main campus in some scenarios).
4. Consideration of opportunities to relocate (or locate additional) plant or equipment to higher floors should a strategy to improve the ability to operate from first floor and above in a storm surge threat situation be of value.
5. Assistance with broader disaster planning initiatives including logistics, building services, risk management, etc.

Appendix A

Risk Summary Tables

Cairns Base Hospital - Structural and Envelope Wind Risk

MHU Wind

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
1	90-124 km/h	Ground			Debris risk to windows at all levels
		First/Roof			
		Roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
2	125-164 km/h	Ground			Debris risk to windows at all levels
		First/Roof			
		Roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
3	165-224 km/h	Ground			Debris risk to windows at all levels
		First/Roof			
		Roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
4	225-279 km/h	Ground			Debris risk to windows at all levels
		First/Roof			Corner windows at possible risk of wind failure
		Roof			Possible roof and plant damage

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
5	280+ km/h	Ground			Debris risk to windows at all levels
		First/Roof			Probable widespread failure of windows due to wind.
		Roof			Probable roof and plant damage

Legend

- Considered structurally resilient
- Caution - some risks exist either during or after an event.
- Do not occupy

Block A Wind

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
1	90-124 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Third			
		Fourth			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
2	125-164 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Third			
		Fourth			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
3	165-224 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Third			
		Fourth			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
4	225-279 km/h	Ground			Debris risk to windows at all levels
		First			Corner windows of building at possible risk of wind failure at upper end of range
		Second			
		Third			
		Fourth			
		Plant/roof			Possible roof damage

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
5	280+ km/h	Ground			Debris risk to windows at all levels.
		First			Probable widespread failure of windows due to wind
		Second			Likely failure of other areas of envelope due to wind at all levels
		Third			
		Fourth			
		Plant/roof			Probable roof damage

Legend

- Considered structurally resilient
- Caution - some risks exist either during or after an event.
- Do not occupy

Block B Wind

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
1	90-124 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
2	125-164 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
3	165-224 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
4	225-279 km/h	Ground			Debris risk to windows at all levels
		First			Corner windows at probable risk of wind failure from lower end of range
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant/roof			Possible roof damage

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
5	280+ km/h	Ground			Debris risk to windows at all levels.
		First			Probable widespread failure of windows due to wind
		Second			Likely failure of other areas of envelope due to wind at all levels
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant/roof			Probable roof damage

Legend

- Considered structurally resilient
- Caution - some risks exist either during or after an event.
- Do not occupy

Block C Wind

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
1	90-124 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
2	125-164 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
3	165-224 km/h	Ground			Debris risk to windows at all levels
		First			
		Second			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
4	225-279 km/h	Ground			Debris risk to windows at all levels
		First			Corner windows at possible risk of wind failure at higher wind speeds
		Second			
		Plant/roof			Possible roof damage

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
5	280+ km/h	Ground			Debris risk to windows at all levels
		First			Probable widespread failure of windows due to wind.
		Second			Likely failure of other areas of envelope due to wind at all levels
		Plant/roof			Probable roof and plant damage

Legend

- Considered structurally resilient
- Caution - some risks exist either during or after an event.
- Do not occupy

Block D Wind

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
1	90-124 km/h	Ground			Debris resilient to AS 1170.2 - 2002
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
2	125-164 km/h	Ground			Debris resilient to AS 1170.2 - 2002
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
3	165-224 km/h	Ground			Debris resilient to AS 1170.2 - 2002
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
4	225-279 km/h	Ground			Debris resilient to AS 1170.2 - 2002
		First			Windows and lightweight envelope at risk of wind failure at higher wind speeds
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant			
		Plant/roof			Possible roof damage

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
5	280+ km/h	Ground			Debris risk to windows at all levels
		First			Probable widespread failure of windows due to wind
		Second			Likely failure of other areas of envelope due to wind at all levels
		Third			
		Fourth			
		Fifth			
		Sixth			
		Plant			
		Plant/roof			Probable roof and plant damage

Legend

- Considered structurally resilient
- Caution - some risks exist either during or after an event.
- Do not occupy

Block E Wind

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
1	90-124 km/h	Ground			Debris risk to windows at all levels where unprotected
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Seventh			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
2	125-164 km/h	Ground			Debris risk to windows at all levels where unprotected
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Seventh			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
3	165-224 km/h	Ground			Debris risk to windows at all levels where unprotected
		First			
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Seventh			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
4	225-279 km/h	Ground			Debris risk to windows at all levels where unprotected
		First			Windows and lightweight envelope at risk of wind failure at medium wind speeds
		Second			
		Third			
		Fourth			
		Fifth			
		Sixth			
		Seventh			
		Plant/roof			

Cyclone category	Gust wind speed as reported by BOM	Floor level	Occupy during event	Occupy after event	Comments
5	280+ km/h	Ground			Debris risk to windows at all levels where unprotected
		First			Probable widespread failure of windows due to wind
		Second			Likely failure of other areas of envelope due to wind at all levels
		Third			
		Fourth			
		Fifth			
		Sixth			
		Seventh			
		Plant/roof			Probable roof and plant damage

Legend

- Considered structurally resilient
- Caution - some risks exist either during or after an event.
- Do not occupy

Cairns Base Hospital - Structural and Envelope Storm Surge Risk

MHU Storm Surge

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + up to 1.77m	up to 3.55m	Ground	Green	Green	Risk of some wave spray ingress
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First/Roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.77m to 2.27m)	3.55m to 4.05m	Ground	Amber	Amber	Debris and wave risk at ground floor
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First/Roof	Green	Green	Possible inundation at ground floor

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.27m to 2.42m)	4.05m to 4.20m	Ground	Red	Amber	Debris and wave risk at ground floor
		First/Roof	Green	Green	Certain inundation at ground floor (150mm)

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.42m to 6.38m)	4.20m to 8.16m	Ground	Red	Amber	Debris and wave risk to ground and (at higher end of this range) first floor external walls
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First/Roof	Red	Amber	Certain inundation at ground floor

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + 6.38m or more	above 8.16m	Ground	Red	Amber	Certain inundation at first floor
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First/Roof	Red	Amber	

Legend

Green	Considered structurally resilient
Amber	Caution - some risks exist either during or after an event.
Red	Do not occupy

Block A Storm Surge

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + up to 1.77m	up to 3.55m	Ground	Green	Green	Risk of some wave spray ingress at ground floor
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	
		Second	Green	Green	
		Third	Green	Green	
		Fourth	Green	Green	
		Plant	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.77m to 2.27m)	3.55m to 4.05m	Ground	Amber	Amber	Debris and wave risk at ground floor
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	Possible inundation at ground floor
		Second	Green	Green	Wave risk to lightweight external walls and doors
		Third	Green	Green	
		Fourth	Green	Green	
		Plant	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.27m to 2.42m)	4.05m to 4.20m	Ground	Red	Amber	Debris risk at ground floor
		First	Green	Green	Certain inundation at ground floor (150mm)
		Second	Green	Green	Significant wave impact risk to external walls
		Third	Green	Green	
		Fourth	Green	Green	
		Plant	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.42m to 6.38m)	4.20m to 8.16m	Ground	Red	Amber	Debris risk to ground and (at higher end of this range) first floor external walls
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	Inundation up to full depth of ground floor
		Second	Amber	Amber	Significant wave impact risk to external walls
		Third	Amber	Amber	
		Fourth	Amber	Amber	
		Plant	Amber	Amber	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + 6.38m or more	above 8.16m	Ground	Red	Amber	
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	
		Second	Red	Amber	
		Third	Red	Amber	
		Fourth	Red	Amber	
		Plant	Red	Amber	

Legend

Green	Considered structurally resilient
Amber	Caution - some risks exist either during or after an event.
Red	Do not occupy

Block B Storm Surge

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + up to 1.77m	up to 3.55m	Ground	Green	Green	Risk of some wave spray ingress at ground floor
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	
		Second	Green	Green	
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.77m to 2.27m)	3.55m to 4.05m	Ground	Amber	Amber	Debris risk to ground floor external walls
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	Possible inundation at ground floor
		Second	Green	Green	Wave risk to lightweight external walls and doors
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.27m to 2.42m)	4.05m to 4.20m	Ground	Red	Amber	Debris risk to ground floor external walls
		First	Green	Green	Certain inundation at ground floor (150mm)
		Second	Green	Green	Significant wave impact risk to ground floor external walls
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.42m to 6.38m)	4.20m to 8.16m	Ground	Red	Amber	Debris risk to ground and (at higher end of this range) first floor external walls
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	Inundation up to full depth of ground floor at high ends of this range
		Second	Amber	Amber	Wave risk to first floor external walls at high ends of this range
		Third	Amber	Amber	
		Fourth	Amber	Amber	
		Fifth	Amber	Amber	
		Sixth	Amber	Amber	
		Plant/roof	Amber	Amber	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + 6.38m or more	above 8.16m	Ground	Red	Amber	
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	
		Second	Red	Amber	
		Third	Red	Amber	
		Fourth	Red	Amber	
		Fifth	Red	Amber	
		Sixth	Red	Amber	
		Plant/roof	Red	Amber	

Legend

Green	Considered structurally resilient
Amber	Caution - some risks exist either during or after an event.
Red	Do not occupy

Block C Storm Surge

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + up to 1.77m	up to 3.55m	Ground	Green	Green	Risk of some wave spray ingress at ground floor
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	
		Second	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.77m to 2.27m)	3.55m to 4.05m	Ground	Amber	Amber	Debris risk to ground floor external walls
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	Possible inundation at ground floor
		Second	Green	Green	Wave risk to lightweight external walls and doors
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.27m to 2.42m)	4.05m to 4.20m	Ground	Red	Amber	Debris risk to ground floor external walls
		First	Green	Green	Certain inundation at ground floor (150mm)
		Second	Green	Green	Significant wave impact risk to ground floor external walls
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.42m to 6.38m)	4.20m to 8.16m	Ground	Red	Amber	Debris risk to ground and (at higher end of this range) first floor external walls
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	Inundation up to full depth of ground floor at high ends of this range
		Second	Amber	Amber	Wave risk to first floor external walls at high ends of this range
		Plant/roof	Amber	Amber	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + 6.38m or more	above 8.16m	Ground	Red	Amber	
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	
		Second	Red	Amber	
		Plant/roof	Red	Amber	

Legend

Green	Considered structurally resilient
Amber	Caution - some risks exist either during or after an event.
Red	Do not occupy

Block D Storm Surge

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + up to 1.77m	up to 3.55m	Ground	Green	Green	Risk of some wave spray ingress at ground floor
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	
		Second	Green	Green	
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.77m to 2.27m)	3.55m to 4.05m	Ground	Amber	Amber	Debris risk to ground floor external walls
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	Possible inundation at ground floor
		Second	Green	Green	Wave risk to lightweight external walls and doors
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.27m to 2.42m)	4.05m to 4.20m	Ground	Red	Amber	Debris risk to ground floor external walls
Ground floor = HAT +2.27m	*Ground floor = 4.05m AHD*	First	Green	Green	Certain inundation at ground floor (150mm)
		Second	Green	Green	Significant wave impact risk to ground floor external walls
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (2.42m to 6.38m)	4.20m to 8.16m	Ground	Red	Amber	debris risk to ground and (at higher end of this range) first floor external walls
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	Inundation up to full depth of ground floor at high ends of this range
		Second	Amber	Amber	Wave risk to first floor external walls at high ends of this range
		Third	Amber	Amber	
		Fourth	Amber	Amber	
		Fifth	Amber	Amber	
		Sixth	Amber	Amber	
		Plant	Amber	Amber	
		Plant/roof	Amber	Amber	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + 6.38m or more	above 8.16m	Ground	Red	Amber	
First floor = HAT +6.38m	*First floor = 8.16m AHD approx*	First	Red	Amber	
		Second	Red	Amber	
		Third	Red	Amber	
		Fourth	Red	Amber	
		Fifth	Red	Amber	
		Sixth	Red	Amber	
		Plant	Red	Amber	
		Plant/roof	Red	Amber	

Legend

Green	Considered structurally resilient
Amber	Caution - some risks exist either during or after an event.
Red	Do not occupy

Block E Storm Surge

Note Block E ground floor is lower than the other blocks and surge reference levels are therefore different

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + up to 1.52m	up to 3.3m	Ground	Green	Green	Risk of some lapping water at ground floor
Ground floor = HAT +1.52m	*Ground floor = 3.3m AHD*	First	Green	Green	
		Second	Green	Green	
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.52m to 1.67m)	3.3m to 3.45m	Ground	Red	Amber	Certain inundation at ground floor (150mm)
Ground floor = HAT +1.52m	*Ground floor = 3.3m AHD*	First	Green	Green	Negligible wave impact risk to ground floor external walls
		Second	Green	Green	
		Third	Green	Green	
		Fourth	Green	Green	
		Fifth	Green	Green	
		Sixth	Green	Green	
		Plant	Green	Green	
		Plant/roof	Green	Green	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + (1.67m to 6.72m)	3.45m to 8.5m	Ground	Red	Amber	Debris risk to ground and (at higher end of this range) first floor external walls
First floor = HAT +6.72m	*First floor = 8.5m AHD approx*	First	Red	Amber	Inundation up to full depth of ground floor at high ends of this range
		Second	Amber	Amber	Wave risk to first floor external walls at high ends of this range
		Third	Amber	Amber	
		Fourth	Amber	Amber	
		Fifth	Amber	Amber	
		Sixth	Amber	Amber	
		Plant	Amber	Amber	
		Plant/roof	Amber	Amber	

Storm Surge Level as reported by BOM (metres above Highest Astronomical Tide, HAT)	Australian Height Datum (AHD)	Floor level	Occupy during event	Occupy after event	Comments
HAT + 6.72m or more	above 8.5m	Ground	Red	Amber	
First floor = HAT +6.72m	*First floor = 8.5m AHD approx*	First	Red	Amber	
		Second	Red	Amber	
		Third	Red	Amber	
		Fourth	Red	Amber	
		Fifth	Red	Amber	
		Sixth	Red	Amber	
		Plant	Red	Amber	
		Plant/roof	Red	Amber	

Legend

Green	Considered structurally resilient
Amber	Caution - some risks exist either during or after an event.
Red	Do not occupy

Appendix B

Sea Level Rise Projections

The following sea level rise projections are taken from the Queensland Coastal Plan (February 2012). The science of climate change is not exact; these values are provided for information only.

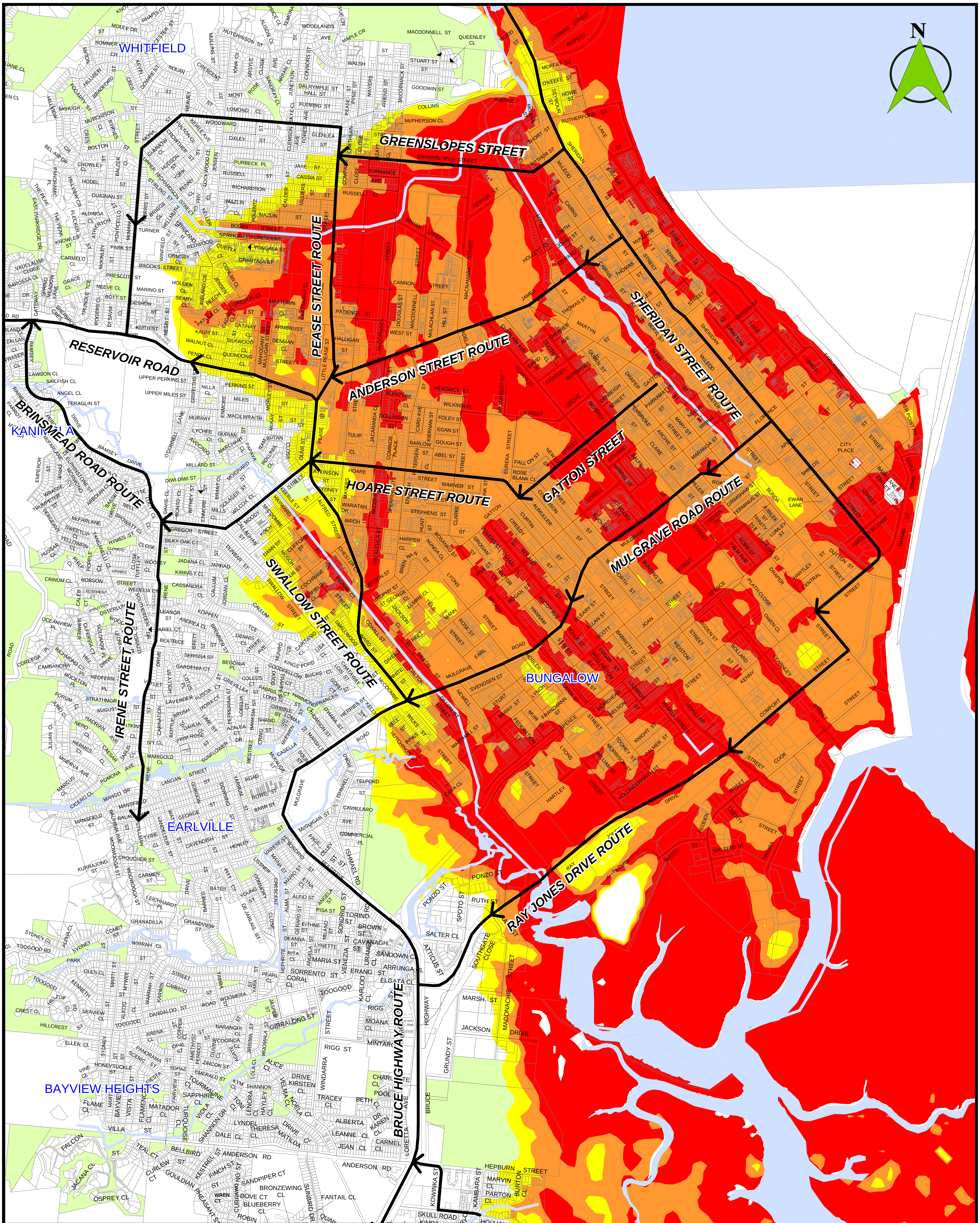
The data illustrates an increased risk into the future of inundation by the same magnitude of storm surge, assuming the general sea level is higher before the storm.

This report does not consider sea level rise.

Year of end of planning period	Projected sea level rise [m]
2050	0.3
2060	0.4
2070	0.5
2080	0.6
2090	0.7
2100	0.8

Appendix C

Cairns Regional Council
Storm Tide Evacuation Map



Storm Tide Evacuation Zones

Yellow	RESIDENTS IN YELLOW ZONE face a moderate risk of flooding from a cyclone storm tide.
Orange	RESIDENTS IN ORANGE ZONE face a high risk of flooding from a cyclone storm tide.
Red	RESIDENTS IN RED ZONE face the highest risk of flooding from a cyclone storm tide.
	Primary Evacuation Route
	Alternative Evacuation Route
	Parks, Open Space and Sports Grounds

How to use the Storm Tide Evacuation Maps

- Identify where your residence is located on the map.
- If your residence is coloured as red, orange, or yellow evacuation zone, you may be at risk from storm tide flooding.
- If your residence is not coloured you are NOT in an evacuation zone and should read Cairns Regional Council's advice on planning for disasters.
- If your residence is coloured identify the primary or alternative evacuation route to your pre-determined safer location.
- During an event, stay tuned to local ABC and/or commercial radio station and/or Cairns Regional Council's Facebook & Twitter sites for updates and advice on evacuations.
- Colour coding of evacuation zones has been provided to the boundary level for properties up to 1 acre (4047m2), if several zones occur then the property is coloured to the highest risk.

Disclaimer

Storm Tide Evacuation Zones are modelled using geographical data and may not be an exact representation of what an event may result in.

Evacuation Zones are designed to provide an easy to understand method for the public to identify coastal areas that may be affected by storm tides caused by tropical cyclones or severe coastal storms. While every care is taken to ensure the accuracy of this data, Cairns Regional Council makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitations, liability in negligence) for all expenses, losses, damages (including indirect or consequential damages) and costs which you might incur as a result of the data.

Cairns Regional COUNCIL

AREA 1 - CAIRNS CBD EVACUATION ROUTES

MAP 1-303