Warwick Farm Village Pty Ltd

Gateway North at Warwick Farm
Proposed Rezoning Application

Site of proposed rezoning at Warwick Farm (Lot 1 DP 1162276)

Preliminary Flood Assessment

October 2015

FloodMit

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1 INTRODUCTION

FloodMit Pty Ltd was commissioned by Warwick Farm Village Pty Ltd to provide a preliminary flood assessment for the proposed rezoning of a site at Warwick Farm (Lot 1 DP 1162276) to allow high density residential development.

The site, shown on **Figure 1**, is bounded by the Hume Highway and Warwick Street (to the north), Governor Macquarie Drive (to the east), Munday Street (to the south) and Manning Street (to the west). The site has a total area of approximately 2.93ha. The western segment of the site previously contained 8 residential dwellings, which were removed during 2013. The eastern segment of the site has been undeveloped for some time.

The site is currently zoned B5 – Business Development under Liverpool LEP 2008. A bulky goods retail outlet was previously proposed for the site, but it is understood that this will not proceed.

The proposed rezoning to R4 – High Density Residential, and other changes proposed to planning controls relating to floor space ratios and building heights, would allow the construction of a number of high rise residential apartments within the site. A concept master plan is illustrated below (Urbis, October 2015).

Illustration 1
Concept Master Plan (Urbis, Oct 2015)

The site has been identified as being affected by flooding from the Georges River, and to a lesser extent Cabramatta Creek. Flood information is available from the Georges River Flood Study, the Georges River Floodplain Management Study, the Cabramatta Creek Floodplain Management Study, and a number of site specific flood assessments undertaken for the Australian Jockey Club (now the Australian Turf Club) between 2005 and 2009. The AJC investigations included the establishment of a two-dimensional TUFLOW flood model to provide more detailed information of flood behaviour on this part of the floodplain, and to allow the assessment of various development proposals.

This report is an update of an earlier investigation prepared for the bulky goods warehouse development previously proposed for the site (FloodMit, April 2011). It has been updated in view of the development now under consideration and subsequent model investigations undertaken during the interim period.

The report provides a preliminary flood assessment of the site, including:

i) an assessment of flood behaviour in the vicinity of the site;

ii) determination of the relevant *Flood Risk* that applies to the site;

iii) an assessment of potential flood impacts due to the proposed development;

iv) an assessment in terms of Council's flood risk management policies; and

v) the impact of potential sea level rise on the proposed development.

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Figure 1
Subject Site and Locality Sketch

2. EXISTING FLOOD BEHAVIOUR

2.1 SOURCE OF INFORMATION

Numerous flood investigations have been undertaken on the Georges River and Cabramatta Creek. The most relevant to the subject site include:

i) Georges River Flood Study (Public Works Department, 1991);

ii) Georges River Floodplain Risk Management Study and Plan (Bewsher Consulting, May 2004);

iii) Cabramatta Creek Floodplain Management Study and Plan – Updated Report (Bewsher Consulting, October 2004);

iv) Georges River Floodplain Risk Management Study – Liverpool City Council Risk Management Precincts (Bewsher Consulting, December 2005);

v) Warwick Farm Racecourse Flood Assessment Report (Bewsher Consulting, July 2009);

vi) Proposed Home Improvement Centre, Warwick Farm – Flood Assessment Report (FloodMit, April 2011); and

vii) ATC Landholdings at Warwick Farm – Proposed Car Parking Areas and Upgrading of Governor Macquarie Drive (FloodMit, April 2012).

Design flood levels along the Georges River are based on results from the 1991 Flood Study report. The 2004 Floodplain Management Study provided further quantification of the flood problem, including mapping of the floodplain into three different flood risk precincts – namely *high*, *medium* and *low*.

A two-dimensional flood model (TUFLOW) was more recently developed for the AJC to provide more detailed representation of flood behaviour in the vicinity of the Racecourse and the subject site. The model is also of sufficient resolution to accurately assess the impacts of potential development on flood behaviour. The model extends from Liverpool weir to Cutler Road on the Georges River, and includes Cabramatta Creek up to the railway line. Boundary conditions for the TUFLOW model have been taken directly from the Georges River Flood Study.

A new flood study on the Georges River is currently being undertaken for Liverpool Council, which is expected to be completed during 2016. The study uses a TUFLOW flood model to assess flood behaviour along the river and floodplain area. This model also includes the subject site; however the resolution of the model is likely to be less detailed in this area than the current AJC TUFLOW model. Nevertheless, the new model may result in new design flood levels being adopted within the Georges River and may affect boundary conditions in the AJC TUFLOW model.

2.2 DESCRIPTION OF FLOOD BEHAVIOUR

A detailed description of flood behaviour at Warwick Farm is available from the AJC TUFLOW model for the 20 year and 100 year ARI floods.

Existing flood behaviour in the 20 year flood is illustrated on **Figure 2**. Floodwater spills over the banks of the Georges River upstream of Governor Macquarie Drive, in the vicinity of the oxidation ponds in the Liverpool Sewerage Treatment Plant. Flooding extends into a low-lying flood storage area known as Horseshoe Pond, on the southern side of Governor Macquarie Drive. Floodwater is confined to this storage area, and drains back to the river once levels have subsided. The subject site is not inundated in the 20 year flood.

Existing flood behaviour in the 100 year flood is illustrated on **Figure 3**. Flooding again spills form the river into the Horseshoe pond storage area, but now inundates a larger area and also overtops Governor Macquarie Drive. An overland flow path is created between the Hume Highway and the racetrack with floodwater flowing to the north to combine with backwater flooding from the confluence of the Georges River and Cabramatta Creek. The entire subject site is estimated to be inundated in the 100 year flood. The former residential segment of the site is estimated to be inundated by an average of 0.2m in the 100 year flood, whilst the eastern segment is estimated to be inundated by an average of 0.5 to 0.6m.

The probable maximum flood (PMF) is 2.3m higher than the 100 year flood, and the entire racecourse site and much of the surrounding land would be inundated. The large increase in the PMF is due to a constriction in the Georges River floodplain downstream of East Hills, which causes a significant back-up in flood levels up to at least Liverpool.

Design flood levels that are applicable to the site are summarised in **Table 1**.

Table 1
Maximum Flood Levels at Lot 1 DP 1162276, Warwick Farm (m AHD)

Flood Event	Georges River Flood Study (PWD, 1991)	TUFLOW Model (Bewsher, 2009)
5 Year	4.9*	Not inundated
10 Year	5.9*	Not inundated
20 year	7.4	Not inundated
100 Year	8.4	8.34
PMF	10.7	10.7

* Supplementary Investigations for Liverpool Council (FloodMit, July 2013)

Design flood levels adopted by Liverpool City Council are based on results from the Georges River Flood Study (PWD, 1991). These results are consistent with the latest model results from the TUFLOW model (Bewsher, 2009).

Design flood levels quoted for the subject site are based on the levels that have been adopted by Council. However, the assessment of flood impacts and flood storage requirements have been based on the latest TUFLOW model results, as this is considered to provide a more accurate representation of flood behaviour across the site.

2.3 CLASSIFICATION OF FLOOD RISK

The Georges River Floodplain Risk Management Study and Plan categorised the floodplain into three different flood risk areas. These include:

High Flood Risk – Land below the 100 year flood that is subject to a high hydraulic hazard or where there are significant evacuation issues;

Medium Flood Risk – Land below the 100 year flood that is not subject to a high hydraulic hazard and where there are no significant evacuation issues;

Low Flood Risk – Land that is above the 100 year food, but still potentially affect by floods up to the probable maximum flood (PMF).

The flood risk maps for the Georges River were refined by Liverpool City Council in December 2005 using improved topographic data from airborne laser scanning (ALS) survey. An extract of the mapping in the vicinity of Warwick Farm is included in **Figure 4**.

The entire site is classified as having a medium flood risk.

2.4 EFFECTIVE WARNING TIME

A flood warning scheme is operated by the Bureau of Meteorology for the Georges River. The scheme monitors rainfall and river gauges in the upper catchment and aims to provide at least 12 hours warning of an impending flood. Warnings are issued to the State Emergency Service who has responsibility for evacuation and other emergency response actions.

The Cabramatta Creek catchment can respond to flooding more rapidly than the Georges River catchment. There is presently no warning system provided for this catchment, apart from warnings that may be issued in the lower catchment in connection with flooding from the Georges River.

The subject site is primarily affected by flooding from the Georges River. The Georges River flood warning system will provide some assistance to residents of Warwick Farm of the need to evacuate the area during major floods, for which up to 12 hours warning may typically be available. The proposed high rise development within the subject site also provides an opportunity for residents to “shelter-in-place” until the flood threat abates.

2.5 ACCESS CONSIDERATIONS

Access to and from the site during periods of flooding is an important consideration for residents. Whilst there will be an ability to “shelter-in-place” within the high rise development, there may be a number of reasons for people to gain access to or from the site during floods, including off-site evacuation, residents returning from work, picking up children, emergencies, etc.

The inundation depth on roads in the vicinity of the site during a 100 year flood is depicted on **Figure 5**. The most appropriate access route during flooding is south on the Hume Highway towards Liverpool. This provides a route from the north side of the site that is above the 100 year flood, and continually rises to a level above the probable maximum flood (PMF). Access to the south on the Hume Highway will be inundated by over 1.0m in the 100 year flood near Cabramatta Creek, and access to the east on Governor Macquarie Drive will be inundated by over 0.8m near Shore Street.

Access from the site to the Hume Highway is currently shown via Munday Street/Governor Macquarie Drive, or Munday Street/Manning Street/Warwick Street. Both routes would be inundated by between 0.2 to 0.4m in a 100 year flood.

Improved access could be provided by providing direct access from the north side of the site to the intersection of Warwick Street and the Hume Highway. Minor regrading of this intersection could provide direct access to the Hume Highway that is above the 100 year flood. In conjunction with raising the internal road to the 100 year level, this could provide access to all buildings that is free from inundation in the 100 year flood.

2.6 POTENTIAL OVERLAND FLOW PATHS

Potential overland flow paths have been identified with the aid of a terrain surface model in the vicinity of Warwick Farm (based on LIDAR survey acquired in 2008) and through a review of the stormwater pipe network provided by Council. A thematic representation of the terrain surface is shown on **Figure 6**. Shades of blue indicate low points within the catchment, and shades of orange to red indicate higher elevations. Contours at 0.25m intervals were also extracted from the terrain surface and used to delineate catchment boundaries. Potential overland flow paths are identified on Figure 6.

The subject site is located within a small catchment area of 32Ha that drains to a depression known as the Horseshoe Pond within land owned by Sydney Water. The site is at the very top end of this small catchment, and there is little, if any, contributing catchment area that drains to the site. The Hume Highway (to the north) and Governor Macquarie Drive (to the east) effectively form the boundary of the catchment.

The stormwater pipe system mainly starts at Munday Street, on the downstream side of the site, which conveys stormwater in a south-easterly direction towards the Horseshoe Pond. There are no stormwater pipes or drainage easements through the site.

A small amount of surface flow appears to flow down Warwick Street, along the northern boundary of the site. The flow along the road corridor is intercepted by a 375mm stormwater pipe, and presumably feeds into the drainage system along the Hume Highway.

The site is located at the very top end of a relatively small catchment area, and there are no identifiable overland flow paths through the site.

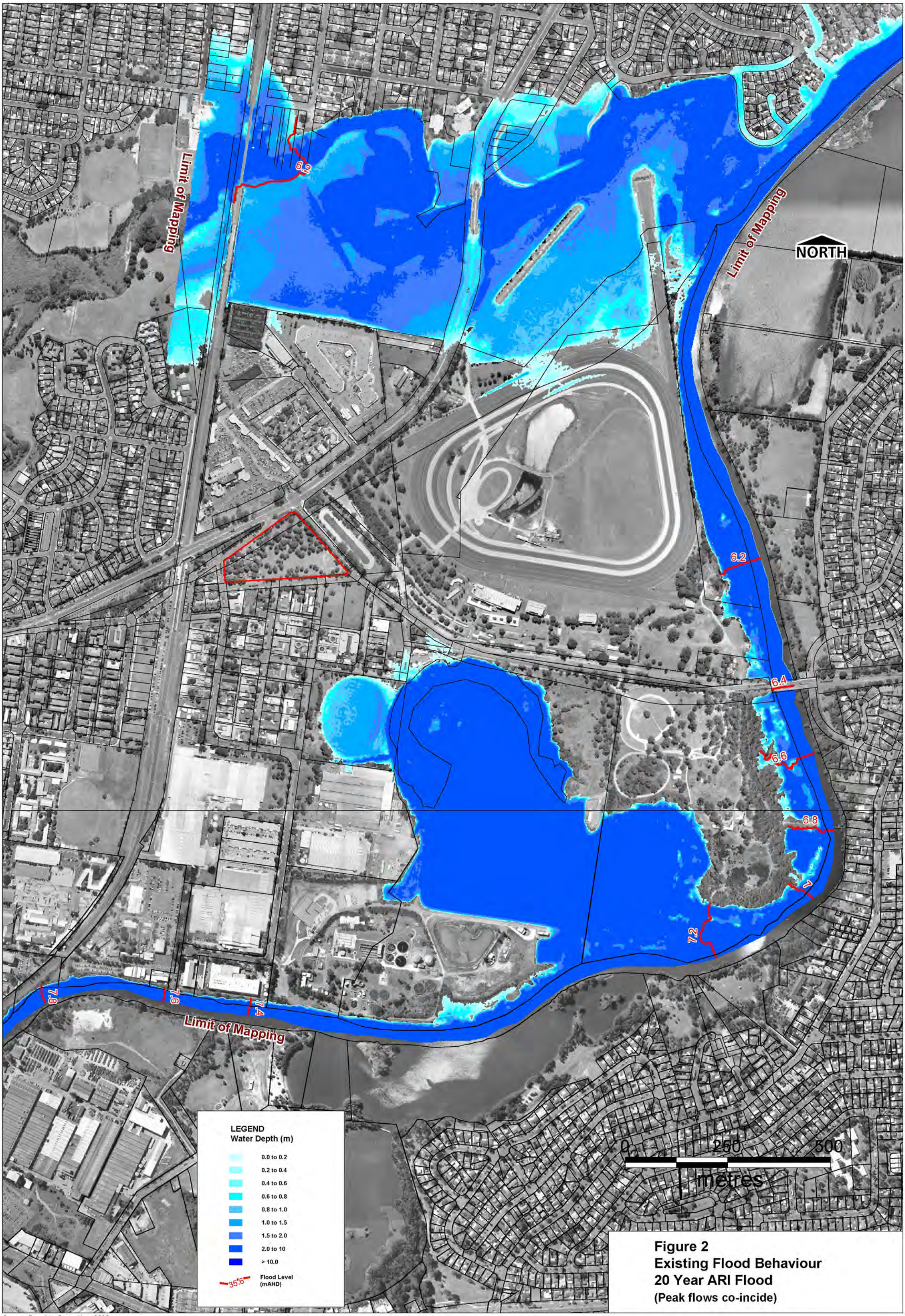

Figure 2
Existing Flood Behaviour
20 Year ARI Flood
(Peak flows co-incide)

Source: Bewsher Consulting, 2009

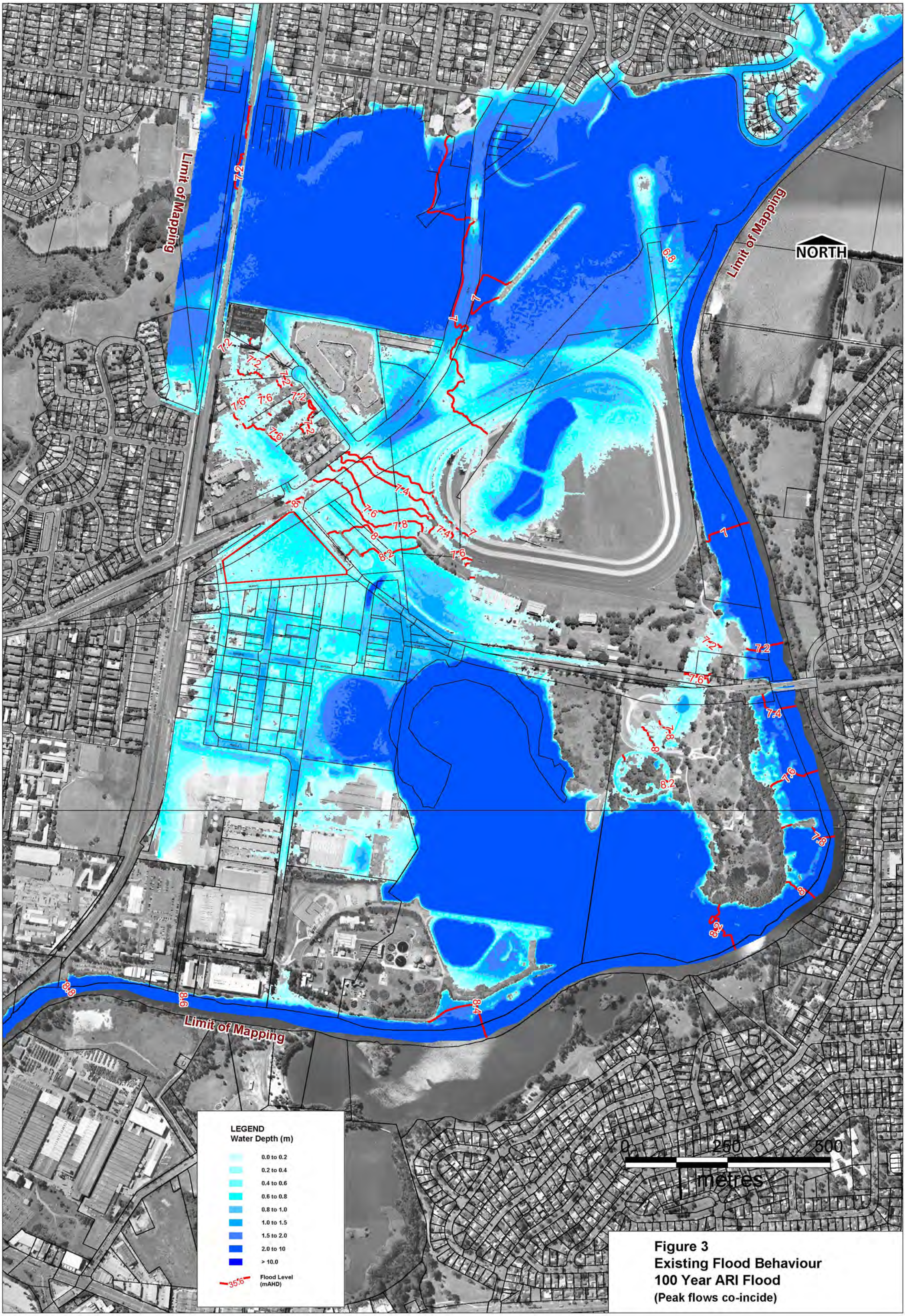

Figure 3
Existing Flood Behaviour
100 Year ARI Flood
(Peak flows co-incide)

Source: Bewsher Consulting, 2009

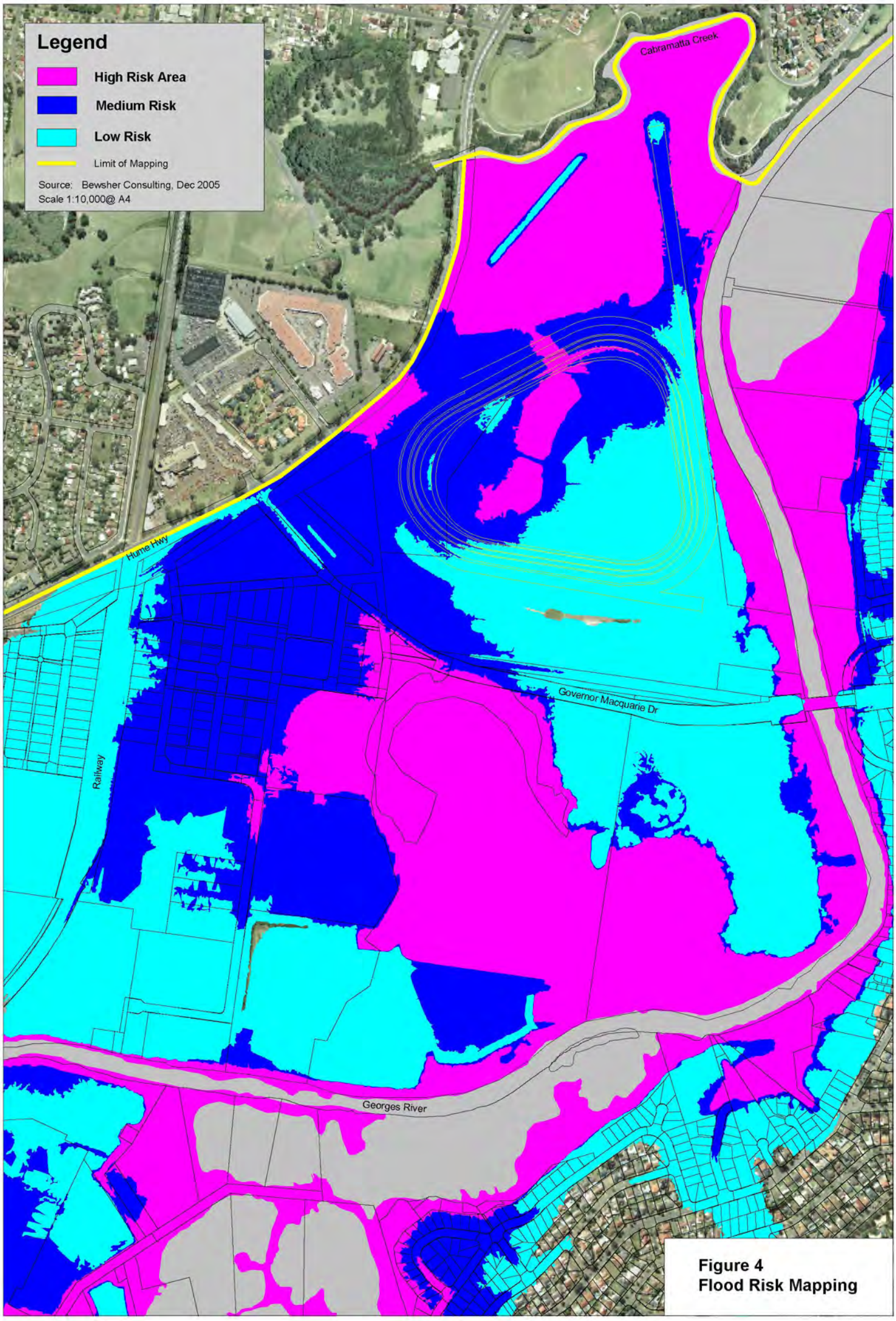

Figure 4
Flood Risk Mapping

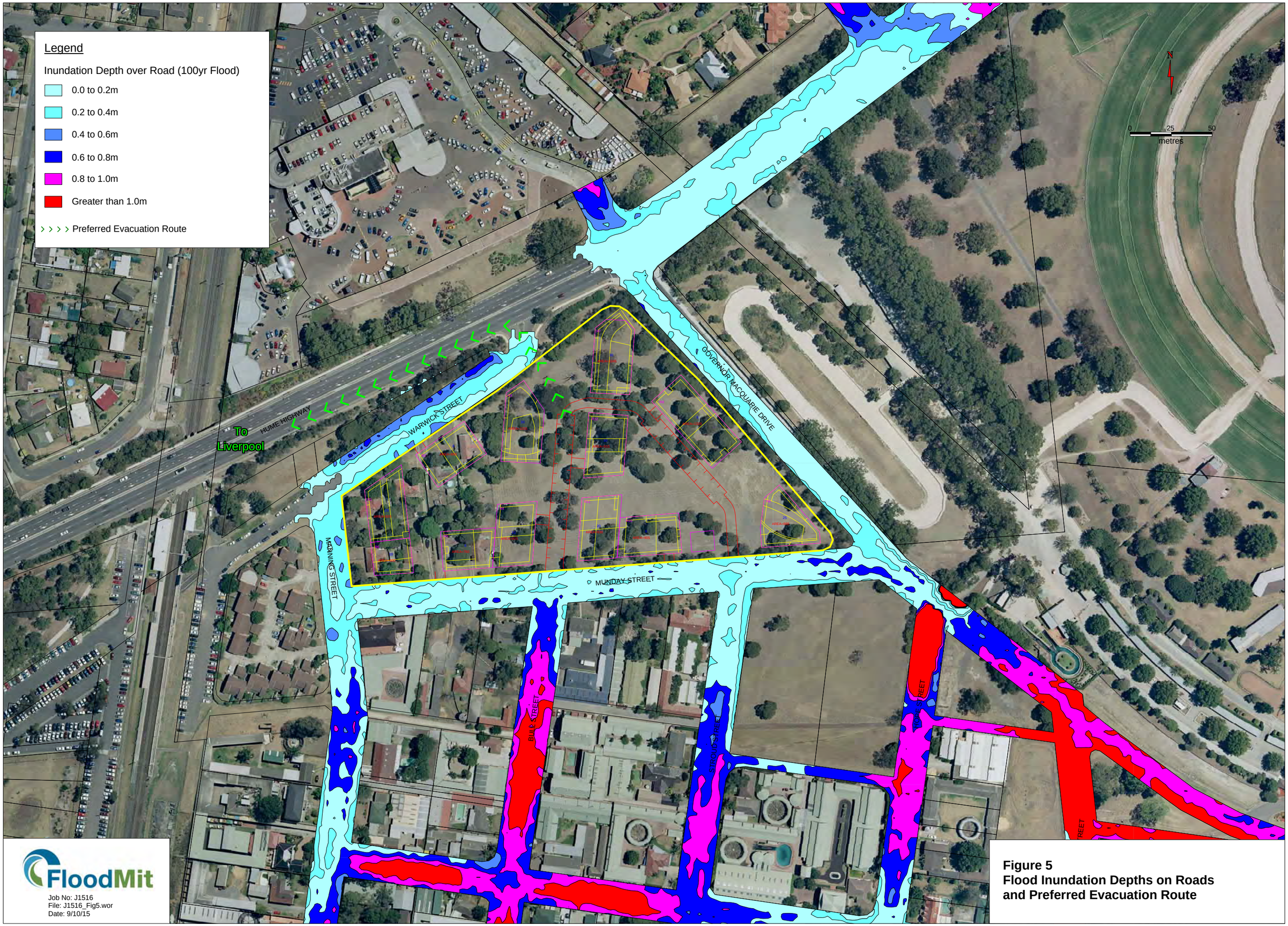

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Figure 5
Flood Inundation Depths on Roads and Preferred Evacuation Route

LEGEND

Catchment Boundary

Stormwater Pipe Network (LCC, 2011)

Direction of Overland Flow

N

0 25 50

metres

PUMP HIGHWAY

WARWICK STREET

GOVERNOR MACQUARIE DRIVE

MANNING STREET

MUNDAY STREET

BULL STREET

STROUD STREET

HOPE STREET

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Figure 6
Identification of Potential Overland Flow Paths

3 POTENTIAL IMPACT OF DEVELOPMENT ON FLOODING

3.1 IMPACT ON FLOOD BEHAVIOUR

The impact of filling and developing the lower lying eastern segment of the site, in conjunction with another site known as “Coopers Paddock”, was previously assessed with the TUFLOW model for the AJC (Bewsher, July 2009). Results of that assessment indicated flood level reductions of up to 50mm in the 100 year flood near the intersection of Governor Macquarie Drive and the Hume Highway, and smaller reductions persisting on the northern side of the Hume Highway. These reductions were due to filling of the subject site, which reduced the quantity of floodwater that spills onto Governor Macquarie Drive near the Hume Highway. All other areas showed no discernible change in flood levels (within ± 20mm).

Subsequent investigations were also undertaken using the TUFLOW model for the ATC in relation to various proposals on the north side of Governor Macquarie Drive (FloodMit, November 2011). These proposals included the removal of a former railway embankment on the north side of Governor Macquarie Drive; the realignment of Governor Macquarie Drive; the provision of up to five car parks between the road and the racecourse; and the development of a thoroughbred horse auction centre.

At Council’s request, the modelling was subsequently updated to include the proposed filling and development of a bulky goods warehouse on the subject site in order to assess potential cumulative flood impacts. Results of the assessment (FloodMit, April 2012) are illustrated on **Figure 7**. The cumulative impact of all development proposals generally resulted in a very small increase in the 100 year flood level of 1mm in the floodplain area upstream (south) of Governor Macquarie Drive. Larger impacts were evident downstream of Governor Macquarie Drive, but these impacts were attributed solely to the ATC proposals in this area.

Prior to the inclusion of development of the subject site in the TUFLOW model, the ATC activities were indicating a very small reduction of 2mm in the floodplain area upstream of Governor Macquarie Drive in the 100 year flood. It can therefore be deduced that filling within the subject site (by itself) has the potential to increase flood levels in this area by approximately 3mm. This is consistent with the findings from the original study (Bewsher, July 2009), but expressed to a much finer resolution.

The estimated 3mm increase in 100 year flood levels from filling the subject site is considered to be minor, and would be further reduced (to 1mm) when considered in conjunction with other planned development on ATC land on the north side of Governor Macquarie Drive. Limiting the amount of fill within the subject site, or including compensatory excavation to mitigate any loss in flood storage, could ensure that this relatively minor impact is further reduced.

It is recommended that potential flood impacts are further verified using the AJC TUFLOW model as part of future detailed investigations.

3.2 FLOOD STORAGE CONSIDERATIONS

The area upstream of Governor Macquarie Drive, including the subject site, acts as a large flood storage area. Any filling within this area will reduce the available flood storage volume and potentially increase flood levels within this area. Liverpool Council's flood risk management policies, outlined in Chapter 9 of Liverpool DCP 2008, also species that there should be no loss in flood storage due to future development.

Filling the entire site to a level that is above the 100 year flood was previously estimated to result in a potential loss in flood storage of 13,200m^3 (FloodMit, 2011). A revised estimate of this storage loss is 12,900m^3. The difference is due to a subsequent adjustment of the property boundary adjacent to Governor Macquarie Drive.

There are three options that could be considered to ensure that there is no loss in flood storage from the development:

i) No Net Importation of Fill

The loss in flood storage could be minimised if no fill is imported onto the site, and earthwork is restricted to minor regrading only.

The site is not inundated in the 20 year flood, but totally inundated in the 100 year flood. The susceptibility of the site to flooding would remain as it is at present (most likely close to a 50 year flood). Some regrading could be considered to even out the inundation depth between eastern and western segments, or to locally elevate internal roads to ensure that inundation depths are no greater than the inundation depth experienced at the main access via Munday Street, which is inundated by 0.2 to 0.4m in a 100 year flood.

All buildings would need to be constructed on piers with minimum floor levels at least 0.5m above the 100 year flood level. Open space car parking could be provided at ground level, but all basement parking will need to be protected from inundation to a level at least 0.1m above the 100 year flood level. It is inevitable that some storage loss would occur around structures providing the entrance to basement parking areas.

Given the scale of the development proposed and the ongoing susceptibility of the site to flooding, including access problems, this option is unlikely to be viable.

ii) Filling part or all of the site and providing Compensatory Excavation off-site

Assuming that the entire site is filled to a level that is at or above the 100 year flood level, the loss in flood storage is estimated at 12,900m^3 (in a 100 year flood). Compensatory excavation of a similar volume would need to be provided nearby in the floodplain.

The previous proposal for a bulky goods warehouse on this site had proposed that the full site would be filled to the 100 year flood level, and that compensatory excavation would be provided elsewhere in the floodplain. Two sites were considered. The first was from within the ATC racecourse, north of Governor Macquarie Drive; and the second from a low lying area between the Horseshoe Pond and Coppers Paddock, south of Governor Macquarie Drive. Further investigation and consultation with Council and the ATC would be required to determine the viability of providing compensatory storage at these locations, or at an alternative location.

Filling the site to the 100 year flood level, in conjunction with improved access via the north of the site to Warwick Street and the Hume Highway, would provide a suitable footprint for the development proposed. However, the viability of off-site compensatory excavation still needs to be established.

iii) Filling part of the site and providing compensatory excavation on-site.

This option assumes that compensatory excavation will be provided from within the existing site. Consequently, only part of the site will be filled (the location of buildings, internal driveways, and promenades). Other areas of the site will be excavated to provide compensatory storage; whilst other areas can be maintained at existing ground levels. The excavated areas could become permanent water features or otherwise restricted to open space areas that would be inundated in floods greater than a 20 year event.

An indicative map, showing earthworks that provide approximately no net loss in flood storage, is shown on **Figure 8**. Storage volumes are summarised in **Table 2**.

Table 2
Balanced Cut and Fill Earthwork Volumes

Description	Total Area (m^2)	Change in 100yr Flood Storage (m^3)
Areas Filled [1]	12,700	+5,410
Area Excavated (Eastern) [2]	5,990	-3,430
Area Excavated (Western) [2]	2,340	-1,960
Existing Levels Maintained	8,270	N/A
TOTAL	29,300	+20 (approx balanced)

1 Assume areas filled to 100 year flood level

2 Assumes all areas excavated to minimum of RL 7.2m AHD (subject to further drainage investigations)

Earthworks shown on Figure 8 are indicative, and likely to be revised as part of future detailed investigations. This could include adjustments to the number and location of buildings within the site, and the final form of the compensatory excavation areas, including the possible inclusion of permanent water features within the development. One building (R8) is currently situated within an area identified for compensatory excavation. The building could be removed, relocated, or alternatively constructed on piers in its current location.

Further consideration is recommended to providing improved access to the site via Warwick Street and the Hume Highway. Minor regrading of the intersection of Warwick Street with the Hume Highway could provide flood free access to the north of the site in a 100 year flood. Combined with internal roads that are also raised to the 100 year flood level, this could considerably improve access to the majority of buildings within the development (Refer Section 2.5).

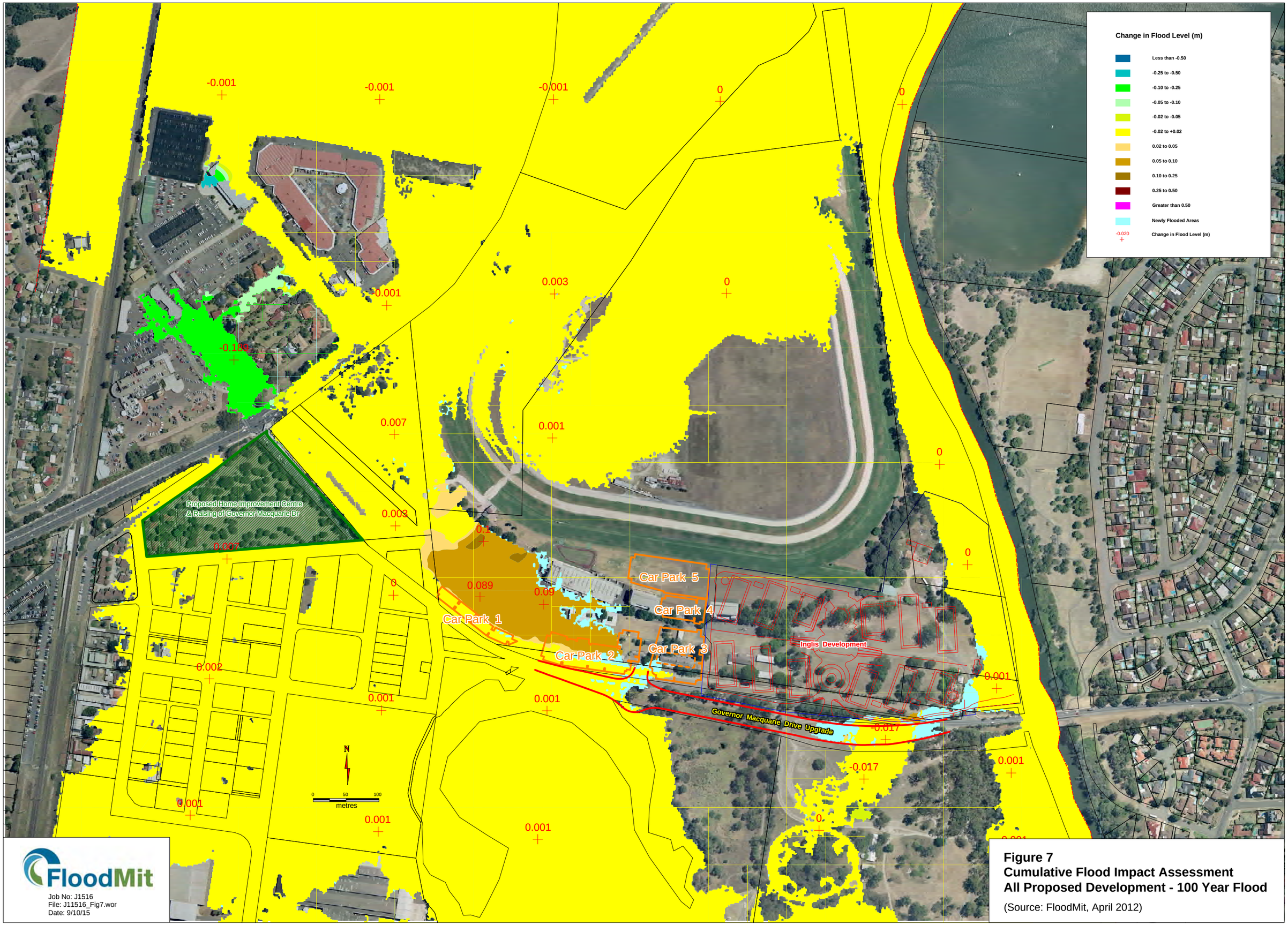

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Figure 7
Cumulative Flood Impact Assessment
All Proposed Development - 100 Year Flood

(Source: FloodMit, April 2012)

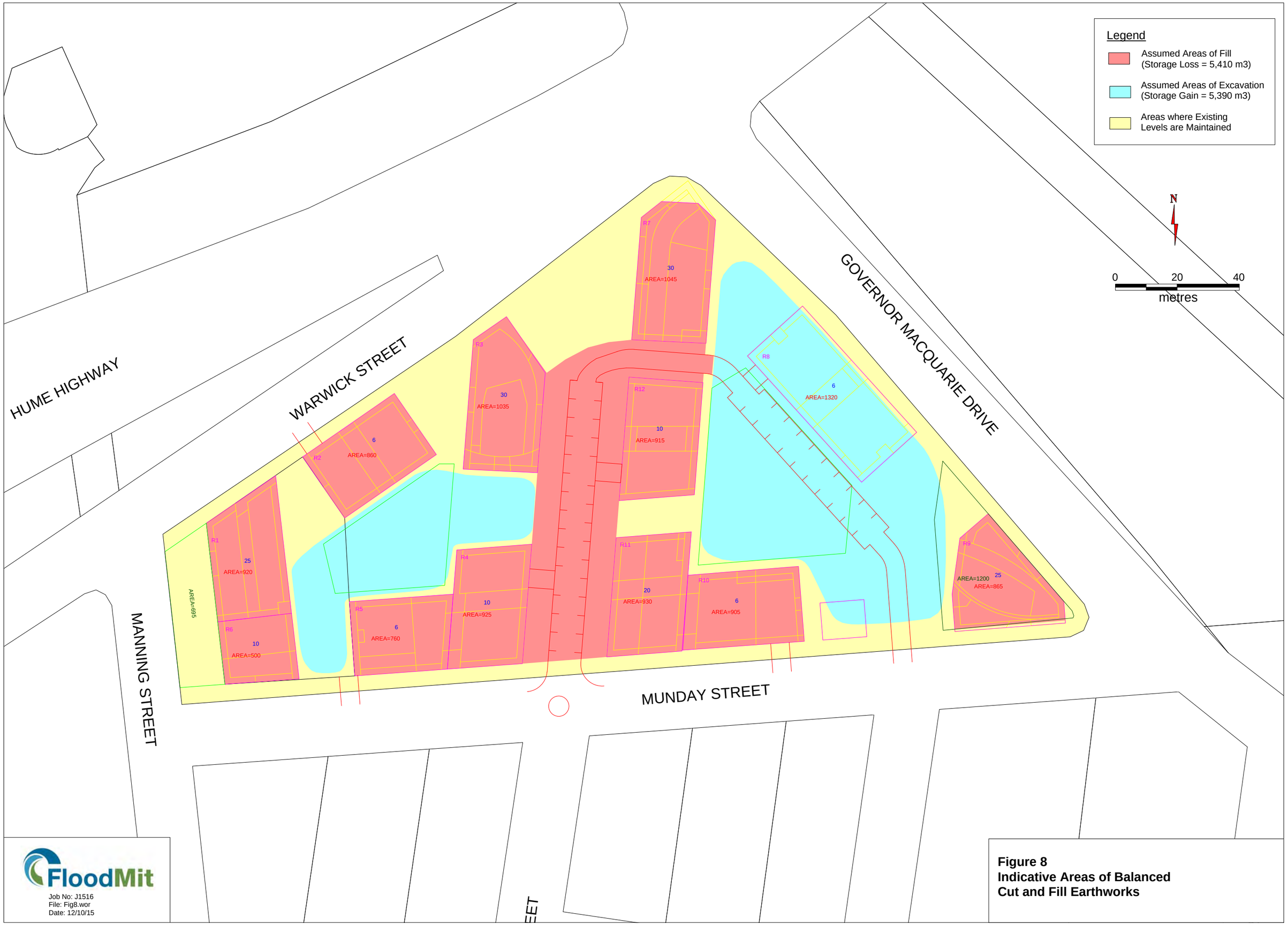

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Figure 8
Indicative Areas of Balanced Cut and Fill Earthworks

4 DEVELOPMENT CONSIDERATIONS

Liverpool Development Control Plan 2008, Chapter 9 Flooding Risk (Liverpool City Council September 2015) outlines controls that apply to future development that is subject to potential flooding. These controls recognise the type of development proposed and the flood risk of the site where the development is to be located.

The proposed development is classified as a 'residential' type development, and is located within a 'medium flood risk' area. Controls that apply to this type of development are detailed below.

4.1 BUILDING FLOOR LEVELS

Requirement 2 – Non habitable floor levels to be as high as practical but no less than the 5% AEP (20 Year) flood level.

This requirement allows for certain floor levels that are not of a residential nature, and where the potential for flood damage is low, to be located as low as the 20 year flood level. This might include maintenance or other ancillary buildings within the development.

Whilst no buildings of this nature have currently been identified, this requirement could be easily satisfied as the entire site is currently above the 20 year flood level.

Requirement 6 – Habitable floor levels to be equal to or greater than the 1% AEP (100 Year) flood level plus 500mm freeboard.

All residential apartments and foyers would need to be located at least 0.5m above the 100 year flood level. The current estimate of the 100 year flood level is RL 8.4m AHD. Consequently minimum floor levels will need to be at or above RL 8.9m AHD.

Requirement 15 – A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest habitable floor area is elevated more than 1.5m above finished ground level, confirming that the undercroft area is not to be enclosed.

This requirement mainly relates to individual residential buildings that are elevated on piers, to ensure that the area beneath the main floor is not subsequently developed or filled.

All buildings are proposed to be constructed on fill, with the possible exception of Building R8 where design details are still to be confirmed. In these circumstances the requirement to include a restriction on the title of the land is not considered to be relevant.

4.2 BUILDING COMPONENTS

Requirement 2 – All structures to have flood compatible building components below the 1% AEP (100 year) flood level plus 500mm freeboard.

All structures are required to have flood compatible building components below RL 8.9m AHD. The only building components that could be below this level include concrete footings or floor slabs, which are flood compatible.

4.3 STRUCTURAL SOUNDNESS

Requirement 2 – Engineers report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP (100 year) flood plus 500mm freeboard.

An Engineers report will be required to certify that all structures can withstand the forces of floodwater, debris and buoyancy. The site is primarily a flood storage area, and is estimated to have minimal flood velocity in the 100 year flood. The proposed filling of the site to a level that is above the 100 year flood will further reduce any potential hazard that could threaten the structural soundness of the building.

Given the nature of the proposed development, it is further recommended that all buildings remain structurally sound under all flood conditions up to the probable maximum flood (PMF). This could be included as part of detailed design requirements for all proposed buildings.

4.4 FLOOD EFFECTS

Requirement 2 – The flood impact of the development is to be considered to ensure that the development will not increase flood effects elsewhere, having regard to (i) loss in flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain. An Engineers report may be required.

Potential flood impacts are discussed in Section 3.1.

Modelling using the AJC TUFLOW model indicates that filling the entire site, without compensatory excavation, could increase design flood levels by as much as 3mm in a 100 year flood. Limiting the amount of fill placed within the site, in addition to compensatory excavation, is anticipated to reduce this impact to nothing.

It is recommended that potential flood impacts are further verified using the AJC TUFLOW model as part of future detailed investigations. This would include verifying boundary conditions of the TUFLOW model with the broader model being developed as part of the wider Georges River Flood Study, should these results be available at the time.

Requirement 4 – A floodway or boundary of significant flow may have been identified in this catchment. This area is the major conveyance area for floodwaters through the floodplain and any structures placed within it are likely to have a significant impact on flood behaviour. Within this area no structures other than concessional development, open type structures or small non habitable structures (not more than 30 sq m) to support agricultural uses will normally be permitted. Development outside the boundary of significant flood may still increase flood effects elsewhere and therefore be unacceptable.

No floodway or boundary of significant flow has been defined for this part of the catchment. This requirement is therefore not applicable.

Requirement 5 – Any filling within the 1% AEP (100 year) flood will normally be considered unacceptable unless compensatory excavation is provided to ensure that there is no net loss in floodplain storage volume below the 100 year flood.

Potential filling of the site, including compensatory excavation, is discussed in Section 3.2.

The site is currently within the 100 year flood extent and at least part of the site is proposed to be filled to a level above the 100 year flood. Compensatory excavation is therefore required to offset any loss in flood storage volume.

Compensatory excavation could be provided off-site from the nearby floodplain (subject to agreements), or included on-site within the subject site. An indicative plan showing balanced cut and fill earthworks provided on-site is shown on Figure 8. Actual earthworks will need to be determined as part of future detailed investigations.

4.5 CAR PARKING AND DRIVEWAY ACCESS

Requirement 2 – The minimum surface level of a car parking space, which is not enclosed (eg open car parking space or carport) shall be as high as practical, but no lower than the 5% AEP (20 year) flood level or the level of the crest of the road at the highest point where the site can be accessed. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 5% AEP (20 year) flood.

The entire site is currently located above the 20 year flood level, which satisfies the requirement for open car parking spaces. Open parking spaces would need to avoid any areas reserved for compensatory excavation.

Requirement 3 – Garages capable of accommodating more than 3 vehicles on land zoned for urban purposes, or basement car parking, must be protected from inundation by floods equal to or greater than the 1% AEP (100 year) flood plus 0.1m freeboard.

All basement parking areas will need to be protected from inundation up to at least the 100 year flood level plus 0.1m (ie a minimum of RL 8.5m AHD). A higher level of protection may be warranted given the number of new parking spaces proposed and the consequence of these areas being inundated.

Requirement 6 – The level of the driveway providing access between the road and the car parking space shall be no lower than 0.3m below the 100 year flood or such that the depth of inundation during a 100 year flood is not greater than either the depth at the road or the depth at the car parking space. A lesser standard may be acceptable for single detached dwelling houses where it can be demonstrated that risk to human life woulf not be compromised.

Levels on internal roads within the site have not yet been determined, but it is anticipated that all internal roads would be constructed at the 100 year flood level. This automatically satisfies the above requirement.

Requirement 7 – Basement car parking or car parking areas accommodating more than 3 vehicles (other than on rural zoned land) with a floor level below the 5% AEP (20 year) flood or more than 0.8m below the 1% AEP (100 year) flood level shall have adequate warning systems, signage and exits.

All basement parking areas will need to include adequate warning signs and safety exits to reduce the risk to occupants should these areas become suddenly inundated. These details would need to be determined during the detailed design of these structures.

Requirement 8 – Barriers to be provided to prevent floating vehicles from leaving the site during a 100 year flood.

Any open space parking areas provided below the 100 year flood level will need to include appropriate barriers to prevent vehicles parked in these areas becoming buoyant and floating off the site.

4.6 EVACUATION

Requirement 6 – The development is to be consistent with any relevant flood evacuation strategy or similar plan.

There is no known flood evacuation strategy for this part of Warwick Farm.

Requirement 9 – Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel.

Evacuation and access issues are discussed in Section 2.5.

Whilst there is up to 12 hours warning of impending flooding within the Georges River, the scale of the proposed development is such to warrant that all residents with a floor level with any susceptibility to flooding (ie below the PMF flood) to have access to a public area within their building that is above this level, where they can safely shelter-in-place until the flood threat abates.

Access to and from the site during periods of flooding is also an important consideration for residents. Whilst there will be an ability to “shelter-in-place” within the high rise development, there may be a number of reasons for people to gain access to or from the site during floods, including off-site evacuation, residents returning from work, picking up children, emergencies, etc. Improved vehicular access could be provided by including direct access from the north side of the site to the intersection of Warwick Street and the Hume Highway. Minor regrading of this intersection could provide direct access to the Hume Highway that is above the 100 year flood. In conjunction with raising the internal road to the 100 year level, this could provide access to all buildings that is free from inundation in such an event.

4.7 MANAGEMENT AND DESIGN

These requirements usually relate to subdivisions, the preparation of site emergency response flood plans, areas to store goods above the 100 year flood level, no storage of potentially hazardous materials, and finished land levels in new release areas. These requirements are not applicable to residential type development within a medium flood risk area, but would be applicable if the development was considered a commercial landuse. It is considered that these requirements can be satisfied, if required.

4.8 FENCING

Requirement 1 – Fencing within a High Flood Risk area, boundary of significant flow, or floodway will not be permitted except for permeable open type fences.

The site is not located within a high flood risk area, boundary of significant flow, or floodway. This requirement is therefore not applicable.

Requirement 2 – Fencing is to be constructed in a manner that does not obstruct the flow of floodwaters so as to have an adverse impact on flooding.

The site is primarily a flood storage area, with little or no flood velocity. Details of proposed fencing are not currently available, but it is anticipated that this requirement can be satisfied.

Requirement 3 – Fencing shall be constructed to withstand the forces of floodwaters or collapse in a controlled manner so as not to obstruct the flow of water, become unsafe during times of flood or become moving debris.

Details of proposed fencing are not currently available, but it is anticipated that this requirement can also be satisfied.

5. CONSIDERATION OF FUTURE SEA LEVEL RISE

5.1 NSW GOVERNMENT'S SEA LEVEL RISE PLANNING BENCHMARKS

The *NSW Coastal Planning Guideline* (NSW Govt, August 2010) and the *Flood Risk Management Guide* (NSW Govt, August 2010) place an onus on Council to identify the increased area of flooding as a result of future sea level rise, and to consider these impacts when assessing new development proposals.

A Sea Level Rise Policy Statement, issued by the NSW Government in October 2009 (DECCW, 2009), nominates sea level rise planning benchmarks to be considered by consent authorities when dealing with development approvals in the coastal zone. The planning benchmarks are an increase above 1990 mean sea levels of 40cm by 2050 and 90cm by 2100.

The Policy Statement notes that "*planning and investment decisions should consider the sea level rise projections over time frames that are consistent with the intended timeframes of the decision*" and that "*these decisions should consider likely sea levels over the expected life of an asset*". In the case of the proposed development, a planning benchmark based on the year 2100 would be appropriate.

The nominated planning benchmark values were subsequently withdrawn by the State Government, allowing Local Government to adopt their own levels based on local conditions. It is understood that there has been no revision to these planning benchmarks on the Lower Georges River.

5.2 IMPACT OF SEA LEVEL RISE ON FLOODING

A 'Sea Level Rise Impact Assessment for the Georges River' was previously undertaken for Bankstown Council (FloodMit, October 2012). The report considers the impact of increases in mean sea level for the 2050 and 2100 planning benchmarks on the 100 year design flood.

The impact on a mean sea level increase of +0.9m at Botany Bay was found to diminish relatively quickly upstream of Botany Bay. At Cabramatta Creek the increase in the 100 year flood level was estimated at +0.04m, and at Liverpool weir the increase was estimated at +0.01m.

The increase in the 100 year design flood at the subject site is therefore estimated at between +0.01 to +0.04m, based on the 2100 planning benchmark. This is a relatively small amount that is well within the freeboard allowance normally added to design flood levels. The impact of potential sea level rise is considered to have little impact on the proposed development of the subject site.

6 CONCLUSIONS

The site of the proposed development is located within the Georges River floodplain, and is potentially affected by flooding from the Georges River. The existing site is not affected by the 20 year flood, but would be inundated in the 100 year flood.

The design 100 year flood level for the site is RL 8.4m AHD (PWD, 1991). More detailed modelling of the Warwick Farm floodplain suggests a slightly lower estimate of RL 8.34m AHD (Bewsher Consulting, 2009). The eastern segment of the site is open space, and would be inundated to a typical depth of 0.6m in the 100 year flood. The western portion of the site was formerly occupied by 8 dwellings, which have recently been removed, and is typically inundated by 0.2m in the 100 year flood. The entire site would be classified as having a 'medium flood risk'.

The probable maximum flood (PMF) level is RL 10.7m AHD.

It is proposed to fill the majority of the site to the 100 year flood level, and to develop a number of high rise residential apartments. It is considered that the development of the site can comply with the requirements of Liverpool DCP 2008, Chapter 9 – Flooding Risk, subject to the following recommendations:

i) The feasibility of providing compensatory excavation, either within the site or off-site, is further evaluated;

ii) The final development footprint and associated earthworks are included in the Warwick Farm TUFLOW model to verify that the proposal has no adverse impacts on flood behaviour. This would include verifying boundary conditions in the model using the new Georges River Flood Study, should these results be available at the time;

iii) All building floor levels are a minimum of 0.5m above the 100 year flood level, and preferably higher;

iv) All basement parking areas are protected from inundation up to a minimum of the 100 year flood level plus 0.1m freeboard, and preferably higher;

v) Access to the site is amended to include access from the north of the site to Warwick Street and the Hume Highway, with minor modification of this intersection to raise it above the 100 year flood level. All internal roads to proposed buildings could then be filled to the 100 year flood level to provide flood free access (to Liverpool) in such an event.

7 REFERENCES

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