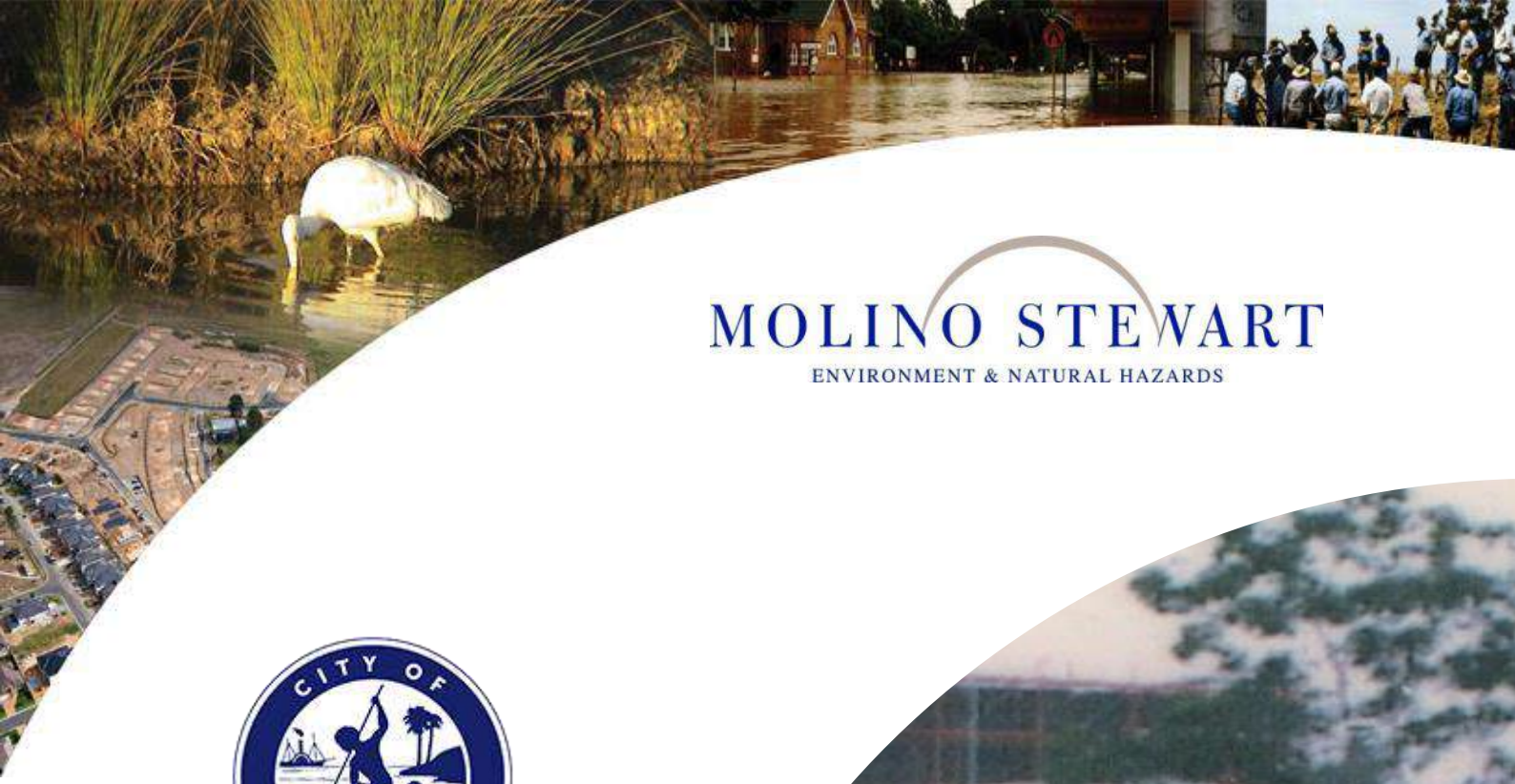

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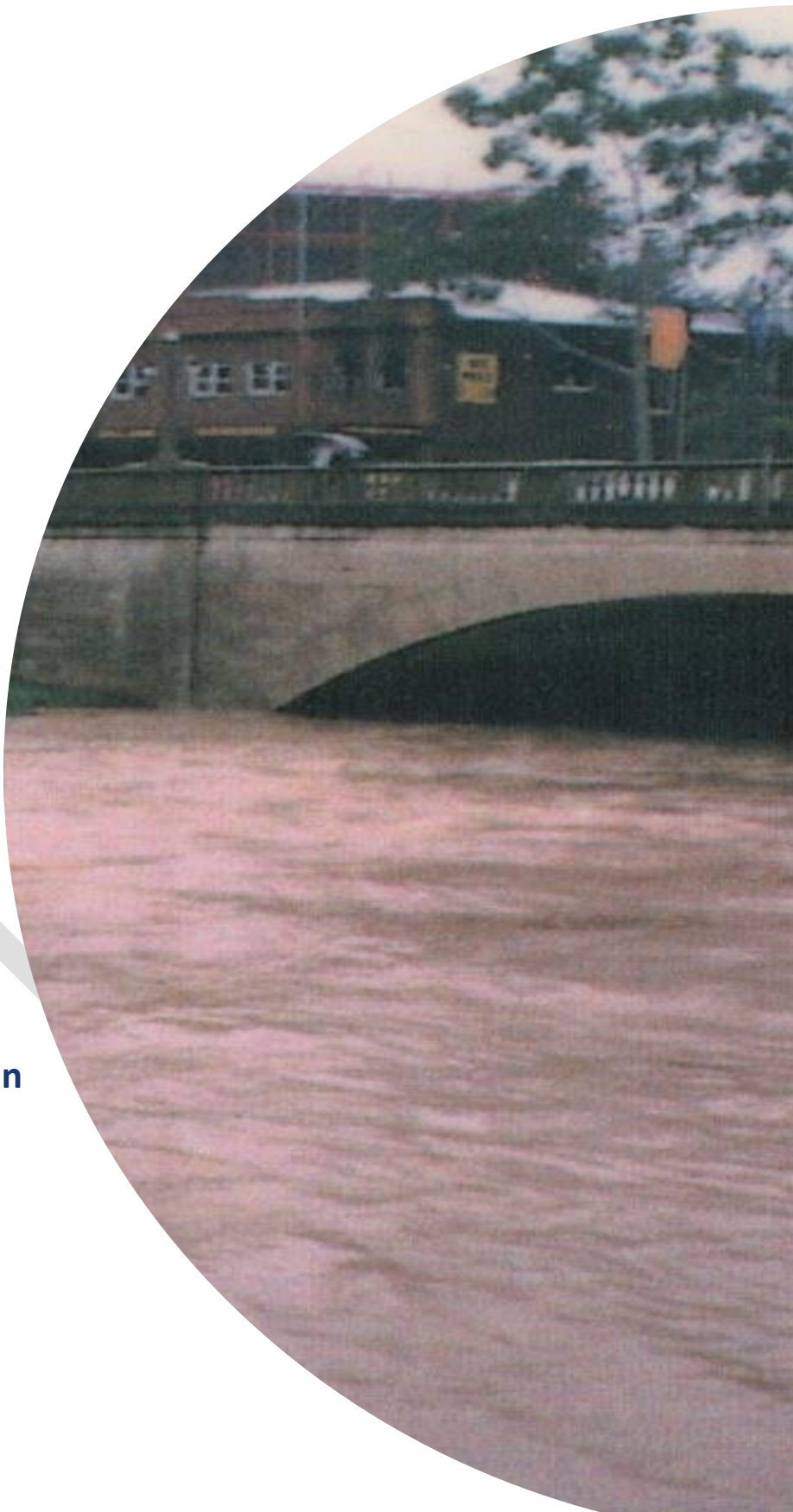

Update of Parramatta Floodplain Risk Management Plans

Draft

Update of Parramatta Floodplain Risk Management Plans

DRAFT

for

City of Parramatta Council

by

Molino Stewart Pty Ltd

ACN 067 774 332

OCTOBER 2019

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DOCUMENT APPROVAL

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EXECUTIVE SUMMARY

Parramatta is located geographically and demographically in the centre of Sydney and is often referred to, both officially and unofficially, as Sydney's second central business district (CBD). The NSW Government and City of Parramatta Council have identified Parramatta CBD as a key growth centre for commercial and residential development.

One of the constraints for development within the Parramatta CBD is that a significant proportion of the area is within the floodplain of the Parramatta River and its tributaries.

As part of its vision for growing the Parramatta CBD, the City of Parramatta Council has prepared the Parramatta CBD Planning Strategy, which is a road map to expanding the CBD through amending a number of planning controls, such as floor space ratios and also expanding the CBD boundaries. As part of the Parramatta CBD Planning Strategy, Council is required to submit a Planning Proposal to the Department of Planning, Industry and Environment to make alterations to the current Parramatta Local Environment Plan (LEP) 2011.

The *Environmental Planning and Assessment Act* 1979 sets out a number of requirements that must be met for planning proposals to be approved. One is Section 9.1 Direction 4.3 which deals with development on floodplains. A requirement of the direction is that a planning proposal must not permit a significant increase in development in that area unless it has been prepared in accordance with the NSW Floodplain Development Manual (2005).

Accordingly, Council has engaged Molino Stewart to review the two Floodplain Risk Management Plans that cover the Parramatta CBD area and prepare an updated Floodplain Risk Management Plan. The review and preparation involved the following steps:

- The existing plans were reviewed to determine which measures in those plans were still to be implemented
- Council officers were interviewed and field inspections of the CBD undertaken to identify practical challenges and risks to life and property which have arisen from existing development in the CBD floodplains
- The draft planning proposal was reviewed to identify opportunities which it provides to address existing flood problems and what new risks it presents
- A comprehensive flood risk assessment was completed with particular emphasis on risk to life to determine whether development intensification in the CBD is appropriate and whether it needs to be controlled to manage flood risk
- A detailed evacuation analysis was undertaken to assess the feasibility of various evacuation options and evacuation infrastructure upgrades
- Flood risk management measures were identified in consultation with the Parramatta Floodplain Management Committee
- A draft Parramatta CBD Floodplain Risk Management Plan was prepared.

This report concludes that the intensification of development in the Parramatta CBD represents a tolerable risk to life and property providing that amendments are made to the Parramatta LEP 2011 and Parramatta Development Control Plan (DCP) 2011 to better manage some of the risks of flooding to life. The review has also identified opportunities for DCP amendments to be made which could result in less development restrictions in parts of the floodplain and improved building design outcomes.

The draft plan proposes:

- An application to the Minister for Planning and Open Spaces for exceptional circumstances to impose controls above the Flood Planning Level for development within the Parramatta CBD affected by the Probable Maximum Flood (PMF)
- The development of four (4) risk to life categories for determining the different types of mitigation and response measures required
- The provision of shelter above the PMF level and a building access at or above the 1% AEP flood level within the LEP rather than just in the DCP to ensure that these minimum life safety measures are applied to all developments
- A total of 14 amendments to Parramatta DCP 2011
- A review of policy in relation to fencing and screening within floodways
- Better communication of the detailed flood information available through Section 10.7 certificates
- Encouraging NSW State Emergency Service to complete the update of the Parramatta Local Flood Sub Plan
- Investigation of Section 7.11 contributions to fund flood mitigation projects
- Improved communication and public education regarding flood risk, preparedness, response and recover
- Further development of the flood early warning system for the Parramatta River
- Encouraging Sydney Water to review its channel maintenance programs
- The preparation of a Flood Emergency Response Plan including plans for evacuation for the CBD

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1 INTRODUCTION

1.1 BACKGROUND

Parramatta CBD is currently undergoing significant growth and redevelopment. One of the potentially limiting factors to this growth is the availability of floor space for commercial and residential use. Currently Parramatta CBD has a shortage of prime commercial office space, with vacancy rates far lower than other major centres in Sydney and the Australian average.

The importance of a successful and growing Parramatta CBD is recognised by the NSW State Government, labelling Parramatta as a "CBD of metropolitan significance" (NSW Department of Planning and Environment, 2014). As such, the government considers the growth of Parramatta CBD to be crucial to the growth of Sydney as a whole. It subsequently released the Greater Sydney Region Plan (Greater Sydney Commission, 2018a) and the Central City District Plan (Greater Sydney Commission, 2018b) which further reinforced Parramatta's strategic role for the entire metropolitan region and the importance of future growth in Parramatta.

In response, City of Parramatta Council developed the Parramatta CBD Planning Strategy (the CBD Strategy), which was adopted on 27th April 2015. Key features of the strategy are:

- Expand the boundaries of the Parramatta CBD
- Increase the floor space ratio controls in certain areas
- Alter solar access controls
- Alter building height restrictions
- Expand the commercial core of the CBD

An implementation strategy for the CBD Strategy has been developed, which includes the development of a planning proposal to modify the Parramatta LEP 2011. In order for the planning proposal to be approved, a number of statutory obligations need to be met. This includes the Section 9.1 Direction 4.3 – Flood Prone Land of the *Environmental Planning and Assessment Act 1979* (the direction). Clause 3 of the direction "When this direction applies" states:

"This direction applies when a relevant planning authority prepares a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land"

The direction goes on to state what the planning authority must do when the direction applies. These requirements are generally in line with the NSW Flood Prone Land Policy and the Floodplain Development Manual (DIPNR, 2005).

One of these requirements is that a planning proposal should not permit a significant increase in development within flood prone land. The direction allows inconsistency with the requirements if the planning proposal is incorporated into a Floodplain Risk Management Plan that has been created in accordance with the principles and guidelines of the Floodplain Development Manual (2005).

Significant areas within Parramatta CBD are flood prone. Floodplain risk management of these flood prone areas is generally undertaken under two existing floodplain risk management plans (the original plans), these are:

- The Floodplain Risk Management Plan for the Upper Parramatta River Catchment, Bewsher Consulting for the Upper Parramatta River Catchment Trust (April 2003)
- The Lower Parramatta Floodplain Risk Management Plan, SKM for City of Parramatta Council (August 2005).

In order to meet the requirements of the direction, Parramatta Council is updating the two original plans in light of the changes that have been made to both the land use and regulatory and planning frameworks as well as the future land use changes proposed by the CBD Strategy.

1.2 OBJECTIVES

The primary objectives of this project are to:

- Update the two original plans in light of the land use and regulatory changes that have occurred since the plans were adopted as well as incorporate the implementation of the plans that has occurred to date.
- Ensure that the planning proposal as part of the CBD Strategy is consistent with Section 9.1 Direction 4.3 of the *Environmental Planning and Assessment Act 1979*.

1.3 STUDY AREA

The study area covered by this project is the planning proposal extent. This area is a subset of the area of the two existing plans, which cover a much larger part of the Parramatta LGA. Some elements of the existing plan review cover areas outside of the planning proposal extent, however, these are not the focus of the study.

Figure 1 shows the extent of the planning proposal area. It also shows the lots that have been identified through preliminary analysis that are likely to be subject to redevelopment as a result of the planning proposal.

The planning proposal area is the subject of the risk assessment that has been undertaken to determine whether the planning proposal meets the requirements of the direction.

1.4 SCOPE OF THE UPDATE

The Floodplain Development Manual (2005) recommends a floodplain management process which involves data collection followed by a flood study then a floodplain risk management study followed by a floodplain risk management plan. This process should be revisited periodically using updated information.

This report is an update of the two existing floodplain risk management plans without new data collection or an update to the flood study or floodplain risk management study.

It relies mostly on data, such as model results, that have been gathered as part of the development of the original plans. The focus of this project is to update the floodplain risk management plan utilising the existing flood data and to apply it in light of:

- Changes to the regulatory framework since the original plans were developed
- Land use changes that have occurred since the original plans were developed and changes that will occur in the future through the planning proposal.
- Changes to the planning environment that has occurred since the development of the Original Plans.

At the time of writing, Council was in the process of finalising a new flood study to cover the Upper and Lower Parramatta River floodplains within the LGA.

It is understood that this new Flood Study will produce significantly more detailed and accurate data for the assessment of flood risks within the LGA. However, it is currently anticipated to be completed in 2020, with an updated floodplain risk management study and plan likely to be completed following that. Therefore this plan update was required to bring the original Plans in line with the new regulatory framework, land use and planning instruments in the interim. It is recommended that this study is reviewed once the new data from this Flood Study has been received.

A draft of this report was forwarded to the then Department of Planning and Environment in support of a request for a Gateway determination on the Draft Parramatta CBD Planning Proposal 2017. That draft of this report recommended that the (then) City of Parramatta Council request that “exceptional circumstances” be granted for the CBD under Section 9.1 Direction 4.3 Flood Prone Land. The Department requested that further investigations be carried out in relation to flood evacuation options to support that request. That report was submitted (Molino Stewart, 2017).

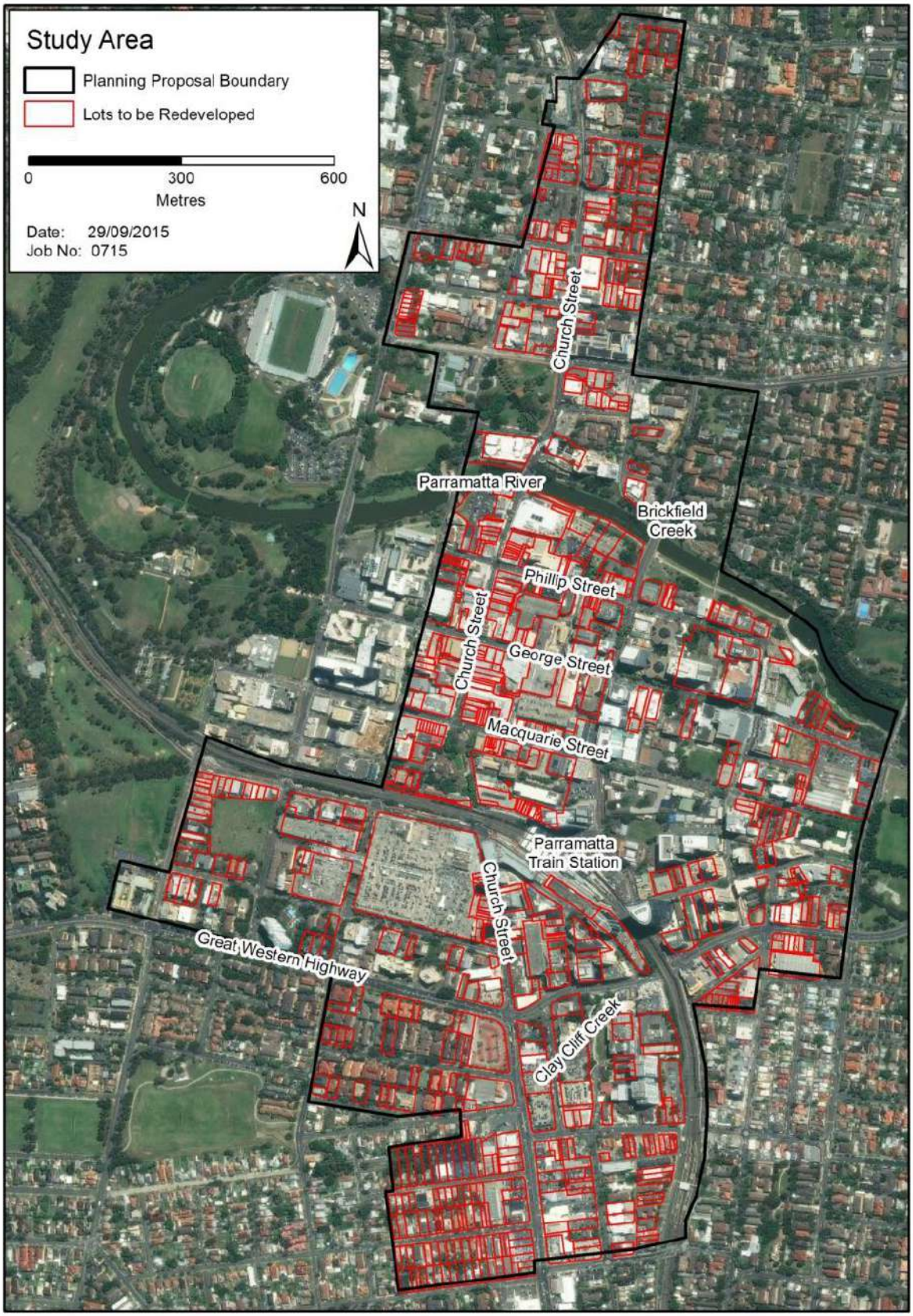

Figure 1: Planning Proposal Extent and potential redevelopment lots

In December 2018, the Department issued a conditional Gateway determination to allow the planning proposal to be updated and consolidated. This included several conditions to seek further clarification or evidence to support the planning proposal.

One of those conditions was that Council:

"update the planning proposal and maps to provide a consolidated explanation of provisions and assessment of the intended outcomes as amended by this Gateway determination, and review the studies that have been prepared to support the planning proposal and update if required."

It also granted exceptional circumstances to enable further agency consultation on the planning controls that will apply to land impacted by the PMF.

To comply with the condition above, the Flood Evacuation Report was updated to incorporate new information which had become available since it was first prepared and this report has been updated to take into account the findings of the Flood Evacuation Report and to incorporate other changes which have occurred since this report was first drafted.

1.5 REPORT FORMAT

This report has been structured in the following way:

- Chapter 2 places the project in the context of the various planning documents and instruments
- Chapter 3 is a review of the existing plan measures, and focuses on whether they have been implemented and which, if any, of those measures need to be carried through or amended in the updated plan
- Chapter 4 describes the planning proposal and outlines its practical implications with regard to flooding
- Chapter 5 is a flood risk assessment which describes the flood risk assessment procedure undertaken on the planning proposal
- Chapter 6 presents the potential Management options arising from the flood risk assessment
- Chapter 7 is the conclusions and recommendations
- Chapter 8 is the recommended Updated Floodplain Risk Management Plan
- Chapter 9 is a list of reference documents used in the project.

2 PLANNING CONTEXT

This chapter sets out the relevant planning documents that have been taken into account when undertaking this project.

2.1 EXISTING FLOODPLAIN MANAGEMENT PLANS

Improvements to floodplain risk management within the study area are currently undertaken according to the two original floodplain risk management plans.

These plans provide a clear set of suggested measures to be undertaken by Council and other authorities in order to reduce the flood risk in the study area. These measures generally fall under three categories:

- Flood Modification Measures: These modify the behaviour of the flood itself by reducing flood levels or velocities
- Property Modification Measures: These modify either the existing buildings (voluntary house purchase/raising) or future development (through development controls) within the floodplain
- Response Modification Measures: These actions modify the response of the population to the flood threat, generally through community education or improvements to emergency management.

Further investigation of potential options may also be measures within a plan.

The original plans have a number of proposed actions that fall into each of these categories. However, since the development of the original plans, a number of these measures have been made redundant, particularly where:

- The regulatory framework has changed such that the suggested measure would no longer be viable (e.g. repeal of REP 28 - Parramatta)
- Further investigations have shown that the suggested measure is not effective or feasible

2.2 STRATEGIC PLANS

The NSW State Government and City of Parramatta have prepared a number of strategies and plans that outline the future growth of Parramatta. These include:

- Greater Sydney Region Plan A Metropolis of Three Cities – connecting people (Greater Sydney Commission 2018a) outlines vision for the Greater Sydney Region, focuses on three cities (Western Parkland, Central River and Eastern Harbour) within the Greater Sydney Region and is based on the expectation that the population will be 8 million residents in 2058. The population in the 'Central River City' is expected to increase from 1.3 million to 1.7 million by 2038.
- Our Greater Sydney 2056 Central City District Plan – connecting communities (GSC 2018b) is a 20 year plan working towards the 40 year vision outlined in the Greater Sydney Region Plan. Parramatta is at the Centre of the Central City District. As part of this strategy an increase of 55,000 to 70,000 jobs throughout Greater Parramatta is planned, to be supported by new development,
- The Economic Development Plan 2017-2021 (City of Parramatta Council 2017) aims to increase the number of jobs in the Parramatta LGA by 20,000 by 2021, 9,500 of which are expected to be in the CBD. This will be supported by the investment and development currently taking place in the CBD, as well as a range of strategies from council.
- The Community Strategic Plan 2018-2038 (City of Parramatta Council, 2018) puts strategies in place to manage the elements of growth that the City can influence, leading to an improved quality of life for all.

In the 2016 Census 137,329 people listed Parramatta as their "Place of Work" with the Economic Development Plan suggesting 47,000 of those were in the Parramatta CBD.

While a significant number of the projected new jobs will be located in various precincts with Parramatta LGA, it is likely that the majority of the growth will occur inside the CBD.

The CBD Strategy has been developed by Council over a number of years as a response to the planned jobs growth and is aimed at amending the planning controls within the CBD. The vision of the strategy is:

"Parramatta will be Australia's next great city, defined by landmark buildings and high quality public spaces with strong connections to regional transport. It will respect its heritage, be an exemplar in design excellence, facilitate job growth and ensure its streets are well activated"

In order to achieve the vision, the CBD strategy proposes to:

- Expand the boundaries of the Parramatta CBD into the neighbouring area.
- Amend planning controls to encourage re-development to create larger buildings. This is achieved through increasing the allowable floor space ratios and removing building height restrictions (where this is not constrained by other factors such as solar access).

2.3 STATE FLOOD PLANNING DOCUMENTS

2.3.1 Environmental Planning and Assessment Act 1979 Section 9.1 Directions

Section 9.1 of the EP&A Act permits the Minister for Planning to issue a direction in relation to the making of local environmental plans. Several of these have been issued including Direction 4.3 which related to flood prone land.

The objectives of the direction are to ensure that the development on flood prone land is consistent with the Flood Prone Land Policy and the Floodplain Development Manual (2005) and also to ensure that the planning proposal considers flood hazard and the flood impacts on and off the subject land.

The requirements of the direction are:

- The planning proposal must be consistent with the NSW Flood Prone Land Policy and Floodplain Development Manual (FDM)
- The planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone
- The planning proposal must not contain provisions that apply to the planning areas which:
  - permit development in floodway areas
  - permit development that will result in significant flood impacts to other properties
  - permit a significant increase in the development of that land
  - are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services
  - permit development to be carried out without consent except for the purposes of agriculture, roads or exempt development
- The planning proposal must not impose flood related development controls above the residential flood planning level for resident development on land, unless adequately justified
- The planning proposal must not determine a flood planning level that is inconsistent with the FDM

The direction also includes an allowance for inconsistencies. A planning proposal may be inconsistent with the direction if it can satisfy the Department of Planning that:

- The planning proposal is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual (2005)

Or

- The provisions of the planning proposal that are inconsistent are of minor significance

As discussed in previous sections of this report, the aim of the planning proposal is to

essentially permit a significant increase in development within the existing and expanded CBD. Because much of the planning area is floodplain, the planning proposal has the potential to "permit a significant increase in the development of" the floodplain. As such, the planning proposal is not consistent with the direction.

In order to satisfy the requirements of the direction, an updated floodplain risk management plan prepared in accordance with the NSW Floodplain Development Manual, is required.

2.3.2 NSW Flood Prone Land Policy

The NSW Flood Prone Land Policy (2005) outlines the approach taken by the NSW Government to development on floodplains.

The primary objective of the policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods where possible.

The policy sets out the roles and responsibilities of those involved in planning and controlling floodplain development. These are:

- Councils are primarily responsible for the management of flood prone land. Their role is to establish planning controls and measures to reduce flood risk by utilising the methods set out in the FDM
- The NSW Government, through the Office of Environment and Heritage, provides financial and technical support to councils to ensure that the approach is applied consistently across the state
- Floodplain Risk Management Committees, community based committees established by Council, are responsible for reviewing the floodplain development process and communicating their aspirations concerning the management of flood prone land.

Some other key sections of the policy include:

- Recognition that flood prone land is a valuable resource and should not be sterilised by unnecessarily precluding its development
- Promotion of a flexible merit based approach to be followed by Council and recognition that if strict criteria are applied then some appropriate proposals may be unreasonably disallowed and alternatively some inappropriate proposals may be approved
- Protection for Council and other public authorities against claims for damages, provided they have acted in accordance with the Policy and the FDM (as per Section 733 of the *Local Government Act, 1993*)

2.3.3 NSW Floodplain Development Manual

The FDM sets out the methodology in which floodplain management is undertaken in NSW. It builds upon the approach set out in the NSW Flood Prone Land Policy and provides guidance on how to enact the principles of the policy.

The manual is built upon a risk management approach. It promotes quantification of the probability (how often will floods occur?) and the consequences (what people and assets are exposed, what is the hazard of the water, what are the tangible and intangible damages) to determine the risk. The manual promotes management measures to reduce the risk, either by decreasing the probability, the consequence or both.

The core of the manual is the Floodplain Risk Management Process which sets out an iterative approach to mitigate the risk, then review and determine if the residual risk can be mitigated. The process generally follows:

- Formation of the Floodplain Risk Management Committee
- Data Collection
- Flood Study
- Floodplain Risk Management Study
- Floodplain Risk Management Plan
- Plan Implementation

Figure 2 concisely outlines the floodplain development process. The floodplain development manual is essentially followed for all floodplain management within NSW.

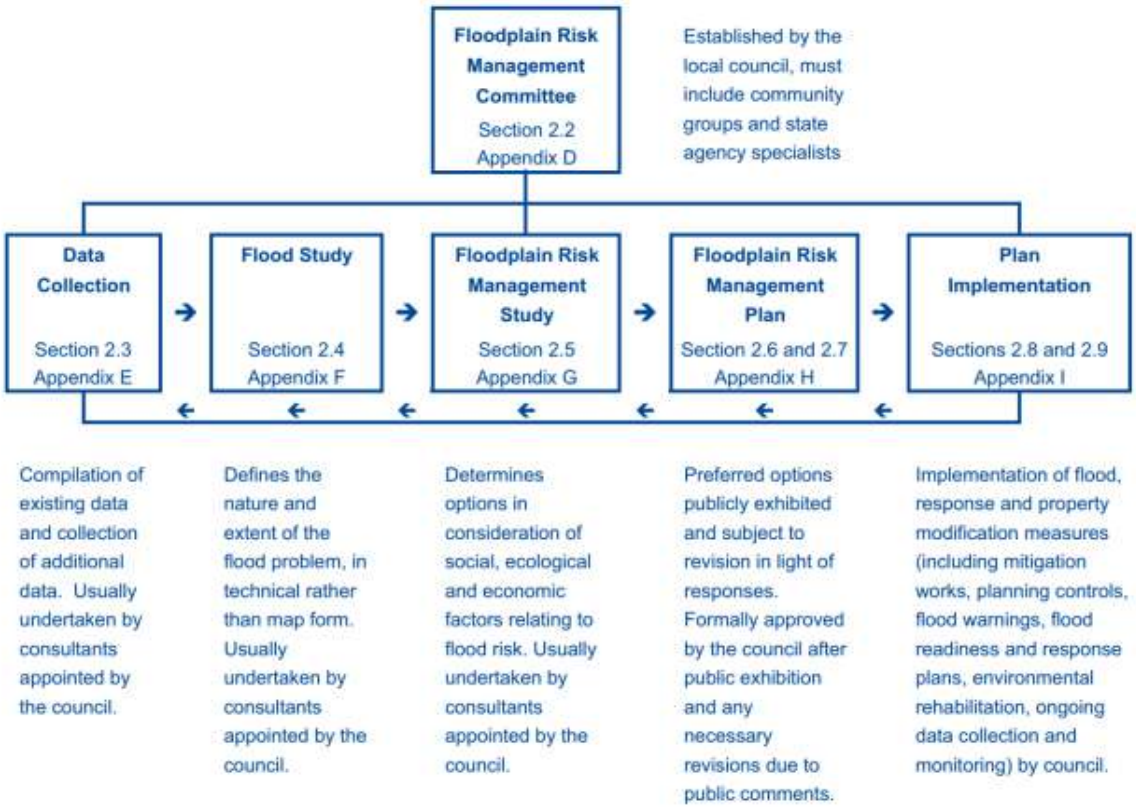

Figure 2: Floodplain Development Process (From DIPNR 2005)

2.4 LOCAL PLANNING INSTRUMENTS

2.4.1 Parramatta Local Environment Plan (LEP) 2011

The Parramatta LEP 2011 applies to the whole area covered by the FRMP. This LEP is a standard instrument LEP and as such the wording and structure are generally set out by the NSW Department of Planning, Industry and Environment. With respect to flood planning, the LEP has a number of conditions that the development must satisfy rather than a number of potential impacts that the consent authority must consider in its determination.

The main conditions for approval are that the development:

- Is compatible with the flood hazard of the land
- Is not likely to significantly adversely affect flood behaviour resulting in increases in the flood affectation of other properties
- Incorporates appropriate measures to manage risk to life from flood
- Is not likely to significantly adversely affect the environment or cause erosion, siltation, destruction of vegetation etc.

The Standard Instrument LEP also sets the flood planning level as the 100 year average recurrence interval (ARI) event plus 0.5 m of freeboard.

2.4.2 Parramatta Development Control Plan (DCP) 2011

The Parramatta DCP 2011 (Included as Appendix B) sets out the development controls with regard to flooding for the Parramatta LEP 2011. One of the aims of the DCP is to assist development in conforming to the requirements of the LEP. Where the LEP lists a requirement for a certain potential impact to be considered, the DCP has been written such that if it is followed, that impact is likely to be minimised.

The DCP uses a matrix of controls depending on the Flood Risk Precinct (Low, Medium or

High) and Land Use Type (Residential, Commercial, Critical Uses & Facilities etc.) and categorises the development controls against a number of aspects, including:

- Floor level
- Building Components
- Structural Soundness
- Flood Affectation
- Car Parking and Driveway Access
- Evacuation
- Management and Design

This approach is consistent with many other Councils within the Sydney Region and is generally considered best practice. However, the Land Use definitions and controls tend to vary between Councils. For example, the Parramatta DCP Matrix would classify a hospital as a "Sensitive Use" while the Fairfield City Wide DCP 2013 and the Bankstown DCP 2015 have classified a hospital as a "Critical Use". The outcome, in terms of planning controls for all three DCPs, is the same for hospitals.

For this project critical controls were compared across the Parramatta, Fairfield and Bankstown DCPs. the controls examined included the floor levels, evacuation and car parking and driveway access controls for the Low and Medium Flood Risk Precincts for Residential and Commercial Development. It was found that the Parramatta DCP was fairly similar to the Fairfield and Bankstown DCPs, with minor variations such as the level of basement car parking (Parramatta uses the 1% AEP plus 0.5 m freeboard, Fairfield the 1% AEP and Bankstown the 1% AEP plus 0.1 m freeboard).

At the time of writing the Parramatta DCP was under review by Council.

The controls set out in the DCP are in line with the objectives of the Floodplain Development Manual 2005.

2.5 PARRAMATTA FLOOD POLICY

Molino Stewart previously reviewed the Parramatta Flood Policy as part of the development of Council's City River Strategy. Council is updating the currently adopted Flood Policy taking into consideration that review.

Four principles influence the current flood policy:

- Flood prone land is a valuable resource that should be managed and developed, subject to a merit approach that provides due consideration to social, economic and environmental criteria, as well as any flooding criteria, as identified in flood studies, independent assessments or strategically developed floodplain risk management studies and plans
- Both mainstream and overland flooding are to be considered when assessing flood risk
- Flood prone land should not be sterilised by unnecessarily precluding development through the application of rigid and prescriptive criteria, however inappropriate proposals should not be accepted
- Measures to increase resilience across the LGA should be encouraged so as to reduce the long term effects of flooding when it occurs.

The Policy is being implemented through the following over-arching processes:

- Preparing co-ordinated development controls
- Establishing a development application process
- Where appropriate and feasible, encouraging the conversion of "High Risk Hazard Zones" or "Floodways" to natural waterway corridors
- Establishing a rolling program of reviews of floodplain risk management studies and plans to ensure flood data is as up-to-date as possible, especially in Council's priority and growth areas
- Establishing an access portal on Council's website to display relevant flood studies, plans and maps adopted by Council

- Implementing a community engagement program, designed to ensure the community in general, and specifically any proponents of development, are aware of the potential flood hazard and consequent risk and liability associated with the use and development of flood liable land.

2.6 FLOOD RESPONSIBILITIES

Table 1 shows the range of organisations involved in floodplain management activities and their diverse responsibilities.

Table 1: Floodplain Management Responsibilities

Floodplain Management Actions		Organisation and its responsibility					
		FMC	**Council**	**DPIE** [1]	**NSW SES**	**Sydney Water Corporation** [2]	**BoM**
Flood Modification	Detention Basins and modifications to drainage infrastructure	Recommend	Approve, Fund, Design, Construct, Maintain	Approve, Co-Fund		Approve, Fund, Design, Construct, Maintain	
	Levees	Recommend	Approve, Fund, Design, Construct, Maintain	Approve, Co-Fund			
	Cleaning Drains	Recommend	Fund and implement			Fund and implement	
Property Modification	Voluntary House Purchase, Voluntary House Raising	Recommend	Approve, Co-Fund	Approve, Co-Fund			
	Planning Controls	Recommend	Draft, Regulate	Approve			
Response Modification	Community Education	Recommend	Approve, Fund, Undertake		Approve, Fund, Undertake		
	Emergency Planning	Recommend	Approve, Fund, Undertake		Approve, Fund, Undertake		
	Flood Warning Systems	Recommend	Approve, Fund, Design, Construct, Operate, Maintain	Approve, Co-Fund	Advise, use		Advise, use

1. DPIE may co-fund some flood mitigation measure using State Government funds or State and Federal Government funds.

2. only has responsibility where drainage assets (principally concrete lined stormwater drains) are SWC assets.

3 EXISTING MANAGEMENT PLAN

3.1 STATUS REVIEW

As part of the update to the Parramatta Floodplain Risk Management Plans, a review of the existing plans was undertaken. The focus of the review was to determine to what extent the existing plan measures have been implemented by Council.

Across the two plan areas there were 39 major recommendations, covering:

- Revisions to planning controls
- Property modifications (voluntary house purchase and house raising)
- Response modifications
- Flood modifications.

A qualitative assessment of the implementation status of the original recommendations follows.

3.1.1 Revisions to Planning Controls

In general, the revisions to planning controls had been completed, or the proposed revisions have become redundant because of changes to planning instruments driven by other considerations.

Some of the issues which have not been fully resolved include:

- changes to wording within the DCP and S10.7 certificates
- investigations into the potential for S7.11 contributions to contribute to flood mitigation measures
- controls on fencing and screening in high hazard and overland flow areas.

3.1.2 Property Modifications

Council has generally implemented the recommended property modifications or upon further investigation has found that they were not feasible.

A number of properties have been voluntarily acquired or raised.

Council is currently undertaking a new flood study that will likely identify a number of areas where further property modifications can be undertaken to mitigate flood risk.

3.1.3 Response Modification

The response modification measures within the plans generally fall within three categories, these are:

- Flood Emergency Response Planning - Council and the NSW SES are continuing to work on the local flood emergency response plans, and significant hydraulic analysis has been undertaken on other areas within the CBD. However, the updates have not been completed because of resourcing constraints, particularly for the Local Flood Plan
- Flood Warning – There is no specific recommendation in either plan regarding flood warning but Council has installed a flood early warning system for the CBD
- Community Awareness and Education - There are a number of recommendations within both plans with respect to community flood risk awareness and community education. Council has implemented its Floodsmart program in association with its warning system implementation. This makes flood related information available of Council's website and there have been other efforts made to disseminate information about flood risks to the community.

3.1.4 Flood Modifications

The existing plans recommended a number of flood modification works, including detention basins and levees and a number of drainage improvements such as culverts and pipes. It was recommended that some be investigated further to determine feasibility. These measures have generally been implemented or otherwise found not to be feasible.

Some investigations are still underway. Some measures have not been put in place because it was determined that it would be more

efficient to resolve the flood problem through re-development.

Additionally, the plans recommended rubbish and vegetation removal and de-snagging within a number of channels. All trunk drainage channels within the CBD area are owned and maintained by Sydney Water. It is understood based on previous advice from Sydney Water that they have a regular operation and maintenance program. Council also requests Sydney Water to clean and remove debris collected within these channels as and when this becomes known to Council and when residents or the general public inform Council through its Service Request System.

3.2 PRACTICAL CHALLENGES

The opportunity was also taken to discuss with Council officers any known practical difficulties or problems which have been identified through implementation of the existing plan.

Discussions with Council officers revealed that the way in which some developments have been built to comply with existing flood planning controls have had unintended consequences or resulted in sub-optimal design outcomes. Issue of main concern are:

3.2.1 Car Parks

If a basement car park is flooded, it will create extremely high hazard waters for anyone that is stuck in the basement or otherwise attempts to access it.

There is a critical difference between basement flooding and over floor flooding. For example, if a normal residence is built at the level of the 1 in 100 Year ARI plus 500 mm freeboard, and a flood level is 0.3 m higher, it will only produce low hazard waters within the dwelling and some property can be protected on tables.

In the same flood, if the flood level is 0.3 m greater than the lip level of a basement car park, it will create an extremely high velocity, high hazard floodway as the floodwaters rush over the lip and into the basement, it will then progressively fill the basement and create extremely deep pools or high hazard water.

For this reason, the DCP discourages basement car parks but if the site requires one it must have be protected to the level of the PMF. Council officers have indicated this can provide significant design challenges.

3.2.2 Critical Infrastructure

As the 2011 floods in Brisbane highlighted, the placement of critical building infrastructure (electricity transformers, lift motors, water pumps) in basements and ground floors can significantly delay the reopening of a building after flooding. Consideration needs to be given to development controls to ensure that this infrastructure is given an appropriate level of flood protection.

3.2.3 Activate Building Edges

An issue which has emerged as developers design buildings in flood prone areas is the connectivity between the footpath and the floor level of the building, particularly in areas where the 1 in 100 Year ARI plus 500 mm freeboard is significantly higher than ground level. This presents an issue for areas such as the CBD where there is typically retail or restaurant development on the ground floor, and the floor level difference presents a barrier to customers. This issue is shown in Figure 3 and Figure 4 where the shop fronts are set back and raised and out of eye level for pedestrians.

Figure 3: Activated Building Edge Example

3.2.4 Fire Exits

There are many examples of recent development in the floodplain where the fire exit door is set at ground level but the minimum building floor level is considerably higher. All fire exits are required to open outwards from the building, however, if the fire door was required to be used during a flood, this door may be impossible to open as it is likely there would be a higher water level outside than inside, and this head (water level) difference would stop the fire exit door from opening. This is highlighted in Figure 4 where the minimum floor level can be seen by the stairs in the blue building, and the fire exit is shown between the two sets of stairs. Figure 5 also shows this where the steel screen on the right is the level of the floodway (these rise during a flood to allow flow underneath) and is shown to be over halfway up the height of the fire exit.

Figure 4: Fire Exit and Ground Level Example 1

Figure 5: Fire Exit at Ground Level Example 2

3.2.5 Flow Under Buildings

In some areas through the CBD, particularly along Clay Cliff Creek, a number of buildings have been set above the ground level with a gap beneath the building to allow for flow. This has been required as the buildings are situated over floodways and if there was no flow underneath the building it would have an impact on their neighbours.

The issue arises where the area beneath the building is screened off so that there is no access, and these screens, in many cases, would not allow any flow through, as can be seen in Figure 6. In some cases, as shown in Figure 7, the flow area has been further blocked by fencing or other materials in an attempt to enclose the flow area and use it for storage.

Figure 6: Screening Example 1

Figure 7: Screening Example 2

3.2.6 Early Flood Warning

City of Parramatta Council has installed an early flood warning system for the Parramatta River. It has had a slow uptake of subscribers and Council is looking at ways to ensure more people are receiving and understanding flood warning messages as well as improving the accuracy and timeliness of warnings.

3.2.7 DCP Wording

Council officers and others have observed that some of the wording in the DCP is ambiguous or misleading. This includes the reference to "flood risk precincts" which are essentially a mapping of flood probability which is only one contributor to flood risk.

3.2.8 S10.7 Certificate Wording

Council officers have observed that property inquiries and sales generate the production of Section 10.7 certificates. In Parramatta the Section 10.7(2), which legally must accompany any property sale contract, only makes some general statements about the flood affection of the property. A more detailed Section 10.7(5) certificate can be purchased to obtain the more detailed information about flood affection of the property.

Council officers want to consider ways in which it could be made clear that the S10.7(2) certificates do not contain all flooding information. Recommended that a guide to making the decision of purchasing S10.7(2) or S10.7(5) is included within the application form.

3.3 MANAGEMENT OPTIONS

Table 2 shows the potential options to be included in the updated plan. These measures are based on the existing plan review, discussion with council officers and field inspections. Some are updates to measures that were recommended as part of the existing plans.

Table 2: Potential Management Options Arising from the Existing Plan Review

Measure Type	Proposed Measure	Source
Planning Control	Revise the wording of the DCP and S10.7 Certificates	Upper and Lower Parramatta Plan, Council officers
Planning Control	Council to consider ways in which S7.11 contributions could be made towards flood mitigation projects.	Upper and Lower Parramatta Plan, Council officers
Planning Control	Council to develop a policy with respect to fencing and screening within floodways. This policy could result in provision of appropriate staffing levels to allow existing floodways to be inspected to ensure pathways are still clear.	Lower Parramatta Plan, Council officers
Planning Control	Review the requirement for basement car parks to be protected up to the level of the PMF.	Council officers
Planning Control	Consider introducing planning controls for the protection of critical building infrastructure	Council officers
Planning Control	Consider planning controls which enable the activation of building edges at street level	Council officers
Planning Control	Consider planning controls which reduce the risk of fire doors being blocked by floodwaters	Council officers
Response Modification	Council to encourage the NSW SES to finalise development of the Local Flood Sub Plan	Lower Parramatta Plan, Council officers
Response Modification	Council review the availability of flooding data to the public and develop a community awareness and education policy and program for ensuring the population at risk is aware of the flood risks to life and property.	Upper and Lower Parramatta Plan
Response Modification	Council continues developing the Flood Early Warning System for Parramatta CBD and includes a program for review and continuous improvement of the system and means of disseminating more accurate and timely warnings to more people.	Council Officers
Flood Modification	Council to encourage Sydney Water to conduct a review of the maintenance program for the channel including removal of rubbish and excess vegetation	Lower Parramatta Plan

4 THE PLANNING PROPOSAL

The planning proposal for the CBD Strategy is to allow for the expansion of the Parramatta CBD boundary as well as amendments to a number of building controls within both the current CBD and the extended CBD area. Primarily these building controls relate to Floor Space Ratios (FSR) and building height restrictions.

The net effect of the planning proposal is to increase the capacity of the CBD both in terms of commercial and residential floor space. This increase in floor space is effectively on top (i.e. higher) than the current development and does not open up any new areas (green fields) for development.

It should be noted that the current controls on the development within and around the CBD allow for reasonably significant redevelopment of the planning proposal area.

In a general sense, the planning proposal would allow the development in the core part of the development for buildings up to around 50 storeys, as opposed to the existing controls which allow buildings up to around 30 storeys, while around the fringes it would allow buildings up to 10 to 30 storeys where buildings of around 5 storeys are currently allowable.

4.1.1 Built Form

Given the current and projected demands for space within the Parramatta CBD area, all re-development is likely to be for the construction of “high rise” buildings for either commercial office space or for residential apartments. Many of these developments will have retail or hospitality establishments on the ground floor; others may be limited to foyers on the ground floor. Car parking will be located either on basement levels or above the ground floor.

4.1.2 Planning Controls

The Parramatta DCP 2011 would classify the land use as either Commercial or Residential (with respect to flooding). For Residential development, the development could also be considered as within the Concessional Development Land Use category, the controls on concessional development are relatively similar to residential development, with some extra conditions such as maintaining floodways.

The DCP planning considerations for both Residential and Commercial are the same for all flood risk precincts with the exception that in the low flood risk precinct a residential development is required to have reliable pedestrian and vehicle access to an area above the PMF (either on site or off site) whereas for commercial development this is not required.

All new residential and commercial buildings would have to have minimum habitable floor levels above the flood planning level which is 0.5m above the level of the 100 ARI flood.

As all new buildings which are redeveloped as a result of the new CBD Strategy will generally be taller than 10 m, it is expected that the redevelopment would provide areas within each building above the level of the probable maximum flood (PMF).

5 FLOOD RISK ASSESSMENT

In accordance with the requirements of the Section 9.1 Direction 4.3A, a flood risk assessment has been undertaken on the CBD Strategy planning proposal. This has been undertaken in accordance with the principles and guidelines of the NSW Floodplain Development Manual and Flood Prone Land Policy. This chapter explains how it was undertaken and the results of the analysis.

5.1 FLOOD RISK APPROACH

The approach taken to this flood risk assessment conforms to the principles of the NSW Floodplain Development Manual (2005). Where possible we have quantified the change in flood risk due to the planning proposal and where quantitative analysis was not possible or not appropriate we have made some qualitative assessments.

The approach was to define the existing flood risks to the existing population at risk and then examine how both the flood risks and population at risk will change due to the planning proposal and to determine whether these changes are significant.

5.2 DATA USED

5.2.1 Flooding Data

Flooding data was provided by Council covering the two original plan areas. For both areas the data provided was produced by MIKE11 one dimensional models.

For the Lower Parramatta River area, the model was developed over a period of time and updated as part of the Flood Study Review, completed in 2005 by SKM. The model utilised over 600 cross-sections and included detailed representation of the Clay Cliff Creek waterway system.

For the Upper Parramatta River area, the model was first developed by the then Department of Water Resources and the Upper Parramatta River Catchment Trust in the early 1980's. Significant work has been undertaken over the years since then to refine the model. The Draft 8 Version of the model has been adopted by Council and the data from this version has been provided and used as part of this study.

The flooding data that has been provided for the area includes:

- Flooding extents from the 20 Year, 100 Year Average Recurrence Interval (ARI) and PMF design events from the Upper Parramatta River and Lower Parramatta as well as other studies that have been undertaken.
- The low, medium and high hazard areas as defined by Parramatta Council (see section 5.3.3).
- Results from the two MIKE11 models (Upstream and Downstream extents) for a range of events in the native DHI .res11 format

The flood model data has been developed over a long period of time and integrates a significant amount of data and intelligence that has been gathered over that time. However, since the time of its development, the modelling software and techniques that have been used have become dated and no longer represents best practice in floodplain risk management. Therefore, there are some limitations to, and assumptions that have been made in respect of, the analysis that has been undertaken due to the limitations to the model results provided.

Council is in the process of preparing a new two dimensional flood model which would include the CBD study area but that was not available at the time of writing.

5.2.2 Topographic Data

Contour data was provided by Council at a 1 m contour interval. This has then been processed into a Digital Elevation Model (DEM) with a 1 m grid resolution. While this process requires some data interpolation, the DEM, with an appropriate colour ramp, is easier to interpret than contour information.

The contour data would also miss any topographic variations that are less than a metre in range. However, the data has primarily been used to determine the Flood Emergency Response Classification of Communities (see Section 5.5.3) and in this process it is unlikely that small topographic variations would have an impact.

5.2.3 Infrastructure and Administrative Data

Infrastructure and Topographical Data has been provided in GIS vector format for a range of features, including:

- Road Centrelines
- Stormwater Pipe and Pit Network
- Watercourse Lines
- Cadastral Parcels

5.2.4 CBD Strategy Planning Proposal Data

The CBD Strategy Planning Proposal data was provided as a GIS layer with features on a lot scale. The layer included floor surface areas (FSA) under the current planning controls (Current Scenario) and for two future scenarios: one where residential development is allowed in the commercial core (FSAR2), and the other where it isn't (FSAR1).

The analysis removed lots where the potential for redevelopment is low, either due to other constraints (e.g. heritage) or if the ownership is too divided (strata titles with greater than 10 owners). Our analysis was only undertaken on the lots that had been provided as part of the floor space analysis.

We took the floor space areas and converted them into a population at risk using the methodology supplied by Council.

For residential FSA we assumed that there will be:

- One dwelling per 100m^2
- 2.33 people per dwelling

For Commercial FSA (both office space and retail) we assumed that there will be:

- One job per 24m^2

As a way of simplifying the data, and as a conservative estimate, we rounded all population estimates up to the nearest integer (or person).

Subsequently, Molino Stewart was commissioned to undertake a detailed evacuation analysis and for that a more comprehensive estimate of population at risk was prepared. That used current and future development scenarios based on existing FSAs of buildings which are unlikely to be redeveloped in the next 30 years and FSAs derived from the incentive floor space ratios (FSRs) in the draft CBD planning proposal. The methodology is detailed in the Parramatta CBD Flood Evacuation Assessment Report (Molino Stewart, 2019). Where appropriate, in this report refers to these numbers.

5.3 NATURE OF THE FLOODING

5.3.1 Flood Mechanism

The primary source of flooding is from the Parramatta River, with the majority of water sourced from upstream of the CBD. The river rises and breaks its banks and expands laterally into the floodplain through the CBD area.

Some areas within the CBD can also be flooded by local overland flow from intense rainfall overwhelming the drainage system without any significant flooding in the River.

Other areas of the CBD are affected by overbank flooding in the Brickfield Creek and Clay Cliff Creek floodplains.

5.3.2 Flooding Patterns

The first streets to be inundated south of the river are the main roads O'Connell Street, Marsden Street, Church Street, Smith Street, Phillip Street, George Street, and Macquarie Street. These flood because local runoff overwhelms the underground drainage system, particularly if the river level is high or drainage inlets are blocked by debris.

From these main roads the flooding spreads throughout the CBD, cutting off many evacuation routes and creating low and high flood islands. Because the CBD is relatively flat, this flooding is generally low velocity with depths varying depending on the local topography.

In events larger than the 1% AEP flood the river breaks its banks south of the river and spreads high velocity floodwaters through the CBD streets. The initial breakout point is just upstream of O'Connell Street.

Wilde Avenue is the first area north of the river to be inundated. Other than Wilde Avenue, the areas north of the river are gradually flooded as the water spreads north across the floodplain.

Flooding also occurs as a result of overbank flooding in the Clay Cliff Creek floodplain. This flooding generally follows the path of the creek from Ollie Webb Reserve, through the CBD to Robin Thomas Reserve, and then progresses laterally across the floodplain. The areas first affected are around Lansdowne Street, Church Street, Parkes Street, Wigram Street, and Hassall Street. The one dimensional modelling suggests that the 20 year ARI event would flood a wide swathe along either side of Clay Cliff Creek.

Brickfield Creek flooding enters the CBD area by crossing Victoria Road and then down Wilde Avenue towards the Parramatta River. In larger floods, in conjunction with overbank flows from the Parramatta River, it can spread west and flood the area between Victoria Road and the River up to Marsden St

Council's currently adopted flood extents for the 20 and 100 Year ARI and the PMF are shown in Figure 8 and the council defined flood hazard layers are shown in Figure 9.

5.3.3 Flood Depths, Velocities and Hazard

a) Depth

Depths are greatest in the areas directly adjacent to the river and on the roads and vary across the floodplain typically decreasing moving laterally from the river. In some areas there are significant depths within the PMF, where a depth of 3 m would likely inundate the entire bottom floor of a building. Figure 10 shows the distribution of depth through the floodplain for the PMF. It was not possible to produce a similar depth map for other events due to the limitations of the Mike11 outputs.

In areas of shallow flooding the flood extent in Figure 10 does not align exactly with the PMF extent in the other figures because there must be slight differences in the ground level values in the topographic data in the flood model and that which was available for the analysis in this report .

b) Velocity

The current modelling uses a "Section Average" velocity, which essentially applies a velocity to the whole channel, so it assumes that the edges of the floodplain are flowing in the same direction and at the same velocity as the primary channel. In reality it is likely that the river portion of the floodplain will be flowing considerably faster than the areas through the CBD and the edge of the floodplain would have minimal velocity.

Due to this modelling assumption it is difficult to ascertain local velocities through the floodplain.

c) Hazard

Flood Hazard data has been provided by Council and is shown in Figure 9. This hazard representation closely aligns with the extents of the 20 Year ARI for high hazard, 100 Year ARI for medium hazard and PMF for the low hazard. We have used this as the basis for our representation of hazard to be consistent with Council. However it should be noted that the typical approach to flood hazard mapping is to produce hazard variations within a single event. For example, there are areas within the low hazard area that would have water depths of over 4 m in a PMF. A depth of 4 m would be described as high hazard in most circumstances.

It is likely that the hazard data has been produced in this way (extent based, rather than depth and velocity based) due to the limitations of the model software that has been used to develop this data.

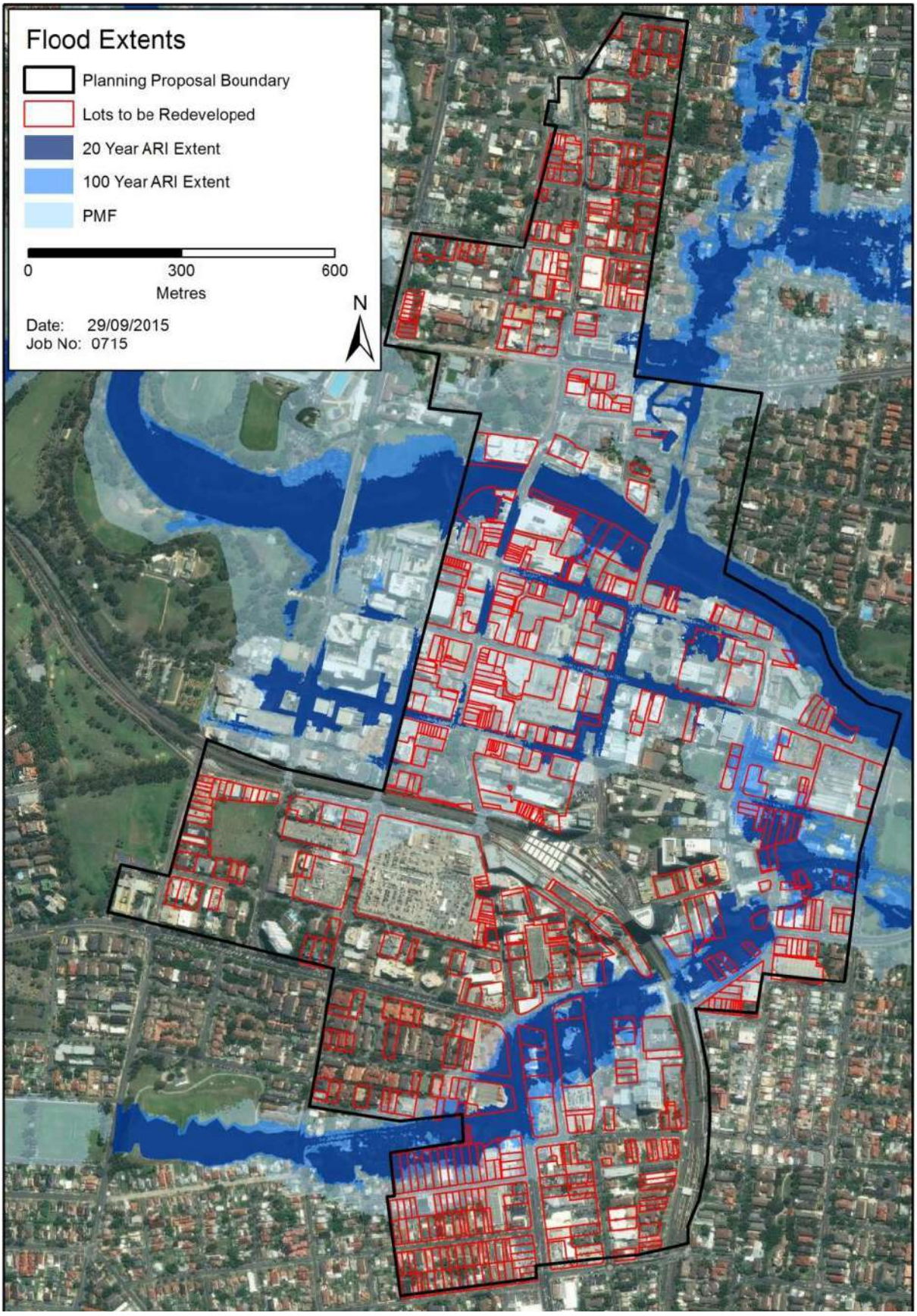

Figure 8: Flood Extents through the study area

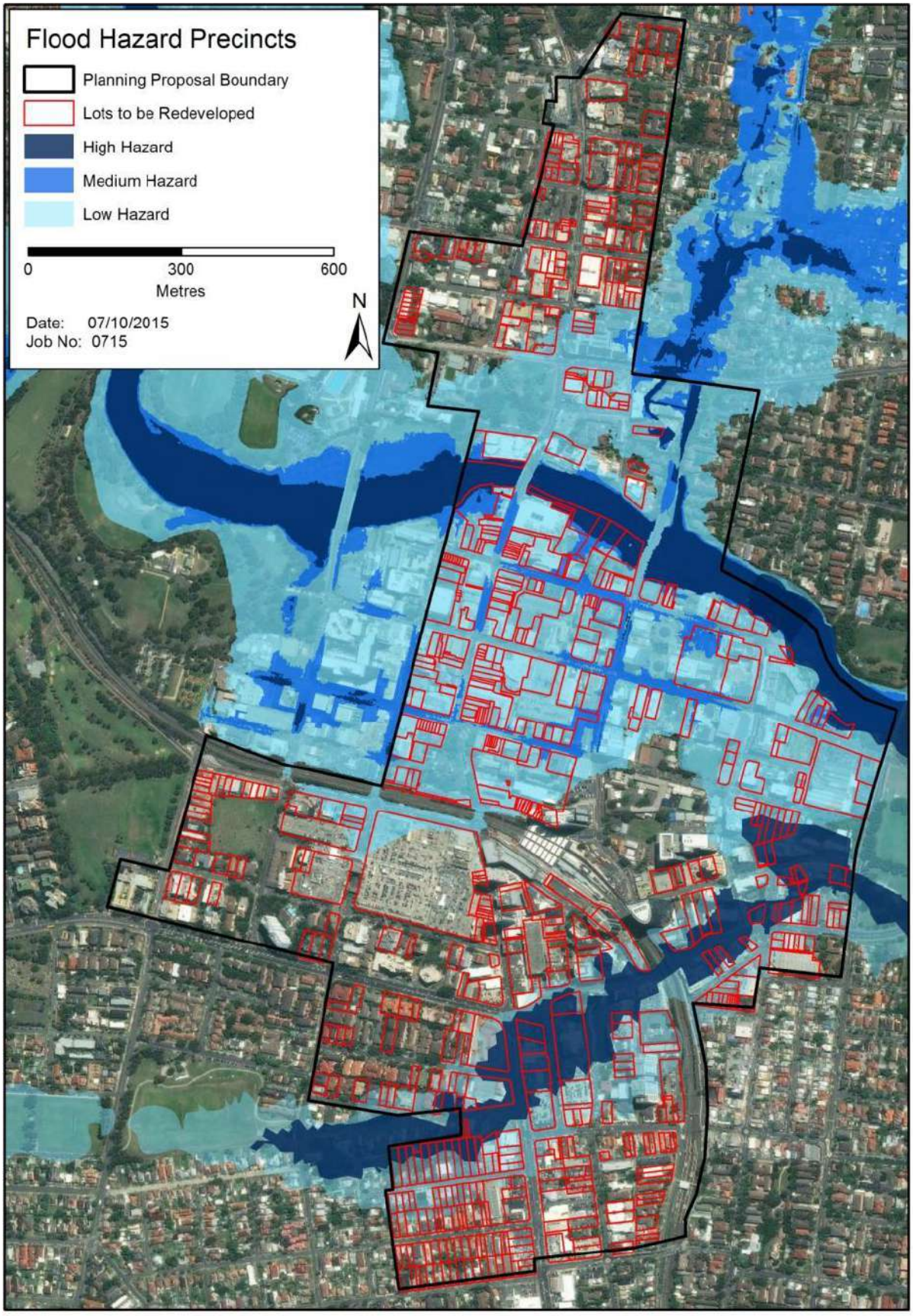

Figure 9: Flood Hazard Precincts

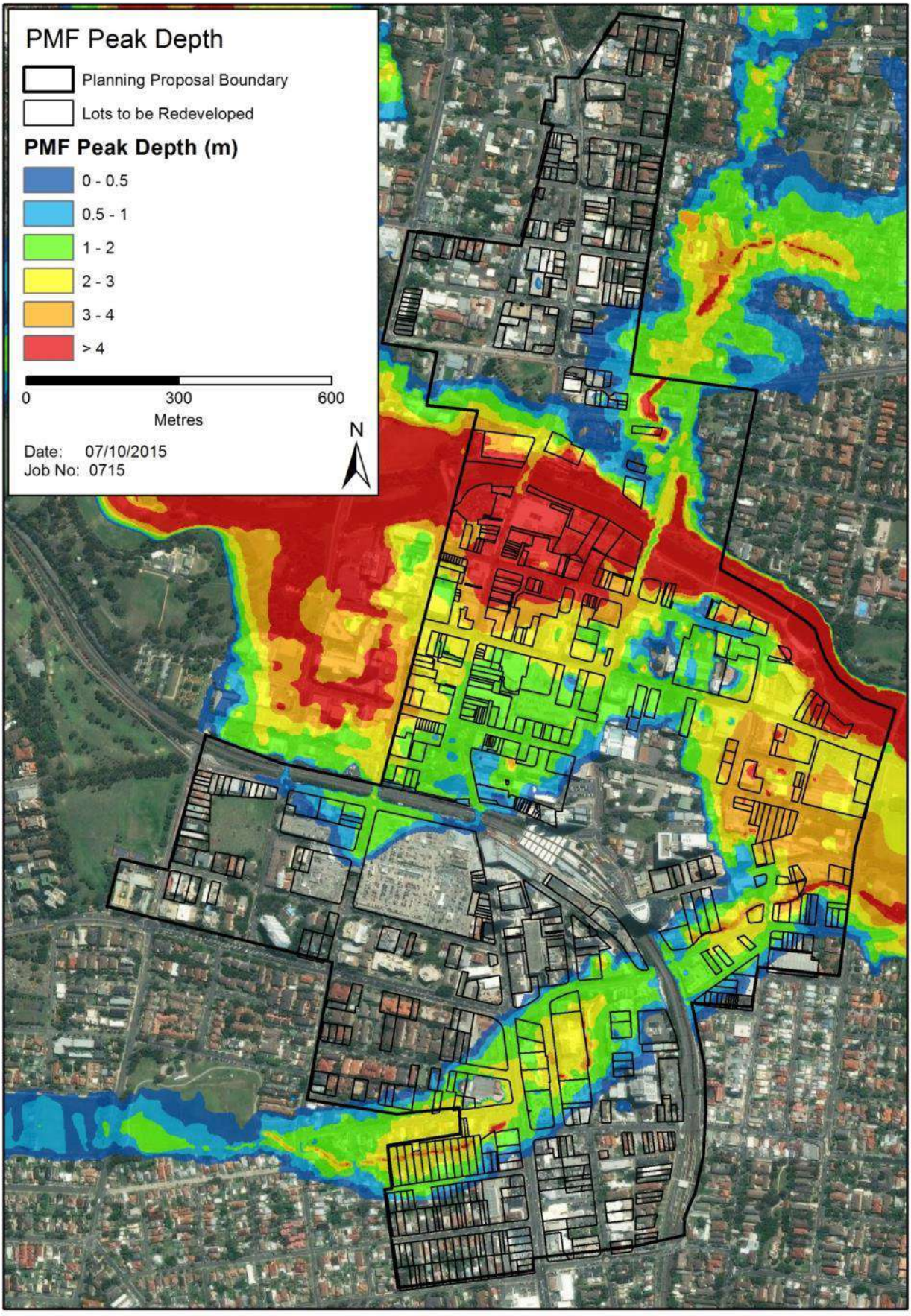

Figure 10: PMF Depth Map

5.3.4 Flood Rate of Rise

The flood rate of rise in the Parramatta River is relatively quick, particularly for the PMF. Figure 11 shows the water surface levels for the 100 Year ARI event and the PMF for just upstream of the Marsden St Weir, which is located just upstream of the study area. Figure 12 shows the same water surface levels for the Charles St Weir, which is at the downstream end of the floodplain.

The average flood rate of rise (across both locations) is around 0.4 m per hour for the 100 Year ARI and 1.6 m per hour for the PMF. The PMF rate of rise is extremely rapid with peak flood levels achieved around five hours after the river has started to rise and levels greater than the peak of the 100 Year ARI event are reached two hours after the river begins to rise.

5.3.5 Flood Durations

Flood durations are the longest in areas directly adjacent to the Parramatta River. These areas are the first to be inundated when the river breaks its banks and would remain under water even when the flood had receded from other areas.

The parts of the CBD with the longest duration of flooding are on Phillip Street between Marsden Street and Smith Street. Lots in this area would be inundated for up to 9.5 hours in the PMF. Figure 13 shows the spatial distribution of the flooding duration for the PMF and Figure 14 shows a frequency distribution for flood durations.

Another area of longer duration flooding is near the northeast end of Clay Cliff Creek. The areas between George Street, Hassall Street, Charles Street and Harris Street would be flooded for between 5 and 6 hours.

Most other areas in the study area would be flooded for less than 5 hours, with an overall average duration of inundation being 4.5 hours in the PMF and over 83% of lots being inundated for less than 6 hours in the PMF

In smaller events, such as the 100 Year ARI flood, only around 27% of the PMF affected lots would be inundated and these would be inundated for a significantly shorter period of time.

5.3.6 Summary of Flood Behaviour

Flooding in the Parramatta CBD is typical of flash flood catchments. Flooding arrives quickly and without significant warning time, while at the same time it also recedes quickly with an average flood duration of less than 5 hours for even the most extreme floods.

In most floods, the flooding is confined to a relatively narrow river corridor. The currently adopted modelling suggests the flood depth in the Clay Cliff Creek floodway will be very high, even in smaller floods such as the 20 Year ARI and this area appears to present the greatest risk to existing and future development. .

In a PMF, which has an estimated 100,000 Year ARI, there is widespread flooding that is relatively deep through large areas of the floodplain.

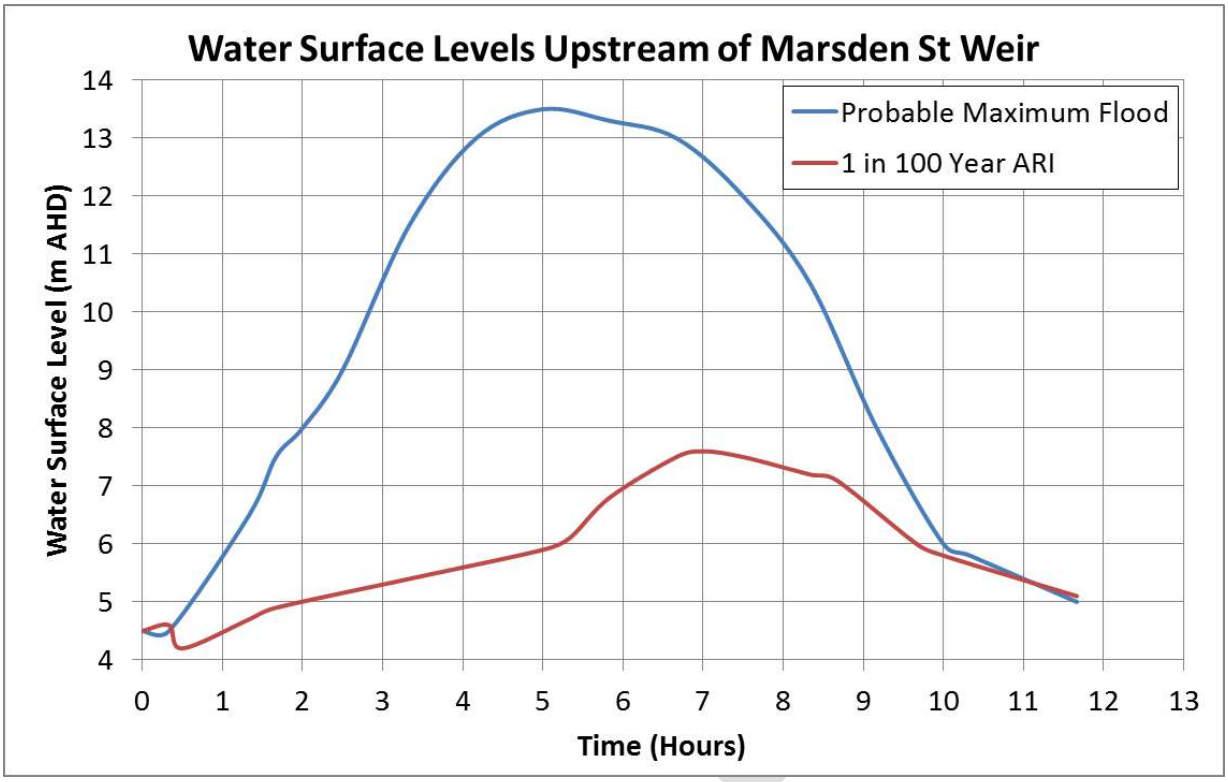

Figure 11: Water Surface Levels Upstream of Marsden St Weir

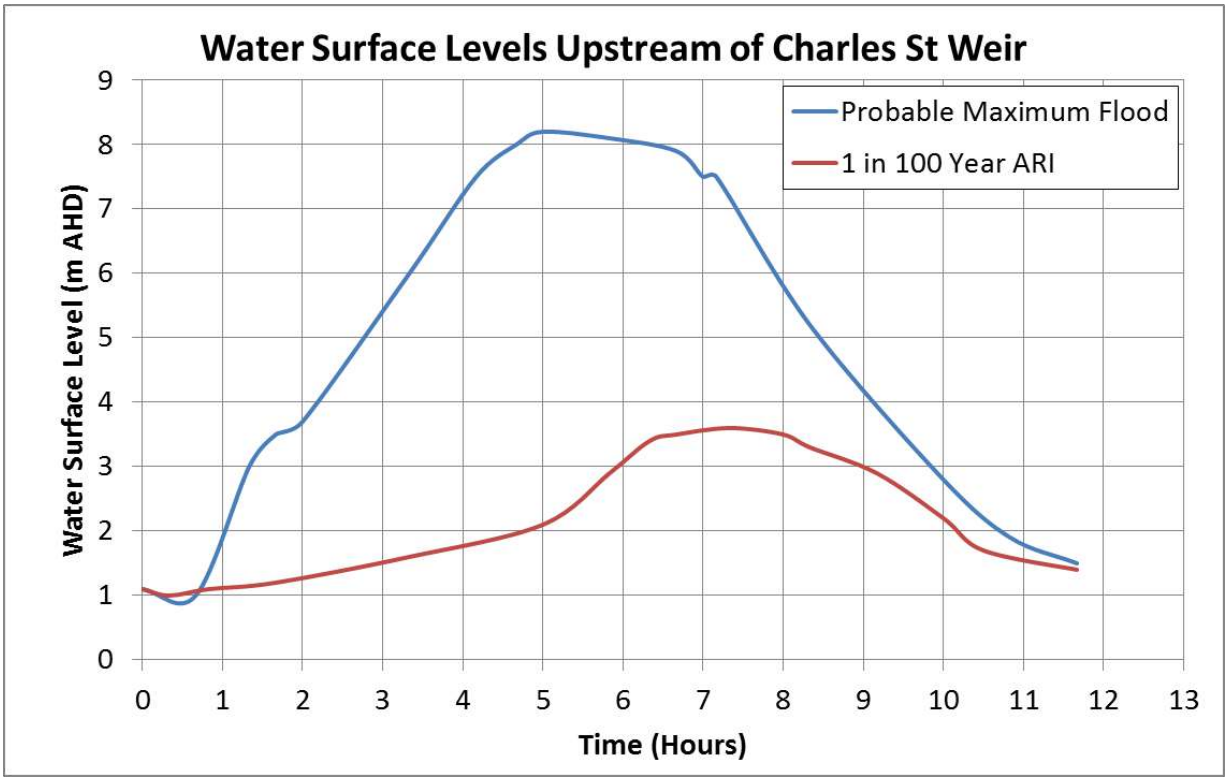

Figure 12: Water Surface Levels Upstream of Charles St Weir

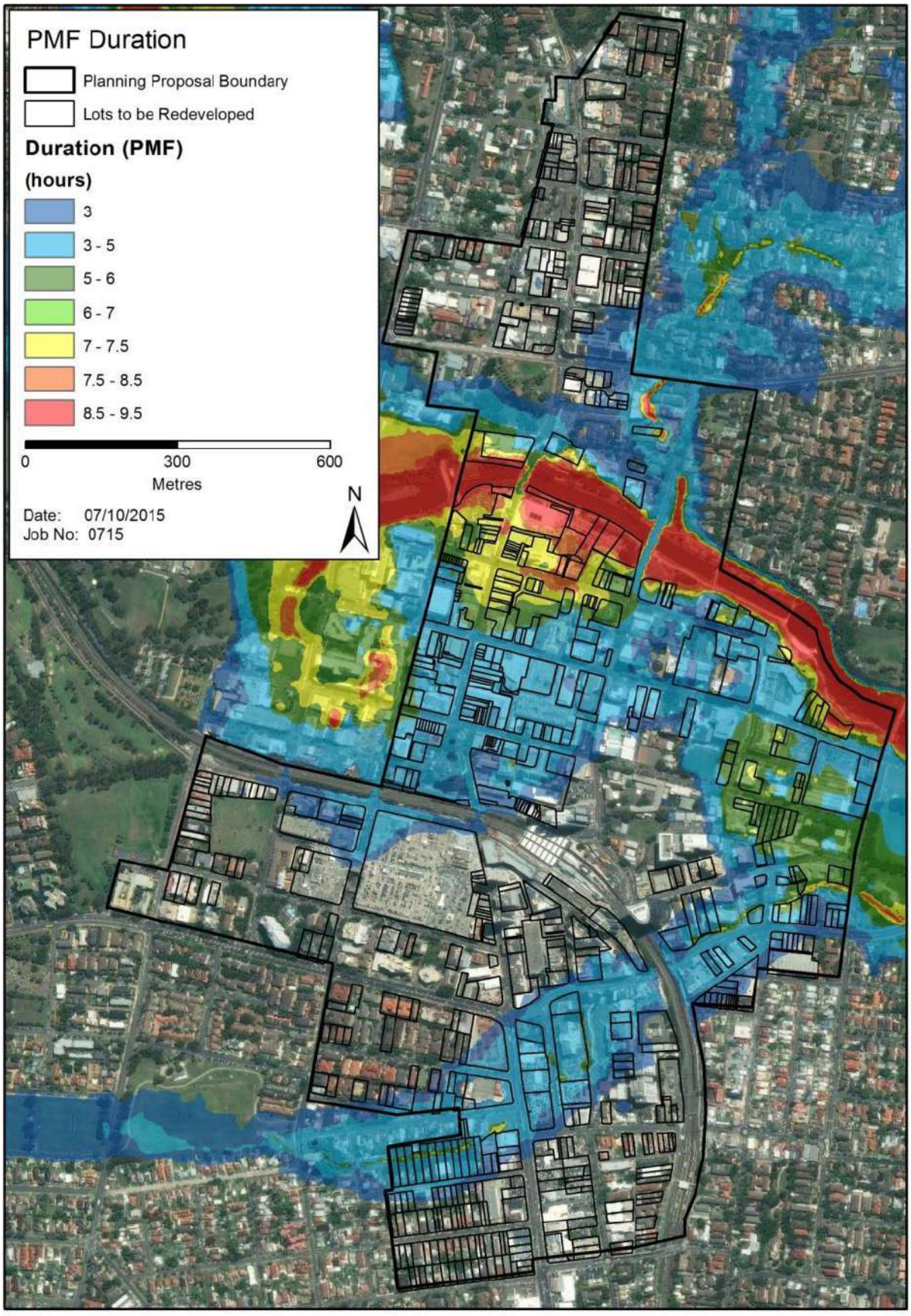

Figure 13: PMF Flood Durations

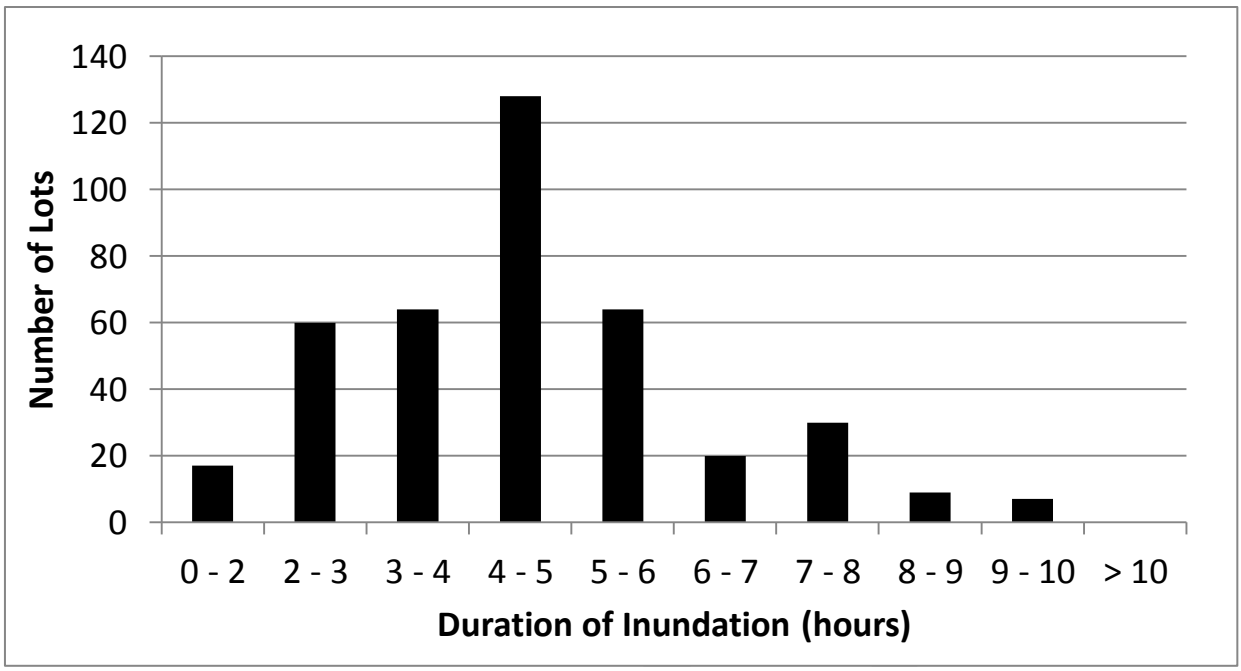

Figure 14: PMF Flood duration distribution

5.4 OTHER PLANNING AREAS

The "Planning Investigation Area" located around the fringes of the planning proposal area is currently being examined for potential changes to the planning controls and to be incorporated into the CBD planning area.

Figure 15 shows the extent of the Planning Investigation Area, and also the Parramatta North Urban Renewal Area (a state managed redevelopment precinct).

It can be seen that the Planning Investigation Area is almost completely flood free and would have limited flooding constraints, should these areas be subject to redevelopment. It is suggested that if flooding constraints are too great in the current planning proposal area, then re-development of the planning investigation area may compensate for any loss of floor space yield.

The new flood study that is being undertaken may identify new areas within the Planning Investigation Area that are flood affected; particularly areas that are subject to local overland flows.

The Parramatta Urban Renewal Area on the other hand is almost entirely within the PMF extent and this needs to be taken into consideration in its planning and the imposition of development controls.

There is also an area of the CBD between Parramatta Park and Marsden Street which is referred to as the "Western Corridor" which is also shown in Figure 15. This area is not included in the Planning Proposal because heritage considerations prevent it from having its building heights increased. Nevertheless, this area would need to evacuate with other parts of the CBD during a flood and accordingly was considered in any CBD evacuation analyses.

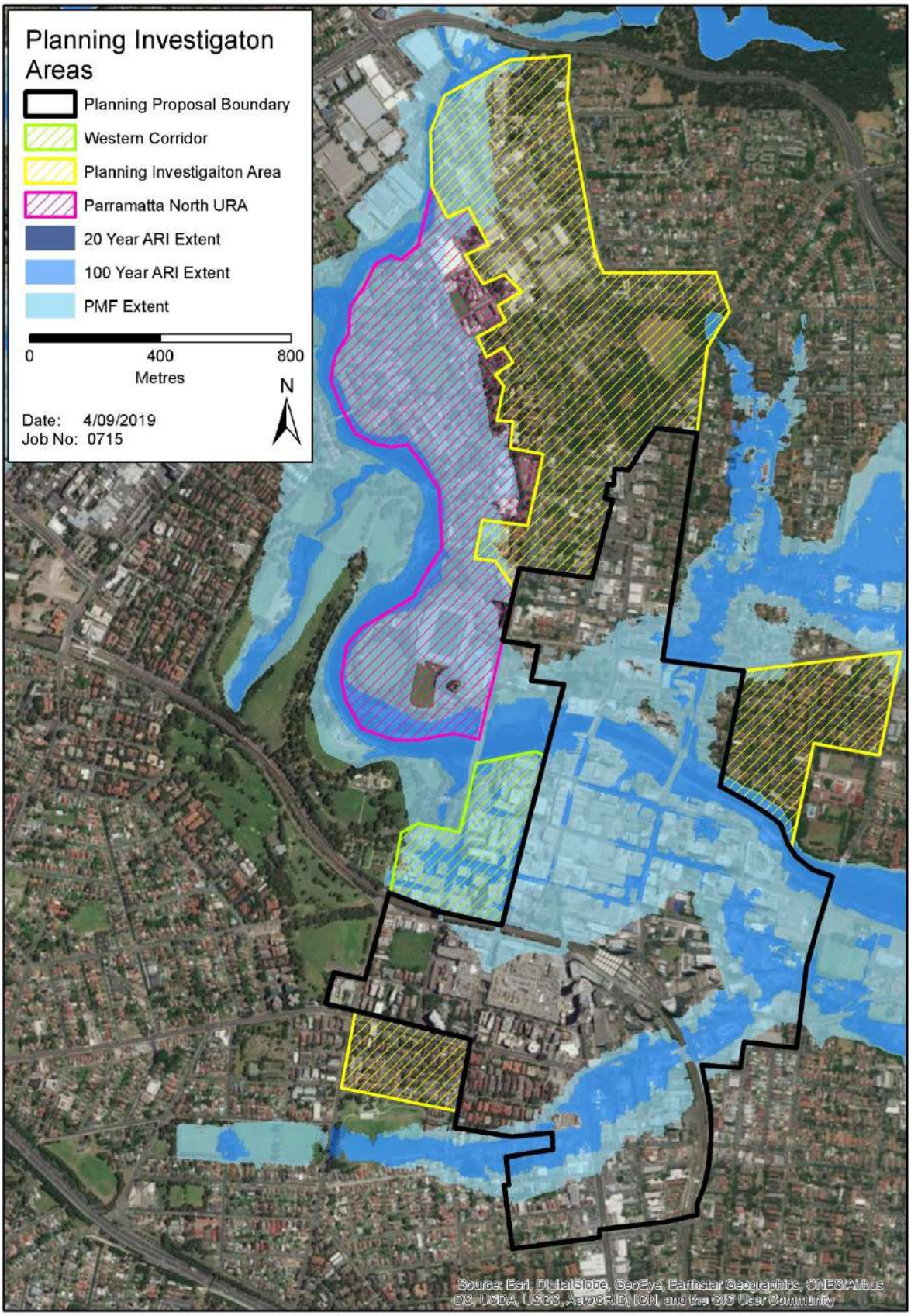

Figure 15: Planning Investigation Areas and Flood Extents

5.5 FLOOD RESPONSE

5.5.1 Available Warning Time

Flood warnings are generally provided by the Bureau of Meteorology (BoM) for developed catchments such as the Parramatta River. However, due to the small size of the catchment and therefore rapid rise of the Parramatta River there is insufficient time for the BoM to issue a warning prior to a flood occurring. Previous studies have shown that it will take approximately 6 hours to develop peak floods levels around the Parramatta CBD area during a large flood (larger than 20 Year ARI) although as discussed in Section 5.3.4 flooding can occur much faster than this.

For this reason the BoM has not developed any flood classification levels (minor, moderate or major) for the Parramatta River nor does it maintain a gauge in the river for flood warning purposes. The State Flood Emergency Sub Plan states that the only warning available for the catchment is a Severe Thunderstorm or Severe Weather Warning provided by BoM. These warning products do not provide a quantified level or time to the flood occurring.

In most circumstances a severe weather warning will not result in significant flooding and therefore the emergency services will generally not mobilise for mass evacuations based on these warnings.

The tributaries that are within the Planning Proposal area, such as Brickfields Creek and Clay Cliff Creek, are significantly smaller than the Parramatta River and flood waters will rise much faster. BoM gives no quantified warnings for them.

Since the preparation of the original draft of this report, City of Parramatta Council developed an early warning system for the River which would potentially provide some warning time for floods on the river. The service issues minor, major and moderate flood warnings for various sub-catchments of the Upper Parramatta River including the CBD. This system is expected to give about two hours warning but this could be considerably less in the more extreme floods which are likely to flood the CBD. It only provides warnings for the Parramatta River and Brickfields Creek but not for Clay Cliff Creek.

5.5.2 Local Flood Planning

The Parramatta Local Emergency Management Plan (EMPLAN) replaced the Parramatta Local Disaster Plan (DISPLAN) which was in place in 2016. The EMPLAN identifies flooding, amongst other hazards, as posing a medium risk to Parramatta. The EMPLAN cross references to a Local Flood Sub Plan but that had not yet been completed by the NSW SES in September, 2019 when this draft report was prepared.

The NSW SES receives flood warnings from the Parramatta River Flood Warning System which uses forecast rainfall as part of its suite of inputs to flood forecasting. However, with only about two hours warning available, it would be challenging for NSW SES to co-ordinate a response before the flood has peaked.

It is understood that significant developments within the floodplain have been approved provided that there is an adequate flood emergency management response plan in place for that particular development. Similarly, for large development areas (such as the river foreshore), Council has produced evacuation strategies for the river precinct that any future development must comply with (Parramatta City River Strategy, PCC 2015b).

5.5.3 Emergency Response Classification

The NSW SES, in conjunction with the former NSW Department of Environment and Climate Change, has developed a topographic classification system known as the "Flood Emergency Response Classification of Communities" (DECC, 2007). The classification indicates the flood risks associated with the topography and assists the NSW SES and other floodplain managers in determining which areas should be given priority for evacuation and what challenges the topography presents to evacuation.

For example, a “low flood island” is where the evacuation route for an area is cut before it is subsequently inundated. These areas are generally high risk because if people fail to evacuate until it looks as though their premises are in immediate danger it will be too late and they will then potentially need to be rescued. A “high flood island” is similarly isolated by flooding, however, the occupants could still escape to an area above the flood waters.

“Areas with rising road access” are of less concern, as the occupants can still evacuate by vehicle or on foot along a formed roadway even if they don’t leave their premises until the floodwaters present an imminent danger. Similarly, “Areas with overland escape routes” may not have rising road access but at least they will be able to escape on foot to areas above the level of the PMF.

The lots within the planning proposal area were classified in accordance with this system and the results are show in Figure 16 for the whole planning proposal area and Figure 17 for those lots that have been marked for potential redevelopment. The classification was undertaken based on ground levels in the dataset provided originally.

It should be recognised that buildings in areas classified as low flood islands are effectively high flood islands if they have internal access to areas above the reach of the PMF. Similarly, apartments and offices above the ground floor in areas classified as having rising road access or overland escape routes effectively become flood islands if they fail to evacuate when the ground floor of the building is threatened by flooding.

a) Low Flood Islands

Due to the fact that the roads are some of the first areas to be flooded in the CBD, there are large areas which are classified as low flood islands. The entire area of the CBD between the river to the north, Macquarie Street to the south, Marsden Street to the west and Smith Street to the east is a low flood island. East of here it also extends between the River and George St to Harris St.

North of the river, the lots which would evacuate onto Palmer Street are a low flood island.

b) High Flood Islands

There is only one HFI in this study area. A small area around Lamont Street, north of the river would be cut off from evacuation but still be able to reach flood free land.

c) Overland Escape Rote

Some areas near Parramatta train station would not be able to evacuate by road due to flood waters, but would still be able to evacuate on foot using an overland escape route. These areas are all between Macquarie Street, the rail line, Marsden Street, and Smith Street. People would be able to walk along grass and paved areas near St Johns Anglican Cathedral and Church Street to get to flood free land south of the train line.

d) Rising Road Access

Areas with rising road access are those lots which are able to evacuate by road before the route is cut by floodwater.

There are many areas in the floodplain which are classified as having rising road access.

The areas between Macquarie Street and Campbell Street which have not already been classified have rising road access along either Marsden Street or Smith Street.

There are also some lots between George Street and Hassall Street which have rising road access either to the south along Harris Street or west along Macquarie Street.

All lots along Clay Cliff Creek which are affected by flooding have raising road access either to the north or south of the creek.

e) Not Affected

All lots in the study area which are not directly affected by flooding are classified as “not affected.” These areas are not inundated by floodwaters, do not require evacuation and occupants are theoretically able to come and go at any time during a flood. However, it should be recognised that they may be indirectly impacted by flooding either through loss of utility services or through having some, but not all, of their access routes cut.

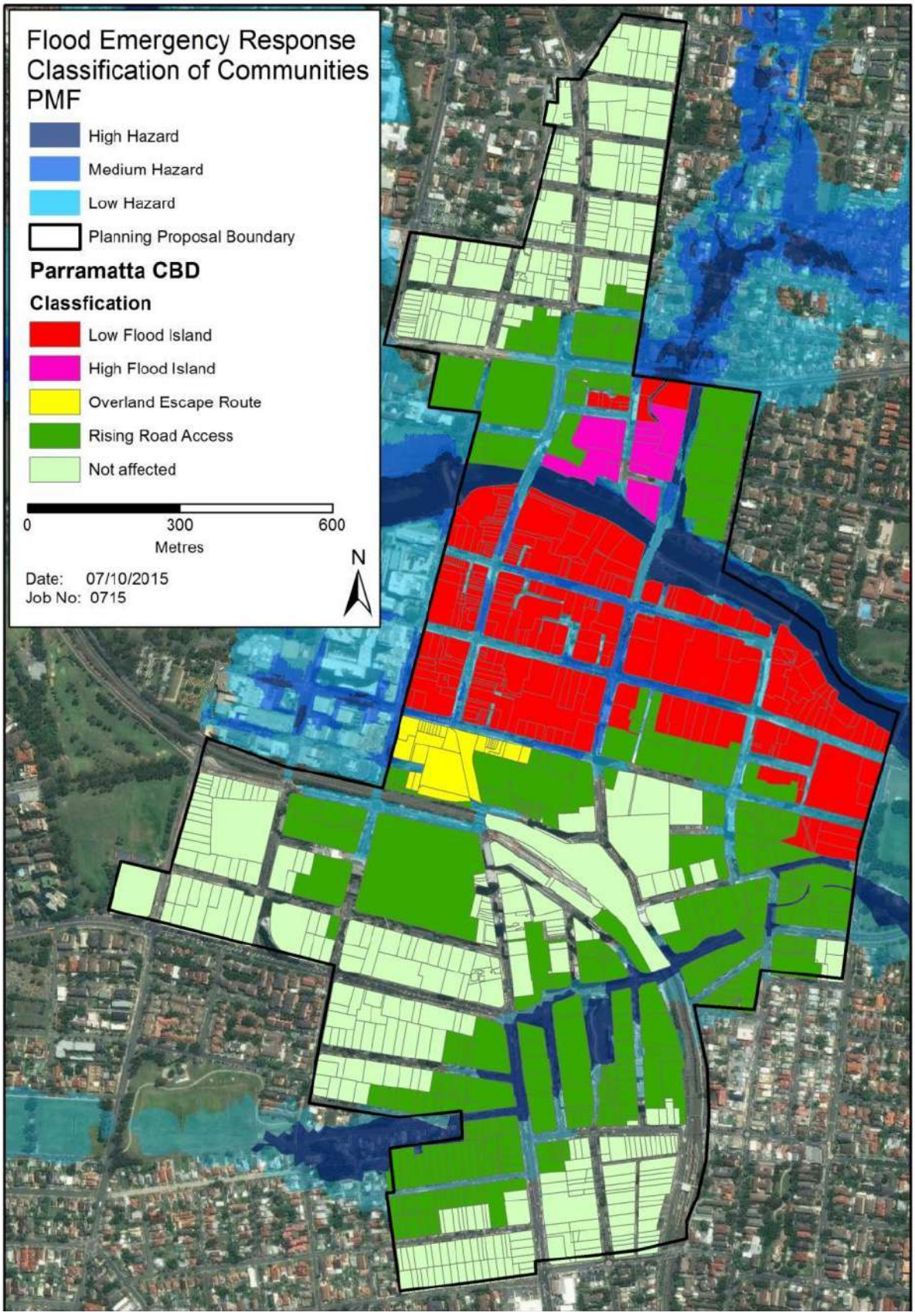

Figure 16: Flood emergency response classification of communities across the CBD

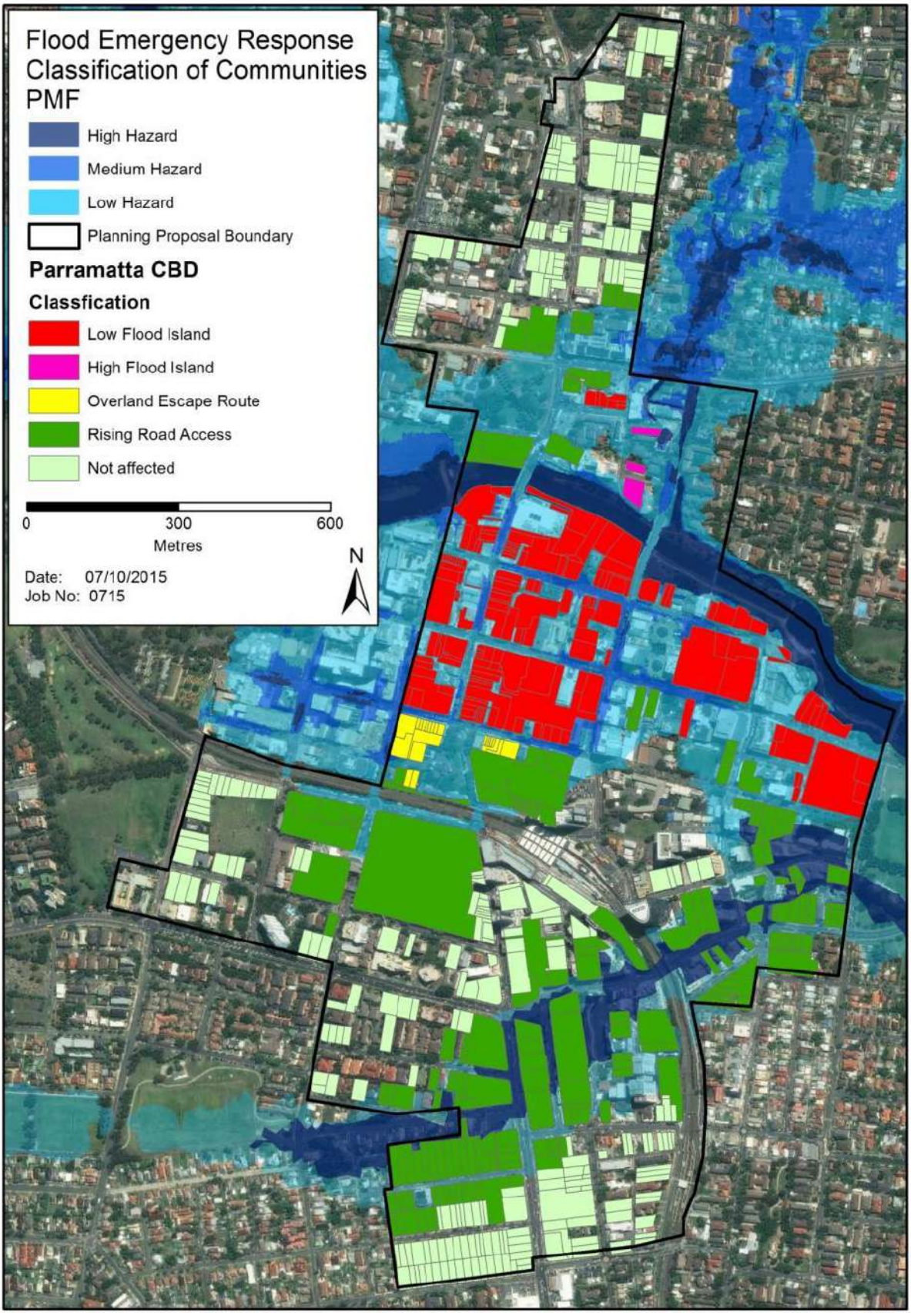

Figure 17: Flood Emergency Response Classification of Communities on developable lots

5.5.4 Evacuation

With respect to flooding, there are generally two main forms of response:

- Evacuation outside of the floodplain to a place of refuge that is above the extent of the flooding
- Shelter in place, sometimes referred to as vertical evacuation, to a location within the building which is above the reach of the PMF.

The NSW SES is primarily responsible for the management of flood emergencies and has a long and strongly held policy of using evacuation outside the floodplain as the primary means of reducing risk to life. The NSW SES is not supportive of new development which relies on sheltering in place as the primary means of reducing risk to life.

However, in the specific case of the evacuation of the Parramatta CBD the preferred SES approach would be problematic for a multitude of reasons. Following completion of the original draft of this report, Molino Stewart was engaged to investigate evacuation options for the CBD in detail (Molino Stewart, 2019). The following is a summary of the findings of the Parramatta CBD Flood Evacuation Assessment report.

a) Vehicular Evacuation

The analysis found that, under existing development, the most number of vehicles would have to evacuate if an evacuation were called during the day. These would principally be workers and visitors in the CBD rather than residents who live in the CBD.

In a 20 Year ARI flood about 9,500 vehicles may need to evacuate, increasing to about 11,500 in the 100 Year ARI flood and increasing to more than 14,000 in a PMF.

About 85% of these vehicles would need to make their way to the Great Western Highway as their principle evacuation route out of the CBD. The other evacuation traffic would be distributed between evacuation routes along Pennant Hills Road, Victoria Road, Church Street and Harris Street.

It was found that trying to safely evacuate all of these vehicles presents several challenges.

1. There are drainage capacity issues within the CBD which would likely flood the local streets early in a flood and prior to them flooding from floodwaters arriving directly from the river.
2. There are multiple traffic signals and one way roads through the CBD, as shown by Figure 18. From the centre of the CBD, around Church St or the car parking facility in Horwood Place, any evacuation would need to go through at least 4 sets of traffic lights which may be inoperable due to loss of power in the flood. This could create gridlock in the road network and floodwaters could overtake people sitting in their cars.
3. The recently developed Parramatta River Flood Warning System is likely to only provide about two hours warning of CBD flooding and possibly less in large, rare flood events in the River. However, the rapid rate of rise of extreme floods means that many of the roads in the CBD would be too dangerous to use before it is known exactly which areas will need to evacuate.
4. The flash flood nature of the flooding means that there would not be the six hours which the NSW SES generally needs to mobilise its staff and volunteers and other emergency responders under its command to conduct door knocking or traffic control operations.
5. There would certainly be no opportunity for the NSW SES or other emergency responders to have time to door knock each building which is the NSW SES preferred method of ensuring most people are reached by an evacuation order.

Figure 18: Traffic Signalling and One Way Roads in the Study Area

6. An evacuation order which has been broadcast by several means (TV, radio, internet, telephone, mobile devices) would have to be relied upon but there is no certainty that all people working in an office environment or sleeping in their apartment would receive the message.
7. The NSW SES, in its evacuation modelling, assumes that it takes two hours for people to begin evacuating once they have received a warning: one hour to accept that the warning is for them and an additional hour to prepare to evacuate. In those two hours the river could have risen to a level which cuts their evacuation routes.
8. Given that it could take two hours for people to be ready to leave in their vehicles and in that time the river could have risen above the 100 year ARI level, water could be on the point of flooding a number of basement car parks which have been constructed under the current planning controls. This could potentially expose people to extreme hazard flood waters as water overtops the lip of the carpark and rapidly floods the basement to great depth.
9. There is no clear and intuitive flood free evacuation route or routes out of the CBD with some roads partially blocked by flooding. Without emergency services directing traffic away from flooding, it is likely that many people in their vehicles will attempt to cross flood waters and become stranded, endangering themselves and blocking the road. However, as pointed out previously, there is unlikely to be sufficient time for emergency service personnel to mobilise.
10. If all of the evacuation routes remained trafficable, it is likely to take more than 8 hours to evacuate the core of the CBD via the Great Western Highway. This is comparable to the total duration of even the more extreme floods. In other words, by the time the last vehicles have evacuated the flooding would have already subsided.
11. If evacuation triggers were set at a lower river level to allow sufficient time for evacuation there would be many circumstances where evacuations would be called and then turn out to be unnecessary.
12. Once vehicles leave the CBD, all of the evacuation routes, other than Pennant Hills Road, require crossing a tributary of the Parramatta River. These are likely to be flooding and therefore vehicles may not be able to get very far past the CBD boundaries
13. There is limited queuing capacity on the evacuation routes above the reach of floodwaters. Given that they may be blocked by flooding then many vehicles could be queued back into the rising floodwaters.
14. If there is other through traffic on the roads then the time to evacuate will be longer and the potential for queuing will be greater.

Despite these many challenges, with effective flood emergency response plans for each development, supported by ongoing community education, it may be possible for vehicular evacuation to occur from some of the fringes of the floodplain where:

- the time to flooding is longer
- there is rising road access
- the distance to flood free roads is short
- the route is unlikely to be blocked by tributary flooding or the vehicle numbers are such that queuing back into the floodwaters is unlikely.

However, it is clear that there are too many things which could go wrong with vehicular evacuation for it to be able to be relied upon for flood emergency response. In much of the floodplain, particularly in the heart of the CBD, it is too risky to even contemplate.

It must also be recognised that while thousands of cars enter Parramatta CBD each day, many thousands of people travel to and from the CBD by bus or train. The peak period services span a time frame of less than three hours and in theory have the capacity to

evacuate all of the people who are reliant on these modes of transport. However, the evacuation may need to occur outside of peak service times or public transport services themselves may be disrupted due to the intense rainfall. In fact, the bus services will share routes as the evacuating cars and will face the same challenges.

Furthermore, those areas which are flood islands may be isolated by floodwaters before people can reach the Parramatta Train Station or the Bus Interchange. With no viable alternative way of getting home, these transport hubs may entice people to walk through floodwaters to get to their means of transport.

A similar situation can arise with people who have parked their cars at one of the many parking stations throughout the CBD which may be remote from the building which they occupy. They too may attempt to traverse floodwaters to reach their vehicles.

b) Pedestrian Evacuation

Pedestrian evacuation would potentially be available for the areas with rising road access or overland escape routes. However for the low flood islands and high flood islands, their escape route would be cut off prior to them attempting to evacuate, unless an evacuation trigger at a lower level is used. Similarly to vehicular evacuation, an earlier trigger may be impractical as the trigger level required to allow enough time would be so low that it is frequently reached while not going on to flood many premises.

Even those areas which are mapped topographically as having rising road access or an overland escape route may become defacto flood islands by the nature of the development. For example, offices or apartments above the ground floor in buildings would be isolated by floodwaters once the ground level floods. Should occupants fail to leave the building before this occurs then they will be trapped in just the same way as people on flood islands. Whether their office acts like a low or a high flood island will depend on whether the highest accessible part of the building is below or above the PMF level respectively.

The Parramatta CBD Flood Evacuation Assessment report (Molino Stewart, 2019) identified those areas where it may be possible to exit a building onto flood free land with rising pedestrian access even if the lower part of the block may be flooding. It did this for the 20 Year ARI and 100 Year ARI floods and the PMF. For those buildings without flood free access, a potential network of elevated pedestrian walkways was investigated and costed as a means of providing flood free access.

Figure 19 and Figure 20 are taken from that report showing the areas which have street level access in the 20 Year ARI flood and PMF respectively and the directions in which evacuees need to travel.

Results show that pedestrian evacuation using elevated walkways would be faster than vehicular evacuation under existing conditions.

Interestingly, the shortest evacuation time (4.4 hours) is achieved in the PMF. This is because the PMF would require a larger network of elevated walkways (because the flood extent is larger), which would result in the CBD evacuees being distributed across a greater number of egress points. For example, in the PMF there would be eight egress points for evacuees heading towards Westfield, while in the 20 year and 100 year ARI events there would be only 4 and 5 respectively.

The challenges with relying upon pedestrian evacuation were found to be:

- Infrastructure cost would be significant and ranging from $94.5 to $324 million
- The elevated walkways would cause major visual impact and overshadowing
- Trees located along the walkway's path may need to be removed and replaced with low-level shrubs
- In events larger than the 20 year ARI, the walkways would need to be directly accessible from the upper levels of each building. This would be difficult to achieve in practice, because floor levels vary between different buildings

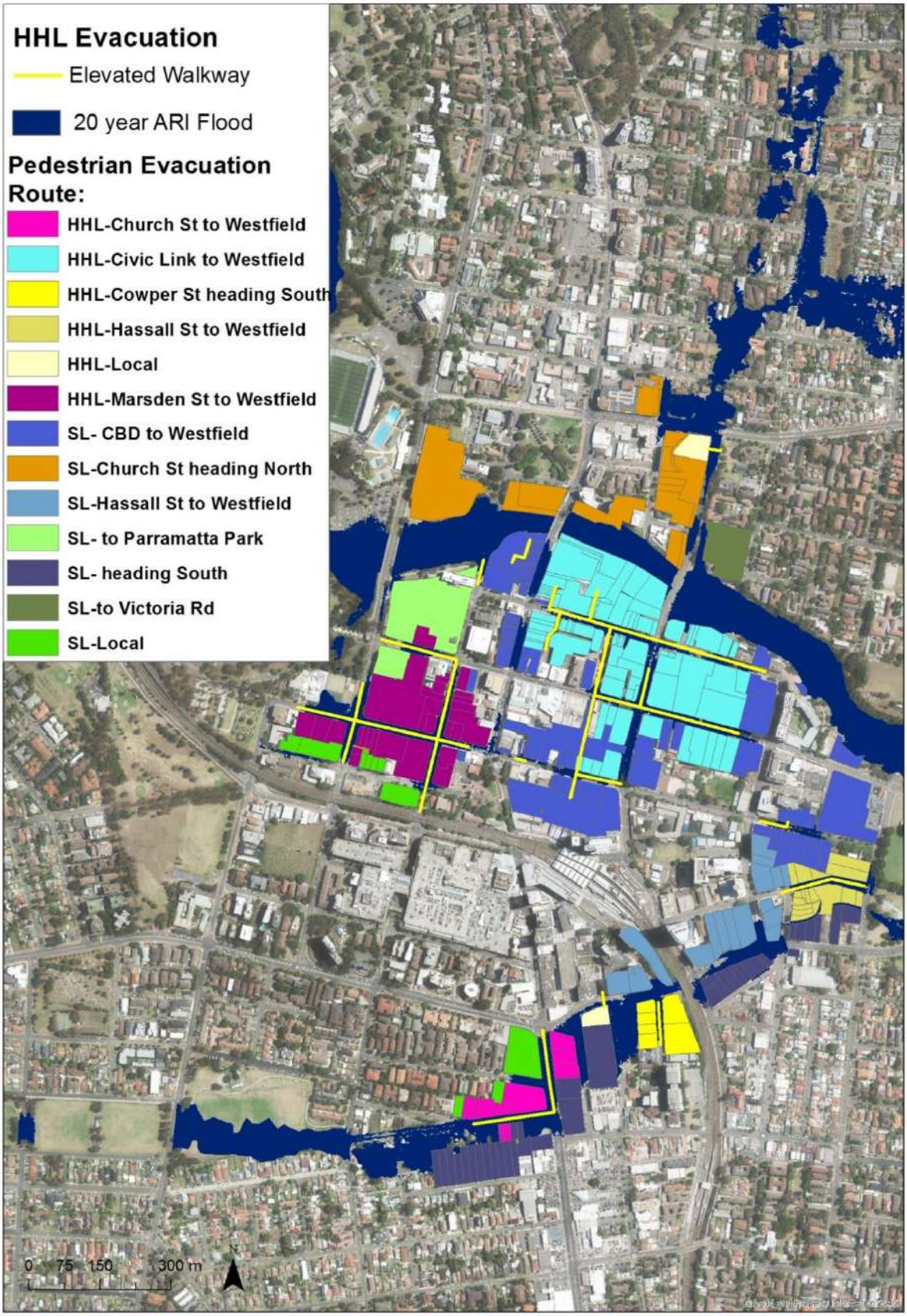

Figure 19: Pedestrian evacuation precincts evacuation routes for buildings affected by the 20 year ARI event.

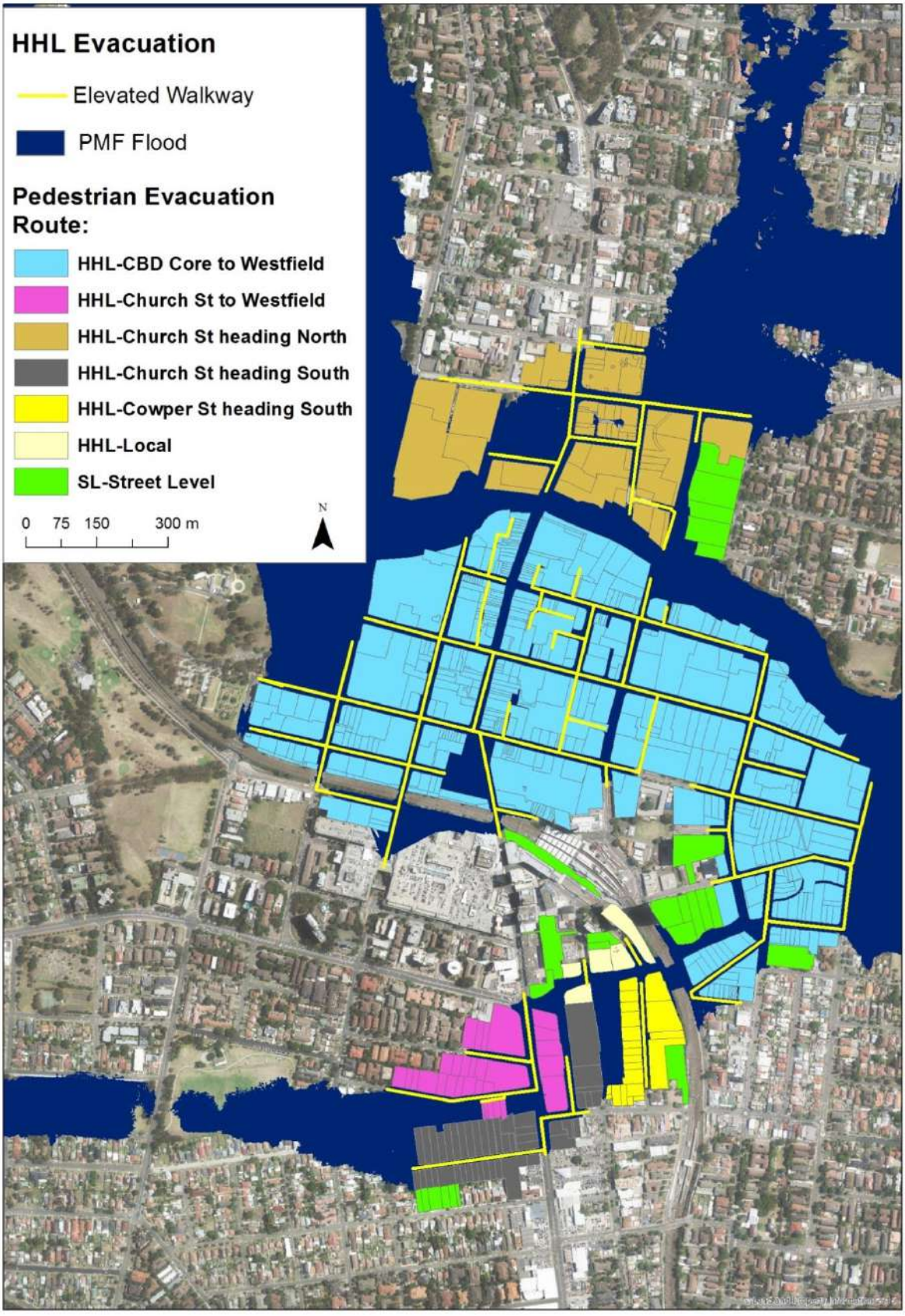

Figure 20: Pedestrian evacuation precincts evacuation routes for buildings affected by the PMF

- Where walkways traverse a road, or a crossroad, large vehicles which are taller than 4.5m would not be able to enter
- It may be a challenge communicating who should use the elevated walkways and who should evacuate at street level
- Pedestrian evacuation times range between 4 to 5 hours and the evacuation process may finish after floodwaters have already receded
- Providing an extensive network of walkways that will not be used on a daily basis, will potentially create issues with informal use and security
- Providing accessibility ramps to the walkways will impact on road layouts within the CBD.
- People will be reluctant to leave a dry building to walk through torrential rain to shelter in another dry building, particularly if they perceive that their building provides shelter above the reach of floodwaters (whether that is true or not);
- Those who arrived by light rail (when it is built) are unlikely to be able to leave by light rail because water across the tracks would stop its operation, many who arrived by bus will not be able to leave by bus because many bus routes will be cut by flooding, those who arrived by train may not be able to leave by train if flooding elsewhere or the inclement weather generally has disrupted rail services. All of these people may be reluctant to leave their buildings if they have no means of leaving Parramatta;
- Residents in particular have demonstrated an unwillingness to evacuate when orders have been given to evacuate in floods throughout Australia in recent years so it may be especially difficult to get people to leave an elevated dwelling in a high rise building on foot in torrential rain.

c) Shelter in Place

Shelter in Place is where the occupants of the building essentially stay where they are until the flood emergency is over. One of the key requirements for successful shelter in place is that all building occupants have access to an appropriate place of refuge. Typically this will be above the level of the PMF in a part of the building which will remain standing in the forces exerted on it by a PMF. Depending on the duration of the isolation and the needs of the occupants, there may need to be emergency provision of electricity, water, food and medications.

The viability of shelter-in-place will depend upon the depth and duration of the flood waters and also the stability of the building itself to flood waters. Additional risks such as the probability of fire or a medical emergency must also be considered, as well as the vulnerability of building occupants and their likely behaviour during a flash flood.

Typically, workers will want to leave the flood threatened building to be able to get home even if the flood duration is only a couple of hours. On the other hand, residents will tend to remain in their dwellings for several hours or more even if they are without services such as electricity. Residents who are outside of the floodplain when the building isolation occurs are very likely to try to reach their homes, risking travelling through hazardous floodwaters in the process.

The current Parramatta Local Emergency Management Plan (EMPLAN) is silent on either shelter in place or evacuation for floods. It is expected that when the Local Flood Sub Plan is prepared that will have more details about specific emergency response actions.

A number of other documents with respect to floodplain management acknowledge the appropriateness of Shelter in Place for flash flood environments. The Flood Preparedness Manual (Australian Emergency Manual Series, prepared by the Attorney-General's Department 1999) states that evacuation is a suitable strategy only when, by evacuating, people are not exposed to greater risks than they would by remaining where they are.

During discussions with the NSW SES for this project, it was acknowledged that flood

evacuation of Parramatta CBD would be impractical, although at the same time shelter in place was not recommended.

In December 2017 the NSW SES wrote to the then Department of Environment and Planning regarding a planning proposal for 180 George St Parramatta. While the letter was specifically responding to that planning proposal, it includes statements such as:

"Despite modifying buildings to reduce the risk, research into human behaviour during actual events has shown that in populations surrounded by a hazard there is always the chance that a person will not behave rationally and remain in place but rather place themselves at unnecessary risk. "

"…where safe evacuation is compromised by a lack of adequate infrastructure and/or warning time, the NSW SES recognises that the situation may result in it being safer for a population at risk to remain in place as long as the building in which the occupants are sheltering is structurally sound and there is sufficient accessible space available above the PMF for all occupants to shelter where adequate services are available and maintained."

"Emergency service response will likely be compromised by the hazardous nature of flash flooding in Parramatta CBD. In this area it is likely that emergency services cannot respond to assist those trapped in buildings due to the rapid onset and hazardous nature of fast flowing floodwater and limitations caused by access and transport issues."

5.5.5 Secondary Emergencies

A secondary emergency is where a non-flood related emergency, such as a building fire or medical emergency, occurs during a flood.

In many cases the flood and secondary emergency will be two unrelated events, however there is potential for floodwaters to damage the electrical system and cause fires or for occupants to use improvised lighting (candles), cooking and heating with naked flames that may also cause fires. The flood could also cause elevated stress levels in occupants that could aggravate pre-existing medical conditions leading to more medical emergencies. At the same time, larger developments are more likely to have emergency sprinkler systems for fire/smoke suppression and designated first aid officers if the building is staffed.

This makes it difficult to quantify the likely chance of a secondary emergency. However, some simple analysis shows that the likelihood is small.

Statistics were unavailable for the chance of building fires locally, however documents produced by the National Fire Protection Association (United States of America) in 2009 suggest that there is approximately a 0.3% chance of a reported (large enough to require assistance) fire in any given household per year (NFPA, 2009). This equals a 1 in 114,000 chance per day that a fire will occur in a household.

Assuming that a flood and fire are independent events, a lot that has a 1 in 100 Year ARI flood probability has roughly a 1 in 4 billion chance that both a flood and a fire would occur in a household on any given day. When the duration of flooding is less than 24 hours then the chance of a fire occurring during a flood is even smaller.

However, as explained above, flooding may increase the probability of a fire. Furthermore, in multiunit buildings a fire in one dwelling is likely to impact on neighbouring dwellings or, in the worst cases, the entire building and even possibly neighbouring buildings.

So while the probability of a fire in a building during a flood is likely to be small, the consequences, should a fire occur, could be significant.

It is also noted that many existing buildings within Parramatta have their fire exits located at ground level and these may not be able to be opened during a flood, as discussed within Section 3.2.4. Redevelopment of these lots would provide potential for this issue to be rectified.

An ambulance emergency is much more likely than a fire. There were on average 2,540 emergency responses per day in NSW during 2013/14 (NSW Ambulance, 2014). At the same time, there were approximately 7.41 million

residents within NSW. This suggests that approximately 1 in 3,000 people will need an ambulance emergency response per day. Given the population of Parramatta is much larger than this, it is likely that there will need to be an emergency response within the CBD during a flood. It should be noted that this data is likely to be significantly skewed by demographic issues, for example, elderly populations are much more likely to require an emergency response, whereas the make-up of Parramatta CBD is likely to be younger. This would particularly be the case during working hours as the vast majority of the working population would be less than 65 years old.

It is noted that the relatively new Westmead Ambulance Station has been built on flood prone land and can be isolated from both Westmead Hospital and Parramatta CBD by flooding in Toongabbie Creek.

While a secondary emergency has a relatively low chance of occurring during a flood, it is important to recognise the potential and manage the risks appropriately with planning controls.

5.6 PLANNING PROPOSAL IMPACTS

5.6.1 Increase in Population

The aim of the planning proposal is to increase the employment and resident population within the CBD. Using the Council supplied parameters, we have estimated the potential increase in population at risk due to the planning proposal.

Table 3 shows the estimated increases in the CBD population under the current planning controls and in the two FSA scenarios described in Section 5.2.4 if the CBD is fully developed. The current estimate for the number of people employed in the entire Parramatta LGA is around 137,000 (ABS 2016) and the number of people living in the suburb of Parramatta is around 26,000 (ABS 2016). Statistics are not available to determine what proportion of these populations is just within the CBD. What the numbers in Table 3 show is that even the existing controls in the CBD will still allow a significant increase in the population should it be fully developed..

It should be acknowledged, however, that the entire commercial population and the entire residential population are unlikely to be occupying the CBD at the same time. During business hours most of the residents will not be at home and when most of the residents are at home (late at night) most of the businesses will be closed.

There will also be a third population in the CBD during office hours and they are visitors who are not counted in either the commercial (jobs) or resident populations. Visitors include patrons of commercial premises, people in the CBD to do business and students at pre-schools, schools and colleges.

As part of the Parramatta CBD Flood Evacuation Assessment (Molino Stewart. 2019) the total number of residents, workers and visitors that would need to evacuate were estimated for 2016, 2036 and 2056 (Table 4). The numbers in Table 4 are not directly comparable with those in Table 3 because the former includes buildings in the Western Corridor and the latter includes buildings in the planning proposal area which do not flood.

Year 2036 was obtained by projecting 20 years into the future the number of evacuees that would be achieved under the existing planning controls, plus some site-specific planning proposals that have at least received Council endorsement to be sent for Gateway determination.

Table 3: Estimated Potential Increase in Population in Planning Proposal Area.

	Commercial	Residential
Existing	35,048	19,576
FSAR1	92,253	58,961
FSAR2	76,096	68,000

Table 4: Estimated Potential Population in Flooded Properties in Planning Proposal Area.

	Residents	Workers	Visitors
2016	10,010	34,931	26,245
2036	32,793	63,130	45,214
2056	50,574	81,826	59,340

It has been demonstrated that neither vehicular nor pedestrian evacuation is viable as a primary flood response across most of the CBD with the current road and pedestrian infrastructure. Providing additional infrastructure for evacuation is problematic

Evacuation would only become more challenging with further development, even for the more modest increases under the current planning rules which are reflected in the 2036 numbers (Table 5).

These times assume that the evacuation routes will remain open for that whole time; which they will not. In the case of pedestrian evacuation it assumes high level walkways will be constructed for flood evacuation.

Table 5: Estimated Vehicular and Pedestrian Evacuation Times.

Year	Event (ARI)	Vehicle (hrs)	Pedestrian (hrs)
2016	20 Year	8.1	4.5
	100 Year	9.0	5.2
	PMF	10.7	4.4
2036	20 Year	8.7	7.3
	100 Year	9.4	8.9
	PMF	10.8	6.8
2056	20 Year	8.9	9.1
	100 Year	9.6	11.2
	PMF	11	7.9

5.6.2 Flood Response Categorisation

The flood emergency response classification of communities, described in Section 5.5.3, has been developed assuming that the occupants are at the ground floor. As described in Section 4.1.1, the planning proposal built form will be high rise buildings where the majority of occupants will be well above the ground level. When taking this into account, essentially all of the new buildings should be considered High Flood Islands.

The reason for this is that the occupants could potentially be unaware of the flooding until they attempt to leave the building, or at least the first sign they will have of flooding is that the ground floor is inundated and their escape route will more than likely be cut off. At the same time, there would be ample opportunity for those occupants to retreat up their stairs to a floor that is above the level of the PMF.

The effect of this change in categorisation depends on the original categorisation, for example:

- If the area was already a high flood island there is essentially no change to the categorisation
- If there was already a building with access to areas above the PMF the building was already a high flood island and the categorisation has not changed
- If the area was previously a low flood island with a building without areas above the PMF, it becomes a high flood island
- If the area was previously a low flood island with a building with areas above the PMF it was effectively a high flood island and that does not change.
- If the area previously had rising road access, or an overland escape route, from a building with areas above the PMF then it was effectively a high flood island and will remain so.
- If the area previously had rising road access, or an overland escape route, from a single storey building then it will effectively become a high flood island.

It should be noted that under the current planning controls, the same type of building (high rise) would be developed in the majority

of these areas, so the planning proposal will not effectively change the flood categorisation of the land or the buildings.

5.6.3 Population at Risk

The planning proposal would increase the potential population at risk within those areas that can flood. When the discussion in Section 5.6.2 is considered, it means that where there was a population on a low flood island that population will be increased but the building will convert the island to a high flood island. This means the population at risk will increase but the risk to each individual in the population at that site will decrease.

In all other areas the population at risk will increase but the risk to individuals in the population will either remain the same or will increase depending on whether it was already a high flood island or previously was low rise with rising road access or an overland escape route.

5.6.4 Risk Reduction Opportunities

The discussion in Section 5.6.3 is based entirely on the flood emergency response classification and a simplistic consideration of final building design and its implications for the population at risk.

It must be recognised that the flood emergency response classification is only one factor in determining flood risk and other considerations such as flood hazard, flood probability and flood duration are also very important.

For example, a building which is isolated by high hazard floodwaters for several hours in a 20 year ARI flood presents a much higher risk than were the same building to be isolated by low hazard floodwaters for less than an hour in a PMF. The planning proposal provides the opportunity to avoid intensification in areas which place people and property at the greatest risk from flooding.

Another consideration is that while an individual building on an individual block may have a particular flood exposure and flood emergency response classification, if a group of buildings or a collection of lots are considered as a whole the exposure and classification may be different.

A broad scale redefinition of floor space ratios, building heights and development controls offers the opportunity for redevelopment to be reconsidered at a precinct level rather than one development at a time and it may provide ways and means of decreasing the population in areas with the greatest flood risks or constructing buildings which collectively change their flood emergency response classification.

This is elaborated upon the in the following sections.

5.7 RISK EVALUATION

5.7.1 Risk to Property

The subject area is all currently developed with a mix of residential and commercial development. In most cases, the development would have occurred prior to the current flood planning controls. Application of current planning controls to redevelopment will result in less flood risk to property.

However, as highlighted in Section 3.2, some of the ways in which new developments have complied with existing flood planning requirements have had unintended outcomes. It will be important that the new planning proposal addresses these without increasing the potential flood risk to property.

Council is currently investigating this issue and examining ways in which the issue can be overcome

Overall it is considered that the planning proposal should be able to be implemented without increasing the flood risk to property.

5.7.2 Risk to Life

Evaluating the risk to life arising from the planning proposal is more complex. Considering the CBD as a whole it will result in more people occupying flood prone areas but in such a way that reduces the probability of them coming in contact with floodwaters inside their building.

Flood behaviour and topography varies across the CBD and an approach is needed which takes this variability into consideration. Given the impracticalities of vehicular evacuation and the challenges of pedestrian evacuation, it is our view that shelter-in-place is the most appropriate flood response for most of the buildings in the Parramatta CBD.

Having said that, it is preferable to encourage development which minimises the chance that people will be frequently isolated in buildings for long periods of time because they may:

- try to leave (or enter) the building through hazardous floodwaters despite advice to the contrary
- need medical assistance
- need to evacuate from a fire

a) Methodology

For the purposes of this project a methodology was developed which considered how frequently buildings are likely to be isolated by flooding, how long they would be isolated and how hazardous surrounding floodwaters would be to those entering or leaving the building on foot.

Table 6 summarises the methodology and criteria used for evaluating the flood risk to life.

The first criterion used was the probability of flooding. This was based on the available modelled flood extents which were limited to the 20 year ARI (5% AEP), 100 year ARI (1% AEP) and the PMF. Flooding above the 100 year ARI (<1% AEP) was considered to be rare flooding and would require minimal measures to manage risk to life. At the other end of the scale flooding more frequent than the 20 year ARI (>5%) would require the greatest controls to manage risk to life.

While flooding larger than the 1% AEP is rare, there have been several examples of major floods within Australia within the past 12 years that have exceeded the flood levels of the 1% AEP design flood, this includes;

- Flooding in King John Creek in Moreton Bay (QLD) in May 2015, which has an estimated 0.1% AEP
- Flooding in Dungog on the Myall Creek and Patterson River in April 2015, which has an estimated 0.2% AEP
- Widespread flooding in Queensland in 2011, including the Brisbane River, Pine River and Lockyer Valley, which has estimates of between the 1% and 0.1% AEP in various catchments
- Widespread flooding in northern Victoria in 2010 and 2011 which has been estimated at less frequent than the 1% AEP with a number of rivers recording 0.5% events
- The “Pasha Bulker” storm in June 2007 which flooded large areas of Newcastle, which has been estimated at much less frequent than 1% AEP.
- A localised storm at Broughton Anglican College near Campbelltown, NSW in April 2007 caused a 0.2% flood
- Rainfall in the Flinders Ranges in South Australia in January 2007 was in the order of a 0.1% event over an area the size of the Sydney Metropolitan Area

The second criterion was depth of flooding in the PMF as this represents the worst case scenario in terms of hazard to anyone trying to enter or leave the building. While hazard is traditionally determined from depth and velocity combinations, the lack of velocity information meant that for this project only depth was used. Two depth thresholds were considered and were based on the most recent Australian research in this area (McLuckie et al, 2014).

A 0.6m threshold was used to represent the depth above which it would be difficult for emergency service vehicles to reach buildings. A depth of 1.2m was used as the other threshold which is the limit at which it is difficult for adults to traverse low velocity flood waters.

Table 6: Flood Risk to Life Evaluation Methodology

Category	Probability (AEP)	PMF Depth (m)	[Depth, Duration] Operator	PMF Duration (hrs)	Flood Emergency Response Classification	Suggested Risk to Life Management Measures
1	< 1%	< 0.6		Any	Rising access	Safe to evacuate or shelter in place. No controls required.
2	< 1%	0.6 < x < 1.2	AND	< 3	Rising access	Safe to evacuate early or shelter in place in accordance with a flood emergency response plan for the building.
3	< 1%	> 1.2	OR	> 3	Rising access	Shelter in place above the PMF in accordance with FERP. Ensure space above PMF for all building occupants to shelter. Provide building fire management system to meet ABCB requirements for high rise building.
4	1%<AEP< 5%	Any		Any	Rising access	Prohibit residential development unless there is internal flood free pedestrian access to development in categories 1 or 2. Permit some types of commercial development below 1% flood level if other planning considerations can justify. Commercial areas shelter in place above the PMF in accordance with FERP or access to development in categories 1 or 2. Provide building fire management system to meet ABCB requirements for high rise building
5	< 1%	< 0.6	AND	< 3	Flood island	Shelter in place in accordance with FERP
6	< 1%	> 0.6	AND	> 3	Flood island	Shelter in place above the PMF in accordance with FERP. Have residential habitable floors above PMF level. Have access to emergency power and water. Provide building fire management system to meet ABCB requirements for high rise building. OR provide internal flood free pedestrian access to development in categories 1 or 2.
7	< 5%	> 0.6	AND	> 8	Flood island	Prohibit residential development unless it has internal flood free pedestrian access to development in categories 1 or 2. OR provide internal flood free pedestrian access to development in categories 5 or 6 AND Shelter in place above the PMF in accordance with FERP. Have residential habitable floors above PMF level. Have access to emergency power and water. Provide building fire management system to meet ABCB requirements for high rise building. Permit some types of commercial development below 1% flood level if other planning considerations can justify providing there is warning system for early evacuation and closure OR flood free pedestrian access to development in categories 1 or 2.
8	> 5%	any	OR	any	Rising access	Prohibit development in these areas unless there is internal flood free pedestrian access to development in categories 1 or 2. No habitable commercial or residential development below 1% flood. Provide building fire management system to meet ABCB requirements for high rise building.
9	> 5%	Any		Any	Flood island	Prohibit development in these areas

The third criterion was duration of PMF flooding as this will determine how long the building and its occupants are likely to be isolated. The available data only allowed us to estimate durations of three hours or less and then hourly increments above that. Given that the NSW SES assumes that it takes two hours for people to be ready to evacuate when ordered to, a threshold of three hours was used to represent a time period in which few people would try and enter or leave the building were it flooded by PMF floodwaters. It would be flooded for less time in small floods.

The next criterion was the emergency response classification with those with either rising road access or an overland escape route considered to be at less risk than those isolated on a flood island.

In combination these criteria produced nine different flood risk categories which need different types of mitigation and response measures.

This flood risk map compares to the three "flood risk" precincts which are currently used for floodplain management in the CBD.

By using all nine categories it enables a gradation of measures to manage risk to life to be used to facilitate intensification of development within the CBD and development in locations which a more simplistic categorisation of the floodplain would prohibit. It would be possible, as part of the planning process, to consolidate some of these categories based on preferred planning controls.

b) Results

Figure 21 maps the results of the nine different combinations of criteria through the planning proposal area and a discussion on recommended measures to manage risk to life in each follows.

Category 1.

It was considered that there would be negligible risk to life in areas with rising access which cannot be flooded to greater than 0.6m depth in a PMF and have less than a 1% chance of being flooded at all. This is because they have a low chance of flooding, they can evacuate on foot ahead of the floodwaters reaching the building, emergency service vehicles could reach the building through floodwaters if needed and people could walk through floodwaters to enter or leave the building if absolutely necessary.

Category 2

Were areas with rising road access to have less than a 1% chance of being flooded but could be flooded to a depth of between 0.6m and 1.2m in a PMF and be flooded for less than three hours these were assessed to have a very low flood risk. This is because they also have a low chance of flooding but might not be able to be reached by emergency vehicles at the peak of a rare flood and if people were to try and walk through the floodwaters they may be at some risk. However, the three hour maximum duration means that there is a low chance of an emergency happening in that time and a low chance of people getting impatient and trying to walk through floodwaters. A building specific flood emergency response plan (FERP) could be used to encourage occupants to evacuate early or shelter in place.

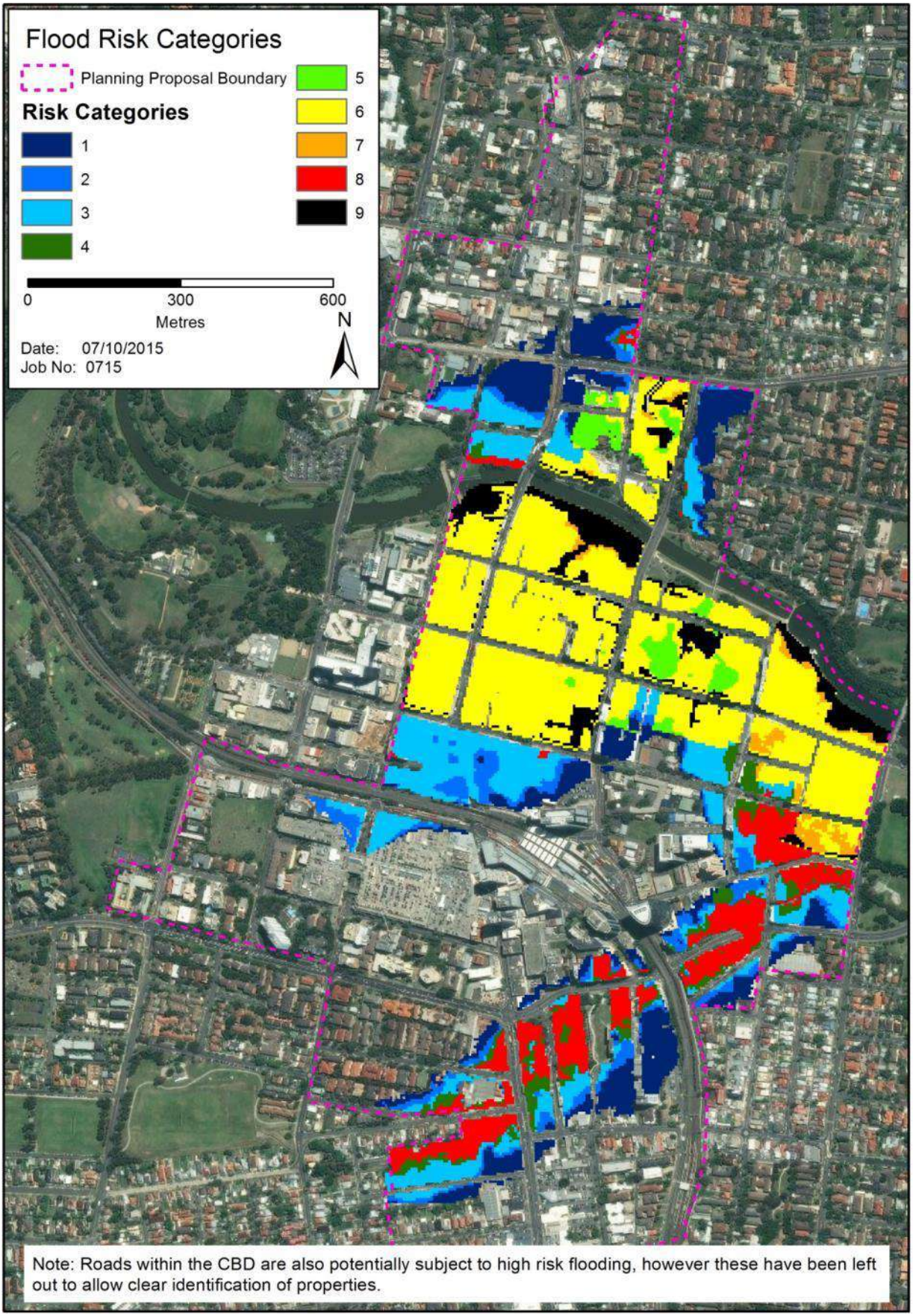

Figure 21: Flood Risk to Life Categorisation of Developable lots

Category 3.

Similar areas where the depth could exceed 1.2m or the duration could be longer than three hours were assessed to have a slightly greater risk because there is a greater chance that people may try and traverse hazardous floodwaters or emergency service cannot reach those needing assistance.

In these locations a FERP would advise people to shelter in place and a fire management system which meets Australian Building Code Board (ABCB) requirements for a high rise building could be used to minimise the chance of a fire in the building placing lives at risk. This would apply even if the building would not be defined as a high rise building (over 25 metres in effective height).

It is noted that in early 2019 the National Construction Code (NCC) was updated. The new NCC has extended the provision of fire sprinklers to lower-rise residential buildings, generally 4-8 storeys. However, non-sprinkler protection is still permitted where other fire safety measures meet the deemed minimum acceptable standard.

It would be necessary to ensure there is sufficient space above the PMF level for all building occupants to shelter.

Category 4

While areas in this category also have a rising road access, they have a much higher chance of being cut off by floodwaters and they will be flooded to greater depths and for longer durations in more extreme floods.

It is our opinion that these areas may be suitable for some commercial development (which has few occupants) below the 1% AEP flood level but above the 5% AEP flood level if there are other overriding planning considerations such as street activation. This could only be permissible if the building were designed to exclude floodwaters from high value assets within the commercial spaces below the 1% level and the commercial areas have free access to a location above the PMF within the building where occupants can shelter. Alternatively they could have internal flood free pedestrian access to development in categories 1 or 2.

Because occupants of commercial spaces may be trapped in the building for some time it would be necessary for the building to have a fire management system which meets ABCB requirements for a high rise building.

Because of the high probability of isolation it is not recommended that residential development be permitted in these areas unless it has internal flood free pedestrian access to development in categories 1 or 2.

The internal flood free access to areas with lower flood risks would mean that the occupants would be able to enter or exit the building through an entrance which has a much lower chance of being cut off by hazardous floodwaters. This access could be achieved by either a contiguous building which spans the flood risk categories or by a covered, elevated walkway connecting the building to a building in the lower flood risk area.

Access to buildings in Category 3 would not be sufficient to permit development in Category 4 areas as they have too high a probability of isolation by high hazard floodwaters and it would not be practical to provide shelter areas above the PMF in an adjacent building.

Category 5

Flood islands create higher risks because there is less of an opportunity to walk to flood free land ahead of floodwaters arriving. With this in mind if these areas have less than a 1% chance of flooding and would have less than 0.6m depth and less than three hours duration of flooding in a PMF they were assessed to have low flood risk because there would not be a significant chance that people would walk through floodwaters to leave or access the building.

However, because there is no opportunity to leave the building and walk ahead of rising flood waters it is recommended that a FERP encourage sheltering in place. No further controls are required.

Category 6

Were either the depth or duration to exceed 0.6m or three hours respectively then the area would be assessed to have a higher flood risk because the long duration increases the

chance that someone will walk through floodwaters and the greater depth increases the chance that doing so would be dangerous.

This requires a FERP which encourages sheltering in place but also the building occupants from commercial floors below the PMF must have free access to a location above the PMF within the building where they can shelter.

It is recommended that in these buildings the minimum habitable floor level of any residential dwellings be above the PMF level plus a freeboard. This should be able to be achieved by specifying that ground floor areas be for non-residential purposes and minimum ceiling heights be placed on those non-residential spaces.

There must be emergency power and water available to the building for the duration of a PMF event.

It would also be necessary for the building to have a fire management system which meets ABCB requirements for a high rise building.

Alternatively, if these buildings have internal flood free access to development in categories 1 or 2 then the controls which apply to those categories only are needed.

Category 7

Flood islands which are below the 1% flood level but above the 5% AEP flood level were all found to have flood depths greater than 0.6m and durations longer than 8 hours in the PMF and therefore present a high risk to life. However, even in these areas there are measures which can be taken to manage risk to life.

Because of the high probability of isolation it is not recommended that residential development be permitted in these areas unless it has internal flood free pedestrian access to development in categories 1 or 2.

Alternatively they can have access to development in categories 5 or 6 providing that:

- habitable floors in the residential dwellings are all above the PMF
- there is access to emergency power and water which would not be affected by the PMF
- There is a fire management system which meets ABCB requirements for a high rise building

Some commercial development below the 1% flood level but above the 5% AEP flood level may be appropriate if there are other overriding planning considerations such as street activation. This could only be permissible if the building were designed to exclude floodwaters from high value assets within the commercial spaces below the 1% AEP level and:

- There is a warning system and FERP which enables the premises to be evacuated and closed with sufficient time for occupants to reach flood free land; or
- There is internal flood free pedestrian access to development in categories 1 or 2.

Category 8

Areas with rising access which are below the 5% AEP flood level and can be flooded to more than 0.6m depth or flooded for longer than three hours were assessed to have a very high flood risk because they would flood relatively frequently and the depth or duration would increase the chance of people trying to traverse hazardous floodwaters.

All development should be prohibited in these areas unless there is internal flood free pedestrian access to development in categories 1 or 2. No habitable commercial or residential development should be permitted below the 1% AEP flood level.

Category 9

Flood islands below the 5% AEP flood level represent an extreme risk to life and habitable commercial and residential development should be prohibited in these areas.

c) Assigning a Category

Figure 21 maps the flood risk categorisation based on the assumption that there is a common access to the building at each location on the map. This will not be the reality. If a single building occupies that lot

then the risk to life which dictates the actual risk to the building occupants will be the one that applies at the entrance of the building which all of the occupants have access to.

Should a building span more than one lot, then it is again the assessed risk at the building common entrance which dictates the risk to life which the development must respond to, an example of where this would potentially be feasible is the Auto Alley area, shown in Figure 22. This provides scope for lot consolidation or building links (e.g. elevated walkways) to reduce the risk to life of a development and reduce the requirements for managing risk to life.

5.8 RATIONALISATION OF RISK CATEGORIES

While the rationale for the risk to life categories is sound and the suggested management measures in Table 6 are appropriate, the use of nine separate life risk categories in a planning scheme is not practical.

Furthermore, the fact that most, if not all, of the redevelopment which will take place in the CBD will be multi-storey, there will be little practical distinction between rising road access and flood islands because dwellings above the ground floor in an area with rising road access will effectively be on a flood island.

Finally, it was recognised that many of the suggested management measures were common across categories with additional measures required as the flood risk to life increased.

In light of these considerations, an alternative flood risk categorisation was developed and a more concise presentation of suggested life risk management measures proposed. These are summarised in Table 7 and an explanation of their rationale follows. Figure 23 is a schematic representation of the various flood emergency management control options in each of the flood risk zones.

Figure 24 shows how they are distributed across the Parramatta CBD after the number of categories were consolidated and micro risk pockets rationalised. Figure 25 has remapped the categories in Figure 24 by cadastral boundary.

For Categories 1, 2, 3 and 4, all buildings located within the PMF must be structurally sound in the full range of floods.

Category 1.

This is as per the original Category 1. In a PMF it would be subject to low hazard, short duration flooding. People would be able to walk away from rising flood waters but should they be trapped by floodwaters it would pose minimal risk to them were they to either shelter in place or choose to leave through the floodwaters.

No particular measures are needed to ensure their safety other than the building being structurally sound in the full range of floods which is not an onerous requirement given the low hazard even in the most extreme events and typical high building construction.

For Categories 2, 3 and 4, shelter in place above the PMF or evacuation to land above the PMF is required.

Category 2.

This category recognised that multistorey development in an area with rising road access is effectively the same as development on a flood island because if occupants above the ground floor fail to evacuate prior to the arrival of floodwaters they are isolated. Using this logic, the original Category 2 presents a similar risk to life as Category 6. The original Category 3 presents a slightly higher risk than these two categories.

Category 5 may appear to have similar flood hazards in the PMF as Category 1, but because it is an island and it may be necessary to traverse higher hazard water away from the site to access flood free ground, it is more logical to group this category into this new Category 2.

The proposed measures for managing life safety are those which apply to category 1 but with some additional requirements to manage the additional risks.

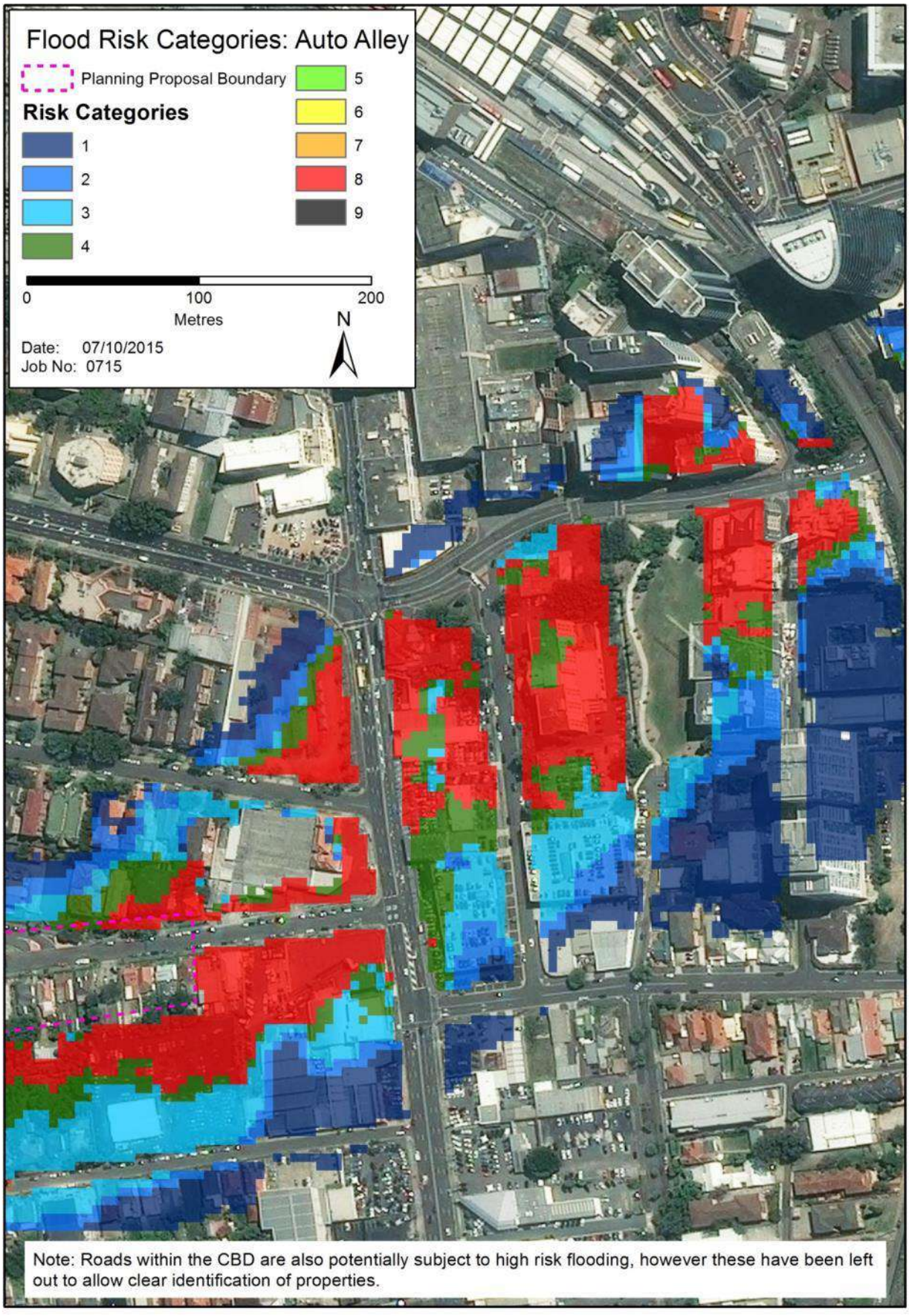

Figure 22: Flood Risk Categories around the Auto Alley Area

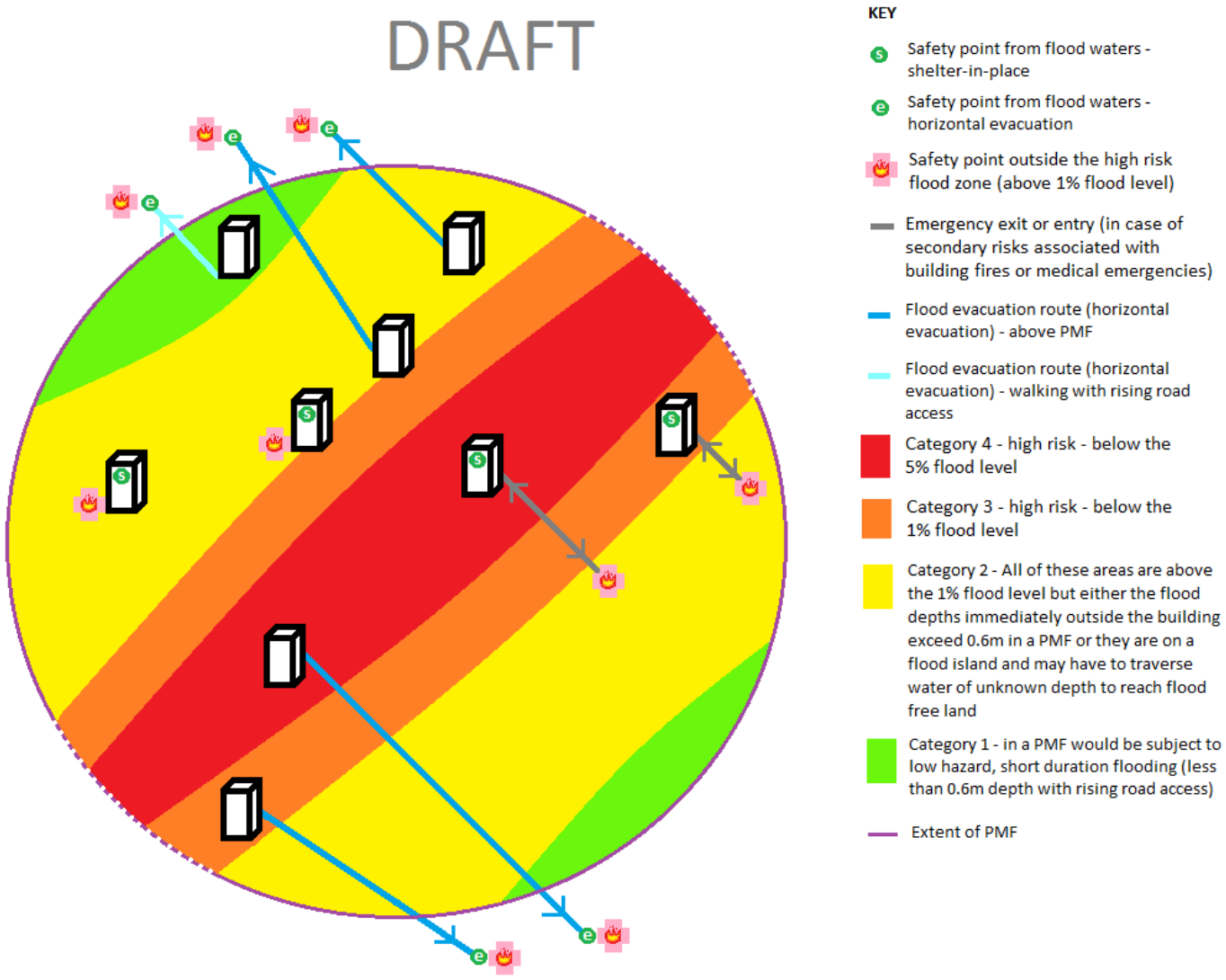

Figure 23: Schematic Diagram of Flood Emergency Response Provisions

Table 7: Concise Life Risk Categorisation and Management Table

			All buildings must do this requirement		AND	All buildings do this	OR	All buildings must do these safety requirements, if indicated by a 'Yes'				AND IF	Commercial included in the building	
Flood Type	**Old Category number**	**New category number**	Building withstand flooding to PMF	Residential floor levels above the 1% flood level plus freeboard		Flood free pedestrain access outside PMF		Shelter for all building occupants above PMF	Fire Safety to ABCB requirements for high rise whether high rise or not	Flood Emergency Response Plan for the Building Maintained by Building Owner or Body Co	Residents able to exit above 1%		Only some forms of commercial development below 1%	Temporarily occupied development only below the 1%
Low Hazard, short duration PMF	1	1	Yes	Yes										
Moderate to High Hazard PMF above 1% AEP (1 In 100 ARI)	2, 3, 5 and 6	2	Yes	Yes		Yes		Yes	Yes	Yes	Yes			
Between 1% AEP (1 in 100 ARI) and 5% AEP (1 in 20 ARI)	4 and 7	3	Yes	Yes		Yes		Yes	Yes	Yes	Yes		Yes	
Greater than 5% AEP (1 in 20 ARI)	8 and 9	4	Yes	Yes		Yes		Yes	Yes	Yes	Yes			Yes

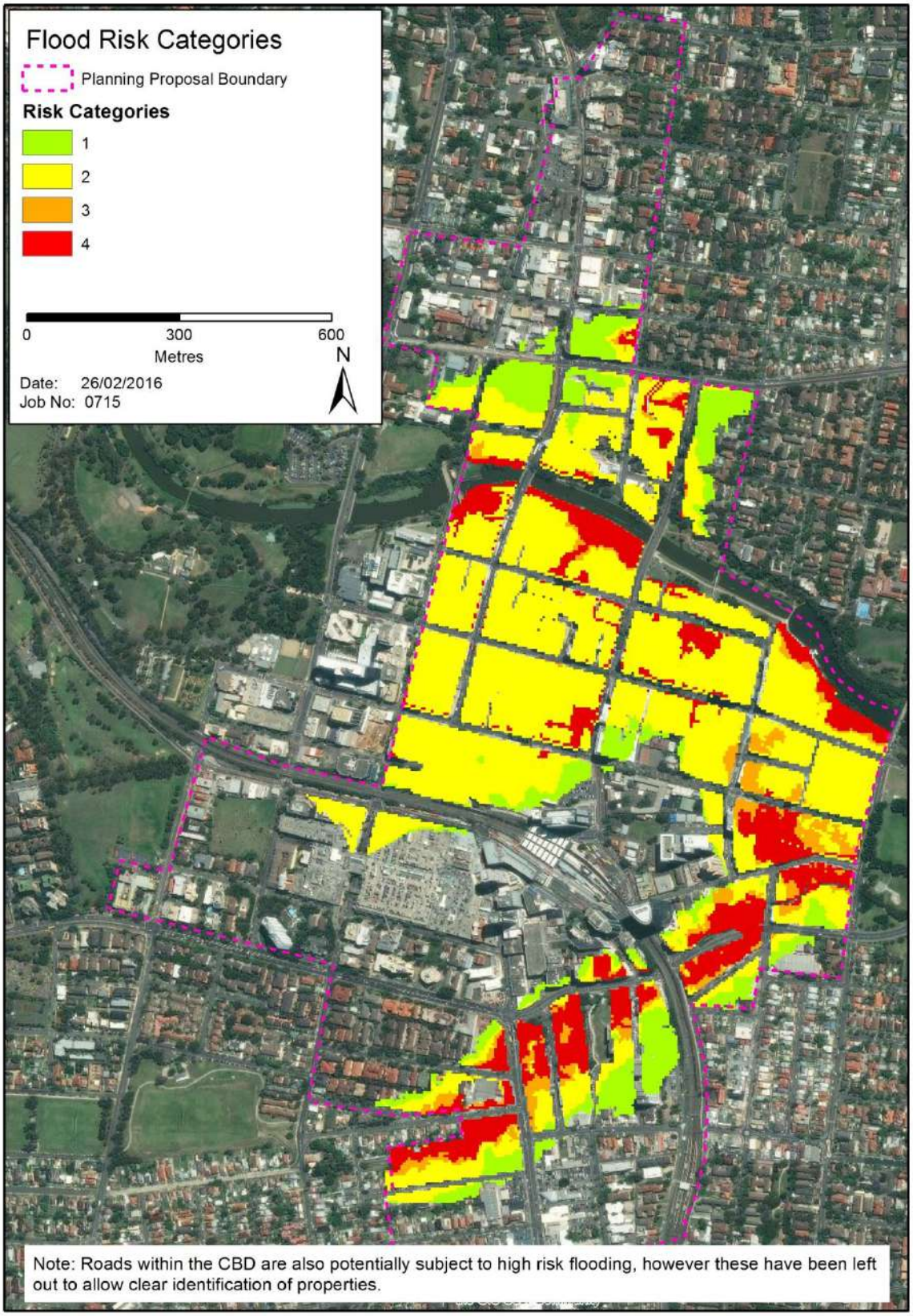

Figure 24: Rationalised Life Risk Categories Mapping

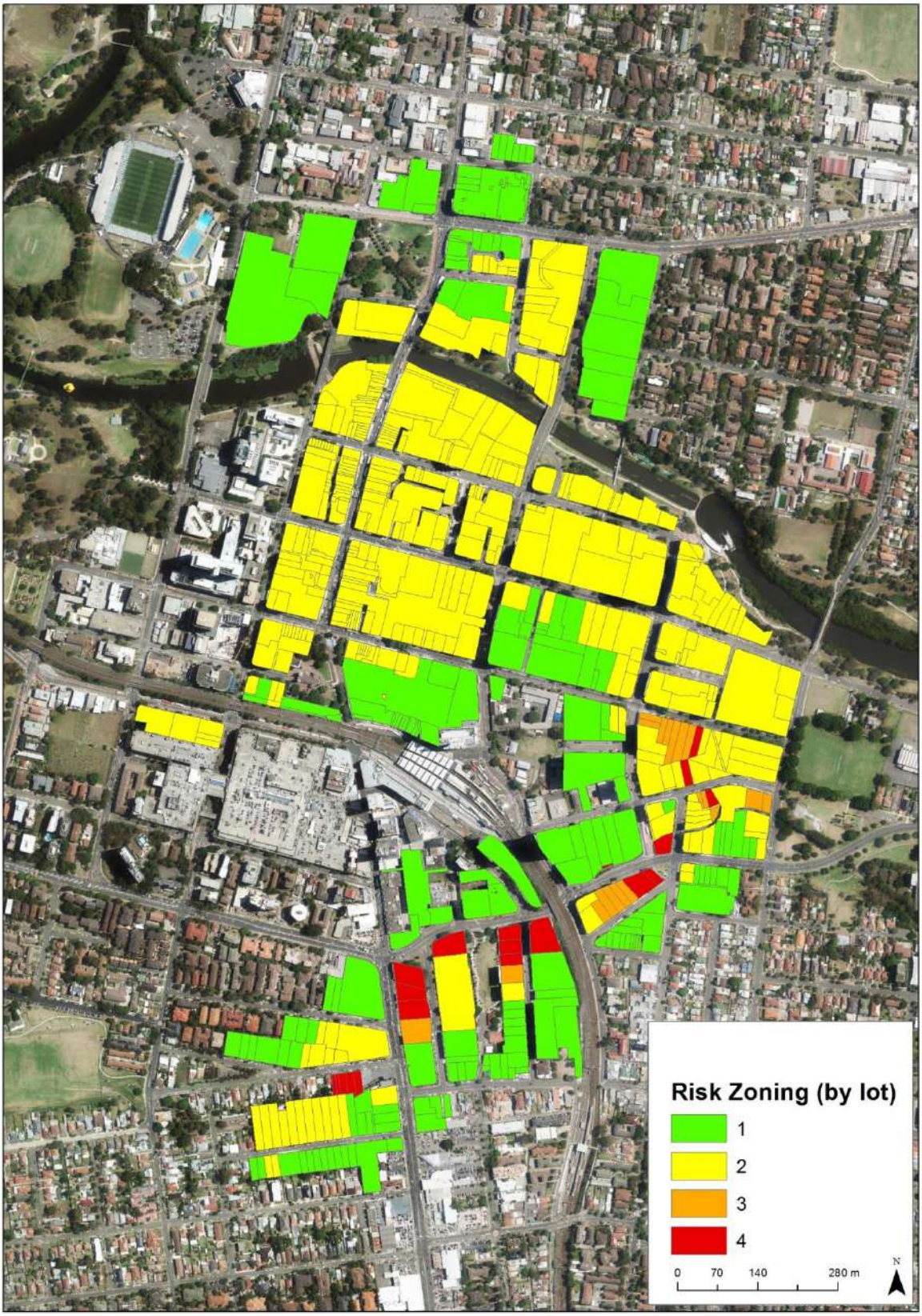

Figure 25: Rationalised Life Risk Categories Mapping by Cadastral Lot:

It is noted that all properties in this category have street frontage to a footpath which is flood free in the 1% AEP flood but they do not necessarily have a current access to a footpath above the 1% AEP flood level. It would have to be a requirement that any redevelopment of these lots has at least one access point, sufficient for fire emergency evacuation of the whole building and accessible for ingress by emergency services personnel which is above the 1% AEP flood level.

If flood free access can be provided for building occupants to an area outside the PMF, then no further controls are required. This could be achieved by having an exit from a building which is above the PMF and is accessible internally to all occupants. Alternatively, it may be achieved by providing a link to a neighbouring building, by means of internal access or a bridge, which has an exit above the PMF.

However, if that is not possible to provide flood free pedestrian access to an area outside the PMF then it would be acceptable for occupants of these buildings to shelter in place provided that:

- There are areas above the PMF sufficient for all building occupants to shelter for up to eight hours and they can be accessed by all building occupants without having to enter floodwaters A flood emergency response plan has been developed for the building and the building owner or body corporate is legally responsible for its maintenance and implementation
- Fire safety features are included within the building to meet the requirements of the ABCB for high rise buildings whether the building is high rise or not.

Category 3.

As with the groupings which make up the new Category 2, it was recognised that the old Category 4 and Category 7 had many things in common, particularly the fact that they lie below the 1% AEP flood level and therefore have a higher probability of being isolated than those in the new Category 2.

It is this particular increased probability of flooding which means that they would be required to have all of the risk management measures of the new Category 2 along with an additional control.

They must have an exit from the building above the 1% AEP flood level which is accessible to all residential occupants such that people would only be trapped inside the building by flooding greater than the 1% flood. In this way, the risk to occupants is brought into line with those in the new Category 2.

This could be achieved through internal access within the building or through a connection to a neighbouring building.

This category also recognises that some types of commercial development may be appropriate below the 1% flood level but that needs to be carefully controlled. For example if other planning considerations such as street activation make a floor level at street level preferable then this could only be permissible if the building were designed to exclude floodwaters from high value assets within the commercial spaces below the 1% level and the commercial areas have free access to a location above the PMF within the building where occupants can shelter.

Category 4.

The new Category 4 replaces the former Category 8 and Category 9. These are areas which are below the 5% AEP flood level and are therefore more frequently flooded and can experience high hazard flooding in larger events.

Occupancy of these areas poses a significant risk to life and property unless carefully controlled. Only temporarily occupied development would be permissible below the 1% flood level here.

In all other respects development in these areas must satisfy all of the controls which apply to Category 3. While at face value this might appear that these highest risk areas are not having stricter controls placed on them, the reality is that it will be more difficult for a development in these areas to meet these requirements. For example higher flow velocities may make it more difficult to construct a building which remains structurally sound within the PMF.

However, a creative design may address this and the other requirements so that a

development in these locations poses no greater risk to life than development elsewhere.

It should also be noted that the available flood data used to map the new Category 4 had less detail than that available to map the other categories. As such the boundaries of the new Category 4 may be somewhat conservative, particularly away from the main channels of the Parramatta River and Clay Cliff Creek.

However, a conservative approach has been taken with the mapping based on Council's currently adopted flood extents.

6 MANAGEMENT OPTIONS

Table 2 summarised required floodplain management actions which have not been implemented from previous floodplain risk management plans as well as issues which council officers advised need to be addressed in a new floodplain risk management plan. In addition, management options need to be developed which appropriately manage any new flood risks which would arise due to the CBD planning proposal.

The scope of this floodplain risk management plan revision was not to undertake detailed investigation of mitigation options. It has therefore been assumed that the required unimplemented actions from the earlier plans will become part of the updated plan. Accordingly, this section focuses on options to resolve issues which relate to challenges arising from current flood planning controls or from the CBD planning proposal.

Community and stakeholder consultation for updating the Floodplain Risk Management Plan was undertaken through the Parramatta Floodplain Risk Management Committee. A committee meeting was held on 20 August 2015 and a presentation was delivered to introduce the committee to the work being undertaken, the implementation challenges with the existing flood planning controls and the risk to life issues in relation to the CBD planning proposal. This had been preceded by a presentation by City of Parramatta Council on investigations into an early flood warning system for the Parramatta River and by the NSW SES on the challenges of flood emergency response in Parramatta.

This was followed by a workshop where ideas and opinions were sought on how to deal with the issues which need to be addressed by the revised floodplain risk management plan. The following discussion has been informed in part by those workshop discussions.

6.1 WORKSHOP IDEAS

6.1.1 Evacuation

The general consensus at the workshop, including from representatives of the NSW SES, was that wholesale vehicular evacuation of Parramatta CBD as a flood response is not practical for all of the reasons given is Section 5.5.4.

It was acknowledged, however, that it is desirable for non-resident occupants to be able to evacuate safely from flooded buildings while it is more realistic to expect residents to choose to shelter within their dwellings. To this end, planning controls are needed which minimise the risk to life of both groups of building occupants.

6.1.2 Development in High Hazard Areas

It was generally accepted by the committee that there were limited opportunities to reduce the potential flood hazard. Amplifying existing channels was suggested, however after discussion it was agreed this was not feasible. The other potential solutions were generally around planning considerations, particularly:

- Using high hazard areas as shared open space
- Using planning mechanisms to encourage lot consolidation to ensure that owners of lots in high hazard areas were not financially penalised.

6.1.3 Flood Isolated Areas

The need for integrating flooding constraints into master planning for the city was stressed by members of the committee.

The committee was generally not opposed to development in flood isolated areas, so long as the following issues were addressed:

- Need to maintain a publically accessible PMF refuge
- Need to ensure services (water, electricity) are maintained

Consideration was also given to placing commercial development within higher risk areas and residential development in lower risk areas.

The concept of having elevated walkways connecting buildings in isolated areas to flood free areas was also explored at length.

6.1.4 Retail Floor Levels

The issue of having retail development disconnected from the street by stairs was discussed and it was agreed by the committee that the issue should be addressed.

A number of potential solutions were discussed, including:

- Use of elevated footpaths to bring the footpath level closer to the local flood planning level
- Having entrance colonnades, or setbacks from the street which allow ramping from the footpath level to the flood planning level inside
- Having terraced floor levels inside the ground floor of the building with flood resistant or easily moved contents on the lower levels (e.g. a restaurant may have its kitchen above the flood planning level but the tables and chairs could be lower)
- A retail space which is sealed watertight when the doors are closed

6.1.5 Other – Street Obstructions

The committee members were given an opportunity to discuss any other potential issues. The NSW SES was concerned that during a flood, there will be a number of obstacles such as street furniture, cars etc. that will impede the passage of flood rescue boats.

The issue was discussed, and potential solutions such as undertaking clear path mapping and some form of barrier to prevent vehicles from floating away were raised. However, given the general need for vehicles and street furniture through the CBD it was agreed that is unlikely that this will be easily resolved.

6.2 NSW SES LETTER

In December 2017 the NSW SES wrote to the then Department of Environment and Planning regarding a planning proposal for 180 George St Parramatta. While the letter was specifically responding to that planning proposal, Appendix 2 of the letter listed site specific design considerations and Parramatta CBD General Design considerations. Both are listed here because the site specific considerations are relevant to many sites in the Parramatta CBD, not just 180 George St.

Site specific design considerations

The site specific design considerations should be applied to this development to assist in minimising additional risk.

1. Residential development: *The habitable floors of any residential development (including aged care) should be located above the PMF with the building structurally designed for the likely flood and debris impacts.*

2. Commercial development (including retail): *To cater for the safety of potential occupants, clients and visitors in commercial development there should be the provision of sufficient readily accessible habitable areas above the PMF.*

3. Child care facilities: *Childcare facilities must be located with floor levels above the PMF level.*

4. Car parking: *Any additional parking should be above ground level and have pedestrian access to a podium level above the PMF.*

5. Making buildings as safe as possible to occupy during flood events. *Ensuring buildings are designed for the potential flood and debris loadings of the PMF so that structural failure is avoided during a flood.*

6. Limiting exposure of people to floodwaters. *This can be aided by providing sufficient readily accessible habitable areas above the PMF to cater for potential occupants, clients, visitors and residents.*

7. Provision of public accessible space for the itinerant population in areas surrounding intensive development in Parramatta CBD. *Provision of publically accessible space or access to space above*

the PMF (with adequate infrastructure to enable the physically impaired to access such space) that is easily accessible 24 hours a day for seven days a week which is clearly identified for this purpose with associated directional signage.

8. Providing adequate services so people are less likely to enter floodwaters. *This includes access to ablutions, water, power and basic first aid equipment. Consideration must be given to the availability of on-site systems to provide for power, water and sewage services for the likely flood duration (up to 12 hours) plus a further period of up to 48 hours to provide allowance for restoration of external services.*

9. Addressing secondary risks of fire and medical emergencies during floods. *Where there is no CBD wide strategy to address secondary risks during flooding. The proponent needs to consult with the relevant emergency service agency.*

Parramatta CBD general considerations

1. Sensitive development including child care: *All new emergency response hospitals, childcare and primary school facilities in Parramatta CBD should be located on land outside the extent of the PMF on land were service interruption is likely to be limited.*

2. Secondary schools and day hospitals: *Ideally new day hospitals and secondary school classrooms should also be located above the PMF level. However, at minimum there should be within a day hospital and high school building, the provision of access to adequate space above the PMF for patients, high school students, staff and visitors.*

3. Reducing human behaviour risks through businesses, schools and childcare centres. *Undertaking regular exercising of a building flood emergency response plan similar to a building fire evacuation drill.*

4. Increasing the flood awareness of current and future communities. *Council should have community awareness strategies that include requiring current and future building owners to participate in increasing this awareness.*

5. Parramatta CBD PA system. *There needs to be consideration given to developing a Parramatta CBD PA system like Sydney CBD to communicate evacuation directions and safety messages to the Parramatta CBD population in the lead up to and during a flood to assist in improving the safety of the community.*

6. Addressing secondary risks of fire and medical emergencies during floods. *To minimise the increased risk of fire and to reduce both the potential for adverse outcomes in the case of a medical emergency and the risks to those who may aid the patient, Council, DPE, NSW SES, Ambulance NSW and the relevant Health Functional area and fire agency servicing the area, should be consulted to determine appropriate risk management strategies during flooding.*

6.3 PLANNING PROVISIONS

The following recommendations take into account the results of the risk evaluation in Section 5.7 and the outcomes of the workshop summarised in Section 6.1 and the recommendations of the NSW SES in Section 6.2. Following is a discussion of recommended planning principles which be applied in the development of the planning proposal for the CBD. It includes some specific measures which should be incorporated into an update of Clause 6.3 of the Parramatta LEP and Section 2.4.2.1 of Parramatta DCP 2011 including Table 2.4.2.1.2 Floodplain Matrix. The revision of the LEP and DCP and the selection of precise wording is a detailed town planning exercise which is beyond the scope of this floodplain risk management plan revision.

It is stressed that these recommendations only relate to the DCP as it applies to the Parramatta CBD and its flood risks. They may not be appropriate for floodplains in other parts of the Parramatta LGA. The LEP provisions would also only apply to the Parramatta CBD.

The following discussion makes reference to the various planning considerations set out in the LEP and DCP.

6.3.1 Flood Risk Precincts

The current DCP divides the floodplain into three flood risk precincts: low, medium and high. However, these are generally defined by the extent of the PMF, 100 Year ARI and 20 Year ARI floods respectively with some consideration of high hazard flooding within the 100 Year ARI extent. They therefore do not so much represent flood risk but mostly flood probability which is only one contributor to risk. As discussed in Section 6.2.6, the current precinct classification results in unnecessarily onerous requirements in some circumstances and inadequate requirements in others with regard to managing risk to life.

There was already a recommendation that the definition of the flood risk precincts be reconsidered.

It is therefore recommended that consideration be given to using criteria in addition to flood probability in defining risk precincts. The method used in Section 5.8 is one approach which could be used but there may be better ways of doing this, particularly when better information is available from the new flood model. Alternatively, additional overlays could be used which define additional considerations to flood probability.

6.3.2 Unsuitable Landuse

Table 2.4.2.1.2 identifies most land uses as being unsuitable in the High Flood Risk Precinct, Critical Uses and Facilities and Sensitive Uses and Facilities as being unsuitable in the Medium Flood Risk Precinct and Sensitive Uses and Facilities being unsuitable in the Low Flood Risk Precinct.

Table 2.4.2.1.1 lists Sensitive Uses and Facilities as: community facilities or public buildings which may provide an important contribution to the flood event; child care centres; hospitals; residential care facilities; senior housing; educational establishments.

This is consistent with the recommendations of the NSW SES as set out in Section 6.2.

It does not have a category called Critical Uses and Facilities but rather Critical Utilities and Uses which includes: Hazardous industries; Hazardous storage establishments; Offensive industries; Offensive storage establishments; Liquid fuel depots; Public utility undertakings which may cause pollution of waterways during flooding, are essential to evacuation during periods of flood or if affected during flood events would unreasonably affect the ability of the community to return to normal activities after flood events; Telecommunication facilities; Waste management facilities.

As it is in the DCP the table can only identify these as being unsuitable not prohibited. Only the LEP is able to prohibit development.

Nevertheless, while there is logic in the identification of these landuses as being unsuitable in some of the flood risk precincts, there are two issues which are overlooked by the DCP.

Firstly, many sites span more than one flood risk precinct and the matrix would suggest they are suitable in one but not the other yet the higher risk precinct gets used to determine the permissibility of a particular development. Council should consider if there is a more appropriate methodology to assess this type of site.

Consideration could be given to setting some additional objective based development controls for some of these land uses.

6.3.3 Minimum Floor Levels

a) Residential

The minimum habitable floor level of residential buildings should be maintained at the 100 year ARI plus 0.5m freeboard. This is consistent with the Section 9.1 Direction. However, it is also recommended that in areas with a chance of hazardous flood depths or longer duration flooding in the PMF that residents shelter in place above the PMF. It is logical that the best place for them to do that would be in their own apartments.

It is therefore recommended that where the street entrance for a dwelling on a flood island could be flooded in a PMF for more than three hours, that the minimum floor level for the dwelling should be constructed at the level of the PMF plus a freeboard.

This would not be consistent with the Section 9.1 Direction which states:

A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

Exceptional circumstances exist in Parramatta CBD which warrant flood planning controls to residential development above the residential flood planning level. In particular, there are short warning times, rapid rates of rise, and no practical means of evacuating the existing populations from the floodplain. Furthermore, the numbers of people who could be isolated by flooding will increase under the existing planning instruments. This planning proposal provides the opportunity for planning controls to be introduced so that as development takes place the risk to life for individuals is reduced.

Alternatively, the same flood risk management outcomes could be achieved by applying planning requirements for other purposes. For example, stipulating that buildings in particular areas must have commercial development on the ground floor and minimum ceiling heights. By default this will set minimum floor levels for residential dwellings which would be well above the residential flood planning level.

As these recommendations are aimed principally at reducing risk to life, it is arguable that it would be better for these particular provisions to be included in the LEP rather than the DCP. In this way they cannot be easily overridden, particularly as they are not consistent with common practice.

b) Commercial

The current requirement to have all commercial floor levels at the 100 Year ARI flood level plus freeboard fails to recognise the high variability in the nature of commercial premises and the opportunities to use areas below the 100 Year ARI with minimal flood damages. It is also resulting in developments with retail spaces which do not address the street well because they require stepping up from the footpath into the building.

It is therefore recommended that particular classes of retail development be permitted to have areas below the 100 Year ARI level if it can be demonstrated that flooding will not cause significant losses to the contents at that level. For example a restaurant may have its kitchen above the flood planning level but the tables and chairs could be set out at a lower floor level. The tables and chairs (and the floors and walls for that matter) would need to be made of flood compatible materials so that they could be cleaned and reused following a flood.

An even broader range of commercial developments may be appropriate at street levels below the 100 Year ARI if the space can be sealed water tight. We would recommend permitting any retail development with a floor level at street level providing that all of the retail space is sealed watertight when the doors are closed. Provision would have to be made to ensure that occupants can access a flood free location from within the building. There would also have to be engineering standards with which the sealing would have to comply.

It is recognised that this would be a change in direction in Parramatta Council's floodplain management principles. However, flooding is only one consideration in urban planning and design and providing that risk to life can be management appropriately and the commercial risks are outweighed by the commercial benefits, such a change may be justified.

6.3.4 Building Components and Soundness

The existing provisions within the DCP are generally satisfactory. If some retail space below the current flood planning level is permitted (see 6.2.2 b) then the current DCP requires that they be flood compatible which is appropriate. Further provisions may need to be included if it is proposed that it be permissible to dry waterproof some commercial development below the 100 year ARI flood.

6.3.5 Flood Affection

The current DCP requirements with regard to flood affectation are sound. However, the way in which some developments have complied with this requirement in terms of under building flow paths has led to some architecturally unattractive and hydraulically questionable buildings.

We would recommend that provision be included within the DCP which requires more than an engineer's report that it does not affect flooding.

6.3.6 Car Parking and Driveways

The existing provisions in the DCP in relation to car parking and driveways are designed to:

- maximise the opportunity for vehicles to evacuate from premises without driving through high hazard floodwaters
- minimise the chance of multivehicle car parks being inundated
- eliminate the risk of people being exposed to floodwaters cascading into basement carparks.

These are all laudable objectives and the provisions in the DCP are an appropriate way of achieving that.

However, if it is accepted that vehicular evacuation from the CBD, or at least those areas which are flood islands, is not a practical proposition, then a different approach is required.

For example the current DCP requirement of providing a driveway no lower than 0.2m below the 100 year ARI flood level is redundant if the access roads some distance from the building are all lower than this. What is needed in the CBD is a means of preventing vehicles from leaving the car parking areas if water has reached hazardous levels in the access roads. If this is not practical then there needs to be a means of preventing vehicles leaving the car parking areas once the water outside the carpark entrance reaches the level of the footpath.

The DCP currently uses the 100 year ARI flood to define the level of protection afforded to multiple vehicles in a car park. This is an appropriate level of protection given their relative worth compared to building contents which are afforded a similar level of protection. These provisions can be maintained.

The final provision relates to basement car parks with design principle P.14 requiring these, if there is no alternative viable parking arrangement, to be protected from the PMF. This is not to protect the vehicles but to protect people who may be in the carpark from water cascading into the carpark and putting their lives at risk. This is supported as an objective.

Additional guidance may need to be provided in the DCP as to what are acceptable solutions. For example, a car park driveway with its crest above the PMF level would be a failsafe means of ensuring a basement car park does not flood. However, there are other means of keeping floodwaters out which require less space such as flood gates or doors which are triggered by flooding or even are floated into place by rising floodwaters.

These alternatives have some chance of failure and decisions need to be made about the level of reliability which needs to be demonstrated by solutions which might be proposed.

6.3.7 Evacuation

The DCP has three requirements in relation to evacuation of residential and commercial development.

For either type of development in any of the flood risk precincts the "Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan." This is appropriate and should be maintained as a requirement.

For residential development in any flood risk precinct and for commercial development in the medium and high flood risk precinct the requirement is "Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (e.g. second storey) or off site."

This is not consistent with the results of the analysis undertaken for this project. Table 8 compares the evacuation provisions of the current DCP with those suggested by the

analysis in Section 5.7. As previously discussed, vehicular evacuation is not required, at least in the flood island areas. Furthermore, pedestrian evacuation off site is only recommended where the assessed risk to life was negligible or very low which is at the fringes of the areas with rising access and even in the areas with low risk to life, refuge above the PMF is not essential. At the same time, the Section 5.7 method is suggesting that commercial development above the 100 year ARI level needs access to a location above the PMF where depths or velocities in the PMF are high.

Given that the areas with the lowest levels of risk to life only represent a small part of the floodplain, the simplest interim change to the DCP would be to remove reference to vehicular evacuation and make this requirement apply to all residential and commercial development.

The practical implication of this is that it will not encourage developments to have a building entrance at the location with the lowest flood risk to life and it would also not require development in the high flood risk precinct to have any additional controls over those in the low or medium risk precincts. Additional controls are needed in the DCP to encourage:

- Building entrances at a point of lowest flood risk to life on a lot
- Consolidation of lots where this will connect a lot with a higher flood risk to life with a lot with a lower flood risk to life
- Pedestrian overbridges which give developments access to lots with a lower risk to life which are on the other side of a road

It is strongly recommended that the above listed access points be flood free in at least the 1% AEP flood. This is so that emergency services have a very low probability of not being able to access the building and occupants have an extremely low probability of not being able to exit the building if another emergency arises in the building while there is flooding outside. Given that this is fundamentally about minimising risk to life there is merit in this being included in the LEP rather than the DCP so that it cannot be easily overridden.

Controls are also needed to prohibit isolated developments in the high flood risk precinct.

Redevelopment of the CBD will result in the creation of new areas of public open space or public domain areas and these and existing public spaces are likely to be used by more people, more often. Currently the DCP only requires that these areas have reliable pedestrian access during a 20 year ARI peak flood and that their development is consistent with any relevant flood evacuation strategy.

We would recommend that a flood emergency response strategy be developed for the public areas of Parramatta CBD which considers flooding up to the PMF. We also recommend that the development or redevelopment of any public open space provide pedestrian pathways of sufficient capacity for all users to be able to walk ahead of a flood rising as fast as a PMF to a location above the PMF. We recommend that these paths be continuously rising to at least above the 100 year ARI flood level and thereafter not drop below this level.

It is noted that there are large areas of publicly accessible space around Parramatta Train Station and Bus Interchange which is flood free. Furthermore, Westfield Shopping Centre is also mostly flood free and should be considered, in consultation with the centre management, as a potential place of flood refuge as part of a CBD flood emergency response plan.

Probably the best means of achieving any of these is by offering additional floor space ratio incentives to developments which do one of the above. This will essentially mean that the more people developers want to put in the floodplain, the lower they will have to make the probability that the entry to the building will be cut by hazardous floodwaters.

Table 8: Evacuation Planning Provisions

Probability (AEP)	**Existing Flood Risk Precinct**	**DCP Evacuation requirements for residential and commercial development**	**Risk to Life Category**	**Suggested Occupant Response**
< 1%	Low	3. Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (e.g. second storey) or off site (residential only) 4. Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan	1	Safe to evacuate or shelter in place. No evacuation controls required.
			2	Safe to evacuate early or shelter in place above PMF in accordance with a flood emergency response plan for the building.
< 5%	Medium	3. Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (e.g. second storey) or off site 4. Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan 6. Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES and other authorised emergency services personnel	3	Evacuate early or shelter in place above PMF in accordance with a flood emergency response plan for the building providing flood free access is available to an exit through an area above the 1% flood level.
> 5%	High	As for medium flood risk precinct but only if development qualifies as concessional development	4	Evacuate early or shelter in place above PMF in accordance with a flood emergency response plan for the building providing flood free access is available to an exit through an area above the 1% flood level.

In the case of the high flood risk precinct, development should be prohibited altogether unless all occupants have reliable access to development in the medium flood risk precinct. Alternatively developments in medium or low flood risk precincts could be permitted to have increased floor space ratios if they dedicate land in the high flood risk precinct to open space uses.

Where commercial of residential development is in the medium risk precinct, or either is permitted as concessional development in the high flood risk precinct, it is a requirement that "adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES and other authorised emergency services personnel." This is in addition to the other requirements above, and is appropriate and should be retained.

6.3.8 Management and Design

There are currently no management and design requirements for development in the low flood risk precinct. Residential and commercial development in the medium flood risk precinct or as concessional development in the high flood risk precinct must have:

- A Site Emergency Response Flood Plan
- An area to store goods above the 100 Year ARI flood plus freeboard
- No storage of materials below the 100 year ARI flood.

These are all appropriate but concessions with regard to the latter two requirements would need to be made if commercial development were permitted below the 100 year ARI flood level by any of the means suggested in Section 6.3.2.

We would also recommend the following additional requirements for any development which has a building entry more than 0.6m below the level of the PMF:

- The building have a building fire management system to meet ABC requirements for high rise buildings
- The building management review the Site Emergency Response Flood Plan annually or following a flood exceeding a 20 year ARI event and communicate the plan to all occupants

The exact wording of the provisions would need to be developed as part of the DCP review.

This is also the most appropriate place within the DCP to introduce provisions to prevent the current practice of having fire doors which open at street level and would be at depth in a flood. We would recommend that the fire doors be at least 0.5m above the level of the 100 year ARI flood. This would encourage building design which puts the fire exit on the high side of the building but also could be achieved by having the last part of the fire exit from the building external to the building.

Additionally, we would recommend that the DCP have provisions to the effect that critical building infrastructure, such as critical electrical, sewer, water and lift infrastructure be placed above the level of the PMF. This will reduce the likelihood that power or water would be disabled during a flood and also decrease the time that the building would be unliveable following the flood. The Queensland Reconstruction Authority has recently published guidelines for resilient electrical infrastructure which includes design guidelines for flood resilient electrical infrastructure in multistorey buildings (QRA, 2019).

6.3.9 Other Considerations

a) Controls on Residential Development above the Flood Planning Level

Most of the redevelopment within the Parramatta CBD is likely to be either entirely commercial development or will be mixed use residential and commercial development.

Mixed use development is likely to have commercial development on the ground floor with residential development above it. As discussed in Section 6.3.3, this may be a way of ensuring that minimum residential floor levels are above the PMF in areas where that is appropriate for managing risk to life in a way which does not contravene the provisions of the Section 9.1 Direction without the need for the granting of exceptional circumstances.

Similarly, recommended provisions with regard to refuge above the PMF, fire management systems, emergency power and water, protection of basement car parks and provision of a building specific FERP, could all be imposed as requirements on the commercial development in such a way that they make adequate provision for the residential development.

However, our recommendation that residential development be prohibited in some locations or be conditional upon it being connected to an area of less flood risk may be incompatible with the Section 9.1 Direction.

The Section 9.1 Direction and guideline appear to say three slightly different things in relation to controls on residential development.

The Section 9.1 Direction states:

"A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land unless a relevant planning authority provides adequate justification for those controls …"

This could be interpreted to permit residential development on top of commercial development without any flood related development controls, even if the land on which the commercial development is built is below the 100 year ARI level, providing that the residential development is above the residential flood planning level.

The Guideline to which the Section 9.1 Direction refers creates more ambiguity as it states:

"Unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land with a low probability of flooding, that is, land above the residential FPL (low flood risk areas)."

This indicates that the controls cannot be applied where the land has a low probability of flooding (which is not what the Section 9.1 Direction says) but then provides to definitions of what that land is:

- Land above the residential FPL
- Low flood risk areas

The former is defined by the 100 year ARI plus 0.5 metres while the latter is usually defined, as it is in Parramatta's mapping, by the 100 year ARI. In areas which are reasonably flat, as parts of Parramatta CBD are, there can be a significant difference in the extent of the excluded area depending on which definition is used.

Given this ambiguity and the uncertainty around the ability to impose some of the controls it would be beneficial to use the arguments put forward in this report as *"adequate justification for those controls to the satisfaction of the Director-General"*.

b) Public Areas

The flood provisions in the LEP and DCP are very much focussed on managing the flood risks associated with the redevelopment of land within each city block. However, such development increases the use of public transport and increases traffic on the city streets. There is no real mechanism within the NSW planning system to manage flood risks associated with those activities.

The risk of traffic gridlock in Parramatta CBD's streets during a flood is real and, should floodwaters rise above the 100 year ARI level, occupants of those vehicles could have their lives at risk. Intensification of development in the CBD will not increase the maximum number of vehicles which could be so affected because the capacity of the streets will not increase. However, it could increase the chance of it happening because there is a higher probability that the streets would be grid locked.

Parramatta Station and the Bus Interchange are flood free but flooding will disrupt bus access and the flood producing weather is sure to disrupt trains. Intensification of CBD development will not change the probability of that occurring but it will increase the number of people affected by it. This will be people stranded in Parramatta unable to leave and those who wish to travel to Parramatta.

Both of these issues, along with the intensification of use of public domain areas, are emergency response issues which must be managed by a well-developed and resourced emergency response plan for the CBD. Such

an emergency response plan would consider flooding as one of many emergencies which need to be managed.

6.4 EMERGENCY PLANNING

Two of the actions which carry through into the updated floodplain management plan from the original floodplain management plan are:

- Update the local flood plan
- Continue developing the Parramatta River Flood early warning system

Both of these need to be informed by the analysis of life safety risks set out in this report and the recommended evacuation and shelter responses.

While it is proposed that buildings in categories 2 to 4 develop and maintain Flood Emergency Response Plans, these need to be consistent with an overarching Flood Emergency Response Plan for the CBD.

This plan would need to identify, amongst other things, which areas need to be warned and evacuated first, which are the safest evacuation routes and what are the most appropriate means of evacuation. It would also need to identify what areas should not be evacuated and what travel routes should be closed and under what circumstances that should occur.

Given the role of Parramatta as a major public transport hub, special consideration will need to be given to the role of public transport in flood emergency response.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

7.1.1 CBD Planning Proposal

There are existing flooding problems within the CBD that need to be addressed and redevelopment provides opportunities to reduce the level of risk to individuals and property.

With reference to the Section 9.1 Direction, it is acknowledged that the planning proposal contains provisions that apply to the flood planning areas which:

- (6)(a) permit development in floodway areas; and
- (6)(c) permit a significant increase in the development of that land

As provided for in clause (9) of the Section 9.1 Direction, these inconsistencies are permissible if "the planning proposal is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual 2005.

The risk assessment in this report has been carried out in line with the principles and guidelines of the Floodplain Development Manual (2005). It is our view that the planning proposal presents a tolerable flood risk to life and property if the recommendations made within this report, with regard to DCP revisions and other flood risk management measures, are implemented.

This conclusion has been made recognising that while the planning proposal increases the overall population at risk, it will also provide the opportunity to decrease the risk to that population through encouraging re-development which is more compatible with the flood risk.

This work has been undertaken using existing flood modelling information, which is currently being updated by Council through a new flood study. It is recommended that the risk to life assessments undertaken as part of this project be revisited following the completion of the flood study, or as part of a subsequent floodplain risk management study.

7.1.2 Planning Investigation Area

The Planning Investigation Area being considered for expansion of the Parramatta CBD is mostly flood free, and as such there would be almost no flooding constraints for redevelopment. The revisions to the planning controls recommended for the CBD Planning Proposal would be sufficient to manage flood risks in the Planning Investigation Area.

7.1.3 Parramatta North Urban Renewal Area

The Parramatta North Urban Renewal Area is almost completely within the Parramatta River floodplain and therefore careful consideration needs to be given to planning controls for that area. Although this report has not investigated flood risks in the Parramatta North Urban Renewal Area, it is likely that it would need similar planning controls to the Parramatta CBD up to the PMF flood extent.

7.2 RECOMMENDATIONS

It is recommended that the City of Parramatta Council adopt the Floodplain Risk Management Plan set out in Section 8 of this report. This plan:

- Carries forward matters from the current Floodplain Risk Management Plan which have not been completed
- Carries forward matters from the current Floodplain Risk Management Plan which had been investigated and not implement but warrant re-investigation in light of the CBD planning proposal
- Proposes continuing development of the flood early warning system for the Parramatta River
- Proposes the preparation of a Flood Emergency Evacuation Plan for the CBD
- Proposes seeking Ministerial Approval to amend Parramatta LEP 2011 with regard

to controls above the Flood Planning Level

- Proposes a revision of the Parramatta DCP 2011 with regard to flooding

The revision of the LEP should address specific recommendations in this report to ensure the Parramatta CBD Planning Proposal meets the section 9.1 direction and represents a tolerable risk to life and property. In particular, it is recommended that the City of Parramatta Council seek Minister Approval to impose controls for development within the Probable Maximum Flood area to enable occupants of buildings in identified areas that have particular evacuation or emergency response issues to:

(a) shelter within a building above the probable maximum flood level; or

(b) evacuate safely to land located above the probable maximum flood level.

Specific provisions should require that new buildings or significant alterations and additions to existing buildings contains either a safe area with emergency electricity and water for all occupants to take refuge in that is located above the probable maximum flood level, or flood free pedestrian access is available between the building and land that is above the probable maximum flood level; and the building is certified by an engineer to withstand the forces of floodwaters, debris and buoyancy resulting from a probable maximum flood event.

The provision of shelter above the PMF level and a building access at or above the 1% AEP flood level should be included within the LEP rather than just in the DCP to ensure that these minimum life safety measures are applied to all developments.

The revision of the DCP should address specific recommendations in this report to ensure that the Parramatta CBD Planning Proposal represents a tolerable risk to life and property. In particular it is recommended that the following amendments to the DCP provisions be made:

- Planning controls not be triggered solely by flood probabilities but other risk factors such as flood depth, velocity, hazard, rate of rise and duration in the full range of floods. This may require renaming or redefinition of the current flood risk precincts although that may be more appropriate following completion of the new flood study
- Consideration be given to permitting some types of commercial development at street level where this is below the current flood planning level, providing they are designed to minimise damage to property and risk to life
- Where the street entrance for a dwelling could be flooded in a PMF for more than three hours require safe refuge for all occupants above the level of the PMF plus a freeboard
- Where the street entrance for a dwelling could be flooded in a PMF for more than eight hours require that the minimum floor level for the dwelling be constructed above the level of the PMF plus a freeboard and have access to emergency water and power
- Additional requirements be considered with regard to flood affectation provisions to try and eliminate the construction of buildings with under building flow paths which are architecturally unattractive and/or hydraulically questionable
- Remove the requirement for buildings in the CBD to have driveways which allow safe access in a 100 year ARI flood and consider including a provision that prevents vehicles from leaving the car parking areas if water has reached hazardous levels in the access roads
- Remove requirements for vehicular evacuation
- Introduce development incentives such as increased floor space ratios to developments which provide building egress points with a lower depth of flooding in a PMF. This will encourage lot consolidation or elevated walkways to provide pedestrian connection to lower flood risk areas
- Prohibit residential and commercial habitable floors in the current high flood risk precinct unless there is a flood free pedestrian access to a building outside of the high flood risk precinct
- Introduce development incentives such as increased floor space ratios to developments which dedicate high flood risk land to open space uses as an

alternative to habitable buildings on that land

- If commercial developments are permitted at street level below the flood planning level then permit the storage of goods below the flood planning level provided they are protected from floods up to the flood planning level
- Require buildings which have their highest building egress more than 0.6m below the level of the PMF to have:
    - a building fire management system to meet ABC requirements for high rise buildings
    - The building management review the Site Emergency Response Flood Plan annually or following a flood exceeding a 20 year ARI event and communicate the plan to all occupants
- External fire doors be above the level of the 100 year ARI flood plus 0.5m
- Critical services infrastructure that could be damaged by flooding; such as electrical, lift, sewer and water are placed above the PMF.

8 UPDATED FLOODPLAIN RISK MANAGEMENT PLAN

The recommended updated floodplain risk management plan is essentially the sum of the recommended measures within Table 2 and Chapter 6. These have been amalgamated below in Table 9. The responses have been prioritised into High, Medium and Low categories. High priority has been given to measures that could be implemented immediately and would have an impact on the flood risk for the current population at risk. Medium was assigned to measures that could be implemented in the medium term and would reduce the risk of any proposed development.

Table 9: Updated Floodplain Risk Management Plan Measures

Proposed Measure	Measure Type	Priority	Source
Make revisions to the DCP as outlined within Section 6.2 and 7.2 of this report	Planning Control	Medium	Existing Plan Review
Council to develop a policy with respect to fencing and screening within floodways. Consideration should be given to the potential for blockage of the screen and effectiveness of the screen to convey water	Planning Control	Medium	Existing Plan Review
Council to consider ways in which it could be made clear that the S10.7(2) certificates do not contain all flooding information. Recommended that a guide to making the decision of purchasing S10.7(2) or S10.7(5) is included within the application form	Planning Control	Medium	Existing Plan Review
Council to consider ways in which S7.11 contributions could be made towards flood mitigation projects	Planning Control	Medium	Existing Plan Review
Council to encourage the NSW SES finalise their development of the Local Flood Sub Plan	Response Modification	High	Existing Plan Review
Council review the availability of flooding data to the public and develop a community awareness and education policy and program for ensuring the population at risk is aware of the flood risks to life and property	Response Modification	High	Existing Plan Review
Council continues developing the Flood Early Warning System for Parramatta CBD and includes a program for review and continuous improvement of the system	Response Modification	High	Existing Plan Review
Council to encourage Sydney Water to conduct a review of the maintenance program for the channel including removal of rubbish and excess vegetation	Flood Modification	Medium	Existing Plan Review

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10 GLOSSARY

THE AUSTRALIAN BUILDING CODES BOARD (ABCB) The organisation responsible for setting and maintaining the national construction code, which defines the minimum safety and design requirements for the construction of buildings

ANNUAL EXCEEDANCE PROBABILITY (AEP): The likelihood of a flood being exceeded in any given year. For example, a flood with an AEP of 1% or 1 in 100 has a 1 in 100 chance of being exceeded in any given year. Synonymous with

AVERAGE RECURRANCE INTERVAL (ARI): The long-term average number of years between the occurrence of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

AUSTRALIAN HEIGHT DATUM (AHD): The standard reference level used to express the relative elevation of different features. A height given in metres AHD is essentially the height above sea level.

BACKWATER: An area inundated by water from a river but outside the general flow of the river.

BANKFULL: The condition of a river when flow is so great that no river banks are exposed.

BoM: The Bureau of Meteorology is the Australian Government Agency responsible for providing weather forecasts. Its legislated responsibility includes, "the issue of warnings of gales, storms and other weather conditions likely to endanger life or property, including weather conditions likely to give rise to floods or bush fires."

CATCHMENT: The land surface area that drains into a reservoir or to a specific point in a river system.

CONTRAFLOW: Altering the normal direction of flow of traffic.

DESIGN FLOOD: A flood where the levels at all points along the river have the same chance of occurrence. It is estimated using hydrologic and hydraulic computer models.

DISCHARGE: The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s).

Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

EVACUATION: The movement of people from a place of danger to a place of relative safety, and their eventual return.

EVACUATION TRIGGER: The flood level that triggers evacuation of a particular area, usually given as the when the evacuation route is cut off by floodwaters or when the area is inundated.

FLASH FLOODING: Flooding that occurs without sufficient warning, usually from heavy local rainfall. For its flood warning purposes, the BoM defines it as flooding which occurs six hours or less from the onset of rain.

FLOOD EMERGENCY RESPONSE PLAN: A plan that sets out the actions and triggers for actions in response to a flood emergency. Usually undertaken on a development scale.

FLOOD FREE: An area that is unlikely to become inundated by flood waters even in a PMF.

FLOOD ISLAND: An area that may be inundated by floodwaters but is initially surrounded before becoming inundated.

FLOODPLAIN: That part of a river valley, adjacent to the river channel, over which a river flows in times of flood.

FLOOD PROGRESSION: The way in which the flood moves across an area.

FLOOD STORAGE: Areas within a flow path that provide critical temporary storage of waters during a flood

FLOOD STUDY: A study commissioned by a Council or Developer to determine the flood extents and levels of an area, utilising hydraulic modelling and hydrological calculations.

FLOODWAY: The area within a flow path that carries the majority of the flow and has higher hazard than the other portions of the flow path

FREEBOARD: A factor of safety that is usually expressed as a height above the designed flood level.

GEOGRAPHIC INFORMATION SYSTEM (GIS): A type of software system that is used to interrogate and undertake analysis on spatial data.

HAZARD: Flood hazard is generally defined by the depth and velocity product which is then categorised based on meaningful thresholds.

HYDROGRAPH: A graph showing the variation over time of water levels or flow.

LOCAL FLOODING: Flooding that occurs as a result of rainfall falling directly over the development.

OVERBANK FLOWS: River flows which cannot be contained within a river channel.

PEDESTRIAN EVACUATION: Evacuation by walking. Pedestrian evacuation should not be relied on as a primary means of evacuation, but may be built in to an evacuation plan as a failsafe mechanism should vehicular evacuation fail in extreme or unforeseen circumstances.

PREMISE: A building or development that is likely to be occupied by residents or employees.

PROBABLE MAXIMUM FLOOD (PMF): The largest flood likely to occur.

RISK: Flood risk is defined as the probability of the event occurring multiplied by the consequence, which can be made up of a number of factors (depth, velocity, damage, duration etc.)

RISING ROAD ACCESS: An evacuation route along a road which is constantly rising to a higher level and eventually to a level above the PMF.

RIVERINE: Of or pertaining to a river.

SECONDARY EMERGENCY: An emergency, such as a fire or medical emergency, that occurs during a flood.

SHELTER IN PLACE: A flood emergency response where the occupants of a premise remain in place until the flood has passed.

APPENDIX A– REVIEW OF EXISTING PLANS

Number	Study Area	Measure Type	Proposed Measure	Review Actions	Status	Revised Measure
1	Lower	Planning Controls	Establish a graded set of planning controls for land uses relative to flood risk that is consistent with the floodplain development manual	Reviewed the current DCP, consulted Flood Policy Review report prepared previously by Molino Stewart	This measure has been implemented, however a suggestion of the Parramatta Flood Policy Review undertaken by Molino Stewart is to consider revising the wording of the DCP which lists terms the precincts as "risk" when these are largely based "hazard" categories. However, this terminology has been adopted across a number of Council DCPs throughout NSW.	It is proposed that Council consider the wording of the DCP to better reflect the nature of the precincts
2		Planning Controls	A range of suggested changes to Parramatta REP 28	Review the Parramatta REP 28 and DCP	The legislation with respect to REP has been repealed, the recommended changes for the REP have been largely carried through the relevant clauses of the updated DCP	N/A
3		Planning Controls	Amend the LEP to provide consistent framework for more detailed controls to be provided in DCP	Reviewed the current LEP and DCP	It is understood that Parramatta LEP 2011 uses the Standard Instrument LEP and the wording is essentially dictated by the Department of Planning and Council has very limited scope to modify it. Clause 6.3 of the Parramatta LEP outlines Flood Planning and only applies to land below the 1:100 ARI flood event plus 0.5 m freeboard. The approach in this clause is not consistent with the Floodplain Development Manual which emphasises a merit based approach and consideration of floods up to the PMF. However, aspects of the DCP do consider the full range of floods The suggested amendment to the LEP are generally captured in the Parramatta DCP. However, the DCP doesn't define a scope for Council to consult with relevant agencies such as the NSW Office of Environment or the NSW State Emergency Service.	It is proposed to include a clause within the DCP along the lines of "The Council may consult with and take into consideration, any advice of the Office of Environment and Heritage, the NSW State Emergency Service and any other relevant agency, in relation to the nature of the flood hazard, the necessity and capacity to evacuate persons, and the consequence and suitability of the development." It is recommended Council consider implementing the requirement for basement car parks to be protected up to the level of the PMF and to determine whether this would be in contradiction to the standard instrument LEP
4		Planning Controls	Utilise the foreshore building line provisions within the LEP to provide greater weight to planning decisions with respect to the high flood risk precinct	Review the current LEP and location of the foreshore building line	The plan recommends matching the foreshore building line to the boundary of the high flood risk precinct. Examination of the foreshore building line does not appear to be coincident with the high flood risk precinct (particularly around George Kendall Park). This suggests that this recommendation has not been implemented. Discussion with Council officers suggests that this recommendation has been found to be unfeasible	N/A
5		Planning Controls	Amend current DCP and Policy as per recommendations found within Appendix C	Review the Appendix C of the Plan, the current DCP and Flood Policy	The policy and DCP are generally not as prescriptive as Appendix C, particularly in terms of the Information Required as part of a DA. The planning control matrix found within the DCP is similar to the recommended matrix within Appendix C of the original Plan. There is no mention of requirements with respect to fencing or screening within the DCP	Council to develop a policy with respect to fencing and screening within floodways. During our investigations a number of screens that are intended to allow flood waters to pass below the building would not be effective and would be prone to blockages.
6		Planning Controls	Notations on Section 149(2) Certificates as per UPRC FRMP	Review of current S149 certificates	There is currently an issue with respect to the S149 certificates as a copy of the S149(2) certificate will not contain flooding information. This is generally not explained to those requesting the S149(2) certificate.	Recommendation that a note should be added, or a guide for those applying for the S149 certificate to ensure that if they require flooding information that they are directed to purchase the S149(5)
7		Planning Controls	Consider specific S94 contributions for specific developments	Review the current S94 Plans	The plan suggests limited scope for S94 contributions towards mitigation measures, however, it recommends that this should be monitored for potential opportunities. The River foreshore park improvements are listed in the Civic Improvement Plan the design principles include improvements to the management of flood events.	Given the scale of the flooding problem within the CBD and also the extent of redevelopment currently occurring, it is recommended that the potential for S94 contributions for flood mitigation works is investigated further. This may require innovative and/or large scale works.
8		Property Modification	Proposed Voluntary House Raising and Voluntary House Purchase Policy	Council to advise	Council is currently operating a Voluntary House Purchase and Voluntary Housing Raising Scheme (Local Floodplain Risk Management Policy 2006)	Recommended that the Council await the outcomes of the current Flood Study prior to pursuing further voluntary house purchase of voluntary house raising.
9		Response Modification	Develop NSW SES Local Flood Plan	Check with SES	The Parramatta DISPLAN has some emphasis on flooding and is currently being updated. An SES local flood plan is currently being developed.	Given the nature and scale of the flood risks within Parramatta, it is recommended that resources are provided for the completion of the Local Flood Plan
10		Response Modification	Distribute Flood Risk Precinct Maps to flood affected lots	Check website, Council to advise	Flood Risk Precinct Maps are not readily available on the Council website and are only available through the flood enquiry application. Advice from Council is that these have not been distributed to areas that are at risk.	Council reviews the availability of flooding data to the public and to develop a policy or program for ensuring that the population at risk is aware of the flood risks to life and property.

11		Response Modification	Discussions re early warning system	Council to advise	Council is currently progressing the installation of a flood early warning system for the Parramatta CBD. The design and price of the system has been presented to the Floodplain Risk Management Committee and was approved by the Committee	Council continues the development of the Early Warning system and implements a continuous improvement and review process to ensure that the system is effective
12		Flood Modification	Ollie Webb Reserve detention basin	Council to advise	Constructed	N/A
13		Flood Modification	Thomas Reserve Box Culvert	Council to advise	Not Constructed after further feasibility investigations	N/A
14		Flood Modification	A'Becketts Creek de-snagging and removal of rubbish and veg	Council to advise	Council advises that this was likely done at the time but there is no ongoing action.	Council and Sydney Water conduct review of maintenance program for channel removal of rubbish, excess vegetation
15		Flood Modification	Duck Creek de-snagging and removal of rubbish and veg	Council to advise	Council advises that this was likely done at the time but there is no ongoing action.	As Above
16		Flood Modification	Duck River de-snagging and removal of rubbish and veg	Council to advise	Council advises that this was likely done at the time but there is no ongoing action.	As Above
17	Upper	Flood and Property Modification	Upgrade of Briens Road Culvert, 5 Voluntary Acquisitions (North Wentworthville FRMSP)	Council to advise	Complete	N/A
18		Flood and Property Modification	Bogalara Road Toongabbie – Pipe Upgrade and Augmentation	Council to advise	Complete	N/A
19		Flood and Property Modification	Oakes Road, Old Toongabbie House Raising (6 homes) and Flood Proofing (4 homes).	Council to advise	Complete – a number of properties owners did not participate	N/A
20		Flood and Property Modification	Wentworth Avenue to Burrabogee Rd, Pendle Hill Channel Formalisation, Culvert Upgrade and Construction of Drop Structure	Council to advise	Not Complete, Council is unsure of the status of this proposed work. I.e. whether it has been found to be unfeasible	Council to determine the reason that this work did not proceed
21		Flood and Property Modification	Burrabogee Rd to Barangaroo Rd, Pendle Hill – Pendle Hills Ck Floodway	Council to advise whether this has been constructed	Complete	
22		Flood and Property Modification	Edison Pde to Einstein Ave, Winston Hills Diversion of drainage around existing levee	Council to advise whether this has been constructed	Complete	
23		Flood and Property Modification	Barangaroo Rd to Fitzwilliam Rd, Pendle Hills – channel improvement and additional cell in Fitzwilliam Rd culverts	Council to advise whether this has been constructed	Complete – however no additional cell was included in the Fitzwilliam Rd culverts as it was not found to be feasible	
24		Flood and Property Modification	O'Connell, Ferris, Iron, Barney and Church St, North Parramatta – pipe upgrade and augmentation	Council to advise whether this has been constructed	Not completed – further investigations by Council and its consultant are on going	Council to continue investigating
25		Flood and Property Modification	Bellotti Avenue, Churchill Drive, Jerome Avenue, Defoe Place and Twain Street, Winston Hills— pipe upgrade and augmentation including modification of pits	Council to advise whether this has been constructed	Some works have been undertaken, others found not to be feasible	
26		Flood and Property Modification	Belmore Street transition chamber and Belmore Park, North Parramatta flood retarding basin.	Council to advise whether this has been constructed	Complete	
27		Proposed Investigation	Brickfield Creek FRMS	Check whether completed	Complete	
28		Proposed Investigation	Fletcher Cl, Old Toongabbie – Flood Wall	Council to advise whether this has been constructed	The investigation was completed and it was decided not to undertake the works	

29		Proposed Investigation	Campbell's Cash and Carry at Kleins Road and Boundary Road, Northmead — investigation into pipe augmentation or trunk drainage diversion works.	Council to advise whether this has been undertaken	The investigation was completed and the issues have been resolved through redevelopment	
30		Proposed Investigation	Scott Street, Andrews Avenue and Lamonerie Street, Pendle Hill— pipe augmentation and channel works.	Council to advise whether this has been undertaken	The investigation was completed and the issues have been resolved through redevelopment	
31		Proposed Investigation	Sherwood Street, Old Toongabbie levee (voluntary purchase completed in 1993).	Council to advise whether this has been undertaken	The investigation was completed and some works were implemented, however it was found that the levee was not required	
32		Proposed Investigation	Lister Street, Winston Hills levee extension and pump out — these works would be additional to the major diversion drain constructed in 1990 to prevent flooding from behind the existing levee.	Council to advise whether this has been undertaken	The investigation was completed and some works were implemented, however no pump was installed	
33		Planning Controls	Change REP No.28	Check App A Vol 2	This legislation has been repealed, therefore remove from the updated FRMP	
34		Planning Controls	Change Council LEPs	Check App B Vol 2	Suggests using foreshore building line as per above measure suggested in the Lower Parramatta FRMP, response as per Item 4.	
35		Planning Controls	Adopt and Implement DCPs or Policies consistent with Flood Planning Matrix and Plan	Check Appendix C	Complete	
36		Planning Controls	Review and revise existing 2(e) zonings over flood liable areas	Check LEP	2(e) zones now redundant as Parramatta LEP 2001 has been replaced, Flood Prone Land Map in New LEP appears to be updated	
37		Response Modification	Make up-to-date flood risk precinct maps readily accessible to public.	Check Council Website	Flood Prone Land Maps not available on Councils Website – obtainable through the LEP however this is difficult for members of public and not the intention of the plan	As Per Item 10
38		Response Modification	Define and map flood way limits in critical areas	Council to advise whether this has been undertaken	Council's current approach is to define hazard through mapping and it is the responsibility of the developer if a DA is submitted to determine the floodway extent. In the future the floodway extents will be defined through the new Flood Study that is currently being commissioned.	
39		Response Modification	Review and revise provisional flood risk precincts from Trust in light of access, warning time etc. considerations.	Council to advise whether this has been undertaken	Council has continued to revise flood precincts. A major revision will be undertaken as per the new Flood Study that is currently being commissioned.	
40		Response Modification	Prepare or adapt existing data to produce flood risk precinct maps for other catchments.	Review existing studies and plans	Flood study reviews or catchment management plans undertaken for Subiaco, Vineyard, Duck, Claycliff Creeks as well as Duck River and localised flooding areas, also the Parramatta Flood Study is currently being reviewed	
41		Response Modification	Collate data on local overland flooding for ready access and use.	Look over data provided, discuss with Council	This will be undertaken with the new Flood Study that is currently being commissioned	
42		Response Modification	Prepare and run an ongoing program to raise community awareness of flood risks	Council to advise whether this has been undertaken	Currently community awareness and education is only being undertaken as per the community consultation that is required under the floodplain risk management process.	Council to develop a community awareness and education program, as per Item 10
43		Response Modification	Brochure on flood-related building controls available.	MS Check Website Council to advise whether this has been undertaken	Council is currently preparing a number of brochures internally, however these are not publically available.	Recommended that the production of brochures with respect to building controls are completed alongside the recommendations outlined in Item 10

44		Response Modification	All councils to send flood notification letters to all owners of flood liable properties every 4 years.	Council to advise whether this has been undertaken	This has not been undertaken	As per Item 10
45		Response Modification	Prepare and make widely available a flood information brochure 'Facts about Flooding'.	MS Check Website Council to advise whether this has been undertaken	This has not been undertaken, however some flooding information is now available on Councils website.	As per Item 10
46		Response Modification	Prepare and make widely available a frequently asked questions brochure.	MS Check Website Council to advise whether this has been undertaken	This has not been undertaken	As per Item 10
47		Response Modification	Consider providing flood certificates or equivalent S149 certificates with comprehensive data on flood levels, ground/floor levels and the flood risk precinct.	Request S149 certificate for flood prone property	This information is available through the flood enquiry application. The form for the flood enquiry can be found online.	
48		Response Modification	Consider using proposed wording for S149(2) certificates.	Request S149 certificate for flood prone property	The S149 certificates currently have an issue as per Item 6	As per Item 6
49		Response Modification	Develop and implement a formal process for release and adoption of updated flood data estimates.	Council to advise whether this has been undertaken	This is undertaken as per the Public Exhibition process when a new Flood Study is undertaken.	

APPENDIX B– CURRENT PARRAMATTA DCP (2011) FLOOD PROVISIONS

2.4 Site Considerations

2.4.1 Views and Vistas

The topographical setting of Parramatta, located in a river basin and bounded by hills to the north and west, means that there are significant views and vistas which contribute to the sense of place for Parramatta. Preservation and, where possible, enhancement of public views to landmark and landscape features allows people to interpret and appreciate the special character of Parramatta.

View sharing between properties is also important to balance access to private views from properties.

Objectives

O.1 To preserve and enhance district and local views which reinforce and protect the City's urban form and enhance legibility.

O.2 To encourage view sharing through complementary siting of buildings, responsive design and well-positioned landscaping.

O.3 To ensure highly visible sites are designed in scale with the City's setting and encourage visual integration and connectivity between places.

Design Principles

P.1 Development is to preserve views of significant topographical features such as ridges and natural corridors, the urban skyline, landmark buildings, sites of historical significance and areas of high visibility, particularly those identified in Appendix 2 Views and Vistas. Refer also to Views and Vistas in the Harris Park Heritage Conservation Area in Part 4 and Views and View Corridors in Parramatta City Centre in section 4.3.3.4.

P.2 Buildings should reinforce the landform of the City and be designed to preserve and strengthen areas of high visibility. In some locations, this may be achieved through uniform heights and street walls as a means of delineating the public view corridor.

P.3 Landscaping of streets and parks is to reinforce public view corridors.

P.4 Building design, location and landscaping is to encourage view sharing between properties.

P.5 Views to and from the public domain are to be protected.

NOTE: For certain developments, 3 dimensional computer simulations or photo montages from selected locations may be required to demonstrate how the proposal affects the setting and views and vistas.

2.4.2 Water Management

2.4.2.1 Flooding

Flooding is a significant issue that affects existing and future development in the Parramatta Local Government Area (LGA). This Section establishes Council's approach to floodplain planning and the general flood prone land requirements relating to development control for the whole LGA. The development of Council's approach to flooding has regard to and complies with the New South Wales Government's Floodplain Development Manual (FDM 2005).

The criteria for determining applications for proposals potentially affected by flooding are structured to recognise that different controls are applicable to different land uses and levels of potential flood inundation and hazard. As a first step in the development consent process, proponents are strongly advised to consult with Council officers, particularly for proposals located in the medium and high flood risk categories.

Objectives

O.1 To ensure the proponents of development and the community in general are aware of the potential flood hazard and consequent risk and liability associated with the use and development of flood liable land.

O.2 To manage flood liable land in an economically, environmentally and socially sustainable manner.

O.3 To ensure that developments with high sensitivity to flood risk (eg. critical public utilities) are sited and designed to provide reliable access and minimise risk from flooding.

O.4 To allow development with a lower sensitivity to the flood hazard to be located within the floodplain, subject to appropriate design and siting controls and provided that the potential consequences that could still arise from flooding remain acceptable.

O.5 To prevent any intensification of the development and use of High Flood Risk Precinct or floodways, and wherever appropriate and feasible, allow for their conversion to natural waterway corridors.

O.6 To ensure that the proposed development does not expose existing development to increased risks associated with flooding.

O.7 To ensure building design and location address flood hazard and do not result in adverse flood impact and unreasonable impacts upon the amenity or ecology of an area.

O.8 To minimise the risk to life by ensuring the provision of appropriate access from areas affected by flooding up to extreme events.

O.9 To minimise the damage to property, including motor vehicles, arising from flooding.

O.10 To incorporate the principles of Ecologically Sustainable Development (ESD).

Design Principles

P.1 New development should not result in any increased risk to human life.

P.2 The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner, property occupants and general community.

P.3 New development should only be permitted where effective warning time and reliable access is available for the evacuation of an area potentially affected by floods to an area free of risk from flooding. Evacuation should be consistent with any relevant flood evacuation strategy where in existence.

P.4 Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with similar developments(s) that are likely to occur within the same catchment.

P.5 New developments must make allowances for motor vehicles to be relocated to an area with substantially less risk from flooding, within an effective warning time.

P.6 New developments must provide an evacuation plan detailing procedures that would be in place for an emergency (such as warning systems, signage or evacuation drills).

P.7 Flood mitigation measures associated with new developments should not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (eg. by unsympathetic house raising) or by being incompatible with the streetscape or character of the locality (including heritage).

P.8 Proposals for raising structures must provide a report from a suitably qualified engineer demonstrating that the raised structure will not be at risk of failure from the forces of floodwaters.

P.9 Development is to be compatible with any relevant Floodplain Risk Management Plan, Flood Studies, or Sub-Catchment Management Plan.

P.10 Development must not divert flood waters, nor interfere with floodwater storage or the natural function of waterways.

P.11 Filling of land up to 1:100 Average Recurrence Interval (ARI) (or flood storage area if determined) is not permitted. Filling of and above 1:100 ARI up to the Probable Maximum Flood (PMF) (or in flood fringe) must not adversely impact upon flood behaviour.

P.12 New development must consider the impact of flooding resulting from local overland flooding whether it is a result of Local Drainage or Major Drainage.

P.13 Where hydraulic flood modelling is required, flow hazard categories should be identified and adequately addressed in the design of the development.

P.14 Council strongly discourages basement car parks on properties within the floodplain. Where site conditions require a basement car park on a property within the floodplain, development applications must provide a detailed hydraulic flood study and design demonstrating that the proposed basement car park has been protected from all flooding up to and including the PMF event. An adequate emergency response and evacuation plan must also be provided where basement car parks are proposed in the floodplain.

Design Controls

All proposals are to have regard to the planning matrix at Figure 2.7. The procedure to determine which design standards apply to proposed development involves:

Step 1: identify the land use category of the development from Table 2.6;

Step 2: determine which flood risk category applies to the land (refer to Catchment Management Unit of Council for the Flood Risk Precincts and relevant flood risk mapping); and

Step 3: apply the objectives and design principles as outlined in this section and then the design standards in the planning matrix at Figure 2.7 as applicable to the floodplain and land use category.

NOTE: An evacuation plan is not enough to negate compliance with all building regulations.

Additional guidelines relating to flood risk management and flood prone land are contained in Council's Local Floodplain Risk Management Policy.

Table 2.6: Land Use Category Definitions

NOTE: Refer to the Parramatta LEP 2011 for definitions of each land use.

LAND USE CATEGORIES	IDENTIFIED LAND USES
Sensitive Uses and Facilities	Community facilities or Public administration buildings which may provide an important contribution to the notification and evacuation of the community during flood events; Child care centres; Hospitals; Residential care facilities; Seniors housing; Educational establishments.
Critical Utilities and Uses	Hazardous industries; Hazardous storage establishments; Offensive industries; Offensive storage establishments; Liquid fuel depots; Public utility undertakings which may cause pollution of waterways during flooding, are essential to evacuation during periods of flood or if affected during flood events would unreasonably affect the ability of the community to return to normal activities after flood events; Telecommunication facilities; Waste management facilities.
Subdivisions	Subdivision of land which involves the creation of additional allotments.
Filling	The net importation of fill material onto a site, except where: (i) final surface levels are raised by no more than 100mm over no more than 50% of the site; or (ii) filling is no more than 800mm thick beneath a concrete building slab only. Compensatory earthworks, involving cut and fill, is not considered to be filling provided that: (i) there is no net importation of fill material onto the site; and (ii) there is no net loss of flood storage at all flood levels.
Residential	Backpackers accommodation; Bed and breakfast establishments; Boarding houses; Community facilities (other than sensitive uses and facilities); Dual occupancies; Dwelling houses; Group homes; Health consulting rooms; Home based child care; Home businesses; Hostels; Multi dwelling housing; Neighbourhood shops; Residential flat buildings; Serviced apartments; Public utility undertakings (other than critical utilities).
Commercial or Industrial	Bulky goods premises; Business Premises; Car parks; Depots; Entertainment facilities; Food and drink premises; Freight transport facilities; Funeral chapels; Funeral homes; Function centres; Hardware and building supplies; Heavy industries; Hotel accommodation; Industries; Landscape and garden supplies; Light industries; Materials recycling or recovery centres; Medical centres; Mixed use development; Office premises; Passenger transport facilities; Places of public worship; Public administration buildings (other than an essential community facility); Pubs; Recreation facilities (indoor); Registered clubs; Restricted premises; Retail Premises; Service stations; Sex services premises; Shop top housing; Tourist and visitor accommodation; Vehicle body repair workshops; Vehicle repair stations; Vehicle showrooms; Veterinary hospitals; Warehouse or distribution centres.

Land Use Category Definitions

LAND USE CATEGORIES	DEFINITIONS
Tourist Related Development	Advertising structures; Kiosks; Markets; Information and education facilities; Signage.
Open Space or Non-urban Uses	Animal boarding and training establishments; Boat launching ramps; Boat repair facilities; Boat sheds; Environmental facilities; Helipad; Jetty; Recreation areas and minor ancillary structures (e.g. Toilet blocks or kiosks); Recreation facilities (outdoor).
Concessional Development	Concessional development is any development or redevelopment that would normally not be permitted under this Plan, but may be permitted as a concession provided it: (i) is kept clear of any floodway; and (ii) involves an acceptably small (see below for limits) addition or alteration to an existing development that will not cause a significant increase in potential flood losses, risks or have an adverse impact on adjoining properties; or (iii) redevelopment for the purposes of substantially reducing the extent of flood affectation to the existing building; provided that such redevelopments incorporate to the fullest extent practical, design features and measures to substantially reduce the existing potential for flood losses and personal risks, and avoid any adverse impacts on adjoining properties – especially obstruction or diversion of floodwaters and loss of flood storage. In the case of residential development, The maximum size of a concessional development is: (i) a once-only addition or alteration to an existing dwelling of no more than 10% or 30m^2 (whichever is the lesser) of the habitable floor area which existed at the date of commencement of this Policy or Plan; or (ii) the construction of an outbuilding with a maximum floor area of 20m^2. In the case of other development categories, the maximum size of a concessional development is a once- only addition to existing premises of no more than 10% of the floor area which existed at the date of commencement of this Policy or Plan.

Table 2.7: FLOODPLAIN MATRIX

Planning & Development Controls

Planning Consideration	Flood Risk Precincts (FRP's)																										
	Low Flood Risk									Medium Flood Risk									High Flood Risk								
	Sensitive Uses & Facilities	Critical Uses & Facilities	Subdivision	Filling	Residential*	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development	Sensitive Uses & Facilities	Critical Uses & Facilities	Subdivision	Filling	Residential*	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development	Sensitive Uses & Facilities	Critical Uses & Facilities	Subdivision	Filling	Residential*	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development
Floor Level		3			2, 5	2, 5	2, 5							2, 5	2, 5	2, 5	1, 5	4, 5								1, 5	4, 5
Building Components		2												1	1	1	1	1								1	1
Structural Soundness		2												1	1	1	1	1								1	1
Flood Affectation		2	2	1	2	2	2					1		1	1	1	2	1								1	1
Car Parking & Driveway Access		1, 3, 5, 6			1, 3, 5, 6	1, 3, 5, 6	1, 3, 5, 6	2, 4, 6, 7						1, 3, 5, 6, 7	1, 3, 5, 6, 7	1, 3, 5, 6, 7	2, 4, 6, 7	1, 5								2. 4. 6. 7	1, 5
Evacuation		2, 4, 6	5		3, 4	4	4					5, 3, 4		3, 4, 6	3, 4, 6	3, 4, 6	1, 4	3, 6								1, 4	3, 4 6
Management & Design		2, 3, 4	1									1		2, 3, 4	2, 3, 4	2, 3, 4	2, 3, 4	2, 3, 4								2, 3, 4	2, 3, 4

Not Relevant Unsuitable Land Use * For redevelopment of an existing dwelling refer also to ' Concessional Development' provisions

i. Freeboard equals an additional height of 500mm.

ii. The Parramatta LEP 2011 identifies development permissible with consent in various zones. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. The above matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.

iii. Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.

iv. Any fencing that forms part of a proposed development is subject to the relevant Flood Effects and Structural Soundness planning considerations of the applicable land use category.

v. Development within the floodplain may be subject to Clause 6.7 Foreshore Building Line in the Parramatta LEP 2011.

Floor Level	
1	All floor levels to be equal to or greater than the 20 year Average Recurrence Interval (ARI) flood level plus freeboard
2	Habitable floor levels to be equal to or greater than the 100 year ARI flood level plus freeboard.
3	All floor levels to be equal to or greater than the Probable Maximum Flood (PMF) level plus freeboard
4	Floor levels to be equal to or greater than the 100 year ARI flood level plus freeboard. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical, and, when undertaking alternations or additions, no lower than the existing floor level.
5	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 subfloor space is not to be enclosed.
Building Components & Method	
1	All structures to have flood compatible building components below the 100 year ARI flood level plus freeboard.
2	All structures to have flood compatible building components below the PMF.
Structural Soundness	
1	An engineers report is required to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year ARI flood level plus freeboard.
2	An engineers report is required to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a PMF level.
Flood Affectation	
1	An engineers report is required to certify that the development will not increase flood affectation eleswhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulate impact of multiple potential developments in the vicinity.
2	The impact of the development on flooding elsewhere to be considered having regard to the three factors listed in consideration 1 above.
Car Parking and Driveway Access	
1	The minimum surface level of open spaces or carports shall be as high as practical, but no lower than 0.1m below the 100 year ARI flood level. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 100 year ARI flood level.
2	The minimum surface level of open parking spaces or carports shall be as high as practical, but no lower than 0.3m above the 20 year ARI flood level.
3	Garages capable of accommodating more than 3 motor vehicles on land zones for urban purposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year ARI flood. Ramp levels to be no lower than 0.5m above the 100 year ARI flood level.
4	The driveway providing access between the road and parking spaces shall be as high as practical and generally rising in the egress direction.
5	The level of the driveway providing access between the road and parking spaces shall be no lower than 0.2m below the 100 year ARI flood level.
6	Enclosed car parking and car parking areas accommodating more than 3 vehicles, with a floor below the 100 year ARI flood level, shall have adequate warning systems, signage, exits and evacuation routes.
7	Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year ARI flood.
Evacuation	
1	Reliable access for pedestrians required during a 20 year ARI peak flood.
2	Reliable access for pedestrians and vehicles required to a publicly accessible location during the PMF peak flood.
3	Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (eg. second storey) or off site.
4	Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan.
5	Applicant is to demonstrate that evacuation in accordance with the requirements of this DCP is available for the potential development resulting from the subdivision.
6	Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES or other authorised emergency services personnel.
Management and Design	
1	Applicant is to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this the relevant FRMS and FRMP
2	Site Emergency Response Flood plan required where the site is affected by the 100 year ARI flood level, (except for single dwelling-houses).
3	Applicant is to demonstrate that area is available to store goods above the 100 year flood level plus freeboard.
4	No storage of materials below the 100 year ARI flood level.

Further Information

Flood Risk Management Plan, Flood Studies, Sub-Catchment Management Plans, and Local Floodplain Risk Management Policy available from Council.

NSW Government's Floodplain Development Manual 2005 – *www.dnr.nsw.gov.au/floodplains/manual.shtml*

Parramatta City Council's Local Floodplain Risk Management Policy, 2006.

2.4.2.2 Protection of Waterways

Objective

O.1 To ensure development contributes to the protection and rehabilitation of waterways in order to improve waterway health and to develop and maintain ecologically sustainable waterways.

Design Principles

P.1 Development is to make provision for buffer areas for the preservation and maintenance of floodway, riparian corridors and habitat protection. Refer to Clause 6.7 Foreshore Building Line and Clause 6.5 Water Protection in the Parramatta LEP 2011.

P.2 Development on land subject to Clause 6.5 Water Protection in the Parramatta LEP 2011 or that abuts a waterway is to be landscaped with local indigenous species, to protect bushland and wildlife corridors and soften the nterface between the natural landscape and the urban environment. Riparian vegetation also plays an important role in stabilising bed and banks and attenuating flood flows.

P.3 The piping, enclosing or artificial channelling of natural watercourses and drainage channels is not permitted. Consideration is to be given to re-opening piped or lined drainage systems wherever feasible.

P.4 Development is to ensure that natural channel design principles are incorporated in any works on or in waterways. Refer to Figure 2.8.

P.5 Ongoing maintenance costs are to be considered in the design of any waterway protection features.

Further Information

Brisbane City Council 2000, *Natural Channel Design Guidelines*

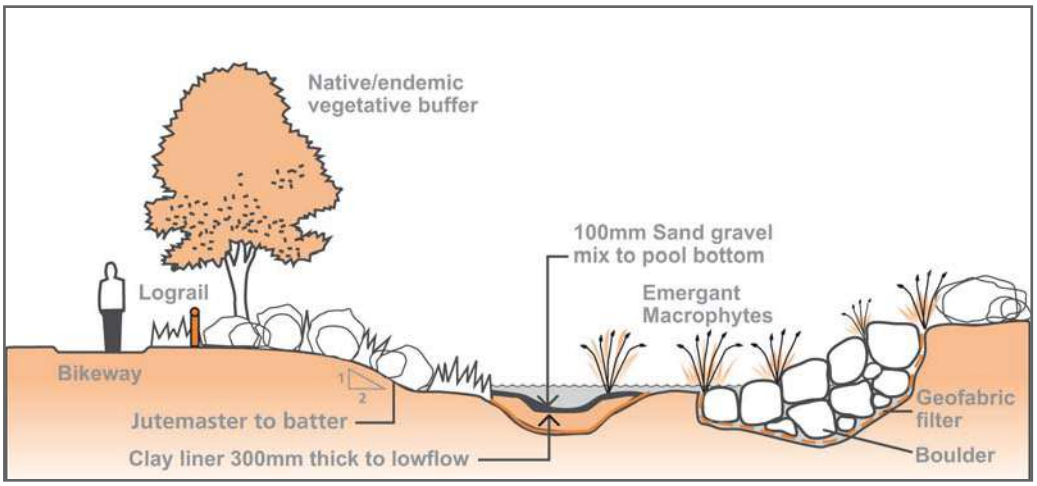


Figure 2.8 *Elements of the Natural Drainage System*
Sources: Stormwater outlets in parks and waterways (Brisbane City Council, 2001)

2.4.2.3 Protection of Groundwater

Objective

O.1 To protect groundwater quality, flows and drainage patterns during demolition, construction and ongoing operation phases of a development.

Design Principles

P.1 Operating practices and technology including dewatering shall not contaminate groundwater or adversely impact on adjoining properties and infrastructure.

P.2 Groundwater is to be recharged where possible while still protecting and/or enhancing groundwater quality.

P.3 Protection measures for groundwater are to be proportional to the risk the development poses. Where the potential risk to groundwater is high, a separate Groundwater Impact and Management Report will be required.

NOTE: The potential risk to groundwater is high when construction involving excavation is below the water table and is within alluvial areas and sandstone environments.

2.4.3 Soil Management

2.4.3.1 Sedimentation

Objectives

O.1 To ensure through effective site controls during and after demolition and construction, that development does not contribute to sedimentation of waterways and drainage systems, or cause wind blown soil loss.

O.2 To ensure that development does not result in environmental damage of waterways and bushland in the City.

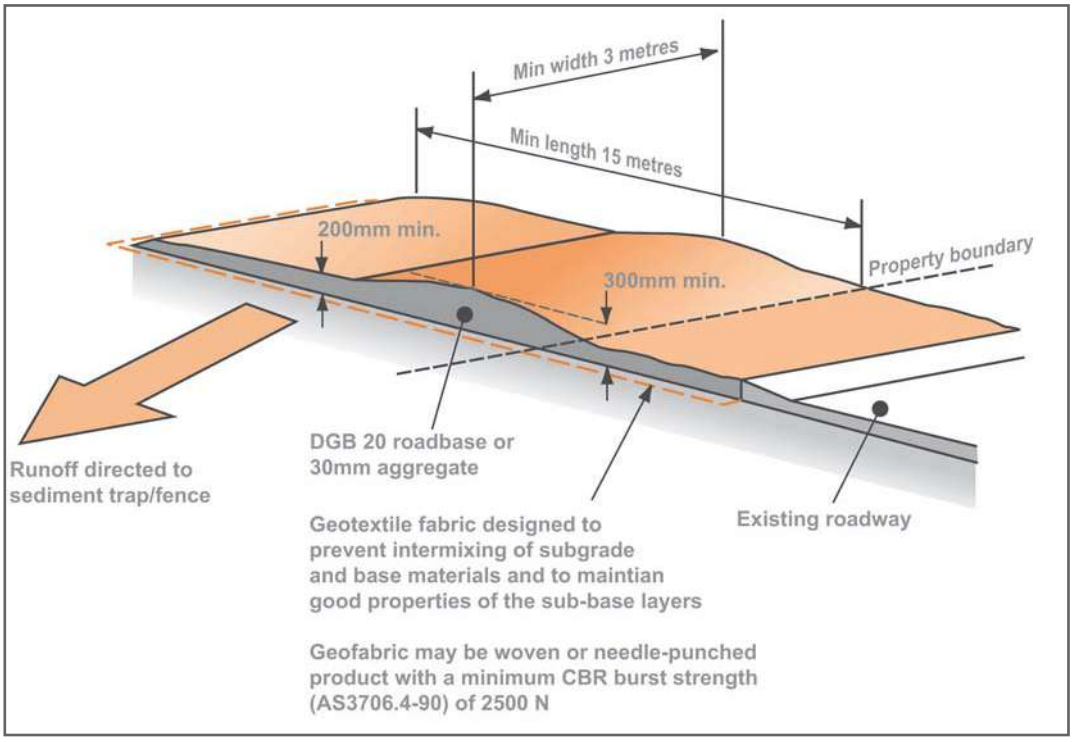
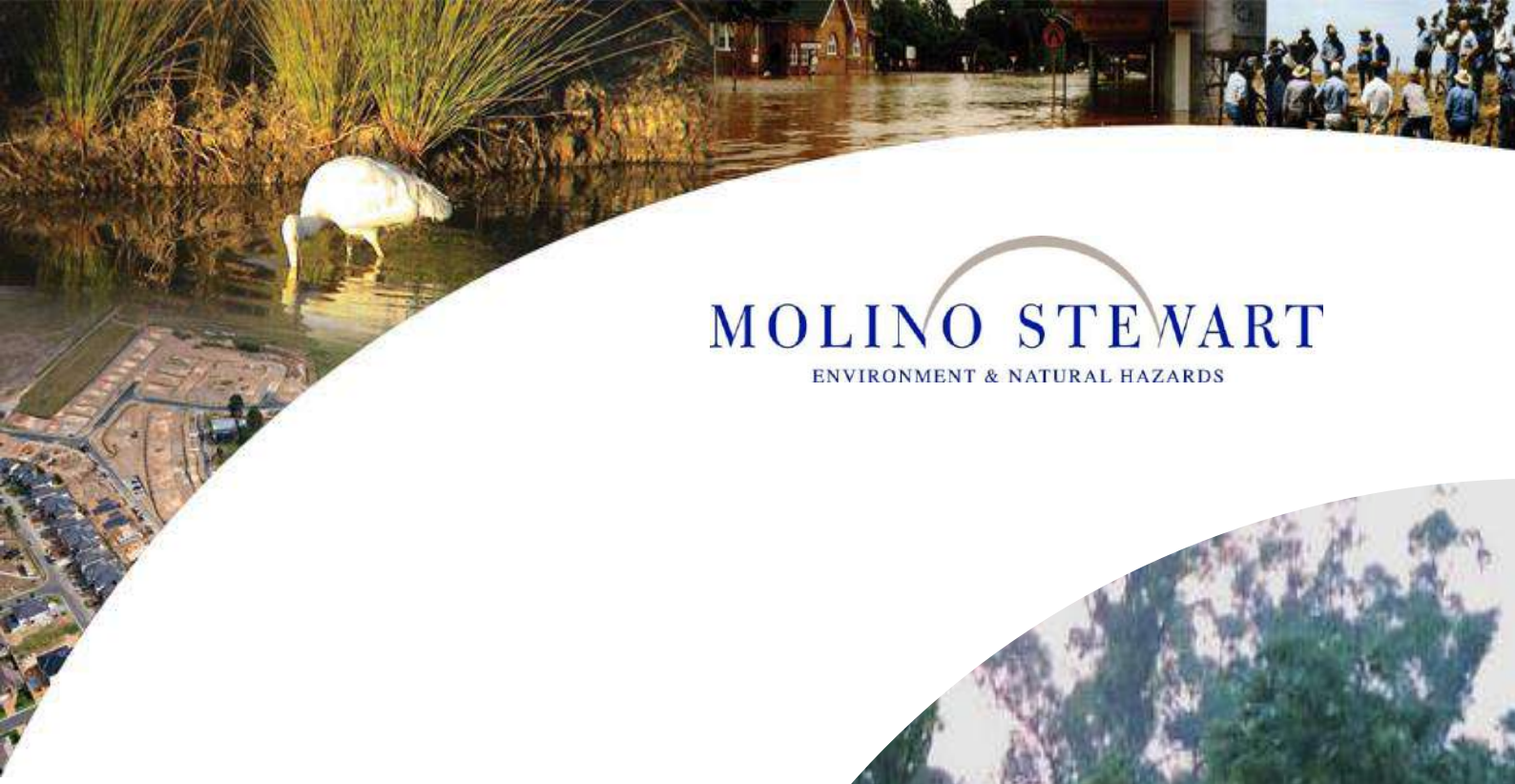


Figure 2.9 *Stabilised Site Access*
Source: Soils and Construction: Managing Urban Stormwater, Landcom, March 2004.



MOLINO STEWART

ENVIRONMENT & NATURAL HAZARDS

Parramatta CBD Flood Evacuation Assessment

Draft Revised Report

Parramatta CBD Flood Evacuation Assessment

DRAFT REVISED REPORT

for

City of Parramatta

by

Molino Stewart Pty Ltd
ACN 067 774 332

SEPTEMBER 2019

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DOCUMENT APPROVAL

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EXECUTIVE SUMMARY

The NSW State Government and the City of Parramatta Council have identified Parramatta CBD as a key growth centre for large-scale commercial and residential development. In April 2015, Council adopted the Parramatta CBD Planning Strategy, detailing the type of development envisaged and devising an implementation plan.

One of the main constraints to development in Parramatta CBD is the risk of flooding from the Parramatta River and its tributaries. The flooding is considered to be flash flooding with floodwaters rising within a few hours from the beginning of the rainfall. The short time available for evacuation and the current lack of a flood warning system make flood emergency response in Parramatta CBD a difficult exercise, even with the current CBD population.

The aim of this study was to identify the most suitable flood emergency response strategy for Parramatta CBD, under existing and future conditions. This was achieved by assessing and comparing the following possible flood evacuation strategies:

- Horizontal Street Level (HSL) evacuation, achieved by vehicle before any roads are cut by floodwaters;
- Horizontal High Level (HHL) evacuation, achieved on foot by using a network of elevated walkways which would allow late evacuation. A draft design and costing of the required infrastructure is provided;
- Vertical Evacuation through Sheltering In Place (SIP), in which evacuees would reach a refuge above the flood level within their building and wait for floodwaters to recede.

The analysis was performed using different flood events (20 year ARI, 100 year ARI, PMF), different degrees of implementation of the Parramatta CDB Planning Strategy (year 2016, year 2036 and year 2056), and different times of the day at which a flood emergency response may be necessary (Midnight, Midday, PM Peak). Using Multi-Criteria Analysis (MCA), the evacuation strategies were compared and the most suitable strategy was identified. The following evaluation criteria were used:

- Strategy effectiveness, in terms of capability to safely evacuate the population before routes are cut by floodwaters. The total evacuation time for each strategy was calculated using state of the art flood evacuation models, including the NSW SES Timeline Evacuation Model. The simulations addressed 24 “worst-case” scenarios, combining flood probability, degree of implementation of the Parramatta CBD Planning Strategy, and time of the day. Evacuation time was then compared with the time available to assess the strategy effectiveness;
- Difficulty of implementation of the strategy, arising from setting-up the necessary infrastructure (e.g. elevated walkways) and from the logistics of the response;
- Risks associated with the strategy and the extent to which these can be reduced;
- Impacts on the urban environment (i.e. due to the elevated walkways);
- Cost of implementation and maintenance of the strategy;
- Load on emergency services.

The results showed that:

- Under the assumptions of the NSW SES Timeline Evacuation Model, safe vehicular evacuation would not be realistically achievable under any circumstances;
- A network of elevated walkways would allow safe HHL evacuation (including late evacuation), however evacuation time would be of the same order of magnitude as the flood duration.

- Importantly, a network of elevated walkways catering for events up to the PMF would have a high cost ($324 million) and very significant impacts on the CBD urban landscape and heritage buildings. A smaller network of elevated walkways, catering for events up to the 20 year or the 100 year ARI flood, would have lower costs (i.e. $94.5 million and $111 million respectively), but would need to be paired with SIP to cater for larger flood events, and the impacts on the CBD landscape would still be significant.
- SIP is the optimal flood emergency response strategy for Parramatta CBD. However, SIP could expose people to a number of secondary risks to life, including (but not limited to) those arising from: building structural failure, medical emergencies, building fires or people deciding to leave the shelter and walk through floodwaters. Provision would also need to be made for building access for people in the public domain. Development controls would need to be imposed on development to reduce these risks to a tolerable level and ensure there was not an increased demand for search and rescue operations by the NSW SES. This report suggests ways in which this can be realistically achieved.

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1 BACKGROUND AND AIM

1.1 CONTEXT

The NSW Government and the City of Parramatta Council (Council) have identified the Parramatta CBD as a key growth centre for large-scale commercial and residential development. Council has developed the Parramatta CBD Planning Strategy (the "CBD Strategy"), which was adopted in April 2015. Key features are:

- Expand the boundaries of the CBD;
- Increase the floor space ratios in certain areas;
- Alter solar access controls;
- Alter building height restrictions;
- Expand the commercial core of the CBD.

An implementation strategy for the CBD Strategy has been developed, which includes the development of a Planning Proposal to modify the Parramatta Local Environmental Plan (LEP) 2011.

However, one of the most significant constraints for development is that the Parramatta River passes through the middle of the CBD, and most of the CBD is within the floodplain of the river or its tributaries. In addition, the relatively small catchment upstream of the CBD results in flash flooding with very short warning times. Even with the current population of the CBD, this lack of warning of an oncoming flood will create significant evacuation challenges, and the proposed population increase could exacerbate these. Council has implemented a flood warning system but even with this in place the warning time available in floods big enough to enter the main areas of the CBD could be less than two hours.

All development proposed in the CBD Strategy should proceed in such a way that people can be protected from hazardous floodwaters.

The NSW SES has a general policy that evacuation of people away from the floodplain is the safest course of action because if they stay:

- They can be isolated in buildings for some time, possibly without power and water;
- If floodwaters rise above their building they area in severe danger;
- It puts SES and emergency service personal at risk when trying to rescue them

In a letter to the City of Parramatta Council dated 2 December 2016, the NSW SES has expressed a strong preference that this should be achieved by evacuating people out of floodplains before the arrival of floodwaters. They concede that this might not be possible in some flash flood areas and that in these circumstances vertical evacuation (Sheltering In Place, or "SIP") may be preferable to trying to evacuate and finding oneself in hazardous floodwaters. However, they have expressed that this is a concession to existing development only and should not be a method of managing flood risk for new development.

The Parramatta CBD consists of existing development which might fit into this category, but new development is proposed which would increase the number of people in the floodplain. At the same time, the urban planning and development approval process presents the opportunity to include development controls which can minimise the risk of flooding to the occupants of buildings should they choose to SIP.

Risk reduction can be achieved either by providing a means of horizontal evacuation to areas which are not flood-affected, or vertical evacuation in buildings to safe refuge above the reach of floodwaters. While horizontal evacuation is traditionally achieved through vehicular or pedestrian evacuation at street level, this can also be achieved through the use of elevated walkways.

While planning controls can in theory be used to create improved flood risk outcomes in Parramatta CBD, statutory requirements currently limit the controls which Council can impose. Specifically, Section 9.1 Direction 4.3 restricts the imposition of flood planning controls on residential development above the Flood Planning Level (FPL) (which is generally defined as the 1% flood level plus 0.5m

freeboard) except in "exceptional circumstances".

Council contends that the flood situation in the Parramatta CBD is such that exceptional circumstances exist and the 2107 version of this report was used to support Council's application for exception circumstances.

In December 2018 the Deputy Secretary of the then Department of Planning and Environment wrote:

"I have decided to grant exceptional circumstances to enable further agency consultation and community consultation. However, consistency with section 9.1 Direction 4.3 Flood Prone Land will require further consideration and agreement from the Department's Secretary."

To support its original case for exceptional circumstances, Council required an evacuation analysis that considered many of the overlapping processes such as warning time, evacuation routes, and population demographics to estimate the ability of people within the Parramatta CBD to evacuate either horizontally or vertically during a flood.

This version of the report includes updates which take into consideration modifications to the Parramatta CBD Planning Proposal.

1.2 PROJECT AIM

City of Parramatta engaged Molino Stewart Pty Ltd to explore, at a high level, the various means of horizontal and vertical evacuation which might be feasible for Parramatta CBD now and into the future. The aim of this project was to assess and compare their feasibility in light of the number of people, the estimated evacuation time and other practical challenges including infrastructure cost and impact on the CBD urban landscape. Namely, the scope of this work was to:

- Prepare a feasibility analysis for each of the three potential evacuation methods: (a) horizontal evacuation at street level, (b) horizontal evacuation at high level, and (c) vertical evacuation;
- Prepare an analysis comparing evacuation capability and risks of the three evacuation methods that considered the following variables: (a) year (2016, 2036, 2056); time of flood (midday, midnight and PM peak); type of flood (20 year ARI, 100 year ARI, PMF);
- Summarise the results of the study with sufficient detail that a case can be presented to support a preferred evacuation option (which may include a combination of methods).

The study used a risk analysis framework which is technically rigorous, transparent and defensible.

1.3 STUDY AREA

The study area includes the extent of the Parramatta CBD Planning Proposal boundary, plus part of the "Western Corridor" (i.e. the blocks west of the Parramatta CBD Planning Proposal boundary, between Marsden St and Parramatta Park). Although the Western Corridor is not included in the Planning Proposal, it was considered in this study because its proximity to the CBD would result in a similar flood response strategy. The study area is shown in Figure 1.

1.4 NATURE OF FLOODING

Flooding in Parramatta CBD occurs as a joint effect of three mechanisms:

- The Parramatta River overtopping its banks and expanding laterally into the CBD;
- Overbank flooding of Brickfield Creek and Clay Cliff Creek;
- Overland flooding of streets caused by intense rainfall.

A detailed description of the flooding behaviour in Parramatta CBD is provided in Molino Stewart (2016). This section will only summarise the key-information about flood timing (e.g. rate of rise and duration) and extent, because, as indicated by NSW SES,

these directly underpin the selection of the most suitable emergency response strategy.

Figure 2 shows the Probable Maximum Flood (PMF) hydrograph upstream of Charles St Weir. The figure also includes the Council's adopted flood levels for the 20 year and 100 year ARI events.

If floodwaters rose as quick as in the PMF (which is the worst case scenario), it would take 180 minutes from the beginning of the rainfall to reach the level of the 20 year ARI, 192 minutes to reach the 100 year ARI level, and 320 minutes to reach the peak of the PMF. After that, floodwaters would begin to recede, and would return to the pre-flood level in about 700 minutes (i.e. 11.6 hours) from the beginning of the rainfall.

Because the PMF would reach its peak within six hours, the flooding of Parramatta CBD is classified as "flash flooding".

Figure 3 shows the extent of the currently adopted 20 year ARI and 100 year ARI floods and the PMF. In addition to informing the peak flood extent, Figure 3 also shows indirectly which areas would flood first (i.e. those exposed to the 20 year ARI flood) and which areas would flood later during the PMF.

It should be noted that updated flood modelling of the Upper Parramatta River and its tributaries is currently being prepared for Council and the shown flood extents may be revised. However, until that work is completed and adopted by the elected Council, the existing flood modelling and mapping applies.

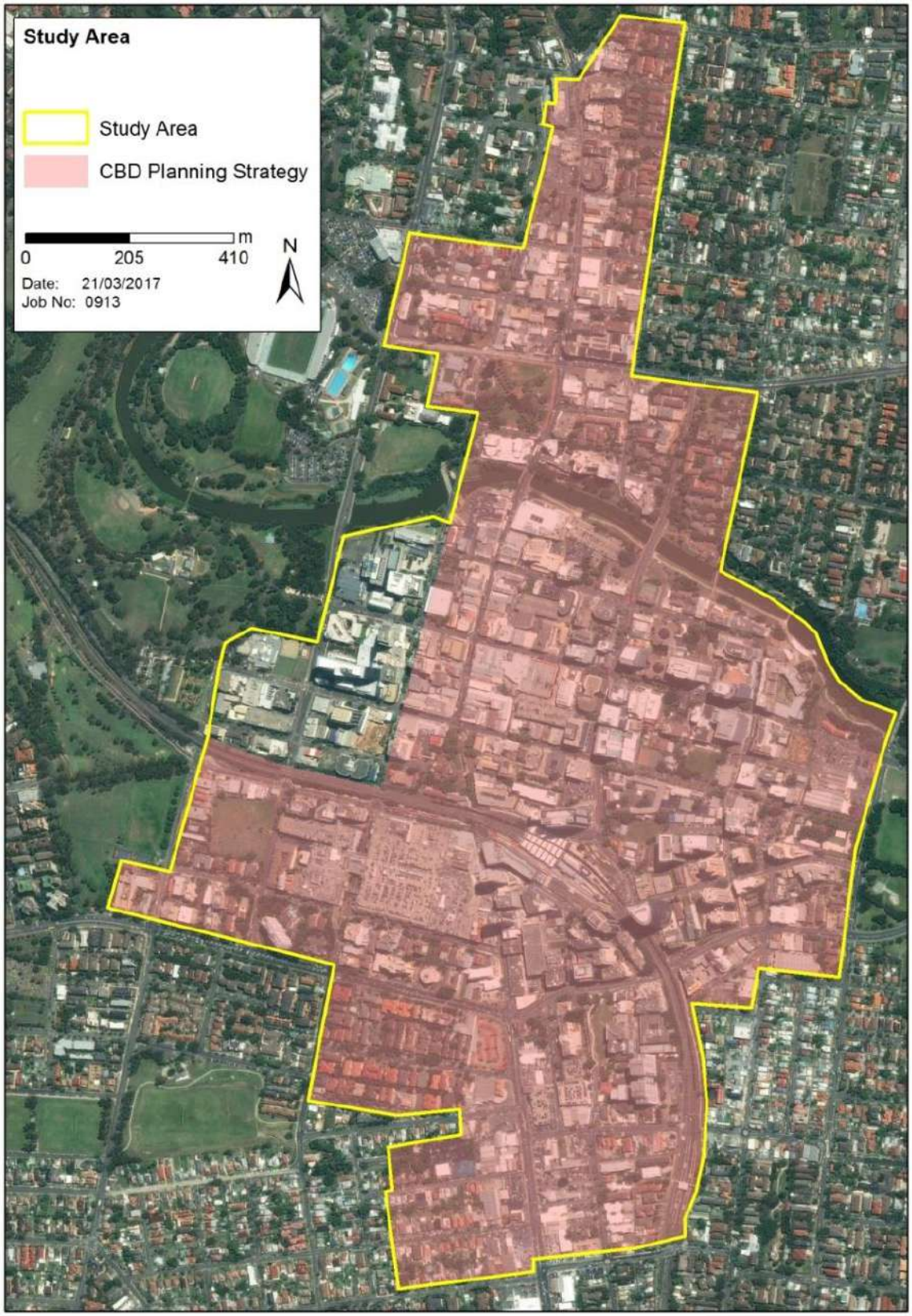

Figure 1: Study Area

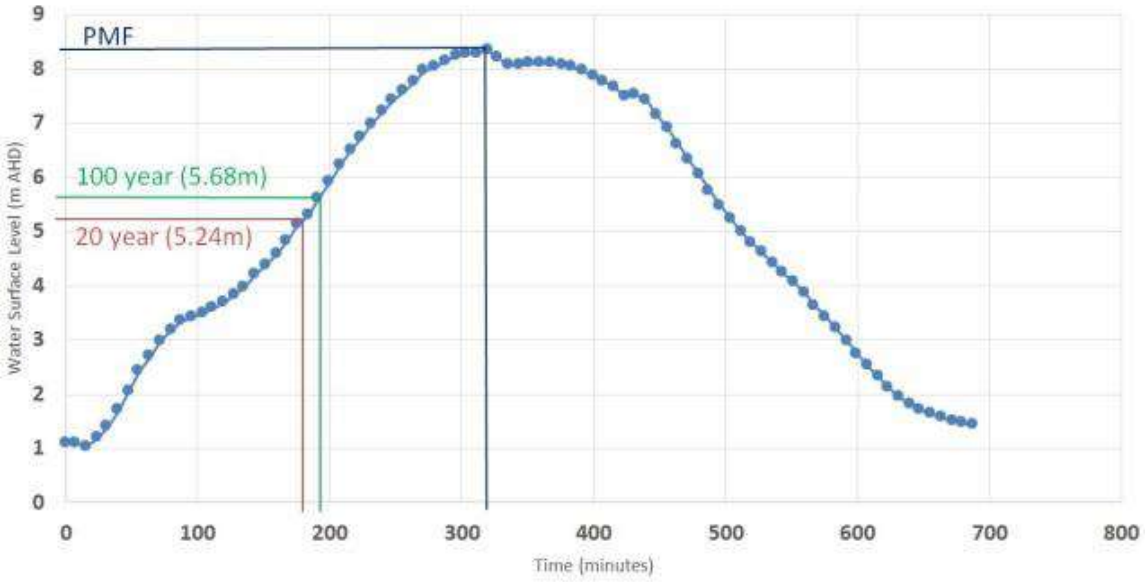

Figure 2: PMF hydrograph upstream of Charles Street Weir

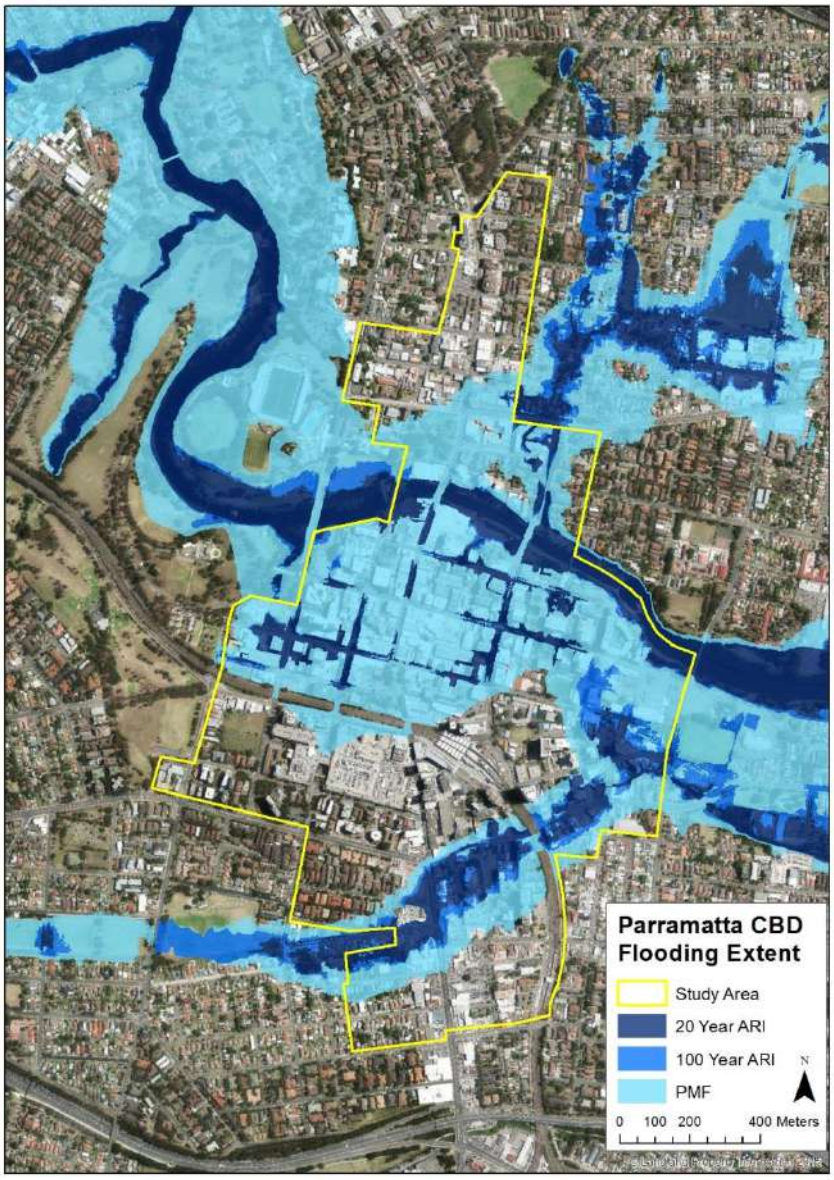

Figure 3: Flood extent in Parramatta CBD

1.5 ANALYSIS OF LOCAL EMERGENCY MANAGEMENT

The NSW SES has been involved in this project since its early stages to provide guidance on the most suitable emergency response strategy under present and future conditions. This section summarises the position of the NSW SES with regard to flood response in Parramatta CBD and vertical evacuation.

1.5.1 NSW SES Letter to the City of Parramatta Council (2016)

The brief of this project was initially submitted to the NSW SES for feedback, which was provided to the City of Parramatta Council together with a letter dated 2 December 2016 about their views on evacuation from the CBD. The letter encompasses the role of the NSW SES in flood emergency response, and points out the view of the NSW SES on some key emergency management principles. These are:

- Risk assessment should consider the full range of design flood events up to the PMF, ideally encapsulating a measure of the variability associated with the flood model results for each event.
- Flood risk assessment should also have particular regard to flood warning and evacuation demand on existing and future access/egress routes.

The NSW SES letter goes on stating that horizontal evacuation should be the primary response strategy during flooding, and should possess the following requisites:

- It should be completed before the onset of a flood;
- Evacuees should use vehicles where feasible (pedestrian evacuation is a backup option);
- It must not require people to drive or walk through floodwaters;
- It should use rising roads leading away from the flood.

With regard to the option of vertical evacuation, also referred to as Shelter In Place (SIP), the NSW SES points out that:

- SIP in isolated buildings represents a higher risk than a properly conducted evacuation and should only be used when evacuation is not possible. In these cases, the risks associated with SIP should be adequately considered and addressed. These include the instability of buildings due to pressure and velocity of floodwaters, risk of medical emergencies, and the risk of people leaving the SIP refuge before floodwaters have withdrawn.
- SIP increases the risk to emergency service personnel during search and rescue operations. If the risk of assisting someone who is taking shelter in place is deemed too high by the emergency responders, assistance may not be provided.
- SIP should only be preferred to evacuation where the risks associated with evacuation are higher than the risks of SIP. This happens, for instance, if evacuation routes are cut by floodwaters before flooding is obvious to residents. In these cases, a response based on horizontal evacuation may result in people driving through floodwaters, as discussed in Haynes et al (2009).

With regard to future development and SIP, the NSW SES letter highlights that:

- Development strategies relying on SIP are not equivalent, in risk management terms, to horizontal evacuation.
- Development strategies assuming that mass rescue of people taking SIP is possible are not acceptable to the SES.
- Future development must not conflict with NSW SES's flood response and evacuation strategy for the existing community.

The letter concludes by referencing the literature landscape around the NSW SES's view on SIP. The next sections include a summary of such literature, which appeared in

the "Three Tributaries Floodplain Risk Management Study" (Molino Stewart, 2015).

a) Opper and Toniato (2008)

- NSW SES holds the position that if development is to occur on floodplains, it must be possible to evacuate people out of the floodplain in advance of floods;
- NSW SES has recognised that in an existing flash flood context, and only in that context, causing residents to attempt to evacuate at the time of flash flooding is occurring, could be a serious risk to life. Only in areas where urban redevelopment cannot be prevented under existing planning policy (e.g. already approved under the gazetted planning policy), , it has therefore been proposed that the DCP for any new or redeveloped dwelling will require an internal refuge area above the level of the PMF. (Note: the Fairfield DCP is one that allows this in parts of some floodplains);
- This concession has been seized upon to wrongly apply it to all flood contexts and to justify any new development;
- In response, NSW SES may have no choice but to adopt a harder line and to not support any redevelopment or development in flash flood areas;
- Two elements of flood isolation risk – which may arise when sheltering in place - are particularly significant: structural fire and medical emergency;
- An example of the problems that can arise due to isolation and the vagaries of human behaviour occurred during flooding in June 2007, when a nursing home at Wyong needed to be urgently evacuated due to its rapid isolation by floodwater and the threat of further inundation. This required six ambulance crews and other emergency services to deal with just this one facility. The management and residents had ignored early advice to evacuate before they were isolated and then had a change of mind once they were surrounded by floodwater;

b) Opper et al. (2011); AFAC (2013)

- The safest place to be in a flash flood is well away from the affected area. Evacuation is the most effective strategy, provided that evacuation can be safely implemented. Properly planned and executed evacuation is demonstrably the most effective strategy in terms of a reliable public safety outcome;
- Late evacuation may be worse than not evacuating at all because of the dangers inherent in moving through floodwaters, particularly fast-moving flash flood waters. If evacuation has not occurred prior to the arrival of floodwater, taking refuge inside a building may generally be safer than trying to escape by entering the floodwater;
- Remaining in buildings likely to be affected by flash flooding is not low risk and should never be a default strategy for pre-incident planning. It is not equivalent to evacuation;
- The risks of 'shelter-in-place' include:

a) Floodwater reaching the place of shelter (unless the shelter is above the PMF level);

b) Structural collapse of the building that is providing the place of shelter (unless the building is designed to withstand the forces of floodwater, buoyancy and debris in a PMF);

c) Isolation, with no known basis for determining a tolerable duration of isolation;

d) People's behaviour (drowning if they change their mind and attempt to leave after entrapment);

e) People's mobility (not being able to reach the highest part of the building);

f) People's personal safety (fire and accident); and

g) People's health (pre-existing condition or sudden onset e.g. heart attack).

- In line with EMA's Manual (2009) and Handbook (2007), NSW SES reinforces that for evacuation to be a defensible strategy, the risk associated with the evacuation must be lower than the risk people may be exposed to if they were left to take refuge within a building which could either be directly exposed to or isolated by floodwater;
- Pre-incident planning needs to include a realistic assessment of the time required to evacuate a given location via safe evacuation routes. This requires consideration of barriers to evacuation posed by available warning time, availability of safe routes and resources available;
- Successful evacuation strategies require a warning system that delivers enough lead time to accommodate the operational decisions, the mobilisation of the necessary resources, the warning and the movement of people at risk;
- Effective evacuation typically requires lead times of longer than just a couple of hours and this creates a dilemma for flash flood emergency managers. Due to the nature of flash flood catchments, flash flood warning systems based on detection of rainfall or water level generally yield short lead times (often as short as 30 minutes) and as a result provide limited prospects for using such systems to trigger planned and effective evacuation;
- Initiating evacuation of large numbers of people from areas prone to flash flooding based only on forecasts may be theoretically defensible in a purely risk-avoidance context but it is likely to be viewed as socially and economically unsustainable. Frequent evacuations in which no flooding occurs, which statistically will be the outcome of forecast-based warning and evacuation, could also lead to a situation where warnings are eventually ignored by the community.

c) NSW SES (2014)

- In the context of future development, self-evacuation of the community should be achievable in a manner consistent with the NSW SES's principles for evacuation;
- Development must not conflict with the NSW SES's flood response and evacuation strategy;
- Evacuation must not require people to drive or walk through floodwaters;
- Development strategies relying on deliberate isolation in buildings are not equivalent to evacuation;
- Development strategies relying on the assumption that mass rescue may be possible where evacuation either fails or is not implemented are not acceptable to the NSW SES;
- The NSW SES is opposed to the imposition of development consent conditions requiring private flood evacuation plans rather than the application of sound land use planning and flood risk management.

d) Summary of the NSW SES position

The NSW SES holds that horizontal evacuation is the preferred emergency response for floodplain communities, where this can safely be achieved. Late evacuation, through floodwater, may be a recipe for disaster and in that situation it might be safer to remain inside the building, though sheltering-in-place has a number of direct and indirect risks associated with it. Evacuating prior to flooding is therefore much preferred. Where current hydro-meteorological monitoring systems, communications systems, road infrastructure and expected community behaviours do not allow this, the NSW SES advocates improvements to these so that evacuation can proceed safely. However, the AFAC (2013) guide makes clear that, even with these improvements, insufficient time may be available to inform evacuation decisions with confidence. If evacuations are ordered

based only on predicted rainfall, the community may eventually come to ignore warnings.

1.5.2 Subsequent SES Correspondence

In December 2017 the NSW SES wrote to the then Department of Environment and Planning regarding a site-specific planning proposal for 180 George St Parramatta. While the letter was specifically responding to that planning proposal, it stated that, *"Ideally, it is better to address flood risk in land use planning activities at a strategic or precinct scale than in the planning proposal stage."* The letter then went on to articulate generic principles which should be adhered to in development planning generally and Parramatta CBD in particular. This includes statements such as:

"Despite modifying buildings to reduce the risk, research into human behaviour during actual events has shown that in populations surrounded by a hazard there is always the chance that a person will not behave rationally and remain in place but rather place themselves at unnecessary risk. "

"…where safe evacuation is compromised by a lack of adequate infrastructure and/or warning time, the NSW SES recognises that the situation may result in it being safer for a population at risk to remain in place as long as the building in which the occupants are sheltering is structurally sound and there is sufficient accessible space available above the PMF for all occupants to shelter where adequate services are available and maintained."

"Emergency service response will likely be compromised by the hazardous nature of flash flooding in Parramatta CBD. In this area it is likely that emergency services cannot respond to assist those trapped in buildings due to the rapid onset and hazardous nature of fast flowing floodwater and limitations caused by access and transport issues."

Appendix 2 of the letter listed site specific design considerations and Parramatta CBD General Design considerations but both are listed here because the site specific considerations are relevant to many sites in the Parramatta CBD, not just 180 George St.

Site specific design considerations

The site specific design considerations should be applied to this development to assist in minimising additional risk.

1. Residential development: *The habitable floors of any residential development (including aged care) should be located above the PMF with the building structurally designed for the likely flood and debris impacts.*

2. Commercial development (including retail): *To cater for the safety of potential occupants, clients and visitors in commercial development there should be the provision of sufficient readily accessible habitable areas above the PMF.*

3. Child care facilities: *Childcare facilities must be located with floor levels above the PMF level.*

4. Car parking: *Any additional parking should be above ground level and have pedestrian access to a podium level above the PMF.*

5. Making buildings as safe as possible to occupy during flood events. *Ensuring buildings are designed for the potential flood and debris loadings of the PMF so that structural failure is avoided during a flood.*

6. Limiting exposure of people to floodwaters. *This can be aided by providing sufficient readily accessible habitable areas above the PMF to cater for potential occupants, clients, visitors and residents.*

7. Provision of public accessible space for the itinerant population in areas surrounding intensive development in Parramatta CBD. *Provision of publically accessible space or access to space above the PMF (with adequate infrastructure to enable the physically impaired to access such space) that is easily accessible 24 hours a day for seven days a week which is clearly identified for this purpose with associated directional signage.*

8. Providing adequate services so people are less likely to enter floodwaters. *This includes access to ablutions, water, power and basic first aid equipment. Consideration must be given to the availability of on-site systems*

to provide for power, water and sewage services for the likely flood duration (up to 12 hours) plus a further period of up to 48 hours to provide allowance for restoration of external services.

9. Addressing secondary risks of fire and medical emergencies during floods. *Where there is no CBD wide strategy to address secondary risks during flooding. The proponent needs to consult with the relevant emergency service agency.*

Parramatta CBD general considerations

1. Sensitive development including child care: *All new emergency response hospitals, childcare and primary school facilities in Parramatta CBD should be located on land outside the extent of the PMF on land were service interruption is likely to be limited.*

2. Secondary schools and day hospitals: *Ideally new day hospitals and secondary school classrooms should also be located above the PMF level. However, at minimum there should be within a day hospital and high school building, the provision of access to adequate space above the PMF for patients, high school students, staff and visitors.*

3. Reducing human behaviour risks through businesses, schools and childcare centres. *Undertaking regular exercising of a building flood emergency response plan similar to a building fire evacuation drill.*

4. Increasing the flood awareness of current and future communities. *Council should have community awareness strategies that include requiring current and future building owners to participate in increasing this awareness.*

5. Parramatta CBD PA system. *There needs to be consideration given to developing a Parramatta CBD PA system like Sydney CBD to communicate evacuation directions and safety messages to the Parramatta CBD population in the lead up to and during a flood to assist in improving the safety of the community.*

6. Addressing secondary risks of fire and medical emergencies during floods. *To minimise the increased risk of fire and to reduce both the potential for adverse outcomes in the case of a medical emergency and the risks to those who may aid the patient, Council, DPE, NSW SES, Ambulance NSW and the relevant Health Functional area and fire agency servicing the area, should be consulted to determine appropriate risk management strategies during flooding.*

2 METHODOLOGY

2.1 A MULTI-SCENARIO APPROACH

This study employed a multi-scenario approach to provide a comprehensive overview of the circumstances under which flood evacuation of Parramatta CBD may be required, today and in the future.

Each scenario is the result of a combination of variables, including flood probability, year (as a proxy of the degree of development of the CBD), type of evacuation, and time of day.

For each combination of year, flood probability, and evacuation type, the worst case scenario was determined by the time of the day. These scenarios were identified and assessed.

The following sections describe in more detail the variables used to construct the evacuation scenarios.

2.1.1 Flood Probability

As advised by NSW SES, evacuation assessment should consider a wide range of flood events, up to the PMF. This study used the following design flood events:

- 20 year ARI
- 100 year ARI
- PMF

These were selected because:

- The 20 year ARI is a relatively frequent flood event that may require evacuation. More frequent events, such as the 10 year or 5 year ARI, are unlikely to require a large-scale response.
- The 100 year ARI is the design event adopted for planning and development purpose.
- The PMF represents the greatest flood extent and flood hazard and is indicative of the potential fastest rate of rise.
- Availability of flood model results.

2.1.2 Year

Evacuation was assessed in three different years: 2016, 2036 and 2056.

Year 2016 represents the existing condition in terms of development and evacuee numbers.

Year 2036 was obtained by projecting 20 years into the future the number of evacuees that would be achieved under the existing planning controls, plus some site-specific planning proposals that have at least received Council endorsement to be sent for Gateway determination.

Year 2056 was obtained by assuming that two-thirds of the additional development capacity introduced by the CBD Planning Proposal would be taken up.

2.1.3 Evacuation Type

The following three types of evacuation were considered in this study.

- Horizontal Street-Level (HSL) evacuation, entirely achieved by vehicle;
- Horizontal High–Level (HHL) evacuation, achieved on foot by means of a network of elevated walkways which would allow evacuees to walk out of the CBD even if this has already flooded;
- Vertical Evacuation (Shelter in Place). Evacuees would reach a designated refuge above the flood level within their building, or within an adjoining building which provides a shelter above the flood level.

In addition to this, a “mixed” evacuation was also considered. In “mixed” evacuation scenarios it was assumed that only buildings not isolated by the 20 year ARI flood would be able to evacuate by car, while the remainder would need to evacuate on foot. These scenarios may represent a more “realistic” situation, in which building blocks at the boundary of the CBD could evacuate by car, while the commercial core of the CBD, which would be reached by local flooding earlier than peripheral blocks, would evacuate on foot using the elevated walkways.

2.1.4 Time of Day

A large number of workers and visitors travel to and from Parramatta CBD on a daily basis. Similarly, many of the CBD residents go to work in different parts of the Sydney Metropolitan Area.

As a consequence of this, the time of day at which an evacuation order is issued would have a profound influence on the number of evacuees, the willingness of evacuees to leave and ultimately on the evacuation duration.

For instance, if the evacuation were triggered late at night, mostly residents would need to evacuate. On the other hand, if an evacuation order were issued during business hours, the majority of evacuees would be workers and visitors, while the number of residents would be much lower.

Additional challenges for emergency responders may then arise in more specific scenarios. For instance, during the PM peak hour, workers and visitors would need to evacuate, but at the same time residents would be returning to the CBD after work. This scenario would be particularly difficult to manage regardless of the selected emergency response strategy (horizontal evacuation vs SIP).

In the case of vehicular evacuation, returning residents would generate significant background road traffic, which would slow down the evacuation of workers and visitors. This would also result in additional load on emergency responders, who, in addition to facilitating evacuation, would have to prevent residents from entering the CBD.

If SIP were the preferred strategy, it would be difficult to ensure that workers would remain within their offices at the end of the day, when they are keen to leave and go home.

The following times of the day and scenarios were considered in the evacuation assessment:

- Midnight: only residents evacuate/SIP;
- Midday: only workers and visitors evacuate/SIP;
- PM peak: only workers and visitors evacuate/SIP, residents return home. This "time of the day" option constitutes in fact a variation of the Midday option, because the number of evacuees would be the same (i.e. workers and visitors). However, because the variables making the PM peak scenario slightly worse than the Midday one (i.e. background traffic, and human behaviour) cannot be modelled using the NSW Timeline Evacuation Model, the additional challenges of the PM peak scenario are only discussed qualitatively.

The AM was not considered to be as problematic as other scenarios because it would involve residents being told to evacuate when they would be leaving the CBD anyway and telling workers and visitors not to enter the CBD which is not expected to be met with a lot of resistance.

2.1.5 Simulated Scenarios

Combining all possible scenario variables would results in 81 scenarios to be modelled and/or discussed. However, for practical reasons, only the 24 "worst case" scenarios were modelled. These are listed in Table 1 and Table 2.

It should be noted that scenarios 7, 8 and 23 are different from all the others.

Scenario 8 represents a situation in which all car spaces within the CBD would evacuate at the same time. This would include residential, commercial and visitor cars. Although such a scenario is unlikely the happen in the real world, this approach is often used by the NSW SES to get a sense of the worst possible situation in terms of vehicular evacuation.

Scenarios 2 and 23 represent "mixed" evacuation types.

Table 1: Evacuation scenarios modelled for each combination of flood probability and year.

	2016	2036	2056
1 in 20	Scenario 1 Scenario 2	Scenario 9 Scenario 10	Scenario 15 Scenario 16 Scenario 17
1 in 100	Scenario 3 Scenario 4	Scenario 11 Scenario 12	Scenario 18 Scenario 19 Scenario 20
PMF	Scenario 5 Scenario 6 Scenario 7 Scenario 8	Scenario 13 Scenario 14	Scenario 21 Scenario 22 Scenario 23 Scenario 24

Table 2: Variables used to generate each evacuation scenario. (year_flood event_time of day_ evacuation type).

Scenario number	Code	Scenario number	Code
1	2016_20yr_Midday_HSL	**13**	2036_PMF_Midday_HSL
2	2016_20yr_Midday_HHL	**14**	2036_PMF_Midday_HHL
3	2016_100yr_Midday_HSL	**15**	2056_20yr_Midday_HSL
4	2016_100yr_Midday_HHL	**16**	2056_20yr_Midnight_HSL
5	2016_PMF_Midday_HSL	**17**	2056_20yr_Midday_HHL
	2016_PMF_Midday_HHL	**18**	2056_100yr_Midday_HSL
7	2016_PMF_Midday_Mixed	**19**	2056_100yr_Midnight_HSL
8	2016_PMF_AllCars_HSL	**20**	2056_100yr_Midday_HHL
9	2036_20yr_Midday_HSL	**21**	2056_PMF_Midnight_HSL
10	2036_20yr_Midday_HHL	**22**	2056_PMF_Midday_HHL
11	2036_100yr_Midday_HSL	**23**	2056_PMF_Midday_Mixed
12	2036_100yr_Midday_HHL	**24**	2056_PMF_Midday_HSL

2.2 DATA COLLECTION

Due to the spatial nature of the information required to build each scenario, a GIS (Geographic Information System) was created.

The input data needed included:

- People: maximum number of Residents, Workers and Visitors at any one time of the day;
- Vehicles: number of residential, commercial and visitor car spaces;
- Buildings: cadastre lots, current and future land zoning, Floor Surface Area (FSA) for residential and commercial development, heritage sites;
- Transport Network: road network, lane numbers, one-way roads;
- Flood model results for the selected design events;
- Flood warning lead time.

In order to be used as input in the evacuation modelling exercise, each dataset had to satisfy the following requirements:

- Possess the highest possible spatial resolution, so that it could be referred to each cadastre lot;
- Be available and evenly distributed across the whole CBD;
- Be available for year 2016, 2036 and 2056.

As only a part of the above-listed data was available, a number of assumptions were introduced to obtain the missing information. These are described in detail in Appendix A.

2.3 EVACUATION MODELLING

The scope of an evacuation modelling exercise is to calculate the time needed to complete a full evacuation and to compare this with the time available before evacuation routes are cut by floodwaters.

The time needed to complete the evacuation is generally estimated using evacuation models, while the time available depends on the lead time provided by the flood warning system.

Evacuation models range from simplified calculation spreadsheet to more sophisticated agent-based algorithms, which simulate the incoming flood, traffic conditions and the behaviour of individual evacuees.

This study employed the NSW SES Timeline Evacuation Model. This was preferred to an agent based model because it incorporates the assumptions made by the NSW SES and provides a level of accuracy that was deemed sufficient for the scope of this work.

In setting up the evacuation modelling exercise, this study introduced a number of assumptions, which are summarised in Appendix A. Each assumption is supported by the relevant literature and was assessed in consultation with the City of Parramatta Council.

At the time this study was originally undertaken, the City of Parramatta Council was developing a flood warning system for the CBD. Preliminary results suggested that a warning time of two hours should be used for the purpose of the evacuation assessment (Assumption 1 – Appendix A). Council has confirmed since commissioning of the warning system that two hours remains an appropriate lead time for evacuation assessment purposes.

This lead time is intended as the notice that would be given before a particular flood level is reached. These warnings would be issued by SMS to the NSW SES and members of the public who are registered to receive flood warnings.

It is possible that during any particular event several warnings will be given as flood forecasting predicts increasing flood levels over time as rain continues. For example, recipients may receive a warning that the 20 year ARI flood level will be reached in two hours' time but 30 minutes later might receive a warning that the 100 year ARI level will be reached in two hours from the second warning, and 30 minutes after that that an even higher level will be reached two hours after this third warning.

It should be noted that once the NSW SES receives each warning it would need to spend time to decide if an evacuation order needs to be issued, and then to disseminate such an order to the population.

The NSW SES in its standard evacuation planning modelling assumes that, after an evacuation order is communicated to the population, a minimum delay of two hours is to be expected before the evacuation begins (Assumption 2 – Appendix A).

This delay, or "lag", is due to two factors:

- The Warning Acceptance Factor (WAF), defined as the time required by a member of the public to acknowledge the evacuation order and accept that it applies to them; and
- The Warning Lag Factor (WLF), defined as the time required by members of the public to get organised for the evacuation and leave their houses.

The NSW SES assumes that the WAF and the WLF will require one hour of time each.

For this reason, a warning time of no more than two hours would leave no time for the population of Parramatta CBD to evacuate at street level. Even if the NSW SES could instantaneously make a decision and issue an evacuation order as soon as it receives a warning, by the time the population is ready to evacuate (i.e. minimum two hours), the water level would already be at the level that the warning system forecast. If rain has continued then the flooding could already be rising above that level during the time it takes people to actually evacuate.

This means that using the standard SES evacuation assumptions, coupled with a warning time of two hours would not allow any type of street-level evacuation at all, regardless on the evacuation means (vehicles or on foot) employed. In the case of Parramatta CBD, the NSW SES will need to find ways to minimise its own decision making and dissemination time for evacuation orders and reduce the response time of evacuees if any evacuation is to be possible.

For this reason, the scope of the evacuation modelling exercise undertaken as part of this project solely estimated the evacuation time under a range of different scenarios and did not compare this with the time available before the evacuation routes would be cut.

Evacuation modelling was performed in two different ways, reflecting the two main evacuation modes (vehicular vs pedestrian). Refer to Appendix A.

2.3.1 Vehicular Evacuation (HSL)

Vehicular evacuation was considered first as this is the evacuation mode recommended by the NSW SES.

Vehicular evacuation, which is herein referred to as "Horizontal Street Level (HSL)", was modelled under the assumption that evacuation routes would not be cut by floodwaters before the evacuation is completed. In other words, vehicular evacuation was considered an "early evacuation option" (Assumption 3 – Appendix A).

In addition to this, it was also assumed that any evacuees that do not have access to a car would be able to evacuate on foot in a time shorter than the time needed to complete the vehicular evacuation. This would therefore not affect the total evacuation time (Assumption 4 – Appendix A). This assumption is consistent with the time it would take for a pedestrian to walk from a location adjacent to the river to the nearest land above the reach of the PMF.

a) Vehicular Evacuation Model

The vehicular evacuation model used in this study is the NSW SES Timeline Evacuation Model (Opper et al., 2009). The model integrates the following recommended parameters (Assumption 5 – Appendix A):

- Lane Capacity: 600 cars per lane per hour;
- Queue length per car: 6m;
- Warning Acceptance Factor: 1 hour;
- Warning Lag Factor: 1 hour;
- Traffic Safety Factor: 1-3.5 hours depending on the duration of evacuation;

- Warning Rate per Hour per Door Knock Team (not used in this study): 12 properties.

b) Evacuation Routes

Vehicular evacuation routes leading out of the CBD were selected by inspecting the regional extent of the PMF and identifying routes that are least likely to be cut by floodwaters within (or in proximity of) the CBD. This analysis shortlisted the following evacuation routes:

- North: Pennant Hills Road;
- East: Victoria Road;
- South: Church Street and Harris Street;
- West: Great Western Highway.

However, it should be noted that the majority of these routes are likely to be cut by flooding at some point outside the CBD. Figure 4 shows the distribution of low points along the main roads around Parramatta CBD.

c) Vehicular Evacuation Precincts

The next part of this exercise allocated the flood-affected CBD cadastre to each of the five selected evacuation routes. This was achieved by:

- Locating each building's driveway;
- Assuming that, upon exiting each driveway, vehicles would move away from Parramatta River, Clay Cliff Creek or Brickfield Creek;
- Assuming that traffic would move according to normal traffic flow direction on roads including one-way roads.

Under these assumptions (Assumption 6 – Appendix A), the shortest path from each building to any of the five evacuation routes was identified and used to allocate each lot to an evacuation route. Lots evacuating to the same route were then grouped in the same vehicular evacuation precinct. The precincts obtained for each flood event are shown in Figure 5, Figure 6 and Figure 7.

A building was assumed to have to evacuate if it was "touched" or isolated by floodwaters in the model. The other buildings in the CBD were assumed not to have to evacuate (Assumption 7 – Appendix A). This may overestimate the number of vehicles which need to evacuate because the extent of flooding in some of these buildings may not be sufficient to require them to be evacuated.

While crossing the river or creeks was generally avoided, to reduce the risk of cars being trapped by traffic and then being overwhelmed by fast flowing water, there was one location where crossing the river was unavoidable. This is discussed in the next paragraph.

There are several buildings in Phillip Street on the corner of Wilde Street which have their parking areas at the rear and they share access to Wilde Street with a large multi-deck carpark adjacent to the river. This direct access to Wilde Street only allows them to turn left onto Wilde Street and cross over the river as there is a median in Wilde Street preventing a right-hand turn. If vehicles need to travel south from this location, away from the river, they need to head towards the river and go under Wilde Street. As this would take people towards more flood prone land it was deemed not to be a suitable vehicular evacuation route for this car park and adjacent buildings.

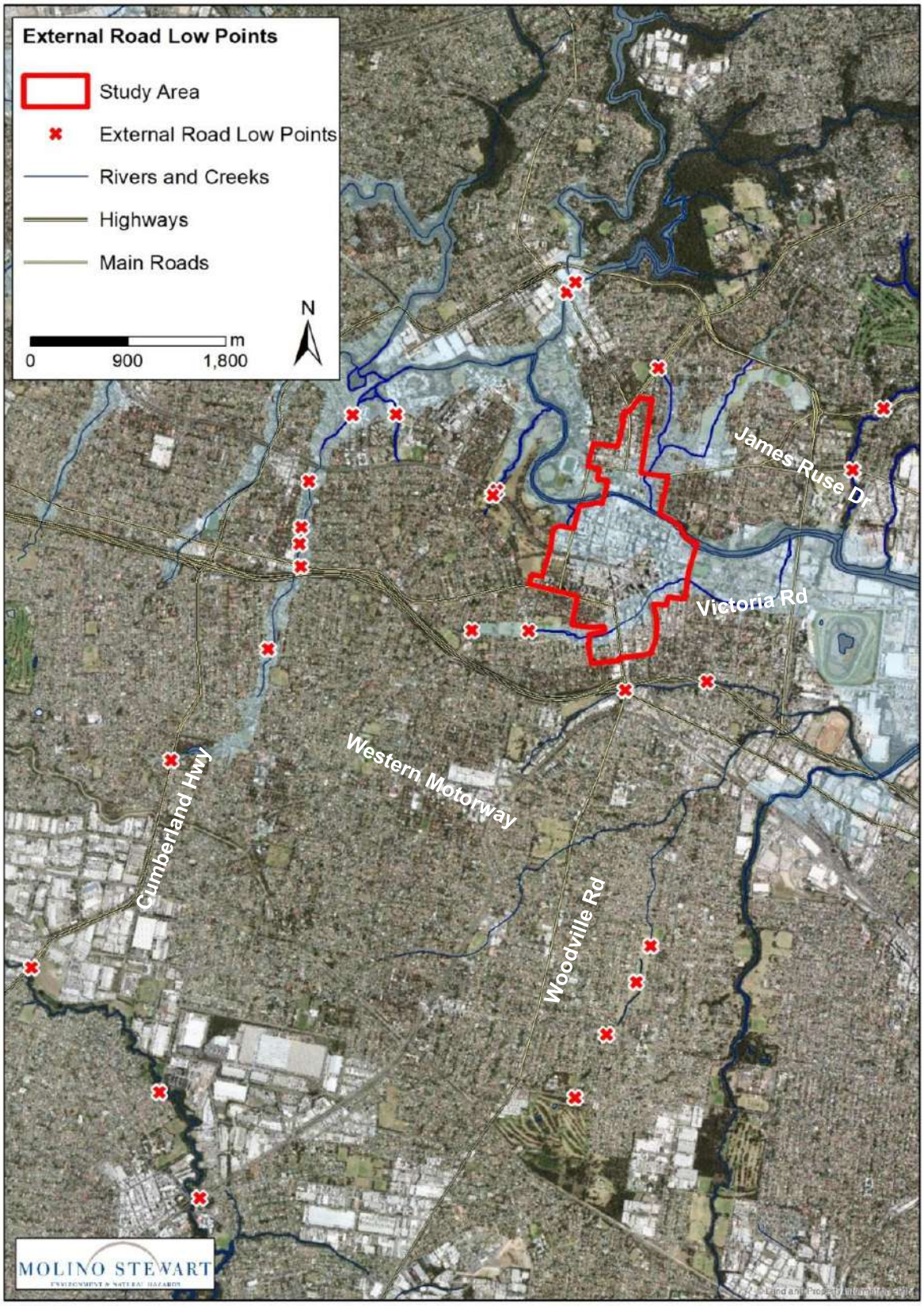

Figure 4: External road low points that may be cut by floodwaters

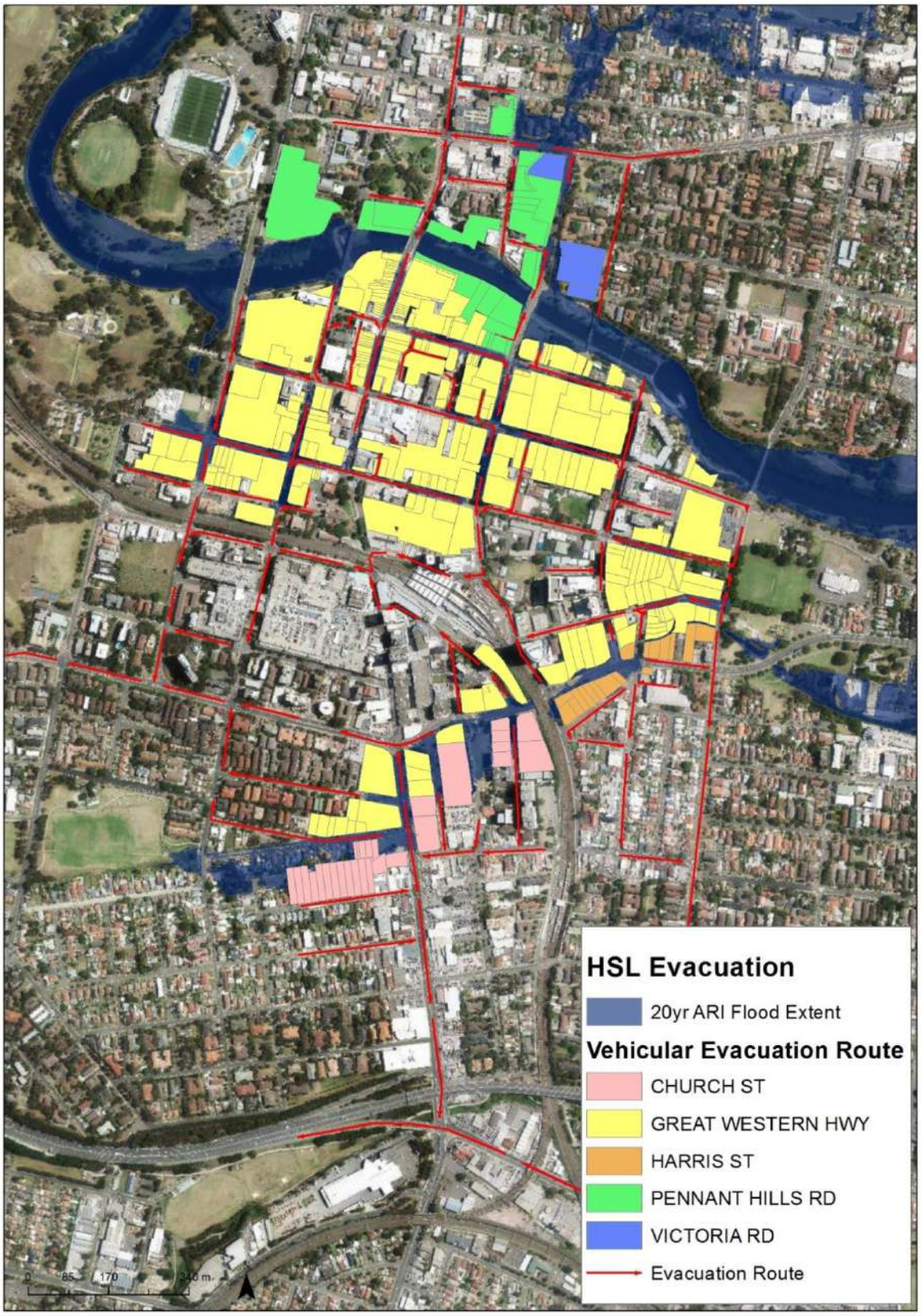

Figure 5: Allocation of buildings affected by the 20 year ARI event to five vehicular evacuation routes and precincts

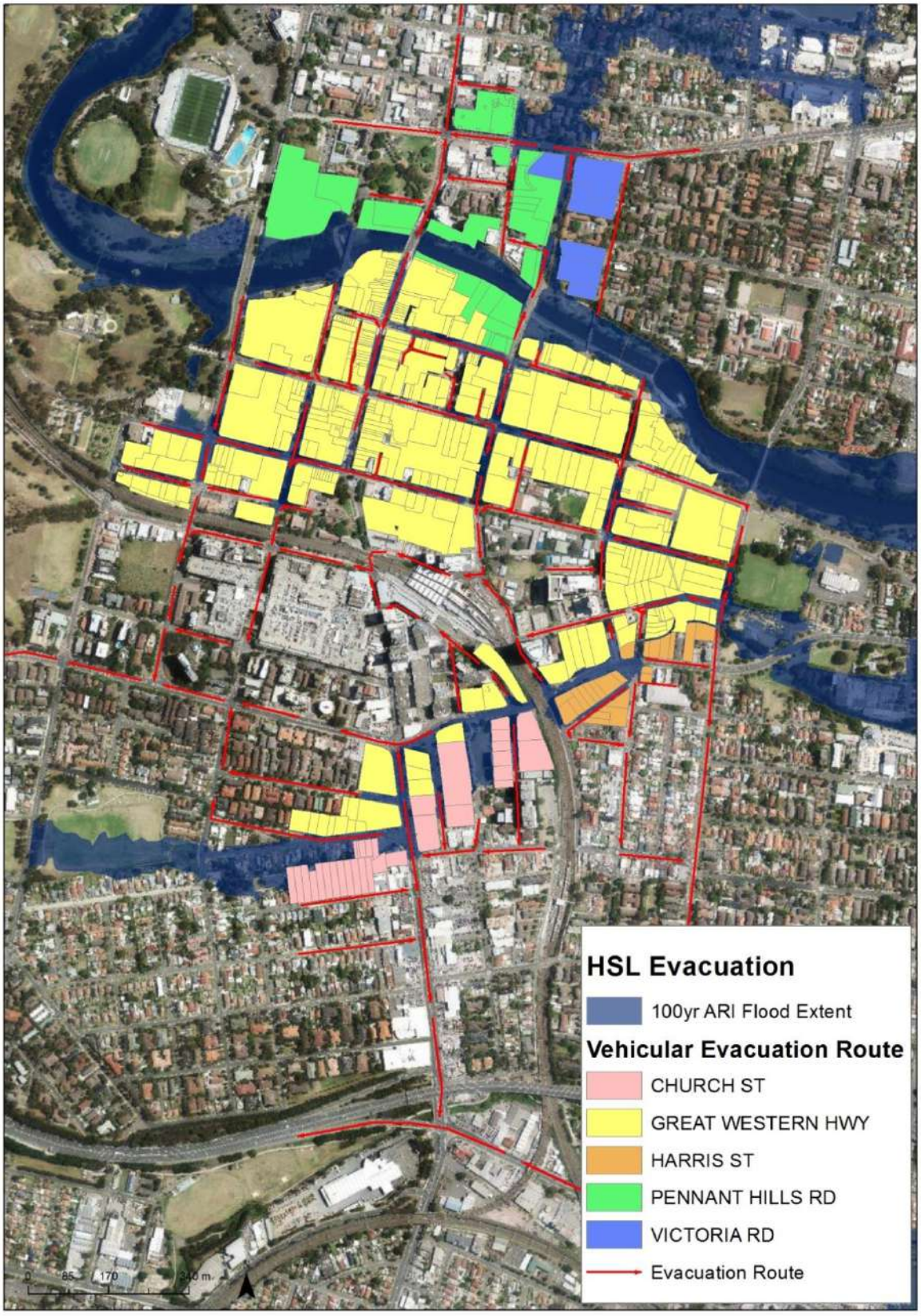

Figure 6: Allocation of buildings affected by the 100 year ARI event to five vehicular evacuation routes and precincts

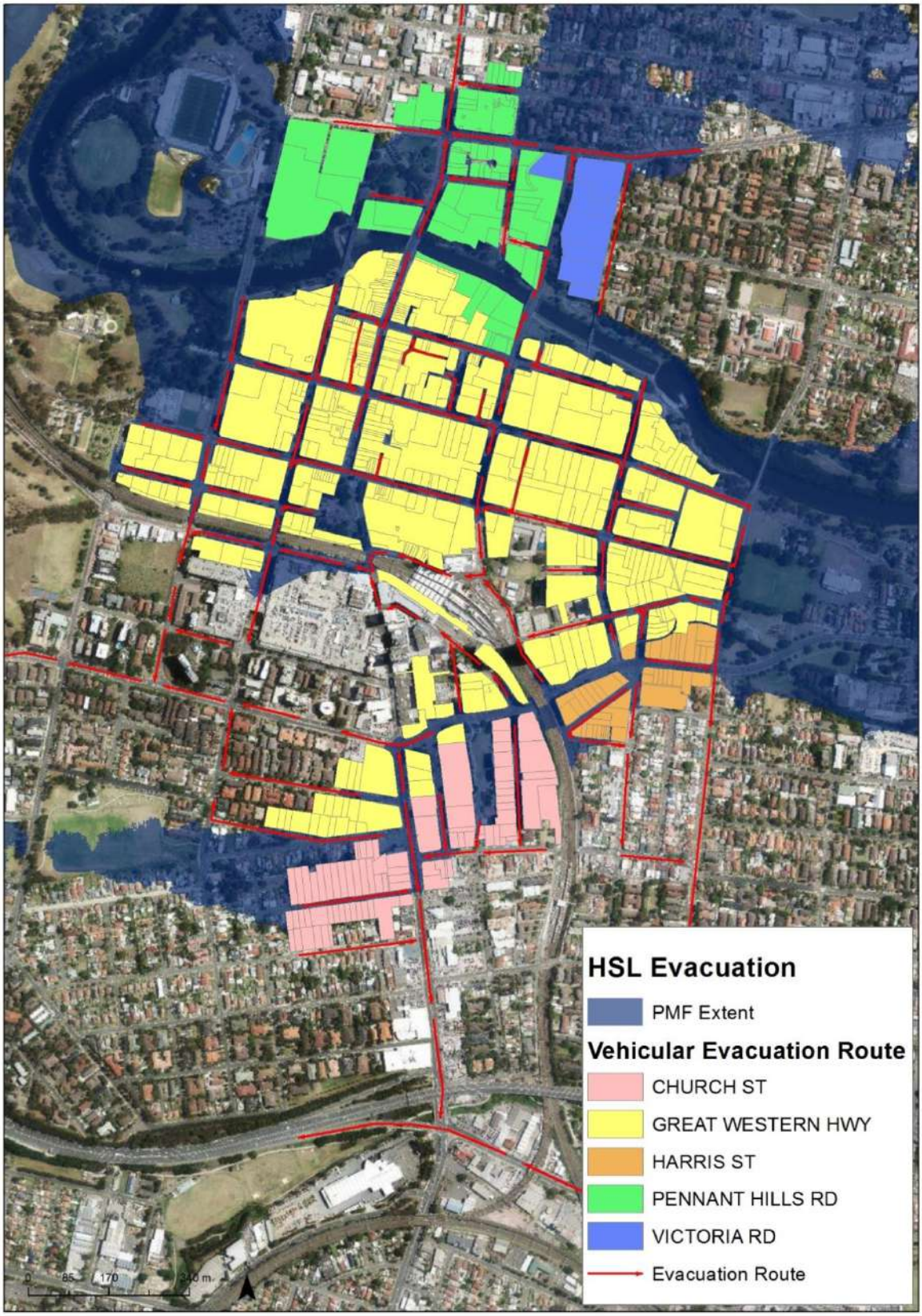

Figure 7: Allocation of buildings affected by the PMF to five vehicular evacuation routes and precincts

2.3.2 Pedestrian Evacuation (HHL)

Pedestrian evacuation, which is also referred to as "Horizontal High Level (HHL)", was considered as an alternative to vehicular evacuation because in Parramatta CBD it offers the following advantages:

- It is not constrained by one-way roads;
- People who do not have access to a car would have to evacuate on foot anyway;
- In Parramatta CBD the furthest distance to a safe flood shelter is relatively short.

a) Where to?

All evacuees between the Parramatta River and Clay Cliff Creek were assumed to head to a building of the scale and location of Westfield, which has:

- capacity to accommodate a large number of people for several hours,
- is open for most of the day.

Although dedicated arrangements would be necessary to make sure that the building designated as the refuge is accessible outside business hours, these should be fairly simple to achieve, for example making use of the 24hour security patrol service.

Evacuees north of the Parramatta River could not cross the river and would need to evacuate to a location to be determined. Similarly, evacuees south of Clay Cliff Creek would need to evacuate south. However, these are a small number compared to evacuees between the Parramatta River and Clay Cliff Creek, and would be relatively easy to accommodate in smaller buildings/refuges.

b) Elevated Walkways

Importantly, this study used pedestrian evacuation as a "late evacuation" option. This means that pedestrian evacuation would need to be a viable option regardless of the time at which people are ready to evacuate.

Because most of the roads of the CBD are within the floodplain, late evacuation on foot could only be achieved by means of a network of elevated walkways. These would need to be installed at strategic locations within the CBD to allow evacuees to safely cross flooded roads. The extent of the elevated walkways would have to be proportional to the size of the flood event up to which these can be used.

As part of this project, a concept design of the elevated walkways was completed by a team of urban planners and architects (i.e. Studio GL). Appendix C includes a report from Studio GL describing and assessing in detail the concept design's extent, dimensions, accessibility and urban planning implications (e.g. visual impact, overshadowing). It should be stressed that, while the concept design is sized to cater for events up to the 20yr ARI, the same design could be conceptually extended to larger flood events.

In events up to a 20 year ARI, it was assumed that evacuees would be able to reach the elevated walkways using communal stairs and ramps accessible from street level, while in larger events a dedicated building-by-building access would be necessary (Assumption 8 – Appendix A). This assumes that in events up to the 20 year ARI event flooding of the roads does not extend onto the adjacent footpaths to a level which would be hazardous for pedestrian to walk through to access the nearest walkway.

If the walkway network were built to cater for the 20 year ARI, then in the event of a larger flood people would not be able to access the walkways and would be trapped in their buildings.

In the case of the 100 year ARI walkway network, people within the extent of the 100 year ARI event would be able to access the walkways in any size flood because they would be accessing them from an upper floor of their building. However, should they fail to evacuate in a flood larger than the 100 year ARI event before the flood reaches the 100 year ARI level then they would not be able to safely return to street level to complete their evacuation.

The PMF walkway network on the other hand would allow people to leave their building at any time and not come in contact with floodwaters.

The extent of the elevated walkways network for each flood event is shown in Figure 8, Figure 9 and Figure 10. As with vehicular evacuation it was assumed that only those buildings which were touched by floodwaters would need to evacuate and all others could remain within their buildings.

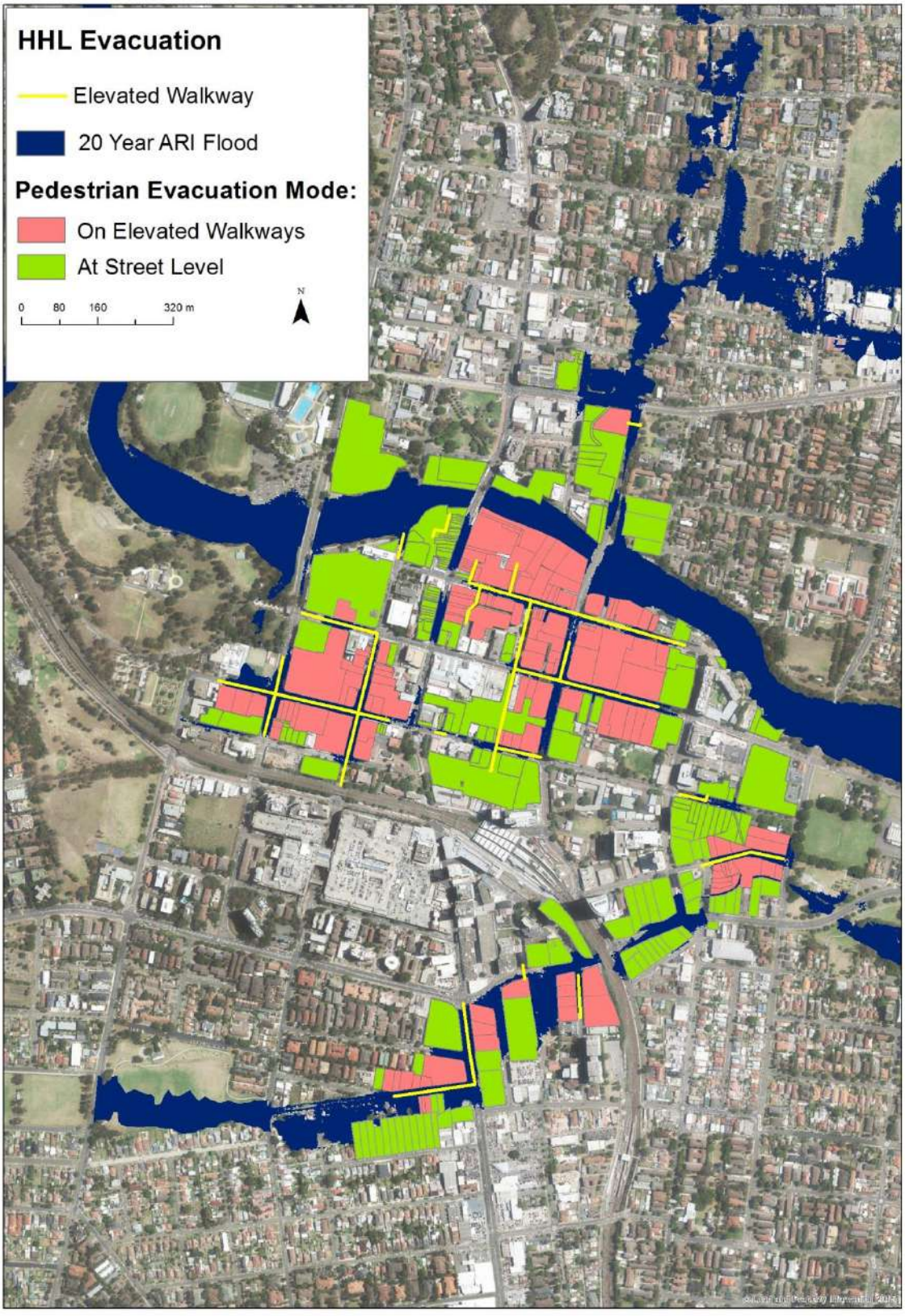

Figure 8: Extent of elevated walkways catering up to the 20 year ARI event.

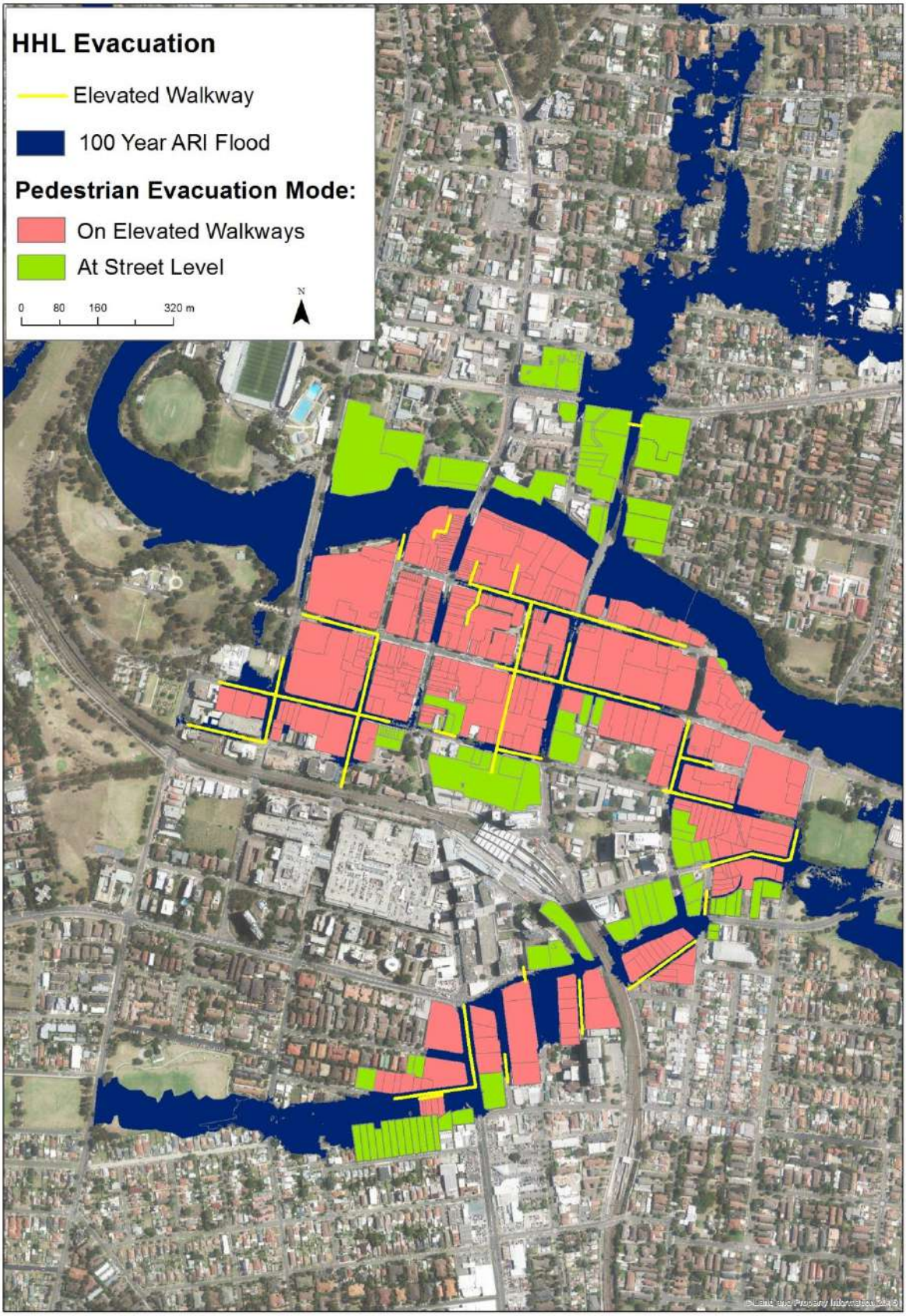

Figure 9: Extent of elevated walkways catering up to the 100 year ARI event.

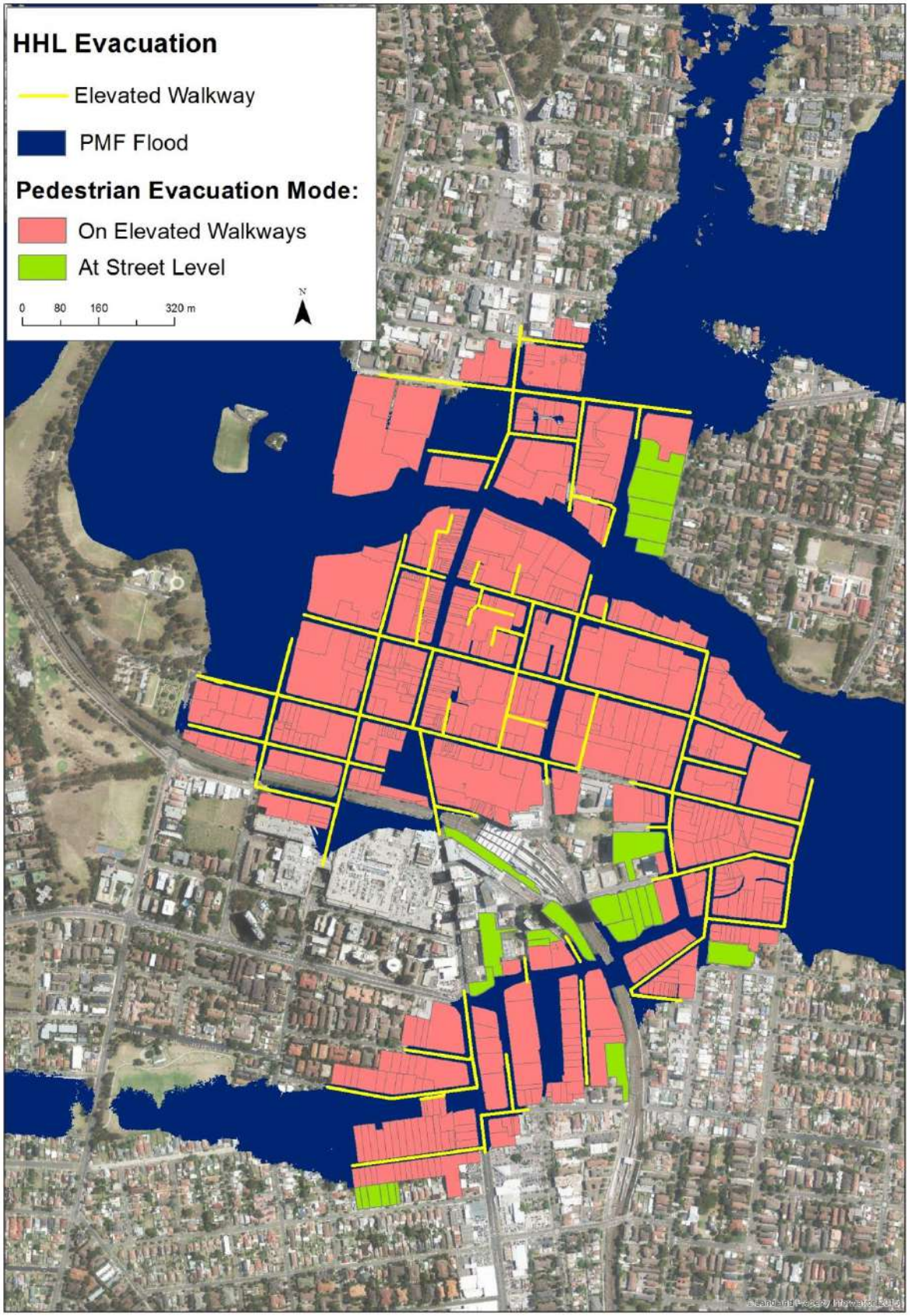

Figure 10: Extent of elevated walkways catering up to the PMF.

c) Pedestrian Evacuation Precincts

As part of the pedestrian evacuation modelling exercise, a new set of evacuation precincts was generated. Pedestrian evacuation precincts differ from vehicular evacuation precincts because:

- Pedestrians would evacuate to different locations; and
- Pedestrians would not need to abide by one-way roads.

Evacuation routes were identified for each building as the shortest "flood-free" path to the designated pedestrian refuge. For most buildings (i.e. those that are isolated by floodwaters), a flood–free path to safety could only be obtained using the elevated walkways. However, for a small number of buildings, pedestrian evacuation could be achieved without making use of the elevated walkways. This is the case of buildings that would be affected by the peak of the flood, but that would still maintain flood-free access to one of the designated pedestrian refuges. In this case, the evacuation route is entirely at street level.

Buildings were then grouped into evacuation precincts based on the narrower "bottleneck" along their designated evacuation route. Buildings sharing the same bottleneck were assigned to the same pedestrian evacuation precinct (Assumption 9 – Appendix A).

A bottleneck is defined as the point along the evacuation route with the slowest evacuation speed. Evacuation speed is inversely proportional to density of evacuees, which in turns depends on the number of evacuees and the width of the evacuation route.

For elevated walkways, which have all the same width of 2.5m, the bottleneck was identified at the walkway's exit point, where the number of evacuees would be a maximum.

Similarly, for street-level evacuation, the bottleneck was identified along the last road before reaching the evacuation refuge.

Pedestrian evacuation precincts are shown in Figure 11, Figure 12 and Figure 13. Precincts identified by the acronym SL (i.e. Street Level) would be able to complete the evacuation remaining at street level, while the remainder would need to make use of the elevated walkways.

d) Pedestrian Evacuation Model

The model used to calculate evacuation time is based on literature findings (Seyfried et al., 2005) regarding the relationship between pedestrian walking speed and density.

The time required for a group of people to walk along a road from point A to point B depends on the walking speed, the distance between A and B, the pedestrian numbers and the path's width.

The time required to clear all pedestrians from an elevated walkway was obtained as:

Walkway Clearance Time (WCT) = (number of pedestrians) / [(walking speed) x (effective width at bottleneck) x (pedestrian density)]

It was then assumed that pedestrians would be able to move at a speed of at least 700 metres per hour, with a density of up to two people per square metre. While elevated walkways have a fixed width of 2.5m, it was conservatively assumed that only 2m of width would be effectively used.

Where the calculated WCT resulted in a shorter time than that which a single person would take to walk the same distance at a speed of 2km/h, the latter figure was used as WCT.

The total pedestrian evacuation time for each precinct was then obtained as:

Precinct Evacuation Time = WAF + WLF + WCT

Where:

WAF = Warning Acceptance Factor (=1hr)

WLF = Warning Lag Factor (=1hr)

Finally, for each scenario, the total evacuation time was obtained as the maximum of all Precincts' Evacuation Times.

The total number of pedestrians to be evacuated in each HHL scenario is shown in Table 3

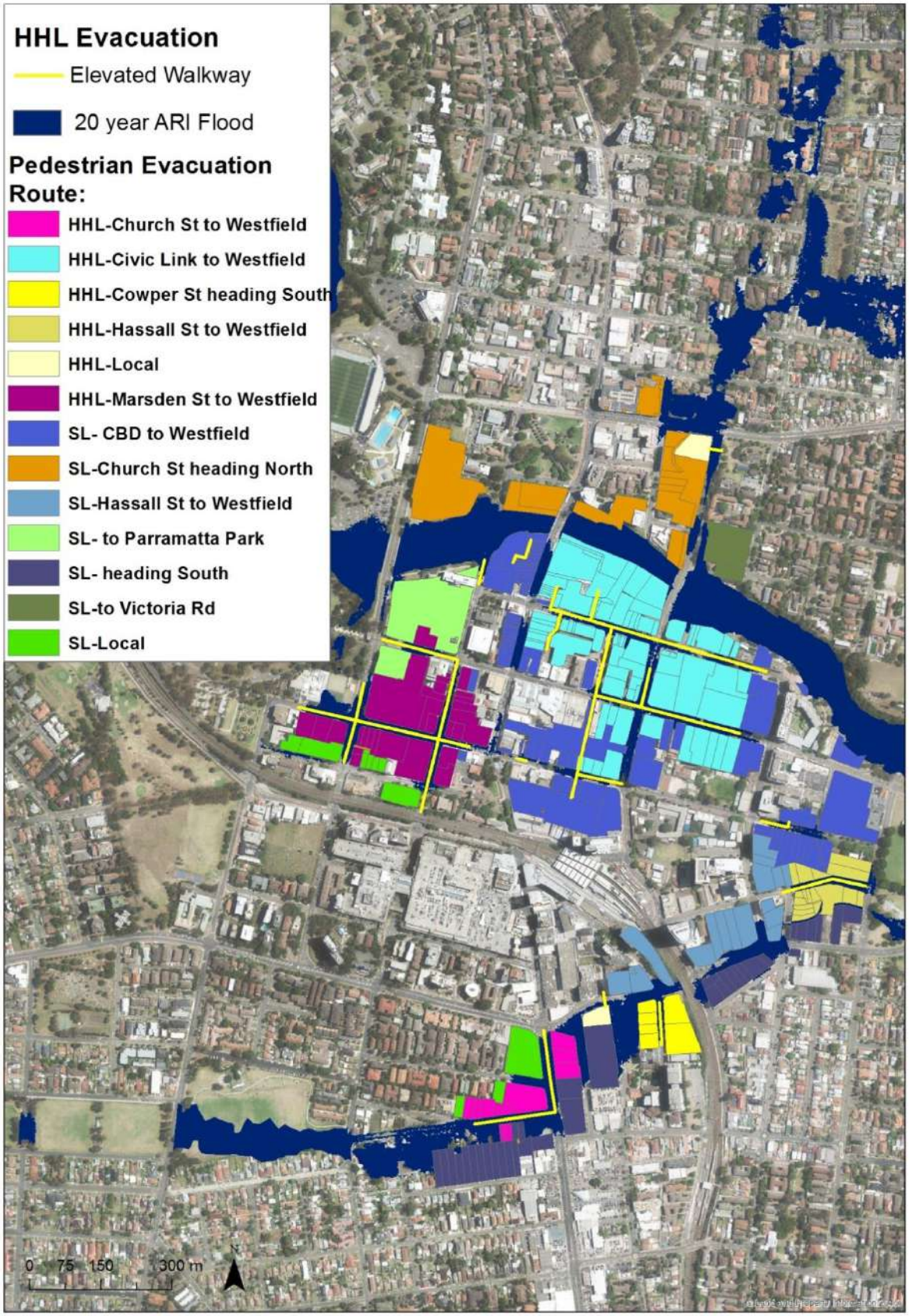

Figure 11: Pedestrian evacuation precincts evacuation routes for buildings affected by the 20 year ARI event.

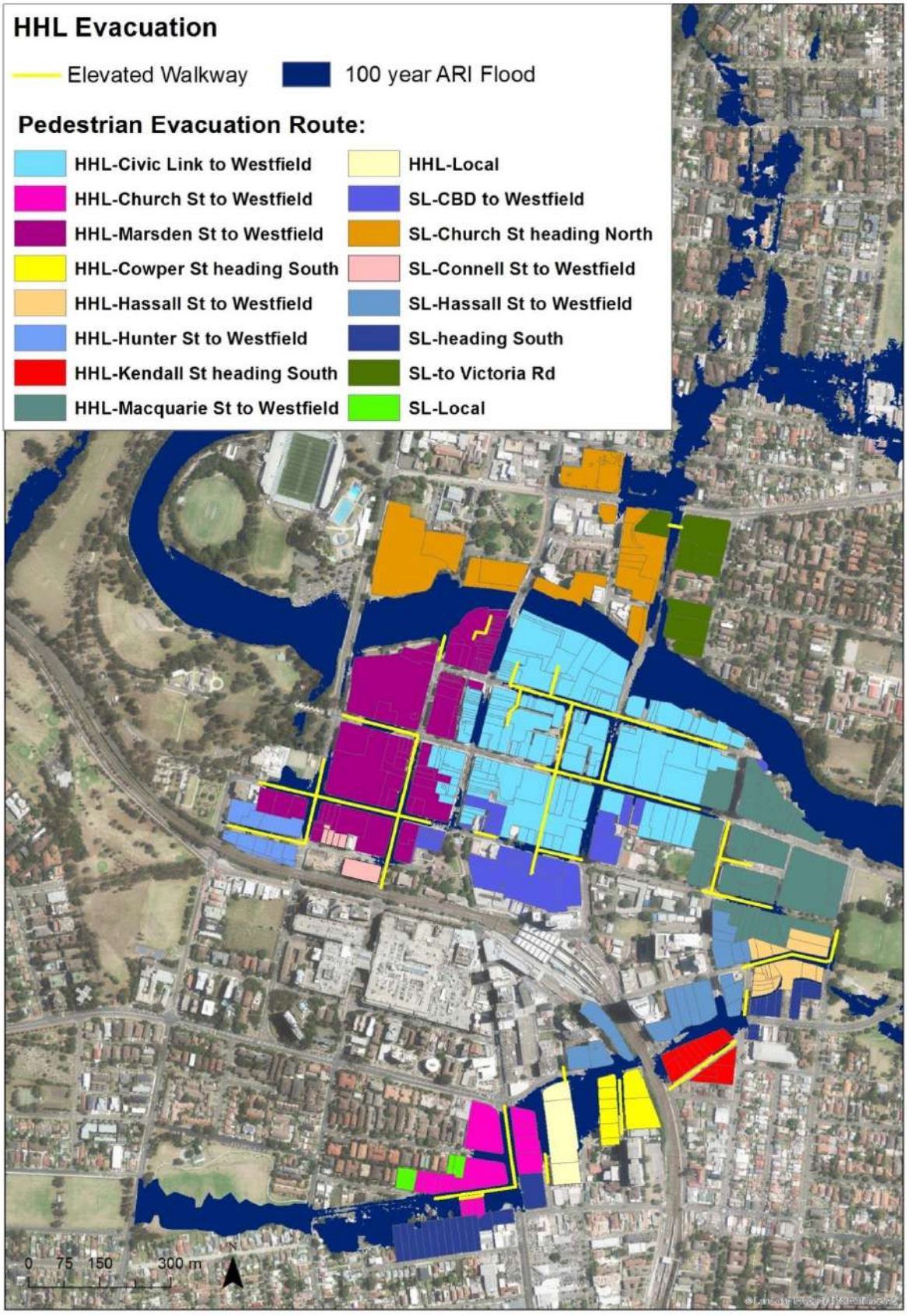

Figure 12: Pedestrian evacuation precincts evacuation routes for buildings affected by the 100 year ARI event

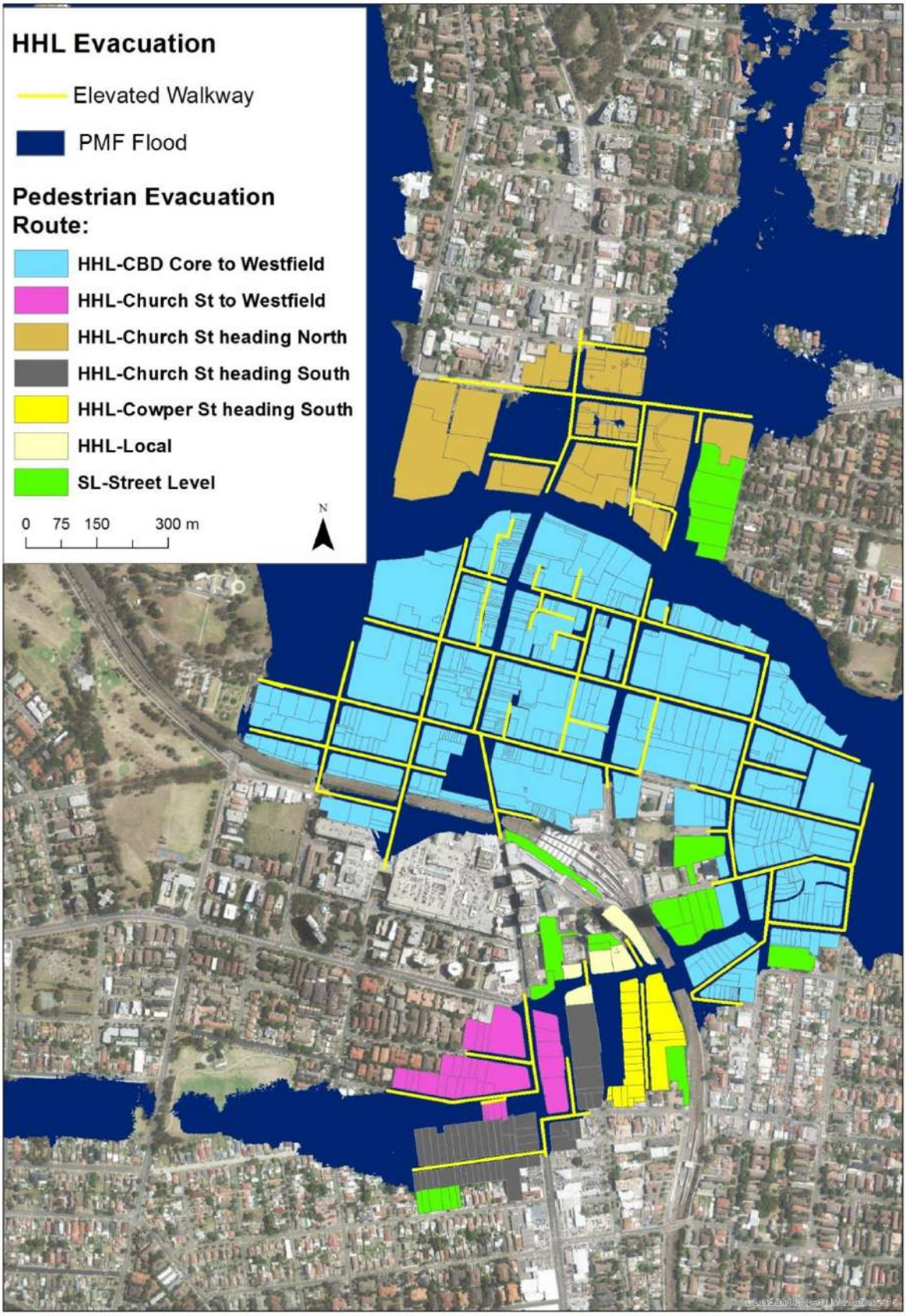

Figure 13: Pedestrian evacuation precincts evacuation routes for buildings affected by the PMF

Table 3: Pedestrians to be evacuated in HHL scenarios

Evacuation Scenario	Total Number of Pedestrians	Pedestrians on Elevated Walkways	Pedestrians at Street Level
2016 + 20yr + Midday	49,147	22,662	26,485
2016 + 100yr + Midday	53,376	44,093	9,283
2016 + PMF + Midday	73,646	68,341	5,305
2036 + 20yr + Midday	92,137	45,744	46,393
2036 + 100yr + Midday	99,324	85,096	14,228
2036 + PMF + Midday	130,245	123,524	6,721
2056 + 20yr + Midday	115,089	60,941	54,148
2056 + 100yr + Midday	123,865	110,070	13,795
2056 + PMF + Midday	167,821	158,733	9,088

3 RESULTS

Table 4 shows the total evacuation time obtained under the assumptions described in Section 2, for each of the selected scenarios. Figure 14 and Figure 15 provide a comparison of evacuation times across different years and flood probabilities, using the worst case scenario in terms of time of the day.

Evacuation times for each precinct are presented in detail in Appendix B.

Table 4: Total evacuation time for each scenario

Scenario number	Code	Total Evacuation Time (hrs)
1	2016_20yr_Midday_HSL	8.1
2	2016_20yr_Midday_HHL	4.5
3	2016_100yr_Midday_HSL	9
4	2016_100yr_Midday_HHL	5.2
5	2016_PMF_Midday_HSL	10.7
6	2016_PMF_Midday_HHL	4.4
7	*2016_PMF_Midday_Mixed*	*5.6*
8	*2016_PMF_AllCars_HSL*	*11.8*
9	2036_20yr_Midday_HSL	8.7
10	2036_20yr_Midday_HHL	7.3
11	2036_100yr_Midday_HSL	9.4
12	2036_100yr_Midday_HHL	8.9
13	2036_PMF_Midday_HSL	10.8
14	2036_PMF_Midday_HHL	6.8
15	2056_20yr_Midday_HSL	8.9
16	2056_20yr_Midnight_HSL	7.4
17	2056_20yr_Midday_HHL	9.1
18	2056_100yr_Midday_HSL	9.6
19	2056_100yr_Midnight_HSL	8.9
20	2056_100yr_Midday_HHL	11.2
21	2056_PMF_Midnight_HSL	9.7
22	2056_PMF_Midday_HHL	7.9
23	*2056_PMF_Midday_Mixed*	*9.1*
24	2056_PMF_Midday_HSL	11

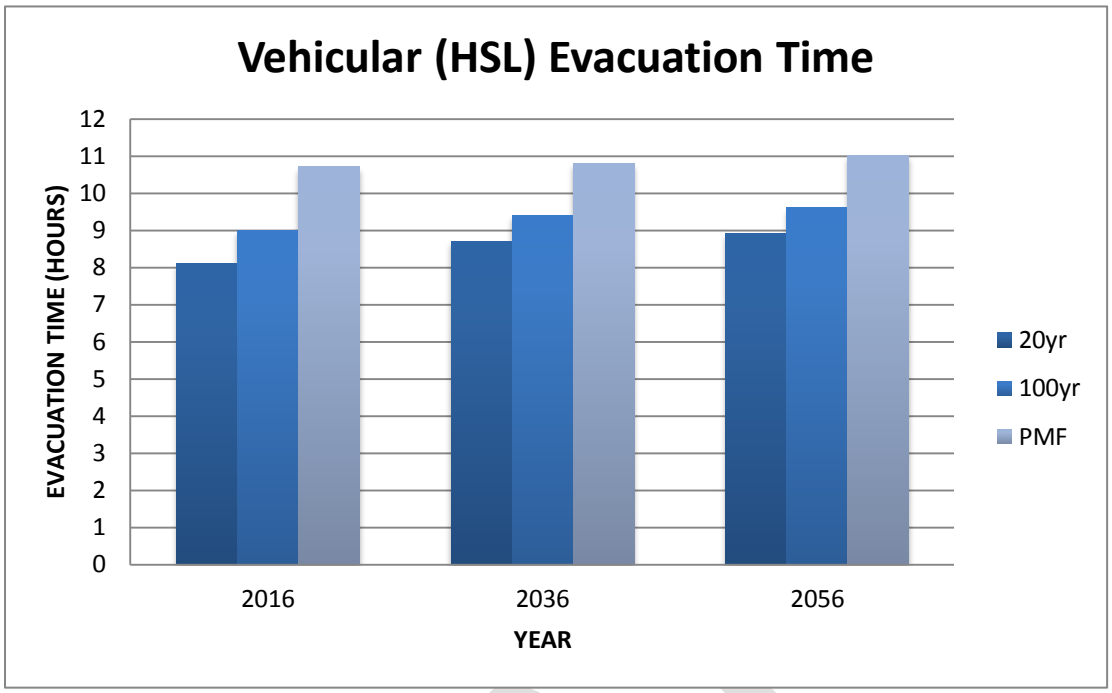

Figure 14: Comparison of vehicular evacuation times obtained for different years and flood probabilities and worst case in terms of time of the day.

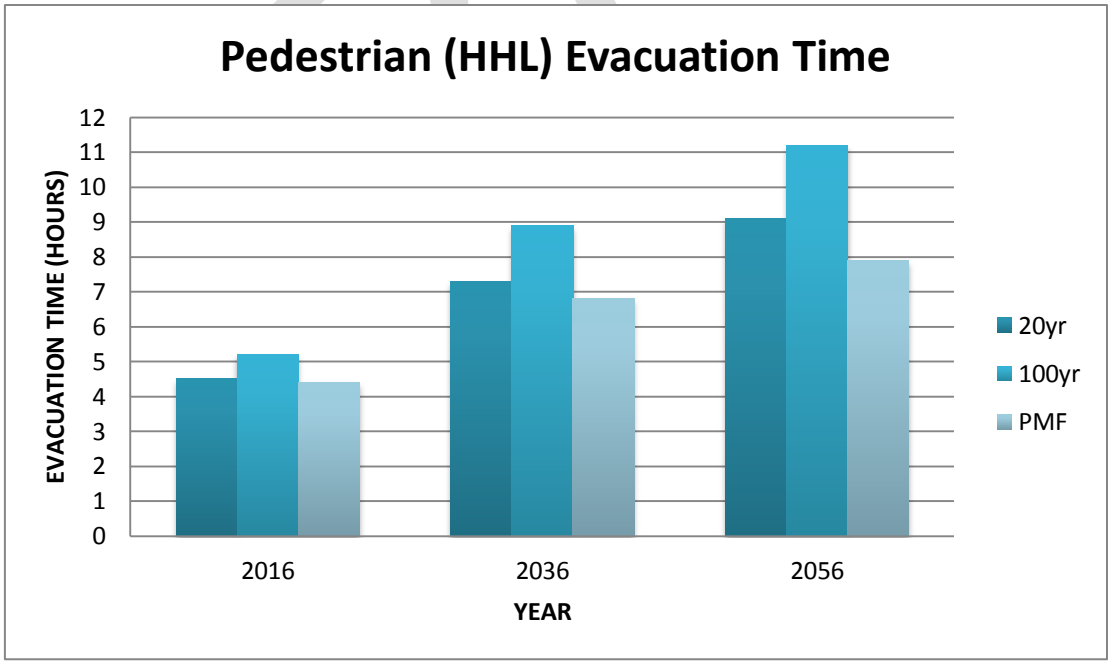

Figure 15: Comparison of pedestrian evacuation times for different years and flood probabilities and worst case in terms of time of the day

4 DISCUSSION

4.1 VEHICULAR EVACUATION (HSL)

4.1.1 Evacuation Time

Results show that, among all scenarios, vehicular evacuation time ranges between a minimum of 8 and a maximum of 11 hours. In all cases, the final evacuation time is driven by the precinct evacuating to the Great Western Highway, which includes the CBD core and, as such, contains the largest number of vehicles.

As expected, evacuation time increases consistently in future scenarios, although with relatively small increments (Figure 14). For example, the average increment from 2016 to 2036 is +4.2%, and from 2016 to 2056 the increment is +6.4%. This is due to the proposed new planning controls regulating the number of commercial and residential car spaces for new development and represents the best case scenario.

While existing controls, which are used in the 2016 scenario, require one commercial car space for every 100m^2 of effective commercial Floor Surface Area (FSA), new controls will allow only one commercial car space for every 50 m^2 of total site area. For mixed-use developments having both residential and commercial components, the new controls for commercial car parking were further adjusted by using the proportion of the commercial floor space to the total floor space of the development. The most obvious consequence of this is that multi-storey commercial buildings will undergo a significant reduction of commercial car spaces, because their site area is likely to be smaller than their commercial FSA.

However, this reduction is balanced out by the overall increase of commercial site area across the CBD. The result is a slight increase of the number of commercial car spaces from 2016 to 2056, which is reflected in the vehicular evacuation time's trend. Another consequence of the new controls on commercial car spaces is that the number of pedestrians in future scenarios will increase, which is accounted for in pedestrian evacuation scenarios.

Similarly to the increment by year, vehicular evacuation time is directly proportional to flood extent. In this case, results show an average increment of +9% from the 20 year ARI to the 100 year ARI event, and +26% from the 20year ARI event to the PMF.

In all scenarios, smaller evacuation precincts, located around the CBD core have evacuation times significantly shorter, ranging between 3 and 5 hours.

While all scenarios considered here are either based on a "midday" or "midnight" evacuation (where only a part of the available car spaces would evacuate), in Scenario 8 all the available car spaces in the CBD are assumed to evacuate at the same time. This scenario was only assessed in existing conditions (i.e. year 2016) and during a PMF event, with the intent of giving a sense of the theoretical upper limit of the evacuation time, which would be just under 12 hours.

4.1.2 Challenges of Vehicular Evacuation

There are several challenges associated with vehicular evacuation of Parramatta CBD:

a) Flood Timing

As discussed in Section 1.3.2, Parramatta CBD is affected by flash flooding. In the PMF, for example, floodwaters would reach the peak level after about 5 hours from the beginning of the rainfall, while local flooding would start affecting the road network almost immediately.

The flood warning system developed by the City of Parramatta Council is likely to be able to provide about two hours' notice of predicted flood levels being reached.

Figure 16 uses coloured arrows to show at what point on the PMF hydrograph the NSW SES would know that a given flood level is going to be reached. For instance, the NSW SES would know that a PMF is going to eventuate after about 3.5 hours from the beginning of the rainfall (this is indicated by the blue arrow in Figure 16). At that point, floodwaters would have already reached the

100 year level, most roads would be cut and vehicular evacuation from the CBD core would be impossible.

Similarly, smaller events such as the 20 year ARI and the 100 year ARI could be predicted no earlier than one hour after the beginning of the rainfall. Even though there are no flood model results for events smaller than the 20 year ARI, it is likely that at that point some degree of local flooding would have already occurred, preventing vehicular evacuation of part of the CBD.

In addition to this, even if vehicular evacuation could begin before streets are cut by local flooding, the number of cars to be directed to Great Western Highway would result in an evacuation time comparable to the flood duration, under any of the scenarios considered here.

b) Evacuation Delays

The willingness for people to evacuate by vehicle will be influenced by many factors including why they are in the building, when they were otherwise intending to leave, and whether they were travelling in the vehicle with others.

Generally, those who are visitors or workers are likely to evacuate promptly, particularly if they intended to leave soon. Those who are residents are more likely to delay evacuation or refuse to evacuate altogether if they consider their dwelling to be a safe refuge above floodwaters.

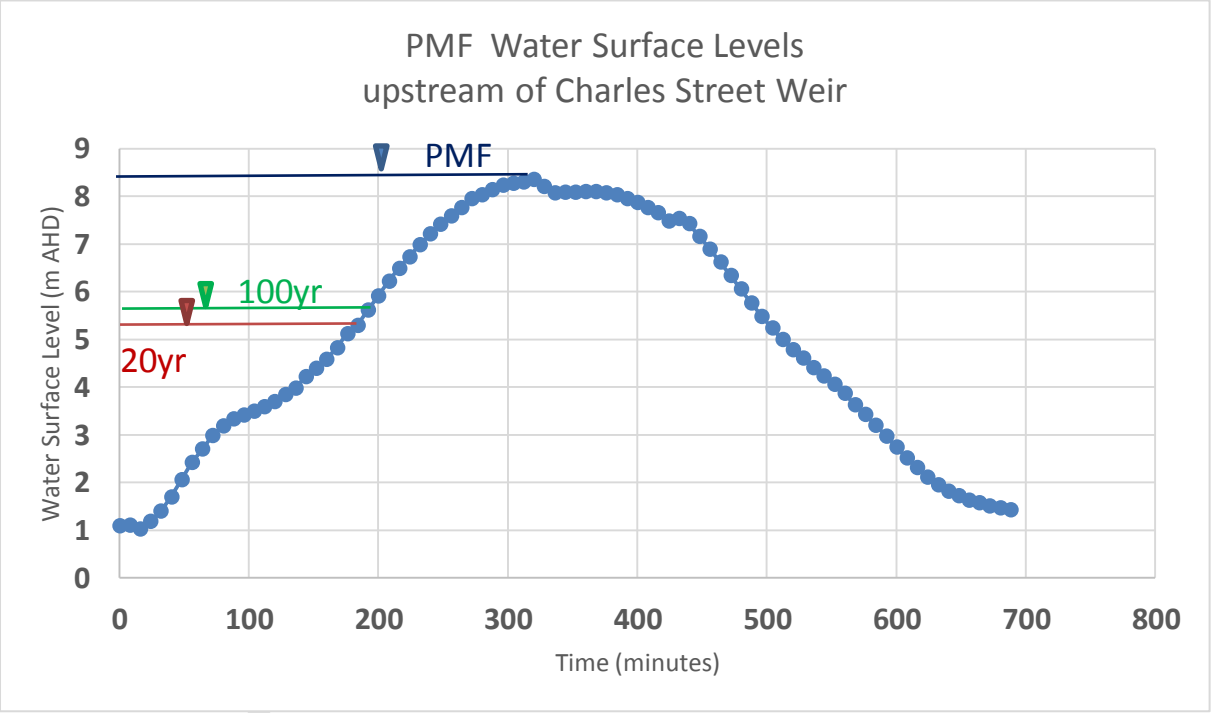

Figure 16: Flood duration and flood warning lead time

c) Regional Road Blockages

Even if evacuation could be successfully completed before roads within the CBD are cut, the extent of the regional flooding (i.e. outside the CBD) would be such that it would be difficult – if not impossible – for the large majority of vehicles to travel long distances before they reach a point on their evacuation route which is cut by flooding (Figure 4). For example, all cars evacuating to the Great Western Highway are likely to be isolated in the area between the Finlayson's Creek (west), Parramatta River (north), Clay Cliff

Creek (east) and the Motorway (south). Similarly, cars heading south on Church Street or Harris Street would most likely have their route cut by A'Becketts Creek.

d) Background Traffic

The evacuation modelling assumes that there is no other traffic on the roads when the evacuation order is given (Assumption 11 – Appendix A). This may be a reasonable assumption if the evacuation is called in the middle of the night but would not be the case during the day. On most weekdays there are considerable traffic delays during morning and afternoon peaks in Parramatta CBD and it can take 30 minutes to access the Great Western Highway or Church Street from some parts of the CBD in the evening peak in the absence of any flooding. If all vehicles are trying to leave the CBD simultaneously there is a risk of gridlocked streets as they try and merge with regional through traffic on the main roads which evacuation traffic will be directed to.

e) Traffic Queues

If cars evacuate from buildings but encounter roads blocked by regional flooding or regional traffic, then traffic will queue back into the CBD and may even prevent vehicles from leaving buildings. For example, there is only sufficient space on the Great Western Highway evacuation routes for about 1,150 cars to queue between the CBD and Finlayson Creek but there are up to 12,677 vehicles which would need to evacuate in such an event. While vehicles could go into side streets to queue above the reach of floodwaters and allow others to evacuated, most people would be reluctant to leave their place in the queue.

f) Returning traffic

In a PM peak there are likely to be many residents returning home by car and this returning traffic will need to be managed to ensure it does not enter the evacuation zone. It is unlikely that there will be sufficient emergency services resources to control this.

4.2 PEDESTRIAN EVACUATION (HHL)

4.2.1 Evacuation Time

Results show that pedestrian evacuation using elevated walkways (HHL) is generally more efficient than vehicular evacuation, particularly in existing conditions (year 2016). The only scenario in which vehicular evacuation would be faster is Scenario 20 (i.e. 2056_100yr_Midday_HHL).

Interestingly, the shortest evacuation time is always achieved in the PMF. The reason for this is that the PMF would require a larger network of elevated walkways (because the flood extent is larger), which would result in the CBD evacuees being distributed across a greater number of egress points. For example, in the PMF there would be eight egress points for evacuees heading to Westfield, while in the 20 year and 100 year ARI events there would be only 4 and 5 respectively.

It should be noted that the extent of the elevated walkways in each scenario was minimised to contain infrastructure costs and other adverse impacts (Assumption 12 – Appendix 2), however shorter evacuation times in smaller flood events could be achieved by extending the network to increase the number of egress points.

4.2.2 Challenges of Pedestrian Evacuation

Pedestrian evacuation using elevated walkways (HHL) would allow late evacuation from- access to- any flood-affected building. However, the following challenges/downsides need to be taken into consideration:

- **Cost:** Infrastructure cost would be significant and ranging from $94.5 to $324 million. A detailed breakdown of costs is provided in Appendix D.
- **Visual impact / overshadowing:** the elevated walkways would cause major visual impact on the urban landscape, particularly on heritage-listed buildings. The walkways would also increase the shadowing effect on

streets and lower levels of buildings. (Appendix C);

- **Impact on street trees:** because most walkways would be built above the footpath and/or parking lane at a height of 4.5m, any trees located along the walkway's path may need to be removed and replaced with low-level shrubs (Appendix C);
- **Compatibility with building levels:** in events larger than the 20 year ARI, the walkways would need to be directly accessible from the upper levels of each building. This would be difficult to achieve in practice, because floor levels vary between different buildings (Appendix C);
- **Limited road access for large vehicles:** where walkways traverse a road, or a crossroad, large vehicles which are taller than 4.5m (e.g. construction vehicles) would not be able to enter;
- **Evacuation Logistics:** all pedestrian evacuation scenarios were simulated under the assumption that people in buildings that are exposed to the flooding, but whose pedestrian evacuation routes are not cut by the flooding, would be able to evacuate at street level. However, this assumption implies that pedestrians would know if they are supposed to use the elevated walkways or not, which poses a challenge in terms of warning messaging. However, we note that this would only be a problem if the elevated walkways were built to cater for floods up to the 20 year ARI event, because only in this case would the walkways be accessible by anyone at street level;
- **Flood Duration:** pedestrian evacuation times range between 4 to 5 hours (in 2016) and 8 to 11 hours (in 2056). If the evacuation order is issued a few hours after the beginning of the rainfall, the evacuation process may finish after floodwaters have already receded.
- **Security:** Providing an extensive network of walkways that will not be used on a daily basis, will potentially create issues with informal use and security, and is an inefficient use of land within the CBD.
- **Road Impacts:** Providing ramps to access the walkway will impact on road layouts within the CBD.

In addition to the aforementioned challenges which are specific to using elevated walkways for pedestrian evacuation the following challenges apply to pedestrian evacuation generally:

- Those who arrived by light rail (when it is built) are unlikely to be able to leave by light rail because water across the tracks would stop its operation, many who arrived by bus will not be able to leave by bus because many bus routes will be cut by flooding, those who arrived by train may not be able to leave by train if flooding elsewhere or the inclement weather generally has disrupted rail services. All of these people may be reluctant to leave their buildings if they have no means of leaving Parramatta;
- People will be reluctant to leave a dry building to walk through torrential rain to shelter in another dry building, particularly if they perceive that their building provides shelter above the reach of floodwaters (whether that is true or not);
- Residents in particular have demonstrated an unwillingness to evacuate when orders have been given to evacuate in floods throughout Australia in recent years so it may be especially difficult to get people to leave an elevated dwelling in a high rise building on foot in torrential rain.

4.3 MIXED EVACUATION

4.3.1 Evacuation Time

Scenarios 7 and 23 incorporate mixed evacuation types, in which it is assumed that local flooding is already occurring (up to the extent of the 20 year ARI event) at the time evacuation begins, but that all buildings which could be affected by the PMF evacuate. Given that the flood warning system developed for Parramatta CBD will provide a relatively short lead time (i.e. two hours), these scenarios represent an attempt to simulate a realistic situation.

Buildings that are not isolated by events up to the 20 year ARI are assumed to evacuate by vehicle (Figure 17). These are, for the most part, located in the CBD's peripheral zones, where local flooding is a lesser issue compared to the CBD core. People in buildings from which vehicular evacuation is not possible because of local flooding in events up to the 20 year ARI are assumed to evacuate on foot.

Some of these people could complete the evacuation by remaining at street level, because even if their vehicular evacuation route is cut by local flooding, their pedestrian route is not. The remainder would need to use elevated walkways (Figure 18). Pedestrian evacuation time for these scenarios is determined by the proportion of pedestrians evacuating at high-level because the walkways are a narrower bottleneck than footpaths.

Because local flooding is assumed to have reached an extent up to the peak of the 20 year ARI event, elevated walkways are here assumed to cater up to the extent of the 20 year ARI flood.

Results of the mixed evacuation modelling show that:

- The total evacuation time would be 5.6 hours (Scenario 7) and 9.1 hours (Scenario 23);
- In both Scenario 7 and 23, the total evacuation time would be determined by vehicular evacuation to the Great Western Highway, which would take longer than pedestrian evacuation within the CBD core;
- Total evacuation times would be lower than the corresponding PMF scenarios in which evacuation is entirely achieved by car (i.e. Scenarios 5 and 24), but higher than the PMF scenarios in which evacuation is entirely done on foot (i.e. Scenarios 6 and 22).

4.3.2 Challenges of Mixed Evacuation

A large flood event with the same rate of rise as the PMF would reach and exceed the 20 year ARI extent in about 3 hours from the beginning of the rain. Because in scenarios 7 and 23 the elevated walkways would only cater up to the 20 year ARI flood extent, all evacuees would need to exit the walkways within 3 hours from the beginning of the rain. However, results of the pedestrian evacuation modelling for the CBD core (i.e. 4.5 hours for Scenario 7 and 9.1 hours Scenario 23) show that this would not be possible, unless the evacuation begins significantly earlier than the rainfall.

Extending the elevated walkways to cover the 100 year ARI flood would buy pedestrians some time (i.e. about 30 minutes), but would still not be enough for them to exit the walkways before the 100 year ARI extent is exceeded in a flood rapidly rising to a level beyond the 100 year ARI peak.

In fact, the only configuration for horizontal evacuation that would guarantee safe pedestrian evacuation of the CBD core in any event in which floodwaters rise as fast as in the PMF would be that in which the elevated walkways network covers the full extent of the flood event being considered. For example, if this event is the PMF, then the CBD core would need to be equipped with an elevated walkways network catering up to the PMF. However, in this case, a fully pedestrian evacuation like the one simulated in Scenarios 6 and 22 would be faster and more practical than a mixed type evacuation, and infrastructure cost would be only marginally higher.

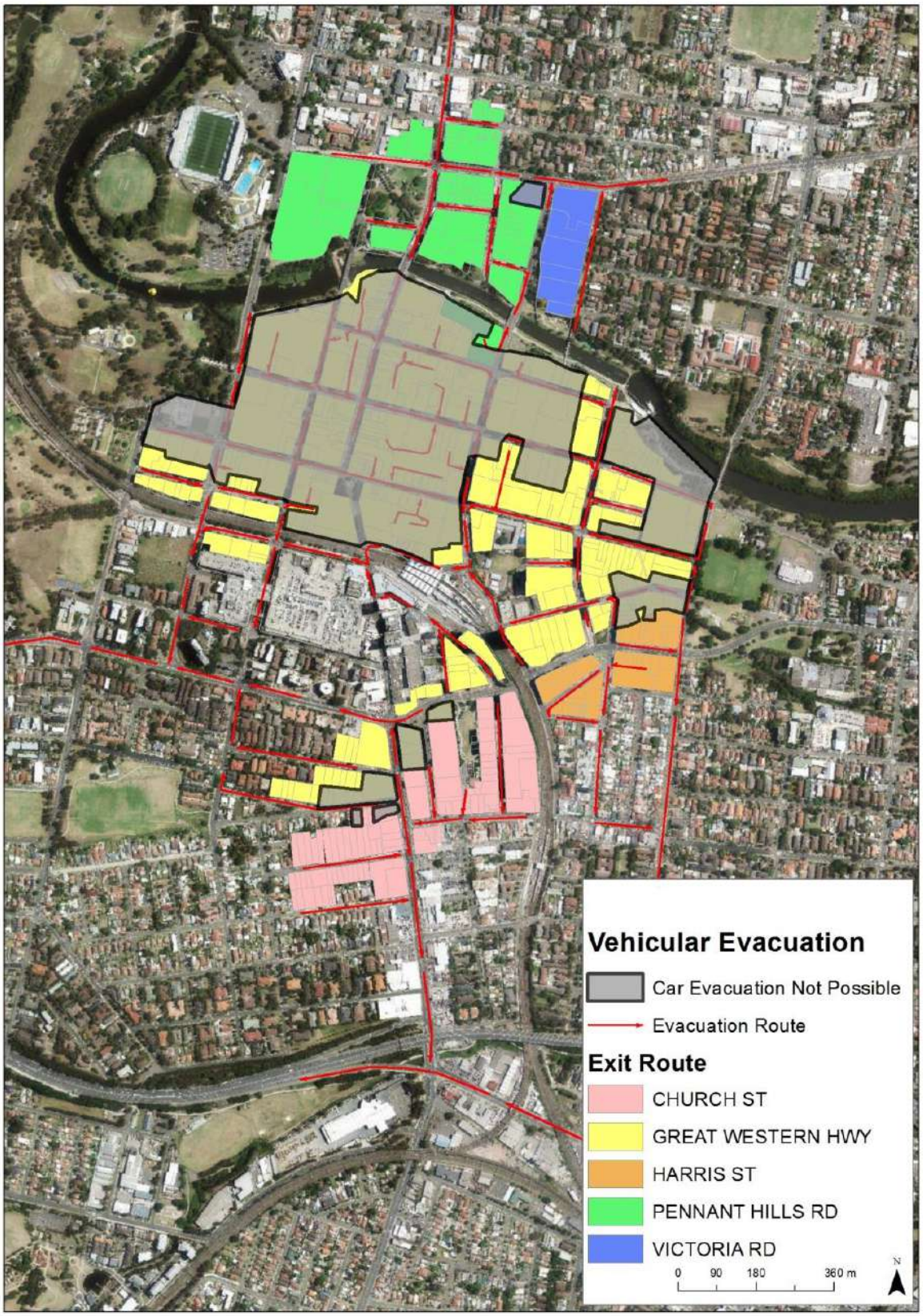

Figure 17: Mixed evacuation scenarios 7 and 23. People in greyed-out lots would not be able to evacuate by car if there was already local flooding up to the 20 year ARI event when the evacuation begins

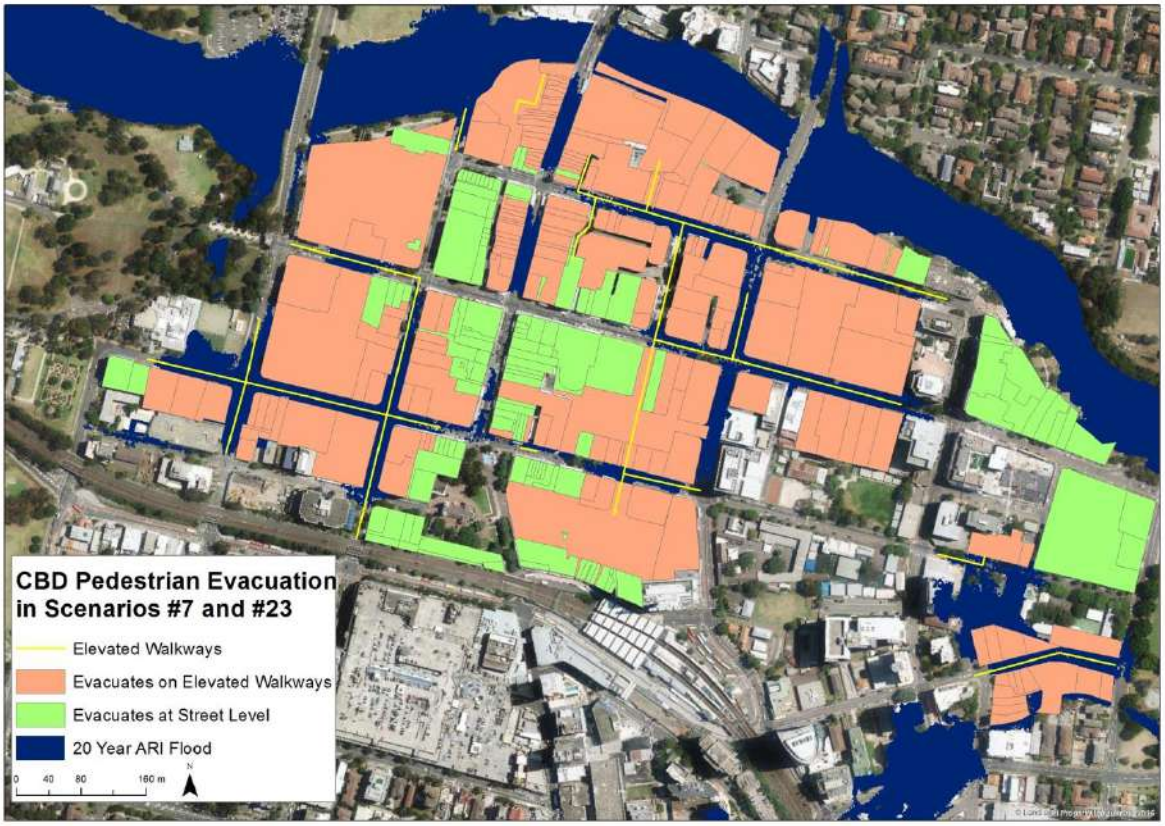

Figure 18: Pedestrian evacuation of the CBD in Scenarios 7 and 23.

4.4 SHELTER IN PLACE (SIP)

4.4.1 Risks of SIP

Shelter in Place (SIP), or vertical evacuation, is often considered a viable option in areas exposed to flash flooding, where there is not enough time for the population to evacuate safely. SIP as a possible flood emergency response strategy in Parramatta CBD is thoroughly discussed in Molino Stewart (2016). While SIP, where appropriate, is a policy requirement for new development, some existing sites may not be able to achieve this (e.g. heritage buildings). This issue is further discussed in Section 4.4.2.

The risks associated with SIP in Parramatta CBD could include:

- **No refuge above the floodwater:** the flooding reaches a peak higher than the highest accessible space in the building;
- **Structural failure:** the building used as a shelter cannot withstand the flood forces and may collapse;
- **Power supply:** the lack of power, which is likely to occur during a major flood, may make the SIP refuge unsafe or uncomfortable. People may decide to leave the building and walk though floodwaters;
- **Medical emergency:** evacuees taking shelter in place may require urgent medical assistance requiring hospital grade care, which would be difficult (and risky) to deliver because the building is isolated by floodwaters;
- **Fire emergencies:** building fires can be triggered during a flood by a short-circuit, or by human behaviour. For instance, evacuees taking shelter in place may use naked flames for improvised lighting or cooking. A building fire happening during a flood would be very difficult to manage, because the building could not be easily accessed by firefighters and it may not be safe to evacuate the building because it is surrounded by hazardous floodwaters;
- **Human behaviour:** evacuees taking shelter in place may decide to leave the building and walk through floodwaters for a number of reasons. For example, if the flood emergency occurs at the end of a working day (e.g. PM peak), workers may not like the idea of remaining in their offices. Similarly, evacuees may leave the building if they cannot communicate with their families, or if the refuge is not functional or safe enough.

Risks associated with SIP can be mitigated in a number of ways. These are summarised in Table 5. However it should be noted that SIP doesn't directly solve the issue of where to put people in the public domain during a flood. This needs to be addressed as part of the overall response strategy by providing access to appropriate buildings.

As part of the work undertaken by Molino Stewart to support the update of Parramatta Floodplain Risk Management Plans (Molino Stewart, 2016), a zoning of the CBD was proposed based on the degree of risks associated with SIP. For each zone, Molino Stewart (2016) generated a set of development controls to reduce these risks. The risk zoning proposed by Molino Stewart is shown in Figure 19 (in which zone 4 has the highest risk, while zone 1 has the lowest). In Figure 20, each lot was allocated to the corresponding risk zone. All lots within zone 1 and 2 have street frontage which is at or above the 100 year ARI flood level. Existing buildings might not have an access currently on that frontage but the development controls would require at least emergency access to these lots at or above the 100 year ARI flood level.

Table 6 shows the proposed development controls for each risk zone, while Table 7 shows how the number of people in each risk zone is expected to change from year 2016 to year 2056 as a consequence of the implementation of the CBD Strategy.

It is noted that the majority of buildings, and therefore people, are in zones 1 and 2. The areas with highest risk (zones 3 and 4) are principally those affected by flooding from Clay Cliff Creek rather than the Parramatta River.

Table 5: Example of mitigation measures for risks associated with SIP

SIP Risks	Examples of Risk Mitigation Measure	Suggested Mechanism for Implementation
Inadequate Refuge	Habitable space above the reach of the PMF is accessible to all occupants	LEP
Structural Failure	Buildings able to withstand PMF forces	LEP
Power Supply	Backup power supply available in SIP refuge	DCP
Medical Emergencies	Managed high level evacuation or access system	DCP & DA
Fire Emergencies	Switchboards that automatically shut down when electrical circuits are in contact with water	DCP & DA
	Fire suppression equipment as required for residential high rise buildings including sprinkler systems	DCP
	Backup power supply above reach of the PMF	DCP
Human Behaviour	Safe, functional and flood-free shelter Managed high level evacuation or access system	DCP & DA

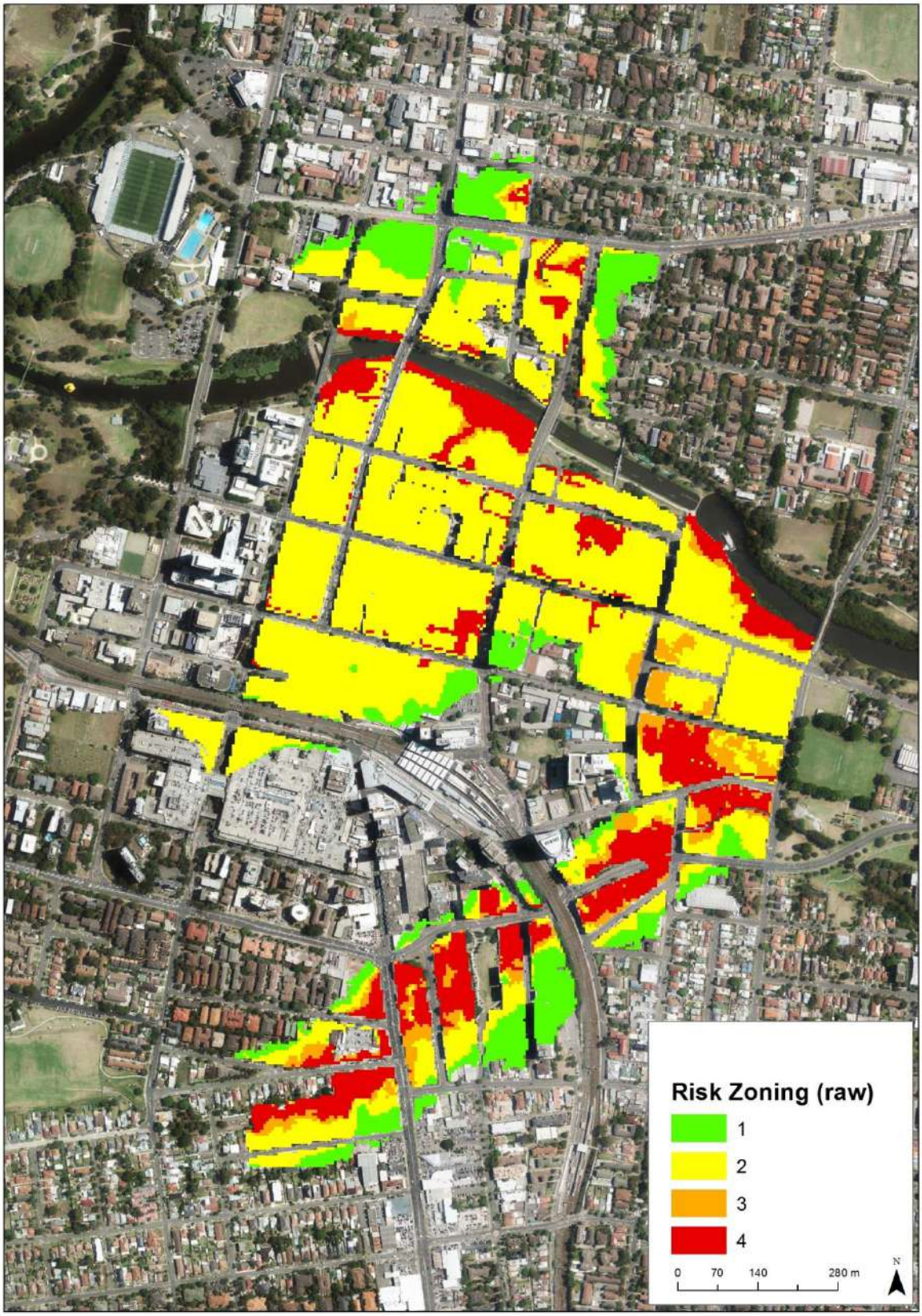

Figure 19: Risk Zoning (raw map) proposed by Molino Stewart (2016) to reduce risks of SIP through development controls. The western part of the study area is not zoned because not included in the scope of Molino Stewart (2016).

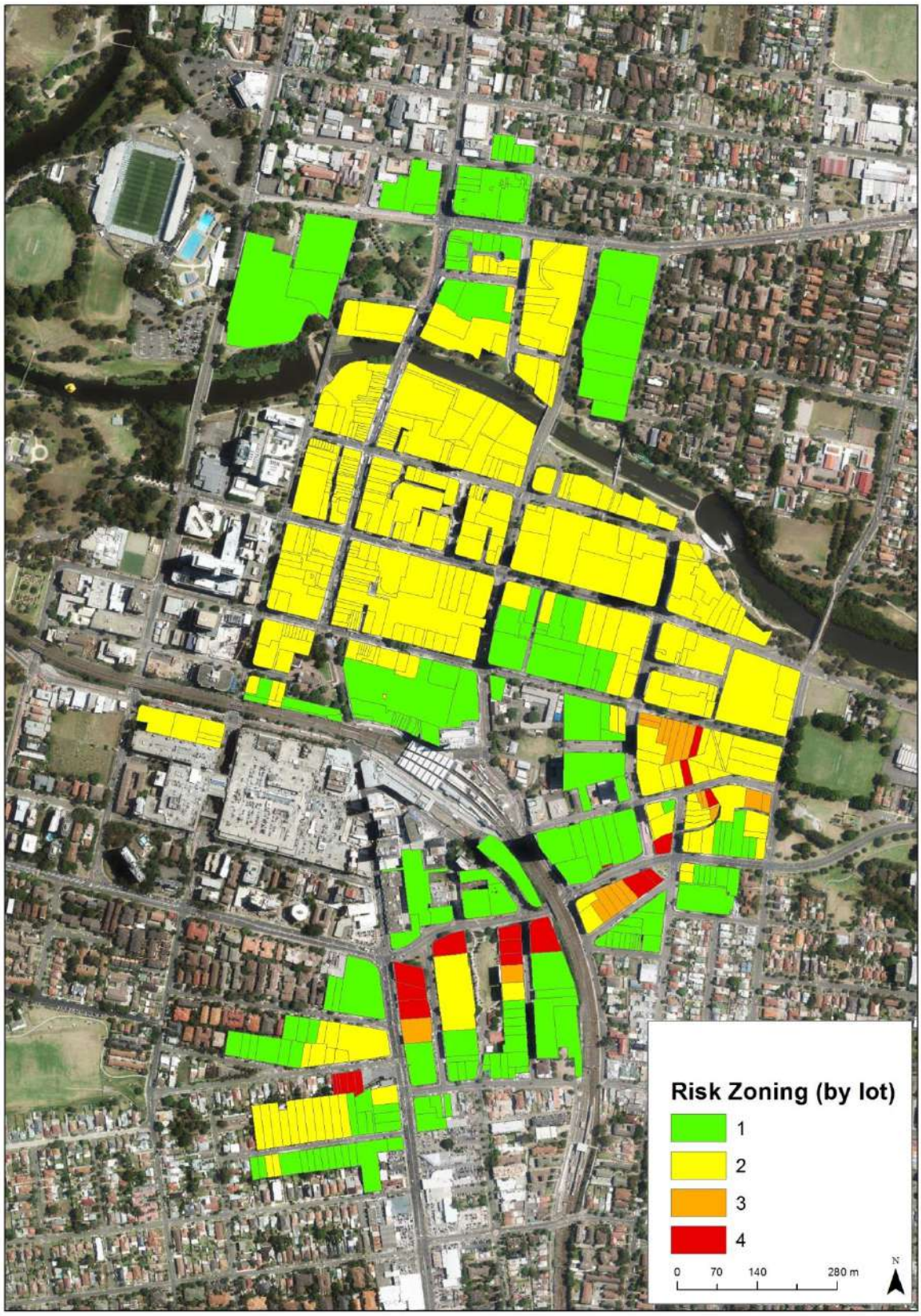

Figure 20: Risk Zoning (interpolated by lot) proposed by Molino Stewart (2016) to reduce risks of SIP through development controls. The western part of the study area is not zoned because it is not included in the scope of the Parramatta CBD Planning Proposal.

Table 6: Development controls to mitigate SIP risks proposed by Molino Stewart (2016)

Probability (AEP)	Existing Parramatta Development Control Plan 2011'		Recommended Amendments to the existing DCP	
	Existing Flood Risk Precinct	**Evacuation requirements for residential and commercial development**	**Risk Zone**	**Suggested Occupant Response**
< 1%	Low	3. Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (e.g. second storey) or off site (residential only) 4. Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan	1	Safe to evacuate or shelter in place. No evacuation controls required.
			2	Safe to evacuate early or shelter in place above PMF in accordance with a flood emergency response plan for the building.
< 5%	Medium	3. Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (e.g. second storey) or off site 4. Applicant is to demonstrate the development is consistent with any relevant flood evacuation strategy or similar plan 6. Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES and other authorised emergency services personnel	3	Evacuate early or shelter in place above PMF in accordance with a flood emergency response plan for the building providing flood free access is available to an exit through an area above the 1% flood level.
> 5%	High	As for medium flood risk precinct but only if development qualifies as concessional development	4	Evacuate early or shelter in place above PMF in accordance with a flood emergency response plan for the building providing flood free access is available to an exit through an area above the 1% flood level.

Table 7:Number of people in each risk zone.

Zone	Year	Residents	Workers	Visitors
1	**2016**	4,545 (45%)	12,947 (37%)	11,778 (45%)
	2036	9,239 (28%)	23,275 (37%)	16,670 (37%)
	2056	15,143 (30%)	26,991 (33%)	19,574 (33%)
2	**2016**	4,658 (47%)	21,468 (61%)	13,471 (51%)
	2036	21,858 (67%)	39,073 (62%)	27,985 (62%)
	2056	32,486 (64%)	51,920 (63%)	37,652 (63%)
3	**2016**	402 (4%)	244 (1%)	371 (1%)
	2036	837 (3%)	385 (1%)	275 (1%)
	2056	1,623 (3%)	1,083 (1%)	786 (1%)
4	**2016**	405 (4%)	272 (1%)	625 (2%)
	2036	859 (3%)	397 (1%)	284 (1%)
	2056	1,322 (3%)	1,832 (2%)	1,328 (2%)

4.4.2 Single-Storey Buildings

It should be noted that SIP is unsuitable in buildings that do not have a level above the PMF (e.g. single-storey buildings, or two storey buildings close to the river). All existing buildings less than 4.5m high are shown in Figure 21. These buildings are unlikely to be suitable for sheltering in place as they probably don't have a second storey and are too low to have direct access to an elevated walkway. This issue could be addressed as part of the CBD redevelopment, with single-storey buildings being redeveloped into multi storey buildings with appropriate features to manage the secondary risks of sheltering in place.

However, the problem remains for single-storey buildings that cannot be redeveloped, for example because they are heritage listed. For these buildings, a different flood response strategy needs to be put in place. These buildings are already at high risk from flooding, regardless of any future development of the CBD, because neither evacuation nor SIP are achievable.

An option for these buildings could be to Shelter In Place in neighbouring buildings that have a safe refuge above the PMF level (24h access to these buildings may need to be provided as part of the response strategy).

Figure 21 shows the location of heritage-listed buildings and buildings whose height is less than 4.5 metres. This shows that most of the single storey heritage listed buildings are in the risk zoning 1 or 2 which means they have access in the 1% AEP flood and some have flood free access. The two exceptions are a brick cottage near the corner of Wigram Street and Hassall Street which is in the Risk Zone 3 and a brick cottage in Lansdowne Street near the corner of Church Street which in is Risk Zone 4.

4.4.3 Existing Buildings Unable to Withstand the Forces of the PMF

SIP is not an option for buildings that do not have a safe refuge above the PMF levels. This includes existing buildings whose structure is not able to withstand the forces of the PMF. For these buildings, redevelopment offers a chance to reduce flood risk. However, until redevelopment can be undertaken, an alternative safe refuge above the PMF should be identified, for example in neighbouring buildings (24 hour access to these buildings may need to be provided as part of the response strategy).

4.4.4 Vulnerable Facilities

If the suggested SIP requirements are satisfied, vulnerable buildings such as hospitals, nursing homes, schools or childcare centres should put in place SIP emergency plans to ensure that all occupants are safely transferred to the refuge area before the peak of the flood is reached. The plan should also include measures to communicate with the families before, during and after the emergency to assure them that their loved ones are safe but also to discourage people trying to access the building through floodwaters.

Alternatively, some of these land uses may need to be prohibited where it is deemed any probability or duration of sheltering in place poses an unacceptable risk although this needs careful thought.

In the case of preschools it is possible to ensure that the children are not coming and going during a flood, but it is more difficult keeping parents from travelling through floodwaters to try and drop off or pick up children.

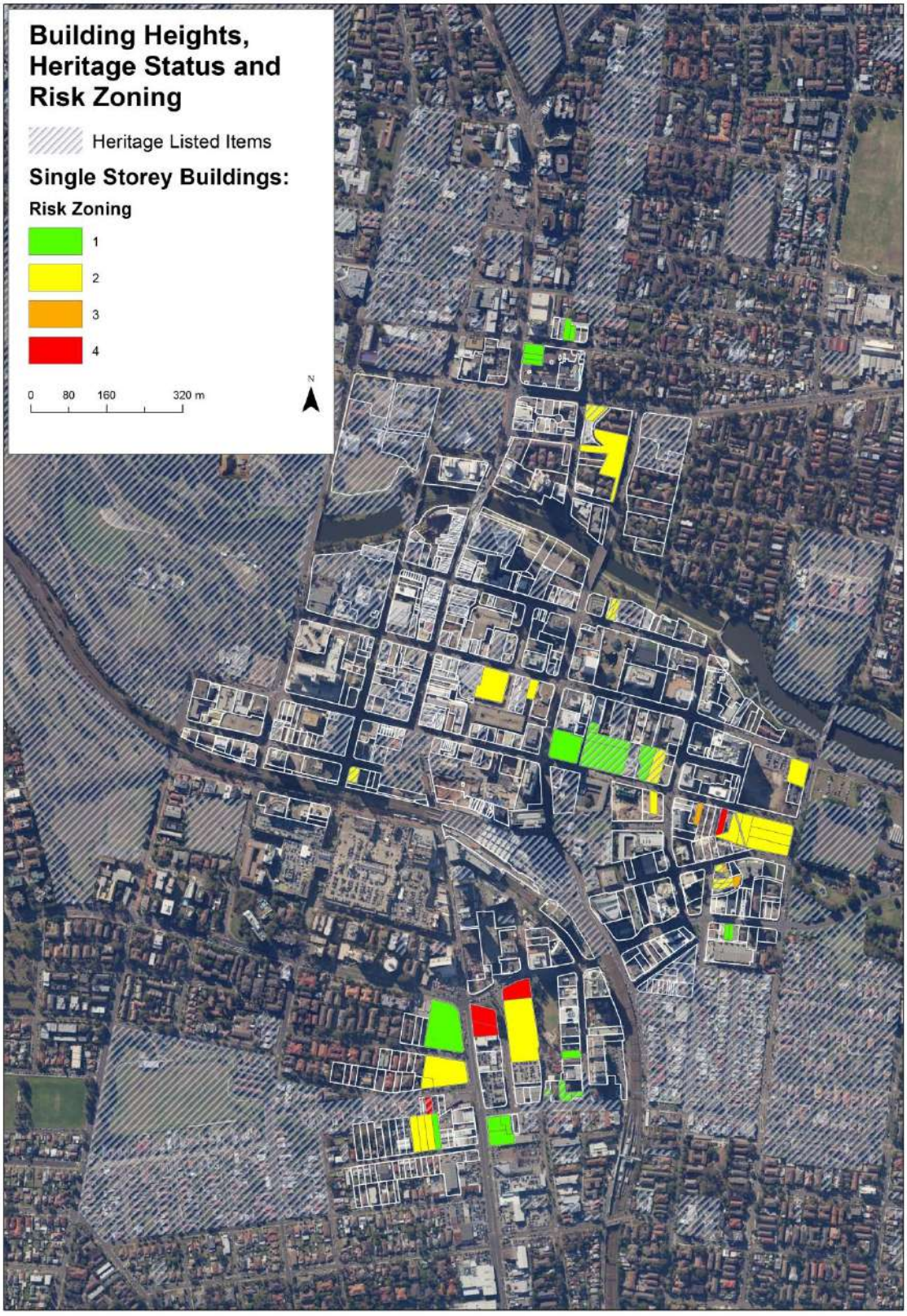

Figure 21: One-storey buildings and heritage listed buildings

4.4.5 SIP to Manage Residual Risk of Horizontal High Level Evacuation

SIP could also be used to manage residual risk in Pedestrian Evacuation Scenarios (HHL). For example, if it was decided to build a network of elevated walkways to cater for flood events up to the 20 year ARI, SIP could be used as the backup emergency response strategy for rarer floods.

4.4.6 Managed High-Level Evacuation/Access System

A substantial part of the risks of SIP, such as the risk of medical emergencies, could be addressed by implementing a "managed high-level evacuation or access system". This would entail the installation of a lightweight system of walkways with managed access to be used mainly by emergency responders. This option would also address a number of the key issues associated with HHL evacuation, namely:

- A suitable walkway width could be provided for emergency responder access, and evacuation of a limited number of people within the existing street pattern;
- Ramped access would not be required to be provided, as emergency personnel could evacuate individuals using specialist equipment/ stretchers where necessary;
- A lightweight single width (approx.1m) walkway could be provided, potentially utilising existing buildings and awnings, significantly reducing overshadowing and visual impact on the street;
- The length of proposed walkways could potentially be reduced by terminating the route at designated multi-storey car parks within the CBD suitable for helicopter access/ evacuation;
- By providing a lightweight, less visually obtrusive and secure walkway system that is only accessible by emergency responders, informal use of the walkways is minimised;
- Providing a lightweight route will enable the retention of more street trees;
- Providing a route that is managed by trained emergency responders enables temporary deployable structures, including bridges, to be utilised reducing the visual impact of the route and not permanently closing streets to high vehicles;
- Narrower and potentially shorter length of walkways, with no accessibility requirements, will keep construction and maintenance costs significantly lower.

Key issues for further investigation, should this option be progressed, include:

- Discussion of the suitability of the concept of a managed high level evacuation route with the NSW SES staff.
- Discussion of access requirements including walkway widths, steps, and ladders with the NSW SES.
- Discussion with Council and the NSW SES regarding ownership and maintenance of the system.
- Investigation of how building codes would apply to the proposal.
- More detailed design investigations of how the walkways would access buildings, the street, and be structurally supported.
- A visual impact study, once design parameters and the suitability of the proposal have been established demonstrating the effect of the proposals on views within the CBD.

5 SENSITIVITY TESTING

Since the original version of this report was prepared in 2017, there have been some changes in the study area which could potentially have some bearing on the results presented in the previous sections of this report.

This section describes those changes and provides an analysis of the extent to which these may affect the evacuation assessment results.

5.1 NEW WARNING SYSTEM

At the time of writing the original version of this report, in 2017, Council was in the process of developing a flood warning system for the Parramatta River. Since that time the system has been commissioned and used.

In Section 2.3 it was assumed that the warning system would be able to provide about two hours' notice. Council has since advised that two hours represents the maximum warning likely to be available in the extreme floods which would enter the CBD (C. Gooch pers comm).

It had also been assumed that the flood warnings would only be sent to the NSW SES and the NSW SES would then have to issue evacuation orders.

The Parramatta Floodsmart warning system, as eventually commissioned, not only sends flood warning messages to the NSW SES, but it also sends warning messages directly to members of the public who have subscribed to the service.

Floodsmart only issues flood warning information, not evacuation orders. Evacuation orders would still need to come from the NSW SES. Those who receive warnings directly from Floodsmart may choose to evacuate without receiving an order from the NSW SES. However, currently only 516 people have registered on Floodsmart which compares to the 30,000 flood affected properties across the entire catchment. Furthermore, many of the registrants are not in flood prone properties.

This means that, unless the number of Floodsmart's registrants increases significantly, it is unlikely to make a significant difference to the sequence of evacuation decisions and departures assumed in the original evacuation modelling.

5.2 DRAFT PLANNING PROPOSAL CHANGES

There have been some minor changes to the draft Parramatta CBD Planning Proposal within the areas affected by flooding.

5.2.1 Zonings

The draft zonings in the Parramatta CBD Planning Proposal, as endorsed by Council in April 2016 for the purpose of seeking a Gateway determination, and the draft zonings which are now proposed (as of June 2019) are identical (Figure 22)

However, at the time that the original version of this evacuation assessment report was being prepared, consideration was being given to a slight variation to the proposed zonings along the southern end of Church Street. These interim zonings, which were the basis of the evacuation calculations, are shown in Figure 23.

The location with the changes are circled in both figures. There are two lots which are zoned partly mixed use and partly commercial whereas during the evacuation analyses they were considered to be completely mixed use.

For the same floor surface area (FSA), commercial office space would have about 1.5 to 1.8 as many people as residential space. However, there would be a decrease in the number of vehicles in the building.

In the case of vehicles evacuating from these premises, they would evacuate onto the Great Western Highway. This is the most congested evacuation route and determines the maximum evacuation time from the CBD. The area of zoning difference is so small compared to all of the areas evacuating onto the Great Western Highway that the decrease in vehicle numbers would not make a significant difference to the evacuation time.

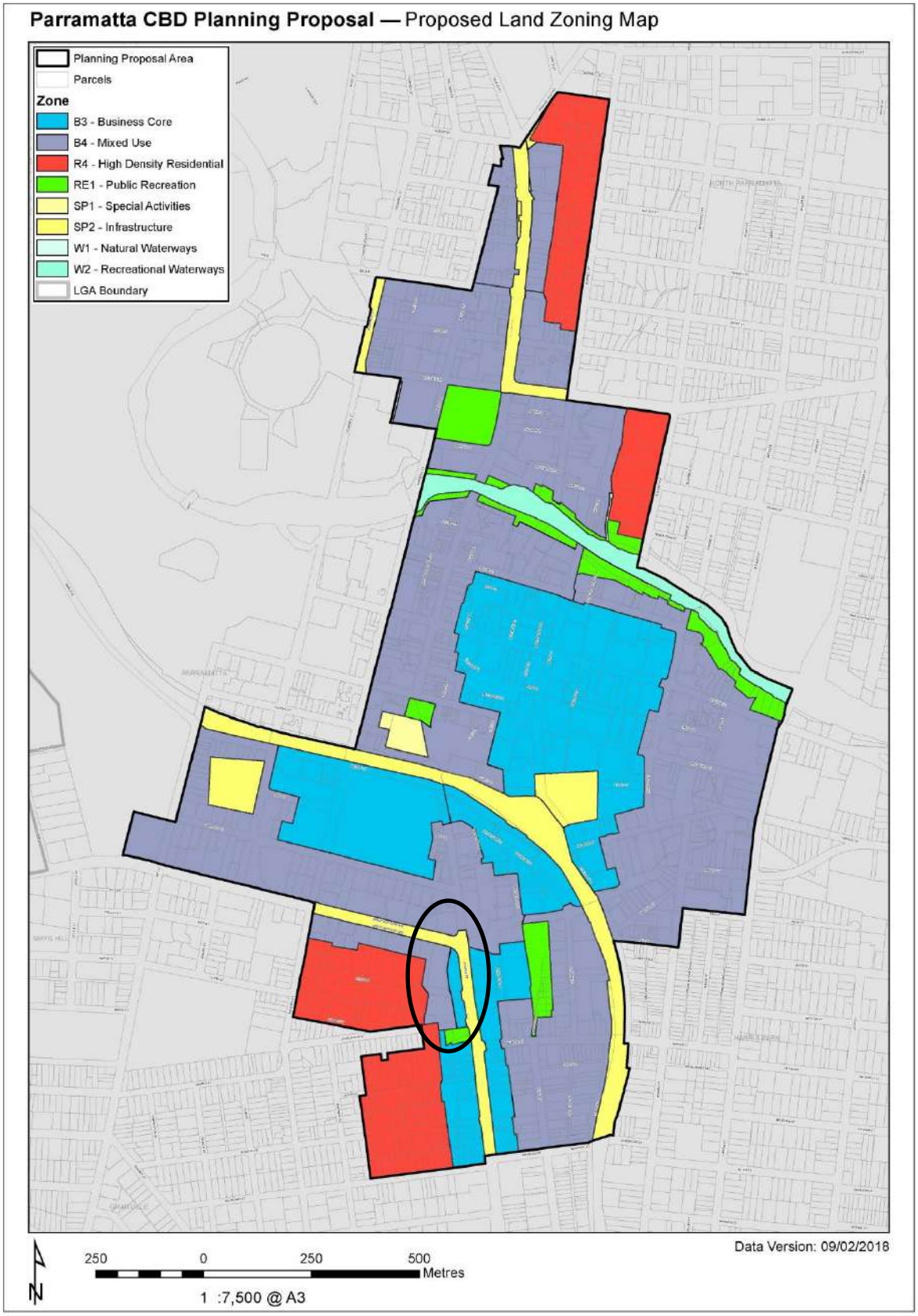

Figure 22: Current Draft Zonings

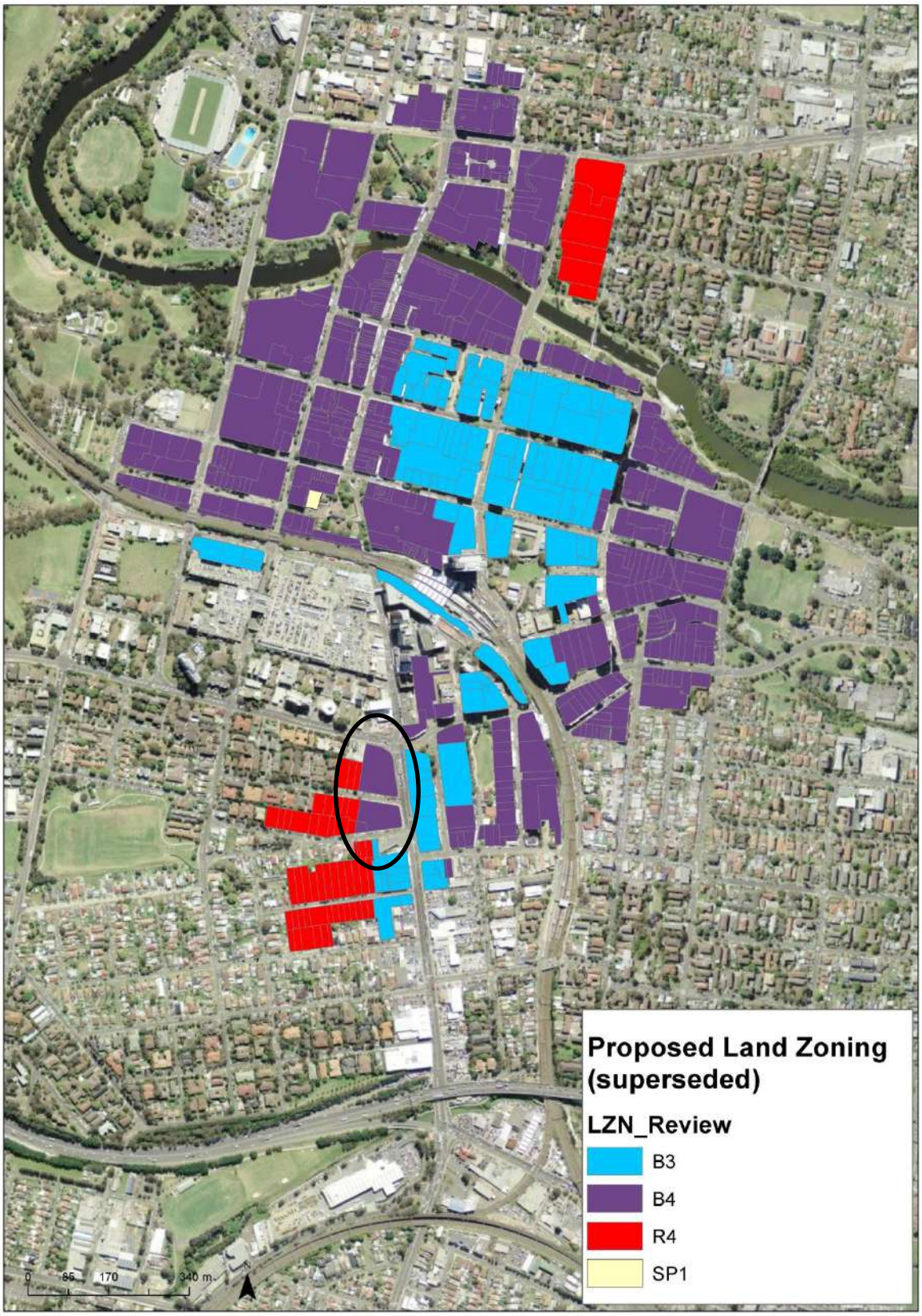

Figure 23: Interim Draft Zonings (used for evacuation calculations).

As far as pedestrian evacuation is concerned, these premises would evacuate north to seek refuge in a building of the scale and location of Westfield. There are only a few people evacuating from this area compared to those evacuating from the core of the CBD north of the railway line. It is the latter area which determines the minimum time for pedestrian evacuation. As such, a relatively small change in the number of people evacuating from Church Street will make no difference to the time needed to safely evacuate the whole of Parramatta CBD. It will have no impact on the cost of infrastructure because the same high level walkway will be required in this location irrespective of the scale of the development.

5.2.2 Floor Surface Area

There have been some substantial changes to floor space ratios (FSRs) and maximum building heights between the Parramatta CBD Planning Proposal as endorsed by Council in April 2016 and the current draft as at June 2019. These changes convert to changes in FSA, which underpinned the estimates of the number of vehicles and pedestrians who would need to evacuate in each future scenario. They have no impact on the Year 2016 evacuation estimates.

The FSRs and building heights which appeared in the April 2016 draft of the Planning Proposal were not the ones used to estimate FSAs and vehicle and pedestrian numbers for the evacuation analyses.

Firstly, all of the sites which had redevelopment approval or commencement since the draft planning proposal exhibition, were assigned actual FSAs in accordance with their planning approval or development approval on the assumption that these would not be redeveloped again within the next 40 years. For the residual properties the incentive FSRs were used because these represented the maximum development possible on each site.

Therefore to determine how changes to FSRs in the revised planning proposal affect the evacuation analyses, the redevelopable lots used in the evacuation analysis (Figure 24) need to be compared with the current planning proposal incentive FSRs (Figure 25).

The following section discusses the changes and the impact they would have on the evacuation analyses. The locations of the changes are highlighted in Figure 24.

a) Cnr Villiers St and Victoria Rd

The site on this corner would evacuate north onto Pennant Hills Road and has had its Incentive FSR reduced from 6.0 to 4.8, which equates to fewer vehicles and pedestrians evacuating from this block if fully redeveloped in the future. This is a relatively small reduction in FSR for a site which is only a small part of the area evacuating along this route.

This route is not a constraint to the vehicle evacuation analysis and is only part of the PMF pedestrian evacuation analysis.

The small changes in FSR for a minor contributor to evacuation in this area would not make a significant difference to the results and conclusions.

b) Between Lamont St and the River

This block has had its Incentive FSR reduced from 6.0 to 5.2. It is one of many blocks which evacuate to Pennant Hills Road. As with the block on the corner of Villiers Street and Victoria Road, the small change in the FSR of a block which makes a small contribution to one of the smaller evacuation flows is not going to make a significant difference to the evacuation analyses.

c) Between Argus St and Harris St

This block was assumed to have an Incentive FSR of 7.2 in the evacuation analyses but had an Incentive FSR of 10.0 in the current draft as at June 2019. This block evacuates onto the Great Western Highway, although its vehicle evacuation routes get cut early in the flooding.

It is only a small contributor to the evacuation traffic onto the Great Western Highway. However, this is the route which has the most traffic and therefore this increase in FSR would only make vehicular evacuation harder to achieve.

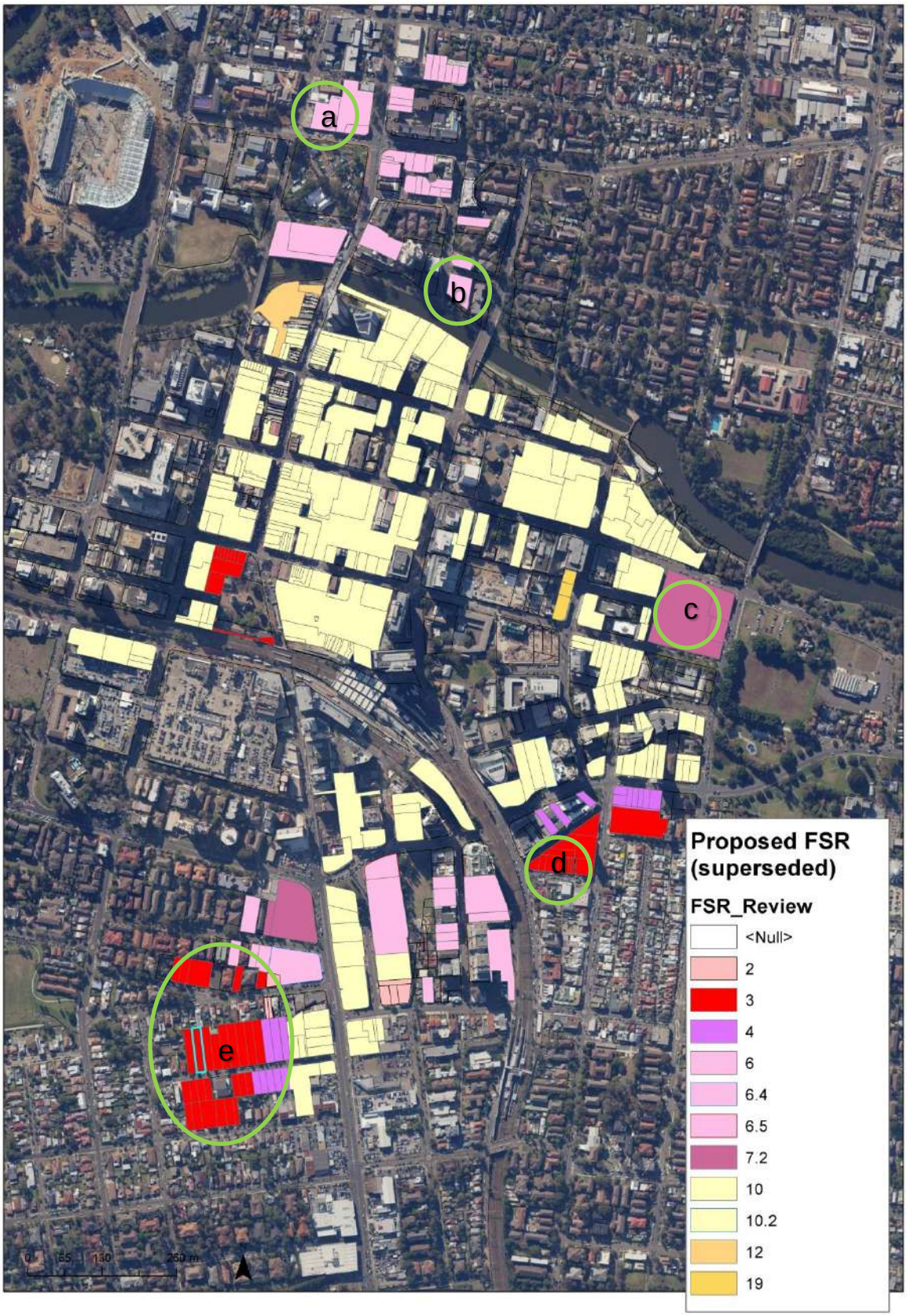

Figure 24: FSRs of Redevelopable Lots used in Evacuation Analyses

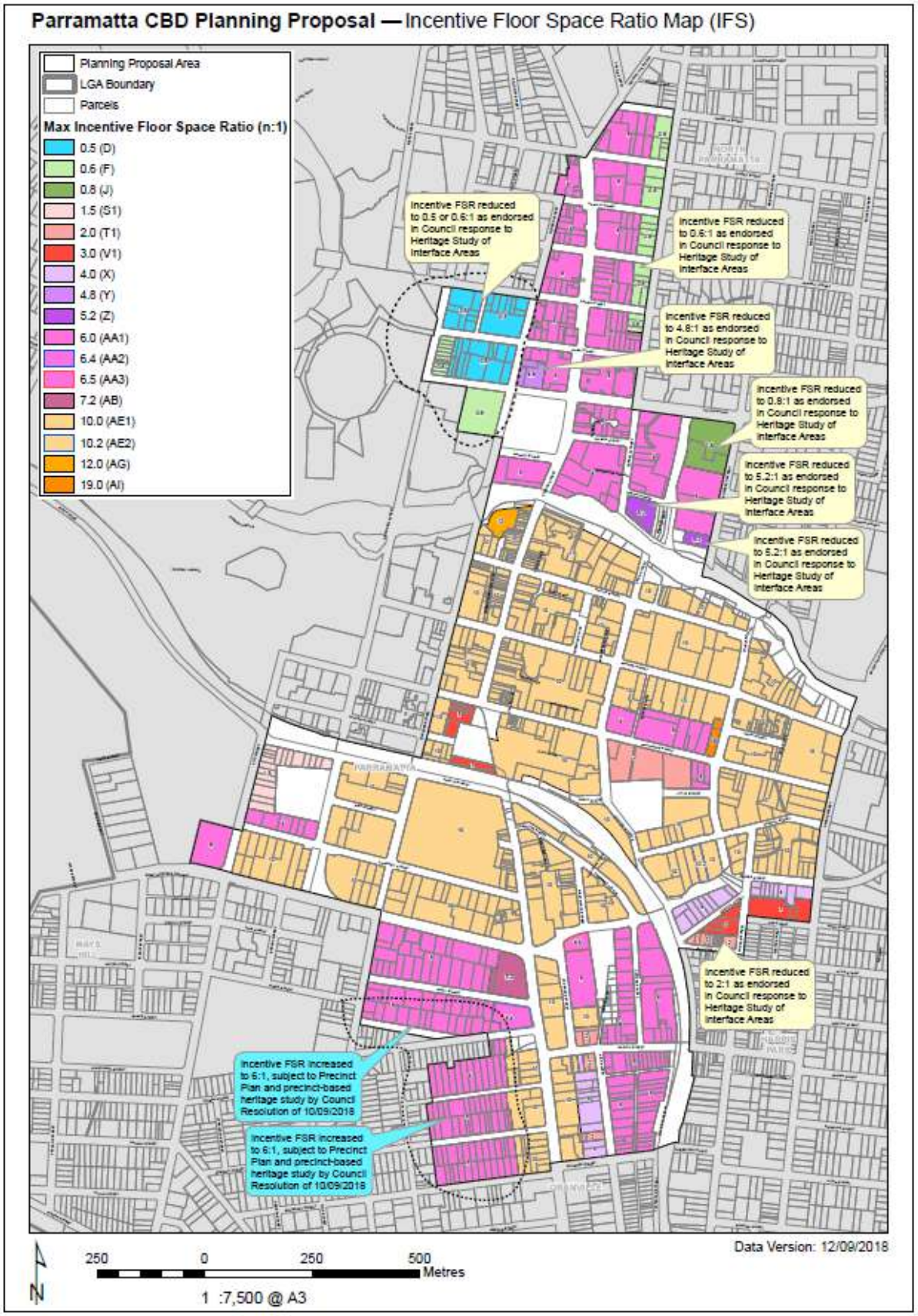

Figure 25: Incentive FSRs in 2019 Draft Planning Proposal

It would not increase the cost of elevated pedestrian infrastructure but would increase the number of people using it.

d) Ada St

There is a strip of properties along this street which have had their Incentive FSR reduced from 3 to 2. While this is a significant percentage reduction in the FSRs for these particular properties, these are a small part of the area which evacuates to Harris Street which itself is the second smallest evacuation precinct.

The changes here would not make a significant difference to the results and conclusions.

e) Lansdowne St and Dixon St

In this area the Incentive FSR is proposed to increase from 3.0 to 6.0, therefore doubling the number of vehicles and people needing to evacuate from these properties.

The few which are affected on the North of Lansdowne Street would evacuate by vehicle to the Great Western Highway and cause an extremely small increase on the route which takes the longest time to evacuate.

The rest of the properties would evacuate to Church Street and head south. Their contribution to this traffic stream would be more noticeable than that of their neighbours because Church Street would not have to accommodate as many evacuees as the Great Western Highway. Nevertheless, this traffic stream would take less than 40% of the total time that the Great Western Highway takes to evacuate so the changes in Church Street evacuation times would not make a difference to previous conclusions about the viability of vehicular evacuation.

These increases would not affect the quantum of elevated pedestrian evacuation infrastructure, just the number of people using it. The increase in the time taken would be small compared to the total time taken to evacuate the CBD core which the most critical to evacuating the viability of pedestrian evacuation as an option.

There would be a significant increase in the number of people needing to shelter in place in this street if that were the adopted response option.

5.1 SUMMARY OF SENSITIVITY ANALYSES RESULTS

Overall, the sensitivity analyses indicated that:

- The new flood warning system does not affect the assumptions of the evacuation modelling exercise
- The updated planning proposal causes only very minor differences in the numbers of people and vehicles evacuating. Where there are decreases it is in the least critical areas. The Great Western Highway, which is most critical for vehicular evacuation, will have more traffic directed to it

6 CONCLUSIONS

Based on the results produced in this work, the following conclusions can be drawn:

- Under the assumptions of the NSW SES Timeline Evacuation Model, HSL vehicular evacuation would take between 8 and 11 hours (depending on year and flood event). It should be noted that the flood warning lead time for Parramatta CBD is about two hours before the peak of any probability event is reached, and that the PMF would reach its peak level in about 5 hours from the beginning of the rainfall.
- In addition to this, the NSW SES assumes a time lag of at least two hours between when the evacuation order is communicated to the population and when the evacuation actually begins. Under this assumption, safe vehicular evacuation would not be realistically achievable under any circumstances.
- HHL pedestrian evacuation would take between 4.5 and 11 hours, and would be generally faster than HSL vehicular evacuation. Still, the pedestrian evacuation time would be of the same order of magnitude as the flood duration. This means that by the time evacuees have reached the designated refuge through the elevated walkways, most likely queuing under intense rain, floodwaters may have already receded.
- A specific urban design analysis, which was undertaken as part of this project, demonstrated that the infrastructure required to allow high-level evacuation (i.e. a network of elevated walkways) would have a cost ranging between $94.5 million and $324 million, depending on the size of the flood event these would need to cater for.
- The elevated walkways would also have very significant impacts on the urban landscape in terms of visual disturbance, overshadowing, removal of urban trees, impacts on heritage buildings, capability of large vehicles to access the CBD, maintenance costs and safety.
- A suitable alternative to evacuation would be for the population to Shelter In Place (SIP) and wait until the floodwaters have receded. SIP would be particularly appropriate in Parramatta CBD due to the type of the development (i.e. most buildings are multi-storey), and to the flashing nature of the flooding which would not allow enough time to evacuate safely.
- SIP could expose people to a number of secondary risks to life, including (but not limited to) those arising from: building structural failure, medical emergencies, building fires or people deciding to leave the shelter and walk through floodwaters These risks would need to be managed. This project, as well as the work by Molino Stewart (2016) suggested a number of achievable risk reduction measures through development controls.
- Furthermore, SIP is not an option for buildings that do not have a shelter above the PMF level (e.g. some of the one-storey buildings), and that do not possess the structural strength to withstand the PMF hydraulic forces (e.g. lightweight timber-frame buildings). However, occupants of these buildings are already exposed to the same level of flood risk, because this study has demonstrated that evacuation of Parramatta CBD is not achievable within the available time. If SIP were deemed the preferred emergency response strategy, measures would need to be put in place to allow the occupants of these buildings to access a suitable refuge in neighbouring, appropriate structures. In the future, redeveloping these buildings will provide an opportunity to reduce their flood risk.
- SIP risks could also be reduced through a “managed high-level

evacuation/access system". This would entail the installation of a network of light-weight elevated walkways to facilitate access of emergency responders to isolated buildings and/or allow evacuation of a small number of people (e.g. those requiring medical attention).

- In addition to these risks, SIP does not directly address the issue of people that are in the public domain when floodwaters begin to rise. The overall response strategy needs to address this issue, for example identifying suitable refuge above the PMF level within buildings that (a) can withstand PMF forces, and (b) can be accessed by the general public at any time of the day.

The analysis included also an assessment of the combined use of some evacuation types. Results showed that:

- Combining HSL (vehicular) and HHL (pedestrian) evacuation types would not provide significant advantages over fully pedestrian HHL evacuation types;
- If the elevated walkways network was designed to cater only for smaller events (i.e. the 20 year ARI), the residual risk associated with larger low-probability events could be managed using SIP.

Based on the results obtained, the following response options may be suitable:

- Mandatory evacuation. This option could theoretically apply to either vehicular (street-level) or pedestrian (high-level) evacuation, although safe vehicular evacuation is likely to be unachievable.
- Optional Evacuation/SIP. This option would leave the decision to evacuate or SIP to the evacuees. Because of the high risks associated with vehicular evacuation, this option is only recommended for high-level pedestrian evacuation (HHL). It should be noted that the use of elevated walkways would in fact eliminate the risk of buildings being isolated by floodwaters, because the occupants would have a safe way out at any time. As a consequence, occupants could either evacuate or remain in their buildings (if these are equipped with a refuge above the flood level and all SIP risks are managed appropriately).
- Mandatory SIP. This option would be required if no elevated pedestrian evacuation routes were available, and would require appropriate development controls to manage all risks associated with SIP.

Results of this study should be interpreted in conjunction with the assumptions made to obtain the evacuation model input data. Please refer to Appendix A for a detailed description of these assumptions.

The sensitivity analysis undertaken using new information which has become available since the completion of the original report does not alter the abovementioned conclusions. . In fact, it suggests that, overall, vehicular evacuation may be slightly more difficult to achieve than originally thought. These should be re-examined when the new Upper Parramatta Flood Study results become available.

7 RECOMMENDED STRATEGY

The identification of the most suitable flood emergency response strategy in Parramatta CBD is a complex exercise, because it depends on the assessment of each alternative's performance against multiple evaluation criteria.

These types of problems involve subjective evaluations and can be simplified using an approach based on Multi-Criteria Analysis (MCA). The main strengths of MCA are that it:

- Provides a structure for decision making while still allowing flexibility and is particularly useful for complex problems;
- Follows naturally from the way people tend to approach problems with multiple objectives;
- Has flexible data requirements;
- Allows information that is agreed upon by all parties to be distinguished from areas of contention;
- Is amenable to sensitivity analysis;
- Does not require assignment of monetary value to all quantities;

The use of MCA allowed us to rank the evacuation strategies in a way that takes account of different evaluation criteria. Each criterion was selected to evaluate the key issues to be addressed by the evacuation strategy, which are discussed throughout this report. The evaluation criteria used in the MCA exercise were:

- The strategy effectiveness, in terms of capability to reduce the risk of casualties during a flood. This is determined by the probability that evacuees have to reach a suitable flood-free area timely and safely, i.e. without any risk of contact with floodwaters. This was assessed using state of the art evacuation models (Section 2.3);
- The difficulty of implementation of the strategy, arising from setting-up the appropriate response infrastructure (e.g. elevated walkways) and from the logistics of the response. For instance, it may be difficult to communicate to the population a very complex evacuation plan in which some of the evacuees use elevated walkways, and some do not. Similarly, it may be difficult to communicate to the population that they should evacuate on elevated walkways in events smaller than the 20 year ARI event, but take shelter in place for bigger events;
- The risks associated with the strategy and the extent to which these can be reduced. This accounts for any risks associated with not being able to evacuate in a timely manner, or risks of SIP (Section 4.4);
- The impacts on the urban environment (i.e. due to the construction of elevated walkways);
- The cost of implementation and maintenance of the strategy;
- The load on emergency services, in terms of the support required from emergency services to support the strategy (e.g. communication of evacuation order, management of traffic, search and rescue).

The alternatives that were assessed against the evaluation criteria were:

- Vehicular Evacuation;
- Shelter in Place;
- Horizontal High-Level (HHL) Pedestrian Evacuation up to the PMF;
- Horizontal High-Level (HHL) Pedestrian Evacuation up to the 20 year ARI, and SIP for larger events;
- Horizontal High-Level (HHL) Pedestrian Evacuation up to the 100 year ARI, and SIP for larger events;

The multi-criteria assessment is summarised in Appendix E.

Under the assumption that all selection criteria have the same weight, results show that the preferable response option is Shelter In Place

(overall score = 22/30), followed by HHL Pedestrian Evacuation up to the 20 year ARI, and SIP for larger events (overall score of 18/30).

SIP scores are relatively low under the following two selection criteria:

- Residual Risk, and
- Load on emergency services.

These scores could be improved by implementing a "managed light weight high-level access system" (Section 4.4.6), which would allow emergency managers to access dwellings requiring urgent assistance and/or to evacuate people who cannot remain in the SIP refuge (e.g. medical emergencies).

It should be noted that his type of system would have a cost of installation/maintenance and would cause a moderate impact on the CBD urban landscape. However, both these adverse effects would be smaller than in the case of a full-sized network of elevated walkways. As such, we recommend that further studies assess in detail the risks, costs and benefits associated with a lightweight managed high-level access system, paired with a SIP policy. Specifically, the issues to be addressed include: access requirements, ownership and maintenance of the system, implications for building codes, detailed structural design and management of visual impact.

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APPENDIX A - ASSUMPTIONS

Evacuation Model Assumptions

Assumption	Description	Notes
1: Warning Time	A minimum two hours lead time is provided by the flood warning system before any size event is reached	At the time this study was undertaken, the City of Parramatta Council was developing a flood warning system for the CBD. Preliminary results suggested that a warning time of two hours should be used for the purpose of the evacuation assessment
2: Time lag between warning and response	After an evacuation order is communicated to the population, a minimum delay of two hours is to be expected before the evacuation begins	This is based on the assumptions underlying the NSW Timeline Evacuation Model. This delay, or "lag", is due to two factors: • The Warning Acceptance Factor (WAF), defined as the time required by a member of the public to acknowledge the evacuation order and accept that it applies to them; and • The Warning Lag Factor (WLF), defined as the time required by members of the public to get organised for the evacuation and leave their houses. The NSW SES assumes that the WAF and the WLF will require one hour of time each.
3: Time available in vehicular evacuation scenarios	Evacuation routes are not be cut by floodwaters before vehicular evacuation is completed	Vehicular evacuation, which is herein referred to as "Horizontal Street Level (HSL)", was modelled under the assumption that evacuation routes would not be cut by floodwaters before the evacuation is completed. In other words, vehicular evacuation was considered an "early evacuation option".
4: Evacuees without access to a vehicle	In a vehicular evacuation scenario, people with no access to a car are able to evacuate on foot in a time shorter than the time needed to complete the vehicular evacuation	Evacuees that do not have access to a car would be able to evacuate on foot in a time shorter than the time needed to complete the vehicular evacuation, therefore not impacting on the total evacuation time. This assumption is consistent with the time it would take for a pedestrian to walk from a location adjacent to the river to the nearest land above the reach of the PMF.
5: Vehicular Evacuation Model	• Lane Capacity: 600 cars per lane per hour; • Queue length per car: 6m; • Warning Acceptance Factor: 1 hour; • Warning Lag Factor: 1 hour; • Traffic Safety Factor: 1-3.5 hours depending on the duration of evacuation	These are the NSW SES recommended parameters for the NSW Timeline Evacuation Model, which is the model adopted in this study to simulate vehicular evacuation.
6: Vehicular Evacuation Precincts	Vehicles move away from rivers and creeks; Vehicles would move according to one-way roads	Each building was allocated to an evacuation route by: • Locating each building's driveway; • Assuming that, upon exiting each driveway, vehicles would move away from Parramatta River, Clay Cliff Creek or Brickfield Creek;

		• Assuming that traffic would move according to normal traffic flow direction on roads including one-way roads.
7: Buildings that need to evacuate	Buildings that are “touched” or isolated by floodwaters will need to be evacuated	This may overestimate the number of vehicles or pedestrians who need to evacuate because the extent of flooding in some of these buildings may not be sufficient to require them to be evacuated.
8: Elevated Walkways	In events up to a 20 year ARI, evacuees would be able to reach the elevated walkways using communal stairs and ramps accessible from street level, while in larger events a dedicated building-by-building access would be necessary	In a 20 year ARI flood there would be a relatively small amount of water ponding in the streets when the evacuation begins. This would allow evacuees t reach the access to the elevated walkways (stairs and ramps) from street level. In larger events, the local flooding would have a larger extent and direct access to the elevated walkways would be necessary
9: Pedestrian Evacuation Precincts	Defined based on the narrower bottleneck along the designated evacuation route	Buildings sharing the same bottleneck are assigned to the same pedestrian evacuation precinct. For elevated walkways, the bottleneck is at the end of the walkway. For on street pedestrian evacuation, the bottleneck is the last road before reaching the evacuation refuge.
10: Pedestrian Evacuation Dynamics	Walking speed: 700metres per hours Density: two people per square metre Effective width of elevated walkways: 2m only are used by evacuees	Assumption based on literature (Seyfried et al., 2005)
11: Background Traffic	Vehicular evacuation is modelled under the assumption that there is no background traffic	In a real world day evacuation scenario, vehicular evacuation time would be significantly longer than the one obtained using the NSW Timeline Evacuation Model.
12: Extent of Elevated Walkways	Minimised to contain infrastructure cost and adverse impacts on the urban landscape	This results in the system of elevated walkways catering for the PMF having a larger number of egress points, and an overall smaller evacuation time. Shorter evacuation times in smaller flood events could be achieved by extending the network to increase the number of egress points.

Input data needed to calculate vehicular and pedestrian evacuation time and relevant codes. Each code is described in the following table.

Exit Road	2016	2036	2056
Number of Residents	A1	A2	A3
Number of Workers	B1	B2	B3
Number of Visitors	C1	C2	C3
Residential Car Spaces	D1	D2	D3
Commercial Car Spaces	E1	E2	E3
Visitor Car Spaces	F1	F2	F3

Description of the assumptions made to obtain the input data

Code	Description
A1	**Number of Residents, 2016.** It was agreed with Council that the existing number of residents in each lot could not be obtained by applying current development controls, because these are based on the existing residential FSA, whose exact value is not known to Council (although an approximate estimate is available). Instead, the existing number of residents in each Travel Zone within the study area was extracted from the NSW Bureau of Transport Statistics website. This figure was then allocated to individual lots according the ratio between the lot's estimated existing residential FSA and the total estimated existing residential FSA in the Travel Zone.
A2	**Number of Residents, 2036.** The number of residents in 2036 was obtained by summing the 2016 number of residents and the additional number of residents expected from 2016 to 2036. The number of residents in 2016 was adjusted to account for any change of land zoning from 2016 to 2036. The additional number of residents (from 2016 to 2036) was obtained by applying the development controls to the additional residential FSA for year 2036. Namely: Additional residents = 2.31 per dwelling Number of additional dwellings = [(2/3)*(additional residential FSA)]/100

Code	Description
	Finally, the number obtained was reduced by a factor of 0.75 to account for the expected residential take-up rate from 2016 to 2036.
A3	**Number of Residents, 2056.** The number of residents in 2056 was obtained by summing the 2016 number of residents and the additional number of residents expected from 2016 to 2056. The number of residents in 2016 was adjusted to account for any change of land zoning from 2016 to 2056. The additional number of residents (from 2016 to 2056) was obtained by applying the CBD Strategy development controls to the additional residential FSA for year 2056. Namely: Additional residents = 2.31 per dwelling Number of additional dwellings = [(2/3)*(additional residential FSA)]/100
B1	**Number of Workers, 2016.** It was agreed with Council that the existing number of workers in each lot could not be obtained by using current development controls, because these are based on the existing commercial FSA in each lot, whose exact value is not known to Council (although an approximate estimate is available). Instead, the existing number of workers in each Travel Zone within the study area was extracted from the NSW Bureau of Transport Statistics website. This figure was then allocated to individual lots according to the ratio between the lot's estimated existing commercial FSA and the total commercial FSA in the Travel Zone.
B2	**Number of Workers, 2036.** The number of workers in 2036 was obtained by summing the 2016 number of workers and the additional number of workers expected from 2016 to 2036. The number of workers in 2016 was adjusted to account for any change of land zoning from 2016 to 2036. The additional number of workers (from 2016 to 2036) was obtained by applying the CBD Strategy development controls to the additional commercial FSA for year 2036. Namely: Number of additional workers = [(2/3)*(additional commercial FSA)]/24 Finally, the number obtained was reduced by a factor of 0.65 to account for the expected commercial take-up rate from 2016 to 2036.
B3	**Number of Workers, 2056.** The number of workers in 2056 was obtained by summing the 2016 number of workers and the additional number of workers expected from 2016 to 2056. The number of workers in 2016 was adjusted to account for any change of land zoning from 2016 to 2056. The additional number of workers (from 2016 to 2056) was obtained by applying the CBD Strategy development controls to the additional commercial FSA for year 2056. Namely:

Code	Description
	Number of additional workers = [(2/3)*(additional commercial FSA)]/24
C1	**Number of Visitors, 2016.** The number of visitors in 2016 was deducted from the number of daily Opal tap offs at Parramatta CBD train and bus stations. Namely, it was assumed that the average number of Opal tap offs between 5am and 12pm includes part of the daily visitors and all workers travelling to the CBD by public transport. The number of workers was then calculated by taking 37% of the total number of workers (obtained as described at point B1), based on the mode share estimate provided by the City of Parramatta CBD Strategic Transport Study (AECOM, 2016). The number of visitors arriving between 9am and 12am was then obtained by subtracting 37% of the total workers from the number of Opal tap offs between 5am and 12pm, under the assumptions that visitors would start arriving at 9am. This was divided by 3 (i.e. the number of hours between 9am and 12pm) to obtain the number of visitors arriving every hour. The result was then multiplied by 6 to obtain the number of visitors arriving (by public transport) over a 9 hour-long day, assuming that visitors would remain in the CBD on average for 3 hours, and that no visitors would be arriving after the 6th hour. The figure obtained was then assumed to correspond to 11% of the total number of visitors travelling daily to the CBD, based on the mode share for household trips in the West Central Region proposed by the 2012/2013 Household Travel Survey Report (BTS, 2014). The maximum number of visitors in the CBD at any one time was finally obtained by dividing the daily total number of visitors by 3, based on the assumption that each visitor would remain in the CBD for 3 hours, over a 9-hour long day. Based on guidance provided by the City of Parramatta Council, it was then assumed that 45% of these visitors would be within the Westfield building. The remaining 55% was allocated to each lot according to the lot's commercial FSA. This was based on the assumption that most visitors travel to Parramatta CBD for shopping/commercial/business purpose.
C2 and C3	**Number of Visitors, 2036 and 2056.** The number of visitors in 2036 (and 2056) was obtained from the number of visitors in 2016, assuming that these would increase at the same rate of workers from 2016 to 2036 (and 2056). This was based on the assumption that most visitors travel to Parramatta CBD for shopping/commercial/business purpose. The number obtained was then adjusted to account for the additional number of visitors (i.e. 1 million extra visitors per year) that from year 2022 are expected to travel to the CBD to visit the new Museum of Applied Arts and Sciences (MAAS), as estimated by PWC (2016), in "Parramatta 2021: Unlocking the potential of a new economy".
D1 and E1	**Number of Residential and Commercial Car Spaces, 2016** Private Residential and Commercial Car Spaces A reliable count of the number of existing private car spaces in the CBD is provided by AECOM (2017), in "Technical Paper 03: Parking Review". This number was obtained on

Code	Description
	a block-by-block basis via a survey recently undertaken by the City of Parramatta Council. The document however does not differentiate between commercial and residential car spaces, and does not go down to the scale of individual lots. The figures provided by AECOM (2017) were therefore modified as follows: • Allocated to each cadastre lot within the relevant block, and • Split between residential and commercial car spaces. This was achieved by: 1. Calculating the estimated number of residential and commercial car spaces in each lot based on current development controls. These are: a. For residential car spaces: one space per dwelling. The City of Parramatta Council assumes an average of 2.38 residents per dwelling (in 2016). The estimated number of residential car spaces per lot was then calculated as = (number of residents in the lot)/2.38. b. For commercial car spaces: 1 space every 100 sq.m. of commercial FSA. Commercial FSA values for 2016 were available for each lot, however it was agreed with Council that this value was not reliable for year 2016. A reliable value of commercial FSA was then obtained from the number of workers in each lot, using the assumption that there is 1 worker every 24 sq.m. of "effective" commercial FSA. Council assumes that the "effective" portion of commercial FSA is 2/3. This resulted in the following equation: (Estimated commercial car spaces in 2016) = 0.36 * (number of workers in 2016) 2. It was then observed that the estimated number of car spaces (residential and commercial) obtained as described at point 1 exceeded the availability of car spaces in each block surveyed by AECOM (2017). Council advised that this is due to previous development controls that would have applied to the older buildings of the CBD when these were originally constructed. To overcome this discrepancy, the number of residential and commercial car spaces in each lot calculated at point 1 was "scaled down" using to the ratio between the estimated number of car spaces within each block (obtained as described at point 1) and the actual number of car spaces within each block (obtained from AECOM, 2017). Public Commercial Car Spaces The City of Parramatta Council provided an estimate of the average number of car spaces used by workers in each of the publicly accessible car parks within the CBD. These are: • Wentworth Street (1,163 car spaces): 80% allocated to commercial use • Horwood Place (558 car spaces):40% allocated to commercial use • Riverside (805 car spaces): 40% allocated to commercial use It should be noted that Westfield is omitted on purpose because not significantly affected by flooding.

Code	Description
D2 and D3	**Number of Residential Car Spaces, 2036 and 2056** Based on guidance from the City of Parramatta Council, it was assumed that in 2036 (and 2056) there will be 0.28 additional residential car spaces per additional resident. The number of residents in each lot was adjusted to account for any change of land zoning from 2016 to 2036 (and to 2056).
E2 and E3	**Number of Commercial Car Spaces, 2036 and 2056** The total number of commercial car spaces in 2036 (and 2056) was obtained by applying the new development controls. These allow one commercial car space every 50 sq.m. of commercial site area. The new controls were applied to the whole CBD but in the Western Corridor, which is not included in the Planning Proposal. For this area the existing development controls were used (i.e. 1 commercial car space every 100 sq.m. of commercial FSA). It was also assumed that the number of commercial car spaces in publicly accessible car parks within the CBD would not change in future scenarios.

F1	**Number of Visitors Car Spaces, 2016.**
	Based on guidance from the City of Parramatta Council, it was assumed that the car spaces available to visitors would include:
	• All on-street car spaces
	• The remainder of the car spaces in the publicly-accessible car parks within the CBD, namely:
	  ○ Wentworth Street (1,163 car spaces): 20% allocated to commercial use
	  ○ Horwood Place (558 car spaces):60% allocated to commercial use
	  ○ Riverside (805 car spaces): 60% allocated to commercial use
	It should be noted that Westfield is omitted on purpose because not significantly affected by flooding.

F2 and F3	**Number of Visitors Car Spaces, 2036 and 2056** Based on guidance from the City of Parramatta Council, this was assumed to be the same as in 2016.

APPENDIX B – EVACUATION MODELLING RESULTS

Scenario 1 – 2016_20yr_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	215	3	1	1	0.1	1	**3.1**
Great Western Hwy	8222	3	1	1	4.6	1.5	**8.1**
Harris St	132	1	1	1	0.2	1	**3.2**
Pennant Hills Rd	978	2	1	1	0.8	1	**3.8**
Victoria Rd	14	3	1	1	0	1	**3**

Scenario 2 - 2016_20yr_Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	6383	1	1	1	2.3	**4.3**
Civic Link	13814	2	1	1	2.5	**4.5**

Scenario 3 – 2016_100yr_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	258	3	1	1	0.1	1	**3.1**
Great Western Hwy	9932	3	1	1	5.5	1.5	**9.0**
Harris St	156	1	1	1	0.3	1	**3.3**
Pennant Hills Rd	1003	2	1	1	0.8	1	**3.8**
Victoria Rd	14	3	1	1	0	1	**3**

Scenario 4 - 2016_100yr_ Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	10236	2	1	1	1.8	**3.8**
Macquarie St	6241	1	1	1	2.2	**4.2**
Civic Link	18142	2	1	1	3.2	**5.2**

Scenario 5 – 2016_PMF_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	501	3	1	1	0.3	1	**3.3**
Great Western Hwy	12023	3	1	1	6.7	2	**10.7**
Harris St	217	1	1	1	0.4	1	**3.4**
Pennant Hills Rd	1520	2	1	1	1.3	1	**4.3**
Victoria Rd	25	3	1	1	0	1	**3**

Scenario 6 - 2016_PMF_Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
CBD Core to Westfield	53699	8	1	1	2.4	**4.4**
Church Street heading North	5697	2	1	1	1	**3**

Scenario 7 - 2016_PMF_Midday_Mixed Evacuation (Vehicular Part)

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	624	3	1	1	0.3	1	**3.3**
Great Western Hwy	4704	3	1	1	2.6	1	**5.6**
Harris St	214	1	1	1	0.4	1	**3.4**
Pennant Hills Rd	903	2	1	1	0.8	1	**3.8**
Victoria Rd	82	3	1	1	0	1	**3**

Scenario 7 - 2016_PMF_Midday_HHL (Pedestrian Part)

Elevated Walkway	Workers + Visitors	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	6692	1	1	2.39	**4.39**
Civic Link	14205	1	1	2.5	**4.5**
Hassal St	453	1	1	0.25	**2.25**
Church St	597	1	1	0.53	**2.53**

Scenario 8 – 2016_PMF_AllCars_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	1463	3	1	1	0.8	1	**3.8**
Great Western Hwy	14048	3	1	1	7.8	2	**11.8**
Harris St	627	1	1	1	1	1	**4**
Pennant Hills Rd	2606	2	1	1	2.2	1	**5.2**
Victoria Rd	255	3	1	1	0.1	1	**3.1**

Scenario 9 – 2036_20yr_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	558	3	1	1	0.3	1	**3.3**
Great Western Hwy	9407	3	1	1	5.2	1.5	**8.7**
Harris St	65	1	1	1	0.1	1	**3.1**
Pennant Hills Rd	1044	2	1	1	0.9	1	**3.9**
Victoria Rd	17	3	1	1	0	1	**3**

Scenario 10 - 2036_ 20yr_ Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	11335	1	1	1	4	**6**
Civic Link	29751	2	1	1	5.3	**7.3**

Scenario 11 – 2036_100yr_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	601	3	1	1	0.3	1	**3.3**
Great Western Hwy	10698	3	1	1	5.9	1.5	**9.4**
Harris St	124	1	1	1	0.2	1	**3.2**
Pennant Hills Rd	1086	2	1	1	0.9	1	**3.9**
Victoria Rd	17	3	1	1	0	1	**3**

Scenario 12 - 2036_100yr_Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	18384	2	1	1	3.3	**5.3**
Macquarie St	10302	1	1	1	3.7	**5.7**
Civic Link	38813	2	1	1	6.9	**8.9**

Scenario 13 – 2036_PMF_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	1053	3	1	1	0.6	1	**3.6**
Great Western Hwy	12292	3	1	1	6.8	2	**10.8**
Harris St	307	1	1	1	0.5	1	**3.5**
Pennant Hills Rd	1722	2	1	1	1.4	1	**4.4**
Victoria Rd	28	3	1	1	0	1	**3**

Scenario 14 - 2036_PMF_Midday_HHL

Exit Road	No.of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
CBD Core to Westfield	108368	8	1	1	4.8	**6.8**
Church Street heading North	4361	2	1	1	0.8	**2.8**

Scenario 15 – 2056_20yr_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	388	3	1	1	0.2	1	**3.2**
Great Western Hwy	9667	3	1	1	5.4	1.5	**8.9**
Harris St	69	1	1	1	0	1	**3**
Pennant Hills Rd	937	2	1	1	0.5	1	**3.5**
Victoria Rd	17	3	1	1	0	1	**3**

Scenario 16 – 2056_20yr_Midnight_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	600	3	1	1	0.3	1	**3.3**
Great Western Hwy	6950	3	1	1	3.9	1.5	**7.4**
Harris St	562	1	1	1	0.3	1	**3.3**
Pennant Hills Rd	1373	2	1	1	0.8	1	**3.8**
Victoria Rd	191	3	1	1	0.1	1	**3.1**

Scenario 17 - 2056_20yr_ Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	12959	1	1	1	4.7	**6.7**
Civic Link	39759	2	1	1	7.1	**9.1**

Scenario 18 – 2056_100yr_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	404	3	1	1	0.2	1	**3.2**
Great Western Hwy	10218	3	1	1	6.1	1.5	**9.6**
Harris St	93	1	1	1	0.1	1	**3.1**
Pennant Hills Rd	980	2	1	1	0.5	1	**3.5**
Victoria Rd	17	3	1	1	0	1	**3**

Scenario 19 – 2056_100yr_Midnight_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	778	3	1	1	0.4	1	**3.4**
Great Western Hwy	9751	3	1	1	5.4	1.5	**8.9**
Harris St	618	1	1	1	0.3	1	**3.3**
Pennant Hills Rd	1400	2	1	1	0.8	1	**3.8**
Victoria Rd	226	3	1	1	0.1	1	**3.1**

Scenario 20 - 2056_100yr_Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	21810	2	1	1	3.9	**5.9**
Macquarie St	11669	1	1	1	4.2	**6.2**
Civic Link	51342	2	1	1	9.2	**11.2**

Scenario 21 – 2056_PMF_Midnight_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	1444	3	1	1	0.8	1	**3.8**
Great Western Hwy	11246	3	1	1	6.2	1.5	**9.7**
Harris St	944	1	1	1	0.5	1	**3.5**
Pennant Hills Rd	2213	2	1	1	1.2	1	**4.2**
Victoria Rd	276	3	1	1	0.2	1	**3.2**

Scenario 22 - 2056_PMF_Midday_HHL

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
CBD Core to Westfield	131071	8	1	1	5.9	**7.9**
Church Street heading North	5393	2	1	1	1	**3**

Scenario 23 - 2056_PMF_Midday_Mixed Evacuation (Vehicular Part)

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	712	3	1	1	0.4	1	**3.4**
Great Western Hwy	3626	3	1	1	2	1	**5**
Harris St	184	1	1	1	0.1	1	**3.1**
Pennant Hills Rd	894	2	1	1	0.5	1	**3.5**
Victoria Rd	82	3	1	1	0	1	**3**

Scenario 23 - 2056_20Yr_Midday_HHL (Pedestrian Part)

Exit Road	No. of Workers + Visitors	No. of Lanes	WAF	WLF	Walkway Clearance Time (Travel Time)	Evac Time
Marsden St	12959	1	1	1	4.6	**6.6**
Civic Link	39759	2	1	1	7.1	**9.1**

Scenario 24 – 2056_PMF_Midday_HSL

Exit Road	Cars	Lanes	WAF	WLF	Travel Time	TSF	Evac Time
Church St	790	3	1	1	0.4	1	**3.4**
Great Western Hwy	12677	3	1	1	7	2	**11**
Harris St	189	1	1	1	0.1	1	**3.1**
Pennant Hills Rd	1509	2	1	1	0.8	1	**3.8**
Victoria Rd	28	3	1	1	0	1	**3**

APPENDIX C – HIGH LEVEL EVACUATION ROUTE CONCEPT DESIGN

Flood Evacuation Assessment for the Parramatta CBD

HIGH LEVEL EVACUATION ROUTE
CONCEPT DESIGN

Final Report

Issued 06 September 2017

Prepared for Molino Stewart and City of Parramatta Council

by Studio GL

Document Information

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Client	Molino Stewart
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01 INTRODUCTION

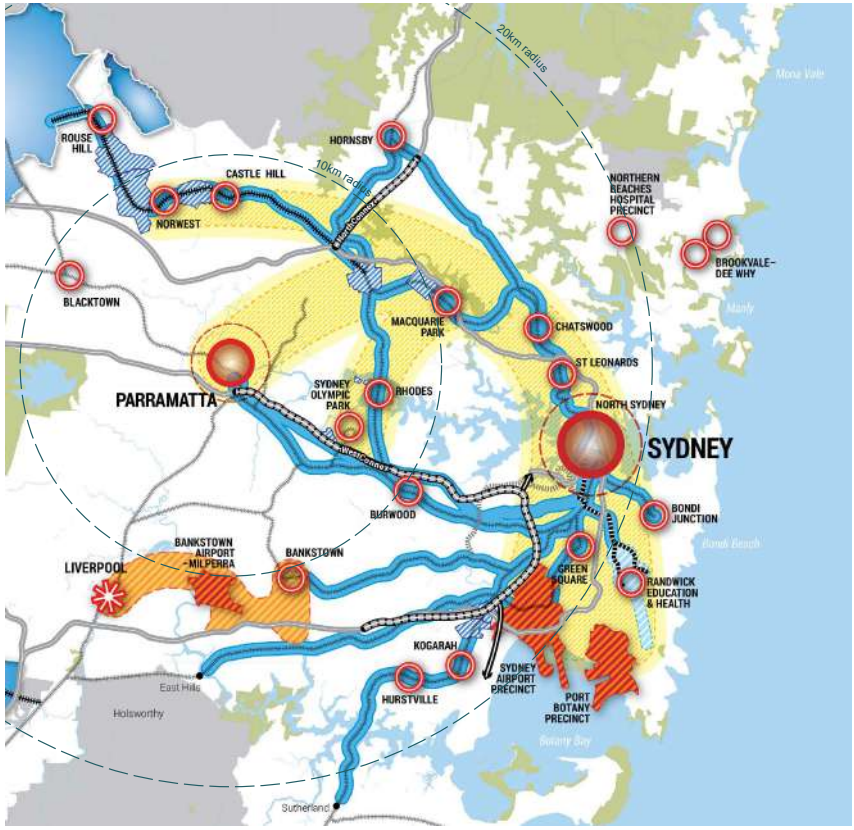


Figure 1 Metropolitan context diagram
(Source: A Plan For Growing Sydney, 2014)

1-1 Background

Parramatta CBD is of metropolitan importance, and in recognition of it's growing role council commissioned a number of studies to identify how the City of Parramatta can develop.

The result of these studies informed a planning proposal to allow additional employment opportunities supported by high density residential development.

As part of this process a draft update of the Parramatta Floodplain Risk Management Plans (2016) was produced by Molino Stewart. The report described how large parts of the Parramatta CBD would be affected by overbank flooding of the Parramatta River, and by flooding due to local overland flows.

One of the key findings of the report is that there is not sufficient advance warning of a major flood to enable evacuation of large parts of the CBD, and therefore for these areas, 'shelter in place' or 'flood free evacuation routes' need to be considered.

Adopting some or all of the recommendations within the Molino Stewart Report would require the imposition of some controls above the flood planning level. This is currently prohibited by state government for residential properties unless 'exceptional circumstances' can be demonstrated.

01 INTRODUCTION

1-2 Flood Evacuation Feasibility Assessment

Council has commissioned a team of consultants lead by Molino Stewart to undertake a Flood Evacuation Feasibility Assessment. The aim of the assessment is to estimate the ability of people within the Parramatta CBD to safely evacuate during a flood event, both now and in the future, when it is predicted there will be higher resident, employee and visitor populations.

The project will assess the benefits and risks of three approaches to evacuation to flood free areas:

- Street Level Evacuation
- Vertical Evacuation (shelter in place)
- Horizontal Evacuation (high level)

The overall purpose of the study is to:

- Help the council identify and understand the long term implications of preferred evacuation strategies.
- To inform a potential application for 'exceptional circumstances'
- To inform further discussions with the NSW State Emergency Services (SES) and Office of Environment and Heritage (OEH).

1-3 Scope of this Document

The scope of this document is

- to provide strategic analysis of potential urban design implications of a high level horizontal evacuation system, and
- to provide a preliminary concept design for a high level evacuation route.

Figure 2 Study Area, Aerial Map

02 KEY ASSUMPTIONS

2-1 Scope of Concept Design

The proposed concept route design is based on the assumption of providing flood free evacuation routes during a 20 year ARI flood event. The proposed design and concept elements have the potential to be scaled to provide flood free evacuation routes during a 100 year ARI flood event and during a probable maximum flood (PMF)

2-2 Access Points

Further to discussions with Molino Stewart, no direct connection between the high level evacuation route and the upper levels of existing buildings has been assumed for the 20 year ARI concept design. Direct connection between the evacuation route and the upper levels of existing buildings would be required if the concept design were scaled for 100 year ARI and PMF events. A high level building access concept design is shown in section 9-1.

To provide a fully accessible system, ramps and stairs have been proposed to access the walkway, and it is assumed these will be accessed when the road is not yet in flood. Lifts have not been proposed due to the potential interruption of power supply during a flood event.

The location of ramps and stairs is based on the assumption of providing access at key intersections, and at regular intervals between these points. These locations are indicative only as detailed design would be required to determine an accurate location.

2-3 Walkway Width

The width of the high level walkway is proposed to be 2.5m. No modelling of evacuation numbers has been undertaken, and the suitability of this width to provide a safe evacuation route has not been assessed.

2-3 Fixed System

A fixed system of walkways has been proposed. To accommodate vehicle traffic within the CBD, and avoid level changes to the walkway when crossing roads, a height to the underside of the walkway has been established at 4.5m.

2-4 Cover to Walkways

No cover has been proposed to the walkways. Covered walkways would provide protection from adverse weather and could encourage use of the system in a flood event, however they would have a significant detrimental effect on visual impact and overshadowing.

2-5 Flood Doors

No internal routes between buildings have been considered as part of this concept design. It is noted that internal flood escape routes could be feasible if redeveloping a number of adjacent buildings simultaneously, however providing internal escape routes via adjoining properties presents a number of issues, including differing internal floor levels, differing uses and floor layouts (e.g office to residential) , building management, fire evacuation and protection measures, and security.

2-3 Street Width

Typical street widths within the CBD have been measured from a cadastre to provide a number of typical street typologies. Footpath and carriageway widths were estimated from street photographs.

Examples of high level walkways

03 OBSERVATIONS - COMMENTS - CONCERNS

3-1 Public Use

It is proposed that the elevated walkway is accessed by ramp and stair from street level, prior to the road becoming flooded. We would question whether members of the public would walk to the nearest stair/ ramp access point, and use an elevated escape route if their street is yet to flood.

3-2 Walkway Width

It is our understanding that the proposed high level walkway will be unmanaged, and open to public access. Figures have not yet been provided for the number of people (current and potential) required to be evacuated via the route, however the proposed routes detailed in section 4 show that the walkways will encompass a number of city blocks, and it is likely thousands of people will be concentrated on routes crossing Macquarie St, and Hunter St.

3-3 Location of Ramps

Stairs and ramps need to be located at regular intervals to provide access to the high level walkway. A large length of ramp is required to ascend 4.8m (4.5m + structural allowance). A 1.5m wide ramp produces a footprint of 21x3m, which has a significant impact on the street layout. Where side streets without walkways cannot be used to locate ramps, the ramp may result in the loss of parking and/or a traffic lane, as well as resulting in a narrower footpath. (fig 3+4).

3-4 Visual Impact

Providing an elevated walkway will significantly affect the character of the CBD, as the supporting columns, walkway deck, stairs and ramps will be prominent features within the street scene. Whilst attractive design and detailing can help create a feature of the infrastructure, its impact will still be significant.

3-5 Daily Use

Roads within the CBD accommodate 2-4 lanes of traffic and there are pedestrian crossings at frequent intersections, therefore it is unlikely that any future walkway will be used to cross the road when it requires ascending 4.8m. This may lead to issues with how the walkways are used on a day to day basis, and whether they become appropriated for inappropriate uses: e.g graffiti/ rough sleeping/ drug use.

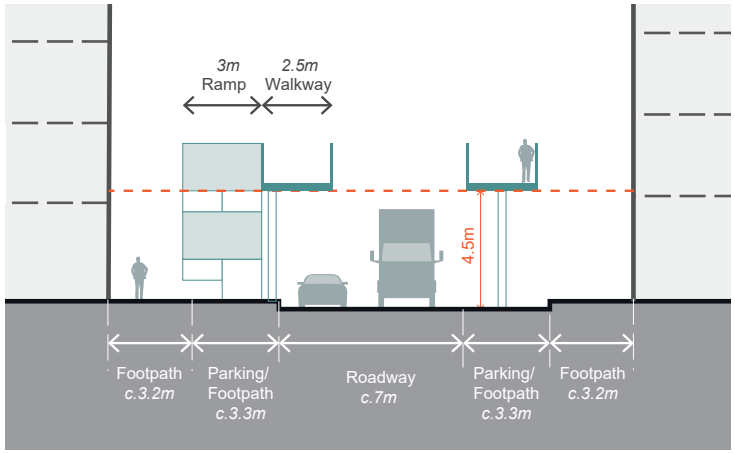


Figure 3 Typical ramp location section

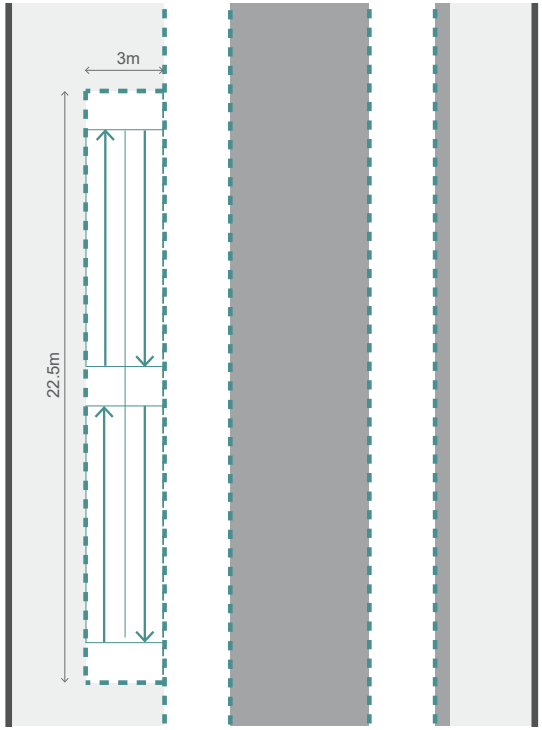


Figure 4 Typical ramp location plan

03 OBSERVATIONS - COMMENTS - CONCERNS

3-6 Overshadowing

Providing an elevated walkway will result in significant overshadowing of the public realm, and ground floor units (fig 5+6). Where taller buildings already shade the street, walkways will still reduce light-levels due to blocking ambient and reflected light. The level of overshadowing is dependant on the walkways width and height, the design of the balustrades also impacts overshadowing.

3-7 Street Trees

There are a large number of street trees within the CBD. In order to accommodate an independent high level walkway a number of these would have to be removed, especially on roads with walkways on both sides. Whilst lower level planting could be introduced beneath or adjacent to the walkways, the loss of mature street trees results in a harsher urban environment.

3-8 Building Levels

If buildings directly connect to the high level walkway in the future ramped access may be required. The proposed walkway height is at approx. 4.8m above road level, which will be significantly above 1st floor level for most buildings. The height of the walkway would compromise windows at the upper levels.

3-9 Deployable Bridges

Proposing a lower height of walkway with temporary deployable bridges to span roads could make it impossible to accommodate fixed walkways over parking bays and traffic lanes. Temporary deployable bridges could also result in a higher risk due to the time and management required in deploying temporary structures.

3-10 Maintenance

The walkways, support structures, ramps, and stairs will require maintenance to ensure they remain safe do not visually deteriorate. This maintenance cost may be significant, especially when it is considered that the structures are unlikely to be in use for decades.

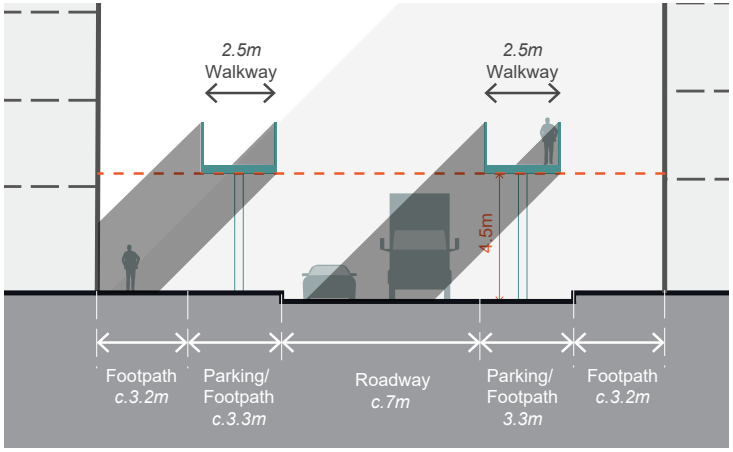


Figure 5 Overshadowing Section Diagram

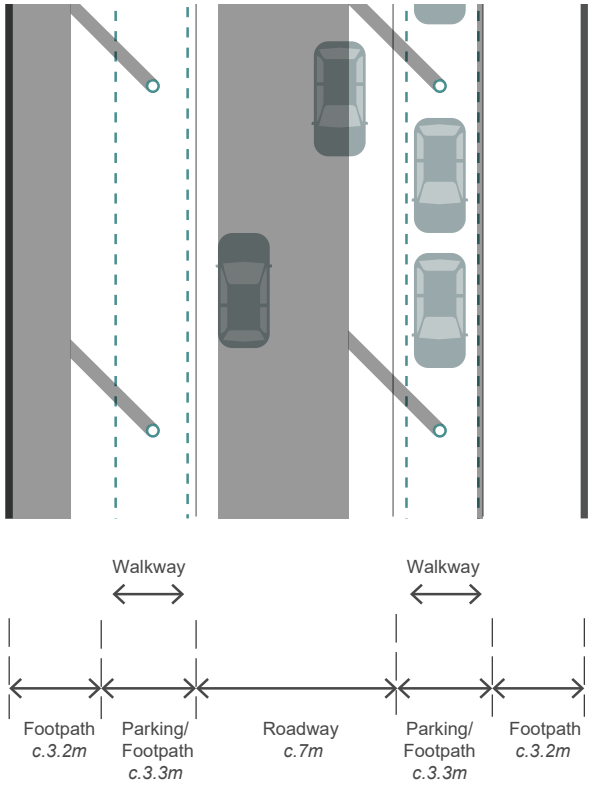
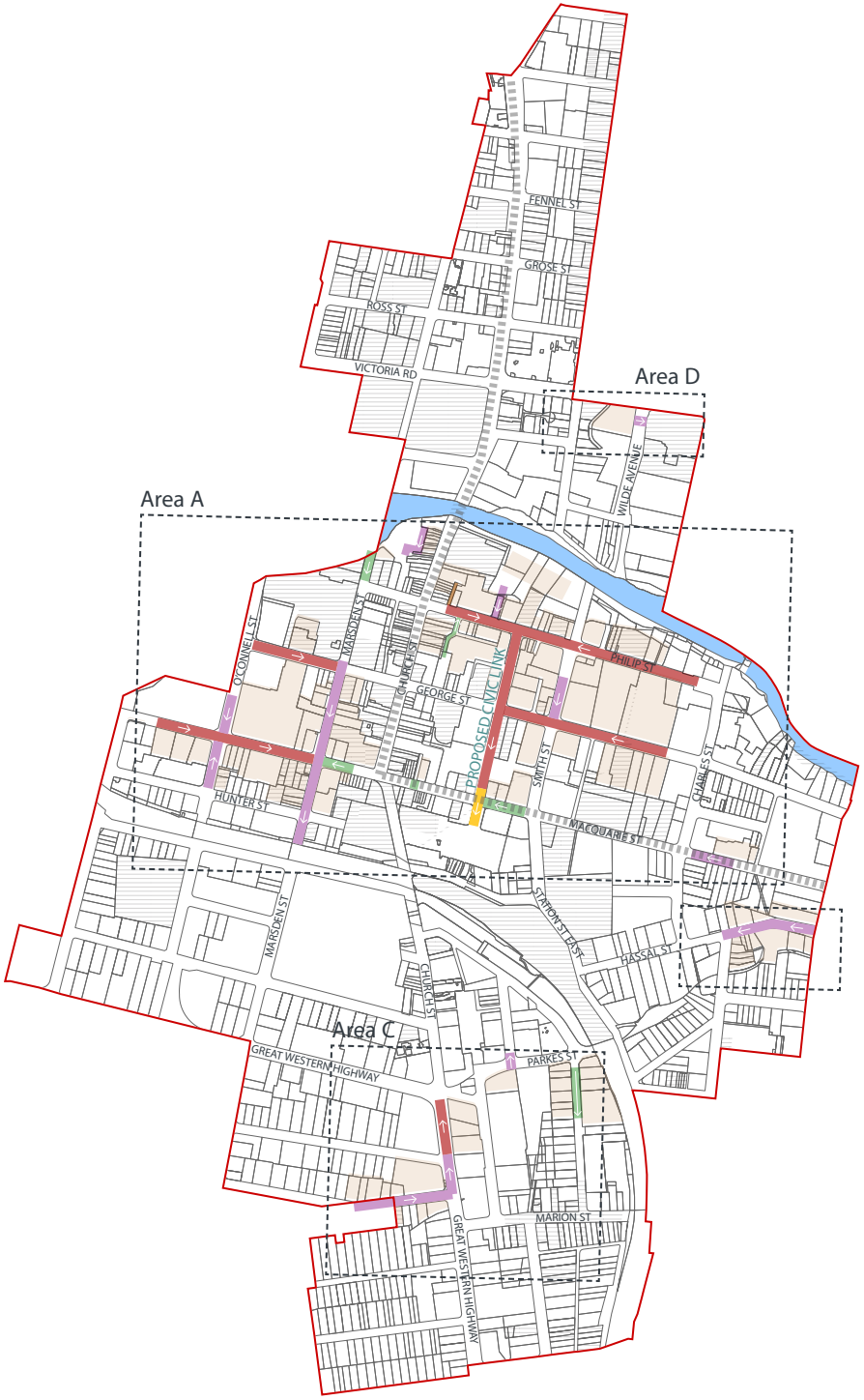


Figure 6 Overshadowing Plan Diagram

4-1 Overview



Walkway Typology 1 (walkways both sides of street)

Walkway Typology 2 (walkways one side of street)

Walkway Typology 3 (walkways one side of street, cantilevered)

Walkway Typology 4 (access street, walkway bridges street)

Walkway Typology 5 (8m height walkway above light rail)

Buildings requiring high level evacuation in a 20 year ARI flood event.

Heritage Items

Preferred Light rail route

Note: Evacuation r
on information prov
Molino Stewart.

Figure 7 Propose

04 EVACUATION ROUTE MAPPING

4-2 Evacuation Route Area A

Area A	
Walkway Typology 1 *(walkway both sides of street)*	1,550m
Walkway Typology 2 *(walkway one side of street)*	800m
Walkway Typology 3 *(walkway one side of street cantilevered)*	300m
Walkway Typology 4 *(access street, walkway bridges street)*	45m
Walkway Typology 5 *(8m height walkway above light rail)*	70m
Total Walkway Length	**2,765m**

Stairs (S)	29
Ramps (R)	36

Key

- Buildings requiring high level evacuation in a 20 year ARI flood event.
- Heritage items
- (C) Junction Type *(detailed in section 6-1)*
- Preferred Light Rail route

Note: Evacuation routes based on information provided by Molino Stewart. Location of ramps and stairs is indicative only. Provided for pricing.

* For walkway options relating to the proposed civic link see work undertaken by other consultants.

Figure 8 Proposed evacuation route map Area A

4-3 Evacuation Route Area B

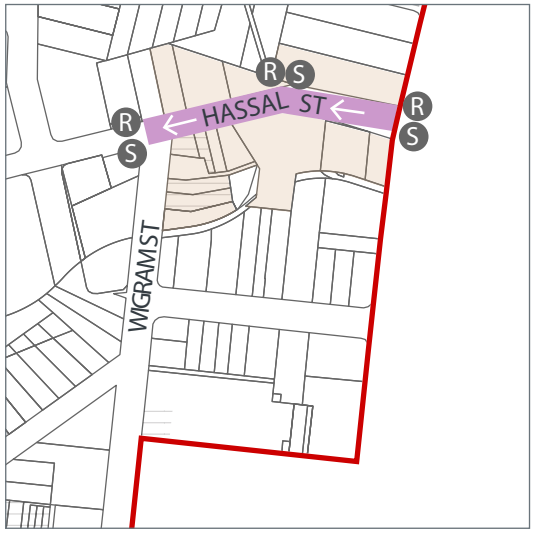


Figure 9 Proposed evacuation route map

Area B	
Walkway Typology 2 *(walkway one side of street)*	170m
Total Walkway Length	170m

Stairs	S	3
Ramps	R	3

4-4 Evacuation Route Area C

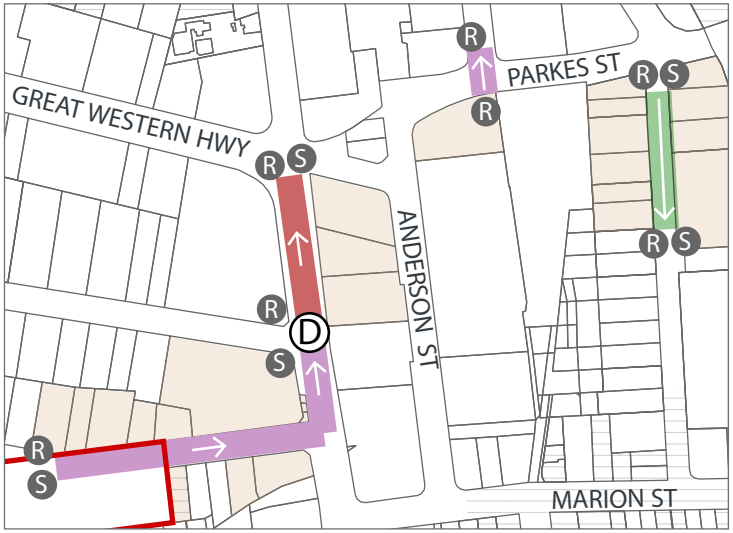


Figure 10 Proposed evacuation route map

Area C	
Walkway Typology 1 *(walkway both sides of street)*	100m
Walkway Typology 2 *(walkway one side of street)*	290m
Walkway Typology 3 *(walkway one side of street cantilevered)*	90m
Total Walkway Length	**480m**

Stairs	S	5
Ramps	R	7

4-5 Evacuation Route Area D

Figure 11 Proposed evacuation route map

Area D	
Walkway Typology 2 *(walkway one side of street)*	25m
Total Walkway Length	25m

Stairs	S	0
Ramps	R	2

Note: Evacuation routes based on information provided by Molino Stewart. Location of ramps and stairs is indicative only. Provided for pricing.

4-6 Evacuation Walkway Schedule

The table below summarises the total lengths of different walkway typologies, and stair and ramp units, proposed in the concept design for providing flood free evacuation routes during a 20 year ARI flood event.

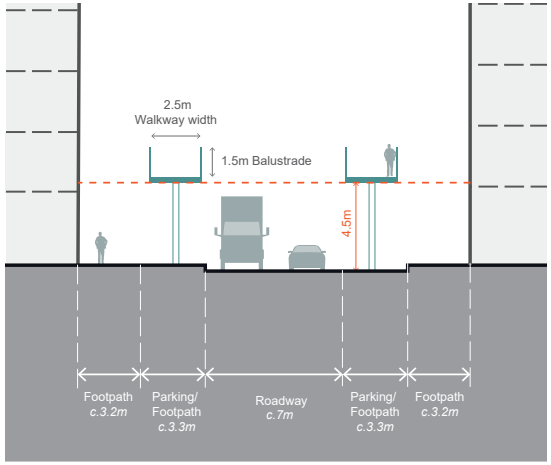
Totals	
Walkway Typology 1 *(walkway both sides of street)*	1,650m
Walkway Typology 2 *(walkway one side of street)*	1,285m
Walkway Typology 3 *(walkway one side of street cantilevered)*	390m
Walkway Typology 4 *(access street, walkway bridges street)*	45m
Walkway Typology 5 *(8m height walkway above light rail)*	70m
Total Walkway Length	3,440m

Stairs (S)	37
Ramps (R)	48

Note: Approximate length of walkway, only provided for costing.

05 ELEVATED WALKWAY TYPOLOGIES

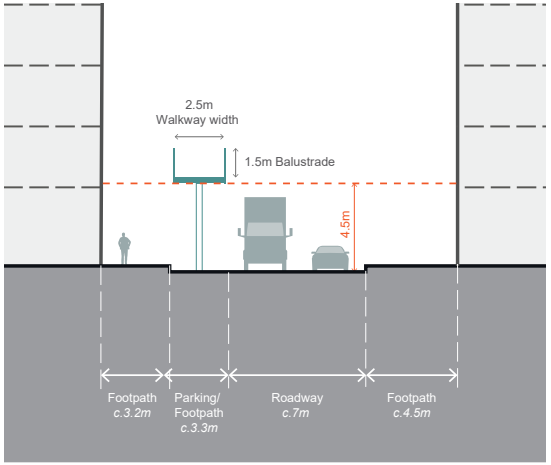
5-1 Walkway typology 1



Walkway typology 1
(walkways both sides of street)

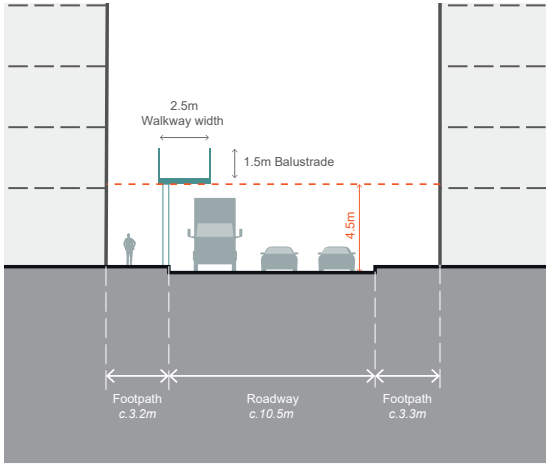
Note: This information is provided for pricing only.

5-2 Walkway typology 2



Walkway typology 2
(walkways one side of street)

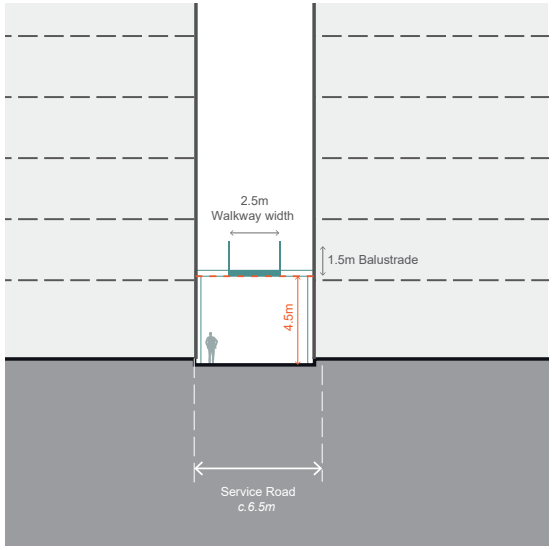
5-3 Walkway typology 3



Walkway typology 3
(walkways one side of street, cantilevered)

05 ELEVATED WALKWAY TYPOLOGIES

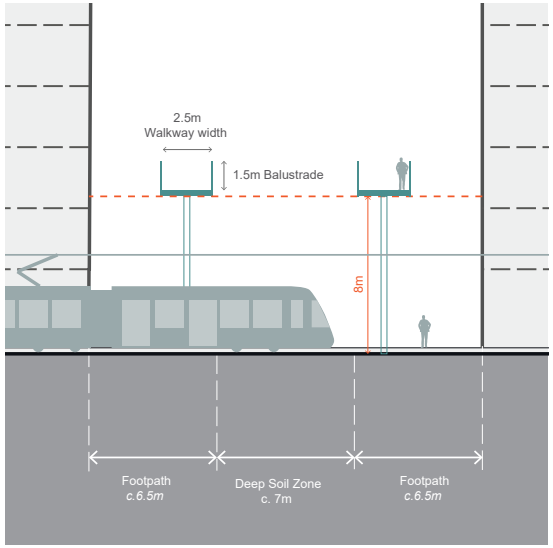
5-4 Walkway typology 4



Walkway typology 4
(Access street, walkway bridges street)

Note: This information is provided for pricing only.

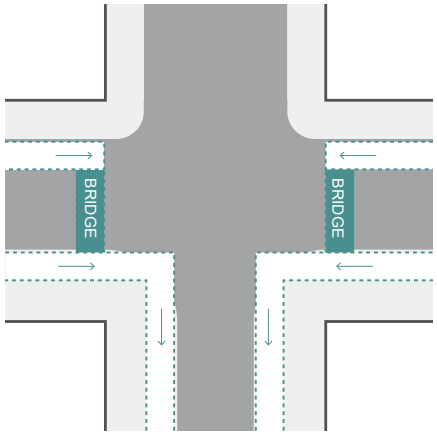
5-5 Walkway typology 5



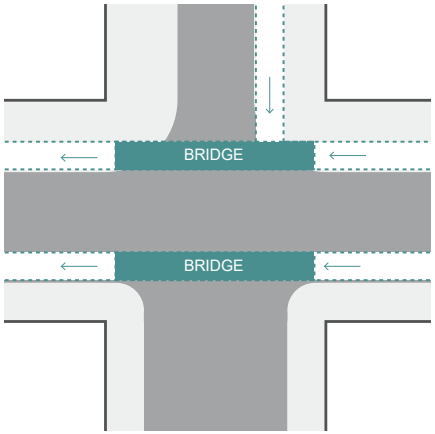
Walkway typology 5
(8m height walkway above light rail)

06 ELEVATED WALKWAY JUNCTION TYPES

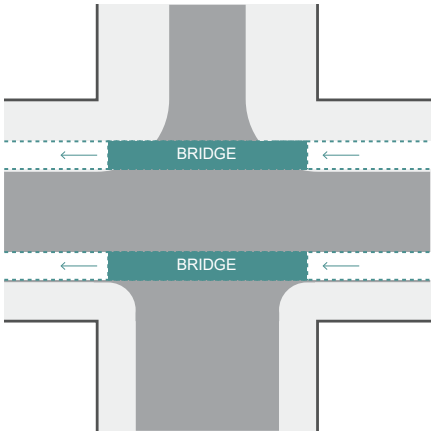
6-1 Junction types



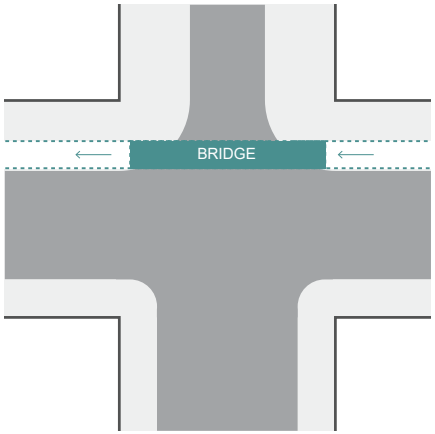
Junction Type A



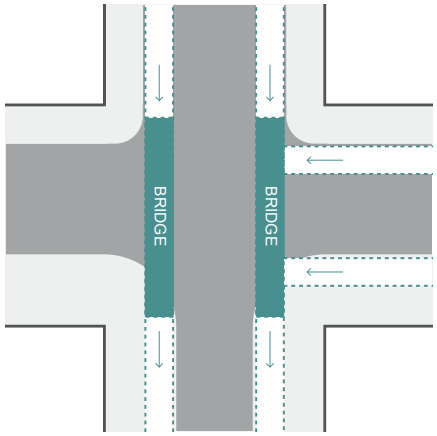
Junction Type B



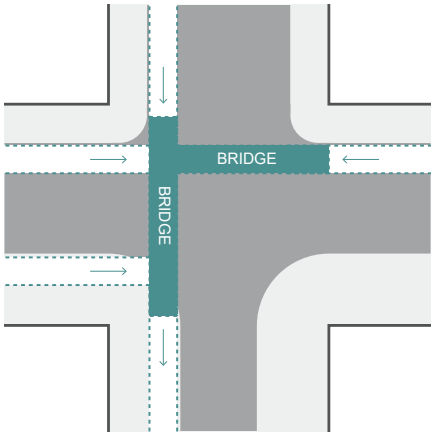
Junction Type C



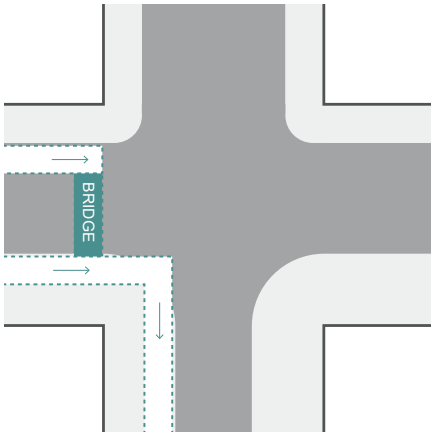
Junction Type D



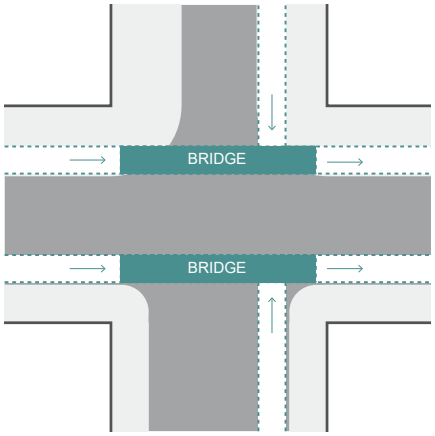
Junction Type E



Junction Type F



Junction Type G



Junction Type H

Note: This information is provided for pricing only.

07 TYPICAL RAMP/ STAIR ACCESS

7-1 Typical design

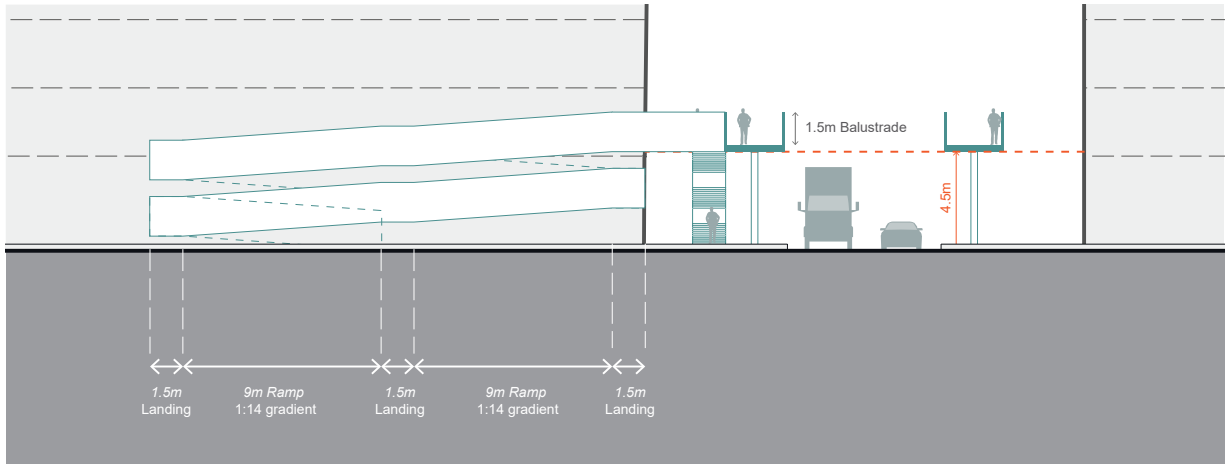


Figure 12 Typical ramp elevation

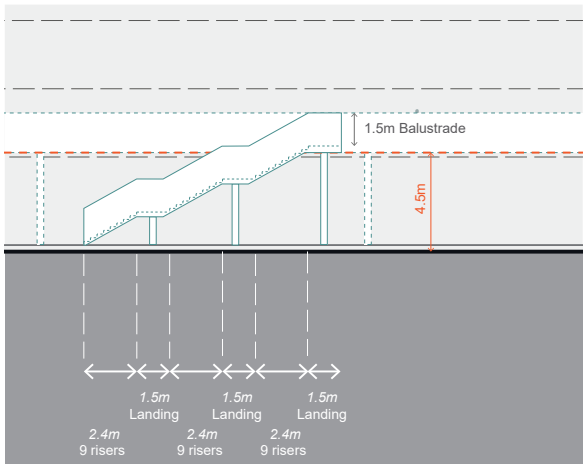


Figure 13 Typical stair elevation

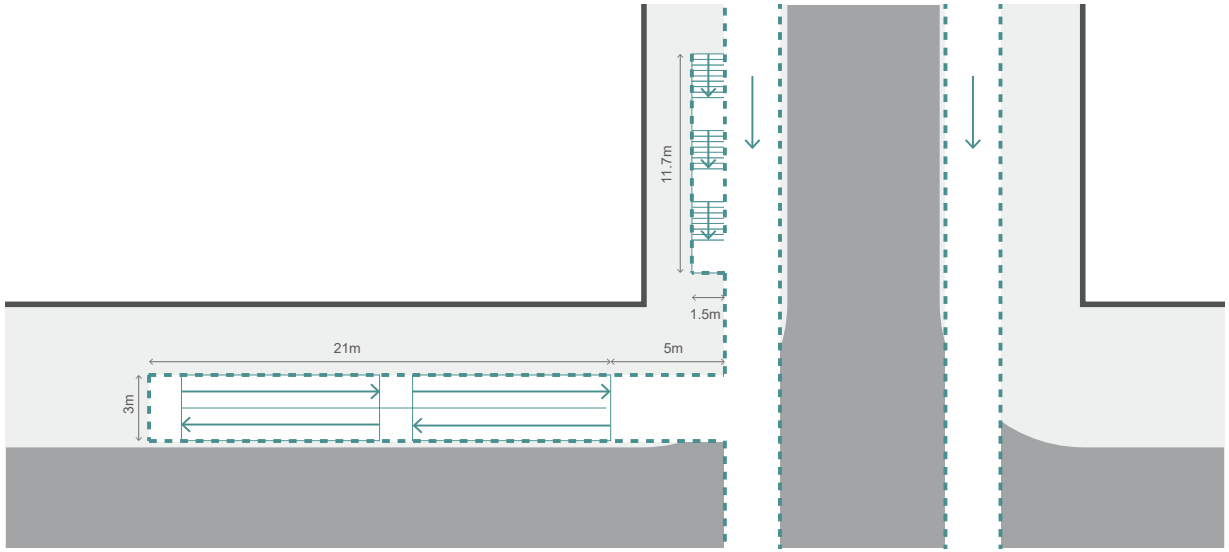


Figure 14 Typical plan

Note: This information is provided for pricing only.

08 CONCEPT WALKWAY CONSTRUCTION

8-1 Concept drawings

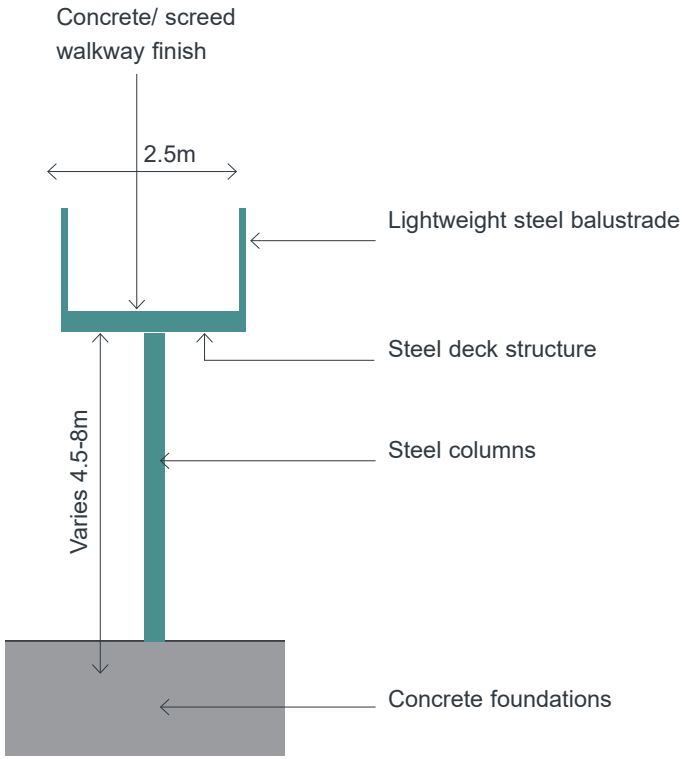


Figure 15 Typical walkway section

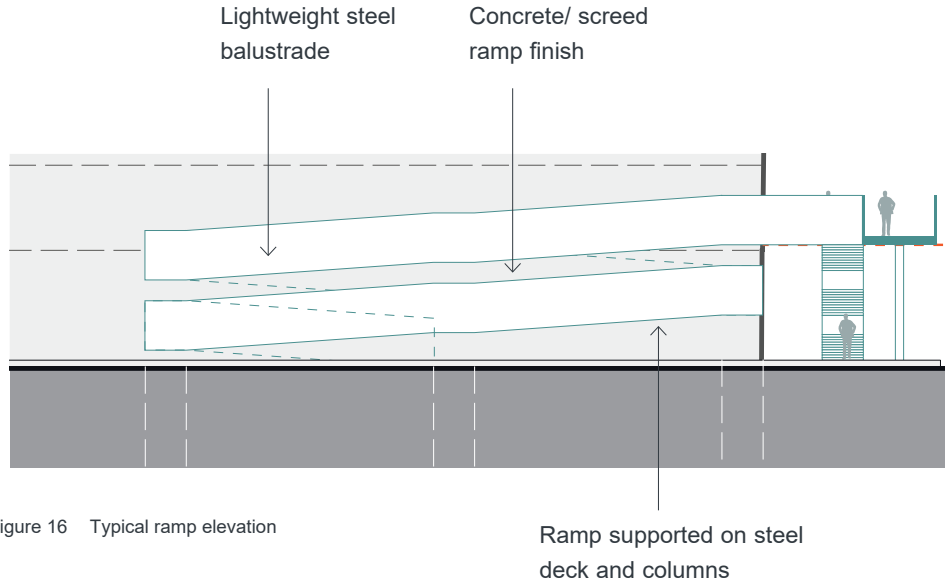


Figure 16 Typical ramp elevation

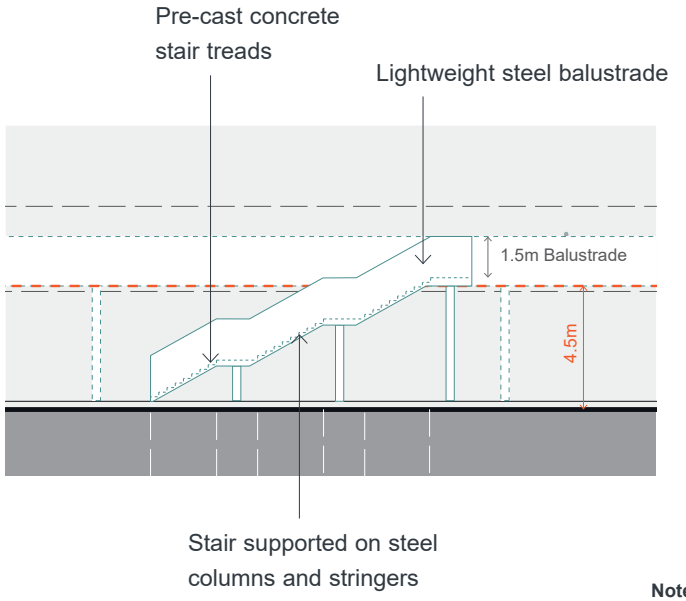


Figure 17 Typical stair elevation

Note: This information is provided for pricing only.

09 100 YEAR ARI FLOOD & PMF

9-1 Concept Design Elements

During a 100 year ARI or PMF event Molino Stewart have advised that direct access may be required from the upper levels of buildings to the high level walkway. Additionally the flood depths in a limited number of locations near the Parramatta River may exceed the 4.5m height of the proposed walkway system, during a PMF event. Concept designs for high level building access, and higher level walkway infrastructure are provided opposite and on the following page.

Providing direct access from buildings to the walkway at high level, in addition to increasing the size of the walkway network, will significantly increase many of the impacts discussed in section 3. Specifically the negative visual impact, and overshadowing created by the system will be increased through the enlarged network affecting the character and amenity of a wider area. These impacts will also be intensified by the increase in structure required for direct building access.

9-2 High Level Building Access Concept Design

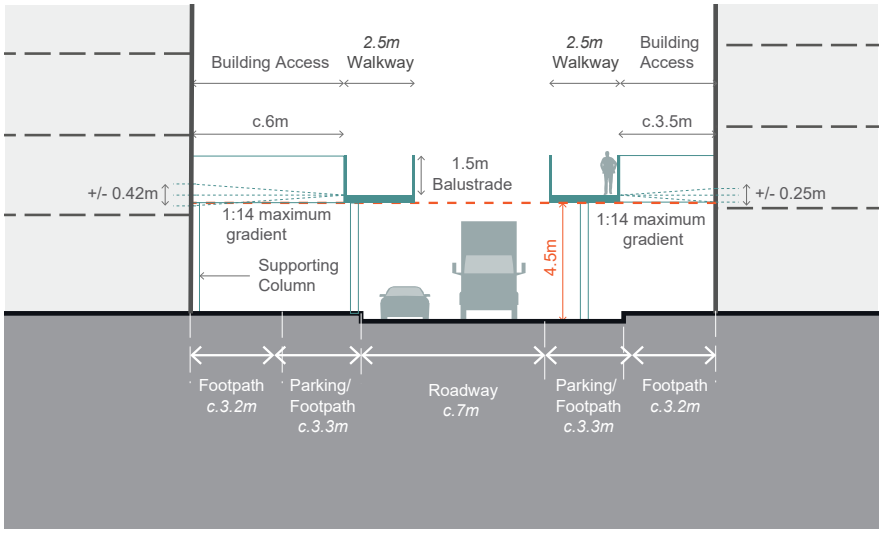


Figure 18 Typical High Level Building Access Arrangement

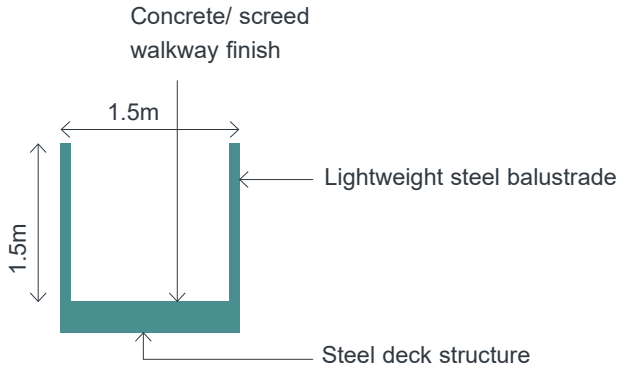


Figure 19 Typical Building Access Section

9-3 Higher Level Walkway Concept Design

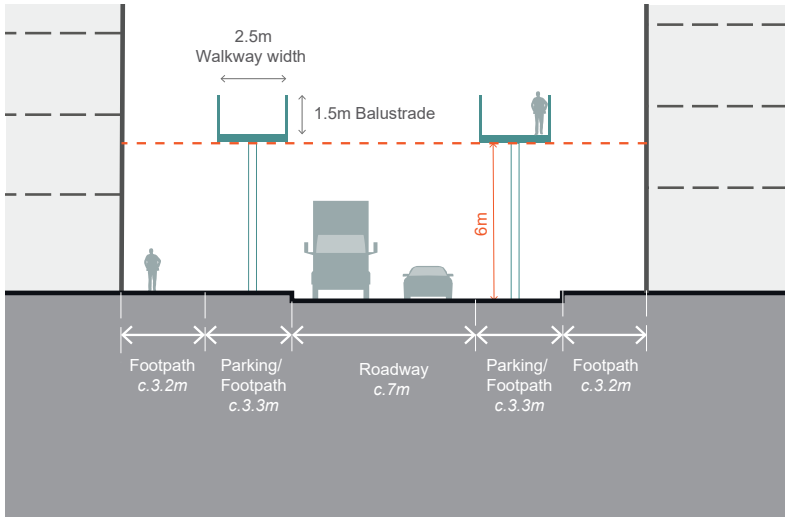


Figure 20 Walkway Typology 6 (6m height walkway)

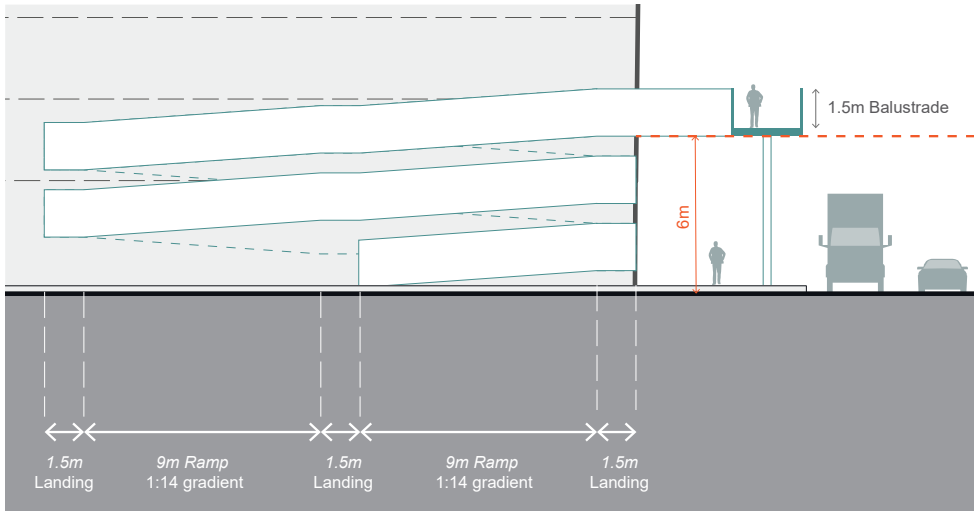


Figure 21 6m Height Ramp, Elevation (typical plan see section 7-1 fig.14)

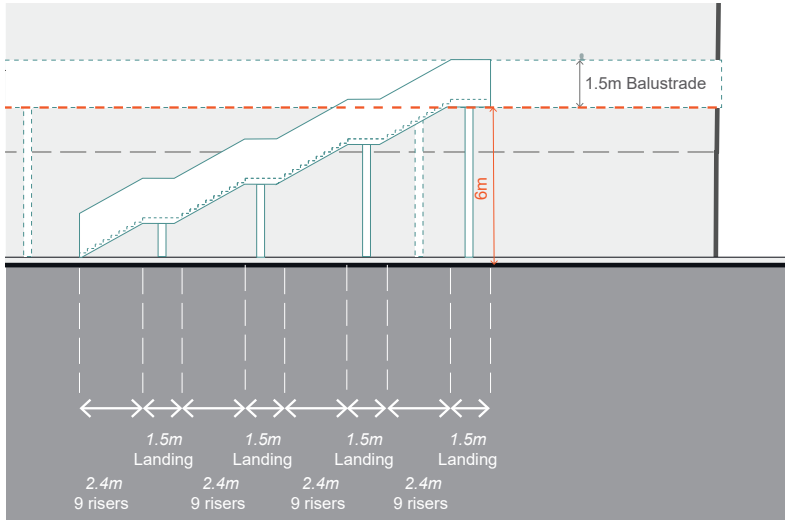


Figure 22 6m Height Stair, Elevation (typical plan see section 7-1 fig.14)

10 HERITAGE IMPACT

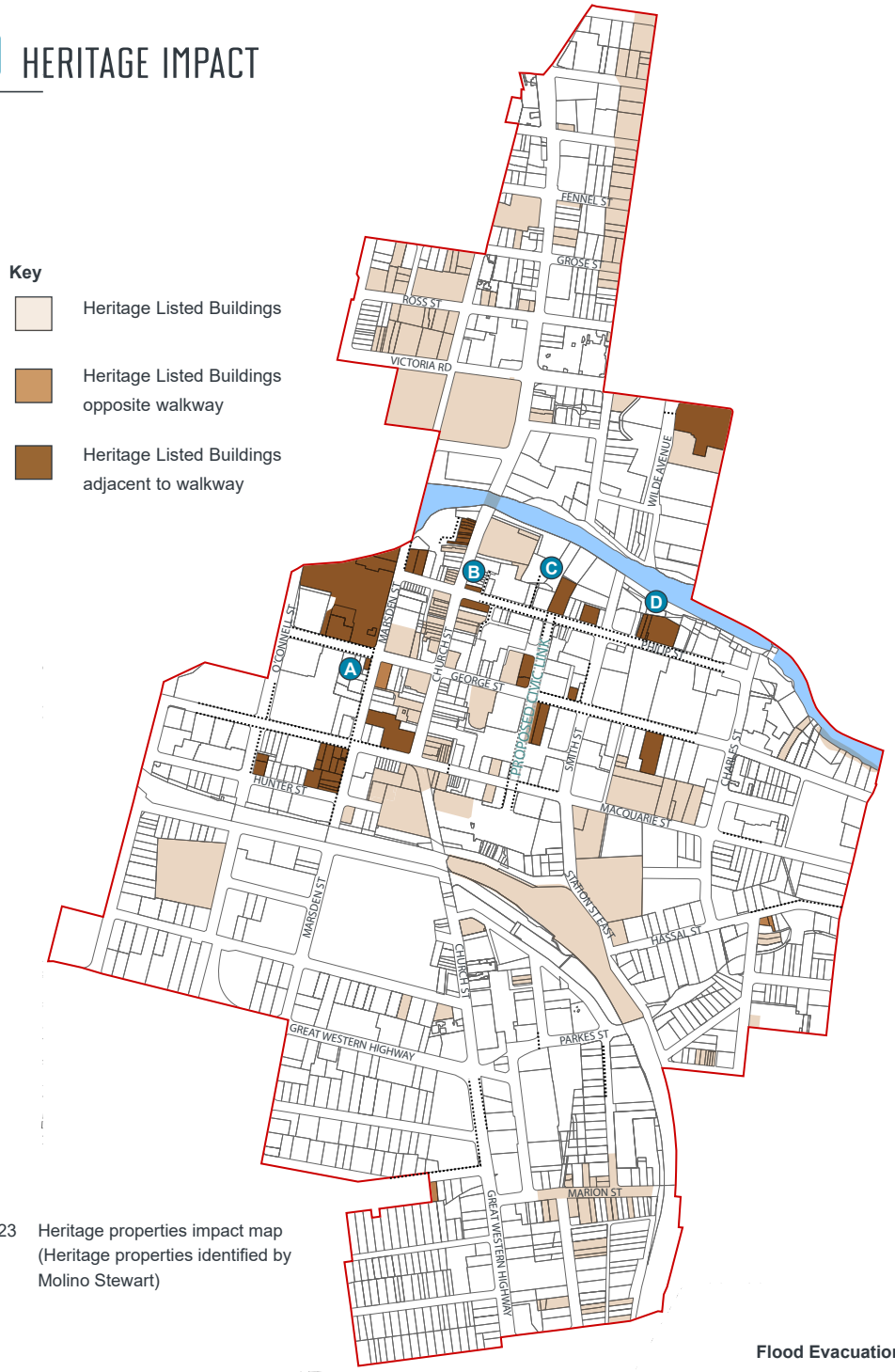


Figure 23 Heritage properties impact map (Heritage properties identified by Molino Stewart)

10-1 Impact on heritage buildings

Locating an extensive network of elevated walkways within the Paramatta CBD will affect a large number of heritage listed buildings.

The concept design proposes locating the walkways approximately 3m off the building property line. The walkways will be elevated approximately 4m above the footpath level.

The visual impact of a 2m wide walkway surface, with upstand balustrades, and associated support structures, will be significant when viewed against generally one and two storey heritage buildings.

The walkway will cut across and obscure key features of the facades of these buildings, including windows and colonnades, and may obscure the upper levels of buildings entirely when viewed from across the street, especially when this occurs from beneath another walkway.

Long views down the street are likely to be severely impacted as the walkways will potentially obscure rooflines and upper level façade details, and be the dominant element in the streetscape.

It is recommended that a detailed visual impact assessment be carried out by a heritage architect to fully understand and document the likely impacts on the range of high value heritage buildings within the Parramatta CBD.

Ⓐ 164 Marsden Street

Ⓑ 306 Church Street

Ⓒ 34 Philip Street

Ⓓ 70 Philip Street

11 MANAGED EVACUATION ROUTE

11-1 Managed high level evacuation route

An alternative to creating a high level unmanaged evacuation route is to provide a managed high level access for emergency responders (e.g SES) to reach members of the public who have sheltered in place and may require assistance. This option addresses a number of the key issues raised in Section 3:

- A suitable walkway width can be provided for SES staff access, and evacuation of a limited number of people within the existing street pattern.
- Ramped access would not be required to be provided, as SES staff could evacuate individuals using specialist equipment/ stretchers where necessary.
- A lightweight single width (approx.1m) walkway could be provided, potentially utilising existing buildings and awnings, significantly reducing overshadowing and visual impact on the street.
- The length of proposed walkways could potentially be reduced by terminating the route at designated multi-storey car parks within the CBD suitable for helicopter access/ evacuation.
- By providing a lightweight, less visually obtrusive and secure walkway system that is only accessible by the SES, the potential for unwanted informal uses of the walkways is minimised.
- Providing a lightweight route will enable the retention of more street trees.
- Providing a route that is managed by trained SES staff enables temporary deployable structures, including bridges, to be utilised reducing the visual impact of the route.
- Narrower and potentially shorter length of walkways, with no accessibility requirements, will reduce maintenance costs.

Key issues for further investigation should this option be progressed include:

- Discussion of the suitability of the concept of a managed high level evacuation route with SES staff.
- Discussion of access requirements including walkway widths, steps, and ladders with the SES.
- Discussion with Council and SES regarding ownership and maintenance of the system.
- Investigation of how building codes would apply to the proposal.
- More detailed design investigations of how the walkways would access buildings, the street, and be structurally supported.
- A visual impact study, once design parameters and the suitability of the proposal have been established, demonstrating the effect of the proposals on views within the CBD.

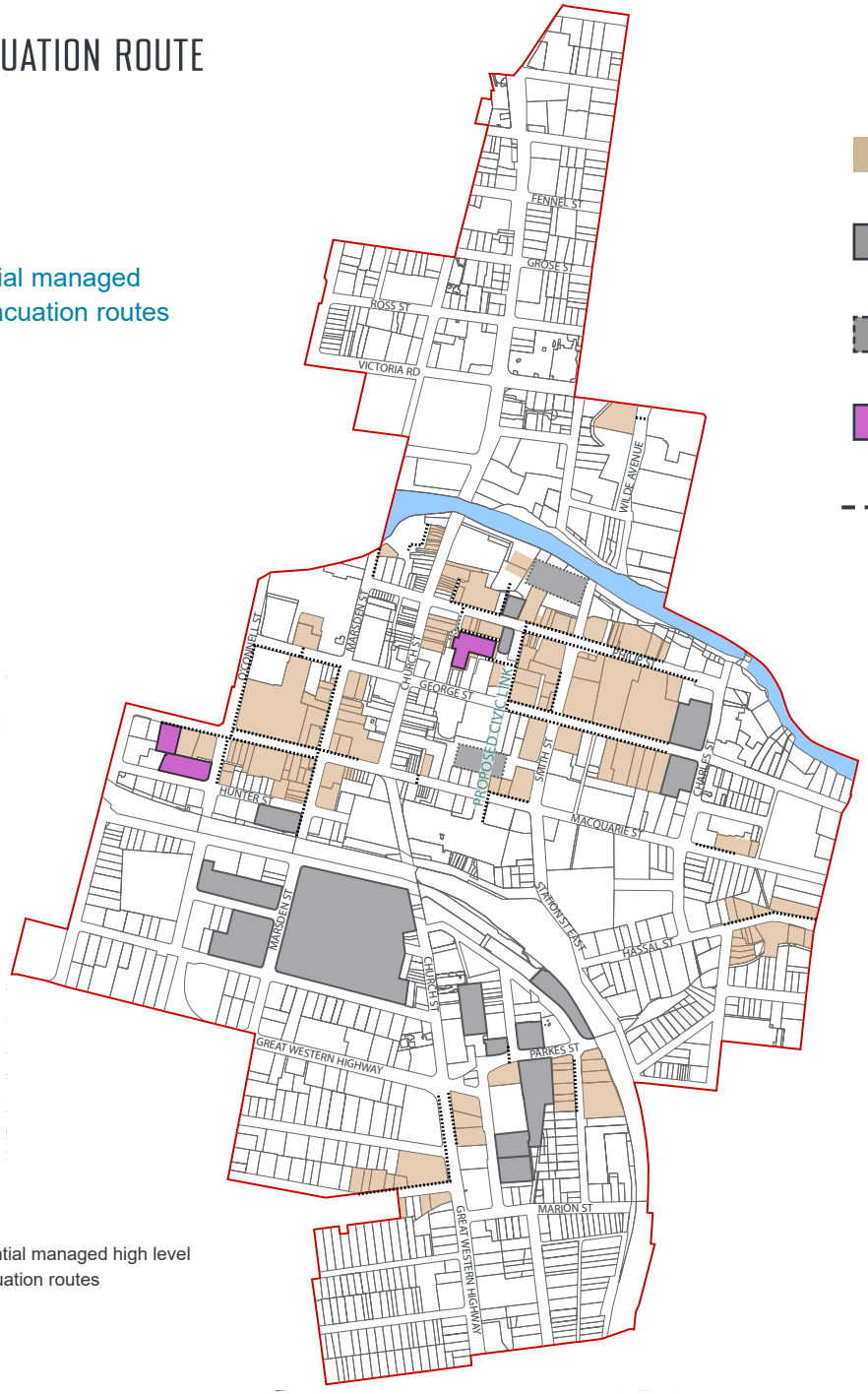




Examples of lightweight high level access/escape solutions.

11 MANAGED EVACUATION ROUTE

11-2 Map of potential managed high level evacuation routes



Buildings requiring high level evacuation in a 20 year ARI flood event.

Existing Car Parking with floor levels above 4m (potential for shelter in place)

Existing Car Parking potentially to be demolished

Relevant car parks with potential for helicopter evacuation

Potential walkway routes

Figure 24 Potential managed high level evacuation routes

12 CONCLUSIONS

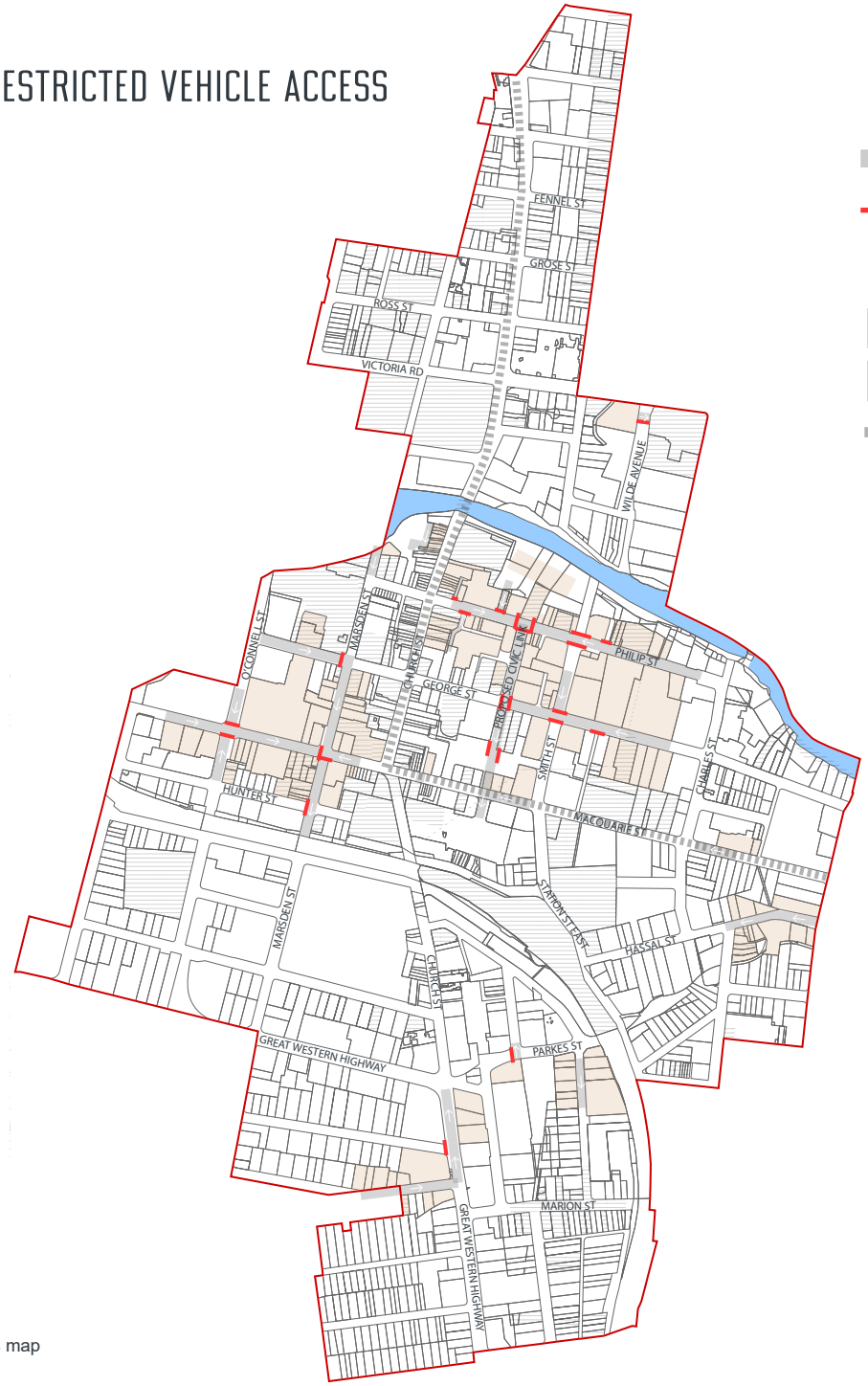
The proposed concept route design is based on the assumption of providing flood free evacuation routes during a 20 year ARI flood event. The proposed design and concept elements have the potential to be scaled to provide flood free evacuation routes during a 100 year ARI flood event and during a probable maximum flood (PMF)

Good design and detailing has the potential to make a feature of the proposed infrastructure, however given the significant detrimental impact on the urban character and heritage of the CBD we do not recommend an unmanaged high level horizontal evacuation route. Key concerns include:

- Providing a high level horizontal evacuation route will significantly impact on the character and amenity of the CBD.
- High level walkways will result in significant overshadowing of the street and ground floor units.
- High level walkways will result in the loss of street trees.
- Providing an extensive network of walkways that will not be used on a daily basis, will potentially create issues with informal use and security, and is an inefficient use of land within the CBD.
- Modelling of likely pedestrian numbers will be required to determine the requirements for the actual width of the walkway to ensure the safety of those evacuating.
- Providing ramps to access the walkway will impact on road layouts within the CBD.

A high level managed evacuation route, as described in section 11, could provide safer access for the SES to members of the public requiring assistance in a flood event, whilst reducing the visual impact and associated costs of the walkway infrastructure.

APPENDIX 01 RESTRICTED VEHICLE ACCESS



Proposed elevated walkway routes

Restricted vehicle access (excludes vehicles over 4.3m)

Buildings requiring high level evacuation in a 20 year ARI flood event.

Heritage Items

Preferred Light rail route

Note: Evacuation routes based on information provided by Molino Stewart.

Figure 25 Restricted vehicle access map

APPENDIX D - UNIT COSTS OF ELEVATED WALKWAYS

NORTH

Flood Evacuation - Parramatta CBD
Strategic Estimate

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
1	**Walkway (Type 1 -3) for 15m (L) span/ Segment *2.5m (W)**									
	1.7t Steelwork/15m									
1.1	Foundation- 1.5*1.5*0.6m- 2*no per segment	Demo	4.00	m3	$ 50	/ m3	2		$ 400	
	2. no columns per segment	Excavation & Disposal	4.00	m3	$ 200	/ m3	2		$ 1,600	
		Blinding- 50mm thick	2.00	m3	$ 50	/ m3	2		$ 200	
		FRP+ supply concrete	1.35	m3	$ 3,000	/ m3	2		$ 8,100	
		Backfill	2.65	m3	$ 50	/ m3	2		$ 265	
1.2	Walkway Steel framework - Tonnage rate	Fabricate, Supply and Install	1.70	T/ 15LM	$ 10,000	/T	1		$ 17,000	Based on 250*8SHS steel column and 200PFC Beam, EA75*5 bracing
1.3										
1.4	Walkway Concrete Deck	15 lm (L)*2.5m (W)	37.50	m2	$ 250	/m2	1		$ 9,375	Assumed 200 thick - Bondek, Precast in the yard
1.5	Handrails (stainless steel)	Supply & Install	15.00	LM	$ 500	/LM	2		$ 15,000	
		Kick rails (stainless steel)	15.00	LM	$ 200	/LM	2		$ 6,000	
		Allowance for seals/fittings	15.00	LM	$ 30	/LM	2		$ 900	No Allowance for Escalation or GST
1.6	Temp. works		1.00	Unit	$ 10,000		1		$ 10,000	Assume free standing
1.7	Traffic Control/ Permits							15%	$ 10,326	Assume pad foundations are sufficient, no allowance for piled foundations
										No Allowance for contaminated material
1.8	Site Survey- 2% of Construction cost							2%	$ 1,583	No allowance to demolish/alter existing building for connection to building access walkway
	Direct Works Total								**$ 80,749**	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
1.9	**Night shift- installation work & Permitt- 30% over**							**30%**	**$ 24,224.80**	Exposed Steelwork assumed to be painted
1.10	**Overhead/Admin/ Margin**							**35%**	**$ 36,740.94**	No allowance for Property Acquisitions
1.11	**Design and Investigation Costs 10% of DC**							**10%**	**$ 8,075**	No Allowance for CCTV
1.12	**Project Management cost - 5.5% on DC**							**5%**	**$ 4,037**	No allowance for relocation of services
1.13	**Contingency based on minimal info. 40-70%**							**55%**	**$ 77,943**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 231,771**	**+GST / 15m segment walkway**
									$ 15,452	**per m**

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
2	**Walkway (Type 4) for 15m (L) span/ Segment *2.5m (W)**									
	2.6t Steelwork/15m									
2.1	Foundation- 1.5*1.5*0.6m- 4*no per segment	Demo	4.00	m3	$ 50	/ m3	4		$ 800	
	4. no columns per segment	Excavation & Disposal	4.00	m3	$ 200	/ m3	4		$ 3,200	
		Blinding- 50mm thick	2.00	m3	$ 50	/ m3	4		$ 400	
		FRP+ supply concrete	1.35	m3	$ 3,000	/ m3	4		$ 16,200	
		Backfill	2.65	m3	$ 50	/ m3	4		$ 530	
2.2	Walkway Steel framework - Tonnage rate	Fabricate, Supply and Install	2.60	T/ 15LM	$ 10,000	/T	1		$ 26,000	Based on 250*8SHS steel column and 200PFC Beam, EA75*5 bracing
2.3										
2.4	Walkway Concrete Deck	15 lm (L)*2.5m (W)	37.50	m2	$ 250	/m2	1		$ 9,375	Assumed 200 thick - Bondek, Precast in the yard
2.5	Handrails (stainless steel)	Supply & Install	15.00	LM	$ 500	/LM	2		$ 15,000	
		Kick rails (stainless steel)	15.00	LM	$ 200	/LM	2		$ 6,000	
		Allowance for seals/fittings	15.00	LM	$ 30	/LM	2		$ 900	No Allowance for Escalation or GST
2.6	Temp. works		1.00	Unit	$ 10,000		1		$ 10,000	Assume free standing
2.7	Traffic Control/ Permits							15%	$ 13,261	Assume pad foundations are sufficient, no allowance for piled foundations
										No Allowance for contaminated material
2.8	Site Survey- 2% of Construction cost							2%	$ 2,033.32	No allowance to demolish/alter existing building for connection to building access walkway
	Direct Works Total								**$ 103,699**	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
2.9	**Night shift- installation work & Permitt- 30% over**							**30%**	**$ 31,110**	Exposed Steelwork assumed to be painted
2.10	**Overhead/Admin/ Margin**							**35%**	**$ 47,183**	No allowance for Property Acquisitions
2.11	**Design and Investigation Costs 10% of DC**							**10%**	**$ 10,370**	No Allowance for CCTV
2.12	**Project Management cost - 5.5% on DC**							**5%**	**$ 5,185**	No allowance for relocation of services
2.13	**Contingency based on minimal info. 40-70%**							**55%**	**$ 100,096**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 297,642**	**+GST / 15m segment walkway**
									$ 19,843	**per m**

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
3	**Walkway (Type 5) for 15m (L) span/ Segment *2.5m (W)**									
	2.2t Steelwork/15m									
3.1	Foundation- 1.5*1.5*0.6m- 2*no per segment	Demo	4.00	m3	$ 50	/ m3	2		$ 400	
	2. no columns per segment	Excavation & Disposal	4.00	m3	$ 200	/ m3	2		$ 1,600	
		Blinding- 50mm thick	2.00	m3	$ 50	/ m3	2		$ 200	
		FRP+ supply concrete	1.35	m3	$ 3,000	/ m3	2		$ 8,100	
		Backfill	2.65	m3	$ 50	/ m3	2		$ 265	
3.2	Walkway Steel framework - Tonnage rate	Fabricate, Supply and Install	2.20	T/ 15LM	$ 10,000	/T	1		$ 22,000	Based on 250*8SHS steel column and 200PFC Beam, EA75*5 bracing
3.3										
3.4	Walkway Concrete Deck	15 lm (L)*2.5m (W)	37.50	m2	$ 250	/m2	1		$ 9,375	Assumed 200 thick - Bondek, Precast in the yard
3.5	Handrails (stainless steel)	Supply & Install	15.00	LM	$ 500	/LM	2		$ 15,000	
		Kick rails (stainless steel)	15.00	LM	$ 200	/LM	2		$ 6,000	
		Allowance for seals/fittings	15.00	LM	$ 30	/LM	2		$ 900	No Allowance for Escalation or GST
3.6	Temp. works		1.00	Unit	$ 10,000		1		$ 10,000	Assume free standing
3.7	Traffic Control/ Permits							15%	$ 11,076	Assume pad foundations are sufficient, no allowance for piled foundations
										No Allowance for contaminated material
3.8	Site Survey- 2% of Construction cost							2%	$ 1,698.32	No allowance to demolish/alter existing building for connection to building access walkway
	Direct Works Total								**$ 86,614**	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
3.9	**Night shift- installation work & Permitt- 30% over**							**30%**	**$ 25,984**	Exposed Steelwork assumed to be painted
3.10	**Overhead/Admin/ Margin**							**35%**	**$ 39,409.52**	No allowance for Property Acquisitions
3.11	**Design and Investigation Costs 10% of DC**							**10%**	**$ 8,661**	No Allowance for CCTV
3.12	**Project Management cost - 5.5% on DC**							**5%**	**$ 4,331**	No allowance for relocation of services
3.13	**Contingency based on minimal info. 40-70%**							**55%**	**$ 83,604**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 248,605**	**+GST / 15m segment walkway**
									$ 16,574	**per m**

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
4	**Staircase & Landing**									
4.1	Foundation- 1.5*1.5*0.6m	Demo	4.00	m3	$ 50	/ m3	3		$ 600	
	3*no per staircase	Excavation & Disposal	4.00	m3	$ 110	/ m3	3		$ 1,320	
		Blinding- 50mm thick	2.00	m3	$ 50	/ m3	3		$ 300	
		FRP+ supply concrete	1.35	m3	$ 3,000	/ m3	3		$ 12,150	
		Backfill	1.75	m3	$ 50	/ m3	3		$ 263	
4.2	Walkway Steel framework - Tonnage rate		1.10	T/ Stair case	$ 10,000	/T	1		$ 11,000	Based on 250*8SHS column and 150PFC stringer
4.3	Precase concrete stair treads- Supply & Install		1.00		$ 110	each	27		$ 2,970	
4.4	Precase concrete landing		2.25	m2	$ 200	/m2	3		$ 1,350	Assumed 100 thick - Bondek
4.5	Handrails (stainless steel)	Supply & Install	12.00	LM	$ 500	/LM	2		$ 12,000	
		Kick rails (stainless steel)	12.00	LM	$ 200	/LM	2		$ 4,800	
		Allowance for seals/fittings	12.00	LM	$ 30	/LM	2		$ 720	No Allowance for Escalation or GST
										Assume free standing
4.6	Traffic Control/ Permits							15%	$ 7,121	Assume pad foundations are sufficient, no allowance for piled foundations
										No Allowance for contaminated material
4.7	Site Survey- 2% of Construction cost							2%	$ 1,092	No allowance to demolish/alter existing building for connection to building access walkway
	Direct Works Total								**$ 55,685**	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
4.8	**Night shift- installation work & Permitt- 30% over**							**30%**	**$ 16,706**	Exposed Steelwork assumed to be painted
4.9	**Overhead/Admin/ Margin**							**35%**	**$ 25,337**	No allowance for Property Acquisitions
4.10	**Design and Investigation Costs 10% of DC**							**10%**	**$ 5,569**	No Allowance for CCTV
4.11	**Project Management cost - 5.5% on DC**							**5%**	**$ 2,784**	No allowance for relocation of services
4.12	**Contingency based on minimal info. 40-70%**							**55%**	**$ 53,750**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 159,831**	**+GST / staircase**
									$ 160,000	**per staircase**

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
5	**Access Ramp**									
	Structural steel frame & Columns									
5.1	Foundation- 1.5*1.5*0.6m	Demo	4.00	m3	$ 50	/ m3	4		$ 800	
	4* no.	Excavation & Disposal	4.00	m3	$ 110	/ m3	4		$ 1,760	
		Blinding- 50mm thick	2.00	m3	$ 50	/ m3	4		$ 400	
		FRP+ supply concrete	1.35	m3	$ 3,000	/ m3	4		$ 16,200	
		Backfill	1.75	m3	$ 50	/ m3	4		$ 350	
5.2	Structural Steel framework - Tonnage rate	Fabricate, Supply and Install	6.80	T/ each	$ 10,000	/T	1		$ 68,000	Assume 4.no columns 250*8SHS, under the landings- 250PFC stringer- EA75*5 angle bracing
5.3	Concrete Deck (71 LM inclusive landing)	15 lm (L)*2.5m (W)	106.50	m2	$ 250	/m2	1		$ 26,625	Assumed 100 thick - Bondek
5.4	Handrails (stainless steel)	Supply & Install	71.00	LM	$ 500	/LM	2		$ 71,000	
		Kick rails (stainless steel)	71.00	LM	$ 200	/LM	2		$ 28,400	
		Allowance for seals/fittings	71.00	LM	$ 30	/LM	2		$ 4,260	No Allowance for Escalation or GST
									$ -	Assume free standing
5.5	Traffic Control/ Permits							15%	$ 32,669	Assume pad foundations are sufficient, no allowance for piled foundations
										No Allowance for contaminated material
5.6	Site Survey- 2% of Construction cost							2%	$ 5,009	No allowance to demolish/alter existing building for connection to building access walkway
	Direct Works Total								**$ 255,474**	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
5.7	**Night shift- installation work & Permitt- 30% over**							**30%**	**$ 76,642**	Exposed Steelwork assumed to be painted
5.8	**Overhead/Admin/ Margin**							**35%**	**$ 116,240**	No allowance for Property Acquisitions
5.9	**Design and Investigation Costs 10% of DC**							**10%**	**$ 25,547**	No Allowance for CCTV
5.10	**Project Management cost - 5.5% on DC**							**5%**	**$ 12,774**	No allowance for relocation of services
5.11	**Contingency based on minimal info. 40-70%**							**55%**	**$ 246,596**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 733,273**	**+GST / 71m access ramp**
									$ 10,328	**per m**

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
6	**Building Access Walkway (Cantilevered walkway)**									
	Cantilevered building access walkway	Height	4.50	m						
	4.5m high, 6m span, 1.5m width	Span	6.00	m						Assume negligible gradient in building access walkway
		Width	1.50	m						
6.1	**Support**									
	Pad footing foundation (1.5x1.5x0.6m)	Length	1.50	m						Assume pad foundations are sufficient, no allowance for piled foundations
		Width	1.50	m						
		Depth	0.60	m						
		Supply Concrete	1.35	m3	$ 350	/m3	1		$ 473	
		Supply reinforcement	0.27	tonnes	$ 1,300	/tonne	1		$ 351	
		Install reinforcement	0.27	tonnes	$ 800	/tonne	1		$ 216	
		Pump concrete	1.35	m3	$ 450	/m3	1		$ 608	
		Formwork	2.25	m2	$ 200	/m2	1		$ 450	
		Saw Cut 150thk	10.00	m	$ 14	/m	1		$ 140	
		Demo	3.75	m3	$ 50	/m3	1		$ 188	
		Excavation & Disposal	3.75	m3	$ 200	/m3	1		$ 750	
		Backfill	2.40	m3	$ 50	/m3	1		$ 120	
		Labour	16.00	hours	$ 84	/hr	2		$ 2,688	Rate allowance includes for nightworks
		Excavator	8.00	hours	$ 100	/hr	1		$ 800	
		Truck	8.00	hours	$ 100	/hr	3		$ 2,400	
	Column (Assume 2 250x9SHS with EA75x5 Bracing)									
	250x9 SHS	Weight	65.90	kg/m						
		Supply	296.55	kg	$ 8,000	/tonne	2		$ 4,745	
	Bracing - Assume EA75*5 - 5.27kg/m	Length	2.80	m						
		Weight	5.27	kg/m						
		Supply	14.76	kg	$ 8,000	/tonne	4		$ 472	
		Allowance for bolts/connections (5%)						5%	$ 261	
		Labour	5.00	hours	$ 84	/hr	2		$ 840	Rate allowance includes for nightworks
		Franna Crane	5.00	hours	$ 200	/hr	1		$ 1,000	
6.2	**Walkway**									
	Concrete walkway (1.5m x 6m)	Area	9.00	m2						
		Supply concrete	1.80	m3	$ 350	/m3	1		$ 630	Assume 0.2m depth
		Pump concrete	1.80	m3	$ 35	/m3	1		$ 63	
		Finish	9.00	m2	$ 4	/m2	1		$ 36	
		Cure	9.00	m2	$ 4	/m2	1		$ 36	
	Steel deck (Assume 200PFC Beam - 25.4kg/m)	Area	9.00	m2						
		Weight	25.40	kg/m						
		Supply (8PFC to make the deck)	152.40	kg	$ 8,000	/tonne	8		$ 9,754	
		Allowance for bolts/connections (5%)						5%	$ 488	
		Labour	11.00	hours	$ 84	/hr	2		$ 1,848	Rate allowance includes for nightworks
		Franna Crane	8.00	hours	$ 200	/hr	1		$ 1,600	
6.3	**Handrails (stainless steel)**	Supply & install	6.00	m	$ 500	/m	2		$ 6,000	
		Kick rails	6.00	m	$ 200	/m	2		$ 2,400	
		Allowance for seals/fittings	6.00	m	$ 30	/m	1		$ 180	Assume supported by to-be-constructed walkway
										No allowance to demolish/alter existing building for connection to building access walkway
		Labour	8.00	hours	$ 60	hr	2		$ 960	No Allowance for Escalation or GST
										No Allowance for contaminated material
6.4	**Traffic Management**	Pedestrian Traffic Management						15%	$ 5,930	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
										Exposed Steelwork assumed to be painted
	Direct costs total								**$ 46,425**	No allowance for Property Acquisitions
6.5	**Overhead/Margin/Admin**							**35%**	**$ 16,249**	No Allowance for CCTV
6.6	**Project management**							**10%**	**$ 4,642**	No allowance for relocation of services
6.7	**Contingency**							**50%**	**$ 33,658**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 100,974**	**+GST / 6m cantilevered building access walkway (4.5m high, 6m span, 1.5m width)**
									$ 16,829	**per m**

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
7	**Building Access Walkway (Standard walkway)**									
	Standard building access walkway	Height	4.50	m						
	4.5m high, 3.5m span, 1.5m width	Span	3.50	m						Assume negligible gradient in building access walkway
		Width	1.50	m						
7.1	**Support**									
	Pad footing foundation (1.5x1.5x0.6m)	Length	1.50	m						Assume pad foundations are sufficient, no allowance for piled foundations
		Width	1.50	m						
		Depth	0.60	m						
		Supply Concrete	1.35	m3	$ 350	/m3	1		$ 473	
		Supply reinforcement	0.27	tonnes	$ 1,300	/tonne	1		$ 351	
		Install reinforcement	0.27	tonnes	$ 800	/tonne	1		$ 216	
		Pump concrete	1.35	m3	$ 450	/m3	1		$ 608	
		Formwork	2.25	m2	$ 200	/m2	1		$ 450	
		Saw Cut 150thk	10.00	m	$ 14	/m	1		$ 140	
		Demo	3.75	m3	$ 50	/m3	1		$ 188	
		Excavation & Disposal	3.75	m3	$ 200	/m3	1		$ 750	
		Backfill	2.40	m3	$ 50	/m3	1		$ 120	
		Labour	16.00	hours	$ 84	/hr	2		$ 2,688	Rate allowance includes for nightworks
		Excavator	8.00	hours	$ 100	/hr	1		$ 800	
		Truck	8.00	hours	$ 100	/hr	3		$ 2,400	
	Column (Assume 2 250x9SHS with EA75x5 Bracing)									
	250x9 SHS	Weight	65.90	kg/m						
		Supply	296.55	kg	$ 8,000	/tonne	2		$ 4,745	
	Bracing - Assume EA75*5 - 5.27kg/m	Length	2.80	m						
		Weight	5.27	kg/m						
		Supply	14.76	kg	$ 8,000	/tonne	4		$ 472	
		Allowance for bolts/connections (5%)						5%	$ 261	
		Labour	5.00	hours	$ 84	/hr	2		$ 840	Rate allowance includes for nightworks
		Franna Crane	5.00	hours	$ 200	/hr	1		$ 1,000	
7.2	**Walkway**									
	Concrete walkway (1.5m x 3.5m)	Area	5.25	m2						
		Supply concrete	1.05	m3	$ 350	/m3	1		$ 368	Assume 0.2m depth
		Pump concrete	1.05	m3	$ 35	/m3	1		$ 37	
		Finish	5.25	m2	$ 4	/m2	1		$ 21	
		Cure	5.25	m2	$ 4	/m2	1		$ 21	
	Steel deck (Assume 200PFC Beam - 25.4kg/m)	Area	5.25	m2						
		Weight	25.40	kg/m						
		Supply (8PFC to make the deck)	152.40	kg	$ 8,000	/tonne	8		$ 9,754	
		Allowance for bolts/connections (5%)						5%	$ 488	
		Labour	9.00	hours	$ 84	/hr	2		$ 1,512	Rate allowance includes for nightworks
		Franna Crane	6.00	hours	$ 200	/hr	1		$ 1,200	
7.3	**Handrails (stainless steel)**	Supply & install	3.50	m	$ 500	/m	2		$ 3,500	
		Kick rails	3.50	m	$ 200	/m	2		$ 1,400	
		Allowance for seals/fittings	3.50	m	$ 30	/m	1		$ 105	Assume supported by to-be-constructed walkway
										No allowance to demolish/alter existing building for connection to building access walkway
		Labour	4.00	hours	$ 60	hr	2		$ 480	No Allowance for Escalation or GST
										No Allowance for contaminated material
7.4	**Traffic Management**	Pedestrian Traffic Management						15%	$ 5,236	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
										Exposed Steelwork assumed to be painted
	Direct costs total								**$ 40,621**	No allowance for Property Acquisitions
7.5	**Overhead/Margin/Admin**							**35%**	**$ 14,217**	No Allowance for CCTV
7.6	**Project management**							**10%**	**$ 4,062**	No allowance for relocation of services
7.8	**Contingency**							**50%**	**$ 29,450**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 88,350**	**+GST / 3.5m standard building walkway (4.5m high, 3.5m span, 1.5m width)**
									$ 25,243	**per m** Rate skewed due to short span and high setup costs

ITEM	DESCRIPTION				RATE	Unit	Qty		AMOUNT	Note
8	**Building Access Walkway (Elevated standard walkway - type 5)**									
	Elevated standard building access walkway	Height	8.00	m						
	8m high, 3.5m span, 1.5m width	Span	3.50	m						Assume negligible gradient in building access walkway
		Width	1.50	m						
8.1	**Support**									
	Pad footing foundation (1.75x1.75x0.8m)	Length	1.75	m						Assume pad foundations are sufficient, no allowance for piled foundations
		Width	1.75	m						
		Depth	0.80	m						
		Supply Concrete	2.45	m3	$ 350	/m3	1		$ 858	
		Supply reinforcement	0.49	tonnes	$ 1,300	/tonne	1		$ 637	
		Install reinforcement	0.49	tonnes	$ 800	/tonne	1		$ 392	
		Pump concrete	2.45	m3	$ 450	/m3	1		$ 1,103	
		Formwork	3.06	m2	$ 200	/m2	1		$ 613	
		Saw Cut 150thk	11.00	m	$ 14	/m	1		$ 154	
		Demo	6.05	m3	$ 50	/m3	1		$ 303	
		Excavation & Disposal	6.05	m3	$ 200	/m3	1		$ 1,210	
		Backfill	3.60	m3	$ 50	/m3	1		$ 180	
		Labour	16.00	hours	$ 84	/hr	2		$ 2,688	Rate allowance includes for nightworks
		Excavator	8.00	hours	$ 100	/hr	1		$ 800	
		Truck	8.00	hours	$ 100	/hr	3		$ 2,400	
	Column (Assume 2 250x9SHS with EA75x5 Bracing)									
	250x9 SHS	Weight	65.90	kg/m						
		Supply	527.20	kg	$ 8,000	/tonne	2		$ 8,435	
	Bracing - Assume EA75*5 - 5.27kg/m	Length	2.80	m						
		Weight	5.27	kg/m						
		Supply	14.76	kg	$ 8,000	/tonne	8		$ 944	
		Allowance for bolts/connections (5%)						5%	$ 469	
		Labour	8.00	hours	$ 84	/hr	2		$ 1,344	Rate allowance includes for nightworks
		Franna Crane	8.00	hours	$ 200	/hr	1		$ 1,600	
8.2	**Walkway**									
	Concrete walkway (1.5m x 3.5m)	Area	5.25	m2						
		Supply concrete	1.05	m3	$ 350	/m3	1		$ 368	Assume 0.2m depth
		Pump concrete	1.05	m3	$ 35	/m3	1		$ 37	
		Finish	5.25	m2	$ 4	/m2	1		$ 21	
		Cure	5.25	m2	$ 4	/m2	1		$ 21	
	Steel deck (Assume 200PFC Beam - 25.4kg/m)	Area	5.25	m2						
		Weight	25.40	kg/m						
		Supply (8PFC to make the deck)	152.40	kg	$ 8,000	/tonne	8		$ 9,754	
		Allowance for bolts/connections (5%)						5%	$ 488	
		Labour	12.00	hours	$ 84	/hr	2		$ 2,016	Rate allowance includes for nightworks
		Franna Crane	4.00	hours	$ 200	/hr	1		$ 800	
8.3	**Handrails (stainless steel)**	Supply & install	3.50	m	$ 500	/m	2		$ 3,500	
		Kick rails	3.50	m	$ 200	/m	2		$ 1,400	
		Allowance for seals/fittings	3.50	m	$ 30	/m	1		$ 105	Assume supported by to-be-constructed walkway
										No allowance to demolish/alter existing building for connection to building access walkway
		Labour	4.00	hours	$ 60	hr	2		$ 480	No Allowance for Escalation or GST
										No Allowance for contaminated material
8.4	**Traffic Management**	Pedestrian Traffic Management						15%	$ 6,396	No allowance for reconfiguration of the existing pavements roads drainage or street furniture
										Exposed Steelwork assumed to be painted
	Direct costs total								**$ 49,513**	No allowance for Property Acquisitions
8.5	**Overhead/Margin/Admin**							**35%**	**$ 17,329**	No Allowance for CCTV
8.6	**Project management**							**10%**	**$ 4,951**	No allowance for relocation of services
8.7	**Contingency**							**50%**	**$ 35,897**	No allowance for Lighting (assumed existing street lighting is sufficient)
	Total								**$ 107,690**	**+GST / 3.5m elevated standard building walkway (8m high, 3.5m span, 1.5m width)**
									$ 30,769	**per m** Rate skewed due to high walkway elevation (based off walkway typology 5)

APPENDIX E – MULTI-CRITERIA ANALYSIS

Multi-criteria Analysis

ALTERNATIVES	CRITERIA (scores range between zero and 5)					
	A. Effectiveness in Reducing Risk to Life	**B.** Difficulty of Implementation	**C.** Residual Risks after Mitigation Measures are Implemented	**D.** Impacts on Urban Landscape	**E.** Cost of implementation	**F.** Load on emergency services
1. **Vehicular Evacuation** **Overall Score: 11**	Score = 0	Score = 1	Score = 0	Score = 5	Score = 5	Score = 1
2. Shelter In Place **Overall Score: 22 (best score)**	Score = 4	Score = 4	Score = 2	Score = 5	Score = 5	Score = 2
3. HHL PMF **Overall Score:16**	Score = 5	Score = 1	Score = 5	Score = 1	Score = 1	Score = 4
4. HHL 20 year ARI + SIP **Overall Score: 18**	Score = 4	Score = 3	Score = 3	Score = 2	Score = 3	Score = 3
5. HHL 100 year ARI + SIP **Overall Score: 16**	Score = 4	Score = 2	Score = 4	Score = 2	Score = 2	Score = 3

Notes

Alternative 1 – Vehicular Evacuation

1A: Under the assumptions of the NSW SES Timeline Evacuation Model, vehicular evacuation cannot be completed before evacuation routes are cut by floodwaters. This poses a very high risk to life.

1B: Implementation would be possible, but very difficult. Drivers in different precincts would need to know where to evacuate. Regional flooding would cut most of the main roads out of Parramatta CBD. Cars evacuating to Great Western Highway would most likely cue back to the CBD preventing more cars to leave their building. Background traffic would need to be managed in day scenarios, particularly in a PM peak scenario (residents returning to the CBD).

1C. This strategy would not reduce risk to life because evacuation cannot be completed before the arrival of floodwaters. In fact, this strategy may even increase risk to life because evacuees would experience inundation while they are blocked in their cars.

1D. There would be no alteration of the urban landscape

1E. There would be no significant implementation costs involved

1F. Emergency Managers would need to deal with the very high residual risks. This would require a complex warning communication strategy to ensure evacuees would know where to drive to, managing evacuating and background traffic, and most importantly rescuing a large number of people from their cars.

Alternative 2 – Shelter In Place up to the PMF

2A. In most instances, people would be able to take shelter in a refuge above the PMF within their own building. People in the public domain as well as people in buildings unsuitable to be used as shelters would need to have access to neighbouring buildings with a refuge above the PMF level.

2B. Ad-hoc communication strategy and risk awareness activities may be required to ensure that evacuees know what to do. A focus should be put on reducing the risk of people leaving the refuge before the emergency has passed.

2C. If risks of SIP are addressed as recommended in Molino Stewart (2016) and in this report, residual risk would be moderate.

2D. There would be no alteration of the urban landscape

2E. There would be no significant implementation costs involved

2F. Emergency responders may need to intervene in case the mitigation measures in place to address SIP risks fail.

Alternative 3: HHL up to the PMF

3A. Each building would have direct access to a flood free area up to the PMF. Risk to life would be minimum.

3B. It is expected that the construction of such a large system of elevated walkways would be very difficult to achieve. Some of the main challenges include the compatibility with existing and future development, maintenance, informal use of the structure causing safety issues and acceptance of the general public

3C. The main risk would be in case occupants of one-storey buildings refuse to evacuate on the elevated walkways.

3D. The impacts on urban landscape would be extremely high. These would include visual impact (particularly on heritage sites), overshadowing, loss of urban trees, inefficient use of land, limited accessibility to the CBD.

3E. Costs would be extremely high (estimated total construction cost of $ 324 Million. Note that this does not include maintenance costs)

3F. With such a system in place, virtually no dwellings would be isolated by floodwaters in any event up to the PMF. This would greatly simplify the role of emergency responders.

Alternatives 4 (and 5): HHL up to the 20 (100) year ARI and SIP in greater events

4(5)A. Risk to life would be significantly reduced

4(5)B. It is expected that the construction of such a large system of elevated walkways would be very difficult to achieve. Some of the main challenges include the compatibility with existing and future development, maintenance, informal use of the structure causing safety issues and acceptance of the general public.

4(5)C. Residual risk would be similar to the SIP only alternative, but SIP would only be required in large flood events

4(5)D. The impacts on urban landscape would be very high. These would include visual impact (particularly on heritage sites), overshadowing, loss of urban trees, inefficient use of land, limited accessibility to the CBD. Because of the smaller size of the elevated walkways network, impacts would be smaller than in Alternative 3 (HHL up to the PMF). Because the 100 year ARI event would require a network of elevated walkways only slightly larger than the 20 year ARI event, impacts would be similar.

4(5)E. The estimated total construction cost would be $ 94.5 Million (20 year ARI) and of $ 111 Million (100 year ARI). Note that this does not include maintenance costs)

4(5)F. Isolation would be avoided up to the 20 (100) year ARI event, so it is expected that the burden on emergency responders would be lower than in a SIP only scenario (Alternative 3)

Horizontal Evacuation Pilot Study

Parramatta CBD

SJB Architects

Project
Horizontal Evacuation Pilot Study

Ref #5568
Date issued: 14/03/2017
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Prepared by: AG, FL, JH, JL
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Introduction

- Parramatta is Sydney's second CBD and is expected to grow significantly in the coming years.

- Parramatta CBD lies within the Parramatta River floodplain, and is subject to flash flooding that can potentially have less than 1 hour warning to evacuate.

- NSW SES has developed a classification of communities to determing priority areas for evacuation, including:
  - **Low flood island (high risk)**
  - **High flood island**

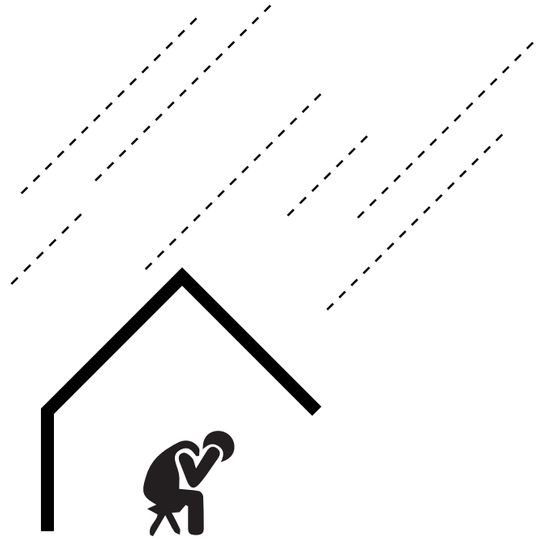
- Safest option for emergency situation was determined to be **Shelter in Place** (not evacuate).

- Saftey concerns for occupants sheltering in some buildings due to:
  - **injury;**
  - **fire;**
  - **duration of flood event; and**
  - **occupants entering hazardous floodwaters.**

- Risk to buildings and occupants is lowered by through connecting buildings via passageways **elevated above the PMF.**

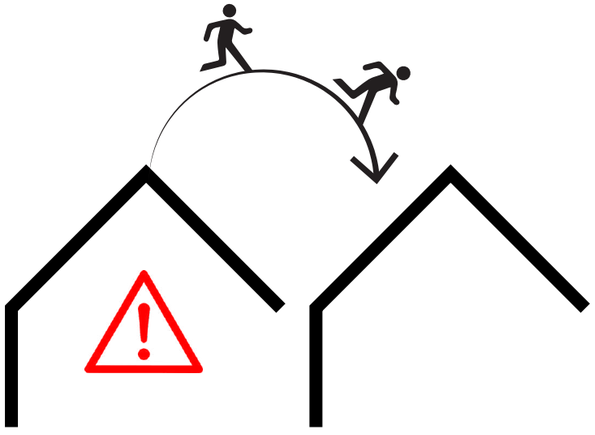
- SJB to investigate potential issues with three methods of connecting passageways above the PMF.

Emergency response



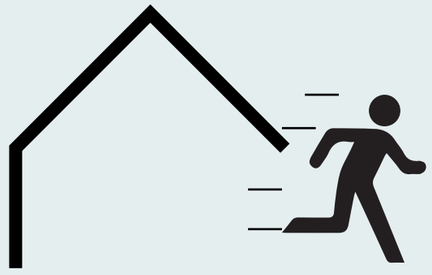
01. Shelter in Place

Occupants are encouraged to stay within the building for as long as possible, unless there is a hazard present such as a fire, or if an occupant requires medical assistance.



02. Evacuate to Adjacent Building to Shelter in Place

Occupants are encouraged to evacuate to the nearest adjacent building that provides a safe space to Shelter in Place.

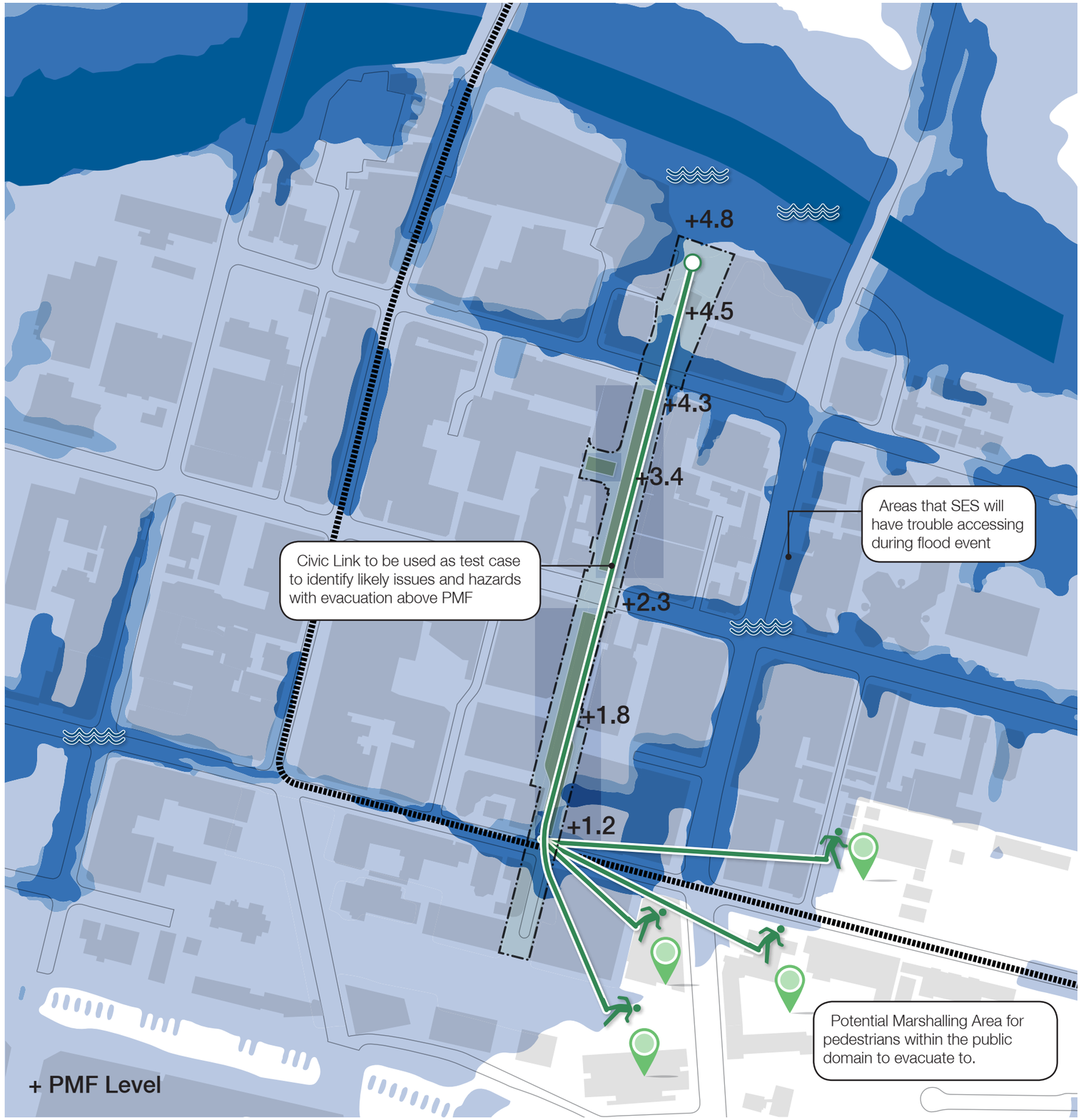


03. Evacuate to Marshalling area

If all adjacent buildings are considered unsafe to Shelter in Place, only then are occupants encouraged to evacuate via the proposed method to a public marshalling area that is located above the PMF.

The Situation

- CoP has identified a rough outline of marshalling areas and evacuation routes for a flood event, however this is largely for **pedestrians within the public domain**.
- Ideally occupants already within buildings will **shelter in place** within the building for the duration of the flood event, which is likely to be a **matter of hours**.
- Using the Civic Link project to test the issues associated with evacuation above the PMF, this report identifies potential issues, conflicts, and saftey concerns with three methods of evacuation:
  - **Above Awning**
  - **Above Podium**
  - **Indoors**
- The areas identified as dark blue are the 1 in 100 year flood levels, and are considered **inaccessesible by SES during a flood event.**
- The area shown in light blue indicates the PMF which varies throughout the CBD as being below and above the height of an awning.



Baseline Review

The *Best Practice Urban Design In Flood Prone Areas Urban Design Strategy Report* was prepared by Architectus for Parramatta City Council and completed in December 2016.

The report considers the particular opportunities and challenges for Parramatta, as a flood prone area that is currently undergoing intensive urban development.

These concerns have generally been addressed according to the particular characteristics of key areas of interest within the Parramatta region. These are identified as the Parramatta CBD, River Foreshore and Clay Cliff Creek, Urban Renewal Areas - Rosehill and Camellia, North Parramatta and Granville.

A series of integrated built form and public domain design strategies have been developed to address the particular flood conditions, in alignment with the requirements of the NSW State Government Flood Prone Land Policy and other relevant legislation, policy and guidelines.

The study addresses the specific issues identified for Parramatta within the following categories:

- Activation
- Density
- Awareness
- High hydraulic hazard
- Car parking

The report recommends an integrated approach to managing Parramatta's urban form and public realm that responds to these five categories, while still ensuring an attractive and accessible urban environment.

Final design recommendations for best practice approaches are supported by relevant case studies and design testing, in addition to consideration of policy context and site conditions,

The following pages provide a summary of key aspects of the report (text extracted from the body of the report).

Objectives

The following objectives are outlines in the introduction section of the report:

- To create active and vibrant streets and public spaces within flood prone areas of Parramatta.
- To minimise flood damage and risks, to increase resilience and to ensure safety within both the public domain and adjacent building spaces.
- To identify lessons learned, their relevance to Parramatta and implication for the existing NSW policy context.
- To address a range of flood conditions and scales relevant to Parramatta from the scale of the city to the riverfront to buildings and their public domain interface.
- To test case study findings against sample building designs (ground level and basement) to demonstrate compliance with standards, building systems design requirements, viability and good urban design outcomes.
- To complement the CBD Planning Framework flood study work being undertaken by Council.
- To provide recommendations for policy that could inform an alternative approach to current practice in NSW and that can be reviewed by Office of Environment and Heritage (OEH) and the State Emergency Services (SES).
- To use diagrams, precedents and technical references to clearly explain analysis and recommendations

Considerations for Flood Management Design

The Human Scale:

A series of height thresholds are proposed to define urban design solutions that vary according to flooding impact, in relation to the human scale. These heights are defined as:
- Seating Height - 450mm and under
- Railing Height - 900mm and under
- Eye Level - 1500mm and under
- Ceiling Height - 1500mm and above

Built Form:

Four main aspects of the management of flood risk in development have been identified as causes of undesirable built form outcomes:

1. Minimum floor level requirements and the Flood Planning Level (FPL)
By constructing minimum floor levels to the current FPL there is often significant grade changes between ground floors and adjacent street levels requiring careful design to ensure activation and aesthetics.

2. Basement entry level requirements
The current basement entry minimum level requirement for FPL cannot feasibly be achieved in developments where the FPL is up to 3 metres higher than adjacent street levels.

3. Flood emergency response requirements
The rapid rate of rise for Parramatta River and its tributaries limits the feasibility of flood emergency response provisions for developments, in particular evacuation.

4. Maintaining flood conveyance and storage
One currently adopted approach to maintaining flood conveyance through sites is to utilise screened undercroft areas below ground floors. This presents difficulties for the streetscape and building design.

Assessment Criteria

An assessment criteria has been established to measure the effectiveness of proposed design strategies and solutions from both an urban design and flood risk management perspective. This criteria is categorised as the following:

Urban Design Criteria:

- Context
- Activation
- Connectivity
- Aesthetics

Flood Management, Feasibility and Risk Criteria Flood Management:

- Flood Risk to Life and Evacuation
- Feasibility

Flood Context - Parramatta

An investigation of the existing flood conditions for Parramatta has been included in the preliminary stages of the report. The flood characteristics particular to the Parramatta region are described on page 12:

'The spectrum of flooding in Parramatta ranges from shallow, fast moving water occurring as a result of frequently occurring heavy storms through to large, slow-subsiding inundations of depths over 3m that occur much more rarely. Flood events affect streets, shops, homes, offices and public space; each has its own specific design requirements and patterns of use.'

The constraints for flood emergency reponse as a result of these conditions are elaborated on further in Section 3.0 'Flood Context' (p.28):

'...Parramatta River and its tributaries is classed as a flash flooding environment as the time to flooding is less than 6 hours, at some locations on tributaries this can reduce to less than 30 minutes. This means that flood emergency response is difficult for the area as there will be very limited time available for emergency services such as the SES to evacuate occupants of the floodplain in the event of flooding.'

The specific flood characteristics for the Parramatta CBD area are identified as the following (p. 21):

- A number of Parramatta River foreshore sites are affected by 100yr ARI high hazard from river flooding.
- Other parts of the CBD are affected in the 100yr ARI by low hazard overland flow flooding which mostly align with the road reserve.
- The majority of the CBD is affected by high hazard flooding (up to 4 metres depth, assumed low velocities) from Parramatta River in the PMF event.
- There is significant overland flow and consequent flooding across much of the CBD reaching higher levels than river flooding.

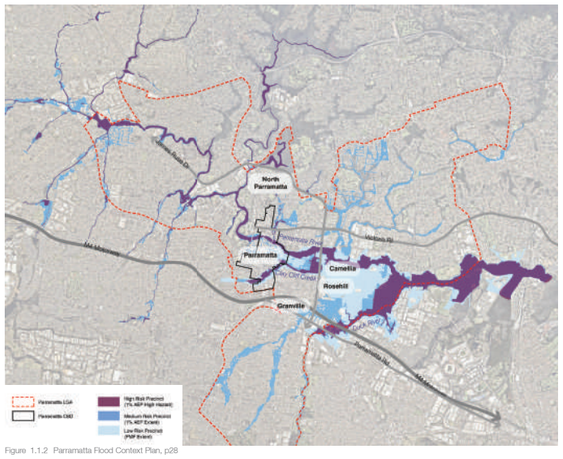


Figure 1.1.2 Parramatta Flood Context Plan, p28

Note: Parramatta LGA boundary is prior to amalgamation on 12 May 2016

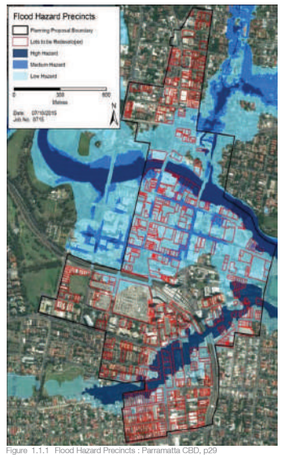


Figure 1.1.1 Flood Hazard Precincts : Parramatta CBD, p29

Flood Response - Case Studies

A series of case studies are presented in the Architectus report to investigate potential design approaches and solutions for the flood prone area of Parramatta. The overarching strategy and key design elements are identified for each case study through an analysis of local and international examples of where it has been implemented.

The following case study categories are included in the report:

1. Placing over the water
Involves the integration of elevated built form elements with the urban environment.

2. Impermanence, Movement and Managed Inundation
Involves the use of public domain elements that can be easily transported or safely submerged during a flood event.

3. Temporary Resistance
Involves the temporary activation of barriers and built form elements during a flood event.

4. Integrated Resistance
Provides permanent flood protection and resilience through the use of flood-resistant built form elements, construction materials and design approaches.

5. Step within the Site
Addresses the management of level changes within a building and across the site.

6. Step within Streets
Addresses strategies for the design and retrofitting of the streetscape to manage floodwaters.

Design Testing

A series of design testing options were developed to provide alternative built form solutions that address the specific flood conditions and urban environments within the Parramatta Context. This included the testing of design strategies for residential, retail and commercial built form typologies as well as elements within the public realm.

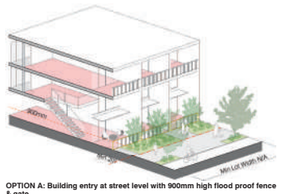
The design testing was informed by the case study research and guided by the following key principles:

1. Human Scale Steps
Aims to minimise the height transition from the public domain to the ground floor of a building. This includes the testing of tiered building setbacks, inclusion of human scaled design elements and defining of a desirable maximum height change within a step.

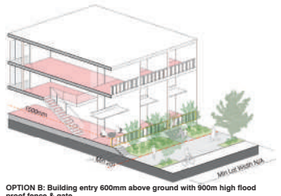
2. Active Spaces - Not Just Transition
Focuses on the activation of transitional spaces through good design integration and connectivity. This includes the integration of amenity within a transition zone, definition of the optimal width that permits an active transition space and the use of upper level promenades to connect buildings.

3. A Two Tier City
Addresses approaches to design for creating safe refuge facilities in the event of the PMF worst case scenario. This involves the provision of active, connected spaces at ground and first floor level.

Figure 1.1.3 Diagrams illustrating Design Guiding Principles, p80



OPTION A: Building entry at street level with 900mm high flood proof fence & gate.



OPTION B: Building entry 600mm above ground with 900m high flood proof fence & gate.

Figure 1.1.4 Residential Built Form Testing, p82

OPTION A: Building entry at street level with internal steps and ramps

OPTION B: Building entry at street level with internal steps and retractable stair / integrated lift system.

OPTION C: Temporary resistance barrier at the property boundary

Figure 1.1.5 Retail & Commercial Testing, p83

Recommendations - Parramatta CBD

The following design recommendations are provided for the Parramatta CBD precinct, in line with the three Design Guiding Principles:

- Step within the Site and connected promenades that allow pedestrian circulation during flood events. Supporting the installation of new and retrofitted green roofs should be considered.
- Streets and adjacent parklets could be upgraded to include new WSUD plantings at footpaths and medians
- More extensive on-street contouring and conversion of parking spaces to landscaped pedestrian zones should be considered where appropriate.
- Implementation of new bicycle path infrastructure should consider additional accommodation of flood water channelling.
- In areas of fine grain retail such as Church Street, utilise temporary resistance strategies to retain the integration between shop fronts, the footpath and outdoor dining areas.
- Managed inundation for a portion of the tenancy adjacent the footpath could also be consider to reduce the impact of steps and ramps on the public domain and building frontage.

Recommendations - Overall

The Best Practice Study provides a set of recommendations that are informed by flood management and response policy, context analysis, case study research and design testing undertaken within the report.

These recommendations are presented under the following categories:

1. Design Approach:

Specific design objectives and principles are provided to address the different characteristics and requirements of the following elements within the urban fabric:
- Interconnected Public Realm
- Precincts and Renewal Areas
- Infill Sites
- Building Typologies (Commercial CBD; Mixed Use; Fine Grain Retail; Adaptive Re-use; Residential Apartments)
- The Details (Emergency Egress; Basement Design; Vehicle Entries and Pedestrian Access; Building Services; High Hydraulic Hazard; Flood Conveyancing; Stairs, Walkways and Ramps; Walls and Materials).

2. Guiding Principles

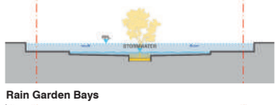
Recommendations that enable the optimum implementation of the three guiding principles (See 'Design Testing') have been derived from the testing of design options.

3. Site Planning and Design Process

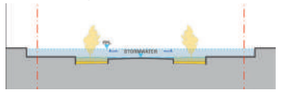
A series of steps are outlined to be undertaken as part of the planning and design process for future development of flood affected sites.

Bicycle Paths

Rain Garden Median



Rain Garden Bays



Park Median

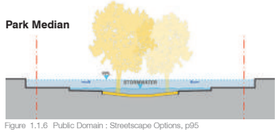
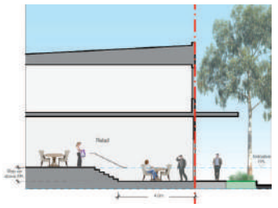


Figure 1.1.6 Public Domain : Streetscape Options, p95



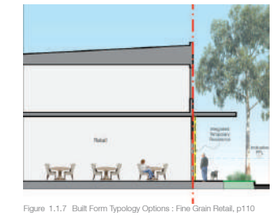
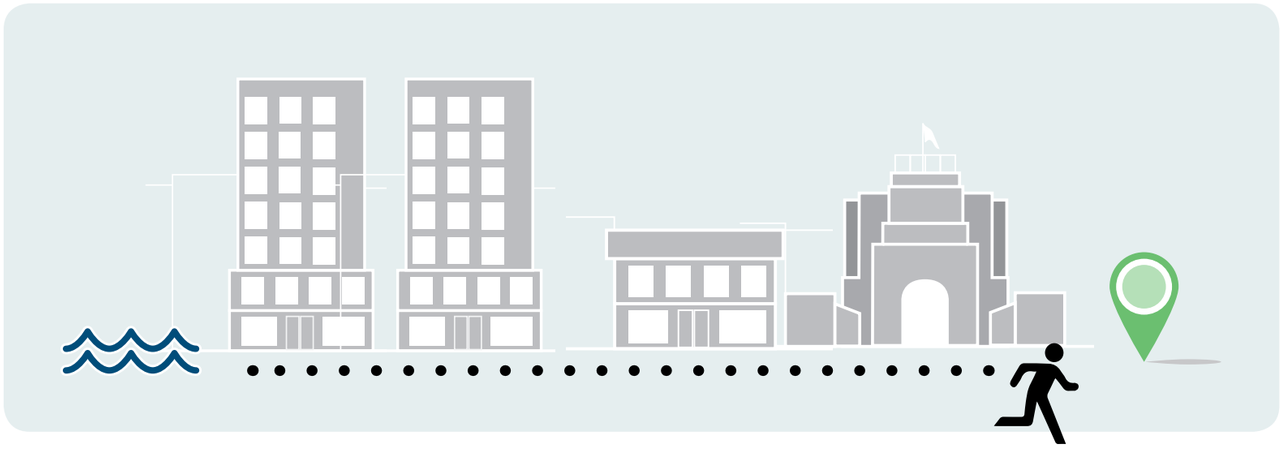


Figure 1.1.7 Built Form Typology Options : Fine Grain Retail, p110

Approach methodolody

01 Urban Conditions - Challenges and Opportunites



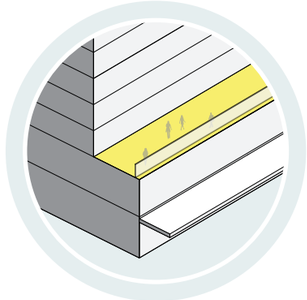
Can be achieved

Difficult to achieve - requires further consultation

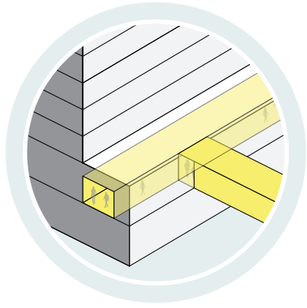
Cannot be achieved

02 Strategies

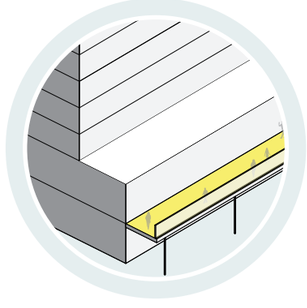
Above Podium



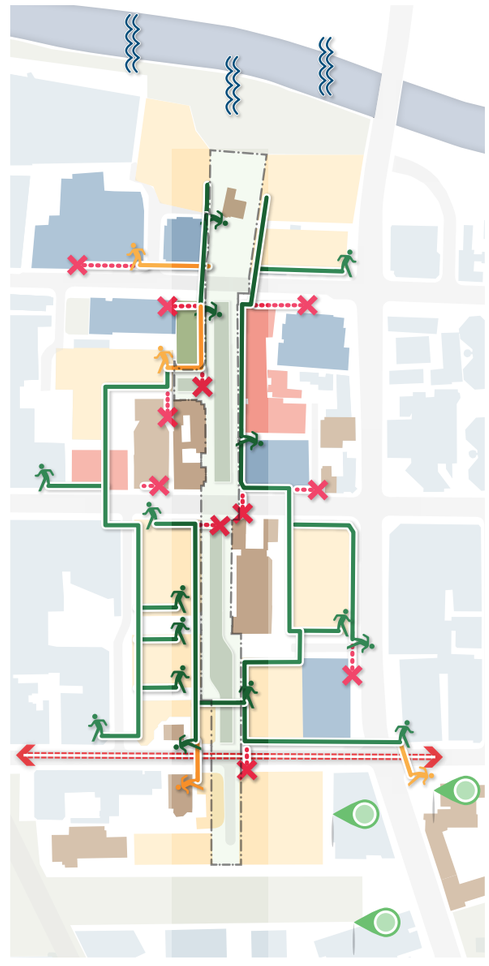
Indoors



Above Awning

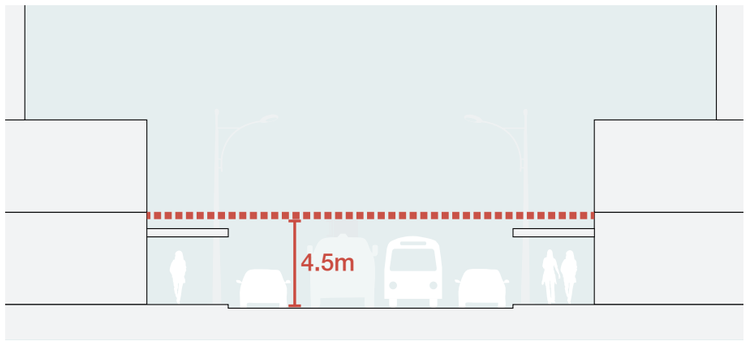


03 Testing on Civic Link



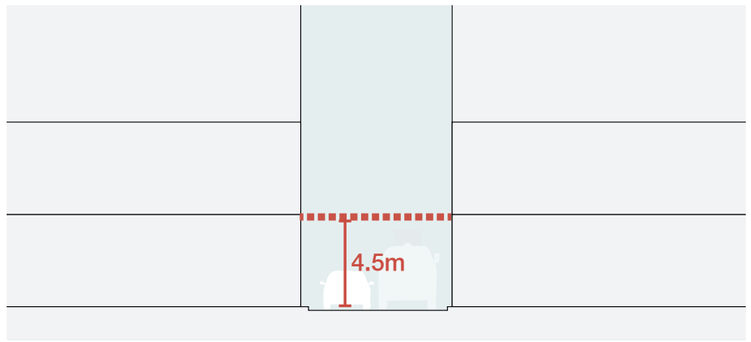
Evacuation Strategies

Urban Conditions



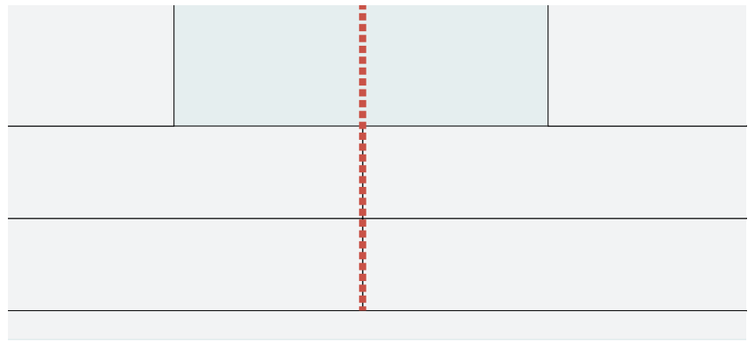
Over the Road

- Maintaining clearance height for service vehicles
- Spans of walkways will be longer and will need structural support within the public domain
- BCA/AS compliance issues
- Feasibility and cost issues



Over Lane

- Spans of walkways will be shorter and may not require structure within the public domain
- Maintaining clearance height for service vehicles
- BCA/AS compliance issues
- Feasibility and cost issues

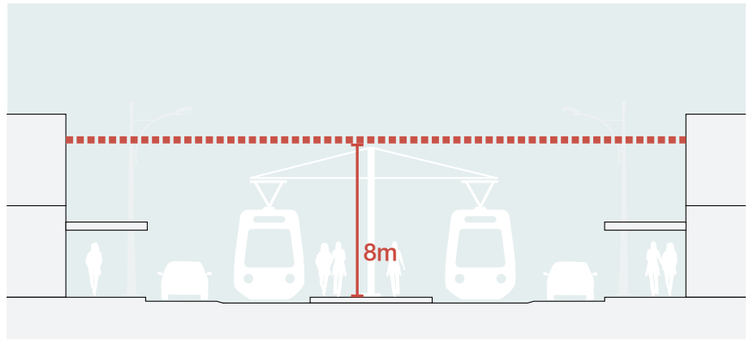


Over Boundary

- Dependant on adjacent buildings have podiums and internal floor levels at similar heights
- BCA/AS compliance issues
- Feasibility and cost issues

Over Public Space

- Visual structure in the space would detract from amenity and character of the public space
- Overhead structure may impede on solar access for open space.
- Requires clearance height for emergency and services vehicles.
- Structure to achieve span of walkways



Over Parramatta Light Rail

- 8m clearance height for light rail vehicles and infrastructure.
- Safety issues regarding interference with power lines and infrastructure.
- Spans of walkways

Evacuation Strategies

Building Conditions

New Building - New Building

- Access paths can be integrated in new building design
- Opportunity to create continuous street wall heights

New Building - ‘Unlikely to Change’

- Spans of walkways will be shorter and may not require structure within the public domain
- Maintaining clearance height for service vehicles
- BCA/AS compliance issues
- Feasibility and cost issues

‘Unlikely to Change’ - ‘Unlikely to Change’

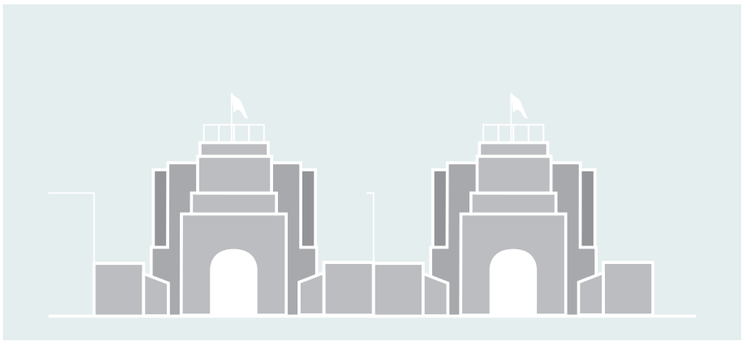
- Dependant on adjacent buildings have podiums and internal floor levels at similar heights
- BCA/AS compliance issues
- Feasibility and cost issues

Heritage - New Building

- Misaligned street walls
- Compromised character of heritage building
- Integration of walkways into heritage fabric and structure
- Structural integrity
- Will be cheaper and easier to retrofit over the top of buildings (for all of Top of Podium)

Heritage - ‘Unlikely to Change’

- Misaligned street walls
- Compromised character of heritage building
- Integration of walkways into heritage fabric and structure
- Structural integrity
- Will be cheaper and easier to retrofit over the top of buildings (for all of Top of Podium)



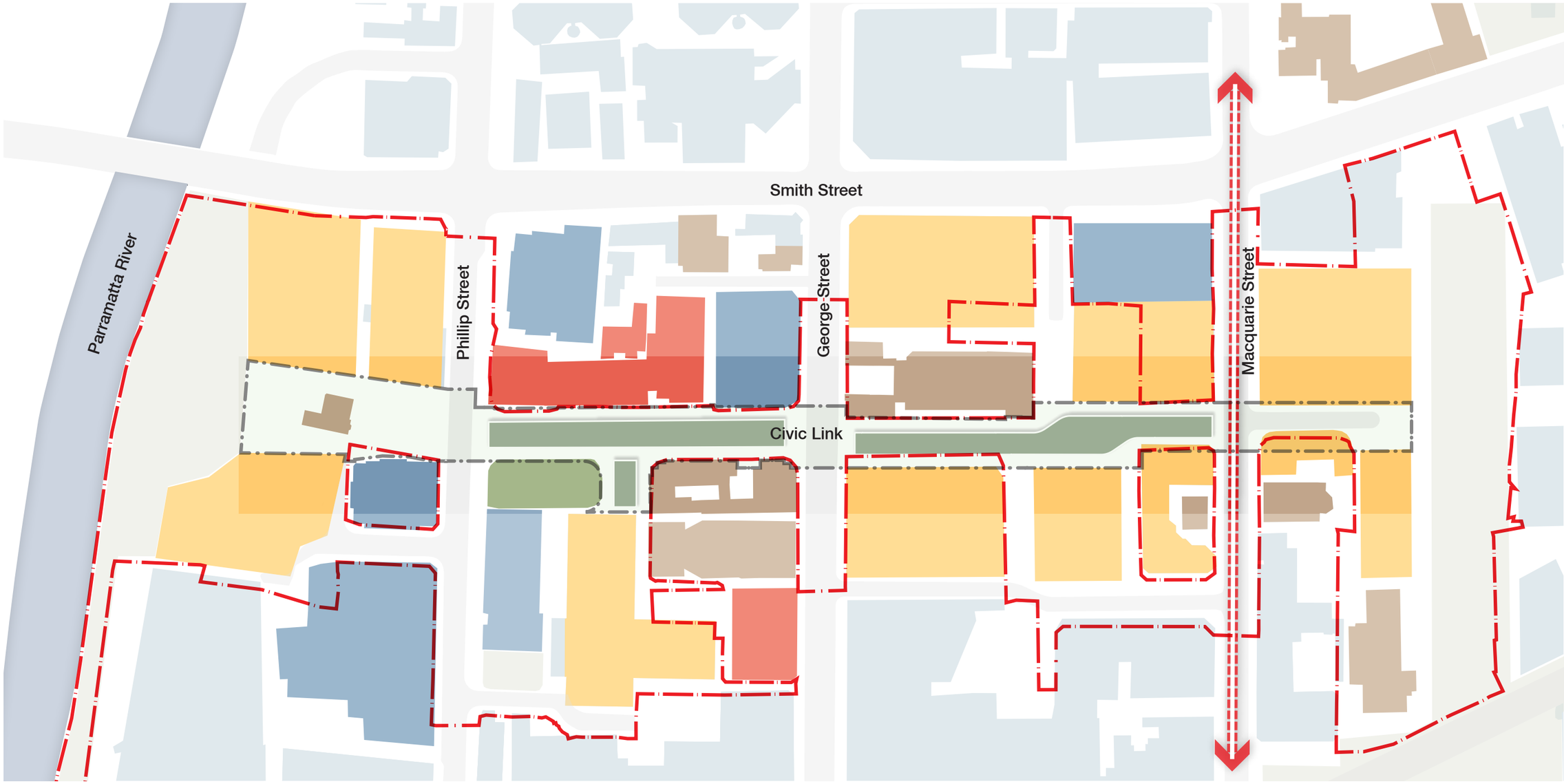
Heritage - Heritage

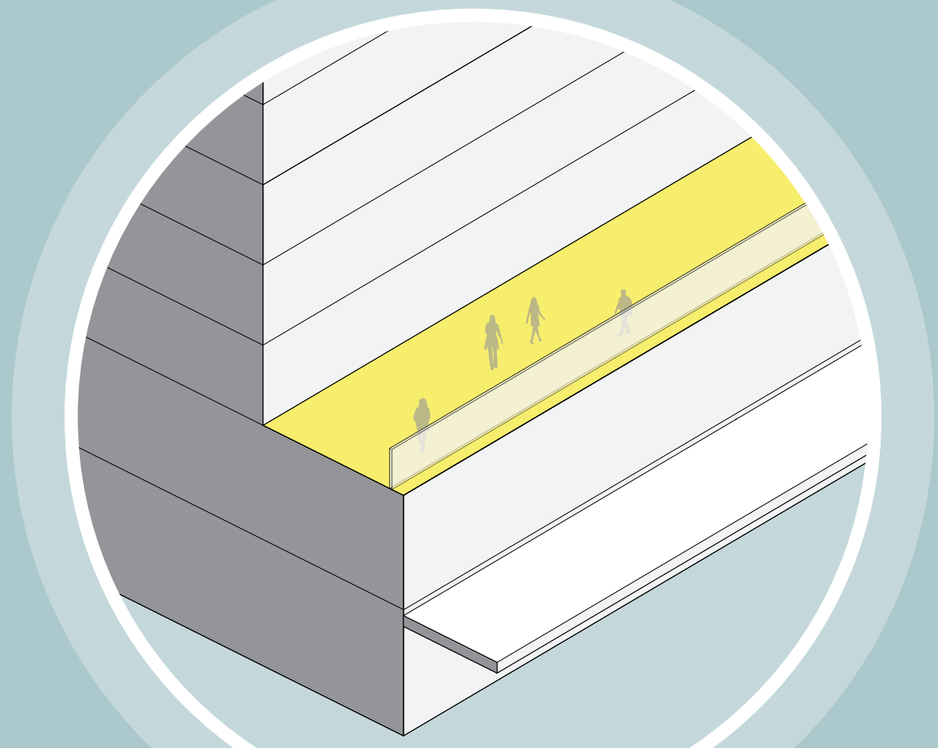
- Misaligned street walls
- Compromised character of heritage building
- Integration of walkways into heritage fabric and structure
- Structural integrity
- Will be cheaper and easier to retrofit over the top of buildings (for all of Top of Podium)

The Civic Link

Building Conditions

- Heritage Item
- Unlikely to Change
- Under Consideration for Redevelopment
- High Likelihood of Change

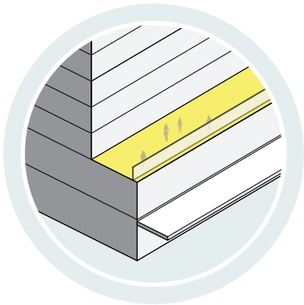




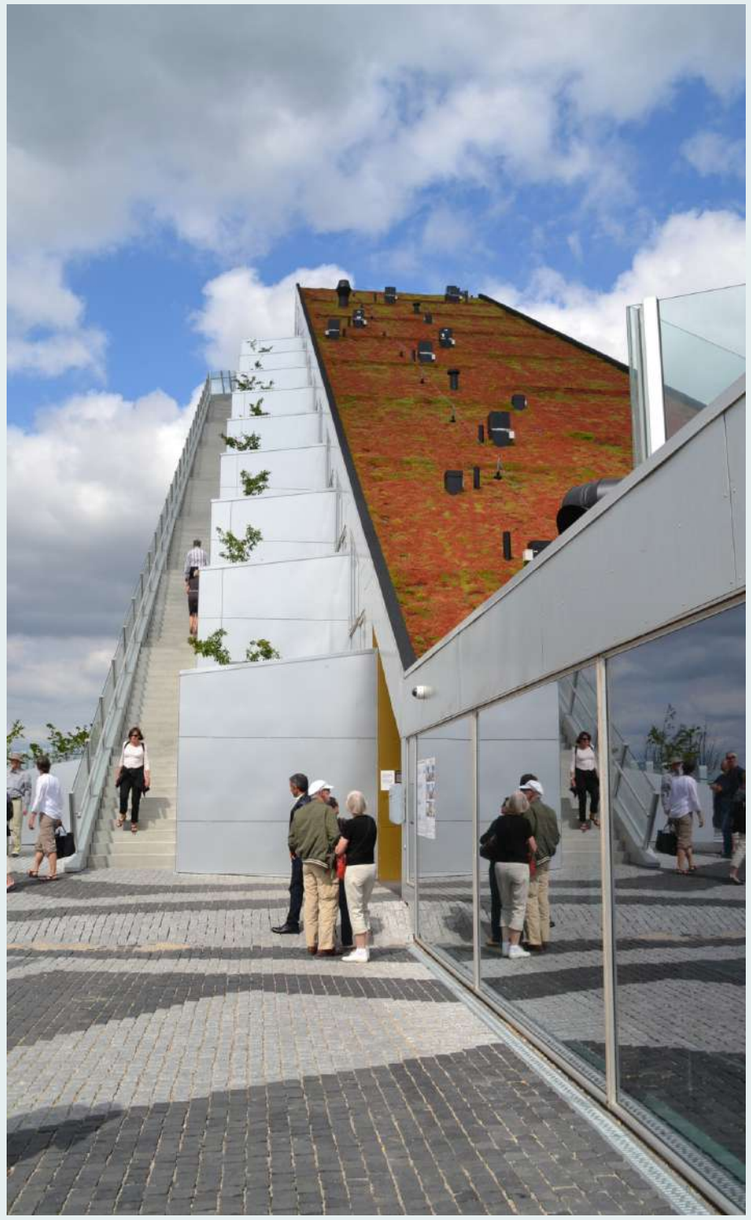
Top of Podium

Evacuation Strategy

Top of Podium

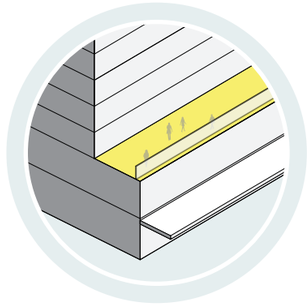


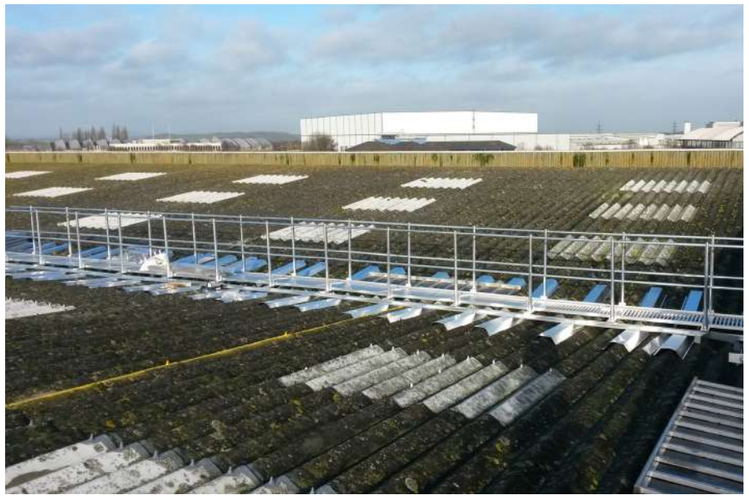
This evacuation method utilises setbacks above the street wall, roofs of existing small scale buildings, and podiums of new larger developments as an evacuation route to safety.
This strategy assumes that most of these spaces are typically not occupied for everyday uses, and can be made to allow for evacuation to other rooftops.
Proposed solutions as a part of this strategy are intended for the purposes of a flood event only and would not provide access at other times.



Case Study

Top of Podium





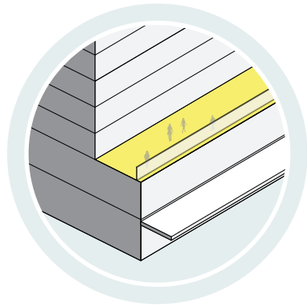
Strategy Evaluation

Top of Podium

✓ Can be achieved

– Difficult to achieve - requires further consultation

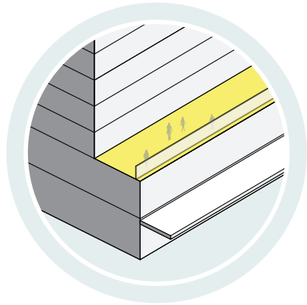
✗ Cannot be achieved



Conditions / Interface	1. New Building - New Building	2. New Building - Existing Building 'Unlikely to Change'	3. Existing Building - Existing Building	4. Heritage - New Building	5. Heritage - Existing Building 'Unlikely to Change'	6. Heritage - Heritage
A. Over Road	✓ · New sky bridge/ temporary structure can be integrated as part of design	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · Bridges and walkways over the road will may impact the integrity of the heritage item
B. Over Lane	✓ · New sky bridge / temporary structure can be integrated as part of design	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	✓ · may require retrofitting of existing structure but narrow width of lane can help conceal built external walkways	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.
C. Over Boundary	✓ · New sky bridge/ temporary structure can be integrated as part of design	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but can be concealed within the building fabric	✓ · may require retrofitting of existing structure but adjaceny of buildings can help conceal built external walkways
D. Over Public Space	✓ · New sky bridge/ temporary structure can be integrated as part of design	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · Bridges and walkways over the road may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item
E. Over Light Rail LIne	✓ · New sky bridge/ temporary structure can be integrated as part of design	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · Required clearances for bridges and walkways over the PLR may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item	✗ · Bridges and walkways over the road may impact the integrity of the heritage item

Civic Link Testing

Top of Podium



- Heritage Item
- Unlikely to Change
- Under Consideration for Redevelopment
- High Likelihood of Change

No streetwall or podium

No streetwall or podium to heritage item

Approximate Public Marshalling Area

Smith Street

Parramatta River

Phillip Street

George Street

Macquarie Street

Civic Link

No streetwall or podium

Link between heritage buildings and unlikely to change is problematic

No streetwall or podium

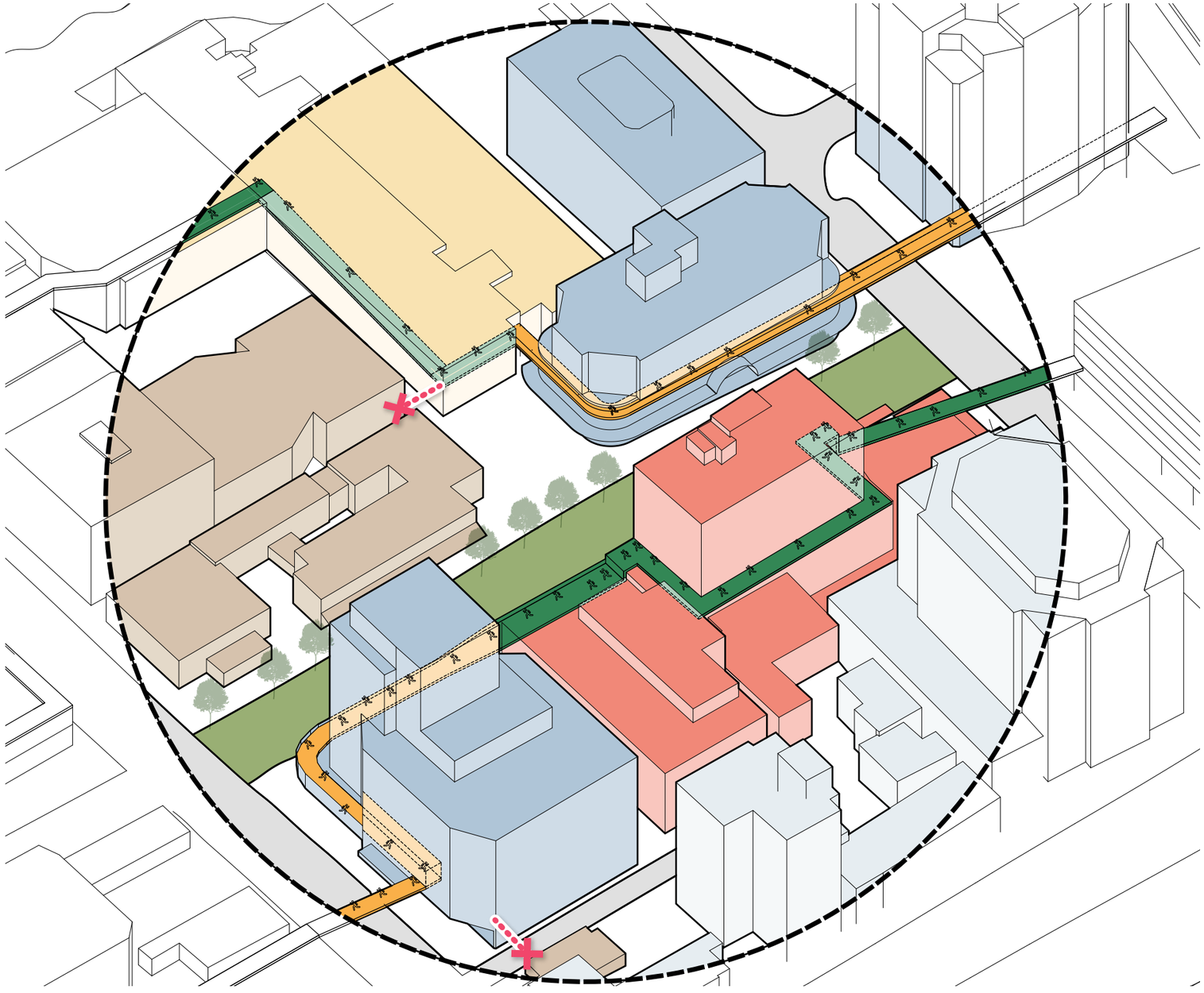
Evacuation path can be integrated into podium parking

Link above Civic Link is discouraged due to impacts upon amenity and character

Discussion

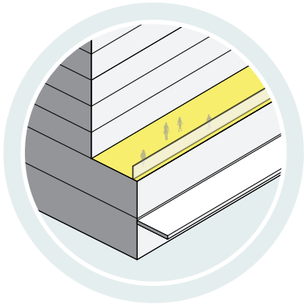
Top of Podium

- Possible to create a route well above the PMF.
- Most adjacent buildings can be connected either via the podium or podium to a rooftop via a staircase.
- Will require coordination between city blocks as to crossing point over a road or lane, should that be required.
- Lifting the path of travel will remove a number of hazards including floating or submerged and moving objects crashing into awnings.
- Hazards may include slips and falls as well as security of buildings.
- Hazard during a thunderstorm with lightning.



Evacuation Strategies

Top of Podium



Challenges

Feasibility
The cost of retrofitting walkways between the tops of podiums or buildings is relatively minor, and could be required as standard for all new buildings.

Heritage value
Due to the height of existing heritage items, this solution may require a walkway that sits above the roof of the building, which would dramatically impact the heritage item. Due to the difficulties involved with evacuating occupants to the rooftop of a heritage item such as new access ways, increased structure required and likely pitched rooves, it is unlikely that this option would an appropriate solution for heritage items, and thus the heritage items would remain a “low flood island” risk.

Visual impact
When retrofitting an existing building, lightweight materials such as aluminium and expanded steel may be utilised to connect to other buildings, or to provide one safe path of access across a rooftop or podium that may otherwise be inaccessible.

Adjacent levels
The various developments occurring around the CBD will provide a range of challenges when connecting between them. Connecting over the top of buildings that vary in height should be able to me managed as lightweight stairs are able to be provided and retrofitted into the system.

Safety
Appropriate safety measures should be able to be employed via handrails and signage. This solution will provide numerous situations for hazards including:
- slipping and falling from walkway
- moving off walkway and onto areas of buildings that are not usually accessible to the public
- hazard of being exposed to downpours of rain.

Additional safety measures to ensure that an evacuation route does not enable people to break into, or inappropriately access, areas of a building that are privately owned.

Wayfinding
Appropriate signage within the building is to be provided to inform occupants that the most appropriate strategy is to Shelter in Place, however if this is no longer safe, to evacuate to the podium or rooftop. Clear descriptions and wayfinding would need to be provided to ensure that evacuees are travelling towards a marshalling area or collection point, or more appropriately into the adjacent building to Shelter in Place. If evacuees are simply moving to an adjacent building, a plan for alerting SES as to the whereabouts of these occupants is crucial.

Structural integrity
Adequate structure will need to be provided if retrofitting existing buildings, and to ensure that these areas are trafficable and safe.

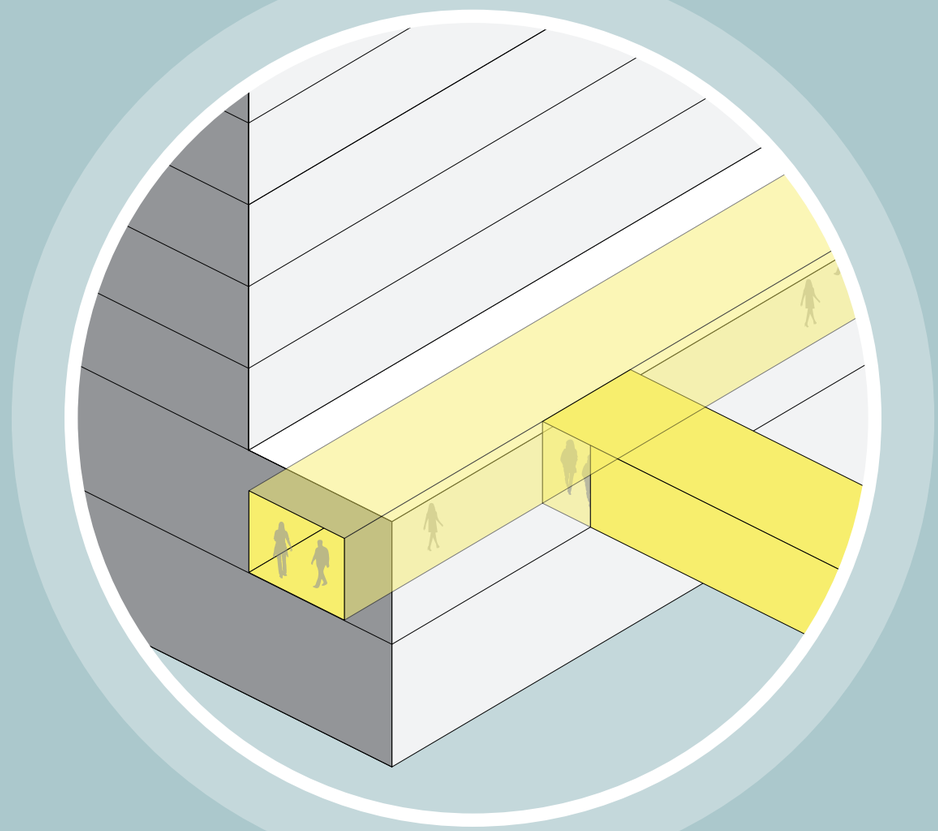
Continuous Path of Travel
This strategy is likely to be able to create a continuous path, however not one that is level. The continuous path will be formed of stairs, ramps and walkways, and can easily connect over the top of roads and public spaces if needed.
If the mechanisms are not permanently set up on the buildings, the way in which these are set up in an emergency event will need to be coordinated by both the CoP and building occupants.
However if evacuees are simply moving from one building to an adjacent building bridges to connect across roads and public spaces will not be required in most cases.

Opportunities

Feasibility
The cost of providing expanded metal walkways to existing buildings is minor, and can be incorporated throughout the city in a reasonably short period of time.

Implementation
If providing lightweight walkways to the buildings around the city, this could be funded by Council and other public sources, and implemented in a reasonable short period of time.

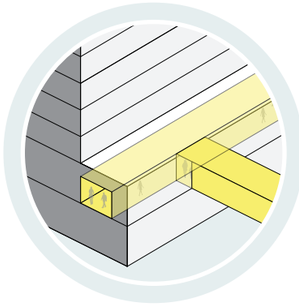
Design
New buildings would be able to incorporate a more permanent option within their design, as well as being better able to nagivate security concerns from the design phase.



Indoor Strategies

Evacuation Strategy

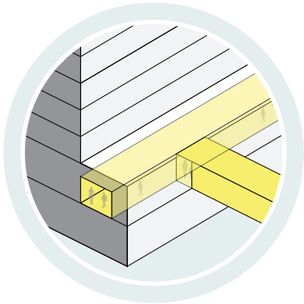
Indoor Evacuation

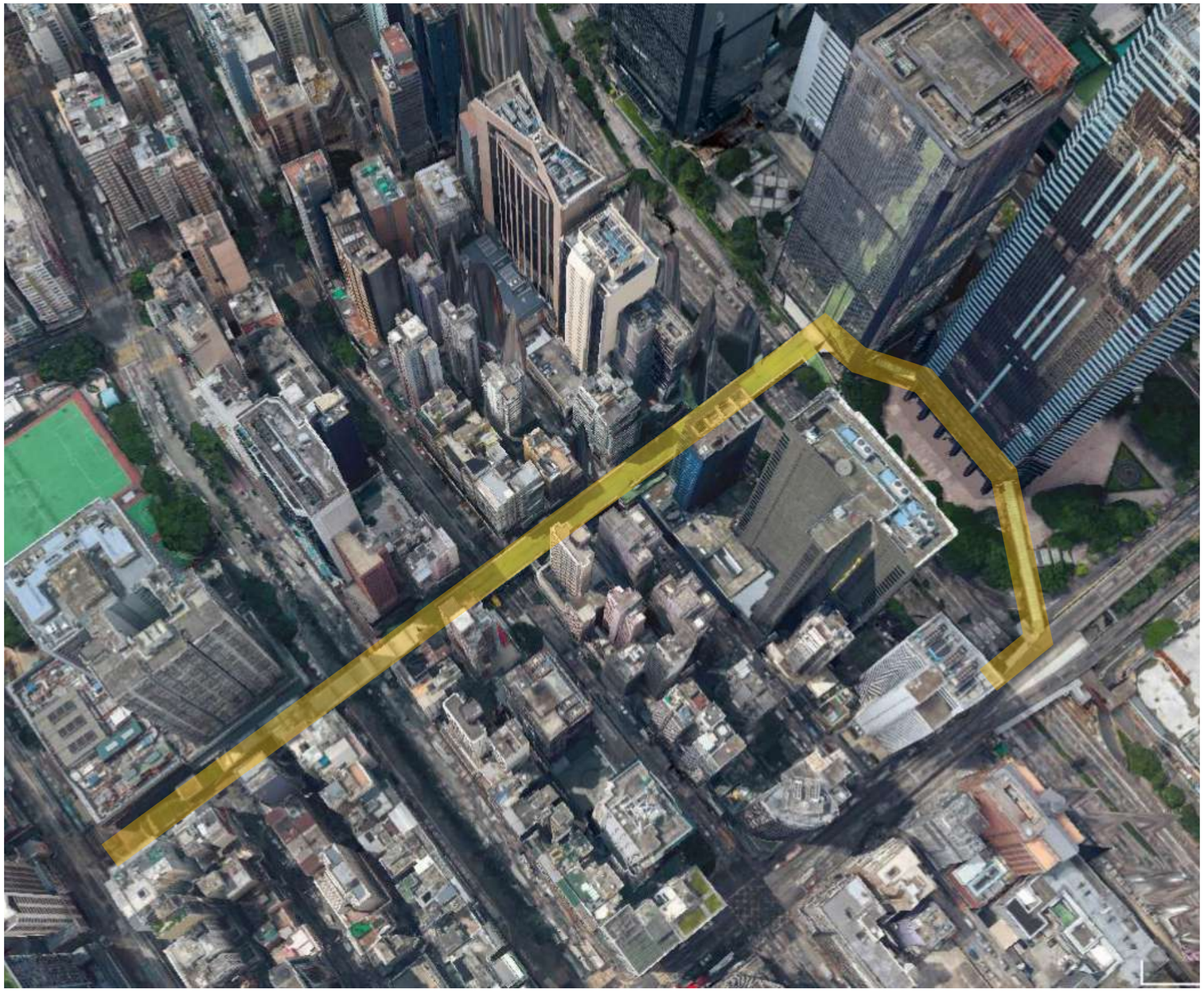


Indoor evacuation relies on the creation of a two tier city, connecting the upper levels of the city with public walkways providing a secondary address to buildings. This strategy assumes that the proposed connection will be internal publicly accessable privately owned space that is accessible 24hours a day. These spaces can be both passive and active, fronted by levels of double height retail spaces, commercial offices suites or planting.

Case Study

Indoor Evacuation





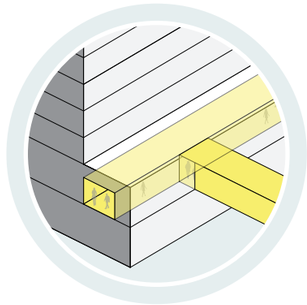
Strategy Evaluation

Indoor Evacuation

✓ Can be achieved

– Difficult to achieve - requires further consultation

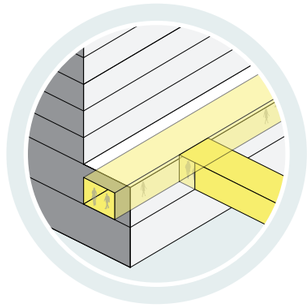
✗ Cannot be achieved



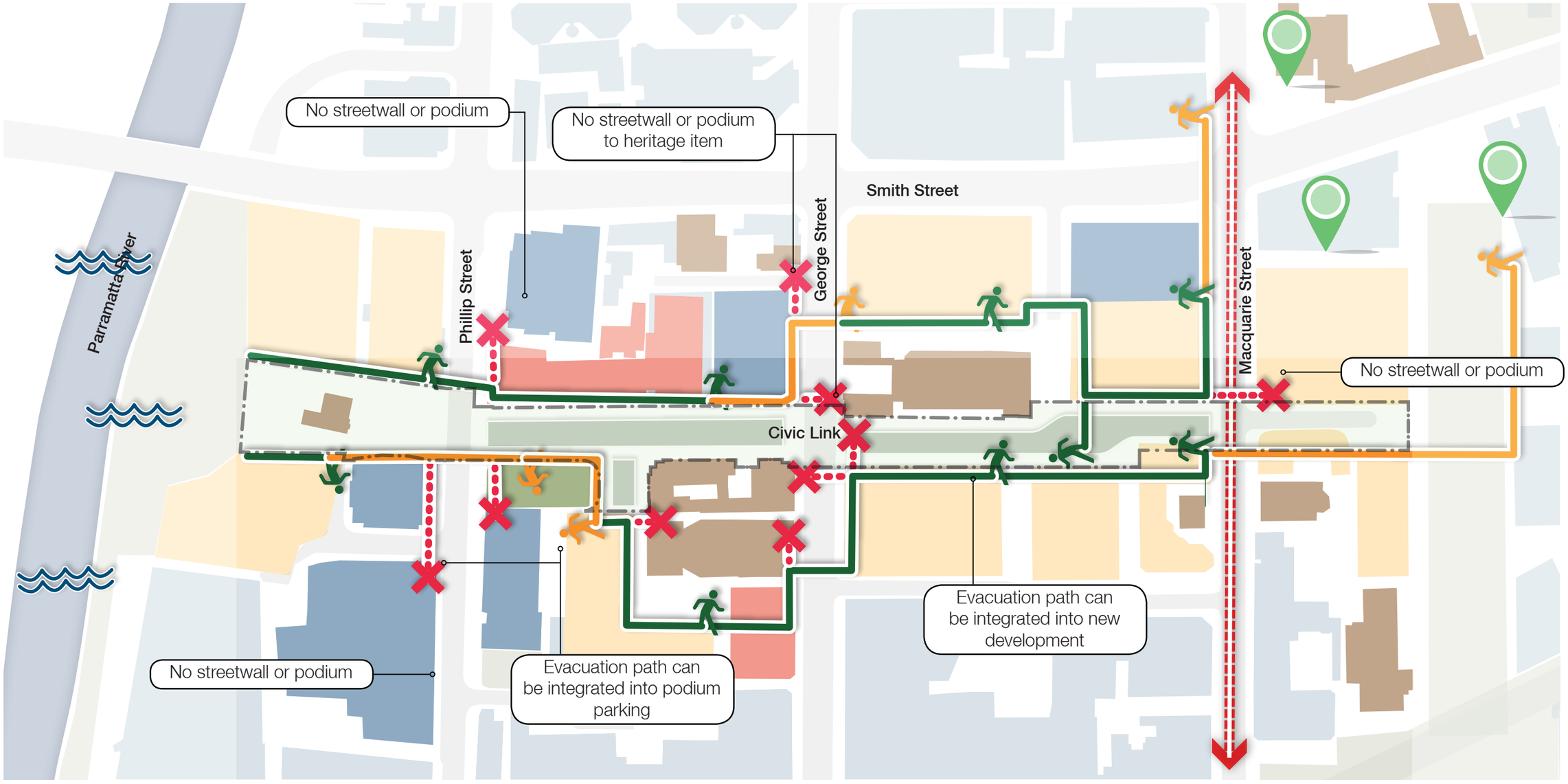
Conditions / Interface	1. New Building - New Building	2. New Building - Existing Building 'Unlikely to Change'	3. Existing Building - Existing Building	4. Heritage - New Building	5. Heritage - Existing Building 'Unlikely to Change'	6. Heritage - Heritage
A. Over Road	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
B. Over Lane	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
C. Over Boundary	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
D. Over Public Space	✓ · New sky bridge/ internal walkways can be integrated as part of design	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items
E. Over Light Rail LIne	– · New sky bridge/ internal walkways can be integrated as part of design. Height clearance	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · may require retrofitted structure on existing building may be visible/ unsightly in the public domain.	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items	✗ · May have significant impact the structural of heritage items

Civic Link Testing

Indoor Evacuation



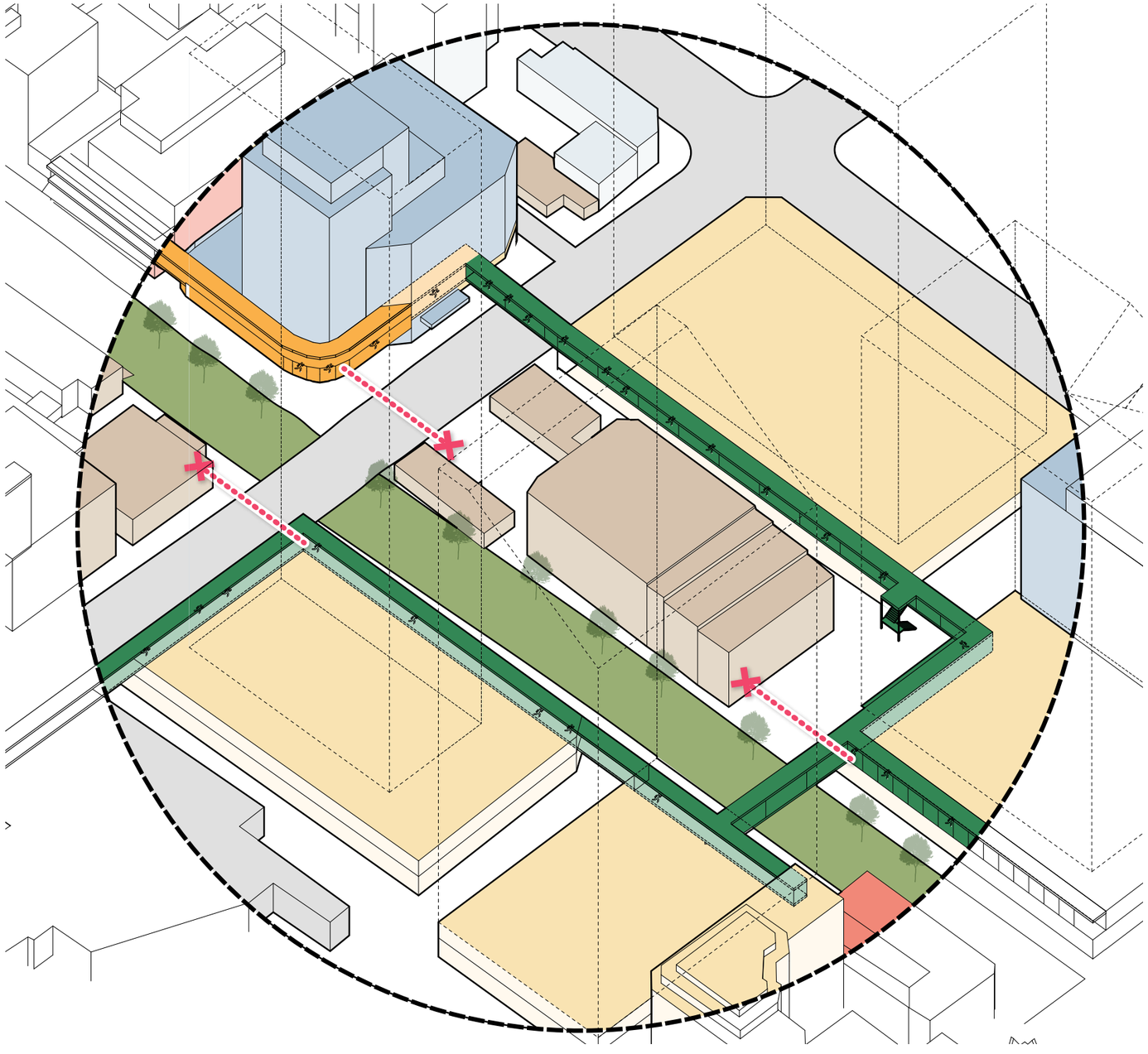
- Heritage Item
- Unlikely to Change
- Under Consideration for Redevelopment
- High Likelihood of Change



Discussion

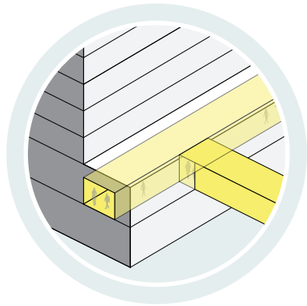
Indoor Evacuation

- Possible to create a route above the PMF, however this will take many years to implement.
- Most adjacent buildings can be internally connected.
- This strategy is costly and will require extensive coordination between land owners. It is unclear who would cover what costs.
- Will require coordination between city blocks as to crossing point over a road or lane, should that be required.
- This option provides a safe path of travel.
- Potential to connect the city and create new two-tiered city.



Strategy Evaluation

Indoor Evacuation



Challenges

Feasibility

This evacuation option is likely to be more expensive due to the cost of integration into the existing fabric of the building. Walkways spanning between buildings also need to be structurally sound, and create a complete seal to the building where they enter.

Heritage value

Creating a walkway that connects into a heritage building would significantly damage or compromise the integrity of the item.

Adjacent levels

Due to the rapid development underway in the CBD, it is likely that there will be existing and new buildings constantly changing. New buildings now have to address flood levels through elevated floor levels, whilst many existing buildings will have floor levels that do not align. Hence the connection of various floors between buildings will pose a challenge to creating a path of access, and an appropriate architectural solution.

Integrity

This is a more complicated approach as the walkways connecting between buildings have not been accounted for in the original design of a building (in the case of retrofitting). This requires additional cost to ensure the structural integrity of the walkway, as well as the cost to the architectural integrity of the building.

Safety

The risk to evacuees moving between buildings is greatly reduced in this option, as the path of travel is sheltered from the weather, and is less likely to create a slip hazard, or allow access to aeas that occupants should not travel to.
In the case that occupants are evacuating because of a fire in a building, this option will not be safe, as appropriate fire measures would need to be in place to separate the buildings. As such, in the case of a fire, these internal walkways would either need to be treated in the same manner as a fire escape, or alternatively, provide separation between the buildings and create an inaccessible area. In the later case, the walkway can no longer serve it's purpose for evacuation. In the first case, the walkway takes up valuable space within a building envelope that is only used in the case of an emergency.

Implementation

This strategy would have a lengthier time frame than the other two strategies, and would require extensive negotiations between land owners, Council, and other government organisations. A holistic strategy could take years to deliver, and in the meantime a more appropriate strategy may need to be implemented to reduce the levels of risk within the CBD. This would suggest that a more appropriate response may be to address the immediate needs of the CBD. Existing uses will also need to be renegotiated to allow public access to parts of the building as a permanent solution.

Continuous Path of Travel

This strategy is unlikely to be able to provide a continuous path of travel due to the private nature of many of the buildings in the CBD. Connecting to different levels between the buildings will cause the main problem for connectivity, as well as some building operators not wishing to create an internal and permanent connection.
As this strategy assumes that there is a new 24 hour public space running above the city, there will be no issues with the need to instigate the emergency response such as connecting bridges over roads. The walkways are permanent and already in place.

Opportunities

Visual impact

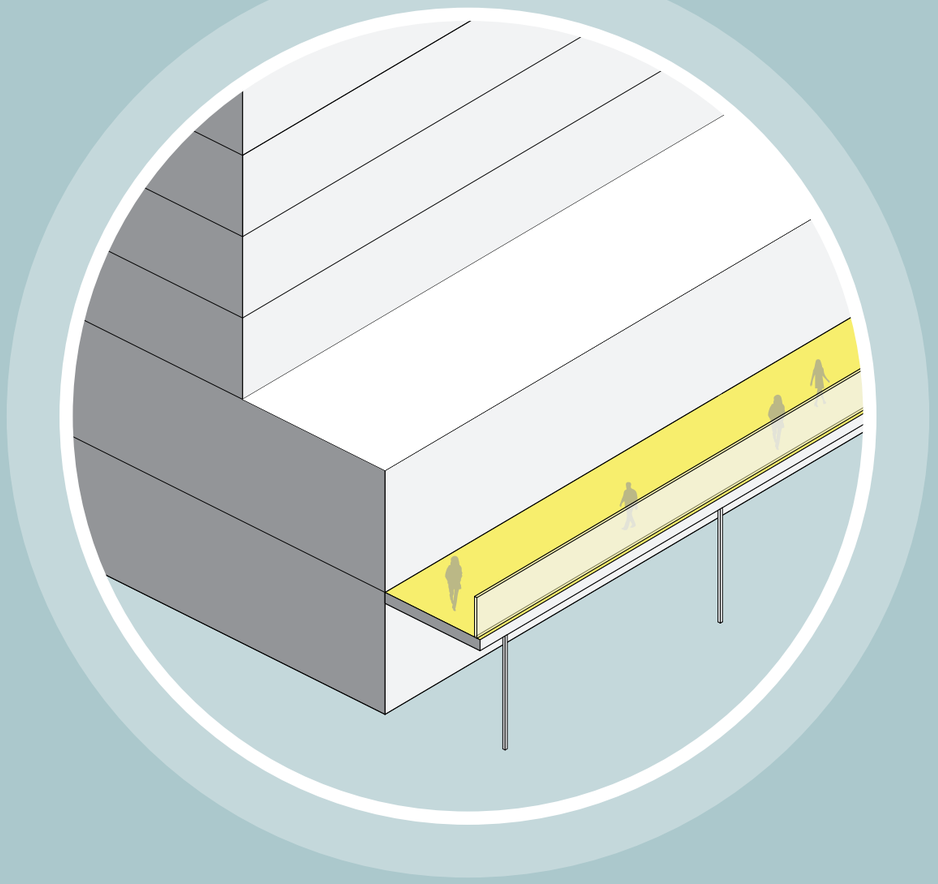
The impact upon the city of this strategy will only be seen between buildings, and could potentially be dealt with in an attractive manner.

Wayfinding

A wayfinding strategy within internal paths of travel would be easier to manage and implement, as the walkways can be clearly signed within the buildings.

Design

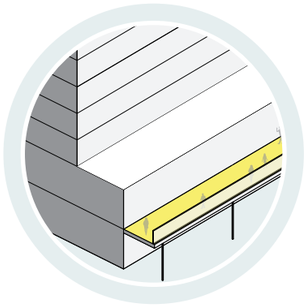
A number of cities around the world have indoor pathways that connect large sections of the city, whether through raised walkways or underground arcades. These can be designed to become the 'second tier' of the city, and provide retail or public amenity to these walkways.



Above Awnings

Evacuation Strategy

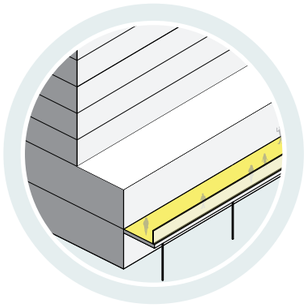
Evacuation via Awnings and external walkways

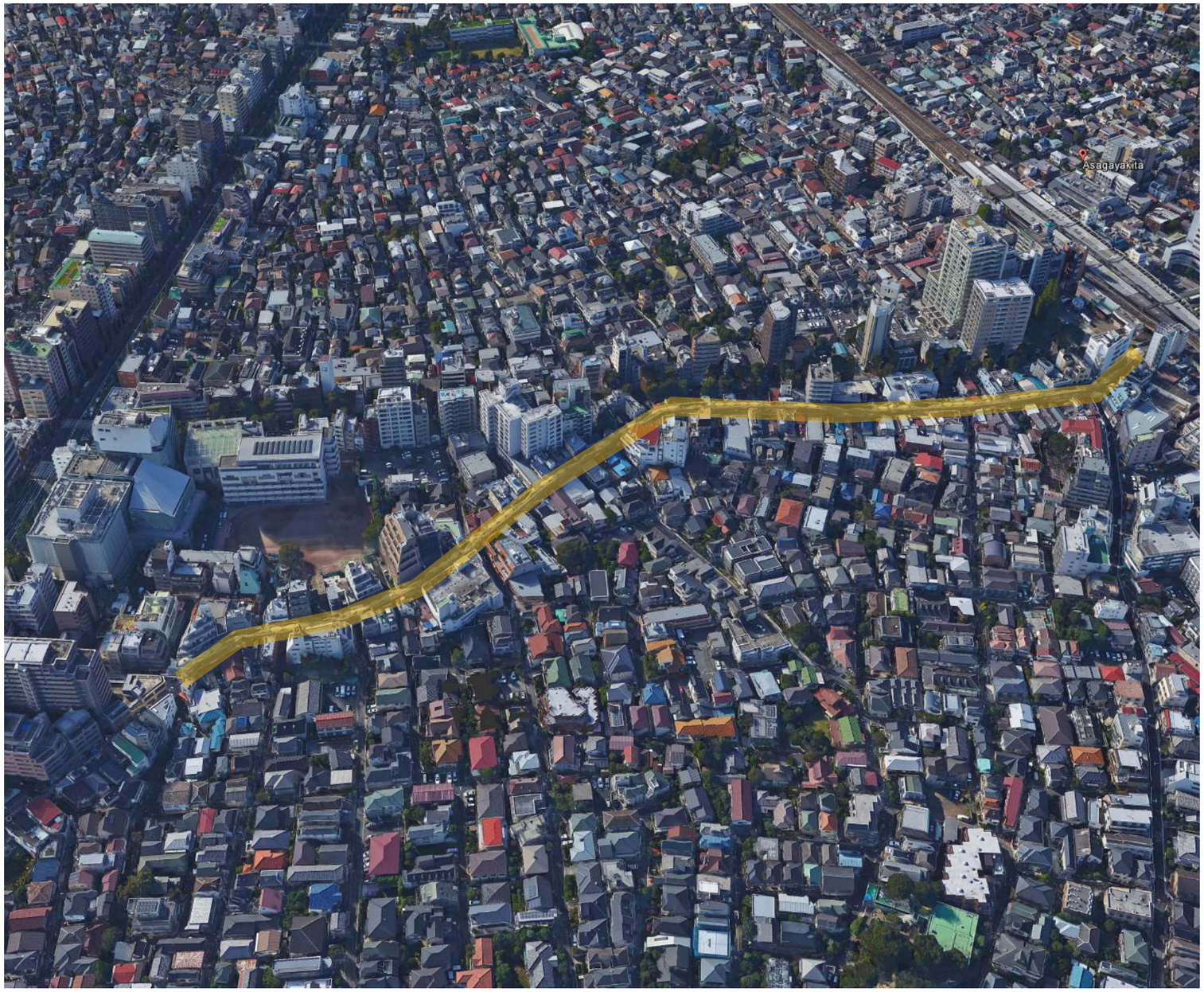


This strategy relies on the construction of trafficable awnings to prove access to refuge in the event of a flood within the CBD. Awnings typically only extend to the front of the building and do not cross streets and lanes, and would require a bridge to cross should evacuees need to move to a public marshalling area.
A continuous awning can be delivered by individual developments or as a single public domain element delivered by the Civic Link.

Case Study

Evacuation via Awnings and external walkways





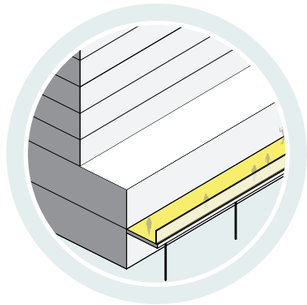
Strategy Evaluation

Evacuation via Awnings and external walkways

✓ Can be achieved

– Difficult to achieve - requires further consultation

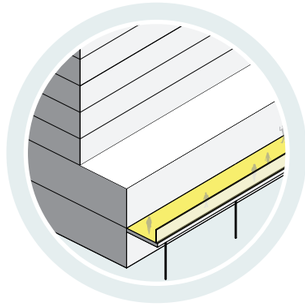
✗ Cannot be achieved



Conditions / Interface	1. New Building - New Building	2. New Building - Existing Building 'Unlikely to Change'	3. Existing Building - Existing Building	4. Heritage - New Building	5. Heritage - Existing Building 'Unlikely to Change'	6. Heritage - Heritage
A. Over Road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require retrofitted structure of existing building to allow for contunied walkway. Dependant on exiting use	– · will require independant structure to cross the roads	– · will require independant structure to cross the road	– · will require independant structure to cross the road
B. Over Lane	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road
C. Over Boundary	✓ · Awnings can be made to align with adjoing properties	✓ · Awnings can be made to align with adjoing properties	✓ · Awnings can be made to align with adjoing properties	– · May have significant impact the integrity and structural of heritage item	– · May have significant impact the integrity and structural of heritage item	– · May have significant impact the integrity and structural of heritage item
D. Over Public Space	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road	– · will require independant structure to cross the road
E. Over Light Rail LIne	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective	✗ · Required height to clear PLR will mean awning is inaffective

Civic Link Testing

Evacuation via Awnings and external walkways



- Heritage Item
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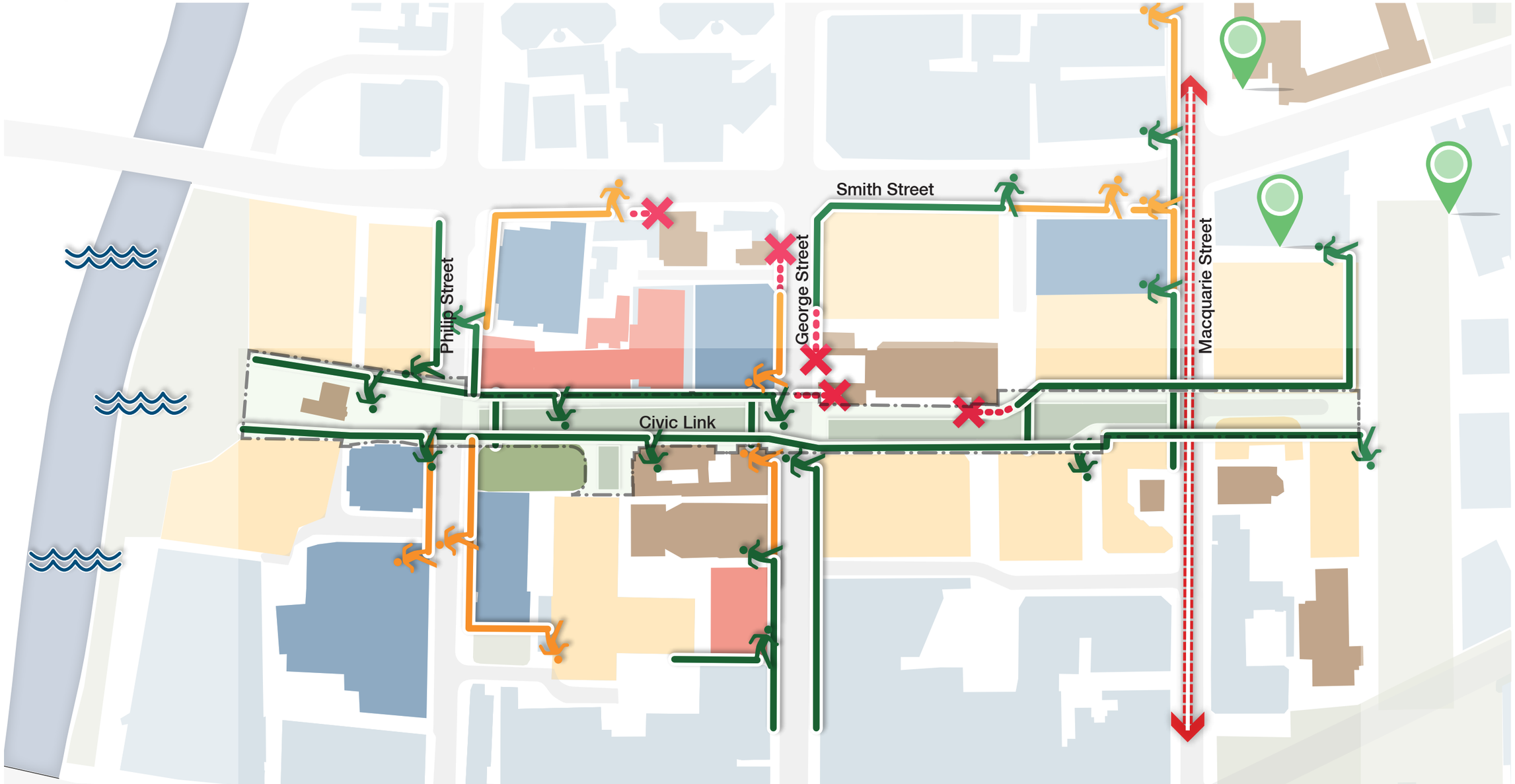


Discussion

Evacuation via Awnings and external walkways

- Possible to create a route, however this is not always above the PMF and hence does not lower the risk of developments.

- Does not create a safe path of travel, with submerged objects moving underwater and crashing into awnings.

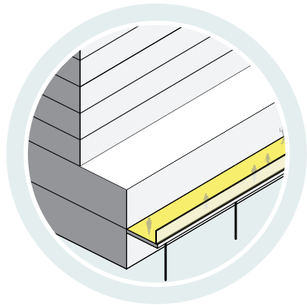
- Most adjacent buildings can be connected.

- This strategy is costly due to most awnings needing to be replaced to carry the load of people walking during an emergency.

- Will require coordination between city blocks as to crossing point over a road or lane, should that be required. This would create a permanent fixture in the public domain which is unlikely to be desireable as an urban design feature.

Strategy Evaluation

Evacuation via Awnings and external walkways



Challenges

Feasibility

There may be challenges in getting a unified roll out of this strategy through the city. Owners of buildings with recently completed awnings will not wish to replace the awnings with new, more structurally sound awnings. Whilst more feasible than the Indoor strategy, it will still be more expensive than the Above Podium option.

Heritage value

Heritage items that have flat and trafficable awnings would need to replace them to ensure their structural integrity. However a number of items have bull-nose awnings which would not be trafficable. Replacing these with a different style would damage the integrity of the item.
In the case where an item has no awning, the addition of an awning would again damage the integrity of the item.

Adjacent levels

The creation of a continuous and level awning throughout the city is a fairly straightforward task, however the PMF level throughout the CBD varies significantly.
It is crucial to an effective evacuation strategy that the evacuation route is above the PMF. As such, this strategy will not be applicable through some areas of the CBD, where the PMF is above typical awning height.

Wayfinding

Wayfinding would be challenging due to the discontinuous path of travel, and having to place signage on the exterior of buildings.

Integrity

To appropriately provide a safe and effective route of travel, the awnings must be structurally sound and able to carry a heavy temporary load. This will require additional cost to a typical awning, and dependant on the size of the building and the number of occupants, may even require structural posts to the street frontage. Awnings of this style can be troublesome due to RMS requirements, and may not be approrpiate within the city.

Safety

Travelling along an awning provides the greatest number of risks to an evacuee including exposure to heavy rain and potential storm conditions. A number of floating objects are also likely to threaten evacuees, such as cars that are floating at or just below awning height.
Safety railing is recommended to be provided to avoid slips and falls, which could pose an unpleasant addition to the built form.
Powerlines from the streets or Parramatta Light Rail may potentially be active and fall, creating additional hazards.

Implementation

This strategy would be reasonably straightforward to implement throughout the city in terms of providing a continous awning and requiring additional safety measures for them, however creating a continuous path of travel around the city would be challenging, and would require a combination of strategies.

Continuous Path of Travel

It will not be possible to have a continuous path of travel through the city, as some awnings are under the PMF height.
When the path of travel comes to a road, lane or public open space, a bridge would be required to connect to the other side. As such, in any application of travel on the awning, a combination of strategies will be required.
If the mechanisms are not permanently set up on awnings, the way in which these are set up in an emergency event will need to be coordinated by both the CoP and building occupants. Allowing time for bridges to be set up throughout the city is something that is unlikely to have time in an emergency event, however simply moving from one building to the adjacent building should not require a bridge in most cases.

Opportunities

Visual impact

This strategy will have minimal visual impact, provided that any additional safety measures are able to be hidden when not in use (i.e. hand rails to prevent slipping and falling).

Design

A continous awning of this nature could be designe and delivered as part of the Civic Link project.

Discussion & Recommendations

Heritage Items

- Evacuating heritage items will always be an issue. Retrofitting any of the three solutions to a heritage item is likely to severely compromise the integrity of the item. As such, any heritage item within the 1 in 100 year flood level will remain a “low flood island” (high risk), and should have a specific evacuation strategy. Occupants of heritage items should evacuate the city in the same way as a pedestrian in the public domain.

Strategies

Indoor

- The indoor evacuation scheme could potentially provide a good outcome for the city, and architecturally could be made to become an asset to the city. However, this strategy is likely to take upwards of 10 years to deliver a city-wide scheme, and will not help the evacuation of the city in a flood event before its implementation.

Above Awning

- The above awning strategy poses a significant cost to the city, without a truly safe evacuation route, or a route that is continuous through the city.

Above Podium

- The above podium provides the most immediate strategy that can be implemented city-wide by the CoP, and has the opportunity to develop into a more permanent and designed solution over time. This solution not only immediately lowers the societal risk within the city, but can also provide safe access to evacuees through the city.
- The nature of the temporary walkway response above podiums will also convey a sense of caution within an emergency event, and minimise the amount of travel that an evacuee will be comfortable to take. This will encourage occupants to remain within a building unless it is necessary that they evacuate.

Recommendations - Above Podium/Elevated Walkways

- It is recommended that Council continue to work with the SES to educate occupants as to a building or **city block emergency management plan** as follows:
    - The emergency response to a flood event for an occupant is to **Shelter in Place** as the first and most preferable response.
    - In the case that occupants must evacuate their building, they are advised to move to the **adjacent building to Shelter in Place**.
    - In the extreme event of all buildings in a city block being unsafe to Shelter in Place, evacuees are permitted to **move between city blocks via the walkways across the podiums or rooftops**. This would require coordination between city blocks to establish the most appropriate crossing point between buildings across a road or laneway.
    - **Clear signage and wayfinding** will be required to ensure that the most efficient route is travelled by evacuees, and that evacuees are made aware that Sheltering in Place is the safest option.
    - **Communication devices** should be made available and clearly marked within all buildings to contact the SES and alert them of the number of people Sheltering within a building.
    - **Flotation Devices and Personal Flotation Devices** may be considered as part of an emergency response, to be made available to evacuees on the way out of a building in the case of evacuation.
    - Given that the natural response of occupants within an emergency may be to evacuate via the fire stairs, it is important that the **fire stairs are clearly signed** to indicate that exiting at the ground or first floor may be hazardous due to flood waters outside the building. The evacuation route for buildings during a flood event will be different to the evacuation route during a fire event. This is important to educate occupants about in the same way a fire drill is conducted, a **flood drill** should also be conducted, and coordinated between city blocks.
- A **city-wide emergency communication system** should also be implemented by Council to inform occupants within the city about the flood event, and provide regular updates.

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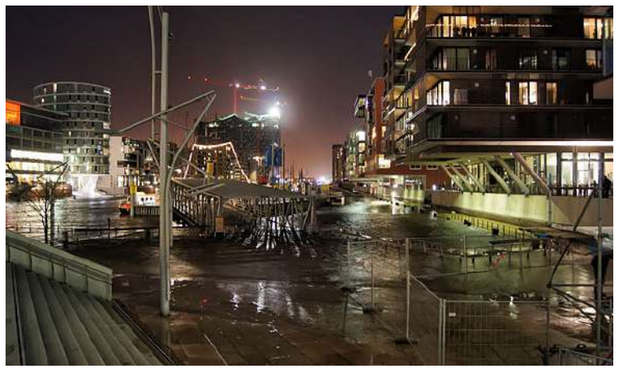
1.1 HafenCity, Hamburg

Key principles

- Hafen uses a high dike which provides a continuous protection along a distance of 100km to protect lower lying areas against flooding.
- Retains access to the water whilst guaranteeing protection from floods
- The first floor of every building on the promenade is dedicated to retail outlets, and exhibition spaces, that are sealed off in times of flooding.
- Buildings behind the promenade are built on “warts” (elevated mounds) 8-9 meters above mean sea level. The streets are also on this higher level and not effected by the neighborhood’s annual flood.

Risks and Challenges

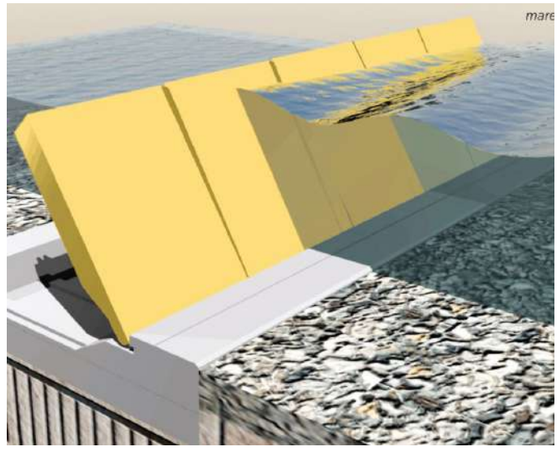
- Three eastern neighbourhoods are more isolated and less integrated in the the city
- Large amounts of built landscape in comparison to green space, in particular in the western part of the district which is due to the fact that the surface of HafenCity is the result of the artificial soil during the construction of the port, it is evident in the lack of trees and other natural elements.
- Dikes are very expensive device for flood management and prevention however warts and sealed off first floor are a relatively inexpensive solution
- Elevated mounds and sealed off first floors would be difficult to implement in existing buildings

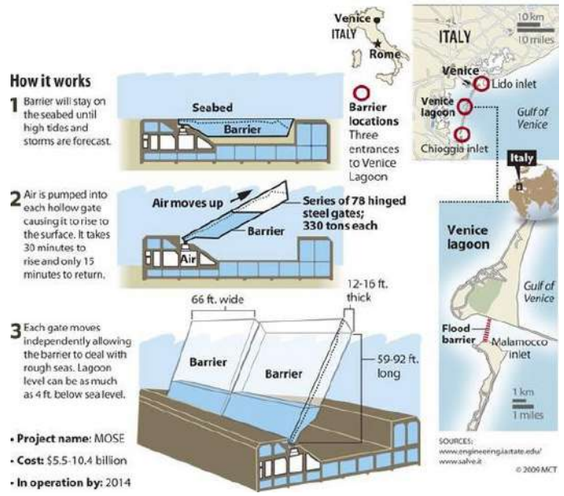


1.2 Piazza San Marco, Venice

Key Principles
- The city installs a network of walkways along the main pedestrian paths, generally at 120cm above the standard sea level
- Water transport becomes available all across all weather routes
- Flood information is provided in real time and usually lasts for 2.5 hours
- Currently underway is a new flood management system called MOSE (MOdulo Sperimentale Elettromeccanico, Experimental Electromechanical Module) a project intended to protect the city of Venice, Italy, and the Venetian Lagoon from flooding. The project is an integrated system consisting of rows of mobile gates installed at the Lido, Malamocco and Chioggia inlets that are able to temporarily isolate the Venetian Lagoon from the Adriatic Sea during high tides. Together with other measures such as coastal reinforcement, the raising of quaysides, and the paving and improvement of the lagoon, MOSE is designed to protect Venice and the lagoon from tides of up to 3 metres (9.8 ft).

Risks and challenges
- Storage of temporary devices
- Tidal appropriate
- Preparation time

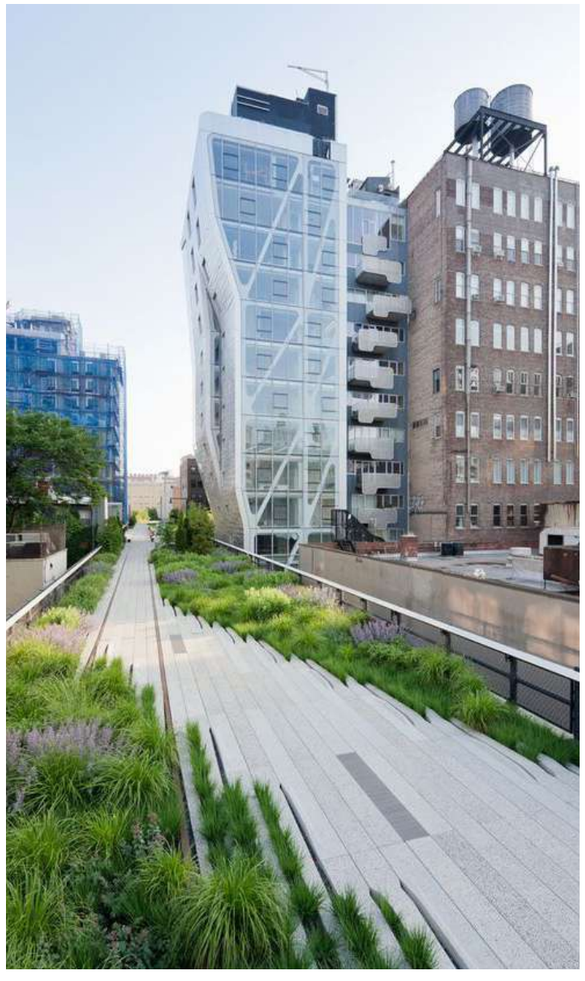




1.3 Evacuation to Permanent Devices in the Public Domain

Delivery challenges:

- Expensive to build into the public domain
- Durable materials would be required to ensure longevity and high use
- Coordination with building owners to decide how these devices are connected to buildings and manage different building levels
- Access from the street to these devices required
- Retrofitting existing public domain would be difficult and require it to be accessible, withstand vandalism and quickly implemented
- Barrier is created between the streets and public domain and therefore a strong connection would need to be created to ensure no dead space
- Capacity of the space needs to be aligned with future growth of the CBD and needs to be structurally sound to hold a large volume of people.
- Impact on the amenity of the public domain need to be considered.



1.4 Evacuation to Temporary Devices in the Public Domain

Delivery challenges:

- Storage requirements for temporary devices would need to be retrofitted into the public domain and/or existing buildings
- Possible vandalism to devices kept in the public domain
- Maintenance to ensure devices are safe and in working condition
- Volume and size of the devices would have to be appropriately designed for to ensure they cater for the estimated number of people that would need it and the amount of water preventing
- Structurally sound to hold people using it
- Time required to setup devices which might always be possible
- Durability of materials to endure weathering, volume of people and possible vandalism
- Would require a coordinated emergency flood management plan