Appendix F Flood Impact Assessment

RJ Green & Lloyd Pty Limited and Westport Pty Ltd
27 November 2015

Attention: RJ Green & Lloyd Pty Limited and Westport Pty Ltd

Dear Michael,

Re: Flood risk considerations for proposed rezoning at
7-23 and 25-33 Water Street, South Strathfield

Introduction

A rezoning from an industrial land use (IN1) to high density residential land use (R4) is proposed for Nos. 7-23 and 25-33 Water Street, South Strathfield. The site is located within the Strathfield Local Government Area. Information about the proposed development is taken from architectural drawings prepared by Robertson and Marks dated 11/12/15. The Appendix shows the proposed building footprint and a section of the proposed basement car parks.

The site is subject to flooding. This letter report describes flood risks at the site and options for managing this risk.

Information on ground levels and flood behaviour has been supplied by WMAwater. It is understood that the flood modelling includes the latest proposed building footprint.

What standards apply?

Strathfield Local Environmental Plan (LEP) 2012 clause 6.3 is reproduced below. This clause applies because the site is located below the applicable flood planning level (defined as the 100 year ARI flood level plus 0.5m freeboard).

Strathfield Council also has an *Interim Flood Prone Lands Policy* directed at ensuring that residential development in flood prone areas does not adversely impact on overland flow paths and that development is designed to minimise the impact of flooding. The Policy stipulates that habitable floors should be *at least* 500mm above the 1 in 100 year flood level and that non-habitable floors are no lower than the 1 in 100 year flood level. The Policy also describes requirements for garages, swimming pools, tennis courts and fencing.

The *Interim Flood Prone Lands Policy* gives the impression that Strathfield Council directs most attention to managing flood impacts in the 100 year ARI flood. However, Council has indicated that flood assessment reports should comment on flooding up to and including the Probable Maximum Flood (PMF). The LEP does not confine its objective of minimising flood risk to life and property to the 100 year ARI flood. Indeed, the NSW Government's *Floodplain Development Manual* requires that the full range of flood sizes including the PMF be considered in the floodplain risk management process. While a PMF event is very rare, floods considerably rarer than the 100 year ARI event have occurred with tragic consequences (e.g. Lockyer Valley, 2011; Dungog, 2015).

Given this, the following section considers flood behaviour, and ways of managing the flood risk, both for the 100 year ARI event and for the PMF.

6.3 Flood planning

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the *Floodplain Development Manual* (ISBN 0 7347 5476 0)published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

(5) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

Flood behaviour

The site is subject to both local overland flows from the north and mainstream flooding from the Cooks River.

The WMAwater letter includes figures showing the extent, level and depth of flooding for the 100 year ARI event and the PMF. To further understand flood regimes, three cross sections (locations shown in Figure 1) are plotted showing ground level and maximum flood levels (Figures 2 to 4).

Figure 1 – Location of cross sections

Note: proposed building footprints shown using hatched polygons

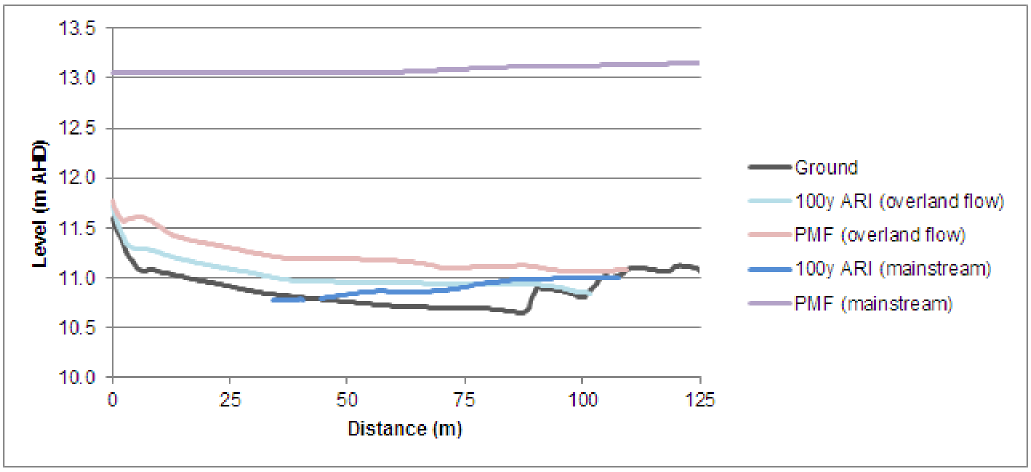

Figure 2 – Cross section 1 (north-south through site)

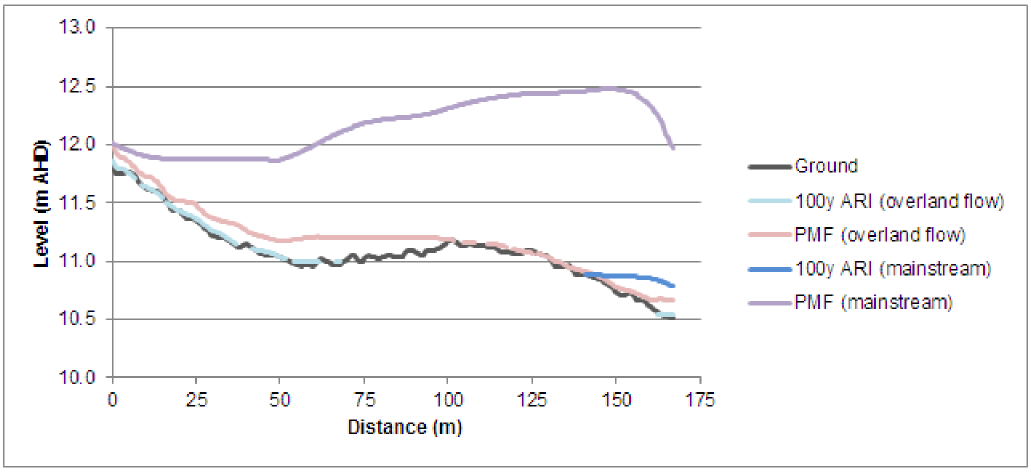

Figure 3 – Cross section 2 (north-south along Water Street)

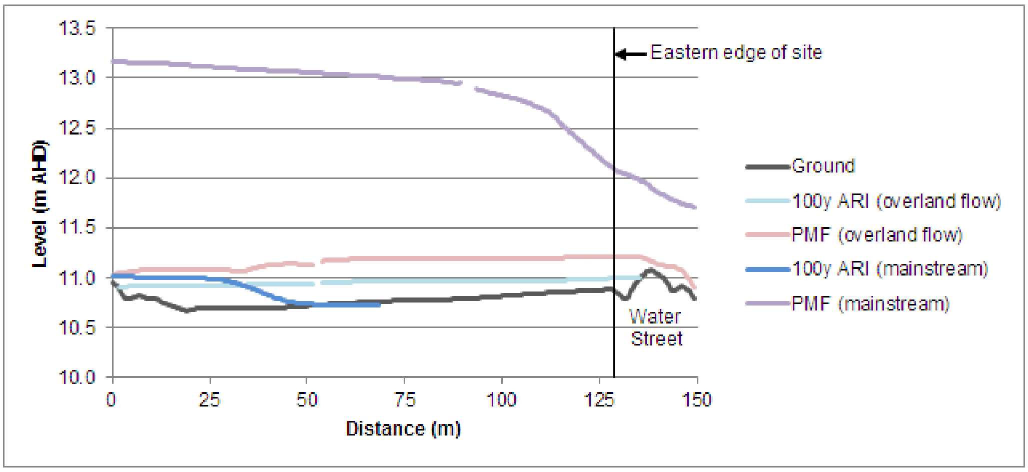

Figure 4 – Cross section 3 (west-east through site)

The maps and cross sections show that flood levels vary across the site. For the 100 year ARI flood, overland flows produce the highest levels in the northern part of the site but mainstream flooding produces the highest levels in the southern part of the site. The mapping shows that overland flows reach up to about 11.8m AHD at the north-eastern corner of the site (see also Figure 3), but 11.0m AHD is a more representative 100 year ARI level for the site as a whole. Flood depths in the 100 year ARI flood are relatively shallow (less than 0.3m) and some areas are not inundated at all. The hydraulic hazard resulting from the combination of depths and velocities is generally low for the 100 year ARI event.

The maximum levels for the PMF are produced by mainstream flooding, with levels reaching almost 13.2m AHD at the western edge of the site, falling to 11.9–12.5m AHD at Water Street on the eastern side (see Figure 4). Depths would be considerable (up to about 2.8m). Velocities would be increased where the flow paths are narrowed between the buildings proposed on the eastern side of the site, reaching about 1.0 m/s near Water Street. Depth-velocity product is modelled to reach about 1.5 m^2/s between buildings 'B' and 'E'.

Figure 5 presents hazard vulnerability curves used for best practice flood risk management in Australia, and Figure 6 maps these categories for the developed site under PMF conditions. A small corner of the site near the Cooks River Bridge is subject to H6 conditions. Much of the site is subject to H5 conditions. A significant proportion is affected by H4 conditions.

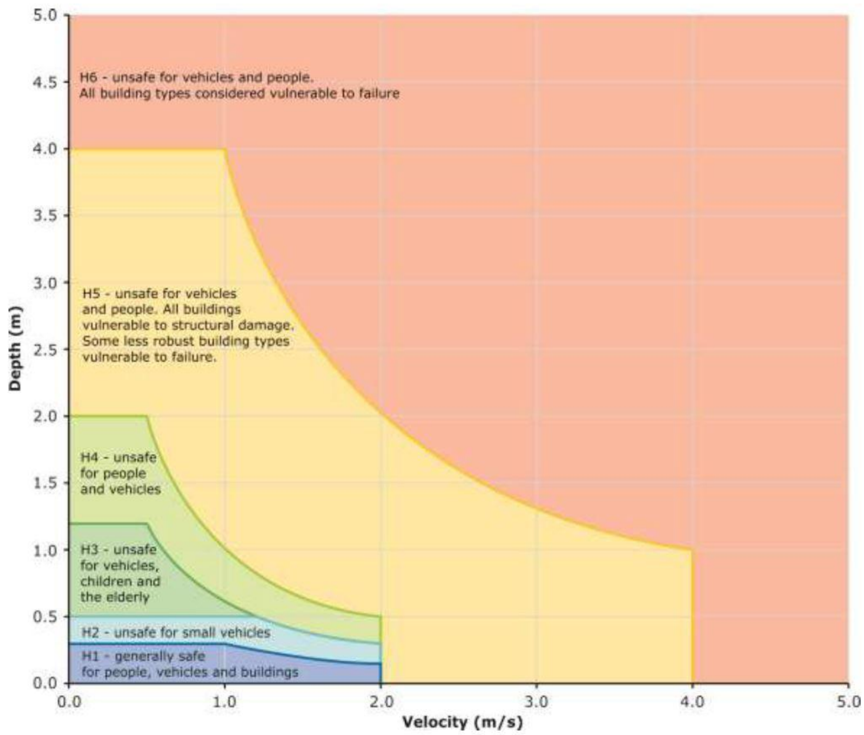

Figure 5 – Flood hazard vulnerability curves

Source: National Flood Risk Advisory Group (2014), *Technical flood risk management guideline: Flood hazard*, Supporting document for the implementation of Australian Emergency Management Handbook 7, Managing the floodplain: Best practice in flood risk management in Australia, Australian Emergency Management Institute.

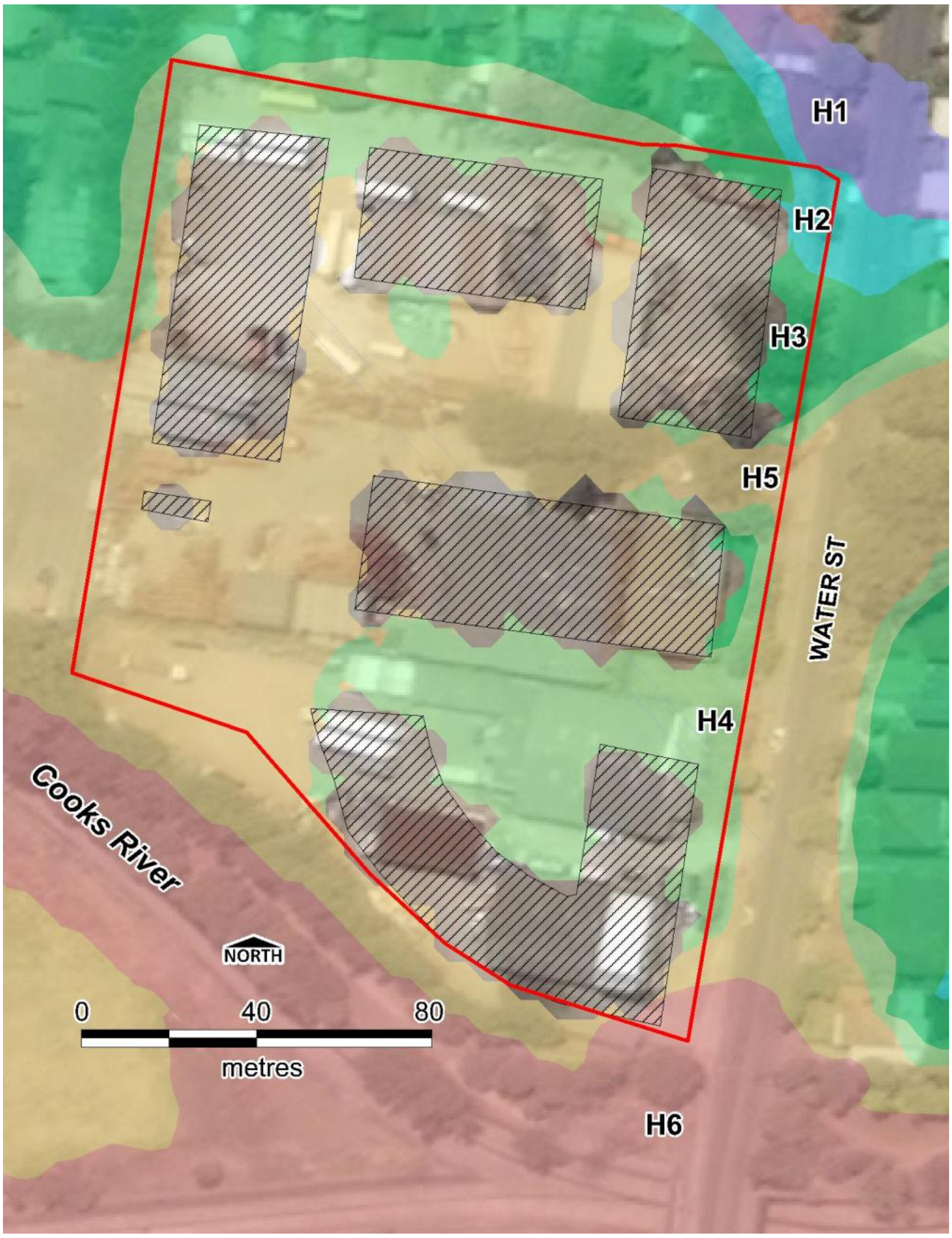

Figure 6 – Flood hazard vulnerability curves for the site under PMF conditions

Note: refer to Figure 5 for definition of hazard categories

Another factor for defining flood behaviour is the rate of rise. Flood hydrographs are presented in Figure 7. The 100 year ARI Cooks River flood takes just one hour to peak from the commencement of the storm. The modelled PMF peaks 1.5 hours after the commencement of rain. But it would begin to inundate the ground at the site after just 25 minutes, and would begin to inundate any units with floor levels at the standard flood planning level (FPL) after just 30 minutes. The rapid rates of rise at the site are indicative of a flash flooding regime, where it is likely there will be insufficient time for people to evacuate the site either in response to flood warnings or to rising water.

Figure 7 also depicts the modelled durations of mainstream flooding. Floodwaters would inundate parts of the site for about 40 minutes in the 100 year ARI event and for a little over 2 hours in the PMF.

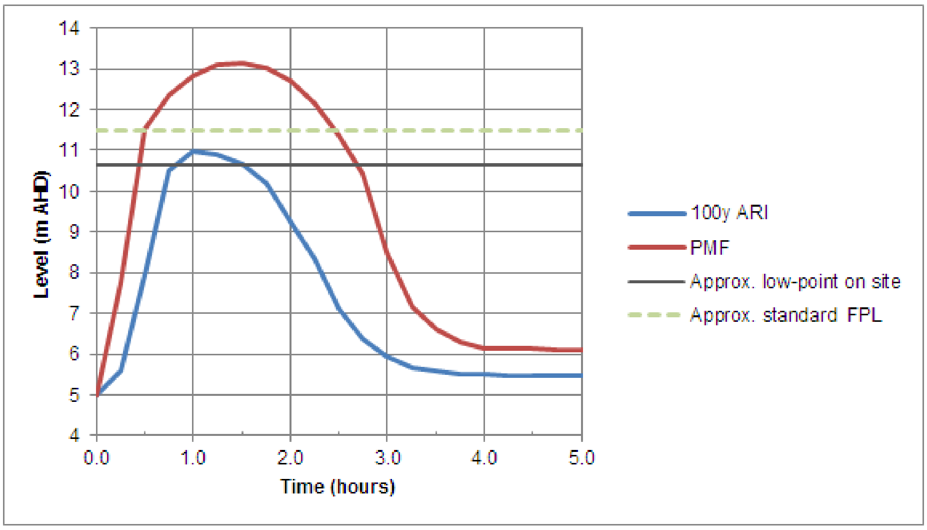

Figure 7 – Mainstream flood hydrographs adjacent to the site

In summary, the 100 year ARI flood, whether from overland flows or surcharging of the Cooks River, presents a relatively low risk to life and property because the depths are relatively shallow. This suggests that more frequent events (e.g. the 20 year ARI event) would present lesser risk still. If as expected building floors and the crest level of the driveways leading to the basement car parks are designed to keep out at least the 100 year ARI flood (plus freeboard), the risk presented by an event of this magnitude (or more frequent, lower floods) would be largely managed. The shallow flooding at the site in this event would fall mostly within the 'H1' category of Figure 5, which points to conditions that are generally safe for people, vehicles and buildings. The depths of inundation also mean that pedestrian movement around the site, or vehicular evacuation from the site to Water Street, are expected to be largely unhindered even taking into account the rapid rate of rise.

It is in rarer floods up to and including the PMF where the risk to life and property may require special consideration to reduce the risks to a tolerable level. The remainder of this letter considers some specific risks and ways in which these risks could be managed.

How can the risk of flooding of units be managed?

The best way of managing the risk of flooding at the home units is to ensure that the buildings are able to structurally withstand PMF inundation and to elevate the habitable floor levels so they are beyond the reach of flooding. The units would need to be *at least* 500mm above the 100 year ARI flood level of about 11.0m AHD to comply with Council's planning policies. But a floor level of 11.5m AHD could still be flooded to a depth of up to 1.7m over floor in a PMF (13.2m AHD). Figure 5 shows that such depths are dangerous for people.

Evacuation off-site is not considered practical for this site because:

- General warnings issued by the Bureau of Meteorology that could provide an indication of potentially flood-producing weather conditions (Flood Watch, Severe Weather Warning, Severe Thunderstorm Warning) would not provide a sustainable basis for evacuating a site;
- No specific flood warnings are issued by the Bureau of Meteorology this far up the Cooks River catchment;[1]
- Even if a local flood warning system is installed using local water level triggers, people tend to resist calls to evacuate before the land around them is obviously flooded.[2] Even if they commenced evacuating prior to the land being flooded, the very rapid rise of floodwaters at this site means that:
  - there would be inadequate time to fully evacuate the site, and
  - they would most likely be exposing themselves to a more dangerous response strategy (going down to ground level to then attempt to evacuate northwards along Water Street).

Evacuating to higher floor levels *within* a unit building is likely to present a safer course of action. This requires that people are alerted to the rising flood in sufficient time to leave their units. A local flood warning system could be developed and maintained. A local trigger level of 10.0m AHD could issue SMS to residents and sound an alarm, which would provide opportunity for residents to observe the rising floodwater[3] and to evacuate upstairs as required. This strategy of sheltering in place could involve a period of isolation during which time the emergency services may find it difficult to service any fire or health emergencies, but these periods of isolation are anticipated to be relatively short (cf. Figure 7).

But relying entirely on an effective operation of a flood warning system and local response plan to mitigate the risk to life in an extreme flood may be unwise. The flood warning system (including technologies for detecting rising water, systems for disseminating warnings, and ongoing education so people know how to respond appropriately) would need to be meticulously maintained by the body corporate/owners corporation. Also, some elderly or disabled residents may have restricted mobility and find difficulty in quickly climbing stairs.

The best way of reducing the risk would be to elevate the floor levels of the lowest set units to the PMF level (up to 13.2m AHD). This, however, may be impractical. It is recommended that the minimum habitable floor levels should be set according to survivable depths in the PMF. Figure 5 shows that depths exceeding 0.5m are considered unsafe for children and the elderly, and that depths exceeding 1.2m are unsafe for all people (both assuming low flow velocities). Making some allowance for the rarity of a PMF, and the opportunity for standing on tables, it is recommended that the minimum floor levels be set to allow flood depths of no more than 0.7m in the PMF, which corresponds to 12.5m AHD at the western edge of the site.[4]

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[1] Manly Hydraulics Laboratory maintains water level recorders for the Cooks River at Canterbury Road, Illawarra Road Bridge and Tempe Bridge. The Bureau of Meteorology does aim to provide 3 hours' warning of heights exceeding 1.3m at Tempe Bridge (NSW State Flood Plan, March 2015).

[2] NSW SES (2003). 'DA's, Flood Risk and Site Specific Evacuation Plans', NSW State Headquarters Wollongong.

[3] In order to see floods at night, adequate lighting of the grounds should be provided.

[4] FFLs would vary for each building depending on the PMF at the site.

How can the risk of the basement car park flooding be managed?

One of the most significant risks for unit developments located within floodplains is flooding of basement car parks. When floodwater gains entry, basement car parks may rapidly become inundated to dangerous depths and people may become trapped. Indeed, some people may put themselves in harm's way in attempt to relocate their vehicles. Seven fatalities from recent flooding in southern France are attributed to this behaviour.[5]

The proposed development has up to four levels of basement car parks, the lowest set at a floor level of -0.5m AHD (see Appendix).

A way of managing this risk would be to raise the driveway crest levels to reduce the frequency of overtopping or, if the crest levels are raised to above the PMF level, to exclude the possibility of overtopping. Even though the PMF level is lower on the eastern side of the site where access to the basement car park is proposed, it may still be impractical to achieve appropriate grades with driveway crest levels at the PMF level. Also, it is noted that the areas proposed for entrances to the basement car park between buildings 'A2' and 'B' and between buildings 'B' and 'E' represent important flow paths in the PMF, so quarantining perhaps one-third of the 18-metre width of these flow paths for elevated and protected driveways would likely raise the PMF flood levels in this area. Nonetheless, if it is practical to extend or realign the driveways to accommodate permissible grades either side of a PMF crest level, this would be a good means of reducing the risk. Another option could be to install flood-proof gates at the highest point on the driveway crest, which are closed automatically when the water level reaches a pre-determined level.

However, another consideration is that in floods that are higher than the floor levels of the lobby area of the buildings, floodwater could potentially gain ingress to the basement car parks through lift wells and staircases. This is why it is desirable to elevate these floor levels as high as is practicable, even to the PMF level. It is important that the level of protection afforded by the design of the driveways is matched by the design of the buildings, and vice versa, since the protection of the basement car parks from floodwater ingress will only be as good as the weakest link.

If the driveway and buildings cannot be designed and built to keep the basement car parks free of inundation for all magnitudes of flooding, various measures will need to be implemented and maintained to mitigate the risk.[6] This includes provision of the following infrastructure:

- an audible and visual alarm system in the basement car parks and in the stairwells below the lobby level,[7] alerting occupants to the need to evacuate, sufficiently prior to likely inundation to allow for safe evacuation; this will likely require the use of automatic water level recorders;
- permanent signage at lifts and stairwell entrances in the basement carparks, indicating that the area is subject to flooding and that people should immediately evacuate up the stairwells in the event of a flood alert; the doors to each stairwell should have no locking mechanism to facilitate this;
- a mechanism for automatically disabling operation of the lifts immediately prior to overtopping of the driveway crest or flooding of the lobby areas of the buildings, to prevent residents unwittingly accessing the basement car parks and encountering rapidly rising floodwaters;

[5] http://www.abc.net.au/news/2015-10-05/french-riviera-flood-victims-drown-in-underground-car-park/6827882

[6] Even if the driveway and buildings are designed to keep basement car parks free of inundation in the PMF, these measures would still provide a sensible redundancy.

[7] The latter is to warn anyone intending to access the car park via stairwells that they should not attempt to do so.

- automatically closing gates at the driveway crests to prevent vehicular entry to the basement car parks during flood events.

How can the risk of flooding for vehicular and pedestrian access be managed?

One of the main dangers in any flood situation is people attempting to drive through floodwater. This is one of the leading causes of flood fatalities in Australia. In the 100 year ARI flood, the depths and velocities on Water Street adjacent to and north of the proposed car park entrances do not appear to present a significant danger to traffic, but this may not be the case for rarer events. Two ways of reducing the risk of inappropriate driving behaviour during floods at the site would be:

- installing automatic gates at the driveway crests to prevent entry to and exit from the basement car parks during flood events;
- installing public signage in Water Street to indicate that the road is subject to flooding and that vehicles should not enter it.

The plans for the development include open space and pedestrian linkages through the site. While it is unlikely that many people would be utilising the outdoors area during the foul weather likely to be occurring when a flood is threatening, permanent signage advising that the area is flood prone and directing people to evacuate upstairs is recommended.[8]

All the options described above involving flood warning systems, the operation of flood gates, etc., would require concerted maintenance by the body corporate, and ongoing education of residents to ensure they understand the flood risk and how to respond (and not to respond).

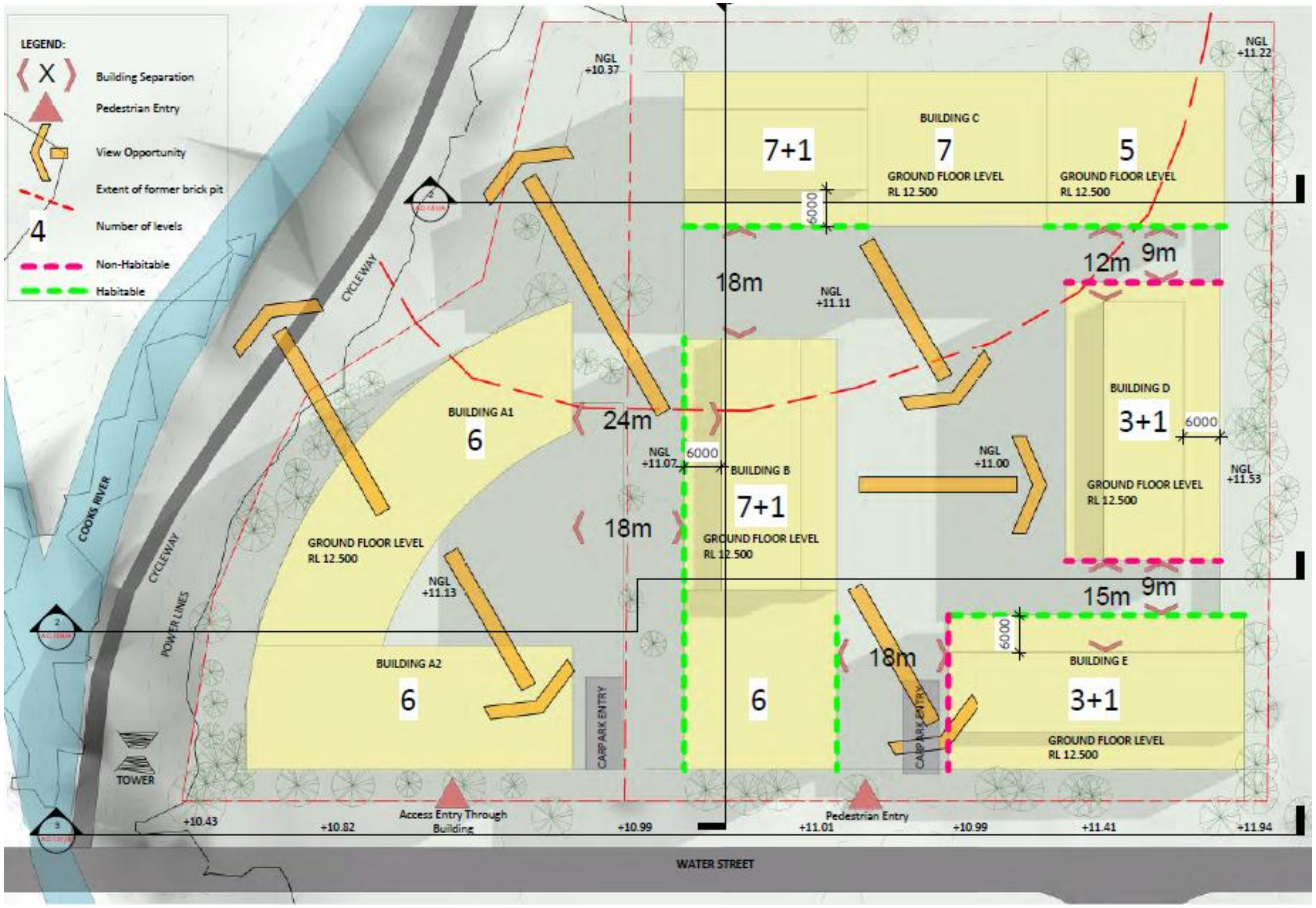
Steve Gray

Dr Stephen Yeo

[8] Although security issues may count against this, consideration should be given to keeping the doors to stairwells off the building lobbies unlocked to enable people caught in floodwaters to quickly escape upstairs.

APPENDIX

Proposed building footprints
(Source: Robertson + Marks, drawing no. AC-101/A, 12/11/2015)



Proposed basement car parks
(Source: Robertson + Marks, drawing no. AC-104/A, 12/11/2015)