MOLINO STEWART
ENVIRONMENT & NATURAL HAZARDS

23/02/2021

Mark Batger
Vice President
Bankstown Golf Club
70 Ashford Ave
Milperra, NSW 2214

Dear Mark,

Flood Evacuation Assessment for Bankstown Golf Club

Background and Scope

The Bankstown Golf Club is proposing to develop a Seniors Living facility on the site of the current Bankstown Golf Club located at 70 Ashford Ave, Milperra. It has submitted a site compatibility certificate application for the site under the State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004. In NSW Department of Planning, Industry and Environment's (DPIE) request for further information regarding the application, it has stated the following:

"While the Flood Planning Level and Permissible Maximum Flood affectations do not preclude the proposed development, it is considered important that these issues be considered and addressed in greater detail to determine the suitability of the site. This is particularly important given the site's location within the floodplain, evacuation requirements and the sensitive nature of its occupants."

To consider these risks in greater detail, Molino Stewart has been commissioned to assess the feasibility of site evacuation given the specific constraints of the development. This constitutes Stage 1 of the work and will be followed by a subsequent Flood Emergency Response Plan (FERP).

The aim of this stage of work is to assess the risk to life from flooding and determine how this risk might be managed. This involves assessing the time and capacity to evacuate in the worst-case scenario. This is represented by a flood rising as fast as the Probable Maximum Flood (PMF) and affecting the site while it is at full capacity. If safe evacuation can be achieved under this scenario, it can be safely achieved in all other circumstances. This is the approach adopted by the NSW SES.

Description of the Proposed Development

The development site is located on the grounds of the existing Bankstown Golf Club at 70 Ashford Avenue, Milperra (Figure 1). The site can be accessed via Ashford Avenue to the east, which is the primary entrance, and Bullecourt Lane to its south. The site of proposed works is approximately 1.6 ha in the southeast corner of the Golf Club property, and there are currently buildings and car parking in this area.

Figure 1. Study site

The proposed plans include the construction of four new main buildings (Figure 2) with a total of 149 retirement living apartments, as well as a new golf club house, a pool, a gym, and other community facilities. The proposed floor levels for the buildings are shown in Table 1. It is expected that the club house and pool will be open for operation from 7am until 8pm, and the Club will have function rooms that may be used for small events. The individual units will be Strata Titled and offered under a 99-year lease.

Table 1. Floor level summary

Building	**Type**	**Number of Storeys**	**Minimum Ground Flood Level (m AHD)**
Building A	22 seniors living apartments, golf club and pro shop	4	6.51
Building B	44 seniors living apartments	6	7.60
Building C	32 seniors living apartments	6	7.60
Building D	51 residential apartments, common rooms, swimming pool and gym	6	7.60

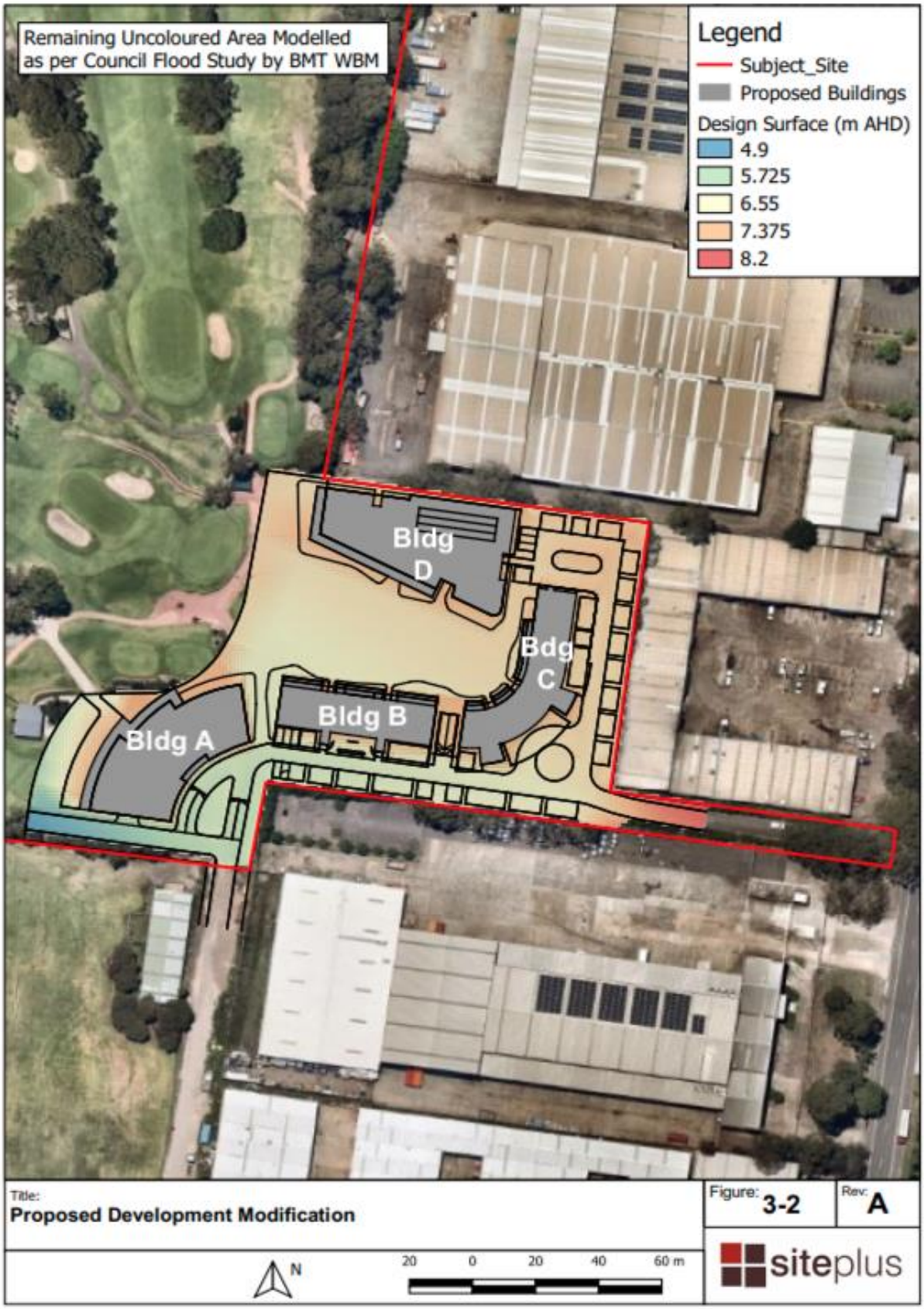


Figure 2. Proposed development design surface (source: Site Plus, 2021)

The approximate maximum numbers of people on site at one time are:

- 298 residents (based on 2 persons per unit)
- 15 staff (including admin and green keeping)
- 50 members and guests in the club house

It is expected that all residents, guests, and staff would have access to their own vehicles. There will be a total of 365 car spaces, 164 of which are associated with the seniors living, and 201 of which are for the club and community facilities. There is both basement and on-grade parking. There will be a Village Manager responsible for general duties, however they will not live on site and there will not be a manager present at the site 24 hours a day.

Description of Flood Behaviour

The site is within the Milperra local stormwater flooding catchment and sits on the floodplain of the Georges River. Flood behaviour from both needs to be considered.

In this assessment, we have drawn on flood information provided in the Site Plus (2021) report prepared for Bankstown Golf Club. The scope of this study included:

- Running the local Milperra Catchment 2D TUFLOW model (BMT WBM, 2015) to assess the current flooding impacts on the site;
- Integrating the proposed development into the Milperra Catchment 2D TUFLOW model to assess the development's impact on future flood behaviour surrounding the site.

The scope of the Site Plus flood study does not include incorporating the proposed design into the Georges River flood model (Bewsher, 2004), only the local Milperra catchment study. This is because the 1% AEP local Milperra catchment flood level is higher than the 1% AEP Georges River flood model, and therefore the former controls what the flood planning level is for the site.

We have additionally obtained Georges River flood information for the site from Canterbury-Bankstown Council, and a Georges River flood hydrograph produced by Cardno (2015) for Anglicare Milperra Village, located adjacent to the Bankstown Golf Club site.

a) Local Milperra Catchment Flooding

Rainfall falling in the local Milperra catchment is carried by underground pipes through the streets into an open drainage network which drains into the Georges River. In the event of very high rainfall the pipe network reaches capacity and the excess flows run across the ground finding the path of least resistance as they flow towards the river.

The Site Plus flood study incorporates the proposed development into Bankstown Council's Milperra Catchment 2D TUFLOW Model (BMT WBM, 2015). It accounts for the changes based on the proposed building materials, pit and pipe network, channels and local topography. It models flows through the site, taking into account the effect that the changes in topography and the presence of buildings will have on those flows.

Appendix F of Council's Milperra Catchment flood study shows the proposed development site being within both medium and low flood risk precincts. The results of the Site Plus flood modelling shows the site being affected by Milperra catchment flooding in the 1% Annual Exceedance Probability (AEP) event and the Probable Maximum Flood (PMF) with the levels shown in Table 2. Based on the Tables 1 and 2, all building floor levels will be above both the 1% AEP flood and PMF levels.

Table 2. Local Milperra catchment flood level summary (source: Site Plus, 2021)

Location on Site	1% AEP Flood Level (m AHD)	PMF Flood Level (m AHD)
Building A and Golf Club	6.01	6.40
Building B	7.06	7.10
Building C	7.10	7.16
Building D	7.10	7.16

In the 1% AEP flood and the PMF, the lowest part of the site which is at 4.9 m AHD (i.e. the loading dock area south of Building A) will experience water depths of up to 1.1 m and 1.4 m respectively. However, this will not impact the ability of people to exit the buildings or site. The golf course grounds will also experience higher flood levels, however the course will become unplayable in flood events much more frequent than the 1% AEP flood, and so there would not be people on the course.

Flood hazard is a measure of the danger posed by flooding. Flood hazard mapping in this report is based on the hazard classification adopted by the Australian Rainfall and Runoff national guideline (Figure 3).

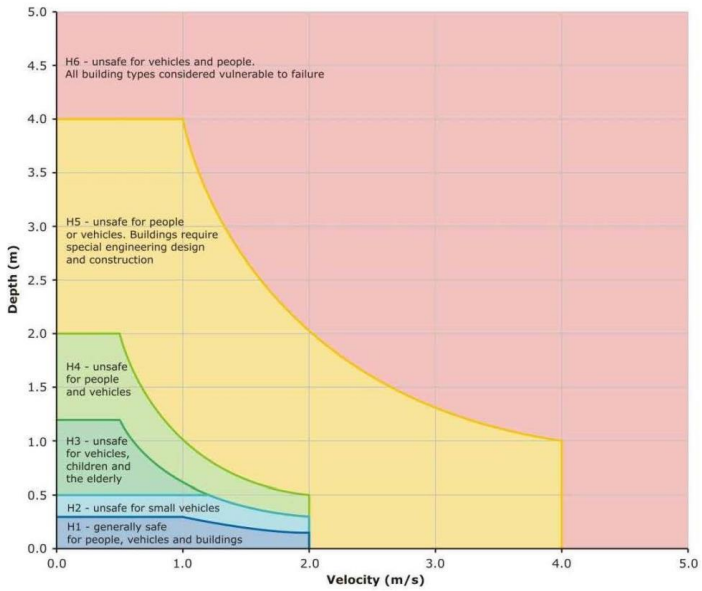


Figure 3. Flood hazard vulnerability curves (source: Smith et al., 2014)

Figure 4 shows that the proposed development experiences minimal flooding in the 1% AEP local Milperra catchment flood, with only low hazard (H1) flood waters around the buildings, which is generally safe for people, vehicles and buildings. In this event, a vehicle exiting the basement car park between Buildings B and C would only have to drive through H1 flood waters to exit the site. While it is not recommended to ever walk or drive through flood waters, there would be no significant risk if this were required. Therefore, local catchment flooding poses a minimal risk to the development in floods up to and more frequent than the 1% AEP flood. In the PMF, H2 flood waters would be adjacent to the proposed buildings, which is unsafe for small vehicles (Figure 5). However, there would only be H1 flood waters between the basement car park and Ashford Avenue so exiting the site would be low hazard.

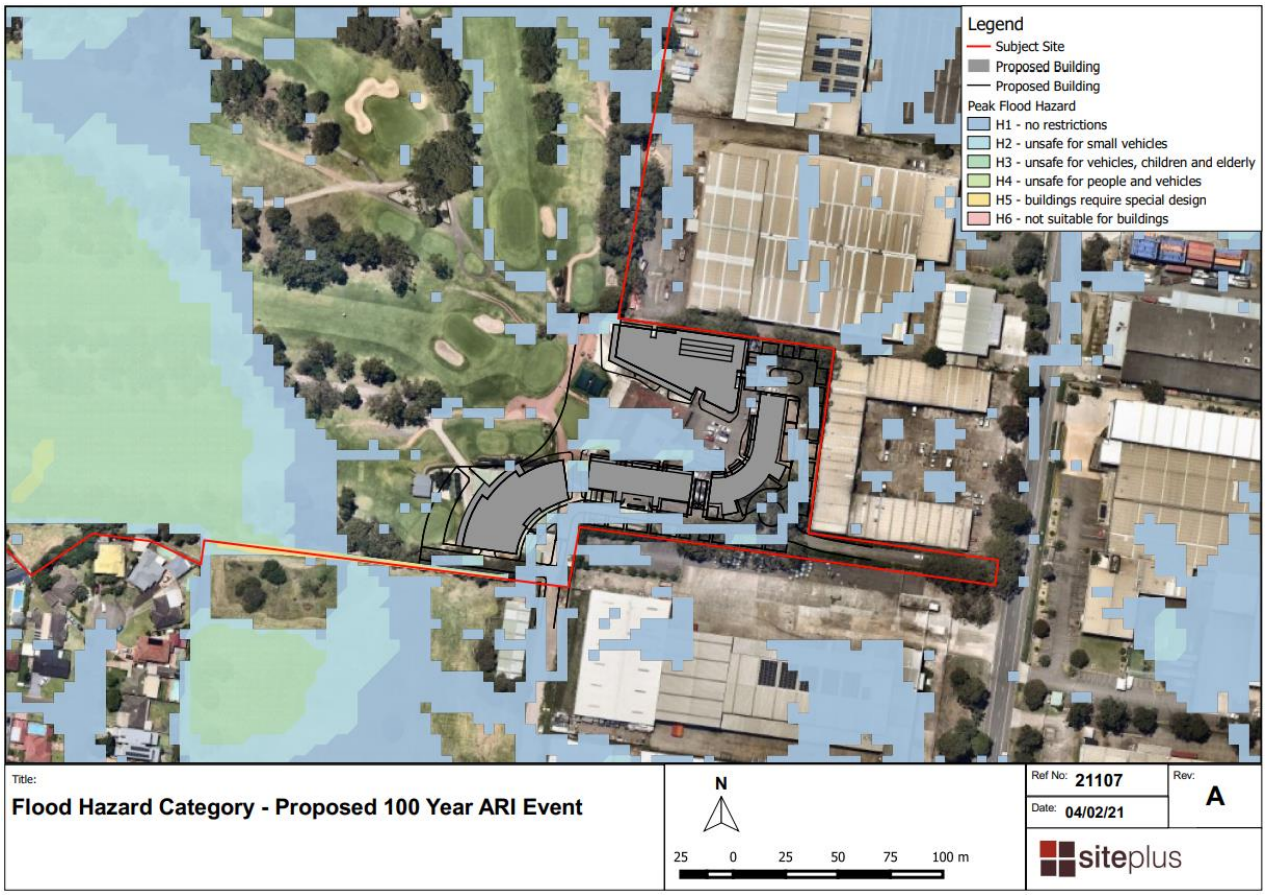


Figure 4. Local Milperra catchment flood hazard for the proposed development in the 1% AEP flood (source: Site Plus, 2021)

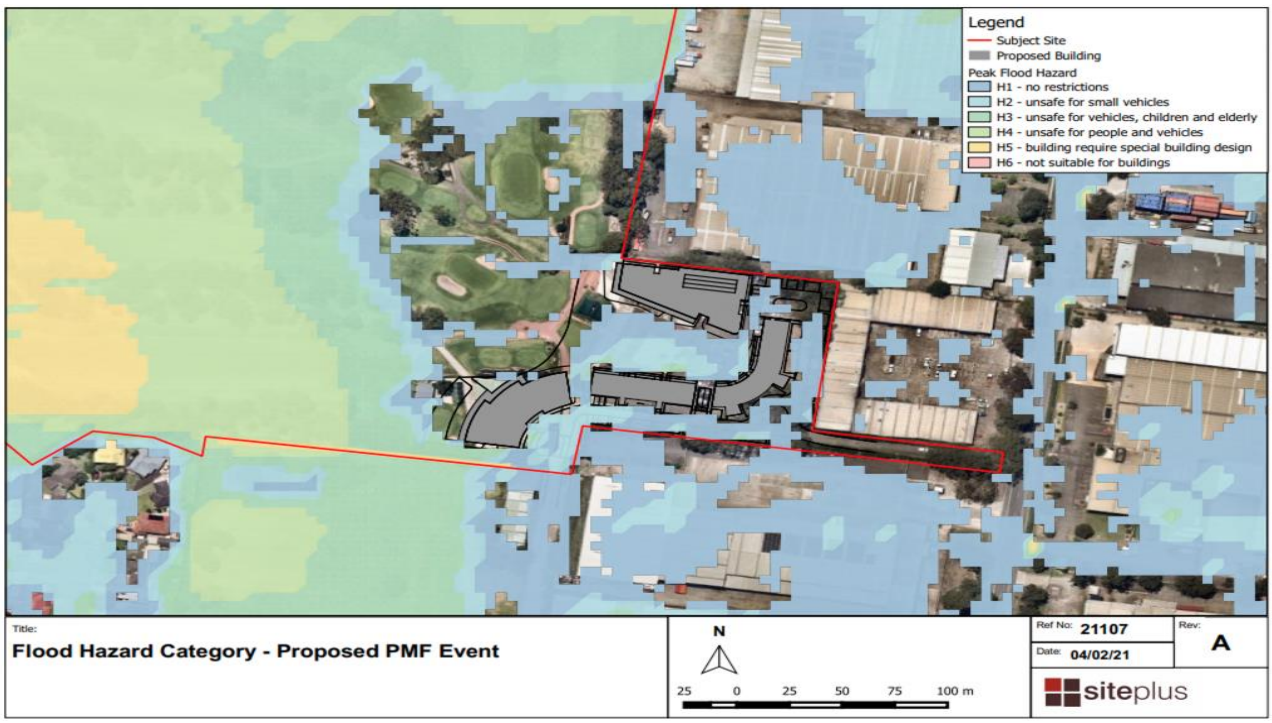


Figure 5. Local Milperra catchment flood hazard for the proposed development in the PMF (source: Site Plus, 2021)

Stage hydrographs show how flood levels vary over time in given storm events. The TUFLOW model of local flooding was used to extract hydrographs for the PMF. The hydrograph from the southwest corner of the site (i.e. the lowest part at the loading dock behind building A) is shown in Figure 6. This shows that it will take about one hour for local stormwater flooding to reach its peak on site, and the flooding will not last more than three hours.

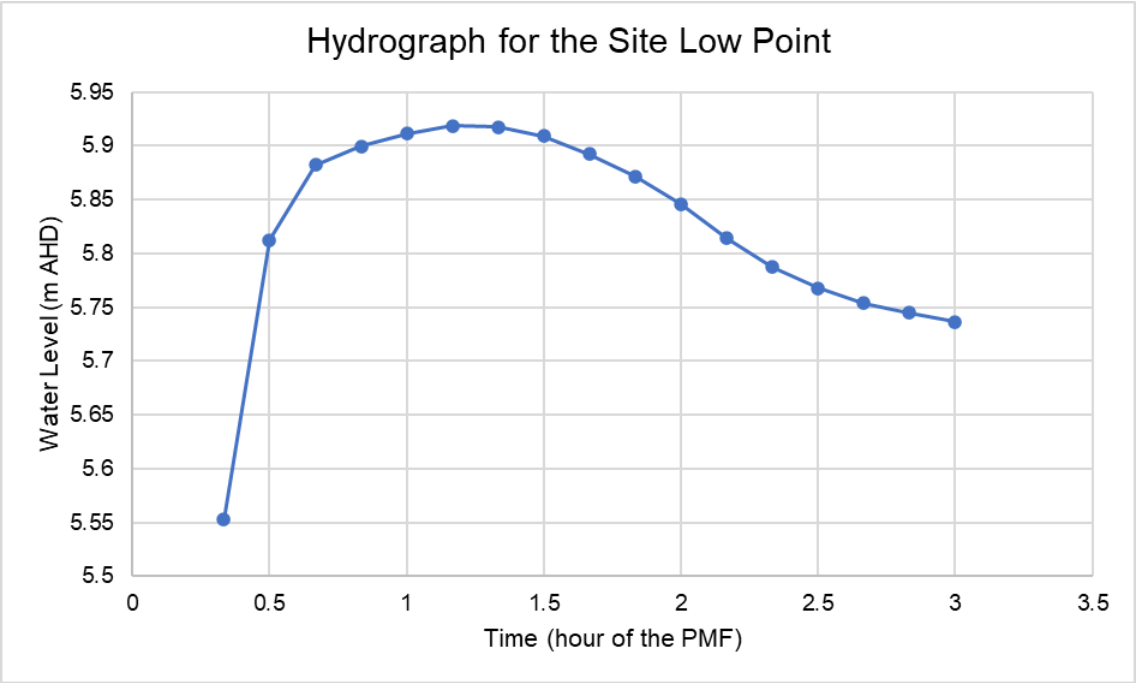


Figure 6. Local Milperra catchment PMF hydrograph for the southwest corner of Building A (i.e. the low point) of the site (source: Site Plus, 2021)

b) Georges River Flooding

Flooding along the Georges River is described in the *Georges River Floodplain Risk Management Study and Plan* (Bewsher Consulting, May 2004). Council has provided the Georges River flood levels shown in Table 3 for the study site.

Table 3. Georges River flood level summary

Flood	**Flood Level on Site (m AHD)**
5% AEP	4.8
1% AEP	5.9
PMF	10.4

This suggests that the 5% AEP flood levels are too low to reach the lowest part of the development, which is in the southwest corner with a design surface level of 4.9 m AHD.

It also shows that in a 1% AEP flood, the ground around the southern part of the site will experience some flooding. The lowest part of the site in the southwest corner will experience flood depths of up to 1 m. Floods of this order of magnitude have been recorded on the Georges River in 1860, 1873, 1887 and 1889. In the PMF, the entire site will be inundated by up to 5.5 m.

Council's flood advice states that the entire property lot is located within a Low, Medium & High Flood Risk zone in the Georges River floodplain. However, Council flood mapping shows that the area of the proposed development site is predominantly within a low flood risk precinct for Georges River flooding, with a small section of medium flood risk in the southwest corner of the site (Figure 7).

The 1% AEP and PMF design flood stage hydrographs were extracted from the Georges River MIKE-11 flood model assembled for the 2004 Floodplain Risk Management Study at the nearest node location to the site (Figure 8). These give a sense of how quickly floodwaters could rise in the Georges River and flood onto the site. Peak levels are reached on the site at about hour 27 of both design floods.

The site will commence flooding when flood levels exceed 4.9 m AHD, which is the lowest design surface for the site. Based on the Georges River PMF hydrograph (Figure 8), this will occur at hour 8 of the Georges River PMF. In the PMF, the site will experience flooding for more than 40 hours.

It should be noted that because Henry Lawson drive restricts the flow of floodwaters onto the site, in the initial stages of a PMF, the flood level on site will likely rise more slowly than the PMF Stage Hydrograph shown in Figure 8. However, once the road is substantially overtopped the flood waters in site will rise faster on site than on the river until they are both at the same level, sometime before the peak of the flood.

Figure 7 shows that the eastern side of the intersection of Bullecourt Avenue and Ashford Avenue is at 10.5 m AHD and continues to rise to the east and south. Therefore, Georges River flooding will not extend east and south of this location.

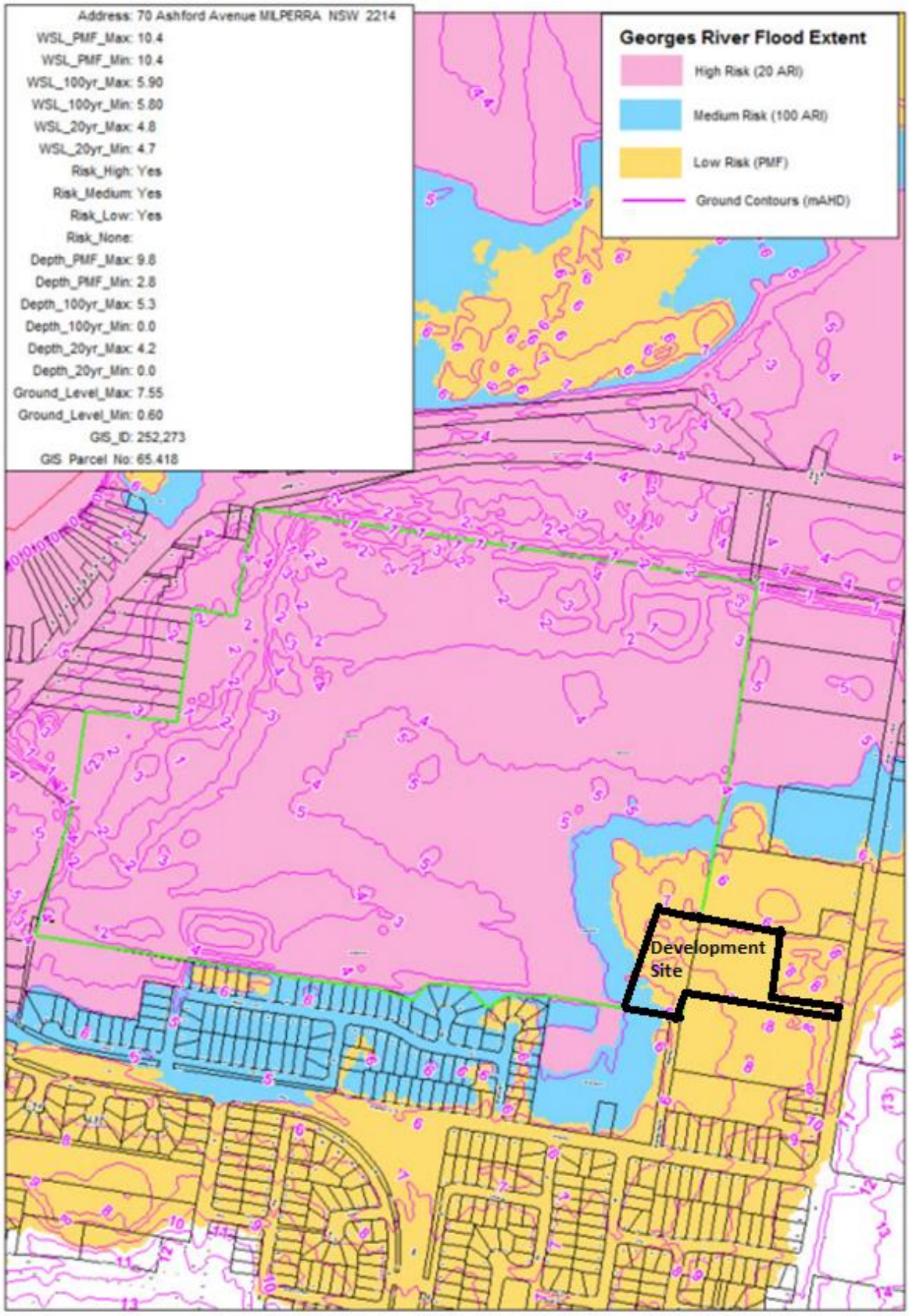


Figure 7. Council flood mapping for the Georges River over the lot (outlined in green)

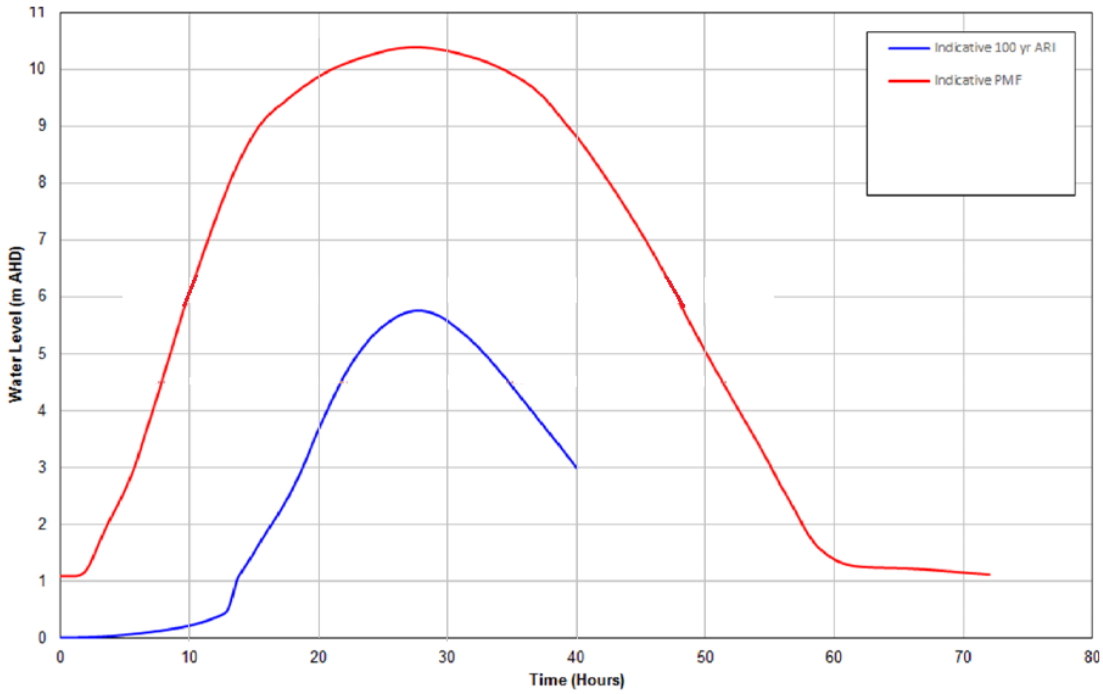


Figure 8. Georges River 1% AEP and PMF hydrographs (source: Cardno, 2015).

Flood Warning

There is no specific flood warning system from the Bureau of Meteorology (BoM) in place for Milperra catchment local stormwater flooding, so there may be no warning that this type of flooding is about to occur on site. There are some warnings which will indicate the possibility of this flooding occurring, including Severe Weather Warnings or Flash Flood Warnings for the Sydney Metropolitan area, or a Flood Watch for Local or Local and Riverine Flooding for the Georges River. Even in a PMF, local catchment flooding will not last more than a few hours. In many instances this flooding could come and go without residents or staff being aware of it if it happens during the night or while they are otherwise occupied.

Flooding from the Georges River would be of much longer duration (>40 hours) and reach higher levels. The Georges River is a large catchment with multiple rain gauges and stream gauges upstream of Milperra. This enables the Bureau of Meteorology to issue quantified flood warnings for the Georges River at Milperra.

There are several sources of forecasts and warnings that can assist with managing flood risk on the site. This includes Bureau of Meteorology rainfall forecasts, weather warnings, and rainfall and river gauges that show recent rainfall. The Milperra Gauge is located immediately to the northwest of the Bankstown Golf Club, by the intersection of Henry Lawson Drive and Milperra Road (https://mhl.nsw.gov.au/Station-213405B or http://www.bom.gov.au/fwo/IDN60233/IDN60233.066168.plt.shtml). The data on the Milperra Bridge website is updated approximately every hour.

The Bureau issues four types of specific flood warnings for the Georges River. All four might be issued in sequence during a specific event or only one or two types of warning will be used. These include:

- A Flood Watch, which is early advice of flooding given up to four days in advance or less than 24 hours in advance of an actual flood depending on current river levels, catchment conditions and developing weather events. A Flood Watch could be for either Local Flooding or Local and Riverine Flooding.
- A Generalised Flood Warning, which states that flooding is expected but no qualitative or quantitative information can be provided based on the available data.
- A Qualitative Flood Warning, providing an indication that either minor, moderate or major flooding is expected and a broad timeframe in which that might occur. At the Milperra Gauge, the following gauge levels correspond to each flood category (noting "Gauge Zero" is -0.5 m AHD):
    - Minor: 2.0 m or 1.5 m AHD
    - Moderate: 3.3 m or 2.8 m AHD
    - Major: 4.2 m or 3.7 m AHD
- A Quantitative Flood Warning, which will provide forecast levels at the Milperra Gauge and when those levels are likely to be reached. These forecast levels are quite precise and are usually within about 0.3 m of the actual level reached. They rely upon data collected by upstream rain gauges and stream gauges.

According to the *Provision and Requirements for Flood Warning in New South Wales* (NSW SES, 2019), the BoM has a target warning lead time of 12 hours for floods greater than 4.0 m, and 6 hours for floods greater than 2.0 m for the Milperra Bridge Gauge. Therefore, there should be at least 12 hours of warning for flooding that will affect the site, which would be classified as Major flooding on the Milperra Gauge.

Evacuation Capability Assessment

All of the buildings on site will have their floor levels above the levels of both the local Milperra 1% AEP flood and PMF. The floor levels are also above the 1% AEP Georges River flood level. While basement car parks will be below this level, their entry ramps will be 0.5 m above the 1% AEP local flood level, and above the local PMF level.

However, floodwaters could rise higher than the 1% AEP levels in the Georges River, in which case flooding could reach hazardous depths within the ground floors of the buildings. PMF flooding could reach almost 4 m above the ground floor level of Building A and the Golf Club, almost 3 m above the ground floors of Buildings B and C, and would entirely fill the basement car parking. Floor levels 1 and higher in all buildings will be above the PMF level. This means all apartments except for the 10 located on the ground floors of Buildings B and C would be above the PMF flood level.

Due to the risk of ground floor flooding and isolation of the site, the proposed response to an expected PMF on the Georges River is the evacuation of all staff and residents.

An evacuation route onto the M5 motorway has been selected that avoids flooding from both the Georges River PMF and local catchment stormwater flows where possible. It exits the site onto Ashford Avenue, which is less flood affected than Bullecourt Avenue directly south of the site. The route is shown in Figure 9.

Figure 9. Potential evacuation route away from the Georges River PMF onto the M5

The capability of the site to safely evacuate was calculated under the following assumptions:

- Evacuation must be possible in the worst case scenario. If it is possible in the worst case, it is possible in any other scenario.
- The worst case scenario flooding is assumed to be a PMF from the Georges River. It is noted that any flood can rise as fast as a PMF, although it would not reach the same peak levels.
- There are a total of 365 car spaces in the proposed development. In the absolute worst case scenario, if flooding were to occur when the site is at full capacity, this is the number of vehicles that would have to evacuate the site.

The site will commence flooding when flood levels exceed 4.9 m AHD, which is the lowest design surface for the site. Based on the Georges River PMF hydrograph (Figure 8), this will occur at t = 8 hours of the Georges River PMF. Therefore, evacuation must be complete by t = 8 hours of the PMF.

The NSW State Emergency Service (SES) has developed the Timeline Evacuation Model (TEM) as an empirical means of consistently estimating the ability of people to safely evacuate by motor vehicle from floodplains (Opper et al, 2009). The primary goal of the TEM is to compare the time required for evacuation with the time available for evacuation.

This can be represented by the: Surplus Time = Time Available – Time Required. Where the Time Available exceeds the Time Required there can be greater confidence that safe evacuation can be achieved.

The worst-case scenario (i.e. a fully occupied site during a Georges River PMF) **Time Required** to evacuate for the development is calculated as follows:

- **1 hour Warning Acceptance Factor.** This is the NSWSES recommended amount of time to account for the delay between receiving an evacuation order and acting upon it.
- **1 hour Warning Lag Factor.** This is the NSWSES recommended amount of time to account for the time it takes for occupants to prepare for evacuation.
- **1 hour Travel Time.** This is a conservative estimate based on the NSWSES recommended rate of 600 cars traveling per lane per hour out of the site.
- **1 hour Traffic Safety Factor.** The NSWSES recommends a minimum of 1 hour of traffic delays to be accounted for.

This equals a total of 4 hours required to evacuate the site. This is assuming that, when it is decided that evacuation must occur, the evacuation order can be issued to all residents immediately. This requires an emergency public address (PA) system with speakers in every unit and common area of the development.

The **Time Available** to evacuate is based on the available triggers. There are several triggers that are available that can be used to provide safe evacuation within the required timeframe. These are summarised in Table 4.

The site will only flood from Major flooding from the Georges River, when flood levels exceed 4.9 m AHD. For flooding of this level, the BoM provides a warning time of 12 hours. Therefore, the site can have up to 12 hours warning for an evacuation, which exceeds the amount of time required to evacuate by eight hours. Additional triggers can be in place to ensure timely evacuation occurs only when it is necessary to do so.

Table 4. Available triggers for flood emergency response actions on the site

Trigger	**Timing**	**Potential Flood Evacuation Phase**
BoM Severe Weather Warning for Sydney Metropolitan Area	Any time	On alert
BoM Flood Watch	Four days to 24 hours before flooding	Ready to implement flood evacuation plan
BoM Quantitative Flood Warning: Milperra Gauge to reach Major flood level (4.2 m Gauge Level or 3.7 m AHD)	12 hours before flooding	Prepare to evacuate
BoM Quantitative Flood Warning: Milperra Gauge to reach buildings (4.4 m Gauge Level or 4.9 m AHD)	12 hours before flooding	Evacuate

In addition to the above BoM warnings, critical trigger levels corresponding to certain Milperra Gauge levels can also be set to trigger evacuation. As shown in Figure 10, the site starts to flood when t = 8 hours on the PMF design flood hydrograph and it takes four hours to evacuate the site. Therefore an evacuation order must be issued 4 hours before the flood reaches the site which is at t = 4 hours on the PMF design flood hydrograph. At this time, Georges River flood levels will be at 2 m AHD. Therefore, a critical trigger level for site evacuation will be when the Milperra Gauge is at 2 m and the river is forecast to continuing to rise above 4.5m on the gauge. Monitoring of the Milperra gauge will be an essential component of flood risk management for this development.

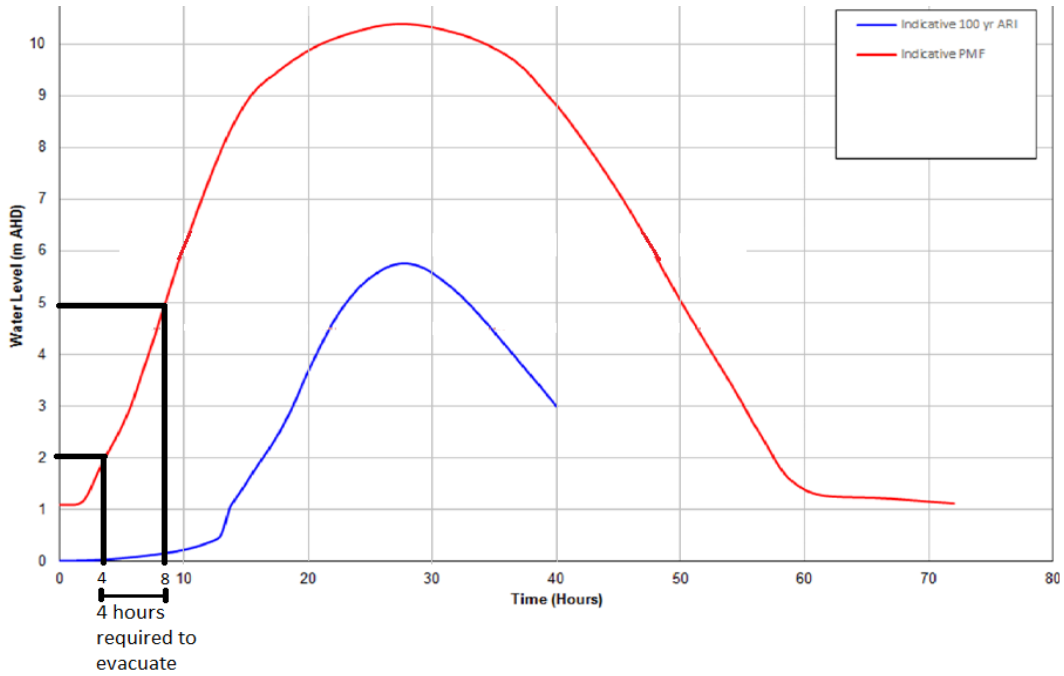


Figure 10. Critical trigger level at t = 4 of the PMF, when the Georges River flood levels reach 2 m AHD.

Factors that Could Delay Evacuation

When evacuating from a Georges River PMF, simultaneous local Milperra catchment flooding could occur. This could be a factor that delays evacuation. However, this flooding will only last three hours at most on the site. As shown above, in a local Milperra catchment PMF, it is still possible to exit the basement car park and drive onto Ashford Avenue by only crossing H1 flood waters, which are not considered hazardous to people or vehicles. While it is not recommended that people walk or drive through any flood waters, even in a local flood as infrequent as the PMF, it would still be possible for people to leave the site via vehicle. If some additional time is added onto the time required to evacuate to account for delays caused by local Milperra catchment flooding, there would still be surplus time to evacuate.

Regional evacuation traffic may also increase the time needed to evacuate the site in a Georges River PMF. Using data from the Australian Bureau of Statistics 2016 Census and Journey to Work data released by Transport for NSW/ Transport Performance and Analytics, the number of additional vehicles that will be evacuating from the local area on to the same evacuation routes have been estimated to be:

- 450 residential vehicles (including cars and buses evacuating from the future Anglicare Milperra Village retirement living and residential care facility), and
- 1,500 non-residential vehicles (only including commuters that do not live locally).

Therefore, in the absolute worst case scenario, there would be 1,950 vehicles in addition to the 365 vehicles from this development, giving a total of 2,315 vehicles using the same evacuation route.

It would take this number of vehicles a total of four hours to evacuate, based on the NSWSES recommended rate of 600 cars traveling per lane per hour out of the site. It would also increase the Traffic Safety Factor to 1.5 hours. This would result in a total time required to evacuate of 7.5 hours.

Since the site can have up to 12 hours warning for an evacuation, even considering this additional traffic, there is surplus evacuation time of 12 – 7.5 = 4.5 hours.

Consequences of Failing to Evacuate by Car

Evacuation by vehicle is the primary means of evacuation for the site. However, if for some reason, this does not occur, there are alternative options.

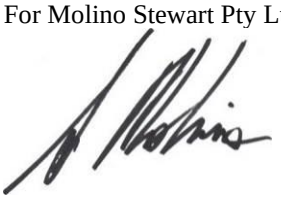
- Pedestrian evacuation is also possible. Should vehicular evacuation fail, it is possible for evacuees to walk 400 m on a continuously rising route south on Ashford Avenue and east on Bullecourt Avenue to reach a location above the reach of the PMF on the Western Sydney University campus.
- As a last resort, if both pedestrian and vehicular evacuation fail, sheltering within the buildings above the level of the PMF is also a possibility. Although the long duration of the Georges River PMF makes this option a last resort, the flood waters in this location would be low velocity, meaning there is minimal risk to the structural safety of the buildings. Only the ground floors of the buildings will be inundated. Out of the 149 seniors living apartments, 139 are on level 1 or higher and will be flood-free above the PMF level. Therefore, the remaining ground floor residents and any other non-residents left within the site would be able to go upstairs and shelter in a location above the PMF if they were prevented in any way from leaving the site.

Conclusions

- The site is impacted by both local Milperra catchment flooding and Georges River flooding.
- Local flooding would only last up to three hours and would not enter any buildings or the basement car park.
- Georges River flooding up to the 1% AEP flood level would not enter any buildings or the basement car park, but would flood the lowest corner of the site (the loading dock) adjacent to Building A to a depth of 1 m.
- Larger floods on the Georges River would enter the ground floors of buildings. A PMF could reach up to 4 m above the ground floor level of Building A and flood the site for more than 40 hours. Therefore, the most appropriate response to a flood exceeding the 1% AEP flood on the Georges River is the evacuation of all staff and residents.
- Timely evacuation of the site from a Georges River PMF is possible, taking into account both the time required to fully evacuate the site and the time available given the proposed triggers for evacuation. This evacuation is dependent on planned monitoring of both BoM warnings and the nearby Milperra Gauge levels.
- There is a direct route from the site to the M5 motorway which quickly rises from the floodplain.
- The ability to evacuate the site by motor vehicle should not be compromised by disruptions to evacuation by local flooding, nor simultaneous evacuation of nearby residential and non-residential developments.
- Should vehicular evacuation fail for whatever reason, it is possible for evacuees to walk 400 m on a continuously rising route south on Ashford Avenue and east on Bullecourt Avenue to reach a location above the reach of the PMF.

Yours faithfully

For Molino Stewart Pty Ltd



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Principal

https://molinostewart.sharepoint.com/sites/Jobs1200-1300/Shared Documents/1267 Bankstown Golf Course FEMP/Reports/Final/1267 Flood Evacuation Assessment for Bankstown Golf Club Final.docx

References

Bewsher Consulting Pty Ltd (2004). Georges River Floodplain Risk Management Stud and Plan.

BMT WBM Pty Ltd (2015). Milperra Catchment, Flood Study Update.

Cardno (2015). Flooding of Lot 272 Bullecourt Ave in Milperra and its suitability for seniors living and an aged care facility. Report prepared for Anglican Retirement Villages.

NSWSES (2019). Provision and Requirements for Flood Warning in New South Wales.

Opper, S., Cinque, P., and Davies, B. (2009). Timeline Modelling of Flood Evacuation Operations, Presented at First International Conference on Evacuation Modelling and Management, Den Haag, The Netherlands, 23-25 September 2009.

Site Plus (2021). Bankstown Golf Club Seniors Living Development Flood Study and Flood Risk Management Study. Prepared for Bankstown Golf Club.

Smith, G.P., Davey, E.K. and Cox, R.J. (2014). Flood Hazard UNSW Australia Water Research Laboratory Technical Report 2014/07 30 September 2014.