AQUIS RESORT AT THE GREAT BARRIER REEF PTY LTD

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2

CHAPTER 12

HAZARDS

12. HAZARDS

12.1 OVERVIEW OF HAZARDS AND RISKS

12.1.1 Information Sources and Hazards Considered

A number of risk assessments have been undertaken in relation to hazards that have the potential to occur in the Cairns region. This chapter collates relevant information gathered by Commonwealth, state and local governments. Specifically it draws on information from the following documents:

- *Community Risk in Cairns – A Multi Hazard Risk Assessment* by the Australian Geological Survey Organisation AGSO (Granger *et al.* 1999) includes a suburb-by-suburb risk assessment for the then Cairns Local Government Area (LGA).
- The *Cairns District Disaster Management Plan* (Cairns DDMP) has been developed by the State Government Cairns District Disaster Management Group (CDDMG 2011), and documents a broad description of hazards potentially occurring in the Cairns district, a risk assessment of the hazard, assigns responsibilities for the response of specific hazards and provides some details regarding the planned response.
- *Local Disaster Management Plan (*LDMP) *Cairns Region* developed by CRC (2011) provides a risk assessment and broad strategy of response for hazards that potentially occur in the Cairns LGA.
- *Natural Hazards in Australia – Identifying Risk Analysis Requirements* by Geoscience Australia (Middelmann 2007) provides a national context for risk analysis requirements and defines important terminology. Not all local hazards are considered.

In addition, there has been a constant development in design and building codes at the national level.

The following discussion addresses key hazards, namely:

- earthquake
- tsunami
- landslide
- bushfire
- flooding
- cyclone (including storm surge)
- shoreline erosion and river migration
- disease outbreak / pandemic
- wildlife hazards
- climate change.

Some of these have already been discussed in previous chapters (e.g. **Chapter 8** - Coastal Processes, **Chapter 9** – Flooding). In these cases brief mention is made of the findings (usually in terms of exposure) and these are discussed in the context of local hazard planning. Additional aspects of hazards described are specified in the ToR and are incorporated into the assessment, namely:

- integrated emergency management planning (mitigation / management only)
- accidents, spillages, fire and abnormal events (assessed from the perspective of impacts and mitigation / management only).

12.1.2 The Nature of Risk

A useful definition of risk is provided by Geoscience Australia (Middelmann 2007) as follows:

> Risk is defined by the risk management standard AS / NZS 4360:2004 as (p. 4): 'the chance of something happening that will have an impact on objectives. A risk is often specified in terms of an event or circumstance and the consequences that may flow from it. Risk is measured in terms of a combination of the consequences of an event and their likelihood.'
>
> 'Likelihood' describes how often a hazard is likely to occur, and is commonly referred to as the probability or frequency of an event. 'Consequence' describes the effect or impact of a hazard on a community. Both likelihood and consequence may be expressed using either descriptive words (i.e. qualitative measures) or numerical values (i.e. quantitative measures) to communicate the magnitude of the potential impact (AS / NZS 4360:2004).
>
> Risk in disaster management has been described … as the probability of a loss, which depends on three factors: hazard, exposure and vulnerability.
>
> A 'hazard' refers to a single event or series of events which is characterised by a certain magnitude and likelihood of occurrence. 'Exposure' refers to the elements that are subject to the impact of a specific hazard, such as houses on a floodplain. 'Vulnerability' is the degree to which the exposed elements will suffer a loss from the impact of a hazard. […]. That is, risk is the interaction between likelihood and consequence. (p33)

The risk assessment matrix used by the Cairns DDMG is shown schematically below. This is a commonly used assessment method and is based on the relevant standard (AS / NZS 4360:2004).

			CONSEQUENCE (IMPACT)				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
LIKELIHOOD	Almost Certain	5	Low +	Medium +	High	Very High	Extreme
	Likely	4	Low -	Medium -	Medium +	High	Very High
	Moderate	3	Negligible	Low +	Medium -	Medium +	High
	Unlikely	2	Negligible	Low -	Low +	Medium -	Medium +
	Rare	1	Negligible	Negligible	Negligible	Low -	Low +

Figure 12-1 Typical risk matrix.

Source: Cairns DDMG (2011).

The use of this matrix involves independently assessing likelihood and consequence and then determining the resultant level of risk. For example, a *Likely* event with a *Major* consequence would result in a *High* risk.

12.1.3 Terms for Expressing Probability (Likelihood)

The probability of occurrence of a hazard includes two alternative concepts:

- **Average Recurrence Interval (ARI)** – the annual period between events of the specified magnitude, expressed in years (i.e. 100 year or 1000 year ARI)
- **Annual Exceedance Probability (AEP)** – the probability that events of the specified magnitude occur in 1 year, expressed as a percent (i.e. 1% AEP or 0.1% AEP). This is the preferred terminology.

These are related concepts in that ARIs of greater than 10 years are very closely approximated by the reciprocal of the AEP (i.e. 100 year ARI = 0.1% AEP). Note that the old approach of referring to probability as, for example, the '1 in 100 year flood', while being statistically identical to 100 year ARI, is no longer in official usage as it implies that rare events are in some way separated by fixed periods of time. As noted above, the preferred terminology is AEP.

12.2 CONSULTATION WITH RELEVANT EMERGENCY MANAGEMENT AUTHORITIES

Consultation has been undertaken with appropriate agencies via an Emergency Services Focus Group meeting and follow-up communications with some of the participants. Details of attendees are listed in **Table 12-1**.

TABLE 12-1 CONSULTATION

COMPANY / AGENCY	REPRESENTATIVE / S	ISSUES
CRC	Ian Fell	• Hazard responses • Flood level monitoring network • Membership on the Local Disaster Management Group (LDMG) • RISK-GIS • Communication in the event of an emergency • Disease outbreak / pandemic • Engineering standards
Queensland Fire and Rescue Service	Stephen Tognolini Neil Fanning	
Queensland Police Service	Owen Kennedy Paul Taylor Rhys Newton	
Cairns & Hinterland Local Ambulance Service Network	Rod Sheather	
State Emergency Service and Emergency Management Queensland	Cheryl-Lee Fitzgerald	

Source: Study team compilation.

Outcomes from discussions held during this meeting plus post-meeting communications are referred to below as appropriate.

12.3 EXISTING SITUATION

12.3.1 Earthquake

a) Risk Assessment

According to Geoscience Australia (Granger et al. 1999) Cairns has experienced at least 11 significant earthquakes over the last 100 years with the most damaging[6] measuring 4.3 on the Richter Scale. While the likelihood of a stronger magnitude earthquake of 5 to 6 would be rare, the consequences would be catastrophic. This study concluded that while all Cairns suburbs have some degree of exposure, buildings on soft sediments of river deltas and coastal plains will suffer the most damage as the soft sediments amplify earthquake shaking and become unstable (liquefaction). It is most likely that these factors make earthquake the third greatest risk to the community according to the Cairns DDMP (2011). See **Table 12-3**.

The earthquake risk assessment (see **Figure 12-2**) shows that Yorkeys Knob has been assessed as having ‘significant risk’ (although the term ‘significant’ is not defined) and it can be interpreted that this largely due to it being located near the Barron River delta and on coastal plains which contain soft sediments. Earthquakes can also cause tsunamis which are considered below.

The LDMP (CRC 2011) considers that an earthquake would be a *Rare* event (1000 year ARI / 0.1% AEP) but the consequences would be *Catastrophic.* Application of **Figure 12-1** to these values produces an overall risk level of *High*.

[6] The report does not expand on what is meant by ‘damaging’.

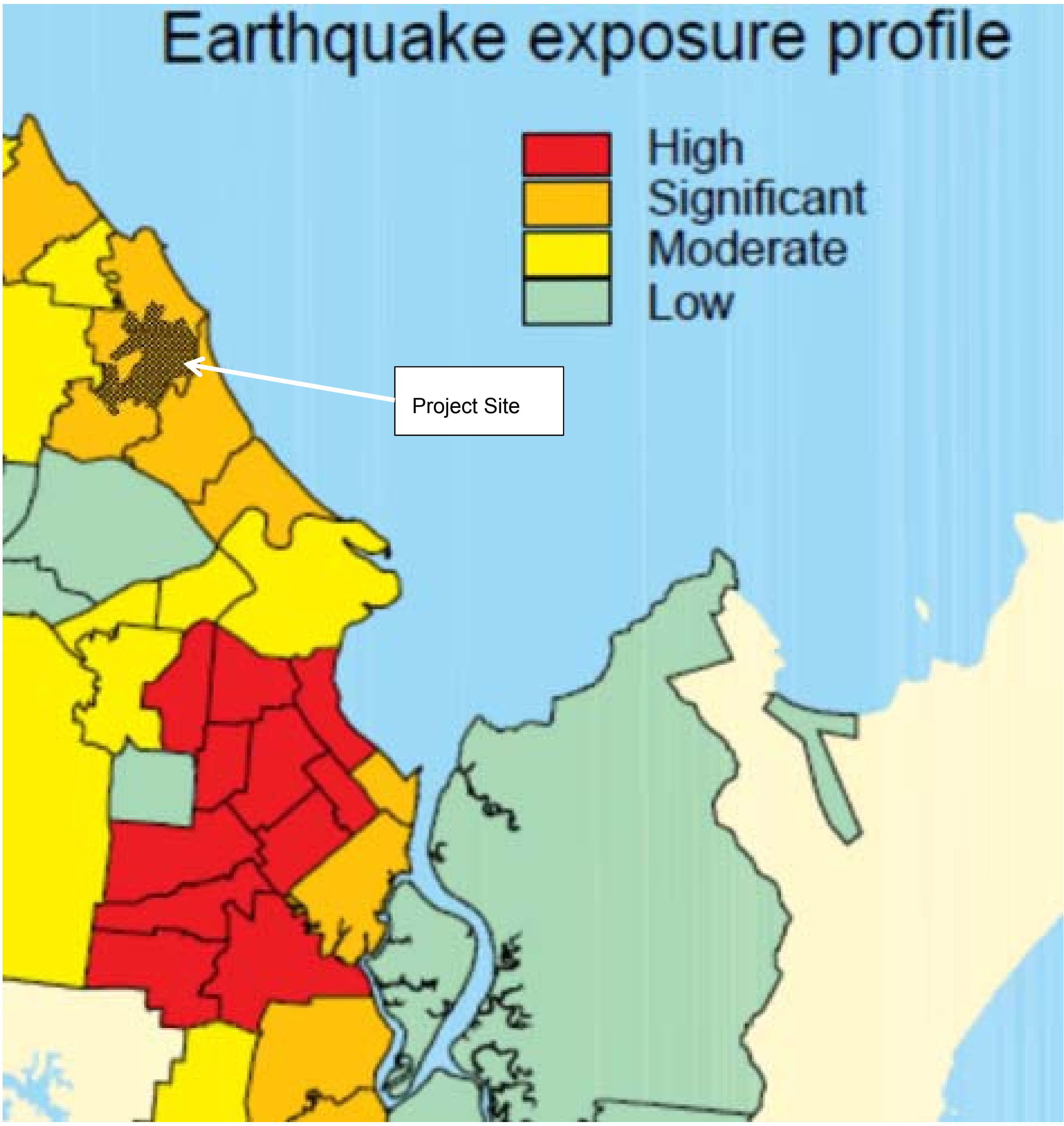

Figure 12-2 Earthquake exposure profile.

Source: Granger et al. (1999).

b) Hazard Management

Earthquake Response

The Standard Emergency Warning Signal is used in the event of an earthquake. However, the nature of earthquakes in Australia is such that there is usually very little warning of their occurrence. General advice is provided on Queensland Government and Commonwealth Government websites regarding what action residents can take in the event of an earthquake and these will be adopted for the project's emergency management plan (see **Section 12.5.2a)**).

Engineering Requirements

According to the Cairns DDMP (CDDMG 2011), the first Australian earthquake loadings standard was published in 1979. However, this standard is not used widely in Queensland and does not include domestic buildings. Nonetheless, many Cairns buildings are earthquake-resistant to a degree, having been designed to comply with wind loading standards from around the late 1950s for engineered buildings and 1982 for domestic buildings.

More recent research into Earthquake Hazards in Australia undertaken by Geoscience Australia (Burbidge 2012) has resulted in the following map of probability which is to be used for engineering application under the Australian Earthquake Loading Code (AS1170.4). This map shows that in the Cairns area earthquake is of low (but not lowest) risk.

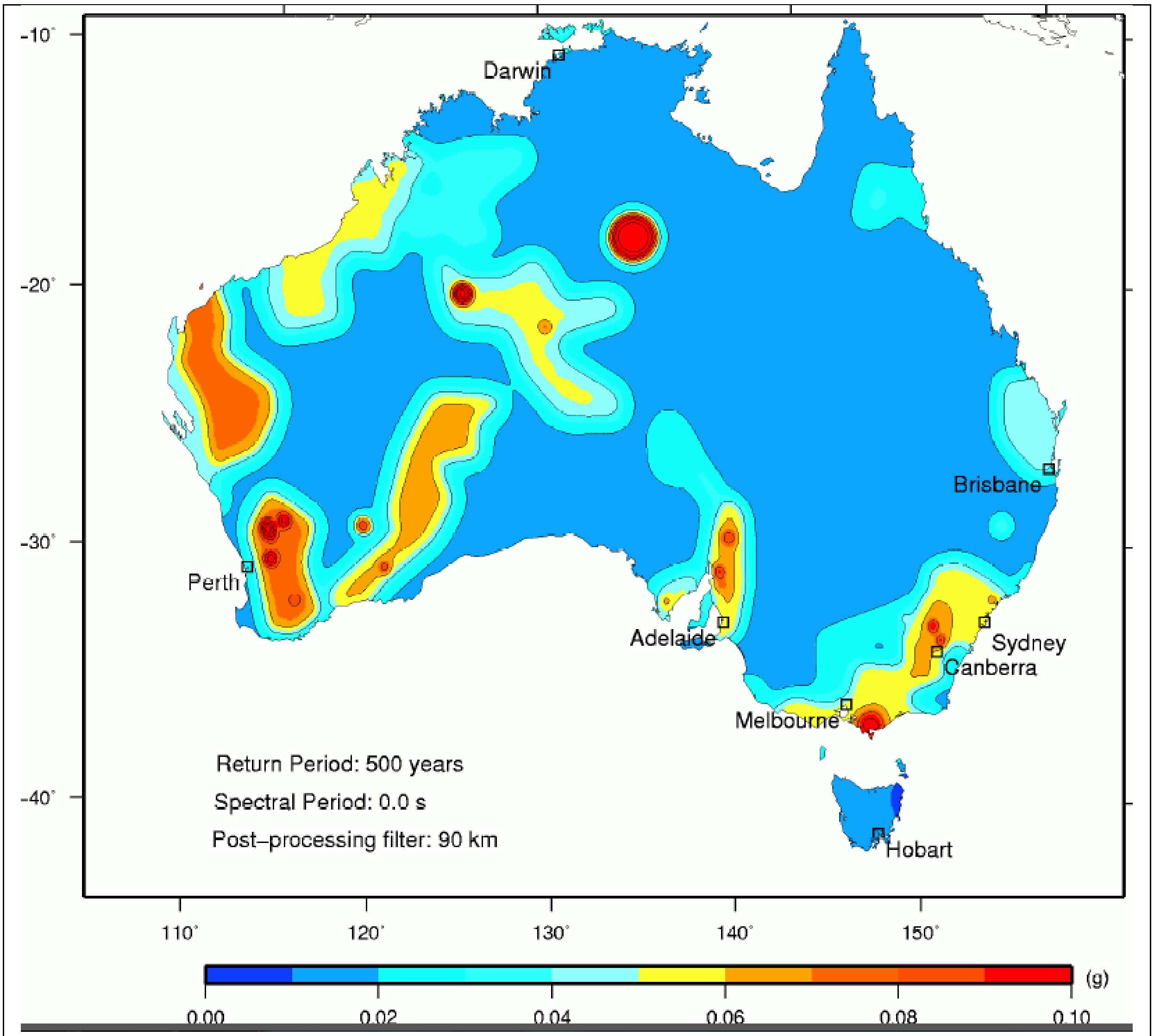

Figure 12-3 500 year ARI (0.2% AEP) earthquake hazard map.

Source: Burbidge (2012).

12.3.2 Tsunami

a) *Risk Assessment*

According to Granger et al. (1999) off-shore earthquakes have the potential to generate tsunamis as do underwater volcanos and landslides. The amplitude of the wave/s depends on the amount of displacement in the water column caused by the triggering event, the off-shore bathymetry, and gradient of the shoreline. According to the Bureau of Meteorology (BoM) (2013) tsunamis are recorded in Australia about once every two years.

The Cairns DDMP considers that a tsunami has an overall risk rating of *Medium*, based on the combination of *Moderate* likelihood (will occur at some time), and *Moderate* consequence (moderate delays, inconvenience, financial loss, etc.). The LDMP (CRC 20122) concludes that the risk is the same (i.e. *Moderate)* but in this case has a lower likelihood (*Rare* – 1000 year ARI (0.1% AEP)) but higher consequence (*Catastrophic*).

Chapter 8 (Coastal Processes) consider tsunamis in more detail and notes that hazard maps produced by Geosciences Australia are defined at a bathymetry water depth contour of 100 m off-shore. This normally falls outside of the Great Barrier Reef or other reef systems. The 100 m depth contour is chosen because:

- estimating the tsunami closer to the coast requires high resolution bathymetric data which does not always exist for the entire coast
- estimating the tsunami closer to the coast is a more computational and time intensive task.

So, while these maps help to identify the areas which are most likely to be at risk to damaging tsunami waves and are used by Australian emergency managers in understanding the tsunami hazard to Australia, they cannot be used directly to infer:

- how far a tsunami will inundate on-shore (inundation extent)
- how high above sea level they will reach on land (run-up)
- the extent of damage
- any other on-shore phenomena.

To estimate the on-shore effect of a tsunami, detailed bathymetry and topography of the specific region concerned is required for input to a detailed inundation model. However, the catalogue of tsunami events can be used by emergency managers, researchers and individuals to develop detailed inundation models at any on-shore location. Recent modelling has been undertaken by DSITIA (Boswood 2013) in the Cairns region (see **Figure 8-2**).

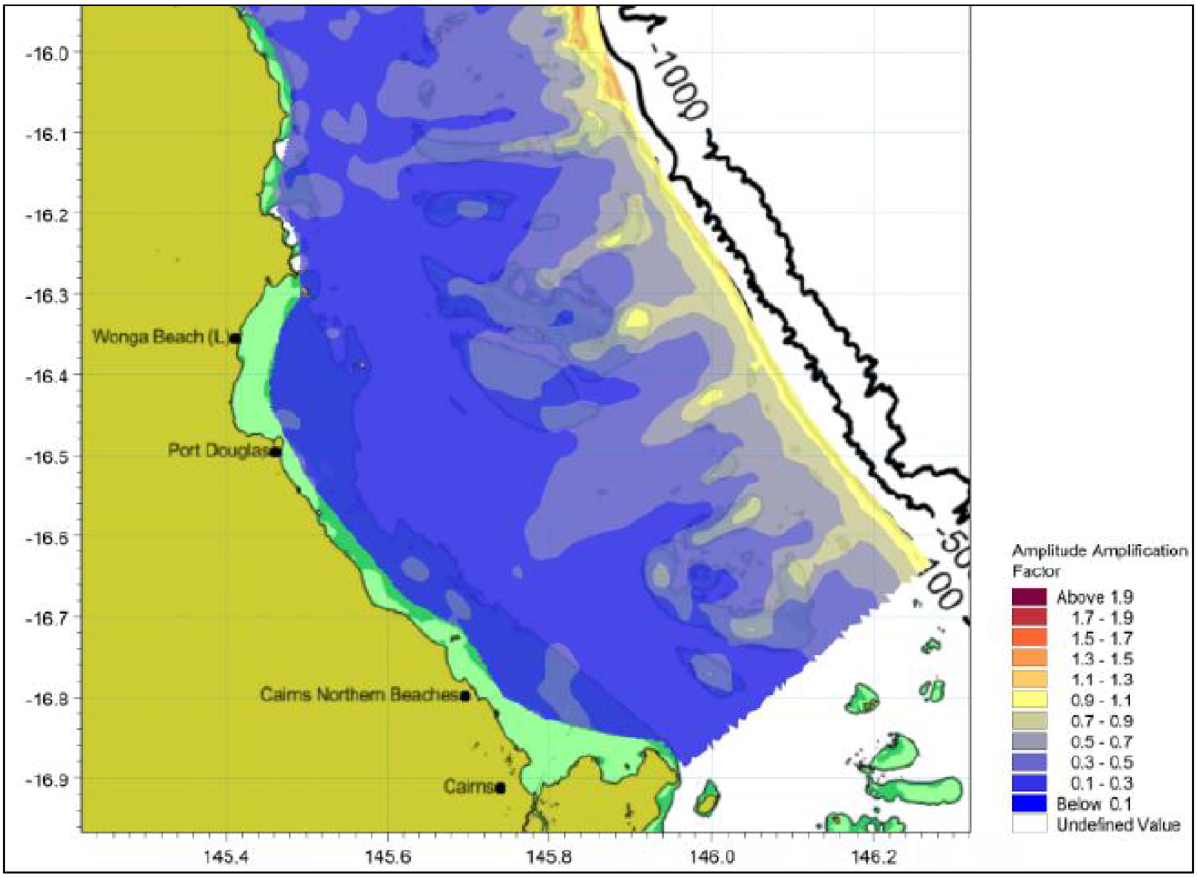

Figure 12-4 Tsunami amplification in reef Lagoon (DSITIA modelling).

Source: Boswood (2013).

The modelling involved propagating a 1.2 m wave through the reef and lagoon) and reveals an amplification factor of 0.2 – 0.5 for near-shore areas in the Cairns region. This means that the 1.2 m tsunami wave height outside the reef could be about 0.2 m to 0.6 m in the near-shore zone near the Aquis Resort site. The study notes that:

> These conclusions are based on amplification factors at the 10 m depth contour based on closed land boundaries. They do not take into consideration the height of coastal dunes or the shoaling nature of the tsunami shoreward of this depth. Cross-sections extracted from the model runs suggest there could be substantial further shoaling and amplification of the tsunami as it continues to propagate to the coast. It is also possible that an amplification factor of less than 1 may still produce a tsunami that may cause inundation for north Queensland communities. Detailed inundation modelling would be required to assess the full risk for coastal communities.

Considering the recent modelling carried out by DSITIA and the possible reduced tsunami wave height of 0.2 to 0.6 m at the -10 m contour, it is unlikely that this will shoal significantly as it propagates to the shore. Additional detailed shoreward propagation and inundation modelling would be required to further assess safe refuge heights for coastal communities in the Yorkeys Knob region. However, it is considered that the selection of the +6 m AHD contour by the CRC is a conservative estimate of a safe zone (see following discussion).

b) Hazard Management

The CRC published a Cairns Tsunami Evacuation Guide for residents in the Cairns area (CRC 2007). The information guide provides a map showing the 6 m Australian Height Datum (AHD) contour and advises that once a tsunami warning is given, residents are to move to higher ground above the 6 m AHD contour. An excerpt from this map is provided below.

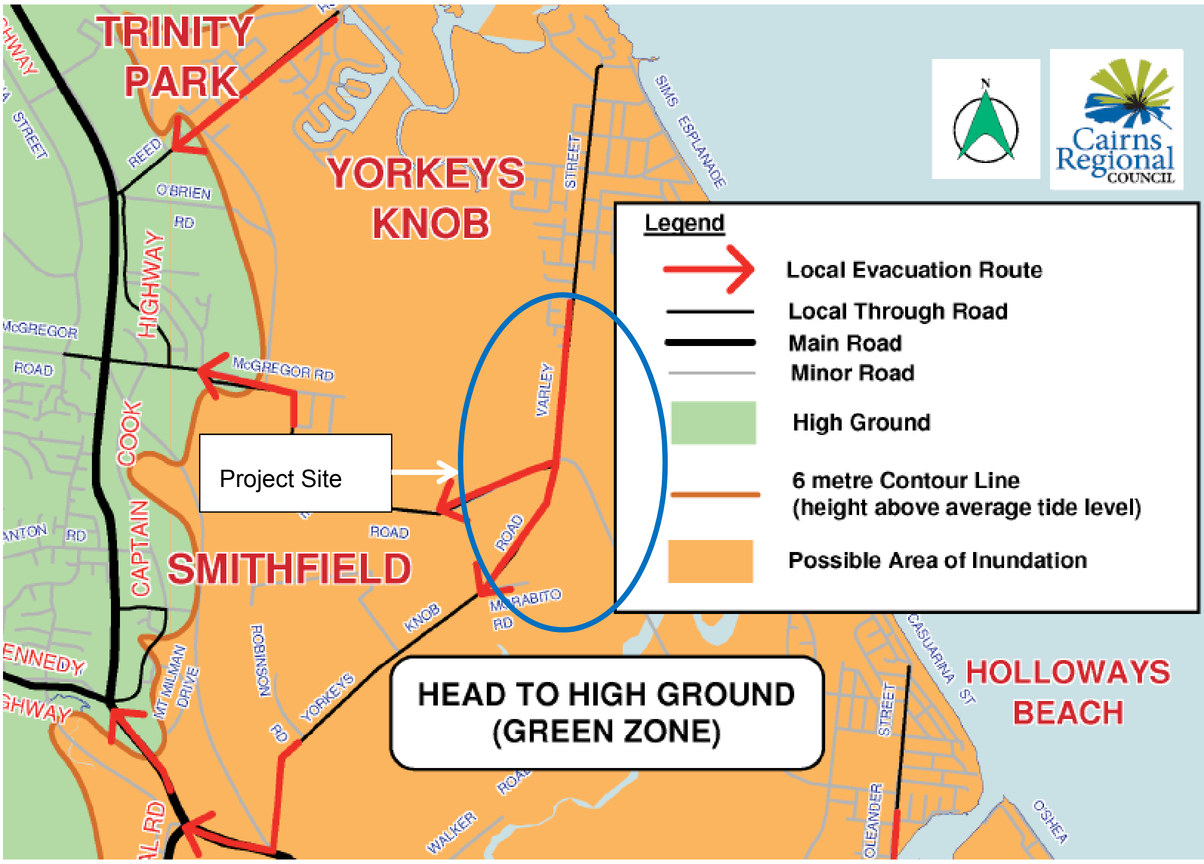

Figure 12-5 Tsunami hazard management.

Source: CRC (2007.)

It should be noted that this guideline warns that:

> Until the Tsunami alert system is developed further, the Bureau of Meteorology will only be able to advise that a Tsunami is approaching. It will not be able to indicate how high the wave is. As a result, Cairns City Council has developed the attached maps to assist the community should a Tsunami alert be issued.

12.3.3 Landslide

a) Risk Assessment

Landslides in Cairns are a significant risk and occur regularly at varying scales. In recent years landslides associated with heavy rains have resulted in large sections of road on the Gillies, Kuranda and Rex ranges becoming impassable and requiring emergency clearing and subsequent reconstruction. The risk assessment (Granger et al. 1999) noted that most landslides in Cairns appear to be associated with disturbances of the natural surface by the construction of infrastructure or building sites. In particular, hillslopes in the Freshwater Creek valley pose a high level of risk.

While the suburb of Yorkeys Knob has been classified as having no landslide risk (see **Figure 12-6**) the risk assessment states that it was undertaken at a broad reconnaissance level and a more detailed site geotechnical investigation at the individual property level would be required for more certainty. However, due to its distance from any steep ground, it is highly unlikely that landslide would directly affect the Aquis Resort site.

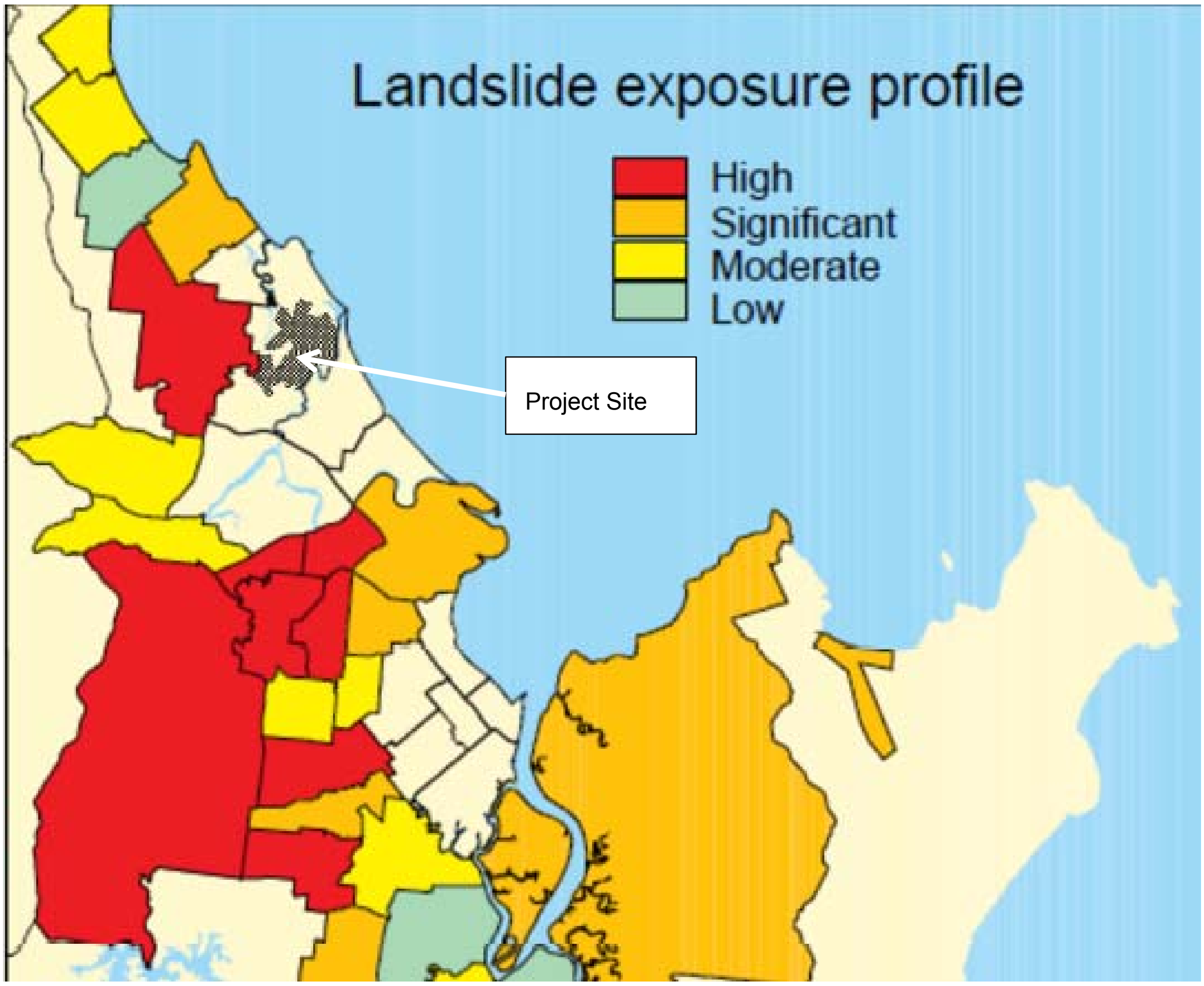

Figure 12-6 Landslide exposure profile.

Source: Granger et al. (1999). See end of text for a larger version of this map.

The LDMP considers that landslip poses a *High* level of risk with a likelihood of *Possible* (100 year ARI (1% AEP)) and consequences of *Moderate*. However, this applies to the broader Cairns area and as discussed above, landslip is unlikely to have a direct impact on the project. It is concluded that for the Aquis Resort site the risk of landslide is *Low*.

b) Hazard Management

The primary mechanism for managing the hazard is through the CairnsPlan which includes an overlay code for hillslopes. Part of the function of the overlay code is to protect slope stability from development.

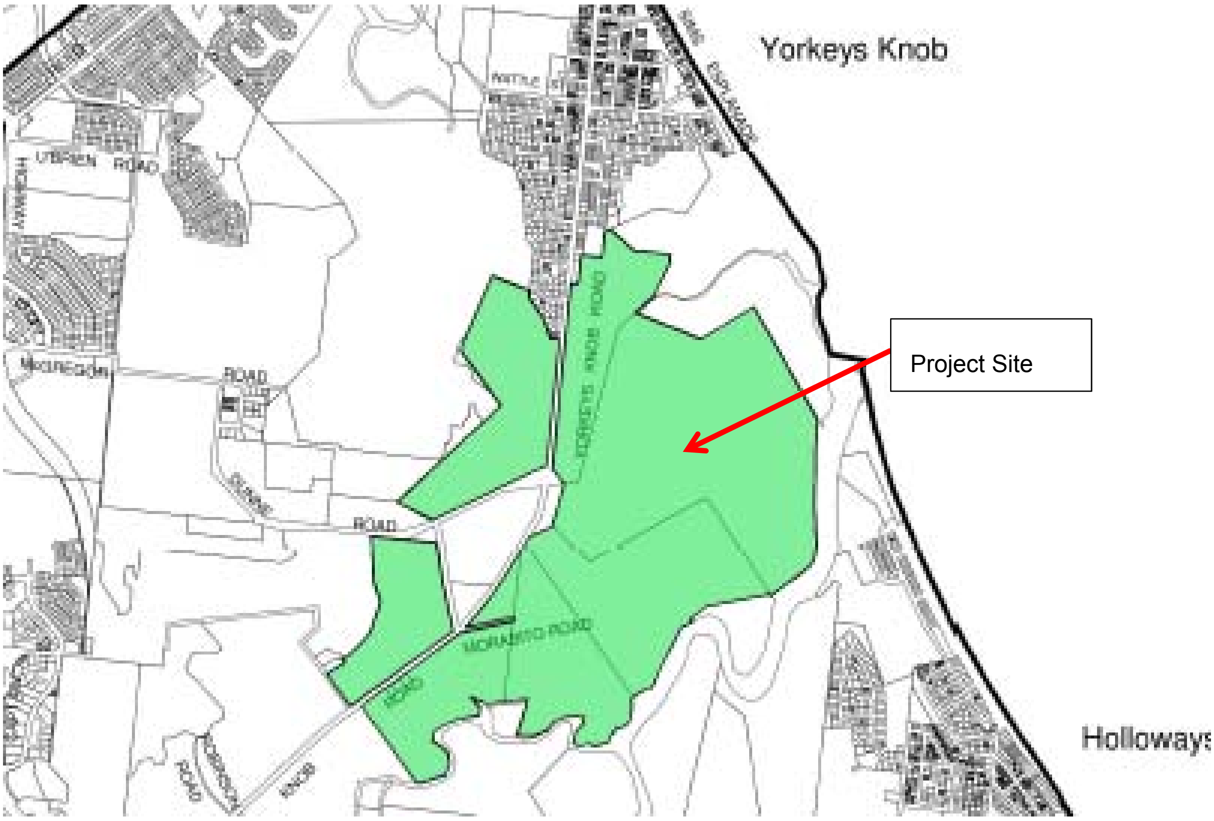

Figure 12-7 Hillslopes Overlay Code.

Source: CairnsPlan. See end of text for a larger version of this map.

Figure 12-7 shows that the hillslope overlay code does not affect the project area. From this it can be inferred that CRC does not see the Aquis Resort site as being exposed to landslide risk.

12.3.4 Bushfire

a) Risk Assessment

Cairns receives high rainfall during the wet season and this results in high vegetation growth rates. During the dry season this biomass dries out and can pose a bushfire threat. CairnsPlan includes a Bushfire Risk Analysis Overlay that shows areas of high and medium risk hazard. This risk analysis was undertaken by the Rural Fire Services.

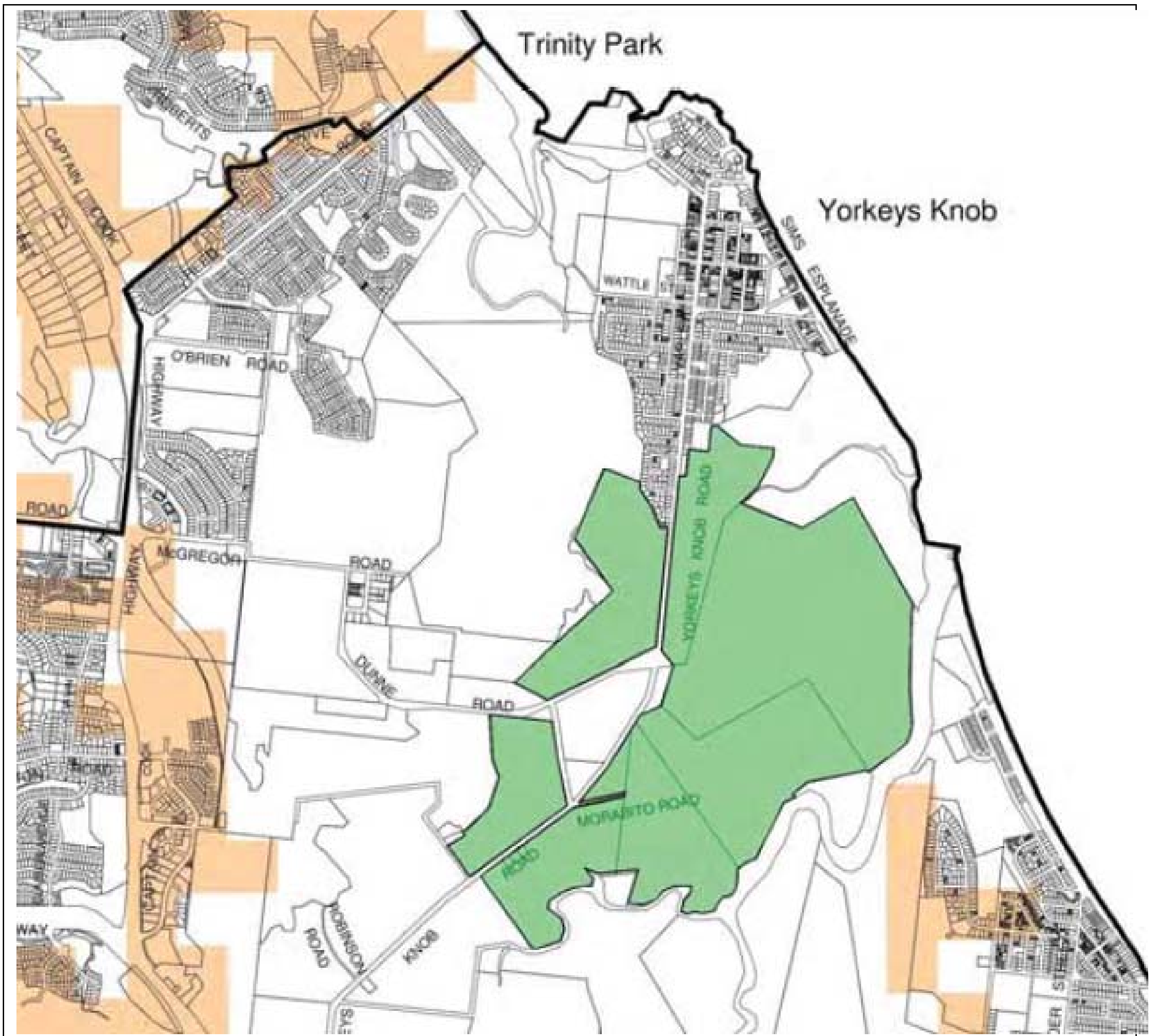

Figure 12-8 Bushfire Risk Overlay Code.

Source: CairnsPlan. See end of text for a larger version of this map.

The above figure shows that the project area is not considered to have a bushfire risk.

b) Hazard Management

Emergency services undertake controlled burns each year to reduce the fuel load and minimise the risk the uncontrolled fires. Furthermore, the overlay code in CairnsPlan provides performance criteria and acceptable measure to mitigate the risk. However, as project is not within a high or medium risk area, the code does not apply to the proposed development.

12.3.5 Flooding

a) *Risk Assessment*

Granger et al. (1999) shows that Yorkeys Knob has a *High* level of exposure of flood from the Barron River. However, the authors consider that flooding posed a relatively limited threat because urban development has (to date) largely been excluded from the most flood-prone areas of the Barron River delta. The most significant economic loss is associated with damage to roads, other infrastructure and sugar cane. The isolation of the northern beachside suburbs from the Cairns CBD and its critical facilities is considered the most significant 'inconvenience'.

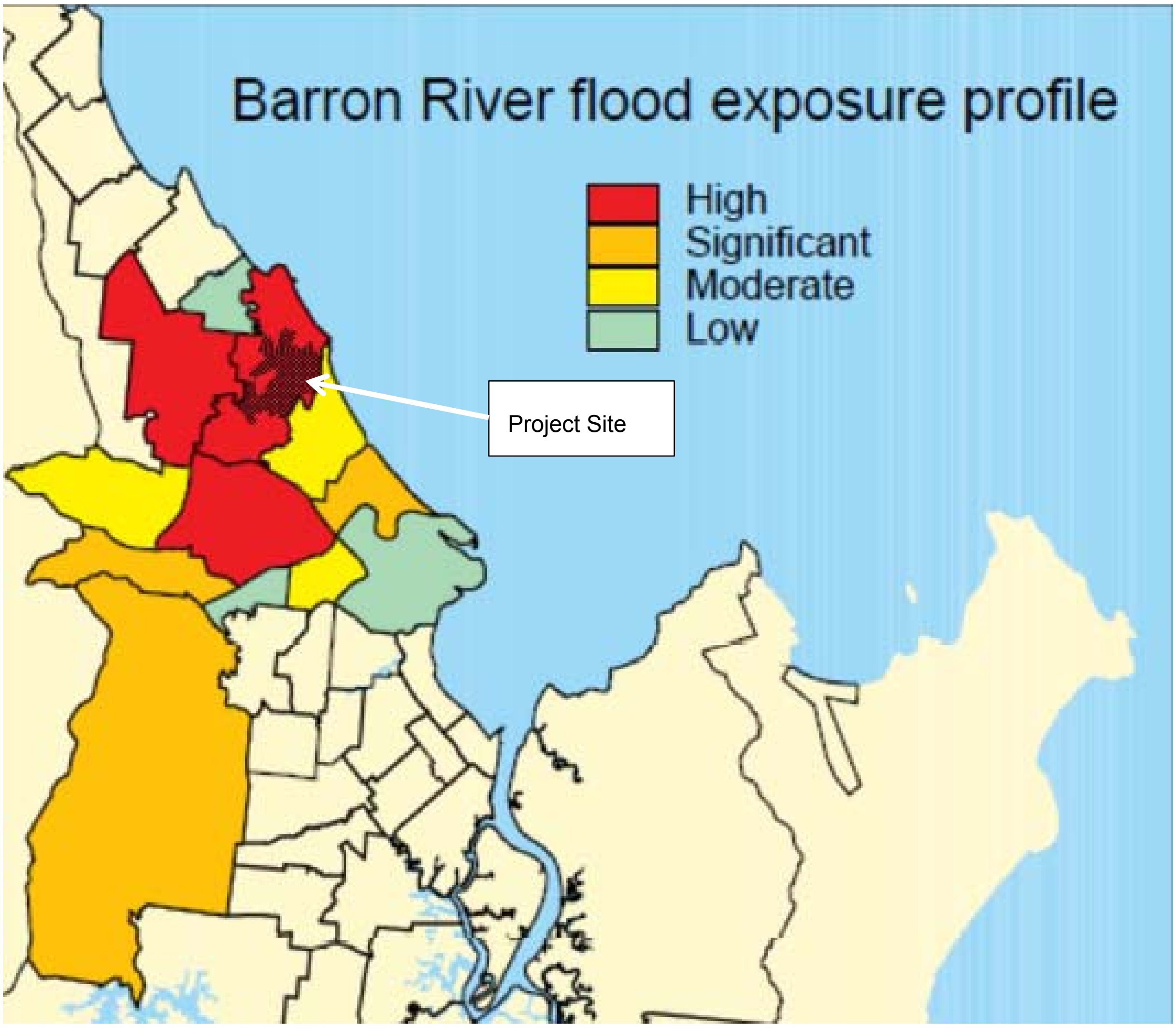

Figure 12-9 Barron River flood exposure.

Source: Granger et al. (1999).

According to the Cairns DDMP (2011), flooding is most likely to be associated with tropical depressions and cyclones during the summer months.

CairnsPlan documents the expected extent of a flood event with an ARI of 100 years (1% AEP) and this is provided below.

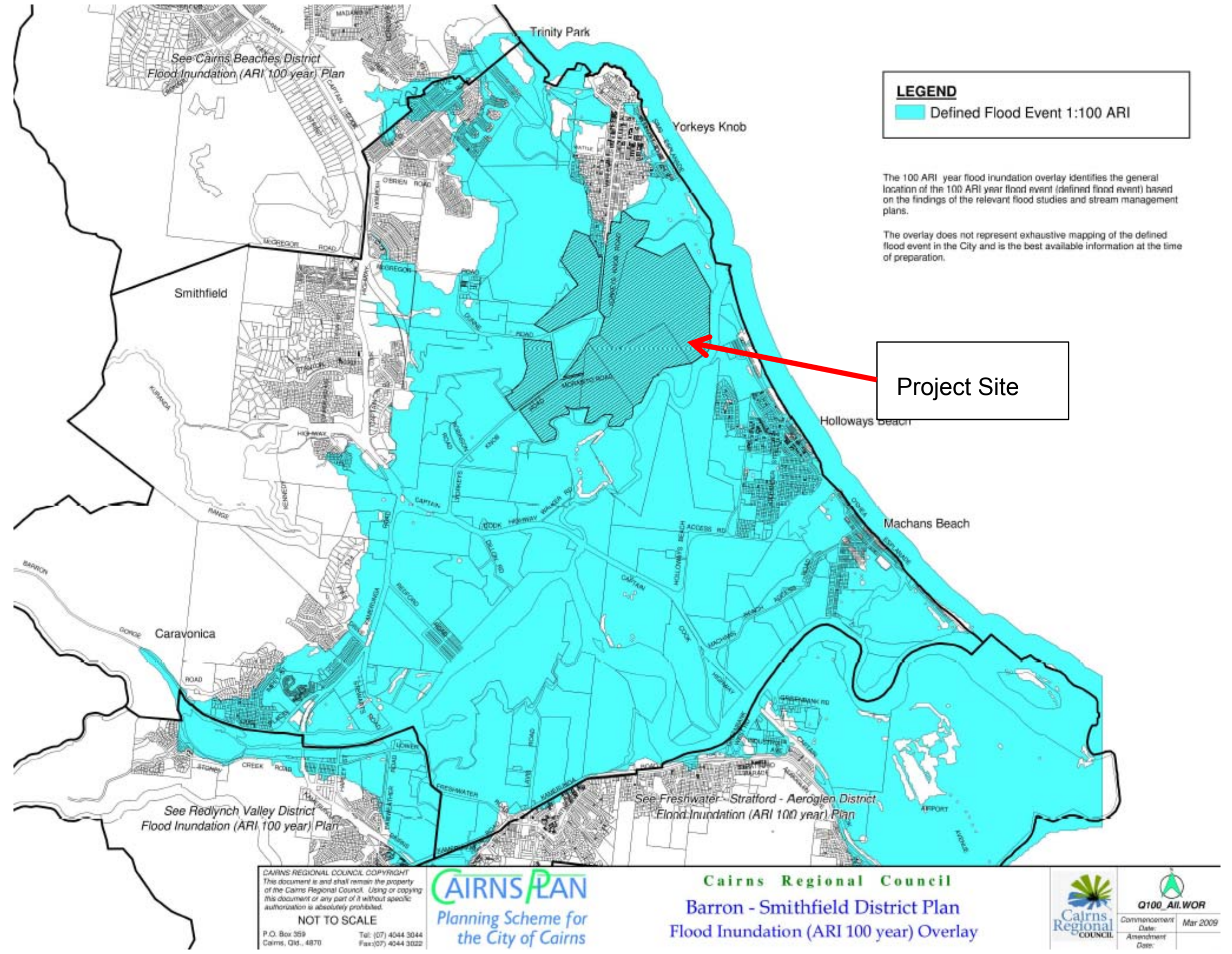

Figure 12-10 Barron River flood exposure.

Source: CairnsPlan Barron – Smithfield District Plan. Flood Inundation (ARI 100 year) Overlay.

A flood up to a 100 year ARI (1% AEP) is considered to have a likelihood of *Possible* by the LDMP. A Probable Maximum Flood (PMF) is considered to have a likelihood of *Rare* (1000 year ARI (0.1% AEP)). However, both are considered to have major consequences, resulting in a high level of risk for both levels of flood.

The site-specific assessment discussed in **Chapter 9** (Flooding) shows that:

- for a 1% AEP the maximum flood level on the site is 4.5 m AHD (i.e. a depth of approximately 2.5 m)
- for the PMF the maximum flood level on the site is 7.5 m AHD (i.e. a depth of approximately 5.5 m).

Consultation with DES revealed that the risk of dam burst (i.e. of the Copperlode Dam on Freshwater Creek) is considered to be *Low* for the Aquis Resort site as the project is located close to the ocean. DES suggest that such an event would result in levels equivalent to approximately a 20 year ARI (5% AEP) Barron River flood.

b) *Hazard Management*

According to Granger et al. (1999) in order to manage the risk for Barron River flooding, the following steps have been taken:

- some flood mitigation works have been established
- a flood warning system has been installed
- formal land use planning constraints have been implemented for development in areas likely to be affected by a flood with an ARI of 100 years (1% AEP).

Regarding the last point, planning controls permit certain development in the delta but require compliance with a number of criteria related to minimum building levels, access provisions, prohibition on affecting other properties (afflux, velocities) and other matters covered in CairnsPlan's *Flood Management Code* and *Excavation and Filling Code.* This is discussed in detail in **Chapter 9** (Flooding).

As part of the Cairns DDMP, the Standard Emergency Warning Signal is used for major floods, flash floods or dam-breaks as well as intense rainfall > 50 year ARI (2% AEP).

Currently, flood warning gauges exist on the Barron River and these are monitored by BoM in conjunction with CRC. Furthermore advice from Council (I Fell pers. comm. 2/9/2013) is that monitoring gauges will be installed at Thomatis Creek to complement the existing network. BoM issues warning when water levels rise to heights that may cause localised flooding (Cairns DDMG 2011). The CRC is responsible for alerting the community and this can be undertaken with adequate time for residents to prepare for the flood or evacuate if needed.

12.3.6 Cyclones and Cyclone-induced Water Level

a) *Risk Assessment*

Tropical cyclones pose a considerable threat to Cairns with a cyclone affecting Cairns on average once every two years. Cyclones can approach the Cairns area from any direction (see **Section 3.6.2**). In terms of local topography and coastal processes, a cyclone that makes landfall just north of Cairns is expected to produce the worst result in terms of flooding (principally on the northern beaches) and risk to human life. The risk assessment found that Yorkeys Knob has a significant destructive wind and flooding exposure profile due to topography and proximity to the coast.

See **Figure 12-11** and **Figure 12-12**.

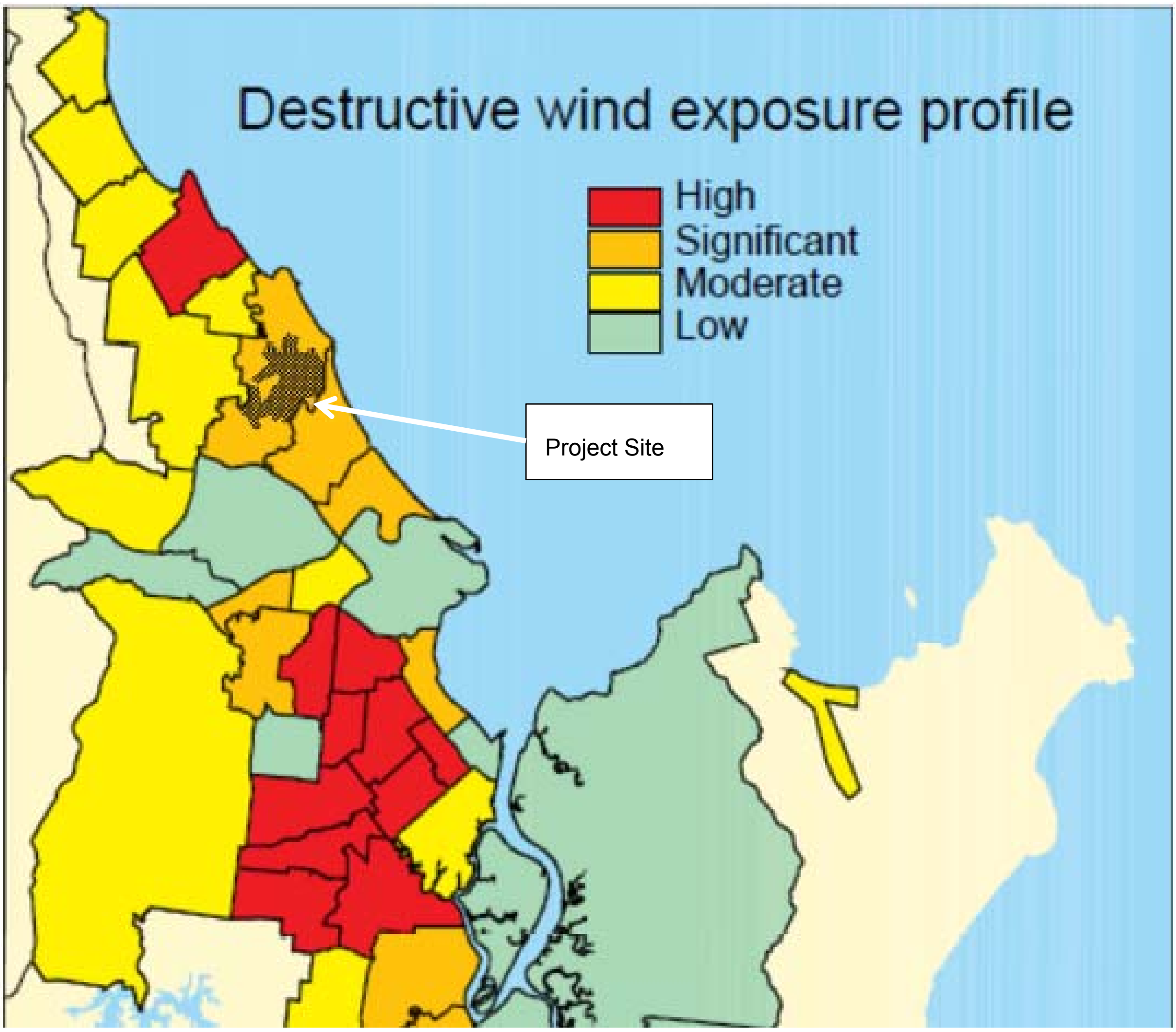

Figure 12-11 Destructive wind exposure profile.

Source: Granger et al. (1999).

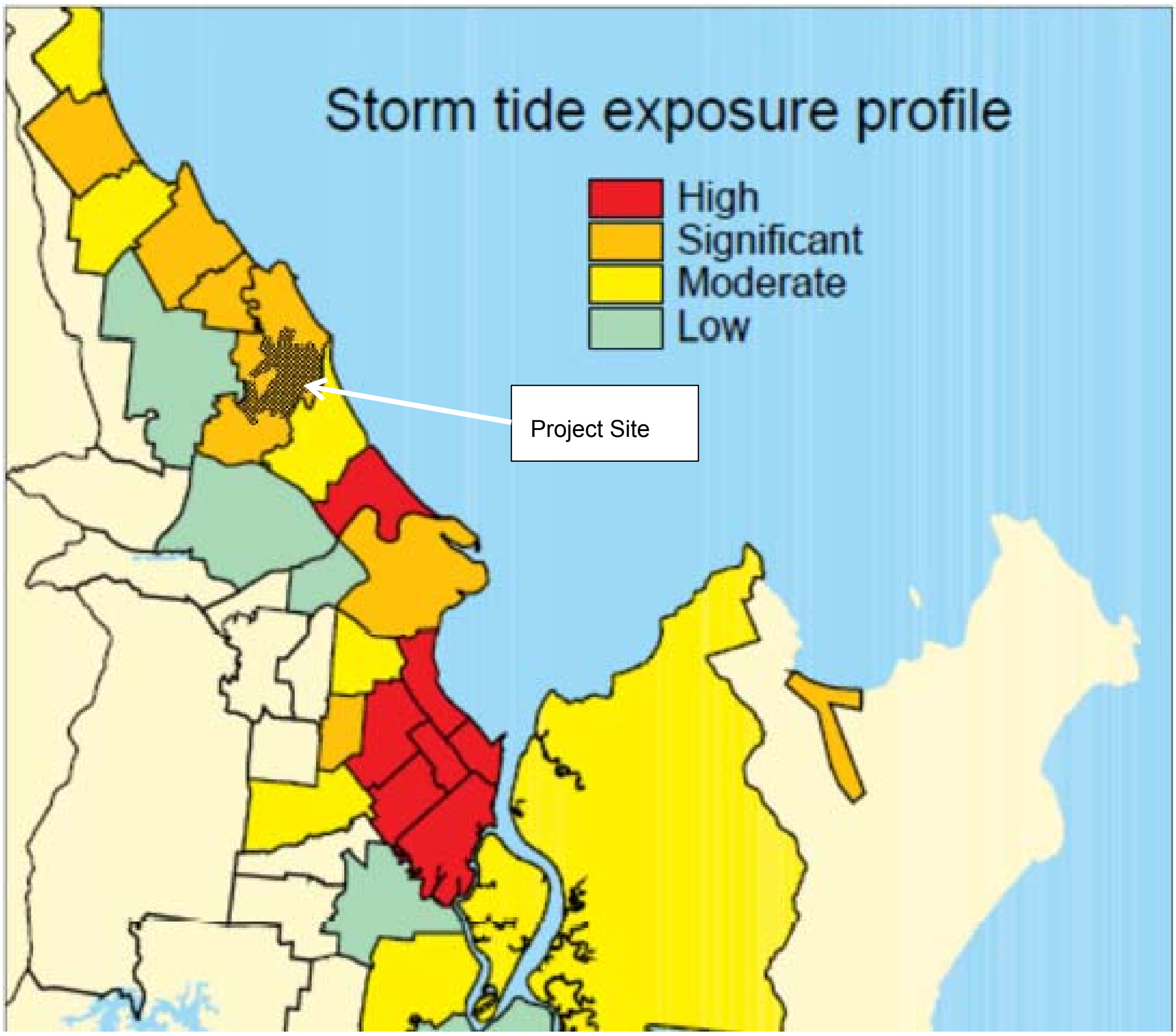

Figure 12-12 Storm tide exposure profile.

Source: Granger et al. (1999).

Cyclones are considered to pose a *High* level of risk to the Cairns area according to the LDMP. This is regardless of the fact that the likelihood and consequences are considered to be *Likely* and *Minor* for category 1-3 cyclone and *Rare* and *Major to Catastrophic* for category 4+ cyclones.

The main effects of a cyclone are:

- strong winds
- elevated water level (see below for a discussion on the components of elevated water level)
- flooding once the cyclone is over, although the two effects are not always a feature of the same event.

In terms of wind, gusts in excess of 90 km / h are common around the centre and, in the most severe cyclones, gusts can exceed 280 km / h. These very destructive winds can cause extensive property damage and are a risk to human life.

The major effects of a cyclone on the Cairns Northern Beaches is the elevated water level that can accompany it and in some cases, the subsequent Barron River flooding (see **Chapter 9**). The peak level for a cyclone with an AEP of 1% (equivalent to an ARI of 100 years) is 3.11 m AHD and for an AEP of 0.01% (equivalent to an ARI of 10 000 years) is 4.69 m AHD. When a projected 0.8 m sea level rise (predicted for the year 2100) is included, the levels above would rise to 3.91 m and 5.49 m AHD respectively.

b) Hazard Management

The Cairns DDMP advises that while the conventional response to impending cyclone impact is for people to take shelter in their own homes, there is an increased risk of residents drowning in low lying areas as a result of storm tide inundation. Hence, evacuation is sometimes necessary and must be completed before winds reach 75 km/hr (approximately six hours before landfall).

CRC has published a Storm Tide Evacuation Guide (CRC no date) for residents to follow in the event of a cyclone. It provides maps that show predicted storm tide flooding associated with a cyclone. Below is the map that shows the Smithfield and Yorkeys Knob area. In particular it can be seen that the project area is considered to have the highest risk of storm tide inundation and the primary evacuation route is via Yorkeys Knob Road, past the development, to the Captain Cook Highway. The alternative route is via Dunne Road and McGregor Road to the Captain Cook Highway.

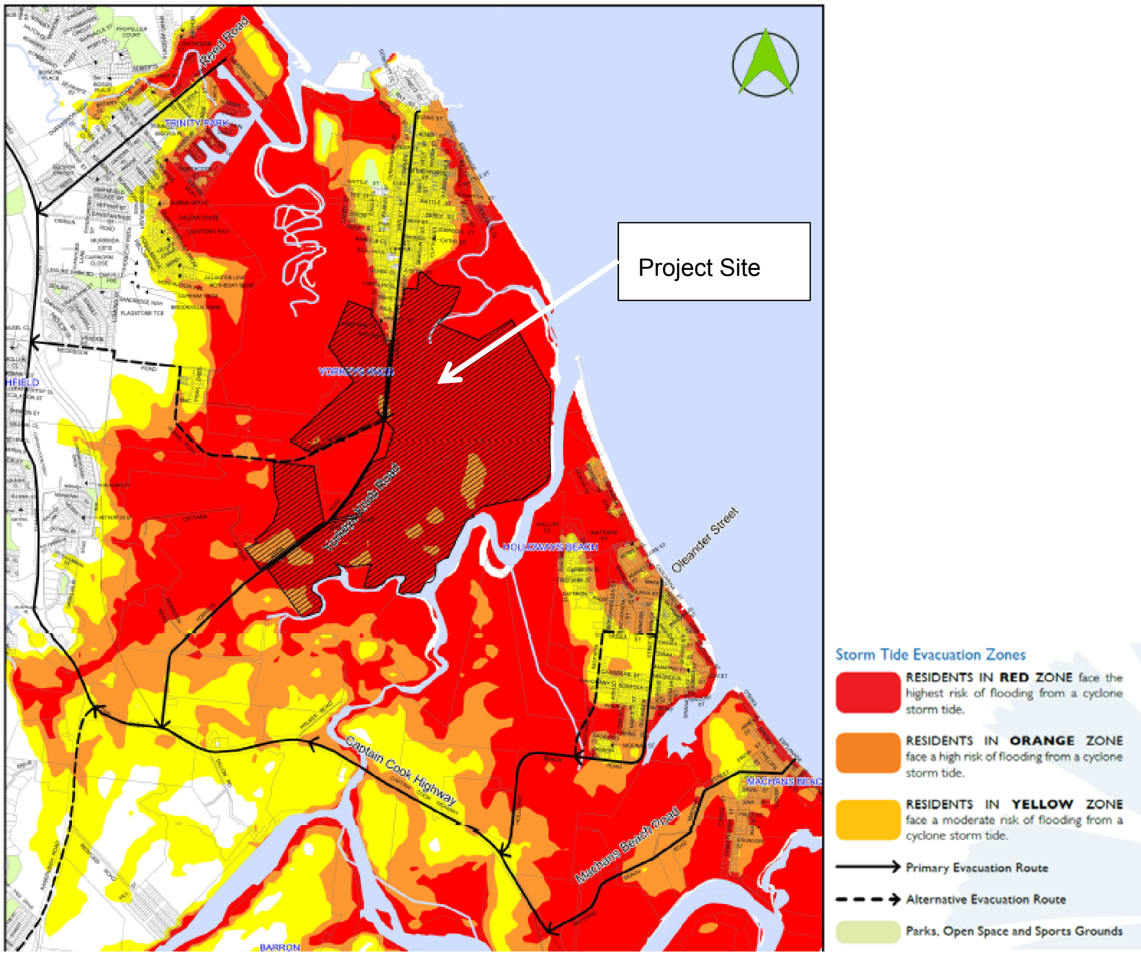

Figure 12-13 Storm tide evacuation zones.

Source: CRC (n.d.) Storm Tide Evacuation Guide.

The Cairns DDMP notes that evacuation for storm tides with AEP of 1% or more, evacuation would be easily managed with appropriate warning, planning and community awareness. However, for more severe storm tides, considerable effort would be required unless the vast majority were prepared to undertaken their own evacuations beginning at least 24 hours before the time of impact. Delay in major evacuations can increase risk due to traffic congestion leaving residents exposed to storm tide and destructive winds.

12.3.7 Erosion Prone Areas and River Migration

a) Risk Assessment

The likely exposure to coastal erosion and river migration has been discussed in **Chapter 8** (Coastal Processes) This concludes that over geological timescales, the beaches adjacent to the Barron River delta have been accreting, although local disturbances such as interruptions to the fluvial supply from rivers such as the Barron River have caused large scale disturbances. Historic changes have involved:

- river mouth changes (including the effect of this on sand supply for beach nourishment)
- longshore sand transport and beach erosion and accretion
- short-term storm erosion potential
- longer term shore erosion, including the effects of sea level rise.

The best estimate of shoreline erosion over a 50 year planning period adjacent to the site is 400 m (including allowance for sea level rise).

In terms of river migration, it appears that the Barron River / Thomatis Creek bifurcation is likely to be less mobile that it was a few decades ago due to the stabilisation works which have been constructed and that have resulted in an increase in sediment build-up and subsequent vegetation growth. In addition, although the distance to the ocean is shorter through Thomatis / Richters Creek than the Barron River and hence the gradient is greater, the size of the relevant channels and their resulting conveyance potential still hydraulically favours the Barron River as the preferred channel. River migration is considered to be possible but not very likely.

The sources listed in **Section 12.1.1** do not include an assessment of risk or response to shoreline erosion and river migration. Based on a review of the geomorphology of the Barron River delta and assessments contained is a number of reports including Department of Harbours and Marine (1981) and Beach Protection Authority (1984), the study team has assessed this risk as *Low*.

b) Hazard Management

<u>Shoreline Erosion</u>

Shoreline erosion as a long term change is managed by controls over development in erosion prone areas (i.e. in the case of Aquis, within 400 m of the ocean) and in the coastal zone in general under the Coastal Protection State Planning Regulatory Provision.

<u>River Migration</u>

There are no current management plans for dealing with major changes in the path of the Barron River and its distributary, the Thomatis Creek / Richters Creek system.

12.3.8 Disease Outbreak / Pandemic

a) Risk Assessment

In the last decade there have been at least two influenza pandemics[7] that posed a threat to Australia.

[7] According to the World Health Organisation (Kelly 2011) the classical epidemiological definition of a pandemic, namely 'an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people'

- The avian influenza outbreak in 2003 and the human swine influenza outbreak in 2009 demonstrated how quickly a pandemic can develop. Cairns is a popular tourist destination and should a disease outbreak be detected, a response would need to be swift. The LDMP documents a risk assessment of a disease pandemic in the Cairns Region. It considers the likelihood of such an event to be *Rare* (ARI 1000 (0.1% AEP)) with the consequences considered to be *Catastrophic*. The risk of an outbreak at the resort could be conceived as being higher than in the general population as the majority of visitors will be direct from international flights arriving at Cairns international airport.
- Dengue and Ross River Fever are mosquito-borne viruses that occur in the Cairns area and have caused epidemics in other countries with tropical climates (e.g. India and Singapore). However, neither is transmissible between humans (Queensland Health 2013). Hence the rate of transmission through the general public and the resort will be slower and unlikely to cause the same level of threat as an influenza virus.

The risk of disease outbreak/pandemic taken to be *High.*

b) Hazard Management

The Council of Australian Governments COAG document titled *Pandemic planning in the workplace* (COAG 2009) was developed to assist businesses with developing contingency plans should a pandemic reach Australia. In it, COAG advises that it is not expected that a pandemic virus would originate in Australia. However, should a pandemic virus arrive in Australia, a staged response for Queensland would be implemented with Queensland Health as the lead agency and DES personnel providing support. COAG (2009) uses the following six-stage approach:

- Alert – to the risk of a pandemic and preparing for a pandemic by increasing Australia's readiness and supporting overseas responses.
- Delay – the entry of the pandemic virus to Australia by applying border measures, supporting the overseas response and increasing surveillance (this may impact on operations at the resort).
- Contain – or slow the early spread of a pandemic virus once it emerges in Australia, including by strategic deployment of the National Medical Stockpile and strengthening public information campaigns to promote individual hygiene practices and community level measures such as social distancing.
- Sustain – the response while a customised vaccine is developed, including by supporting maintenance of essential infrastructure and services and strengthening community social distancing measures.
- Control – the pandemic with a customised pandemic vaccine when it becomes widely available.
- Recover – providing the necessary support and stimulus to help the Australian community return to normal living as quickly as possible following a pandemic.

This response was developed following the H1N1 influenza (human swine influenza) outbreak in 2009 and is now being considered as the appropriate response for any other human virus that can become a pandemic.

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includes nothing about population immunity, virology or disease severity. By this definition, pandemics can be said to occur annually in each of the temperate southern and northern hemispheres, given that seasonal epidemics cross international boundaries and affect a large number of people. However, seasonal epidemics are not considered pandemics. A true influenza pandemic occurs when almost simultaneous transmission takes place worldwide. In the case of pandemic influenza A(H1N1), widespread transmission was documented in both hemispheres between April and September 2009. Transmission occurred early in the influenza season in the temperate southern hemisphere but out of season in the northern hemisphere. This out-of-season transmission is what characterizes an influenza pandemic, as distinct from a pandemic due to another type of virus.

12.3.9 Wildlife Hazards

a) Risk Assessment

Because of the site's location there are a number of hazards arising from wildlife are assessed as summarised in **Table 12-2**. Given that the lake will not be used for contact recreation, likelihood is assessed at Rare for shark and marine stingers. However, crocodiles are capable of moving across country and the likelihood of an encounter is considered to be moderate.

TABLE 12-2 ASSESSMENT OF WILDLIFE HAZARDS AND RISKS

ITEM (SOURCE)	LIKELIHOOD	CONSEQUENCE	RISK
Crocodiles **(Appendix F, G)**	Moderate **(see Chapter 20)**	Moderate	Medium-
Sharks **(Appendix F)**	Rare	Moderate	Negligible
Marine stingers **(Appendix F)**	Rare	Moderate	Negligible

Source: Study team compilation based on **Appendix F** and **Appendix G** and using the likelihood / risk table set out in **Figure 12-1**.

Refer to a detailed assessment of these wildlife hazards in the discussion on health and safety in **Chapter 20**.

b) Hazard Management

Current relevant hazard management exists for crocodiles as discussed in **Chapter 20** (Health and Safety). This involves the use of Crocodile Management Plans (CMPs) for the key areas that experience a higher level of potential crocodile / human interaction than other population centres. In essence, the Cairns CMP protects the estuarine crocodile as a vulnerable species while addressing a range of management issues. The Cairns CMP sets out a risk-based approach to crocodile management on a zonal basis. The Aquis Resort is on Zone 2 where the objective is to remove all crocodiles 2 m or greater in length or any crocodile displaying aggressive behaviour once a sighting is confirmed.

12.3.10 Climate Change

a) Risk Assessment

A discussion of the likely effects of climate change has been presented in **Section 3.6.6**. This discussion reveals the following most likely effects:

- sea level rise – the mid-case scenario adopted by EHP, namely:
  - 0.4 m for 2060 (50 years)
  - 0.8 m for 2100 (100 years)
- changes to intensity and frequency of extreme events (especially cyclones and rainfall):
  - stronger but shorter rainfall season during January and February, leading to dryer autumns
  - number of rainy days will decrease but the amount of rain falling on wet days may increase by up to 20%
  - extreme rainfall events are predicted to also become more frequent during the summer months.

For the purposes of this EIS, likelihood of climate change occurring is taken as *Almost certain* and the consequence will vary from *Insignificant* to perhaps *Moderate* over the design life of the Aquis Resort. This results in an assigned risk rating of between *Low*+ and *High*.

b) Hazard Management

The management of the hazard imposed by climate change involves a risk-based approach to adaptation – i.e. a weighing up of the costs and benefits of allowing for the likely effects in terms of design of levels and structures. As a general rule, actions that could be considered to be 'no regrets' such as adopting additional freeboard to extreme water levels from all sources and taking a conservative approach to design loads to allow for stronger winds may be appropriate, depending on individual circumstances.

12.3.11 Summary of Risks

a) Formal Risk Assessment

No formal risk assessment has been undertaken. When the Commonwealth Government (Middelmann 2007) undertook a study into risk assessment requirements, it found that a significant body of information is required before a robust assessment can be undertaken. It is understood that such an assessment has yet to be undertaken.

The table below summarises all available aspects of risk assessment work previously undertaken by the Commonwealth and Queensland Governments and the CRC for those of the above hazards where this information is available.

b) Summary of Available Assessments

In the following table, the best available information has been used to summarise the likelihood, consequence, and corresponding risk. It should be noted that in not all cases does the risk quoted conform to what might be expected by the application of the risk matrix presentment in **Figure 12-1**. In addition, the Commonwealth assessment introduces the *Significant* risk category which is not consistent with normal risk analysis. The reasons for the various discrepancies are not obvious and the original data is presented faithfully. In some cases where considered relevant the study team has provided an assessment of risk based on local knowledge.

TABLE 12-3 SUMMARY OF RISK ASSESSMENTS

HAZARD	LIKELIHOOD (S,L)	CONSEQUENCE (S,L)	RISK (S,L,C)
Earthquake	*Unlikely* *Rare*	*Catastrophic* *Catastrophic*	*Medium+* *High* *Significant*
Tsunami	*Moderate* *Rare*	*Moderate* *Catastrophic*	*Medium-* *Moderate* *NR*
Landslide [1]	*Likely* *Possible*	*Major* *Moderate*	*High* *High* *NR* Study team assessment is *Low*
Bushfire [2]	*Moderate* *Likely*	*Moderate* *Minor*	*Medium -* *High* *NR* Study team assessment is *Low*
Rural fire [2]	*Moderate* *Likely*	*Moderate* *Minor*	*Medium -* *High* *NR* Study team assessment is *Low*
Flooding	*Moderate* *Possible/Rare*	*Moderate* *Major*	*Medium -* *High* *High*
Cyclone	*Almost Certain* *Likely/Rare*	*Catastrophic* *Minor/Major to Catastrophic*	*Extreme* *High* *Significant*
Storm tide	*Moderate* *Rare*	*Catastrophic* *Catastrophic*	*High* *High* *Significant*
Coastal erosion and river migration	Not assessed in quoted sources. Study team assessment is *Rare*	Not assessed in quoted sources. Study team assessment is *Catastrophic*	Not assessed in quoted sources. Study team assessment is *Low+*
Disease outbreak/pandemic	*Unlikely* *Rare*	*Catastrophic* *Catastrophic*	*Medium +* *High* *NR*
Wildlife hazards - crocodiles	Not assessed in quoted sources. Study team assessment is *Moderate*	Not assessed in quoted sources. Study team assessment is *Moderate*	Not assessed in quoted sources. Study team assessment is *Medium-*
Wildlife hazards – sharks and marine stingers	Not assessed in quoted sources. Study team assessment is *Rare*	Not assessed in quoted sources. Study team assessment is *Moderate*	Not assessed in quoted sources. Study team assessment is *Negligible*

Source: Study team compilation based on **Appendix J** and **K** and the following sources.

S: State Government Risk Assessment documented in Cairns DDMP (2011)
L: Local Government Risk Assessment documented in LDMP (2011)
C: Commonwealth Government Risk Assessment documented in Granger et. al (1999)
NR: No risk assessment provided.
Note 1 Overall risk taken to be *Low* due to distance of the site from any steep land.
Note 2 Overall risk taken to be *Low* based on CairnsPlan Bushfire Risk Analysis Overlay.

Shading has been added to allow a visual interpretation of relative risk established by the State Government Risk Assessment documented in Cairns DDMP (2011) (‘S’ above) unless noted otherwise. This table shows that:

- the hazard with the highest associated risk is a cyclone (*Extreme*)
- storm tide / surge associated with a cyclone is slightly lower (*High*) due to a lower likelihood (not all cyclones produce damaging storm tide)
- earthquake and disease outbreak are both assessed as *Medium+*.

As noted in the Cairns DDMP, careful implementation and management of proposed major residential precincts (presumably this applies equally to the Aquis project) is required to minimise risks to the community (including guests and staff of the resort) in the event of a hazard. The following section describes implications of risk for the Aquis project and adopted actions.

12.4 IMPACTS

12.4.1 Impact Avoidance / Minimisation

The previous section describes the risks that hazards pose to the project area. Some hazards (e.g. landslide and bushfire) are not relevant to the Aquis project while others (earthquake and wind associated with a cyclone), while posing a high level of risk, this can be mitigated by adherence to engineering requirements in building codes (i.e. to provide the necessary structural stability). The main hazards that could affect the Aquis project at the concept design stage are considered to be:

- elevated water levels associated with each of flooding, storm surge, and tsunami
- coastal erosion and river migration

These hazards impose constraints on the design levels of various components of the Aquis Resort and the overall form of the development. While other hazards, such as pandemics, require a principally management-oriented response, all hazards require further attention during detailed design to ensure that their effects on the project and on the properties around it are minimised.

a) Current Hazard Management and Agency Views

The available responses to rare natural events are essentially:

- shelter-in-place (requires that safe and secure infrastructure is available and that systems are in place to handle the necessary ‘internal evacuation’)
- evacuation.

Current responses to the major hazards described previously are as follows:

- Earthquake. No local response developed. General advice is provided on Queensland Government and Commonwealth government websites regarding what action residents can take in the event of an earthquake. These will be incorporated into the project’s emergency management plan.
- Tsunami. Evacuation of low-lying areas (once a tsunami warning is given, residents are to move to higher ground above the 6 m AHD contour following the routes designated on CRC’s Cairns Tsunami Evacuation Guide for residents in the Cairns area (CRC 2007)).
- Landslide. Not relevant to Aquis.
- Bushfire. Not relevant to Aquis.
- Barron River flooding. BoM issues warning when water levels rise to heights that may cause localised flooding (Cairns DDMG 2011). The CRC is responsible for alerting the community and this can be undertaken with adequate time for residents to prepare for the flood or evacuate if needed.

- Cyclones. Shelter-in-place except in low-lying where there is a risk of drowning as a result of storm tide inundation. Evacuation is sometimes necessary and must be completed before winds reach 75 km/hr (approximately six hours before landfall). Evacuation routes are shown on CRC's Storm Tide Evacuation Guide (CRC no date). In the vicinity of the Aquis site the primary evacuation route is via Yorkeys Knob Road, past the development, to the Captain Cook Highway. The alternative route is via Dunne Road and McGregor Road to the Captain Cook Highway.
- Disease Outbreak. As lead agency, Queensland Health will coordinate the response recommended by COAG (2009) with DES personnel providing support. The COAG six-stage approach (see **Section 12.3.8b)**) involves Alert, Delay, Contain, Sustain, Control, and Recover activities.

Several of these options were discussed in detail at the Emergency Services Focus Group meeting held on 2 September 2013. Based on those discussions, it is considered that storm tide is the most extreme foreseeable hazard that can be planned for. Although the levels associated with a PMF are actually higher (see **Table 12-5**, they are unlikely to involve as high a structural load as a direct-hit cyclone and storm tide. While initially preferring that Aquis restrict a shelter-in-place response to Barron River flooding because of the perceived risk to structures during the more violent tsunami and storm tide events, it was concluded that the sheer size of the likely Aquis guest and staff population would make evacuation logistically difficult.

The meeting concluded that, for a shelter-in-place response to be acceptable, it will be necessary that the structure chosen to be the evacuation facility is able to withstand a maximum direct-hit cyclone (wind, cyclone induced water level), tsunami, and the PMF.

Also, a 'shelter-in-place' approach requires that hard infrastructure such as a medical facility, emergency generators, etc. need to be located above the evacuation level. It will be necessary to ensure that the design allows for radio communication from within the building and that emergency supplies including food, water, fuel, bedding, etc. are stockpiled so that the resort can independently cater for all visitors for a period of at least three days.

b) Adopted Responses

The assessment of risk for the various hazards gives guidance on the likelihood and consequence of an event. While this is a useful statistic, what needs to be decided is the design response to the event. This involves making decisions on the following factors:

- design water levels for a suite of AEPs ('normal' to 'rare')
- a decision on the response to 'rare' events (i.e. to evacuate or to shelter-in-place)
- selection of associated design floor levels
- provision of infrastructure and systems to cope with the selected response (or perhaps a combination of the two)
- the possibility of contributing to the development of external infrastructure to manage risk
- the development of an Integrated Emergency Management Plan to cover all eventualities.

The following table provides a summary of adopted solutions to the identified hazards.

TABLE 12-4 SUMMARY OF HAZARD RESPONSE SOLUTIONS

HAZARD / ISSUE	DESIGN RESPONSE
Shelter-in-place or evacuate?	• The sheer size of the likely guest and staff population would make evacuation logistically difficult. Hence, a shelter-in-place response is preferred. • For a shelter-in-place response to be acceptable, the structure chosen to be the evacuation facility will need to be able to withstand a maximum direct-hit cyclone (wind, cyclone induced water level), tsunami, and the PMF.
Earthquake	• Build habitable structures to Australian earthquake loading code (AS1170.4).
Tsunami	• Build habitable structures where safe refuge is required to withstand a tsunami with a height to 6 m AHD. • Ensure emergency supplies including generators are located above foreseeable tsunami level (CRC plans for 6 m AHD tsunami height). 7.5 m AHD has been adopted.
Landslide	• N/A.
Bushfire	• N/A (other than normal fire management and design).
Barron River flooding	• Construct compensatory waterways to convey flood and provide floodplain storage with zero afflux outside site for 1% AEP flood and acceptable velocities. • Adopt minimum floor levels for habitable rooms as 1% AEP plus 500 m freeboard. Adopted levels vary from 5.0 m to 5.5 m AHD. • Design of robust structures and provision of safe refuge above the PMF level. • Locate emergency supplies, generators etc. above PMF level. 7.5 m AHD has been adopted. • Design buildings to enable vertical evacuation of visitors. • Obtain access to council flood level monitoring system and / or incorporate standalone monitoring and associated response plans. • Raise access road to, and around, the project to a level comparable to flood immunity of Bruce Highway (to allow evacuation if necessary).
Cyclone	• Design buildings to withstand an event with an AEP of 0.01% in terms of both wind strength and storm surge. • Ensure buildings to be used as 'shelter in place' evacuation centre/s are designed to be critical infrastructure and allow radio communications from within the building to emergency service providers (applies for all emergencies). • Locate emergency supplies and generator above maximum foreseeable storm tide height. 7.5 m AHD has been adopted. • Design internal transport/pedestrian routes to facilitate access to evacuation centres. • Incorporate a helipad above PMF to allow evacuation of injured visitors.
Shoreline erosion and river migration	• Construct bank protection works on Richters Creek where erosion is currently occurring. • Investigate value of contributing to Aquis Resort / government works to stabilise the Thomatis Creek bifurcation.

HAZARD / ISSUE	DESIGN RESPONSE
Disease outbreak / pandemic	• Design medical centre to provide level of medical care required in the event of a disease outbreak. • Collaborate with Queensland Health to develop appropriate procedures.
Accidents, spillages, fire and abnormal events	• Prepare element of EMP (Construction) to cover these events.
Wildlife hazards – crocodiles	• Design lake edges to discourage crocodiles. • Implement Crocodile Management Plan (refer **Chapter 20**).
Wildlife hazards – sharks and marine stingers	• See **Chapter 11** (Water Quality) – involves design of screened inlet and an overall Lake Management Plan for removing problem fauna.
Climate change	• Allowed for in design flood levels. • Design stormwater drainage system for increased runoff. • Design for increased wind loads.
All relevant hazards	• Design Integrated Emergency Management Plan specific to the project and tailored to the cultural background and demographic of the visitors
Detailed floor levels	• Refer to **Table 12-5**.

Source: Study team compilation.

c) Hazard Mitigation via Design

Detailed work has been documented in earlier chapters (**Chapter 8** – Coastal Processes and **Chapter 9** – Flooding) for the major hazards listed above. This detailed work is referred to in summary form below. Relevant solutions for avoiding or minimising the risk of the identified hazards to the Aquis Resort are:

- flooding – recommendations for final fill levels above the Barron River PMF flood – made possible by the construction of the lake to act as a compensatory waterway to mitigate external flood impacts – (or higher levels if recommended by cyclone criteria)
- cyclone (including storm surge) – recommendations for final fill levels above the 1% AEP storm tide with safe refuge above the 0.01% AEP level (or higher levels if recommended by flooding criteria)
- tsunami – no special recommendations (levels determined by flood immunity are adequate to accommodate tsunami risk)
- shoreline erosion and river migration:
  - construction of minor bank protection works on the eroding bend of Richters Creek
  - recommendations for consideration of possible works at the Thomatis Creek bifurcation to protect all downstream infrastructure (i.e. Aquis Resort and the townships of Yorkeys Knob and Holloways Beach).

Design Floor and Safe Refuge Levels

The consensus of emergency planners consulted (**Table 12-1**) is that 'shelter-in-place' with 'vertical evacuation' in all natural events should be planned for, as long as the structures providing the safe refuge can withstand the event safely. Evacuation and re-supply post-emergency should also be allowed for. The shelter-in-place option requires a decision on floor levels for the design events and this is as follows:

- lowest habitable floor: based on higher of Barron River flooding (PMF) and storm tide (1% AEP) plus allowance for freeboard
- evacuation floor: based on the worst of PMF, 0.01% storm tide, and 'rare' tsunami.

These levels and the recommended levels for the purposes of this EIS are shown in **Table 12-5** below with reference to the Concept Land Use Plan. Although the minimum requirement for floor levels in the Barron River delta is based on a 1% AEP flood plus freeboard, the proponent has opted for the higher standard of PMF plus freeboard. This means that all habitable floor levels at the Aquis Resort will be above the necessary evacuation level.

TABLE 12-5 DESIGN FLOOR AND SAFE REFUGE LEVELS

TYPE	AEP + FREEBOARD	LEVEL (m AHD)		
		Resort Complex (North)	Resort Complex (South)	South of Resort Complex
Lowest habitable floor - details	1% + 0.5 m	4.41 (storm tide)	4.85 (flooding)	5.05 (flooding)
Lowest habitable floor – adopted	See next columns	5.0	5.5	5.5
Evacuation floor - details	0.01% storm tide / PMF / rare tsunami	6.0 (tsunami)	6.5 (flooding)	7.5 (flooding)
Evacuation floor – adopted	See next columns	7.5	7.5	7.5

Source: Study team compilation based on **Appendix 8** and **Appendix 9**.

The levels quoted above are shown on the following schematic.

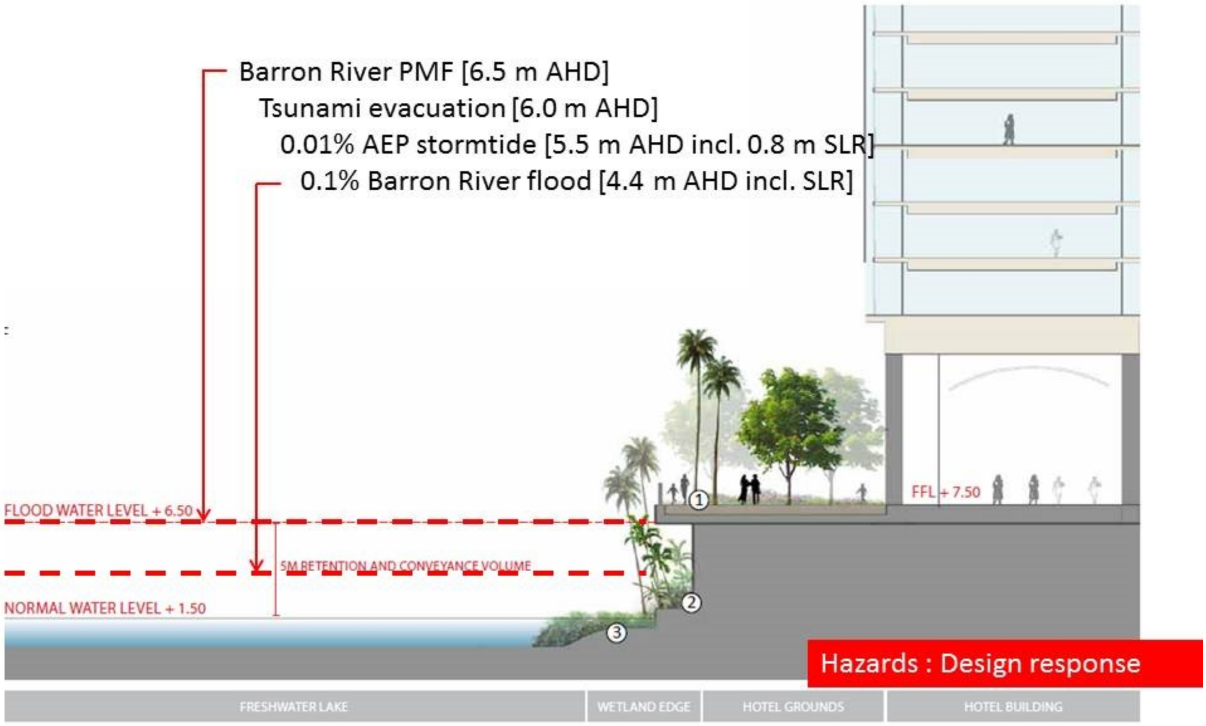

Figure 12-14 Schematic showing design and hazard levels at Resort Complex Precinct.

Yorkeys Knob Road Levels

As noted above, evacuation and re-supply post-emergency should also be allowed for and this requires an upgrade to the Yorkeys Knob Road to an appropriate level of flood immunity. This will benefit not only the resort but also residents of Yorkeys Knob and the emergency services personnel.

Details are provided in **Chapter 9** (Flooding).

12.4.2 Impacts of Mitigation Works

a) Flooding

As described in detail in **Chapter 9** (Flooding), flood modelling undertaken in accordance with CairnsPlan shows that the design meets the relevant CairnsPlan codes and that the residual impacts (afflux and velocities) are acceptable.

Flood Management Code

Modelling demonstrates that the resort can feasibly be designed to achieve a no significant worsening impact on private land beyond the site, in terms of actionable damage and nuisance. In particular it shows that:

- upstream of the development, there are extensive areas of predicted flood level reduction and no unacceptable flood level increases
- downstream of the development, significant impacts are contained to non-urbanised areas
- predicted velocities across the site are generally less than 1 m/s and therefore are non-scouring for grassed areas and are not highly hazardous to people

- flood modelling and impact assessment has also been carried out for a range of events and this reveals that acceptable flooding impacts can be achieved across the full range of flood frequencies.

Overall, the design complies with the Flood Management Code and has net beneficial impacts due to the lowering of flood levels on many Holloways Beach properties.

Excavation and Filling Code

A detailed construction methodology will be developed to ensure that the site is secure from floods and does not impact on external areas at all times. This will be designed to comply with the Excavation and Filling Code.

b) Cyclone-induced Water Levels

As described in detail in **Chapter 8** (Coastal Processes), storm tide and other components of cyclone-induced elevated water levels approach the site from the sea and therefore encounter development at Yorkeys Knob and Holloways Beach before affecting the Aquis Resort. Under these circumstances Aquis Resort is ‘downstream’ of the settled areas and will have no influence on cyclone-induced elevated water levels and waves.

c) Tsunami

The same circumstances apply to a tsunami, that is, Aquis Resort is ‘downstream’ of the settled areas and will have no influence on levels or velocities.

d) Erosion Prone Areas

No mitigation of coastal erosion is proposed, other than providing a suitable buffer of land setback. This will have no effect on external areas.

e) River Migration

Proposed protection works on the eroding bank of Richters Creek will have no effect on external areas (other than perhaps preventing a major change of course in Richters Creek that could be catastrophic for the Yorkeys Knob area). The likelihood of this occurring in the absence of the Aquis Resort mitigation is rare.

f) Impacts of Mitigation Works on Protected Areas

With the exception of the minor bank stabilisation works proposed on the banks of Richters Creek at the site of the eastern lake overflow, there will be no works external to the site required to mitigate any hazard. This applies to flooding, cyclone-induced water levels, erosion prone areas, and river migration. The bank stabilisation works are in an area where natural vegetation is absent and environmental values are low. Accordingly, there will be no impact on the marine park or Fish Habitat Areas.

12.5 MITIGATION AND MANAGEMENT

12.5.1 External Impacts of Aquis Resort Mitigation Works

The previous discussion reveals that the Aquis Resort solutions to hazards will not have adverse impacts on surrounding areas.

Accordingly, no mitigation and management actions are required.

12.5.2 Risks to Aquis Resort

The adopted design solutions summarised in **Table 12-4** include a combination of design responses (previously described) and management needs. These management needs will be addresses in two ways:

- within the framework of an Integrated Emergency Management Plan
- under various components of the EMP (Construction) and EMP (Operation & Maintenance).

a) Integrated Emergency Management Plan

Overview

A key operational element of Aquis Resort's response to hazards is the development and implementation of an Integrated Emergency Management Plan, specific to the project and tailored to the cultural background and demographic of the visitors. During discussions with the Local Disaster Coordinator and DES, it was raised that the potential function of the resort as a shelter for the community would need to be considered and decided in consultation with the LDMG as it has implications for the management of emergencies in the wider community and would require specific safety measures. Hence it is expected that an Integrated Emergency Management Plan would be developed in consultation with the LDMG. This could be achieved through Aquis Resort requesting membership of the LDMG and would facilitate communication between the project and senior emergency response personnel.

In discussing potential information to be contained within the Integrated Emergency Management Plan, initial advice from the Local Disaster Coordinator and DES is that the plan should include the following:

- definition of triggers for the escalation of response to emergencies
- implementation of evacuation and operational responses and rehearsal of these
- notification / communication methods throughout the resort to emergency personnel and general public outside the resort, including sufficient warning for evacuation to main refuge.
- management of staff in the event of emergency, given that many will want to defend and protect their own premises.

In view of the fact that the construction of the project will be staged over a period of four years and involve large pieces of plant and equipment an Integrated Emergency Management Plan will also need to be tailored for this period.

Although it is premature to develop a final Integrated Emergency Management Plan at this early stage of project planning, some consideration has been given to the following key issues:

- tsunami
- storm tide and flooding
- disease outbreak / pandemic.

Consideration should be given to the management of an incident (e.g. bomb threat) at a large scale event (conference, concert, etc.).

Design Population

For tsunami, storm tide, and flooding events, sufficient warning will be available such that steps can be taken to reduce the number of people on the site when the event occurs. Assumptions are as follows:

- resort occupancy will already be low. It is expected that normal wet season numbers will be 50% of the maximum of 12 000 i.e. 6000 guests
- resort occupancy will be diminished to 3000 (i.e. 25%) during this time, on the assumption that warnings of the impending cyclone will reduce arrivals and result in some early departures
- no day guests are present, on the assumption the resort will close all day guest facilities
- a skeleton staff of 1000 is maintained, on the assumption that locally-based resort staff will want to attend to their own properties during the event.

The final Emergency Management Plan will be framed to handle the above resort population (i.e. approximately 4000 people including staff) with respect to all services and facilities previously discussed. In addition, the function of the resort in relation to the rest of the community will need to be decided in consultation with the Local Disaster Management Group, coordinated by council. This is a difficult issue as there could be security and logistical issues in handling an undetermined number of evacuees and catering for them for an unknown time. This is a matter requiring thorough consideration during the detailed design phase.

Detailed Risk Assessment

A comprehensive risk assessment will be undertaken as an input to detailed design, in accordance with relevant standards so that mitigation by design and operational procedures can be developed and incorporated, and a residual risk can be determined.

Initial Detail – Flood and Storm Tide Response

The following is an outline of a flood and storm tide response that will need to be developed in detail as design progresses.

Key Elements

Key elements of the proposed emergency flood management plan include:

- 2% AEP flood and storm tide trafficable route from the site to high ground
- cyclone warning monitoring
- sophisticated continuous river gauge monitoring system with automated warnings and action triggers
- early evacuation strategies for river flood and cyclone surge events managed by the resort for special needs and medical emergency requirements
- on-site safe refuge for guests and staff above the PMF level, with suitable emergency water and food supplies, independent on-site power supply, suitable medical facilities, and communication equipment
- a helipad above PMF level for emergency medical evacuations
- internal access routes to resort refuge.

Cyclone Events

The strategy for major cyclone events will be one of ‘shelter-in-place’ for guests and staff. Evacuation will only be considered for special needs people, and this evacuation would be early, or for medical emergency cases.

The resort management will closely monitor Bureau of Meteorology cyclone tracking and track predictions and warnings.

A dual fire / cyclone and flood alert, alarm and control system with appropriate evacuation warnings and orders will be required on all the resort's facilities. A similar system has recently been approved by Gold Coast City Council for the Florina Gardens Development at Merrimac.

EMQ and local emergency management agencies support a 'shelter-in-place' approach, subject to the resort being able to provide safe refuge above the level of the design event. This requires structures relied upon for this purpose be designed to withstand the loads imposed by the event.

Flood Events

The Barron River has in place an extensive ALERT flood warning system, run by the Bureau of Meteorology (BOM). The BOM's stated aim is to provide between three and nine hours warning of flood heights exceeding 5 m at Kamerunga. This equates to less than 1000 m^3/s (approximately an 50% AEP event).

The BOM operates 13 field stations, of which six measure rainfall and river height, seven measure rainfall only, and one monitors the water level at Lake Placid.

This information is continuously monitored by CRC and the BOM, and the resort will install a third monitoring system, using sophisticated Greenspan equipment and software. A comprehensive emergency flood management plan is to be prepared in subsequent design stages, similar to that prepared for the Florina Gardens Gold Coast project.

With a 2% AEP trafficable route proposed to be provided from the site, it is estimated evacuation times for medical emergency or special needs cases will be available 12 to 24 hours after the BOM's initial flood warning of greater than 5 m depth at the Kamerunga gauge.

Safe refuge facilities within the resort hotels (above RL 7.5m AHD) will be provided for staff and guests. This could also provide additional safe refuge for residents in the surrounding Yorkeys Knob area.

The actual size of the refuge will be defined in detailed design, but with multiple hotel towers, there should be ample room available above the first floor level.

Minimum space required for the refuge should be 3.5 m^2/person. Each floor of each hotel tower of the IAS proposal has an area exceeding 2000 m^2. With multiple towers, each with >10 stories above PMF level, it would be possible to house the entire full occupancy of guests and all staff safely above the extreme flood levels, extreme cyclonic storm tide and wave level, and above severe tsunami level.

EMQ and local emergency management agencies support a 'shelter-in-place' approach, subject to the resort being able to provide safe refuge above the level of the design event. This requires that structures relied upon for this purpose be designed to withstand the loads imposed by the event.

<u>Disease Outbreak / Pandemic</u>

The response to disease outbreak and consequent pandemic is coordinated by Queensland Health with assistance from both the LDMG and the Australian Government. Response to potential or actual disease outbreak at the resort will be managed in the same way as in the general population. That is, consultation will be undertaken with the LDMG and a response will be undertaken as directed by Queensland Health. It is proposed that general medical facilities will be provided at the resort and this may assist with managing the spread of disease.

b) Environmental Management Plan

During the detailed design phase, planning will be undertaken to develop a comprehensive approach to the management of all likely hazards that could occur during construction and operation. These include accidents, spillages, fire, and abnormal events. In particular, detailed work will be undertaken to identify all hazardous substances to be used, stored, processed or produced and the rate of usage.

Much of this work will be required in support of various ERAs under the EP Act and will be the subject of future development conditions. In addition to usual controls over such substances, special attention will be given to minimising the risk of release of any materials that could adversely affect the receiving environment in the event of a hazard (especially flood and stormtide). For the Resort Complex Precinct, this will not be an issue as the finished ground level will be above all possible water levels. Accordingly, the focus of the management will be on other precincts with a lower immunity for these events.

12.6 RESIDUAL RISK

12.6.1 Summary of Responses to Risk

The following table provides details of all hazards assessed, associated risk, recommended mitigation, and residual risk. This is of necessity undertaken at a preliminary level but is adequate to identify the key project risks.

TABLE 12-6 SAFEGUARDS AND RESIDUAL RISK

HAZARD	RISK (Note 1)	MITIGATION	RESIDUAL RISK	NOTES
Earthquake	*Medium+*	Design structures to appropriate standards.	*Low*	Structural response only.
Tsunami	*Medium-*	Design structures to withstand calculated loads. Provide safe refuge above current evacuation level and associated management.	*Low*	Combination of structural and management response.
Landslide	*Low*	Nil.	*Negligible*	Nil.
Bushfire	*Low*	Incorporate appropriate fire design and management.	*Negligible*	Incorporate in EMP (Construction) and EMP (Operation and Maintenance).
Flooding	*Medium*	Design structures to withstand calculated loads. Provide safe refuge above PMF and associated management.	*Low*	Combination of structural and management response.
Cyclone	*Extreme*	Design structures to withstand calculated wind loads.	*Low*	Combination of structural and management response.
Storm tide	*High*	Design structures to withstand calculated surge loads. Provide safe refuge above 0.01% AEP and associated management.	*Low*	Combination of structural and management response.

HAZARD	RISK (Note 1)	MITIGATION	RESIDUAL RISK	NOTES
Coastal erosion and river migration	*Low*	Contribute to stabilisation of Thomatis Creek bifurcation (Note 2).	*Low*	Thomatis Creek works require joint Aquis Resort / Queensland Government response..
Disease outbreak / pandemic	*Medium+*	Combination of infrastructure and collaborative systems and associated management.	*Low*	Requires collaboration with Queensland Health to develop procedures.
Wildlife hazards (crocodiles)	*Medium-* (see **Table 12-2**)	As per actions set out in **Chapter 20**.	*Negligible*	Implement crocodile Management Plan as outlined in **Chapter 20**. Incorporate in EMP (Operation and Maintenance).
Wildlife hazards (sharks and marine stingers)	*Negligible* (see **Table 12-2**)	As per actions set out in **Chapter 11** (e.g. screening of inlets, lake management).	*Negligible*	Implement Lake Management Plan as outlined in **Chapter 11**. Incorporate in EMP (Operation and Maintenance).
Climate change	*Low+* to *High*	Design of floor levels.	Impossible to predict	Possible future adaptation required. See **Section 12.6.3**.
Accidents, spillages, fire and abnormal events	Low (see **Section 12.5.2a)**)	Incorporate appropriate fire design and management.	*Low*	Incorporate in EMP (Construction) and EMP (Operation and Maintenance).

Source: Study team compilation based on **Appendix F** and **Appendix G**

Notes:

1. See **Table 12-3**.
2. This is the only hazard where works can be undertaken to reduce the likelihood (as opposed to consequence) of a hazard.

As noted above, the mitigation of all risks requires a combination of the following tools:

- structural design to withstand loads imposed by identified natural hazards (especially tsunami, cyclone, and flood)
- provision of safe refuge above designated design levels
- ‘vertical evacuation’ procedures to lead people without harm to the safe refuge areas, and allied plans, actions and associated infrastructure (e.g. communications) under the umbrella of an Integrated Emergency Management Plan (see **Section 12.5.2a)**)
- management actions to be incorporated in the EMP (Construction) and EMP (Operation & Maintenance)
- collaboration with appropriate Queensland Government and local agencies for integrated planning.

Provided that the above actions are taken, the residual risk to all hazards is considered to be Low, despite the fact the location is exposed to a number of hazards.

12.6.2 Contribution to the Development of External Infrastructure

There is some risk that river migration could occur (specifically of Richters Creek but also of the Barron River itself) if there were changes in the Barron / Thomatis Creek flow share. While this has been assessed as having low risk, if it did occur it would be catastrophic to the project (if unprotected). It would also be catastrophic for the communities of Yorkeys Knob and Holloways Beach in the short term (flooding, erosion) and for beaches in these areas together with Machans Beach in the long term (reduced sediment inflow of beach nourishment leading to major shoreline erosion).

Stabilisation works were contemplated in the Barron River Delta Investigation and the Mulgrave Shire Northern Beaches Report. There may be an opportunity of Queensland Government / Aquis collaboration in funding the previously recommended (or other appropriate) works to further stabilise the Thomatis Creek bifurcation.

If this occurs then there would be considerable community benefit. No commitment to this work has been made and it is clearly a matter for further consideration.

12.6.3 Climate Change

In terms of the above hazards, climate change has been considered as follows:

- The Resort Complex is to be built on a raised podium set at 7.5 m AHD. This level:
  - is approximately 5 m above natural ground level
  - is above the Probable Maximum Flood (PMF) for all parts of the site
  - provides 2 m freeboard to the 0.01% AEP storm tide (allowing for 0.8 m sea level rise)
  - is also well above the 6 m AHD refuge level set by CRC for tsunami
  - provides adequate allowance to any conceivable extreme event, even with sea level rise.
- Flood modelling (**Chapter 9** – Flooding) has taken into account the 0.8 m predicted sea level rise. This shows that under such circumstances flood levels would be only marginally higher than currently considered because the frontal dune is the critical tailwater control in both the current and future cases.
- The discussion on Coastal Processes (**Chapter 8**) concludes that the Aquis Resort is set approximately 400 m landward of the current shoreline and as such is located well behind current coastal dunes and associated sand transport processes. Due to the low lying nature of the site, the predicted year 2100 HAT + SLR water level is located approximately 3.5 km to 4 km inland and therefore landward of the development. The coastal processes that would be involved in shoreline migration from its current position to a new year 2100 location as a result of SLR is impossible to predict, given the complex array of tidal creeks in the Barron River delta and beyond. However, it is likely that structural works will be constructed at the communities of Holloways Beach and Yorkeys Beach to protect these areas from such changes at an early stage, due to their proximity to the sea. This protection will interrupt coastal processes in the region and, in this circumstance, it is unlikely that the Aquis Resort will further impact coastal processes at any time. This situation is impossible to predict as it involves vagaries of climate change, community values, and government policy.

The residual risk of climate change is considered to be small initially. Over time, some adaptation may be required but what this might entail is impossible to predict. The Resort Complex Precinct level takes into account SLR, so the most likely adaptation may be levees around the perimeter of the site.