Flood and Tsunami Emergency Response Plan

8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

59919086

Prepared for
Landcom

13 July 2023

Stantec

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Executive Summary

This Report details a Flood and Tsunami Emergency Response Plan (FTERP) for the mixed-use development at 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly. This development was created through the adaptive re-use of the former Queenscliff Community Heath Centre.

The Report describes:

- Flood behaviour at the site in floods up to the Probable Maximum Flood (PMF),
- Tsunami risks
- A Flood and Tsunami Emergency Response Plan for the development, including:
  - A Flood Warning System;
  - A Tsunami Warning System
  - Evacuation strategy, measures, procedures and plan; and
  - A FloodSafe Plan

Guidance for Residents

The following guidance is adapted from the general guidance provided by Northern Beaches Council at: https://www.mhl.nsw.gov.au/users/NorthernBeaches-BeFloodSafe

Be Flood Safe

Familiarise yourself with this plan.

There are some precautions you can take to minimise damage to your property or danger to you and your family members. For further information see the SES webpage.

Before a flood

- Know the risk of flood impacts in Queenscliff
- Know which roads will be cut off and plan your evacuation. Be prepared to act quickly if you plan to evacuate off-site prior to flash flooding
- Review the attached FloodSafe Plan
- Place medication, personal documents such as passports, prescriptions and valuables in a waterproof container that can be easily carried
- Put together an emergency kit containing a portable radio, mobile phone, torch, spare batteries, bottled water, first aid kit and a list of emergency contacts in a portable waterproof container
- Decide what to do with any pet(s) if there is a flood

During a flood

- Turn on your radio (ABC radio am:702) and listen for updates or keep an eye on the SES webpage
- Stack furniture on benches & tables, secure possessions that can float and place electrical items at the highest possible point (Ground Floor only)
- Block toilets and floor drains with sand bags from inside your home to prevent sewage backing up (ground floor only)

- Turn off gas and electricity at the mains
- Follow the FloodSafe Plan
- If surrounded by floodwater keep your family together and remain inside the building on Level 1 or Level 2
- Follow any directions by the emergency services

After a flood

- Ensure it is safe to return to the Ground Floor. Check for damage to windows, walls and be aware of potential contaminants
- Ensure the electricity and gas is turned off before returning to the Ground Floor and if needed use a torch
- If power points or any electrical equipment have been exposed to floodwater get them inspected by a qualified electrician before use
- Gas appliances and gas bottles exposed to floodwater should also be inspected before use
- Wear protective clothing including boots and gloves when cleaning up
- Be aware of any trip or fall hazards
- Never eat food which has been in contact with floodwater
- Only use clean utensils, clothes and personal items
- Have a supply of bottled drinking water available

The following guidance is adapted from the general guidance provided by Northern Beaches Council at: Tsunami | Northern Beaches Council (nsw.gov.au)

Be Tsunami Safe

Familiarise yourself with this plan.

There are some precautions you can take to minimise damage to your property or danger to you and your family members. For further information see the SES webpage.

Before a tsunami

- Know the risk of tsunami impacts in Queenscliff
- Know which roads will be cut off and plan your evacuation. Be prepared to act quickly if you plan to evacuate off-site prior to land-threat tsunami inundation
- Review the attached FloodSafe Plan
- Place medication, personal documents such as passports, prescriptions and valuables in a waterproof container that can be easily carried
- Put together an emergency kit containing a portable radio, mobile phone, torch, spare batteries, bottled water, first aid kit and a list of emergency contacts in a portable waterproof container
- Decide what to do with any pet(s) if there is a tsunami

During a tsunami warning

- Turn on your radio (ABC radio am:702) and listen for updates or keep an eye on the SES webpage
- If the warning is for land-threat tsunami inundation to a level higher than 3.0 m AHD then

  - Stack furniture on benches & tables, secure possessions that can float and place electrical items at the highest possible point (Ground Floor only)
  - Block toilets and floor drains with sand bags from inside your home to prevent sewage backing up (ground floor only)
  - Turn off gas and electricity at the mains
  - Evacuate to higher ground if safe to do so.
- If surrounded by water keep your family together and remain inside the building on Level 1 or Level 2
- Follow any directions by the emergency services

After a tsunami

- Ensure it is safe to return to the Ground Floor. Check for damage to windows, walls and be aware of potential contaminants
- Ensure the electricity and gas is turned off before returning to the Ground Floor and if needed use a torch
- If power points or any electrical equipment have been exposed to water get them inspected by a qualified electrician before use
- Gas appliances and gas bottles exposed to water should also be inspected before use
- Wear protective clothing including boots and gloves when cleaning up
- Be aware of any trip or fall hazards
- Never eat food which has been in contact with water
- Only use clean utensils, clothes and personal items
- Have a supply of bottled drinking water available

Emergency contact numbers are as follows:

Agency	
Ambulance	Emergency Telephone: 000
Bureau of Meteorology (BoM)	http://www.bom.gov.au/nsw/warnings/ Telephone: 1300 659 219 (for flood warnings)
Police	Northern Beaches Local Area Command Cnr St David Ave & Fisher Rd, Dee Why 2099 Telephone: (02) 9971 3399 Manly Police Station, 4–10 Sydney Rd, Manly 2095 Telephone: (02) 9976 8099 Emergency Telephone: 000
Fire & Rescue NSW	Emergency Telephone: 000
State Emergency Services (SES) for storm damage, flooding, disasters and rescue)	Emergency Telephone: 132 500 General enquiries: (02) 4251 6111
Northern Beaches Council (NBC)	Telephone: 1300 434 434
Disaster Welfare Services Assistance Line	Telephone: 1800 018 444

Northern Beaches Council also lists emergency contacts which can be accessed at:
https://www.northernbeaches.nsw.gov.au/services/emergency-preparedness/emergency-contacts

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1 Introduction

1.1 Background

This Report details a Flood and Tsunami Emergency Response Plan (FTERP) for the mixed-use development at 8 Palm Avenue and 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly. This development was created through the adaptive re-use of the former Queenscliff Community Heath Centre.

The mixed-use development is a boarding house, comprising 12 rooms on the ground floor, and seniors housing comprising 25 self-contained dwellings on the upper floors (known as the Queenscliff Project).

The subject site is located on the Manly Lagoon floodplain in the Northern Beaches LGA.

Figure 1 identifies the location of the building on 8 Palm Avenue and 2-4 Lakeside Crescent in North Manly which is subject to the adaptive re-use, and compares the proposed revised Lot 1 boundary with the current lot boundaries.

The property is flood-prone and the adaptive re-use of the existing building responds to flooding and tsunamis and the associated risks.

Figure 1 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly
(Source: nearmap; accessed 5 February 2019)

1.2 Flooding Considerations

It is noted that flooding investigations have been previously completed for the Manly Lagoon floodplain in the vicinity of the subject property. The flooding context is provided in several studies as follows:

- The Manly Lagoon Flood Study prepared by BMT WBM in August 2013;
- The Manly Lagoon Flood Study - Flood Planning Levels Report prepared by BMT WBM in August 2013;
- The Manly Lagoon Floodplain Risk Management Study and Plan prepared by WMAwater in October 2018.

1.3 Tsunami Considerations

It is noted that tsunami inundation investigations have been previously completed for the NSW coastline and including Manly Lagoon in the vicinity of the subject property. The tsunami context is provided in the following study:

- NSW Tsunami Inundation Modelling and Risk Assessment prepared by Cardno in July 2013;

1.4 Emergency Contacts

Emergency contact numbers are as follows:

Agency	
Ambulance	Emergency Telephone: 000
Bureau of Meteorology (BoM)	http://www.bom.gov.au/nsw/warnings/ Telephone: 1300 659 219 (for flood warnings)
Police	Northern Beaches Local Area Command Cnr St David Ave & Fisher Rd, Dee Why 2099 Telephone: (02) 9971 3399 Manly Police Station 4–10 Sydney Rd, Manly 2095 Telephone: (02) 9976 8099 Emergency Telephone: 000
Fire & Rescue NSW	Emergency Telephone: 000
State Emergency Services (SES) for storm damage, flooding, disasters and rescue)	Emergency Telephone: 132 500 General enquiries: (02) 4251 6111
Northern Beaches Council (NBC)	Telephone: 1300 434 434
Disaster Welfare Services Assistance Line	Telephone: 1800 018 444

Northern Beaches Council also lists emergency contacts which can be accessed at:
https://www.northernbeaches.nsw.gov.au/services/emergency-preparedness/emergency-contacts

2 Flood Risks

The flood risks experienced on 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly are as follows.

2.1 Flood Levels and Hazards

2.1.1 Flood Extents and Levels

The estimated 20% AEP, 1% AEP and PMF flood extents under current conditions reported by WMAwater, 2018 are plotted in **Figure 2.** The flood levels on the site are:

- 10% AEP flood level without climate change 2.55 m AHD
- 5% AEP flood level without climate change 2.7 m AHD
- 1% AEP flood level with climate change 3.2 m AHD
- 1% AEP flood level with 5% AEP tailwater 3.16 m AHD
- Flood Planning Level 3.66 m AHD
- PMF level 5.7 m AHD

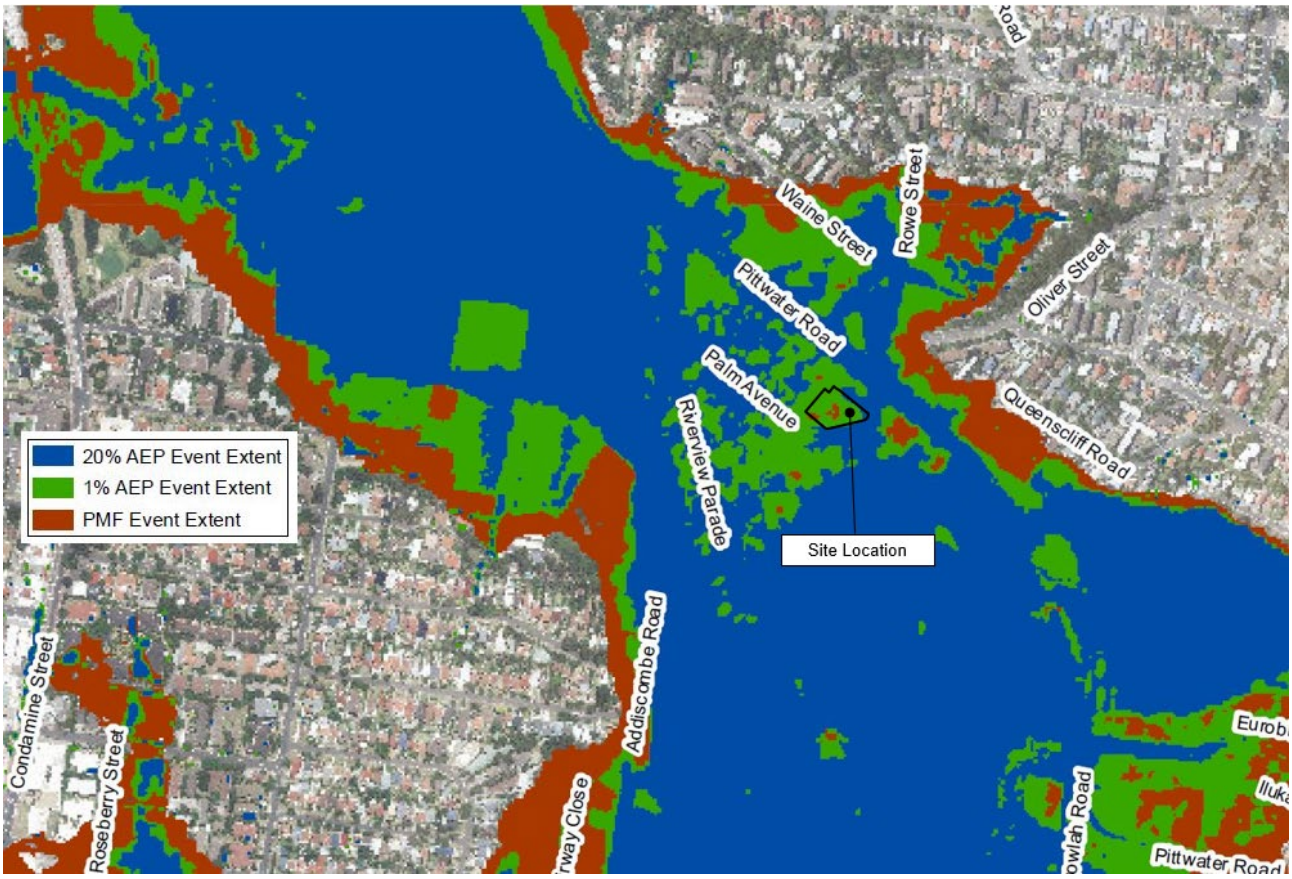


Figure 2 Design Flood Extents (after Figure 7, WMAwater, 2018)

2.1.2 Hydraulic Categories

The hydraulic categories mapped by WMAwater, 2018 in the vicinity of the subject site for the 1% AEP and 1% AEP flood with 5% AEP tailwater are plotted respectively in **Figures 3** and **4**.

It is noted that in both these cases the site is mapped as Flood Storage and Flood Fringe.

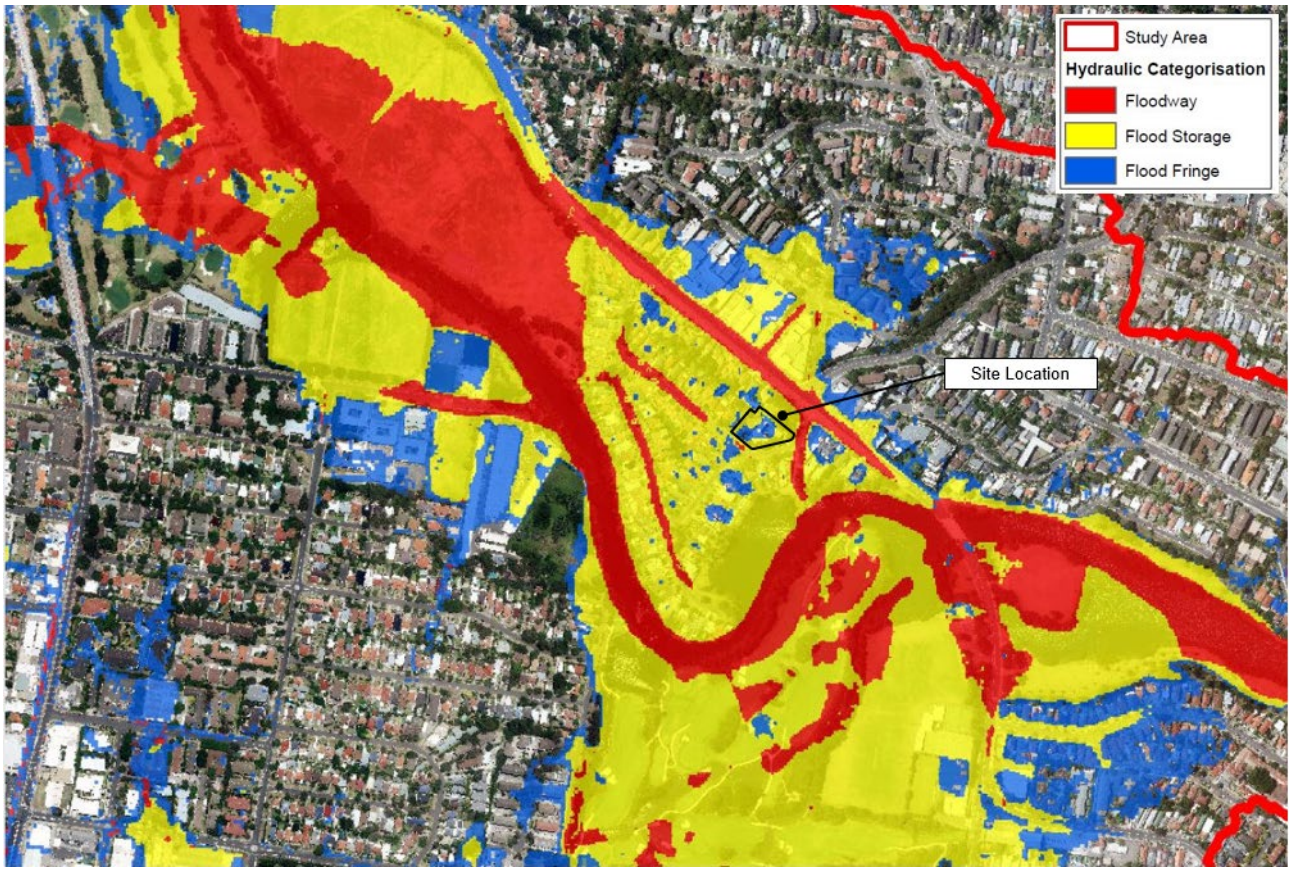


Figure 3 Hydraulic Categories under 1% AEP Flood (after Figure 13, WMAwater, 2018)

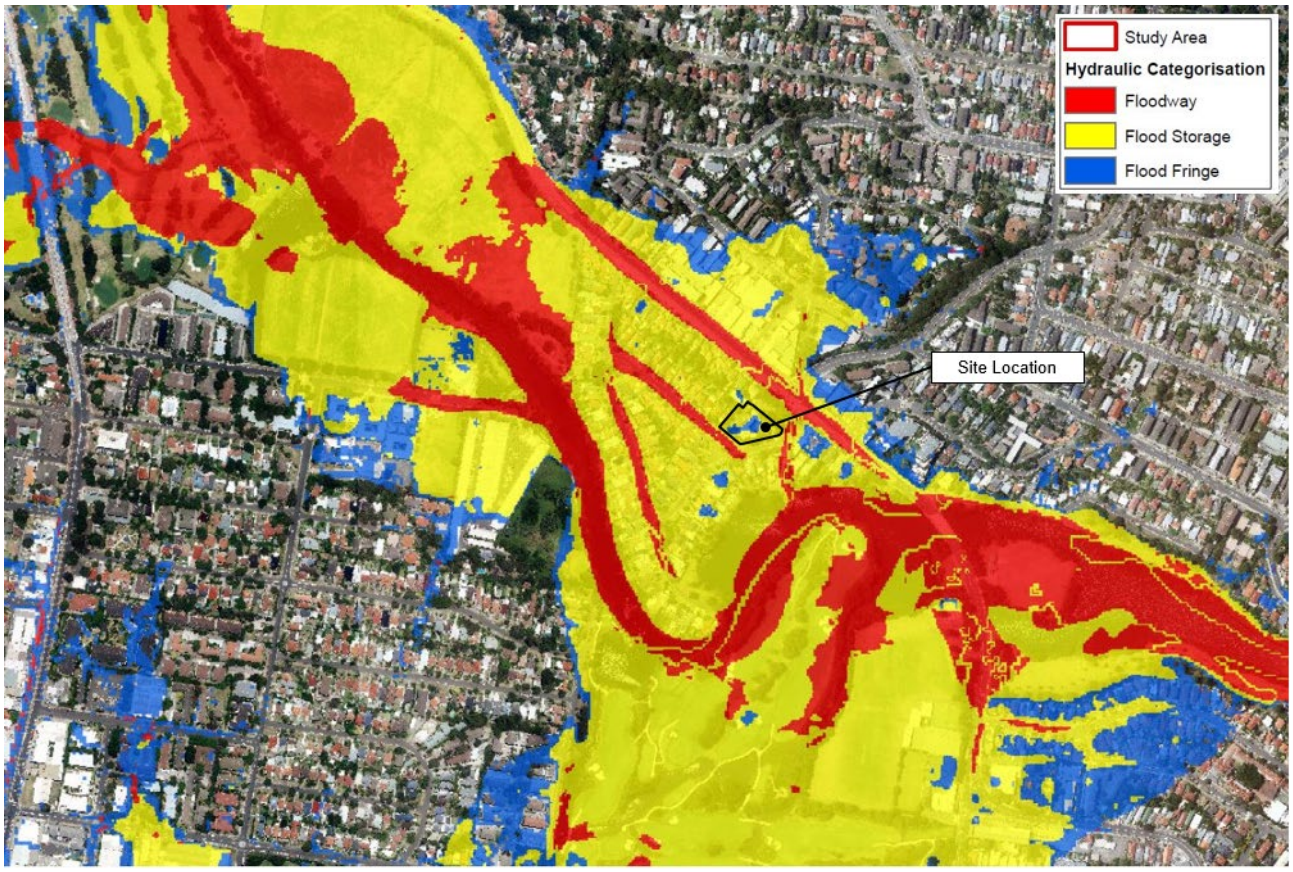


Figure 4 Hydraulic Categories under 1% AEP Flood with 5% AEP Tailwater
(after Figure 17, WMAwater, 2018)

2.1.3 Hazard Categories

The 2023 Flood Risk Management Guideline FB03 released on 30 June by NSW DPE includes a plot of flood hazard vulnerability curves based on six hazard categories H1 – H6 as follows.

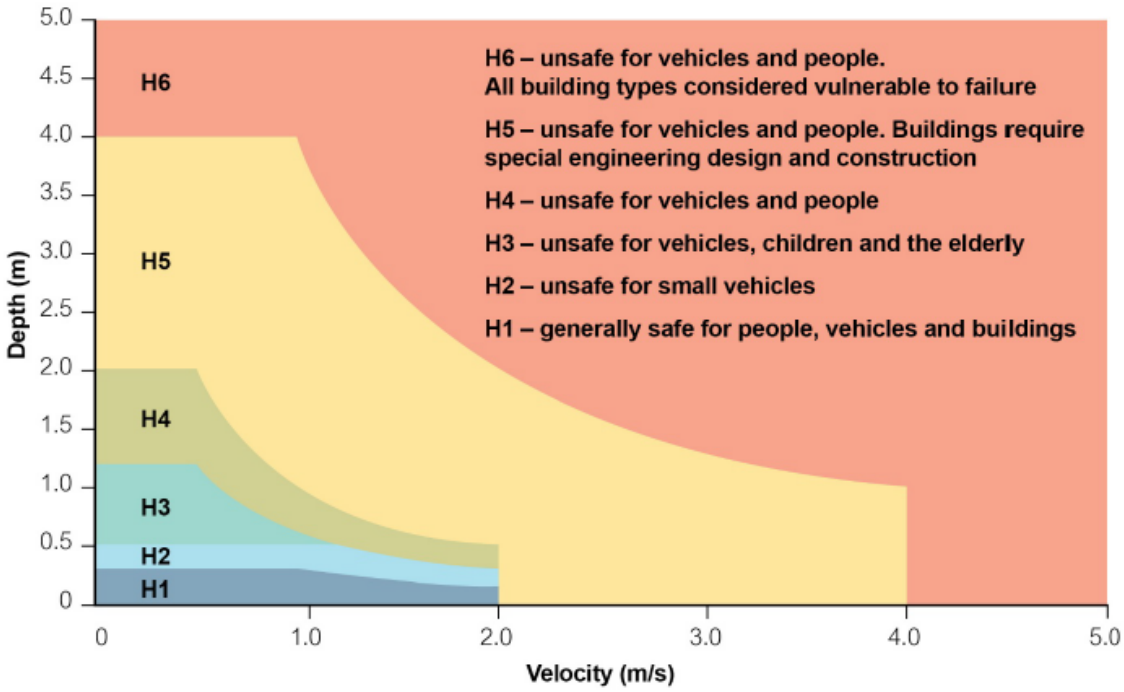


Figure 1 General flood hazard vulnerability curve

Note: Categories H1 to H4 in this guideline are equivalent to low hazard and H5 to H6 equivalent to high hazard in the 2005 *Floodplain development manual* (DIPNR 2005).

Source: Figure 6 AIDR 2017b.

As described in part by WMAwater, 2018:

> *Hazard categories are often grouped based on consequences. Figure 18 to Figure 25 provide the hazard classification for all the design events, with H1 & H2 and H3 & H4 grouped into two categories due to their similarity in consequences.*

The hazard categories mapped by WMAwater, 2018 in the vicinity of the subject site for the 1% AEP and 1% AEP flood with 5% AEP tailwater are plotted respectively in **Figures 5** and **6**.

The variation of the indicative velocity and depth during the 1% AEP flood and PMF at Locations CP2, P1, L2 and L4 (refer **Figure 7**) in comparison to the hazard zones are plotted respectively in **Figures 8** and **9**.

It is noted that the external areas on the property (as exemplified by Location CP2) are classified as category H3 in a 1% AEP flood and category H5 in a PMF.

Figure 5 Flood Hazard under a 1% AEP Flood (after Figure 21, WMAwater, 2018)

Figure 6 Flood Hazard under a 1% AEP Flood with 5% AEP (after Figure 25, WMAwater, 2018)

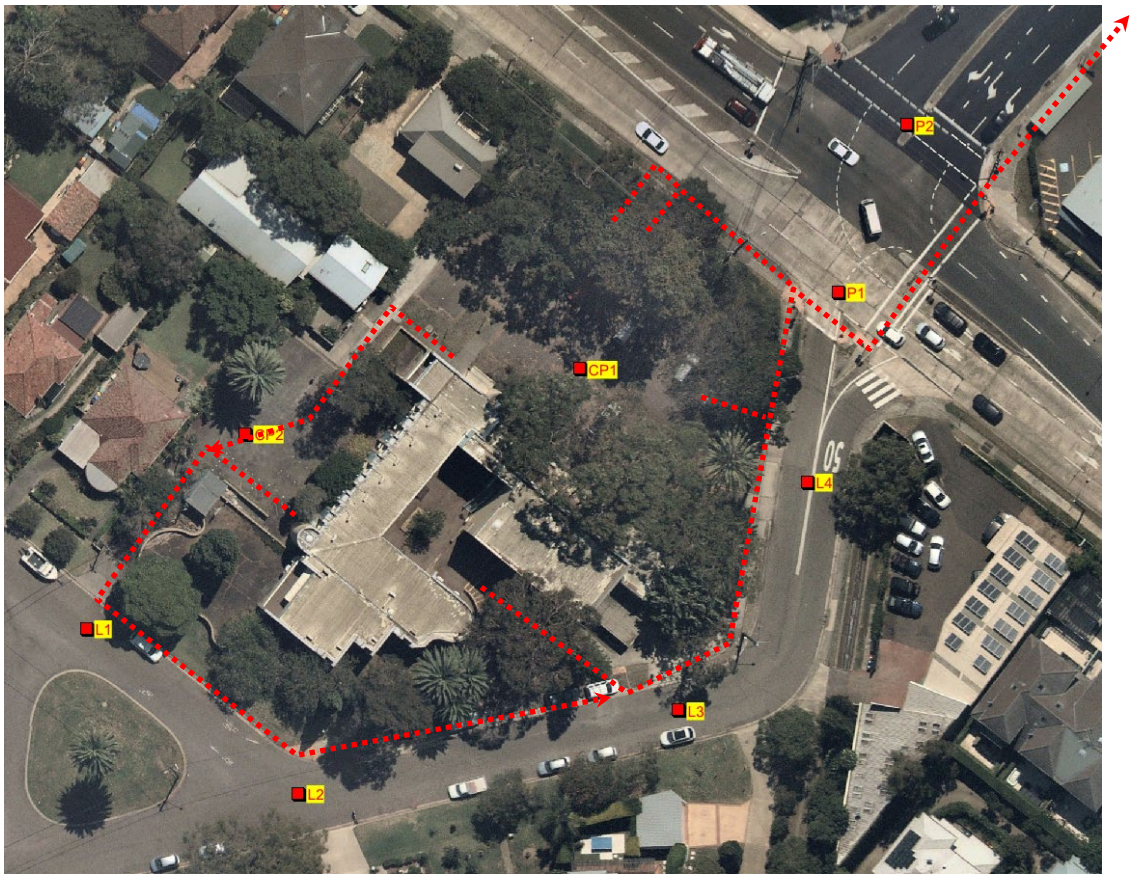


Figure 7 Reference Locations and Indicative Evacuation Routes (➝)

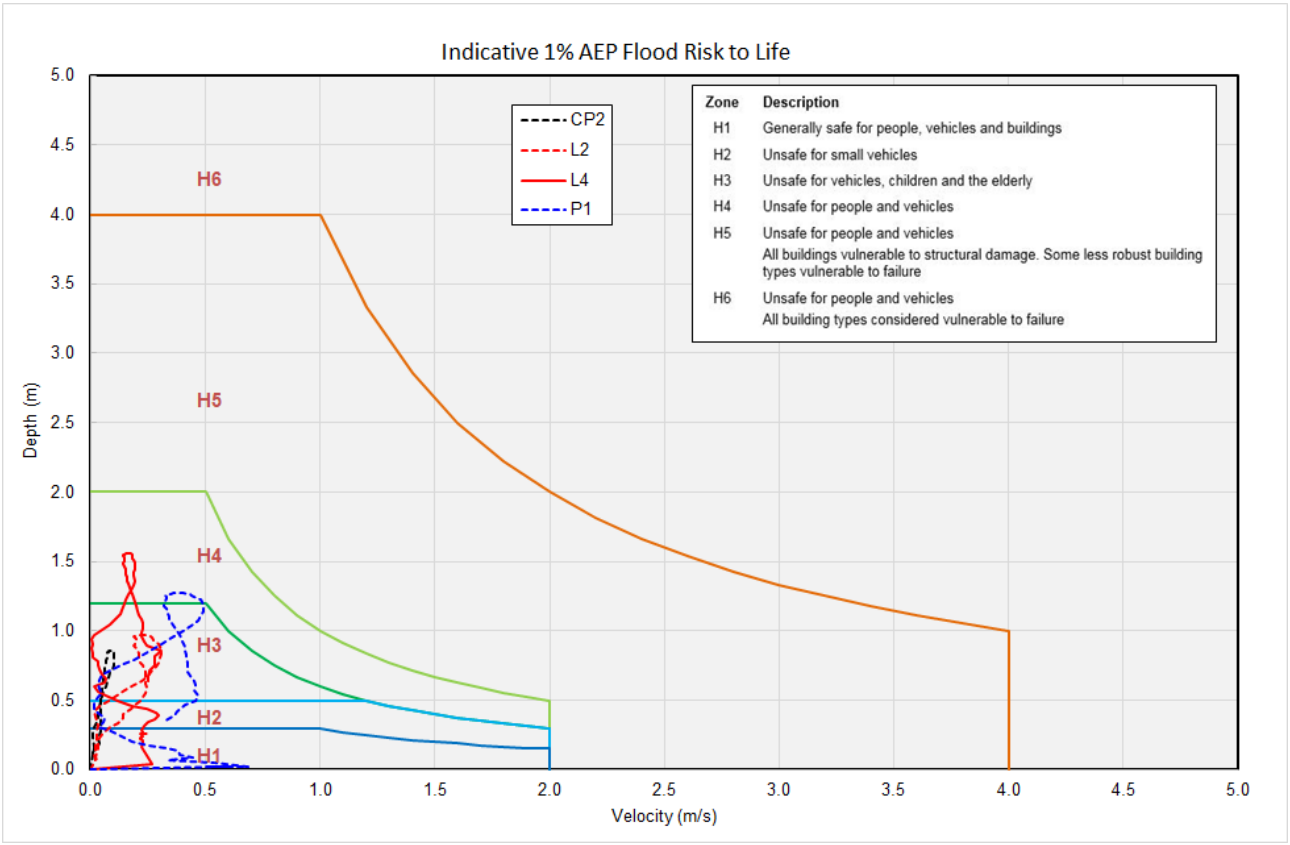


Figure 8 Indicative 1%AEP Flood Risk to Life at Selected Locations

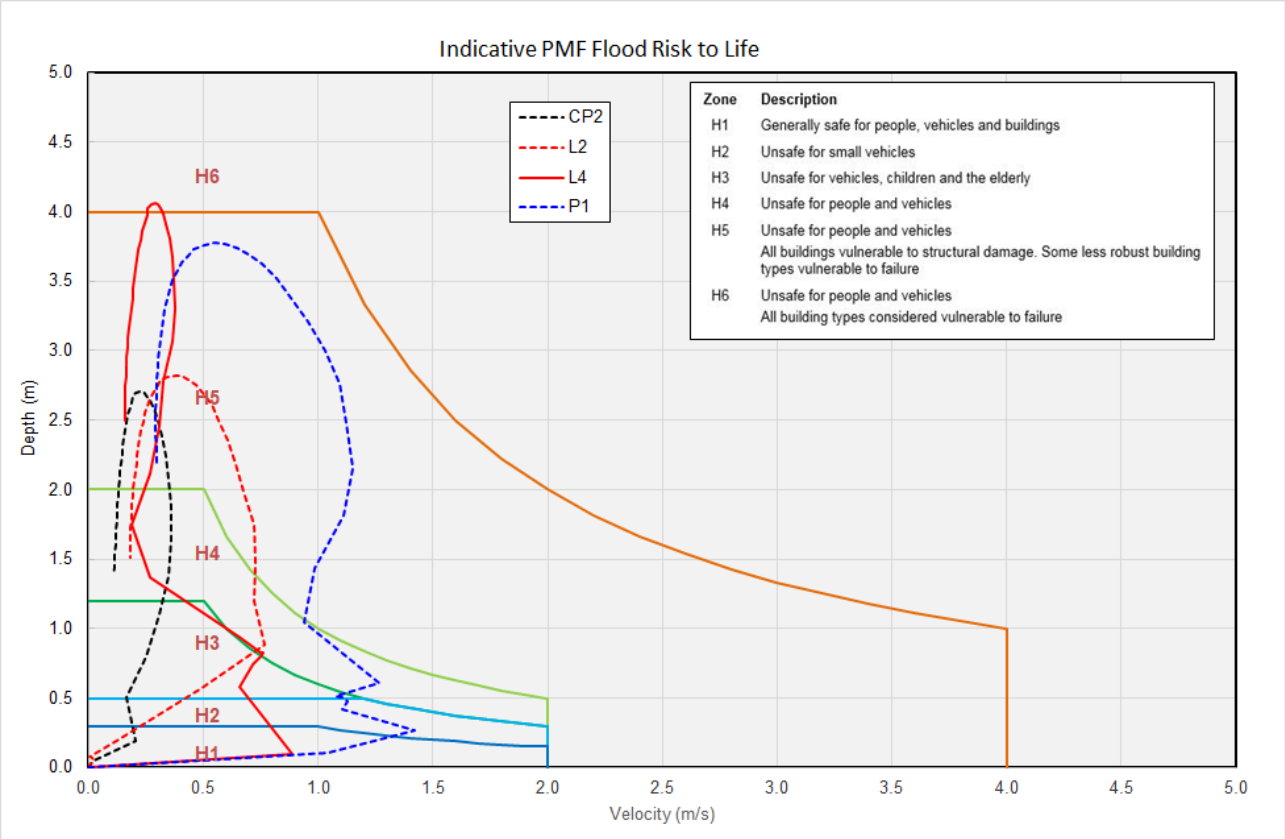


Figure 9 Indicative PMF Risk to Life at Selected Locations

2.2 Rate of Rise of Floodwaters

To understand the likely warning times and associated response times during flood events it is necessary to estimate the expected rate of rise of floodwaters in the vicinity of the subject property.

The variation in the rise and fall of flood depths at Locations CP2, P1, L2 and L4 (refer **Figure 7**) in the 1% AEP flood and the PMF are plotted respectively in **Figures 10** and **12**.

The variation in the rate of rise and fall of floodwaters at Locations CP2, P1, L2 and L4 (refer **Figure 7**) in the 1% AEP flood and the PMF are plotted respectively in **Figures 11** and **13**. It should be noted that the rates of rise and fall were calculated at time intervals of 5 mins.

Figure 10 and **11** discloses that at Location L4 an initial surge in flood levels up to a depth of around 0.25 m is experienced before a more gradual rise in flood levels commences around 160 mins after the start of the 1% AEP storm burst. A similar initial surge to a depth of around 0.2 m is noted at Location CP2 when floodwaters rise to a level which inundates the location. This then settles down rapidly to a more gradual rate of rise of floodwaters at all locations. The peak 1% AEP levels are experienced 400 mins after the start of the 1% AEP storm burst.

Figure 12 and **13** disclose a similar behaviour with an initial surge in PMF levels at Locations L4 (to 0.5 m depth) and P1 (to a depth of 0.22 m) which then flatten before floodwaters commence rising further at all locations. The peak PMF levels are experienced 115 mins after the start of the PMP storm.

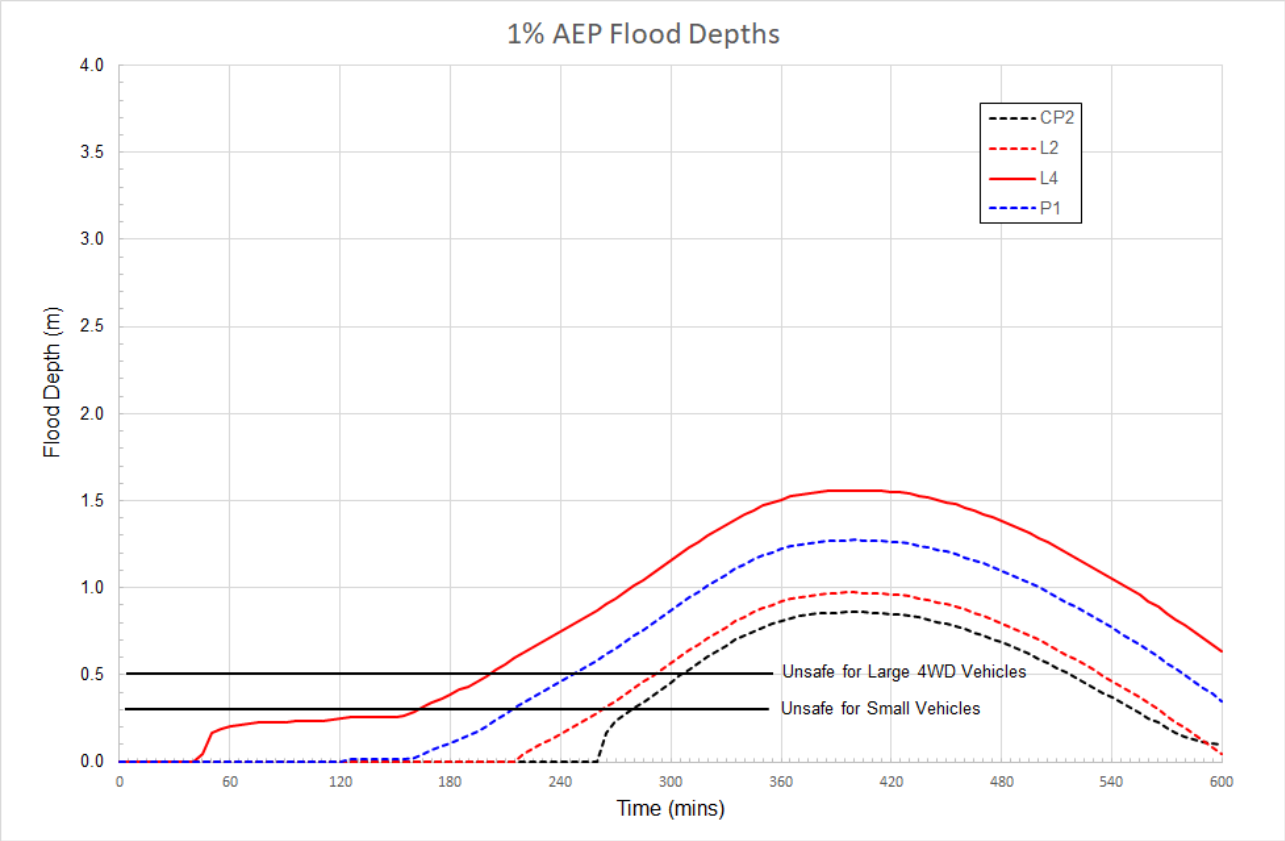


Figure 10 Rise and Fall of 1%AEP Flood Depths at Selected Locations

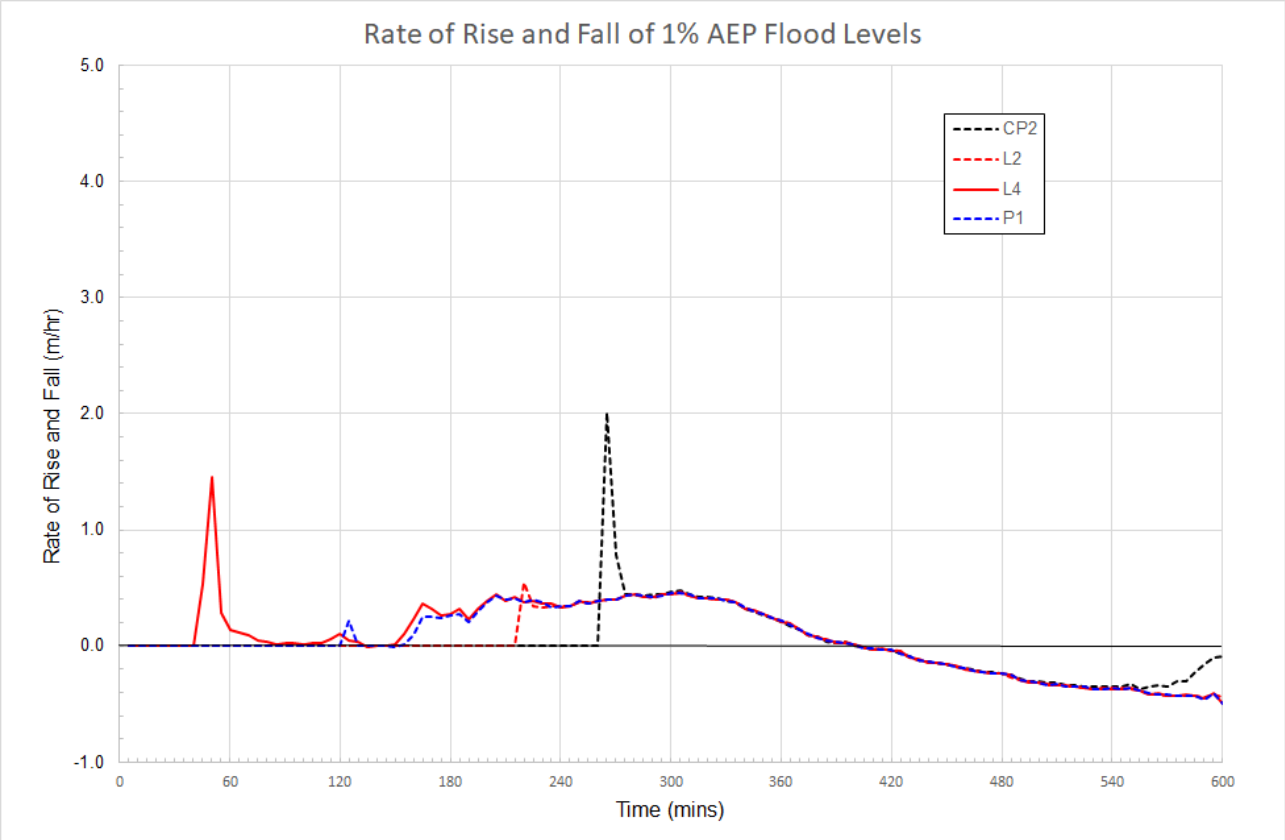


Figure 11 Rate of Rise and Fall of 1%AEP Flood Levels at Selected Locations

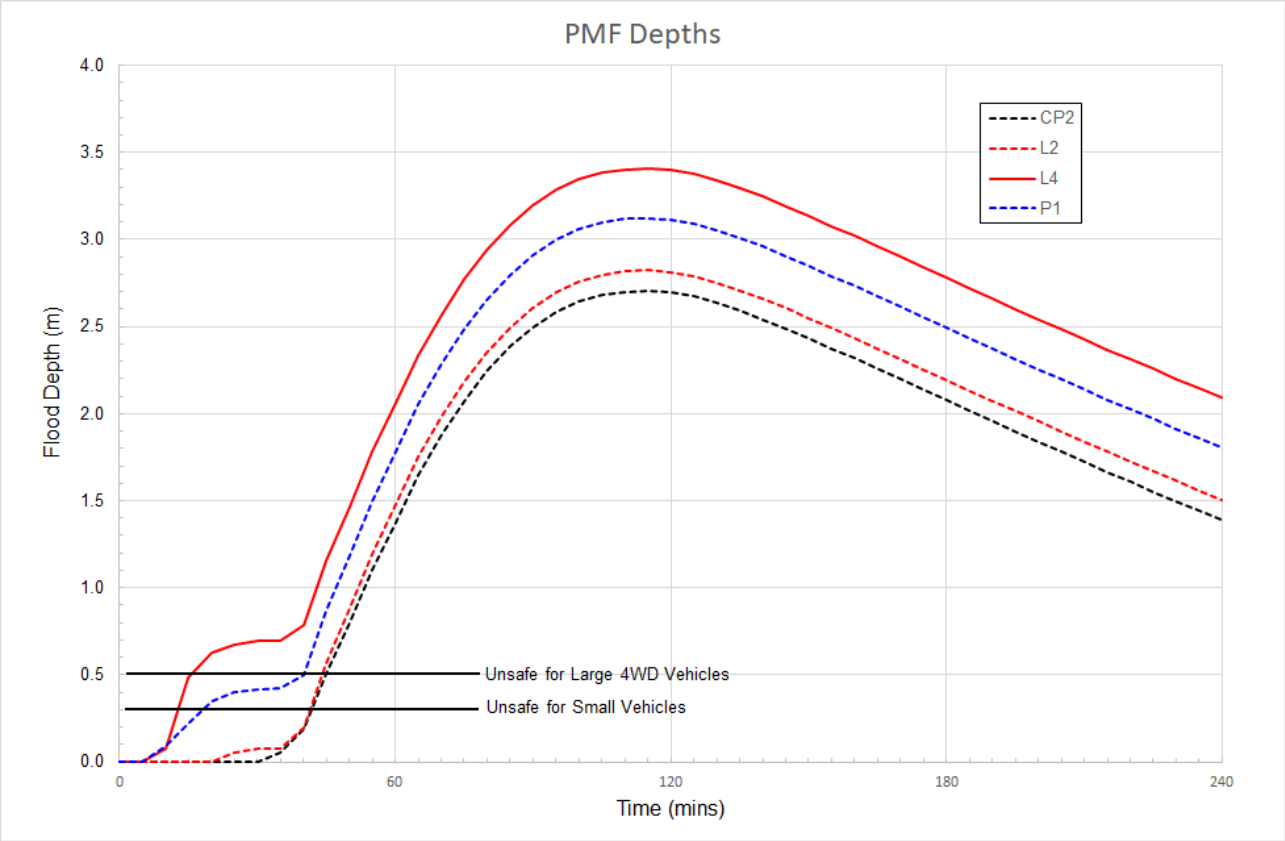


Figure 12 Rate of Rise and Fall of PMF Depths at Selected Locations

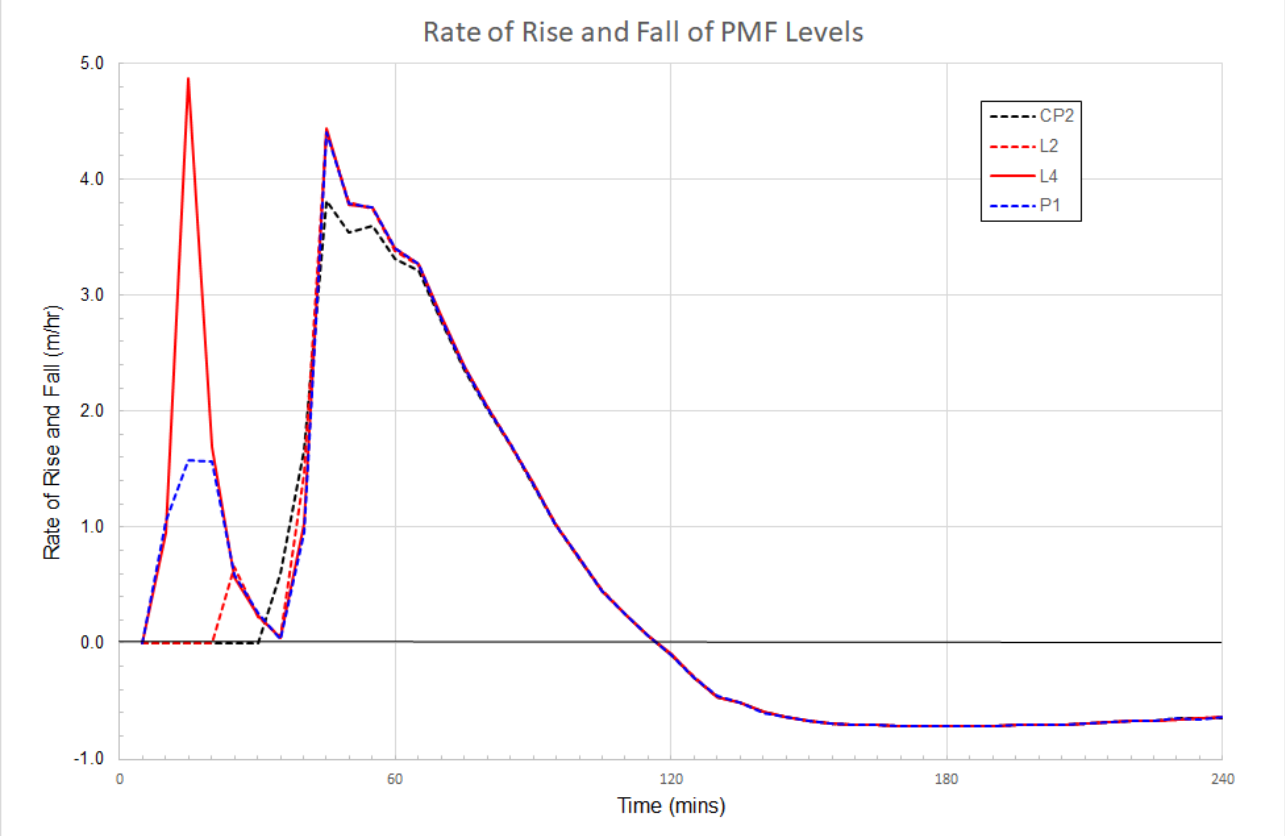


Figure 13 Rate of Rise and Fall of PMF Levels at Selected Locations

2.3 Pedestrian and Vehicular Stability in Floods

The latest edition of Australian Rainfall and Runoff released in 2019 provides guidance on both pedestrian and vehicle stability in floods as does the 2023 Flood Risk Management Guideline FB03 released on 30 June by NSW DPE.

2.3.1 Pedestrian Stability

The 2023 Flood Risk Management Guideline FB03 released on 30 June by NSW DPE includes the following plot of thresholds for the stability of people in floods.

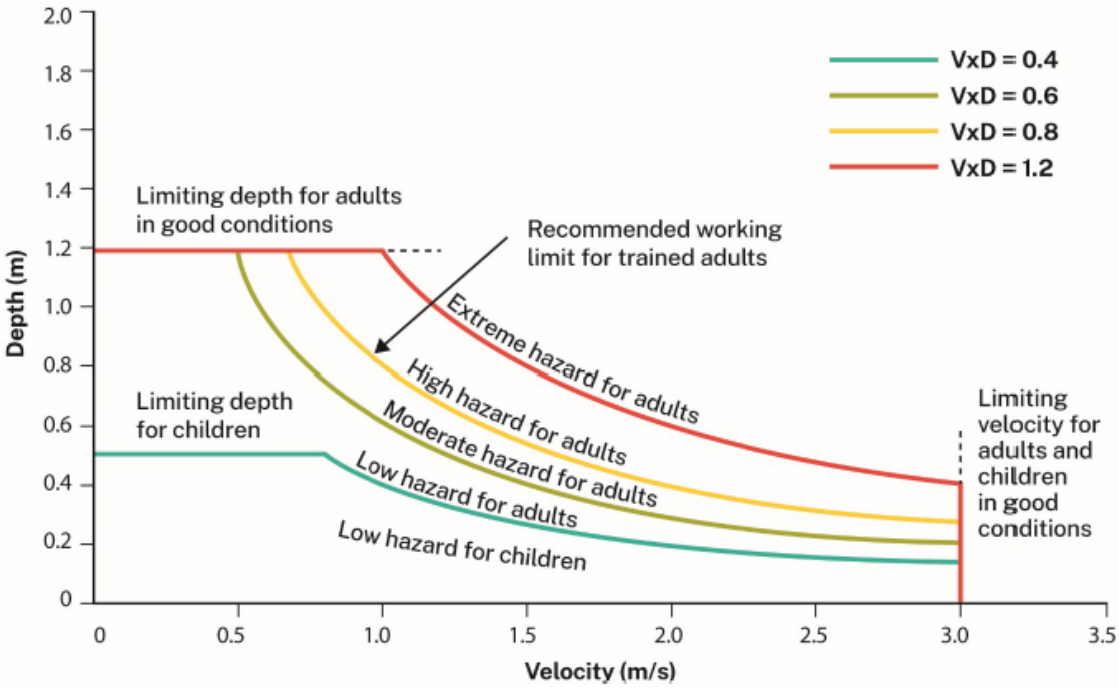


Figure 2 Thresholds for the stability of people in floods

Notes: D.V = VxD = velocity x depth.

Source: Figure 8 AIDR 2017b; modelled after Cox, Shand and Blacka (2010).

The variation in flood depths and velocity in a 1% AEP flood and the PMF at the reference location L4 (refer Figure 7) are plotted and compared to the pedestrian stability limits respectively in **Figures 14** and **15**.

Three scenarios are assessed as follows:

(i) Location L4 on the centreline of Lakeside Crescent in the vicinity of the low point

(ii) Opposite L4 on the footpath

(iii) Opposite L4 on the footpath but under conditions where the footpath has been raised to provide a rising path from the corner of Palm Avenue to Pittwater Road (ie. raising the current footpath level at this location by 0.22 m)

Based on the criterion for pedestrian stability, the periods of time that conditions would be unsafe for children and adults at the Location L4 are given in **Table 1.**

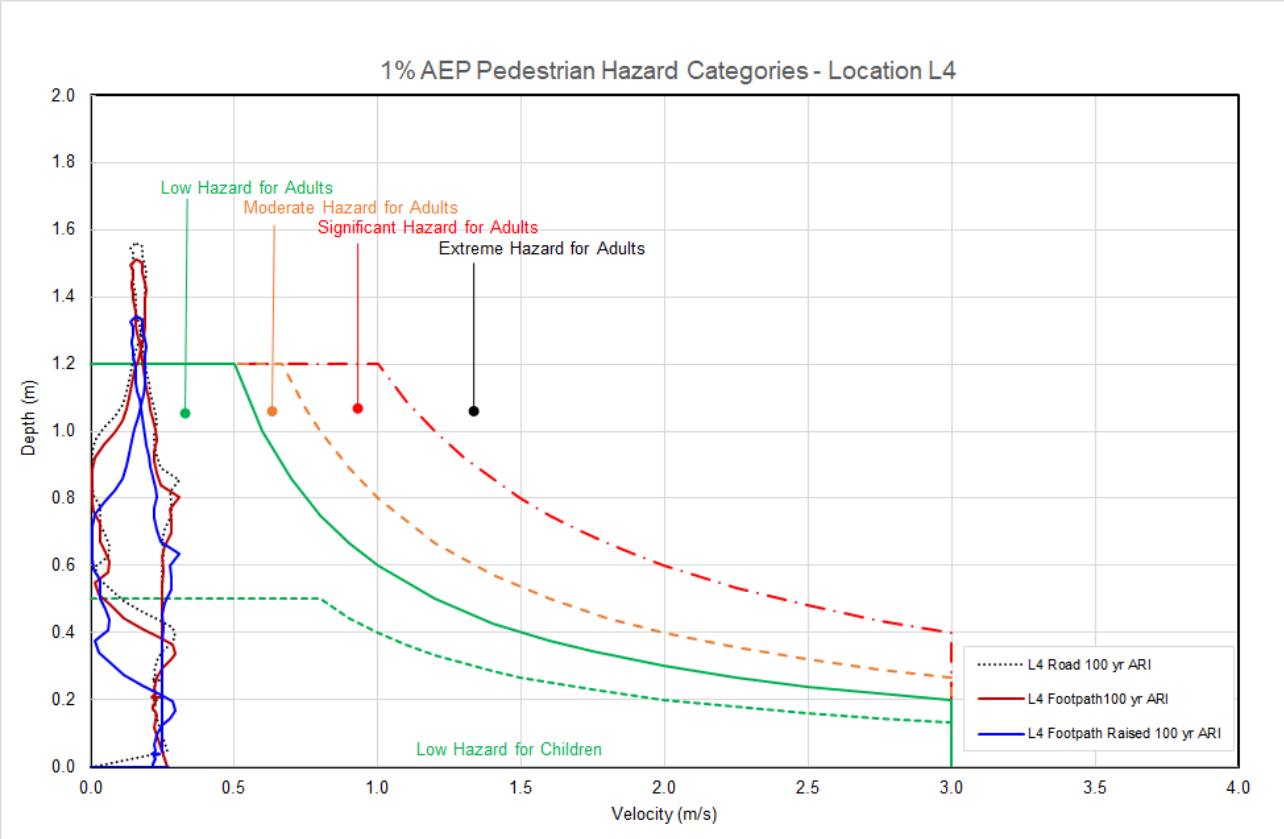


Figure 14 1% AEP Pedestrian Hazard Categories at Location L4

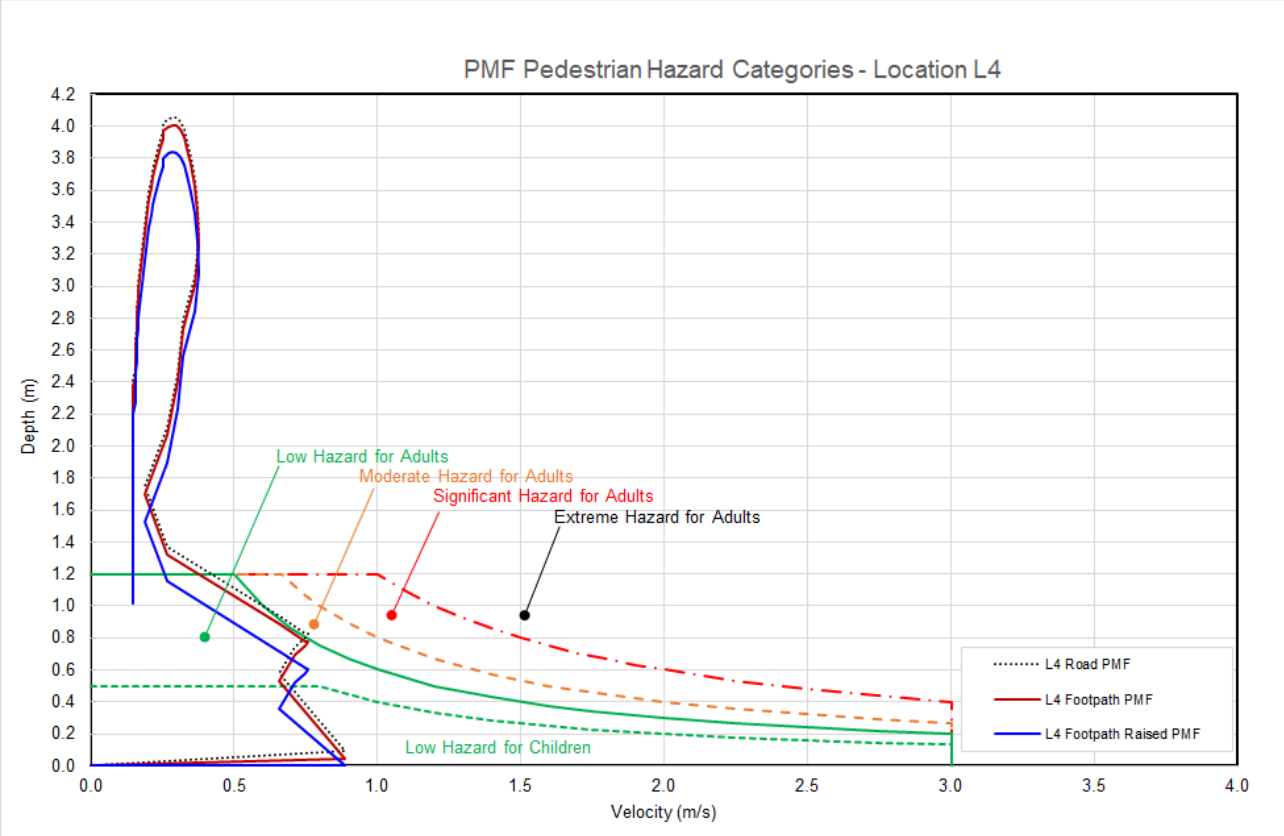


Figure 15 PMF Pedestrian Hazard Categories at Location L4

Table 1 Available Warning Time and Duration of Unsafe Conditions for Pedestrian Evacuation

	Elapsed Time from Start of Storm Burst until Unsafe Conditions Reached (**mins**):			
	Children	Adults	Children	Adults
Location	1% AEP		PMF	
L4 Road	205 3 hrs 25 mins	310 5 hrs 10 mins	15 15 mins	35 35 mins
L4 Footpath	210 3 hrs 30 mins	315 5 hrs 15 mins	25 25 mins	35 35 mins
L4 Footpath Raised	240 4 hrs	340 5 hrs 40 mins	20 20 mins	45 35 mins

	Duration (**mins**) it is Unsafe for:			
	Children	Adults	Children	Adults
Location	1% AEP		PMF	
L4 Road	415 6 hrs 55 mins	210 3 hrs 30 mins	370 6 hrs 10 mins	310 5 hrs 10 mins
L4 Footpath	405 6 hrs 45 mins	195 3 hrs 15 mins	365 6 hrs 5 mins	285 4 hrs 45 mins
L4 Footpath Raised	350 5 hrs 50 mins	135 2 hrs 15 mins	350 5 hrs 50 mins	270 4 hrs 30mins

It will be noted that in short duration extreme floods that unsafe conditions can develop rapidly on Pittwater Road. In longer duration storms the time available to evacuate by vehicle increases. It is also noted that conditions become unsafe on Lakeside Crescent more rapidly than on Pittwater Road and would prolong the period of isolation of any residents relying on egress via Lakeside Crescent.

Table 1 discloses that:

(i) In a 1% AEP flood, conditions:

- adults would be able to evacuate through floodwaters for an additional 3+ hours longer than would unaccompanied children;
- Raising the footpath to provide a rising path from the corner of Palm Avenue to Pittwater Road would:
  - reduce the time it would be unsafe for unaccompanied children and adults to evacuate by around 1 hour;
  - reduce the duration of unsafe conditions for adults to around 2 hrs and 15 mins

(ii) In a PMF conditions it would be:

- Unsafe for children for around 6 hours and unsafe for adults for around 4 hours and 45 mins;
- Raising the footpath to provide a rising path from the corner of Palm Avenue to Pittwater Road would:
  - reduce the time it would be unsafe for unaccompanied children and adults to evacuate by around 15 – 25 minutes;
  - reduce the duration of unsafe conditions for adults to around 4 hrs and 30 mins

2.3.2 Vehicle Stability

The 2023 Flood Risk Management Guideline FB03 released on 30 June by NSW DPE includes the following plot of thresholds for vehicle stability in floods.

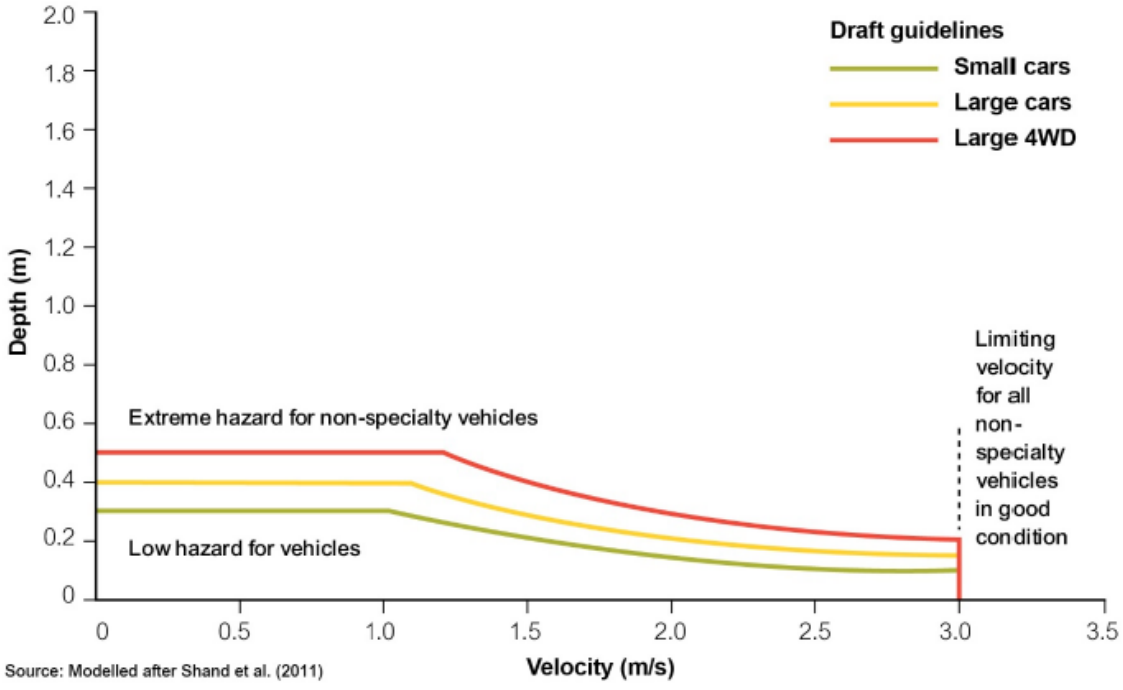


Figure 3 Thresholds for vehicle stability in floods
Source: Figure 9 AIDR 2017b; modelled after Shand et al. (2011).

H1 and H2 categories have been adopted as representative categories for vehicular stability respectively for small vehicles and large (4WD) vehicles.

Table 2 summarises the time it takes from the onset of a major storm for unsafe conditions to develop at selected locations for small vehicles and 4WD vehicles in a 9 hr 1% AEP storm and a 1.5 hr PMF event. The results for a 2 hr 1% AEP storm are not currently available but it is expected that they will be similar to the times estimated for the 1.5 hr PMF event.

It will be noted that in short duration extreme floods that unsafe conditions can develop rapidly on Pittwater Road (Location P1). In longer duration storms the time available to evacuate by vehicle increases. It is also noted that conditions become unsafe on Lakeside Crescent more rapidly than on Pittwater Road and would prolong the period of isolation of any residents relying on egress via Lakeside Crescent.

2.4 Evacuation to Ground higher than the PMF Level

As indicated in **Figure 7**, the nearest ground which is higher than the PMF level nearby to 8 Palm Ave and 2-4 Lakeside Crescent is along Oliver Street. It can be accessed via Palm Avenue, Lakeside Crescent and Oliver Street. The estimated time to walk along the footpath path to Lakeside Crescent intersection then cross at the pedestrian crossing on Pittwater Road before walking up Oliver Street to a level higher than the PMF is 4 minutes to 6 minutes based on a walking pace of 4 km/hr – 2 km /hr and allowing 2 minutes to cross Pittwater Road.

Table 2 Available Warning Time and Duration of Unsafe Conditions for Vehicular Evacuation

Warning Times	9 hr 1% AEP	1.5 hr PMF	Comment
Conditions become unsafe for small vehicles at Location L4	175 mins *2 hrs 55 mins*	13 mins	From start of storm burst *In hours and minutes*
Conditions become unsafe for 4WD vehicles at Location L4	200 mins *3 hrs 20 mins*	16 mins	From start of storm burst *In hours and minutes*
Conditions become unsafe for small vehicles at Locations P1, P2	215 mins *3 hrs 55 mins*	13-18 mins	From start of storm burst *In hours and minutes*
Conditions become unsafe for 4WD vehicles at Locations P1, P2	245 mins *4 hrs 5 mins*	40 mins	From start of storm burst *In hours and minutes*

Duration of Unsafe Conditions	9 hr 1% AEP	1.5 hr PMF	Comment
Isolated on site if relying on egress via Lakeside Cres	480 mins *8 hrs*	385 mins *6 hrs 25 mins*	Due to unsafe conditions for small vehicles on Lakeside Cres (L4)
Isolated on site if relying on egress via Lakeside Cres	420 mins *7 hrs*	365 mins *6 hrs 5 mins*	Due to unsafe conditions for 4WD vehicles on Lakeside Cres (L4)
Isolated on site if relying on egress along Pittwater Road	390 mins *6 hrs 30 mins*	355 mins *5 hrs 55 mins*	Due to unsafe pedestrian conditions on Pittwater Rd (P1) (Depth > 0.3 m)
Duration flood level exceeds Flood Protection Measures	0 mins	185 mins *3 hrs 5 mins*	Flood Protection Measures protect the Ground Floor up to 3.66 m AHD

3 Tsunami Risks

The SES NSW website provides the following information regarding land-threat tsunami.

3.1 Tsunami Evacuation Map

The NSW SES advises:

> *The NSW State Emergency Service (NSW SES) has released new maps showing evacuation areas in the event of a land-threat tsunami.*
>
> *While the likelihood of a land-threat tsunami on the east coast of Australia is low, the maps show the areas where residents and workers would have to move to higher ground in the event of a land-threat tsunami.*
>
> *Marine-threat tsunamis occur once about every six years, but are usually only dangerous to swimmers and boaters because of the dangerous currents. There is no record of a land-threat tsunami in Australia since European settlement.*

The tsunami evacuation map for the Manly Lagoon floodplain is given in **Figure 16.**

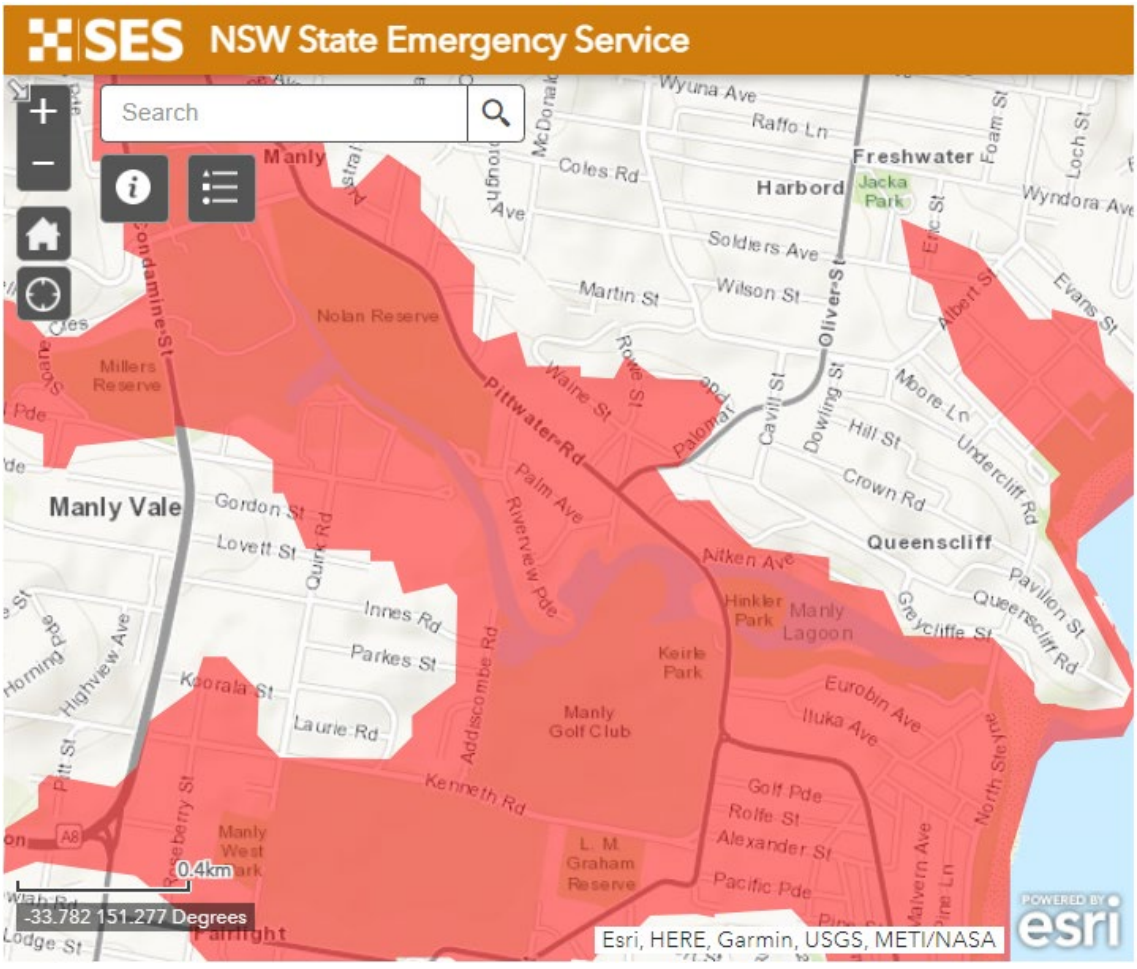


Figure 16 Many Lagoon Tsunami Map

Source: Tsunami Evacuation Map | NSW State Emergency Service

If there is a threat of land inundation from a tsunami, move to higher ground, at least ten meters above sea level or one kilometre away from the coast and rivers. Be sure to listen to your local radio station for information, warnings and advice.

3.2 Tsunami Risk

Australia has been affected by over 50 Tsunami in the past 200 years

The largest Tsunami to have affected the NSW coast in recent times occurred in May 1960 after a 9.5 magnitude earthquake in Chile resulted in a 1 metre tidal fluctuation at Fort Denison in Sydney Harbour. This caused widespread damage to marine infrastructure along the NSW Coast including damage to boats, wharves, jetties and beaches.

Detecting Tsunami

The Joint Australian Tsunami Warning Centre monitors earthquakes that could potentially cause tsunami that affect Australia by operating an enhanced network of seismic stations nationally and has access to data from international monitoring networks. It determines the magnitude, location and characteristics of a seismic event which has the potential to generate a Tsunami.

Based on this seismic information, the Joint Australian Tsunami Warning Centre runs a tsunami model to generate a first estimate of the tsunami size, arrival time and potential impact locations. The Joint Australian Tsunami Warning Centre verifies the existence of a tsunami using information from an enhanced sea level monitoring network of buoys situated strategically between the key earthquake zones and the NSW coastline.

The Joint Australian Tsunami Warning Centre then sends advice and warnings on any possible tsunami threat to State & Territory emergency management services, media and the public.

Source: Know Your Risk - Tsunami | NSW State Emergency Service

3.3 2013 NSW Tsunami Risk Assessment

In August 2013 Cardno prepared the NSW Tsunami Inundation Modelling and Risk Assessment for the NSW Office of Environment and Heritage and the NSW State Emergency Service. This assessment is summarised as follows.

The NSW Tsunami Risk Assessment was borne from a need to better understand tsunami risk in order to underpin detailed emergency response planning as part of the NSW Tsunami Emergency Sub Plan (a sub plan of the NSW State Disaster Plan; NSW SES, 2008). This study forms Stage 2 of the NSW Tsunami Risk Assessment, and has involved the detailed inundation modelling and exposure assessment of vulnerable low-lying coastal areas.

This report has been prepared under grant funding from the Attorney-General's Department Natural Disaster Mitigation Program by Cardno Coastal & Ocean for both the NSW Office of Environment and Heritage and the NSW State Emergency Service. The report describes detailed tsunami inundation modelling, deterministic hazard mapping and exposure assessments for five specific sites along the NSW coast, all identified during Stage 1 as being potentially more vulnerable to tsunami.

The five coastal locations include:-

- *Swansea/Lake Macquarie;*
- ***Manly;***
- *Botany Bay/Cronulla/Kurnell;*
- *Wollongong/Port Kembla; and*
- *Merimbula.*

The overall objective of the Stage 2 project was to identify and outline areas of 'high hazard' resulting from potential major tsunami events along the NSW coastline. This will allow for an improved understanding of the tsunami risk to the NSW coastline, enabling future consideration of tsunami impacts in coastal zone management and planning and assist in the development of tsunami emergency planning, response and community education. Furthermore this study has attempted to expand the current understanding of nearshore tsunami behaviour, specifically how it is affected by variables such as source zone location, initial rupture magnitude as well as the impact of coastline types.

…….. this assessment only considers tsunami generated by earthquakes along subduction zones. This is in keeping with the findings of the Stage 1 Assessment, which found that subduction zone earthquakes are the most likely source of significant tsunami to the NSW coastline.

Inundation modelling was completed using the Delft3D hydrodynamic modelling system, which has been extensively used and tested to model tsunami events worldwide.

…. to overcome the lack of site-specific field data of overland inundation a series of 'benchmark' events were assessed in order to validate the Delft3D model. Referred to as 'benchmark verification' this process provides confidence that the numerical scheme and model setup utilised performs to an industry standard.

In both the benchmark verification and site-specific verification, the Delft3D models were shown to perform well and with a suitable level of accuracy to be applied to the NSW Tsunami Risk Assessment. …….

Five individual models were established for each of the study sites. The extent and size of the individual study area grids vary depending on site specific features such as landforms (headlands and embayments) and the topographic lie of the land.

In total, 24 scenarios were assessed for each study site and detailed output from the inundation modelling ……

The nature of the inundation at each study site is dependent on the topography of nearshore and foreshore areas, however a qualitative assessment of the model outputs suggests that the threshold for significant inundation is between the 1000 and 2000-years ARI levels for four of the study sites, while for Manly this threshold is between the 500 and 1000-years ARI levels. ….

Tsunami Run-up Factors

Run-up factors calculated from the Stage 2 modelling ranged between 1.0 and 1.7 (wave height at 20m depth / maximum run-up height see Appendix C). …….

Tsunami Run-up Level

As can be seen from the inundation and hazard mapping (Section 8), the spatial distribution of peak run-up level and the extent of tsunami inundation are highly dependent on local topographic features. A simple measure of the run-up level can be made using the maximum run-up level at a given site. Figure 9.7 presents the maximum run-up level (envelope result at each ARI level) against the maximum near shore crest level (wave height plus tide level at the 5m water depth). The correlation shows a predominantly linear response, which suggests that the influence of coastline/embayment shape (which is distinct for each site) is not a dominant factor in ultimate run-up levels over complex low-lying foreshore areas. Furthermore, the magnitude of maximum run-up is comparable to the magnitude of tsunami wave crest, albeit around 10-30% larger. However, the use of the maximum run-up level would significantly overestimate the total area of inundation (it being an isolated peak level); therefore tsunami ***wave crest levels at 5m water depth, being more representative of average run-up levels*** *across the study areas, are deemed appropriate for estimating tsunami run-up levels and hence the exposure at a given site.*

Count of Cadastral Lots Subject to Inundation

The estimation of cadastral lots subject to inundation using the revised-broad based assessment is provided in Appendix E (see **Table 3**)*. To assess the reliability of the revised broad-based approach, the resulting number of lots affected by inundation can be compared to the total number identified by the detailed inundation modelling and hazard mapping (as summarised in Table 9.1). This comparison is presented in Table 9.4 at the 2000- years ARI level, considered an appropriate level to identify particularly vulnerable sites based on inundation thresholds at each of the Stage 2 study sites.*

Table 3 Tsunami Vulnerability Calculations (after Table E.1, Cardno, 2013)

Suburb	Swansea	Manly	Kurnell	Cronulla	Wollonong	Pt Kembla	Merimbula	Pambula
Postcode	2281	2095	2231	2230	2500	2505	2548	2549
Stage 2 Site	LMQ	MLY	BBY	BBY	WPK	WPK	MBA	MBA
Continental Slope (100m to 5m depth)	0.005482	0.008218	0.010428	0.010428	0.006547	0.006547	0.004614	0.004614
Total Cadastral Lots below 5mMSL	1798	781	977	340	613	97	320	26
ARI (yrs)	Tsu-DAT Wave Height @ 100m water depth (m)							
200	0.40	0.37	0.39	0.39	0.32	0.32	0.32	0.32
500	0.64	0.50	0.57	0.57	0.59	0.59	0.57	0.57
1000	0.88	0.76	0.81	0.81	0.83	0.83	0.70	0.70
2000	1.08	1.03	1.12	1.12	1.02	1.02	0.99	0.99
5000	1.55	1.38	1.49	1.49	1.51	1.51	1.48	1.48
10000	1.85	1.74	1.94	1.94	1.91	1.91	1.97	1.97
ARI (yrs)	Estimated Wave Height (m) @ 5m Water depth							
200	1.62	1.14	1.02	1.02	1.18	1.18	1.51	1.51
500	2.48	1.49	1.41	1.41	2.00	2.00	2.52	2.52
1000	3.32	2.15	1.91	1.91	2.73	2.73	3.05	3.05
2000	4.03	2.84	2.57	2.57	3.33	3.33	4.23	4.23
5000	5.69	3.74	3.35	3.35	4.84	4.84	6.22	6.22
10000	6.75	4.66	4.31	4.31	6.07	6.07	8.21	8.21
ARI (yrs)	Estimated Wave Crest Level (mMSL) @ 5m Water depth (≈ mean run-up height mMSL)							
200	2.72	2.24	2.12	2.12	2.28	2.28	2.61	2.61
500	3.58	2.59	2.51	2.51	3.10	3.10	3.62	3.62
1000	4.42	3.25	3.01	3.01	3.83	3.83	4.15	4.15
2000	5.13	3.94	3.67	3.67	4.43	4.43	5.33	5.33
5000	6.79	4.84	4.45	4.45	5.94	5.94	7.32	7.32
10000	7.85	5.76	5.41	5.41	7.17	7.17	9.31	9.31
ARI (yrs)	Estimated % of Properties below 5mMSL Affected by Inundation							
200	54%	45%	42%	42%	46%	46%	52%	52%
500	72%	52%	50%	50%	62%	62%	72%	72%
1000	88%	65%	60%	60%	77%	77%	83%	83%
2000	103%	79%	73%	73%	89%	89%	107%	107%
5000	136%	97%	89%	89%	119%	119%	146%	146%
10000	157%	115%	108%	108%	143%	143%	186%	186%
ARI (yrs)	Estimated Lots Affected by Inundation							
200	1268	245	289	132	196	31	122	9
500	1671	283	343	157	266	42	170	13
1000	2063	356	412	188	329	52	195	15
2000	2391	431	502	229	381	60	250	19
5000	3168	529	609	278	510	81	343	27
10000	3664	630	740	338	615	97	437	34

4 Flood Protection Measures

This section discusses the flood protection measures incorporated into the development.

4.1 Protection Measures

The strategy which is proposed to meet the intent of Council's flood planning level is to protect the ground floor of the existing building up to the flood planning level by a combination of:

- installing flood walls within the landscape areas with openings for access as needed. These walls to be tied into existing walls which do not have any openings which would permit the ingress of floodwaters up to the flood planning level; and
- installing flood barriers across access openings as appropriate; and
- installing flood doors on any external doors which are not otherwise protected.

The proposed flood doors are external doors. These doors open outwards so that when floodwaters reach these doors the external water pressure presses the doors into the door seals to provide a watertight barrier. These doors are self-closing and would be closed. These doors would be opened only by residents or staff when entering or leaving the building.

There are three doors which are identified as flood doors, but also identified as requiring "automatic door openers to meet AS 1428.1 requirements". One available approach is to operate these doors with push to open buttons on the doors. In the event of an electrical failure the intent is these doors automatically close and do not get stuck open. A further consideration would be installing a sensor such that when floodwaters reach the flood doors that any system for electrically opening the doors is disabled so that the flood doors achieve their intended purpose.

An alternative to flood doors might be to install flood barriers to exclude flood waters entering the ground floor. A 0.7 m high flood barrier would protect any entry up to and including the Flood Planning Level (FPL).

4.2 Potential Failure of Protection Measures

The proposed mitigating measures will be constructed to appropriate standards and are not intended to fail. This is the same as all engineered structures, that while there always remains the possibility of failure, are designed to avoid intolerable risks. The fact that the complex will be managed by a CHP provides greater assurance that the structures will be maintained to appropriate standards.

A flood door would only fail to operate if the door was physically blocked from self closing. One of the responsibilities for the flood warden(s) will be to confirm that all flood doors are fully closed at the time that any evacuation of the Ground Floor is initiated ie. prior to floodwaters reaching the Ground Floor.

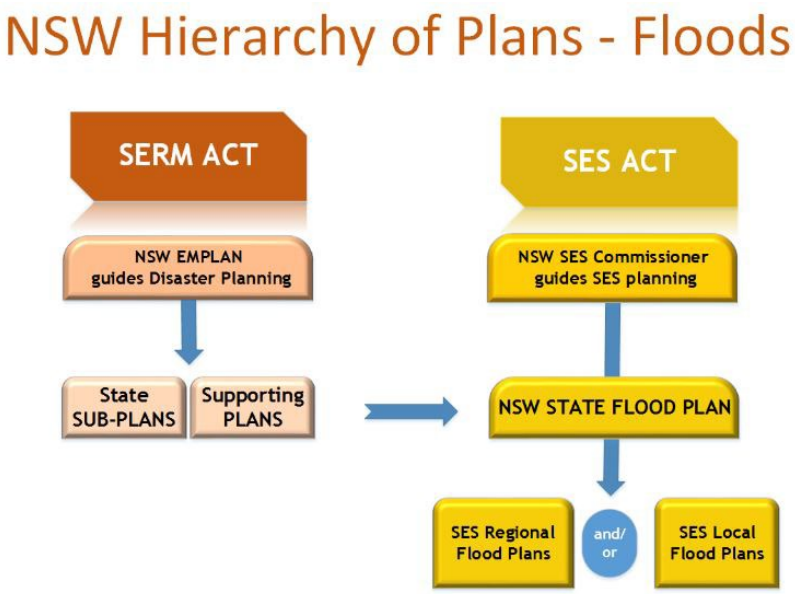
If the flood door seals are in need of maintenance then any "failure" would result in leaks around the door seal that would very slowly inundate the ground floor. Given that any evacuation of any remaining residents on the Ground Floor will have already commenced prior floodwaters reaching the door sill any failure would have minimal impact on the evacuation of Ground Floor residents.

During the detailed design stage an assessment will be undertaken of the vulnerability of any flood doors to damage by floating debris. If a door is assessed to be vulnerable in events where floodwaters rise up to the FPL then measures would be identified to protect any vulnerable flood door eg. bollards. Once floodwaters rise above the FPL it is intended that the ground floor be inundated so any "failure" of a flood door is a non-issue in extreme floods.

5 Emergency Planning

5.1 Flooding

The hierarchy of plans which guide the planning for floods in NSW is as follows:



5.1.1 2017 NSW State Flood Plan

The NSW State Flood Plan is a sub plan of the State Emergency Management Plan (EMPLAN) (NSW Government, 2017). It has been prepared in accordance with the provisions of the State Emergency Service Act 1989 (NSW) and is authorised by the State Emergency Management Committee in accordance with the provisions of the State Emergency and Rescue Management Act 1989 (NSW).

The latest plan was provisionally endorsed by the State Emergency Management Committee at Meeting 107 held on 5 December 2017.

The purpose of this plan is to set out the arrangements for the emergency management of flooding in New South Wales

As described by the Plan:

> *The Plan sets out the emergency management aspects of prevention; preparation; response and initial recovery arrangements for flooding and the responsibilities of individuals, agencies and organisations with regards to these functions.*
>
> *The Plan recognises the existence of the problem of coastal inundation and erosion caused by severe weather. The management system for dealing with episodes of coastal erosion is described in the New South Wales State Storm Plan.*
>
> *The Plan recognises the existence of the threat posed by tsunami to NSW coastal communities. The arrangements for the emergency management of tsunami are contained within the State Tsunami Emergency Sub Plan.*

This Plan is intended to be read in conjunction with:

(a) The New South Wales State Emergency Management Plan (EMPLAN), of which the State Flood Sub Plan is a sub-plan;
(b) The New South Wales State Storm Plan, which covers arrangements relating to severe storm events; and
(c) NSW Floodplain Development Manual.

5.1.2 North West Metropolitan District Disaster Plan

On 27th June 2012 the Interim Version of the "North West Metropolitan District Disaster Plan (Displan)" was endorsed by Chairman, State Emergency Management Committee, The Displan was prepared by the North West Metropolitan District Emergency Management Committee in compliance with Section 23 (1) of the State Emergency and Rescue Management Act, 1989, (as amended). The Northern Beaches LGA is one of the LGAs covered by this plan.

The Plan details emergency preparedness, response and recovery arrangements for the North West Metropolitan Emergency Management District, Local Emergency Management Areas and local government. It recognises that many of the details contained in the plan are similar to those contained in Local Plans and therefore this Plan may be utilised and applied at a local level in conjunction with a Local Displan.

The Plan's aim is to ensure a controlled response to emergencies by all agencies having responsibilities and functions in emergencies, (Section 12 (2) of the SERM Act), and it reflects and applies in conjunction with arrangements agreed to at State level and detailed in the State Disaster Plan

5.1.3 Northern Beaches Local Emergency Management Plan

As described by WMAwater, 2018 in Section 9.3.2:

> *The Manly Lagoon catchment is covered by the Northern Beaches Local Emergency Management Plan (EMPLAN) July 2017. The plan covers and details arrangements for the prevention, preparation, response and recovery for emergencies within the area. Major arterial roads within the catchment include:*
>
> - *Warringah Road;*
> - *Pittwater Road;*
> - *Condamine Street;*
> - *Burnt Bridge Creek deviation;*
> - *Wakehurst Parkway (which is noted to close often due to flooding);*
> - *Sydney Road; and*
> - *Manly Road.*

5.1.4 Local Flood Plan

The EMPLAN identifies that the combat agency for flooding is the NSW SES, however there is currently no Local Flood Plan for the area, although this is currently being drafted (WMAwater, 2018).

5.2 Tsunami

The NSW State Tsunami Plan is a sub plan of the State Emergency Management Plan (EMPLAN) (NSW Government, 2017). It has been prepared in accordance with the provisions of the State Emergency Service Act 1989 (NSW) and is authorised by the State Emergency Management Committee in accordance with the provisions of the State Emergency and Rescue Management Act 1989 (NSW).

The latest plan was endorsed by the State Emergency Management Committee on 18 September 2018.

The purpose of this plan is to set out the state wide multi-agency arrangements for the emergency management of tsunamis in New South Wales including Lord Howe Island.

As described by the Plan:

> *This plan sets out the state wide emergency management arrangements for prevention, preparation, response and initial recovery arrangements for tsunami activity at the strategic level. The plan accounts for all tsunami magnitudes and generation mechanisms.*
>
> *In this plan, a 'tsunami' is defined as a series of ocean waves generated by a sudden displacement of large volumes of water of sufficient severity to threaten lives and cause damage to property, vehicles, infrastructure, vegetation and the coastal environment.*
>
> *This plan recognises that agencies have responsibilities during emergencies allocated under the NSW State EMPLAN or other Sub or supporting plans to the NSW State EMPLAN. This plan does not duplicate those responsibilities or roles but does refer to them. ……*
>
> *Supplementary material published in previous versions of the State Tsunami Plan is now available on the NSW SES website at: https://www.ses.nsw.gov.au/about-us/flood-storm-and-tsunami-plans/.*
>
> *Supplementary documents include:*
>
> a. *The Tsunami Hazard and Risk in NSW*
> b. *Tsunami Warning Arrangements*
>
> *Further information on tsunami hazard and warning is located on the following websites:*
>
> a. *Australian Institute for Disaster Relief (AIDR) https://knowledge.aidr.org.au/resources/tsunami-planning-handbook/*
> b. *Joint Australian Tsunami Warning Centre (JATWC) http://www.bom.gov.au/tsunami/*
> c. *NSW SES https://www.ses.nsw.gov.au/disaster-tabs-header/tsunami/*

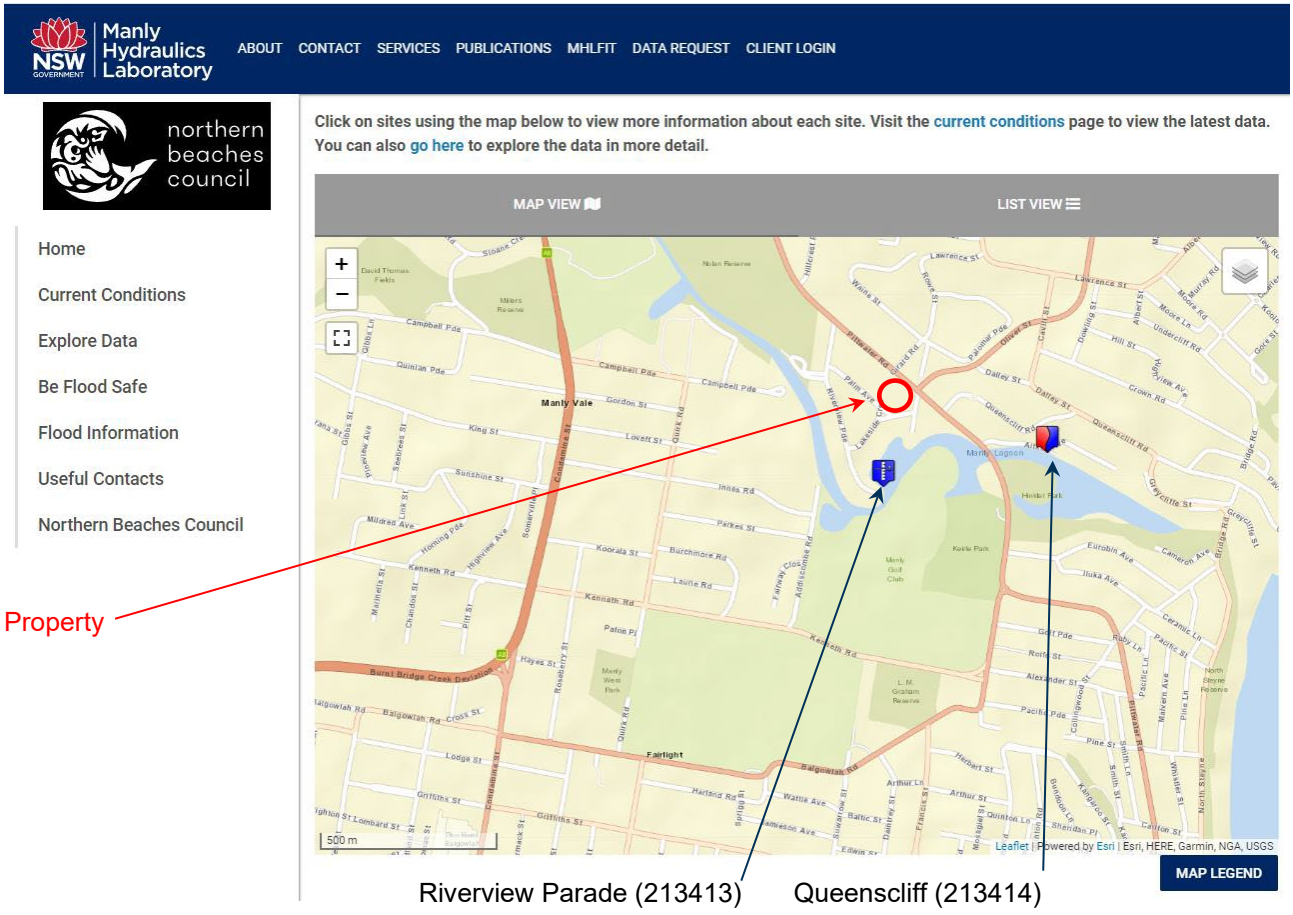
6 Flood Warning

6.1 Northern Beaches Flash Flooding Warning System

As described in Section 9.3.2 RM02: Flood Warning and Emergency Response Strategies in WMAwater, 2018:

> *… The Manly Lagoon catchment is already covered by the Northern Beaches Flash Flooding Warning System (Reference 6). This system provides live, publicly available data on the rainfall and stream gauges situated in the Northern Beaches area.*
>
> *The aim is to provide a basic flash flood warning system to the community, through live publishing of rainfall and water level gauges. ……*
>
> *As well as publishing live and historical gauge information the website provides some emergency planning information. Current advice is to watch out for 70mm rainfall in 3 hours and/or 150mm rainfall in 24 hours and states that "when flash flooding is likely, leave low-lying homes and businesses well before any flooding begins. Evacuation is the best action to take, but only if it is safe to do so".*
>
> *The current gauges located within the Manly Lagoon catchment are:*
> - *Manly Lagoon at Queenscliff;*
> - *Manly Lagoon at Riverview Parade.*

The Northern Beaches Flash Flood Warning System can be accessed at: https://www.mhl.nsw.gov.au/users/NorthernBeaches/. The Home page is as follows:



The gauge details are as follows:

Riverview Parade	
Station No.	213413
Location	-33.7840, 151.2773
Description	Manly Lagoon at Riverview Parade
Datum	Australian Height Datum
Ownership	Northern Beaches Council
Active Sensors	Level
Data Availability	16/03/2019 - 10/10/2021

Queenscliff	
Station No.	213414
Location	-33.7832, 151.2823
Description	Manly Lagoon at Queenscliff
Datum	Australian Height Datum
Ownership	Northern Beaches Council
Active Sensors	Level, Rain
Data Availability	07/09/1990 - 10/10/2021

6.2 Flood Warning System for 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

As advised by Northern Beaches Council at https://www.mhl.nsw.gov.au/users/NorthernBeaches-FloodInformation

Several factors contribute to flash flooding on the northern beaches. The two key elements are rainfall intensity and duration. Intensity is the rate of rainfall, and duration is how long the rain lasts. Rainfall amounts provide an indication of the likelihood of flooding.

6.2.1 Primary Warning System

It is proposed that the Northern Beaches Flash Flood Warning System be the primary warning system. It can be accessed at: https://www.mhl.nsw.gov.au/users/NorthernBeaches/.

As advised by Northern Beaches Council, the Flood Warden or his/her designated representative(s) need to monitor rainfall and levels in Manly lagoon.

Forecast rainfall of 70 mm or more in 3 hours or 150 mm in 24 hours is a trigger to monitor the water levels at the:

- Riverview Parade gauge (213413); and
- Queenscliff (213414)

This information is accessed through the Current Conditions tab at:
https://www.mhl.nsw.gov.au/users/NorthernBeaches-Conditions

This information can be also accessed through the Explore Data tab at:
https://www.mhl.nsw.gov.au/users/NorthernBeaches-Data

Under this tab the user needs to zoom into the Manly Lagoon and to select the Riverview Parade gauge and the Queenscliff gauges separately.

If the water level at the gauge reach:

(i) 2.0 m (AHD) then it is unsafe for small vehicles to attempt to drive through the flooded low point in Lakeside Crescent (Location L4 – Figure 7);

(ii) 2.1 m (AHD) then it is unsafe for large 4WD vehicles to attempt to drive through the flooded low point in Lakeside Crescent (Location L4 – Figure 7);

(iii) 2.2 m (AHD) on the gauges then it is unsafe for small vehicles on Pittwater Road (Locations P1 and P2 – Figure 7);

(iv) 2.4 m (AHD) on the gauges then it is unsafe for large 4WD vehicles on Pittwater Road (Locations P1 and P2 – Figure 7);

(v) When the water level at the gauge reach 2.4 m (AHD) then residents and any visitors on the ground floor are to be warned that they may need to evacuate to Level 1;

(vi) If the water level at the gauge reaches 3.0 m (AHD) then evacuation of residents and any visitors on the ground floor to Level 1 is to commence;

(vii) The indicative time available to evacuate residents and any visitors on the ground floor to Level 1 is expected to be around the same time it takes for water levels at the gauges to rise from 2.4 m to 3.0 m.

It should be noted that if the gauge level reaches 2.4 m this may be an indicator of a 10% AEP flood only and the water levels at the gauges may not reach 3.0 m. If the water level continues to rise at the gauges and reaches 3.0 m AHD, then this is the trigger for evacuation. If this increase occurs over 10 mins – 20 mins then this is an indicator of an extreme flood and there is a need for prompt action.

It should be also noted that floodwaters could rise above 3.0 m AHD but not overtop the flood protection measures at a level of 3.66 m AHD. While under these circumstances residents and visitors on the Ground Floor would be protected it remains safer to retreat to the flood refuge on Level 1 until floodwaters drop below the ground floor level.

6.2.2 Secondary Warning System

A secondary warning system will be to visually monitor the progressive inundation of the main entry ramp.

This secondary system is proposed to respond to two possible scenarios, namely:

(i) the two gauges continue to operate but communication with both gauge is lost and it is not possible to access water level readings at the gauges; or
(ii) the Northern Beaches Flash Flood Warning System website is not accessible and it is not possible to monitor water levels at the gauges.

It is proposed that a marker be installed beside the ramp or a visible mark is included in the ramp which indicates a level of 2.4 m AHD. An indicative location is identified in **Figure 17.**

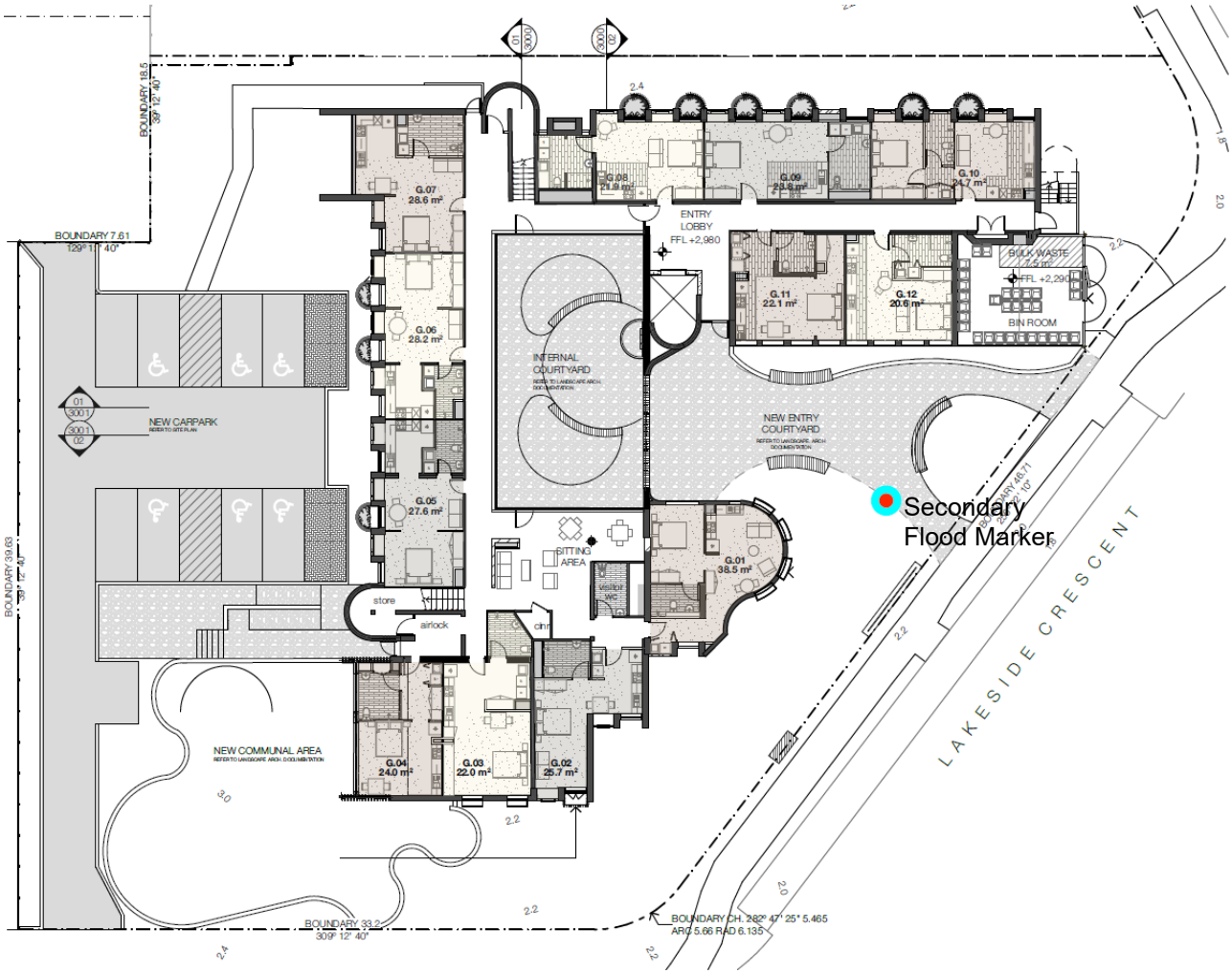


Figure 17 Indicative Location of Secondary Flood Marker

It is proposed that water levels be monitored visually from any location within the building that has a clear view of the main entry ramp and the marker as follows:

(i) If floodwaters are observed in the vicinity of the property and these floodwaters reach the level of the marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to be warned that they may need to evacuate to Level 1;

(ii) If floodwaters continue to rise and reach the level of the top of the ramp ie. around 2.9 m AHD), then evacuation of residents and any visitors on the ground floor to Level 1 is to commence;

(iii) The indicative time available to evacuate residents and any visitors on the ground floor to Level 1 is expected to be around the same time it takes for water levels at the gauges to rise from 2.4 m to 3.0 m.

6.2.3 Summary

In summary, the actions are:

- When rainfall of 70 mm or more in 3 hours or 150 mm in 24 hours is forecast the this is a trigger to monitor the water levels at the Riverview Parade and Queenscliff gauges:
- Commence monitoring the water level and the rate of rise of the water level at the at the Riverview Parade and Queenscliff gauges;
- Also monitor any flooding of Lakeside Crescent;
- If the water level at the gauges reaches 2.4 m (or if floodwaters reach the marker beside the main entry ramp), then warn ground floor residents and any visitors of possible need to evacuate to Level 1 and prepare to implement actions listed in the FloodSafe Plan,
- Continue to monitor the gauges and the main entry ramp and check if the water levels at the gauges and/or on the entry ramp are rising consistently; and
- When the water level at the gauge reaches 3.0 m (or if floodwaters reach the level of the top of the main entry ramp), then commence the evacuation of residents and any visitors from the ground floor to Level 1.

6.3 Other Sources

An important indication of likely imminent flood activity would be intense local rainfall. As well as monitoring the Northern Beaches Flash Flood Warning System website other sources of flood information are as follows.

6.3.1 The Bureau of Meteorology

The Bureau of Meteorology does not prepare flood predictions for the Manly Lagoon, but does issue Severe Thunderstorm Warnings and Severe Weather Warnings for Sydney.

Severe Thunderstorm Warnings are issued together with maps indicating the current location and predicted path of thunderstorms. Severe Weather Warnings are for severe weather not related to thunderstorms, cyclones or fire, such as “east coast lows” or other causes of intense rainfall or storm surge.

These warnings are available at:
http://www.bom.gov.au/nsw/warnings/.

BoM also provides real time rain radar coverage for Sydney at:
http://www.bom.gov.au/products/IDR713.loop.shtml.

6.3.2 The NSW SES

The local SES unit is Manly.

The NSW SES operates a Facebook page for informing members of the public at: (https://www.facebook.com/NSW.SES)

The SES issues Local Flood Advices. These are issued on the basis of localised valley watch information for locations for which the BoM does not issue Flood Warnings. They normally predict which class of flooding (minor, moderate or major) will occur, and must not contradict any Flood Warnings provided by the BoM for other gauges on the same river. Local Flood Advices are to be clearly identified as being issued by the SES.

6.3.3 Local television and radio stations

Local television and radio stations would disseminate warnings from the Bureau of Meteorology, SES and other relevant sources.

7 Tsunami Warning

7.1 Joint Australian Tsunami Warning Centre (JATWC)

As described by the Bureau of Meteorology (BoM) (see **Figure 2**):

> *The Joint Australian Tsunami Warning Centre (JATWC) is operated by the Bureau of Meteorology (Bureau) and Geoscience Australia (GA). Based in Melbourne and Canberra, it has been established so that Australia has an independent capability to detect, monitor, verify and warn the community of the existence of tsunamis in our region and possible threats to Australian coastal locations and offshore territories.*

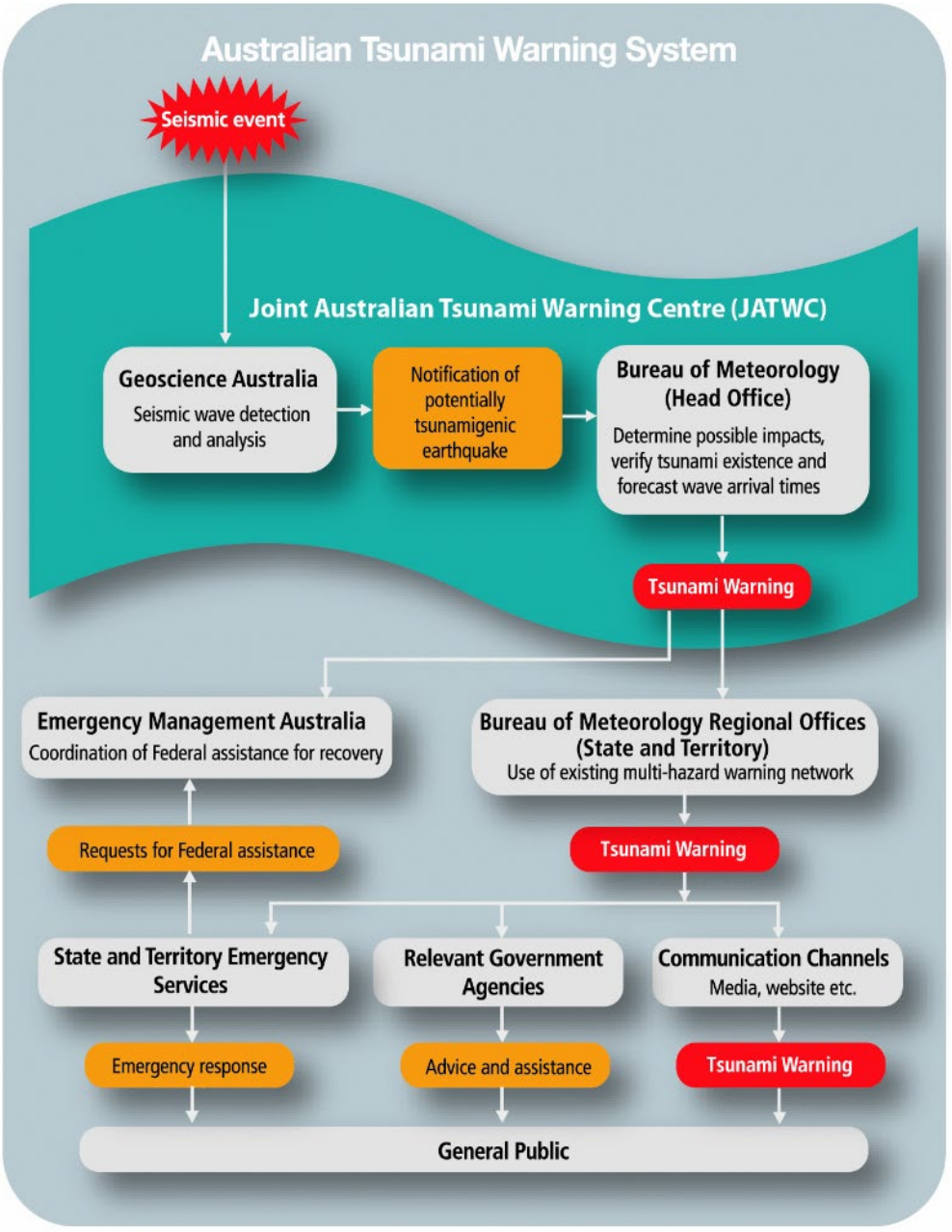


Figure 17 The Australian Tsunami Warning System
Source: [About the Joint Australian Tsunami Warning Centre (bom.gov.au)]

The Bureau and GA use their combined expertise in the relevant science and technology areas including seismic and sea level monitoring and warning systems to provide a 24/7 tsunami monitoring and analysis capacity for Australia. Previously, Australia relied on the Pacific Tsunami Warning Centre (PTWC) and the Japan Meteorological Agency (JMA) for more limited tsunami information to interpret for Australia and feed into the former Australian Tsunami Alert System (ATAS).

The centre boasts world class scientific technology with the expressed aim of providing the longest lead time of any potential tsunami threat. The major objective of the JATWC is to provide emergency managers with a minimum of 90 minutes warning of a likely tsunami impact on mainland Australia. The centre is a long term investment in Australia's security and has the real potential to save lives and infrastructure.

The JATWC was officially launched in 2008 as part of the Australian Tsunami Warning System (ATWS) which replaces the ATAS. The ATWS also has contributions from the Attorney-General's Department through its role in public education, national crisis coordination, and support for State/Territory emergency agencies.

As advised by NSW SES at Be aware of tsunami | NSW State Emergency Service:

Tsunami Watches, Warnings, No Threat Bulletins and Tsunami Watch or Warning Cancellations can be issued in a number of different ways. Warnings may not always be issued using all of these methods.

You should always act early based on the first warning you hear.

The sources of tsunami warning could include:

Radio and television broadcast
Radio and television broadcasts are the most common communication tool to inform the public of a Tsunami Watch or Warning. These may be preceded by the Standard Emergency Warning Signal (SEWS).

Tsunami Warning Siren
If you are on or near a public beach, a siren like warning may be activated by Surf Life Saving NSW or council lifeguards. People in the water, or the immediate foreshore area may be instructed to evacuate and move away from the area.

A text or recorded message on your phone
A text or recorded voice message may be sent to people in the affected area. Once this message has been received, it is then advised that people follow the steps to safety. People should not wait for this message if they have heard it via other sources.

Low flying aircraft equipped with public address systems.
Aircraft with the ability to fly lower than normal may be tasked to disseminate warnings. This would be coordinated by the NSW SES.

Advice may come from other government agencies, emergency services and authorised persons

While the JATWC are the authoritative agency for Tsunami Warnings, local authorities and other government agencies can be a way of issuing advice on tsunami. You should also continue to listen to the radio for further advice and do not return to the evacuation zones until authorities have given the all-clear.

Two-way radio / Marine Satellite Phone

UHF CB, marine VHF radios and where appropriate marine satellite phones may also be used to advise marine users of any warnings.

Internet

All warnings issued by the Joint Australian Tsunami Warning Centre will be placed on the Bureau of Meteorology website. Tsunami Warnings will also appear on the NSW SES website.

Social Media

Warnings issued by the Joint Australian Tsunami Warning Centre will also be shared via NSW SES social media including Facebook and Twitter. Other agencies and local community organisations may also share warnings with their audience as well.

7.2 Tsunami Warning System for 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

7.2.1 Primary Warning System

It is proposed that the Australian Tsunami Warning System be the primary warning system.

All warnings issued by the Joint Australian Tsunami Warning Centre will be placed on the Bureau of Meteorology website. Tsunami Warnings will also appear on the NSW SES website.

7.2.2 Secondary Warning System

A secondary warning system will be to visually monitor any progressive inundation of the main entry ramp.

It is proposed that water levels be monitored visually from any location within the building that has a clear view of the main entry ramp and the flood marker as follows:

(i) If the land-threat tsunami inundation level is forecast to be 3.0 m AHD or lower and inundation is observed in the vicinity of the property and the inundation reaches the level of the flood marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to be warned that they may need to evacuate to Level 1;

(ii) If inundation continues to rise and reaches the level of the top of the ramp ie. around 2.9 m AHD), then evacuation of residents and any visitors on the ground floor to Level 1 is to commence promptly;

(iii) If the land-threat tsunami inundation level is forecast to be higher than 3.0 m AHD and inundation is observed in the vicinity of the property and the inundation reaches the level of the flood marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to promptly evacuate to Level 1.

7.2.3 Summary

In summary, the actions are:

- If a land-threat tsunami warning is issued on the Bureau of Meteorology and/or NSW SES websites then this is a trigger to monitor the water levels in the vicinity of the property;
- Continue to monitor the Bureau of Meteorology and/or NSW SES websites;
- If the land-threat tsunami inundation level is forecast to be up to 3.0 m AHD and inundation is observed in the vicinity of the property and the inundation reaches the level of the flood marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to be warned that they may need to evacuate to Level 1;
- If inundation continues to rise and reaches the level of the top of the ramp ie. around 2.9 m AHD), then evacuation of residents and any visitors on the ground floor to Level 1 is to commence promptly;
- If the land-threat tsunami inundation level is forecast to be higher than 3.0 m AHD and inundation is observed in the vicinity of the property and the inundation reaches the level of the flood marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to promptly evacuate to Level 1.

8 Evacuation

Consideration of the limited warning times in extreme floods led to a decision to adopt a “shelter-in-place” strategy based on relocating any residents and any visitors who do evacuate off-site early from the ground floor to Level 1 in extreme floods or tsunamis which rise above the ground floor level.

8.1 Persons at Risk

The maximum number of persons at risk on the ground floor in a PMF is 24. In a PMF the time weighted Persons at Risk (PAR) on the ground floor is 18.4.

It is estimated that up to 24 persons who would need to retreat from the ground floor to Level 1 when an evacuation is triggered.

The maximum number of persons indirectly at risk on Levels 1-2 in a PMF is 50. In a PMF the time weighted Persons at Risk (PAR) indirectly at risk on Levels 1-2 is 38.5.

8.2 Evacuation versus Shelter-in-Place

As described in Section 9.3.2 RM02: Flood Warning and Emergency Response Strategies in WMAwater, 2018 in part:

> *… Current advice is to watch out for 70mm rainfall in 3 hours and/or 150mm rainfall in 24 hours and states that “when flash flooding is likely, leave low-lying homes and businesses well before any flooding begins. Evacuation is the best action to take, but only if it is safe to do so”.*

Tables 1 and 2 set out the available time from the start of a 1% AEP 9 hour storm burst before it becomes unsafe to evacuate along Palm Avenue, Lakeside Crescent and cross Pittwater Road to Oliver Street.

The conditions become unsafe on Lakeside Crescent more rapidly than on Pittwater Road and would limit to time available to evacuate by car via Lakeside Crescent (Location L4). In short duration extreme floods unsafe conditions can develop rapidly on Pittwater Road (Location P1). In longer duration storms the time available to evacuate by vehicle increases.

Given the limited time available to evacuate after the onset of flooding a designated flood refuge area is included on Level 1 which is above the PMF level. This area can accommodate up to 25 persons from the ground floor based on 2 m^2 per person. The area includes an accessible toilet.

It is proposed that any ground floor residents who do not evacuate off-site early and prior to the onset of flooding in Lakeside Crescent retreat to the designated flood refuge area on Level 1 under conditions where floodwaters rise to around the ground floor level (around 3.0 m AHD). All remaining residents on Levels 1 and Levels 2 should also remain within their self-contained dwellings.

In relation to evacuation of any remaining residents from the Ground Floor to the refuge area on Level 1 at the time of major floods, there is a hierarchy of evacuation methods which will be implemented.

(i) Evacuate by internal lift (vulnerable residents would be given priority)

(ii) If the lifts cease to operate then:

  (a) Able bodied residents walk up the stairs

  (b) vulnerable people for the ground floor to the flood refuge on Level 1 using the installed stair lift

(iii) If the stair lift ceases to operate then flood wardens would manually assist any vulnerable persons on the ground floor up the stairs to Level 1.

9 Response to Floods and Tsunami

9.1 Flood and Tsunami Awareness

The Building Manager and the designated Flood Wardens are to be aware of the flood hazard and tsunami risk and evacuation procedures through a combination of measures.

Evacuation plans detailing the evacuation procedures are to be provided in key locations on the ground floor.

Warning signs may be provided to raise awareness of flooding and tsunami during dry times, but also to alert visitors and staff to the depth of floodwaters and tsunami inundation during extreme events.

Annual evacuation drills will be carried out.

9.2 FloodSafe Plan

A preliminary FloodSafe Plan has been prepared and supplied as **Appendix A**. This preliminary Plan will need to be finalised to include evacuation procedures developed by staff and management prior to occupation.

The FloodSafe Plan will need updating at regular intervals in the future in response to evolving operations and the needs of different resident profiles over time.

The evacuation actions are equally applicable during any tsunami.

9.3 Flood Refuge

It is proposed that the flood refuge be equipped with an emergency kit as well as blankets, towels, kitchenette, storage for medications and a toilet capable of storage in event of sewer backing up.

The emergency kit contents will include:

- Portable radio with spare batteries
- Torch with spare batteries
- First aid kit (with supplies necessary for your household)
- Candles and waterproof matches
- A list of Emergency contact numbers
- Copy of this FTERP
- Waterproof bags for valuables

9.4 Hazardous Materials

Possible hazardous materials that may be stored in the building include:

- Cleaning chemicals

9.5 Critical Infrastructure

The following items have been identified as infrastructure relevant in flood emergencies: electricity, telephone, gas and water.

During significant storms, interruptions may be experienced to electricity and telephone services due to lighting strikes, fallen trees and high winds, which affect the networks.

Water and gas may also become unavailable during severe flood events due to offsite network issues.

Any back-up measures, in the event that there is a disruption to the provision of utilities, should also be documented in the FloodSafe Plan.

Mobile charging from battery source would overcome landline as all landlines are now broadband based and dependant on power ie. susceptible to loss of mains power during events.

It is intended that battery backup for all equipment be provided most likely by trickle charged mains battery system.

9.6 Operations and Responsibilities

Flood Wardens will be present on site and able to co-ordinate emergency response at all times. There will be 3 designated resident Flood Wardens – one for each level of the building, plus the building manager, who is the Chief Flood Warden. An organisational chart is shown in **Figure 18**.

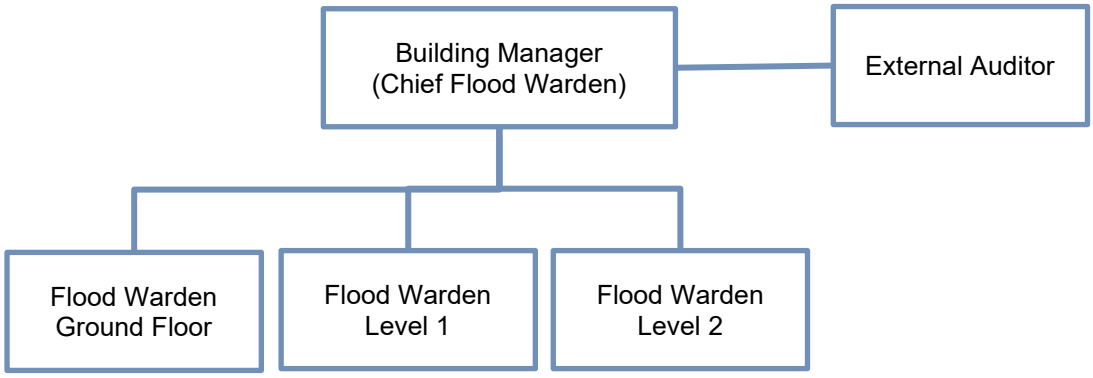


Figure 18 Emergency Response Organisational Chart

Flood Wardens will be inducted and trained by the Chief Flood Warden (building manager) or another suitable person. A training register will be maintained by the building manager with annual audits to ensure that sufficient flood wardens are trained in the procedures. An external auditor will review the documentation to ensure compliance with requirements.

The Flood Wardens will be responsible for inducting new residents to ensure that residents are aware of the flood and tsunami risks and how to respond to flood or tsunami inundation near or on the property.

Notwithstanding warnings and orders given by the SES, police or other authorities, Flood Wardens are responsible for issuing directions and warnings to residents and visitors.

One of the responsibilities for the flood warden(s) will be to confirm that all flood doors are fully closed at the time that any evacuation of the Ground Floor is initiated ie. prior to floodwaters reaching the Ground Floor.

In relation to evacuation of any remaining residents from the Ground Floor to the refuge area on Level 1 at the time of major floods, Flood Wardens will be responsible for implementing the hierarchy of methods to evacuate Ground Floor residents:

(i) Evacuate by internal lift (vulnerable residents would be given priority)

(ii) If the lifts cease to operate then:

(a) Able bodied residents walk up the stairs

(b) vulnerable people for the ground floor to the flood refuge on Level 1 using the installed stair lift

(iii) If the stair lift ceases to operate then Flood Wardens are to manually assist any vulnerable persons on the ground floor up the stairs to Level 1.

A copy of this FERP or (a) future version(s) will be stored on site in hardcopy in a weather proof, easily accessible location that is clearly marked and available to emergency services. Additional copies will be available for staff training and reference in an emergency.

9.6.1 Auditing

A schedule will be implemented to ensure appropriate auditing of the flood protection system.

Evacuation drills will also be required.

9.6.2 Operations & Maintenance

Details on any installed equipment will be included as well as recommended schedules for testing and maintenance of the equipment. The report must clearly delineate responsibilities, timing and tasks to ensure compliance will be readily achieved.

Details on all flood doors and any flood barriers will be appended to this report as well as recommended schedules for testing and maintenance each of the measures as appropriate. The responsibilities for and timing of maintenance to be undertaken in accordance with requirements detailed by suppliers which will be clearly identified.

9.7 Emergency Procedure

9.7.1 Monitoring

Local rainfall and Manly Lagoon water levels can be monitored via the Northern Beaches Flash Flood Warning System website (refer **Section 6.2**).

If a land-threat tsunami warning is issued on the Bureau of Meteorology and/or NSW SES websites then this is a trigger to monitor the water levels in the vicinity of the property and to continue to monitor the Bureau of Meteorology and/or NSW SES websites (refer **Section 7.2**);

9.7.2 Flood Warden Actions

In accordance with the trigger level set out in **Section 6.2 for floods** the following actions must be co-ordinated by the Flood Wardens.

- When rainfall of 70 mm or more in 3 hours or 150 mm in 24 hours is forecast the this is a trigger to monitor the water levels at the Riverview Parade and Queenscliff gauges;
- Commence monitoring the water level and the rate of rise of the water level at the at the Riverview Parade and Queenscliff gauges;
- Also monitor any flooding of Lakeside Crescent;

- If the water level at the gauges reaches 2.4 m (or if floodwaters reach the marker beside the main entry ramp), then warn ground floor residents and any visitors of possible need to evacuate to Level 1 and prepare to implement actions listed in the FloodSafe Plan,
- Continue to monitor the gauges and the main entry ramp and check if the water levels at the gauges and/or on the entry ramp are rising consistently; and
- When the water level at the gauge reaches 3.0 m (or if floodwaters reach the level of the top of the ramp), then commence the evacuation of residents and any visitors from the ground floor to Level 1.

In accordance with the trigger level set out in **Section 7.2** for a tsunami, the following actions must be also co-ordinated by the Flood Wardens.

- If a land-threat tsunami warning is issued on the Bureau of Meteorology and/or NSW SES websites then this is a trigger to monitor the water levels in the vicinity of the property;
- Continue to monitor the Bureau of Meteorology and/or NSW SES websites;
- If the land-threat tsunami inundation level is forecast to be up to 3.0 m AHD and inundation is observed in the vicinity of the property and the inundation reaches the level of the flood marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to be warned that they may need to evacuate to Level 1;
- If inundation continues to rise and reaches the level of the top of the ramp ie. around 2.9 m AHD), then evacuation of residents and any visitors on the ground floor to Level 1 is to commence promptly;
- If the land-threat tsunami inundation level is forecast to be higher than 3.0 m AHD and inundation is observed in the vicinity of the property and the inundation reaches the level of the flood marker (at 2.4 m AHD), then residents and any visitors on the ground floor are to promptly evacuate to Level 1.

9.8 Recovery

The manager, Flood Wardens and State Emergency Service will advise when it is safe to:

- Return to apartments on the ground floor; and/or
- Leave the site.

Re-entry and clean-up of the areas that are inundated is to take account of the storage of any hazardous materials as noted above and/or any surface ponding of water which may be hazardous.

Flood Wardens and if appropriate residents are to:

- Check for damage to windows, walls and be aware of potential contaminants
- Ensure the electricity and gas is turned off before returning to the Ground Floor and if needed use a torch;
- If power points or any electrical equipment have been exposed to floodwater get them inspected by a qualified electrician before use
- Gas appliances and gas bottles exposed to floodwater should also be inspected before use;
- Wear protective clothing including boots and gloves when cleaning up;
- Be aware of any trip or fall hazards;
- Never eat food which has been in contact with floodwater;
- Only use clean utensils, clothes and personal items; and
- Have a supply of bottled drinking water available.

10 References

BMT WBM (2013) “Manly Lagoon Flood Study - Flood Planning Levels”, *Final Report*, R.N2069.006.02_Warringah, prepared for Warringah Council, August, 5 pp.

BMT WBM (2013) “The Manly Lagoon Flood Study”, *Final Report*, R.N2069.005.03, prepared for Warringah Council, August, 114 pp + Apps.

Cardno (2013) “NSW Tsunami Inundation Modelling and Risk Assessment”, *Final Report*, Version 4, prepared for the NSW Office of Environment and Heritage and the NSW SES, August, 62 pp + Apps

WMAwater (2018) ”Manly Lagoon Floodplain Risk Management Study and Plan”, *Final Report,* prepared for Northern Beaches Council, October, 86 pp + Apps.

8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

APPENDIX A
DRAFT FLOODSAFE PLAN

Stantec

FloodSafe Plan for 8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

Potential impacts of flooding on Residents, Staff and any Visitors	Severity level
People's health and safety are compromised	High
Frail and elderly resident evacuation	Very High
Property is damaged or destroyed	High
Cars in open car parking damaged	High
Service provision stopped	Medium-High
Domestic pets health and safety	Medium
Lift wells may be flooded and lifts may stop working	Medium
Paperwork and records are ruined	Low

Triggers for Actions now and always

- Actions that can be done immediately and maintained to reduce the potential impact of flooding are:

Actions

Action	How to do it	Who will do it	What you will need	Estimated time needed	Completed
Inform residents that flooding is a real but small risk	Train flood wardens	Building Manager, Flood Wardens	Training procedures and policies, this plan	1 hour for training	[ ]
Make the FloodSafe Plan and the Flood Emergency Response Plan readily available	Store copies of the FloodSafe Plan Flood Emergency response Plan in locations readily available to the Flood Wardens and manager	Building Manager	Copies of the FloodSafe Plan and the Flood Emergency Response Plan	30 minutes	[ ]
Encourage flood wardens to participate in development & implementation of this plan	Meeting	Building Manager, Flood Wardens	FloodSafe Plan and computer	2 hours	[ ]
Ensure OH&S procedures cover specific risks associated with floods	Management to formulate/update evacuation procedures where necessary	Building Manager	Copies of the FloodSafe Plan and the Flood Emergency Response Plan	2 hours	[ ]
Maintain an up to date list of emergency contact numbers for staff and services	Review contact details	Building Manager	Various updated contact details and maintain data base	30 minutes	[ ]
Train flood wardens in flood procedures	Training session(s)	Building Manager	Copies of the FloodSafe Plan and the FERP	1 hour	[ ]
Incorporate flood awareness in building management and staff induction training	Staff induction manual	Building Manager	Staff induction manual	1 hour	[ ]

Prepare Emergency Kits	Gather items and store in suitable location on-site and accessible.	Building Manager	Emergency kits[1]	2 hours	[ ]
Ensure flood wardens know flood evacuation routes	Staff training and emergency drills	Building Manager	Copy of the FloodSafe plan	2 hours	[ ]
Awareness of which residents will require assistance	Keeping a log of residents that would require assistance	Building Manager	Log contained with the emergency kits	1 hour	[ ]
Action plan for evacuation of these residents if needed	Identify special needs as required	Building Manager	Knowledge of particular needs of residents	2 hours	[ ]
Store backups of important computer files and critical paper records off-site and out of floodplain.	Create computer backups and paper copies of critical documents and store off-site.	Building Manager	Off-site storage location	1 hour	[ ]
Ensure staff know flood evacuation routes	Display plan of evacuation routes	Building Manager	Evacuation plan	30 minutes	[ ]

[1] Emergency kit to contain torch with spare batteries, portable radio with spare batteries, first aid kit, candles, waterproof matches, waterproof bag for valuables and mobile phone, and a copy of the emergency contacts list

Triggers for actions when flooding is likely

- Heavy rainfall
- Forecast rainfall of 70 mm or more in 3 hours or 150 mm in 24 hours
- If the water level at the Riverview Parade gauge or the Queenscliff gauge reaches 2.4 m (AHD) or
- Floodwaters reach the marker at the main entry ramp.
- The Bureau of Meteorology issuing a Flood Watch
- The Bureau of Meteorology issuing a Severe Weather Warning or Severe Thunderstorm Warning indicating a likelihood of flash flooding
- The State Emergency Service issuing a Flood Bulletin

Actions

Action	How to do it	Who will do it	What you will need	Estimated time needed	Completed
Notify flood wardens, residents and any visitors of any warnings	In person and using wardens	Building Manager, Flood Wardens	Flood warden list and Visitor list	30 minutes	[ ]
Prepare for evacuation if the water level at the Riverview Parade gauge or the Queenscliff gauge reaches 2.4 m (or if floodwaters reach the marker beside the main entry ramp)	Undertake actions identified by flood wardens to prepare residents to evacuate to Level 1..	On-Site Manager and flood wardens	Checklist of actions identified by staff to prepare residents for evacuation	Time available varies – see below	[ ]
Keep radio tuned to local radio station, keep in contact with SES and monitor relevant websites	Tune radio to ABC Radio 702 AM; http://www.bom.gov.au/nsw/warnings/ http://www.bom.gov.au/products/IDR713.loop.shtml http://new.mhl.nsw.gov.au/Site-213435	Building Manager	Radio, 3G enabled device and spare batteries	While flooding is likely	[ ]

Triggers for Actions during a Flood
• The water level at the Riverview Parade gauge or the Queenscliff gauge reaches 3.0 m (AHD) or • Floodwaters reach the level of the top of the main entry ramp

Actions					
Action	**How to do it**	**Who will do it**	**What you will need**	**Estimated time needed**	**Completed**
Keep in contact with flood wardens and keep them updated on the situation	Implement contacting strategies using meetings, telephone calls and emails	Building Manager	Radio to obtain up-to-date information and liaison with the SES; computer or 3G device to check websites	Ongoing during event	[ ]
Do not enter flood water or attempt to leave the protected parts of the building	Ensure manager and flood wardens are trained and providing relevant information to any visitors	Building Manager and flood wardens	Latest information and Flood Safe Plan	Ongoing during event	[ ]
Keep radio tuned to local radio station, keep in contact with SES and monitor relevant websites	Tune radio to ABC Local Radio 702 AM; http://www.bom.gov.au/nsw/warnings/ http://www.bom.gov.au/products/IDR713.loop.shtml	Building manager and flood wardens	Radio, spare batteries, phone, computer and 3G mobile device	During event	[ ]
The water level at the Riverview Parade gauge or the Queenscliff gauge reaches 3.0 m (AHD) or floodwaters reach the level of the top of the main entry ramp.	Evacuate residents and any other persons to the Level 1 communal area..	Building Manager and flood wardens	Checklist of actions identified by staff for the orderly evacuation of affected residents	Time available varies – see below	[ ]
Back up important computer files and critical paper records and store these on Level 1 or on Level 2.					[ ]

Triggers for Actions after a Flood
• On-Site Manager or flood wardens issue all clear • The NSW State Emergency Service issuing an all clear

Actions					
Action	**How to do it**	**Who will do it**	**What you will need**	**Estimated time needed**	**Completed**
Before reoccupying the Ground Floor undertake an OH&S risk assessment	Conduct a visual risk assessment of external areas and Ground Floor for structural damage, damage to services, dangerous debris, etc.	Building Manager and Flood Wardens	Advice from SES that we can return and safety equipment that is deemed necessary		[ ]
Communicate with residents and assist them in returning					[ ]
Remove debris and clean, repair and disinfect the Ground Floor as needed	With appropriately skilled personnel	Building Manager to organise			[ ]
Replace lost furniture, floor coverings and fittings as needed					[ ]
If needed replace essential plant, equipment as soon as possible					[ ]
Restore critical records, computer equipment and files					[ ]

Staff Contact List

Name	Number	Mobile	Flood role / issues
Building Manager (Chief Flood Warden)			
Flood Warden 1 (Ground Floor)			
Flood Warden 2 (Level 1)			
Flood Warden 3 (Level 2)			

Emergency Contact List

Name	Number	Mobile
Ambulance	000	
Bureau of Meteorology (for flood warnings)	1300 659 219	
NSW SES	132500	
Fire – Emergency	000	
Police – Emergency	000	
Manly Police Station	(02) 9976 8099	
Sydney Water – Faults	132090	
Gas		
Electricity		
Electrician		
Disaster Welfare Services Assistance Line	1800 018 444	

For emergency help in floods and storms phone the SES on 132500

8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

# APPENDIX B
MANUAL(S)

Stantec

8 Palm Avenue and 2-4 Lakeside Crescent, North Manly

APPENDIX C
FLOOD DOOR DETAILS

Stantec