

**BLACKWATTLE BAY CATCHMENT
FLOODPLAIN RISK MANAGEMENT
PLAN
FINAL REPORT**





Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: 9299 2855
Fax: 9262 6208
Email: wma@wmawater.com.au
Web: www.wmawater.com.au

BLACKWATTLE BAY CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

FINAL REPORT

SEPTEMBER 2015

Project Blackwattle Bay Catchment Floodplain Risk Management Plan		Project Number 113046
Client City of Sydney		Client's Representative Shah Alam
Authors Dr. Chin Cheah Steve Gray Felix Taaffe		Prepared by <i>Felix Taaffe</i>
Date 12 May 2017		Verified by 
Revision	Description	Date
6	Final Report	Sep 2015
5	Final Draft Report	Mar 2015
4	3rd Draft Report for Public Exhibition	Sep 2014
3	2nd Draft Report	Jul 2014
2	Draft Report	May 2014
1	Stage 1 Report	Oct 2013

BLACKWATTLE BAY CATCHMENT FLOODPLAIN RISK MANAGEMENT PLAN

TABLE OF CONTENTS

	PAGE
FOREWORD.....	i
EXECUTIVE SUMMARY	ii
1. FINDINGS OF FLOODPLAIN RISK MANAGEMENT STUDY	1
1.1. Background	1
1.2. Flood Hazard Classification	1
1.3. Economic Impact of Flooding.....	2
2. RECOMMENDED MANAGEMENT MEASURES	4
2.1. Flood Modification Measures	4
2.1.1. New Drainage – Belvoir Street and Detention Basin at Prince Alfred Park (FM – BB01)	4
2.1.2. New Drainage – Mitchell Street to Wentworth Park (FM – BB02).....	5
2.1.3. New Outlet to Blackwattle Bay (FM – BB03).....	5
2.1.4. New Outlet to Blackwattle Bay and Drainage Upgrade – Bridge Road (FM – BB04)	5
2.1.5. Underground Storage at Council Depot (FM – BB06)	5
2.1.6. Drainage Upgrade – Cleveland Street to Wentworth Park and Underground Storage at Council Depot (FM – BB07).....	6
2.2. Property Modification Measures.....	6
2.2.1. Flood Planning Levels (PM – BB01)	6
2.2.2. Development Control Planning (PM – BB02)	7
2.2.3. Flood Proofing (PM – BB03)	7
2.2.4. Minor Property Adjustments (PM – BB04).....	7
2.3. Response Modification Measures	8
2.3.1. Flood Warning and Evacuation (RM – BB01).....	8
2.3.2. Flood Emergency Management (RM – BB02 and RM – BB03).....	8
2.3.3. Community Awareness Programme (RM – BB04)	9
2.4. Recommended Management Measures – Table.....	9
3. ACKNOWLEDGEMENTS.....	12
4. REFERENCES	13

LIST OF TABLES

Table 1: Hazard Classification.....	2
Table 2: Estimated Combined Flood Damages for Blackwattle Bay Catchment	3
Table 3: Recommended Management Measures	10

LIST OF FIGURES

Figure 1: Study Area
Figure 2: Peak Flood Depth - 1% AEP Design Flood Event
Figure 3: Peak Flood Depth - PMF Event
Figure 4: Hazard Categories - 1% AEP Design Flood Event
Figure 5: Hazard Categories - PMF Event
Figure 6: Flood Risk Mitigation Options

FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Flood Prone Land Policy, the management of flood liable land remains the responsibility of local government. The NSW Government, and administered through the Office of Environment and Heritage (OEH), provides financial assistance and specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Australian Government may also provide financial assistance in some circumstances.

The Flood Prone Land Policy provides for specialist technical and financial support to Councils by the NSW Government through the stages set out in the "Floodplain Development Manual – the management of flood liable land, NSW Government, 2005". This Manual is provided to assist Councils to meet their obligations and responsibilities in managing flood liable land. These stages are:

1. ***Flood Study***
 - Determine the nature and extent of the flood problem.
2. ***Floodplain Risk Management Study***
 - Evaluates management options for the floodplain in respect of both existing and proposed development.
3. ***Floodplain Risk Management Plan***
 - Involves formal adoption by Council of a plan of management for the floodplain.
4. ***Implementation of the Plan***
 - Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Blackwattle Bay Catchment Floodplain Risk Management Plan constitutes the third stage of this management process. This plan has been prepared by WMAwater for the City of Sydney (Council) under the guidance of Council's floodplain management committee (Committee). This plan provides the basis for the future management of those parts of the Blackwattle Bay catchment which are flood liable and within the City of Sydney local government area.

EXECUTIVE SUMMARY

The recommended Floodplain Risk Management Plan for Blackwattle Bay catchment has been prepared in accordance with the NSW Floodplain Development Manual (Reference 1) and:

- Is based on a comprehensive and detailed evaluation of all factors that affect and affected by the use of flood prone land; and
- Provides a long-term path for the future development of the floodplain.

The Blackwattle Bay catchment is located in Sydney's inner-west, in the City of Sydney Local Government Area (LGA). The 315 hectare catchment is fully urbanised, with runoff draining to Blackwattle Bay via a pit and pipe stormwater system. There are significant overland flowpaths in the catchment, which are active when the capacity of the pit and pipe network is exceeded. Flood liability exists across the area, including several locations where overland flow is trapped by unrelieved depressions in the catchment topography.

The Blackwattle Bay Catchment Floodplain Risk Management Study (Reference 2) undertook a detailed assessment of flood risk in the catchment. The assessment included a description of flood hazard in the catchment, as well as an estimate of the economic impact of flooding. The study gave a description of the flood emergency response arrangements in the area, as well as a review of the flood planning level and flood planning area.

The floodplain risk management study also included an investigation of possible options for the management of flood risk in the area. These included structural works, such as drainage upgrades and detention basins, as well as planning measures and SES-related actions. The measures were assessed for their ability to reduce flood risk while also considering their economic, social and environmental impact. A multi-criteria matrix assessment was used to directly compare the options. Of the options investigated, fourteen were recommended for implementation, with a priority and time frame assigned to each.

Following public exhibition of the studies in November and December 2014, the Floodplain Risk Management Study and Plan were adopted by Council on 18th of May 2015.

1. FINDINGS OF FLOODPLAIN RISK MANAGEMENT STUDY

1.1. Background

The Blackwattle Bay catchment is located in Sydney's inner city suburbs of Glebe, Chippendale, Ultimo, Darlington, Camperdown, Redfern, Pyrmont and Surry Hills (refer Figure 1). This region lies within the City of Sydney Local Government Area and has been extensively developed for urban usage. Land use is predominantly medium to high-density housing as well as commercial and industrial developments. In addition, there are pockets of open space sporadically positioned throughout the catchment, such as Wentworth, Victoria, and Prince Alfred Parks.

The catchment covers an area of approximately 315 hectares with some 50 hectares of land draining directly into Blackwattle Bay and the remaining portion draining to Sydney Water's major trunk drainage system (known as SWC 17) to route flows from the upper regions of the catchment. The trunk drainage system is linked to Council's feeder drainage system consisting of covered channels, in-ground pipes, culverts and kerb inlet pits.

A number of locations within the catchment are flood liable. This flood liability mainly relates to the nature of the topography within the study area as well as the capacity of service provided by drainage assets. The topography of the catchment is steep in the upper areas, steep and undulating in the middle sections, and then flat particularly in the lower regions close to the Bay. The upper regions of the catchment experience the greatest relief with a maximum elevation of approximately 60m AHD occurring in the vicinity of Surry Hills. Urbanisation throughout the catchment occurred prior to the installation of road drainage systems in the 1900s and many buildings have been constructed on overland flow paths or in unrelieved sags. Due to these drainage restrictions, topographic depressions can cause localised flooding as excess flows have no opportunity to escape via overland flow paths. This creates a significant drainage/flooding problem in many areas throughout the catchment.

The Blackwattle Bay Catchment Flood Study (2012) was carried out to define existing flood behaviour for the Blackwattle Bay catchment in terms of flood levels, depth, velocities, flows, hydraulic categories and provisional hazard. The 1% AEP peak flood depth is shown on Figure 2, while Figure 3 shows the Probable Maximum Flood (PMF). As can be seen on Figure 2, there is significant overland flow in large flood events, with over 1 metre of water along the natural depression upstream of Wentworth Park, as well as in some isolated trapped low points. Figure 4 and Figure 5 show the hazard categories for the 1% AEP and PMF events respectively. Areas of high hazard in the catchment generally correspond to the major overland flowpaths, including Bridge Road, Buckland Street, around Mountain Street and adjacent to Mitchell Street.

1.2. Flood Hazard Classification

Classification of flood hazard in the catchment was based on a combination of the provisional flood hazard categories and a range of other factors that are not captured by the provisional categories. These factors include, but are not limited to: rate of rise of floodwater, duration of

flooding, community awareness and effective warning time. A qualitative assessment of these factors was undertaken, the results of which are summarised in Table 1. The provisional hazard categories complement this assessment, as they delineate areas of the floodplain where the depth or velocity of floodwaters is considered hazardous.

Table 1: Hazard Classification

Criteria	Weight ⁽¹⁾	Comment
Size of the Flood	Medium	Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation.
Depth & Velocity of Floodwaters	Medium	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event.
Rate of Rise of Floodwaters	Medium	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events.
Duration of Flooding	Low	The greater the duration of flooding the more disruption to the community and potential flood damages. Permanent inundation due to sea level rise is of indefinite duration.
Flood Awareness and Readiness of the Community	High	General community awareness tends to reduce as the time between flood events lengthens and people become less prepared for the next flood event. Even a flood aware community is unlikely to be wise to the impacts of a larger, less frequent, event.
Effective Warning & Evacuation Time	Medium	This is dependent on rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act.
Effective Flood Access	High	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication.
Evacuation Problems	Medium	The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. Mobility of people, such as the elderly, children or disabled, who are less likely to be able to move through floodwaters and ongoing bad weather conditions is a consideration.
Provision of Services	Low	In a large flood it is likely that services will be cut (sewer and possibly others). There is also the likelihood that the storm may affect power and telephones.
Additional Concerns	Low	Floating debris, vehicles or other items can increase hazard. Sewerage overflows can occur when river levels are high preventing effective discharge of the sewerage system.

Detailed description of the flood hazard classification is given in Section 3.4 of the Blackwattle Bay Catchment Floodplain Risk Management Study.

1.3. Economic Impact of Flooding

The economic impact of flooding in Blackwattle Bay catchment was assessed as part of the floodplain risk management study. Damages were calculated for residential and commercial/industrial properties, based on a floor level survey of properties inundated in the 1% AEP event. The flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account flood damages to any basements or cellars, hence where properties have basements damages can be under estimated.

The damages assessment found that 171 properties within the catchment are liable to over floor inundation in the 1% AEP event, while 94 properties are liable in the 2 year ARI event. The assessment estimated the average annual damage to be approximately \$7.8 million for the

catchment. Table 2 gives the estimated tangible damages for the catchment (both residential and commercial/industrial properties).

Table 2: Estimated Combined Flood Damages for Blackwattle Bay Catchment

Event	Number of Properties Flood Affected	No. of Properties Flooded Above Floor Level	Total Tangible Flood Damages	Average Tangible Damages Per Flood Affected Property
2 year ARI	202	94	\$ 8,851,400	\$ 43,900
5 year ARI	236	112	\$ 11,010,900	\$ 46,700
10% AEP	246	131	\$ 12,258,600	\$ 49,900
5% AEP	259	141	\$ 13,526,500	\$ 52,300
2% AEP	268	163	\$ 14,627,600	\$ 54,600
1% AEP	283	171	\$ 16,229,800	\$ 57,400
PMF	307	255	\$ 25,050,200	\$ 81,600
Average Annual Damages (AAD)			\$ 7,783,100	\$ 25,400

Detailed description and results of the damages assessment is given in Section 5 of the Blackwattle Bay Catchment Floodplain Risk Management Study.

2. RECOMMENDED MANAGEMENT MEASURES

The Blackwattle Bay Catchment Floodplain Risk Management Study made a full assessment of the existing flood risk in the catchment. Based on this assessment of flood risk, the study investigated a range of management measures for the area, which can be categorised as Response Modification Measures, Property Modification Measures and Flood Modification measures, as per the NSW Floodplain Development Manual (Reference 1). Measures were assessed for their efficacy across a range of criteria, which allowed them to be compared against one another and their overall effectiveness ranked. Measures which improved the management of flood risk in the catchment were selected and form the primary content of this Plan.

The measures have been categorised by their type (Response, Flood or Property) and given a priority ranking. The ranking is based upon a combination of reduction in flood risk, ease of implementation, cost/funding implications and outcomes based on the multi-criteria matrix assessment (refer Section 10.4 of the Study). More information on each measure is available in the Floodplain Risk Management Study, including discussion of its implementation and its effect on the existing flood behaviour.

2.1. Flood Modification Measures

The following sections detail the flood modification measures recommended for implementation in the catchment. Figure 6 shows the location of the options in the catchment, including FM-BB05, which was investigated as part of the study but not recommended for implementation.

2.1.1. New Drainage – Belvoir Street and Detention Basin at Prince Alfred Park (FM – BB01)

Option FM – BB01 is proposed to mitigate flooding in the vicinity of Chalmers/Pembroke St, Surry Hills area. The provision of a new drainage pipe along Belvoir St would provide relief for the trapped depression on Elizabeth St, Buckingham St, Pembroke St and Chalmers St, thus reducing flood liability for the properties located on these roads. A detention basin with storage capacity of 20,500 m³ (area approximately 8,500 m² with depth up to 3 m) is proposed on Prince Alfred Park to store the additional discharge coming from this new pipeline. Furthermore, to fully utilise the basin storage, the basin outlet capacity is reduced which would help retain local runoff and reduce downstream peak flood levels.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its benefit cost ratio, and issues related to its technical and political feasibility. The measure is recommended to be implemented by City of Sydney in the long term, for example when other drainage works are being undertaken in the area.

2.1.2. New Drainage – Mitchell Street to Wentworth Park (FM – BB02)

Option FM – BB02 is proposed to alleviate flooding and over floor flood liability on Mitchell Lane and its surrounds by constructing a new drainage pipe (and new pits) connecting the existing system at the Glebe Street/Mitchell Street intersection with the trunk drainage system downstream at Wentworth Park. The proposed work would facilitate the transfer of overland flows to the sub-surface drainage system subsequently reducing the volume of floodwaters discharging onto the low point at Mitchell Lane East.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its benefit cost ratio, and issues related to its technical and political feasibility. The measure is recommended to be implemented by City of Sydney in the long term, for example when other drainage works are being undertaken in the area.

2.1.3. New Outlet to Blackwattle Bay (FM – BB03)

Option FM - BB03 provides an additional outlet for the drainage system along Bridge Road to discharge onto Blackwattle Bay, with the outlet situated across from Bellevue Street. The outlet would enable prompt discharge of road runoff from Bridge Road and Wentworth Park Road in the major flood events with minimal modification to the existing drainage system.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its benefit cost ratio, its economic merits and its long term performance. The measure is recommended to be implemented by City of Sydney in the medium to long term, for example when other drainage works are being undertaken in the area.

2.1.4. New Outlet to Blackwattle Bay and Drainage Upgrade – Bridge Road (FM – BB04)

This option is an extension from Option FM – BB03 with further upgrade to the Sydney Water-owned drainage system along Bridge Road to the 5% AEP capacity. Also, works have to be undertaken to enhance the capacity of the surrounding pits to facilitate the transfer of floodwaters from above surface to the sub-surface drainage system.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its benefit cost ratio, its economic merits and its long term performance. The measure is recommended to be implemented by City of Sydney in the medium to long term, for example when other drainage works are being undertaken in the area.

2.1.5. Underground Storage at Council Depot (FM – BB06)

With this option, an underground storage tank with a capacity of 40,000 m³ (area approximately 20,000 m² with depth up to 2 m) is proposed at the current Council depot site to alleviate flooding of the surrounding roads including Wattle Street, Wentworth Park Road and Bay Street whilst reduce flood liability for nearby properties. Furthermore, works have to be undertaken to

enhance the capacity of the pits on Macarthur Street to facilitate the transfer of floodwaters from above surface to the underground storage tank. This option is only feasible on condition that the depot undergoes major refurbishment as it requires major excavation work.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on its benefit cost ratio, its economic merits and issues related to its political feasibility. The measure is recommended to be implemented by City of Sydney in the long term, for example, it may be considered if the Council Depot site is redeveloped.

2.1.6. Drainage Upgrade – Cleveland Street to Wentworth Park and Underground Storage at Council Depot (FM – BB07)

Option FM – BB07 is proposed to alleviate flood risk along the Sydney Water-owned major trunk drainage system from Cleveland Street to Wentworth Park as well as improving accessibility along Parramatta Road and surrounding access roads. The trunk drainage system is upgraded to the 5% AEP capacity with the surrounding pits enhanced to facilitate the transfer of floodwaters from above surface to the sub-surface drainage system. This option is also undertaken in conjunction with Option FM – BB06 to mitigate the increased flows discharged downstream as a result of the augmentation of the trunk drainage conveyance capacity.

The measure has been given a low priority in the Floodplain Risk Management Plan, based on issues related to its technical and political feasibility as well as its financial feasibility. The measure is recommended to be implemented by City of Sydney in the long term, for example when other drainage works are being undertaken in the area.

2.2. Property Modification Measures

2.2.1. Flood Planning Levels (PM – BB01)

The flood planning level (FPL) is used to define land subject to flood related development controls and is generally adopted as the minimum level to which floor levels in the flood affected areas must be built. The FPL includes a freeboard above the design flood level. It is common practice to set minimum floor levels for residential buildings, garages, driveways and even commercial floors as this reduces the frequency and extent of flood damages. Freeboards provide reasonable certainty that the reduced level of risk exposure selected (by deciding upon a particular event to provide flood protection for) is actually provided.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on long term floodplain risk management in the catchment, and its community acceptance and economic merits. A review of the FPLs put forward by Council in their *Interim Floodplain Management Policy* (Reference 4) was carried out as part of the Floodplain Risk Management Study and it was recommended that case studies be provided to illustrate how these levels could be applied to individual developments to assist in development applications.

2.2.2. Development Control Planning (PM – BB02)

Within the Blackwattle Bay catchment there is continuing pressures for both redevelopments of existing buildings as well as for new developments. The strategic assessment of flood risk can prevent development occurring in areas with a high hazard and/or with the potential to have significant impacts upon flood behaviour in other areas. It can also reduce the potential damage to new or redeveloped properties likely to be affected by flooding to acceptable levels.

The measure has been given a high priority in the Floodplain Risk Management Plan, based on its positive effect on long term floodplain risk management in the catchment, and its community acceptance and financial feasibility. Recommendation for an update of the planning documents (i.e. Sydney DCP 2012 and Sydney LEP 2012) has been discussed in the Floodplain Risk Management Study in order to inform of the development controls as published in the Interim Floodplain Management Policy (Reference 4). Inclusion of these provisions would ensure that the controls can be enforced which also take into consideration the potential impact of climate change. The update is recommended to be implemented within City of Sydney in the next 12 months.

2.2.3. Flood Proofing (PM – BB03)

An alternative to house raising for buildings that are not compatible or not economically viable, is flood proofing or sealing off the entry points to the building. This measure has the advantage that it is generally less expensive than house raising and causes less social disruption. Flood proofing requires sealing of doors and possibly windows (new frame, seal and door); sealing and re-routing of ventilation gaps in brick work; sealing of all underfloor entrances and checking of brickwork to ensure there are no gaps or weaknesses in mortar. It is generally only suitable for brick buildings with concrete floors and it can prevent ingress from outside depths of up to one meter. Greater depths may cause structural problems (buoyancy) unless water is allowed to enter. Generally an existing house can be sealed for approximately \$10,000. New development and extensions allow the inclusions of flood appropriate materials and designs meaning the actual cost of flood proofing can be significantly less when compared to buildings requiring retro-fitting of flood proofing measures.

The measure has been given medium priority in the Floodplain Risk Management Plan, based on the number of properties it can benefit and its economic merits. The measure is recommended to be implemented by local business owners in the short term.

2.2.4. Minor Property Adjustments (PM – BB04)

In overland flow areas minor property adjustments can be made to manage overland flow passing through private property. Such adjustments can include amendments to fences, construction of fences which act as deflector levees, modifying gardens, changing easements etc all of which can affect the local continuity of overland flow paths.

The measure has been given low priority in the Floodplain Risk Management Plan, based on its

limited benefit and the difficulty in administering the measure. The measure is recommended to be implemented in the short term by local residents with overland flow on their property.

2.3. Response Modification Measures

2.3.1. Flood Warning and Evacuation (RM – BB01)

Flood warning can significantly reduce damages and risk to life and studies have shown that flood warning systems generally have high benefit/cost ratio if sufficient warning time is provided.

Flood warning and the implementation of evacuation procedures by the SES are widely used throughout NSW to reduce flood damages and protect lives. The Bureau of Meteorology (BoM) is responsible for flood warnings on major river systems and the SES is disseminating these warning to the local community. Adequate warning gives residents time to move goods and cars above the reach of floodwaters and to evacuate from the immediate area to designated evacuation points or flood free ground. The effectiveness of a flood warning scheme, known as the effective flood warning time, depends on;

- The maximum potential warning time before the onset of flooding;
- The actual warning time provided before the onset of flooding. This depends on the adequacy of the information gathering network and the skill and knowledge of the operators; and
- The flood awareness of the community responding to a warning.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations and risk to life, as well as its relatively strong community acceptance. The measure is recommended to be implemented within the catchment in the next 12 months.

2.3.2. Flood Emergency Management (RM – BB02 and RM – BB03)

As mentioned previously, it may be necessary for some residents to evacuate their homes in a major flood. This would usually be undertaken under the direction of the lead agency under the DISPLAN, the SES. Some residents may choose to leave on their own accord based on flood information from the radio or other warnings, and may be assisted by local residents. The main problems with all flood evacuations are;

- They must be carried out quickly and efficiently;
- There can be confusion about 'ordering' evacuations, with rumours and well-meaning advice taking precedence over official directions which can only come from the lead agency, the SES;
- They are hazardous for both rescuers and the evacuees;
- Residents are generally reluctant to leave their homes, causing delays and placing more stress on the rescuers, and

- People (residents and visitors) do not appreciate the dangers of crossing floodwaters.

For this reason, the preparation of a flood emergency response plan helps to minimise the risk associated with evacuations by providing information regarding evacuation routes, refuge areas, what to do/not to do during floods etc. It is the role of the SES to develop this plan for vulnerable communities.

The measures have been given a high priority in the Floodplain Risk Management Plan, based on their positive effect on SES operation in the catchment and the resultant reduction in flood risk. The measures also have relatively high community acceptance. The DISPLAN (RM - BB02) is recommended to be prepared by the SES in the next 12 months, while the Local Flood Plan (RM - BB03) is recommended to be prepared in the same time frame by City of Sydney and the SES.

2.3.3. Community Awareness Programme (RM – BB04)

The success of any flood warning system and the evacuation process in reducing flood losses and damages depends on:

- *Flood Awareness*: How aware is the community of the flood threat? Has it been adequately informed and educated?
- *Flood Preparedness*: How prepared is the community to react to the threat of flooding? Do they (or the SES) have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented?
- *Flood Evacuation*: How prepared are the authorities and the residents to evacuate households to minimise damages and the potential risk to life during a flood? How will the evacuation be done, where will the evacuees be moved to?

Public information and the level of public awareness are keys in reducing flood damages and losses. A more aware community will suffer less losses and damage than an unprepared community.

The measure has been given a medium priority in the Floodplain Risk Management Plan, based on its positive effect on SES operations and risk to life, as well as its relatively strong community acceptance. The measure is recommended to be implemented within City of Sydney in the next 12 months.

2.4. Recommended Management Measures – Table

The recommended measures described in the previous sections are summarised in Table 3 in order of priority. The table provides a reference point for the Plan's recommendations, and represents one of the main outcomes of the floodplain risk management process for the Blackwattle Bay catchment.

Table 3: Recommended Management Measures

REF ¹	MEASURE	PURPOSE	PRIORITY	RESPONSIBILITY	TIME FRAME	COST
RM-BB02	Prepare DISPLAN for the Sydney West Emergency Management District (SES) (Section 9.6.2)	Minimise the risk associated with evacuations	High Priority	SES	12 months	Internally within SES
RM-BB03	Prepare Local Flood Plan to inform evacuation centres, identify vulnerable facilities and evacuation routes (Section 9.6.2)	Inform evacuation centres, identify vulnerable facilities and evacuation routes	High Priority	City of Sydney and SES	12 months	Internally within Council
PM-BB02	Update Sydney DCP 2012 and LEP 2012 based on FRMS&P outcomes and to inform of Council's Interim Floodplain Management Policy (Section 9.5.2)	Prevent development occurring in high hazard areas or impacting existing flood behaviour	High Priority	City of Sydney	12 months	Internally within Council
RM-BB04	Develop ongoing flood awareness programmes for the community (Section 9.6.3)	Increase community's general awareness to reduce damages and risk to life	Medium Priority	City of Sydney	12 months	Internally within Council
PM-BB01	Review FPLs following completion of FRMS&P for Blackwattle Bay catchment. Provide case studies to assist DA (Section 9.5.1)	Reduce the damages of flood affected properties by having elevated floor level.	High Priority	City of Sydney	2-3 years	Internally within Council
RM-BB01	Make available flood warnings on Council's website or social media, investigate feasibility of installing flood warning systems at key locations (Section 9.6.1)	Increase community's awareness during and after a flood event to reduce damages and risk to life	Medium Priority	City of Sydney	12 months	Internally within Council
PM-BB03	Investigate flood proofing techniques for flood affected commercial/industrial properties (Section 9.5.4)	Reduce the damages of flood affected properties by preventing ingress of floodwaters.	Medium Priority	Local Business Owners	Short term	Low to investigate
PM-BB04	Investigate potential for property adjustments to manage overland flow at flooding hot spots (Section 9.5.5)	Manage overland flows through private property by directing away from dwellings	Low Priority	Local Residents	Short term	Low to investigate
FM-BB03	Additional outlet into the bay opposite Bellevue Street (Section 9.4.3)	Improve duration of flooding on major road and reduce risk to nearby affected properties	Low Priority	City of Sydney	Medium to long term	Medium

FM-BB04	Drainage upgrade along Bridge Road & additional outlet opposite Bellevue Street (Section 9.4.4)	Improve duration of flooding on major road and reduce risk to nearby affected properties	Low Priority	City of Sydney	Medium to long term	Approx. \$2,000,000 capital, \$2,000 ongoing (annual)
FM-BB07	Drainage upgrade between Wentworth Park & Cleveland Street & underground storage tank under council depot (Section 9.4.7)	Improve duration of flooding on major roads and reduce risk to nearby affected properties	Low Priority	City of Sydney	Long term	Approx. \$36,000,000 capital, \$34,000 ongoing (annual)
FM-BB02	Additional drainage along Mitchell Street (Section 9.4.2)	Reduce risk to affected properties in the area	Low Priority	City of Sydney	Long term	Approx. \$3,000,000 capital, \$5,000 ongoing (annual)
FM-BB06	Underground storage tank under council depot adjacent to Wentworth Park (Section 9.4.6)	Reduce risk to affected properties in the area, reduce inundation of roads in the area.	Low Priority	City of Sydney	Long term	Approx. \$10,000,000 capital, \$21,000 ongoing (annual)
FM-BB01	Additional drainage & detention basin near Prince Alfred Park (Section 9.4.1)	Reduce risk to affected properties in the area.	Low Priority	City of Sydney	Long term	Approx. \$7,000,000 capital, \$15,000 ongoing (annual)

¹Reference of measure in the Blackwattle Bay Floodplain Risk Management Study

3. ACKNOWLEDGEMENTS

WMAwater wish to acknowledge the assistance of the City of Sydney Council staff and the Floodplain Management Committee in carrying out this study as well as the NSW Government (Office of Environment and Heritage) and the residents of the Blackwattle Bay catchment. This study was jointly funded by the City of Sydney Council and the NSW Government.

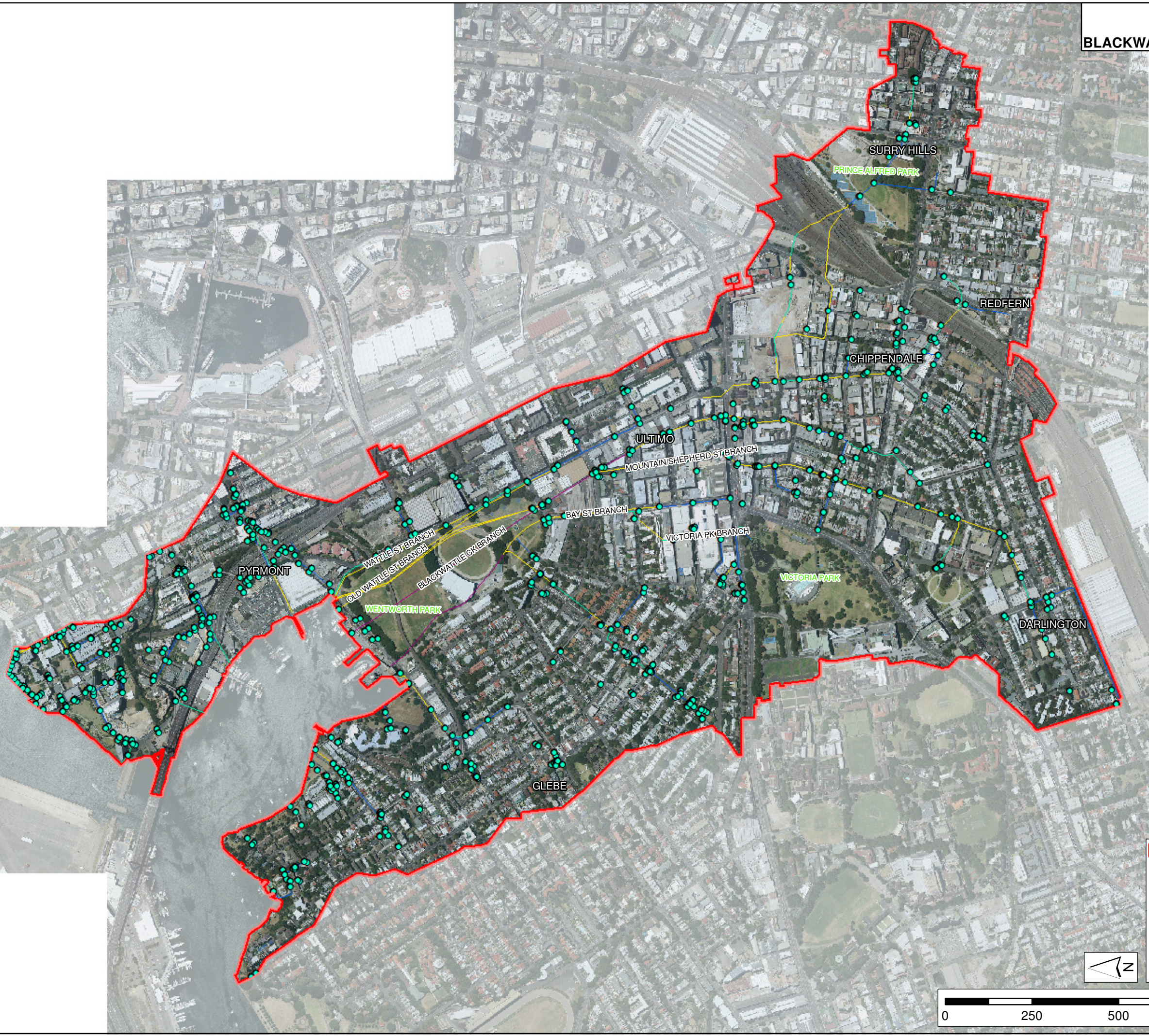
4. REFERENCES

1. NSW Government (2005) Floodplain Development Manual – the Management of Flood Liable Land, Department of Infrastructure, Planning and Natural Resources
2. WMAwater (2014), Blackwattle Bay Catchment Floodplain Risk Management Study, Draft Report
3. WMAwater (2012), Blackwattle Bay Catchment Flood Study, Draft Report
4. City of Sydney (2014), Interim Floodplain Management Policy



Figures

FIGURE 1
STUDY AREA
BLACKWATTLE BAY CATCHMENT



Study Area

- Study Area
- Pits

Pipe/Culvert Diameter (m)

- 0.1 - 0.45
- 0.45 - 0.75
- 0.75 - 1.0
- 1.0 - 2.4
- 2.4 - 3.8

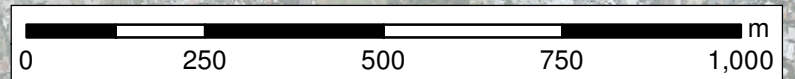
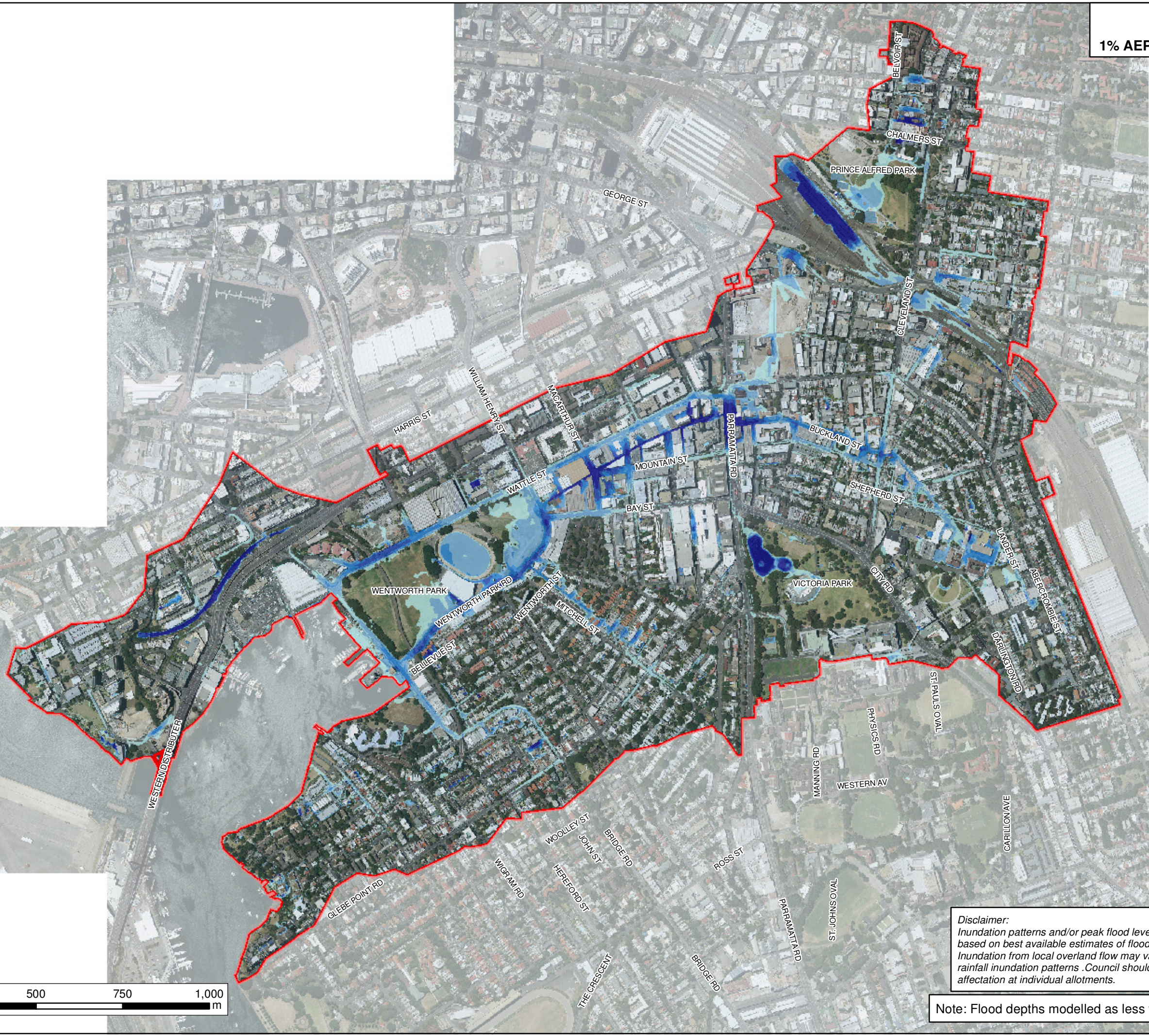


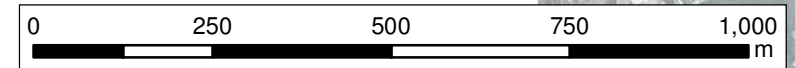
FIGURE 2
PEAK FLOOD DEPTH
1% AEP DESIGN FLOOD EVENT



J:\Jobs\113046\ArcGIS\ArcMaps\FRMS&P_Report\BWA\FRMP\Figure02_Peak_Flood_Depth_1%AEF.mxd



- Study Area
- Depth (m)**
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- > 1

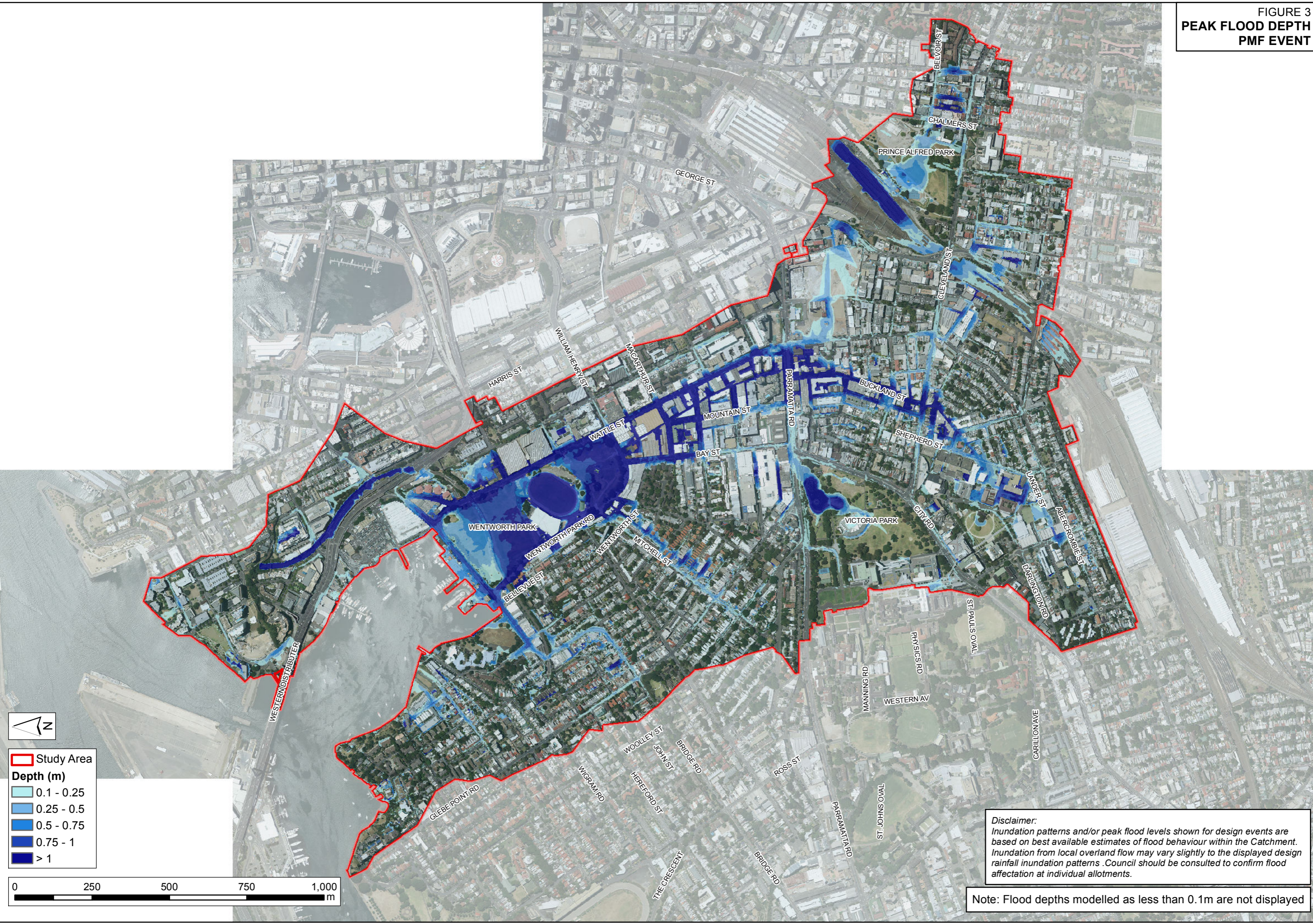


Disclaimer:
 Inundation patterns and/or peak flood levels shown for design events are based on best available estimates of flood behaviour within the Catchment. Inundation from local overland flow may vary slightly to the displayed design rainfall inundation patterns. Council should be consulted to confirm flood affectation at individual allotments.

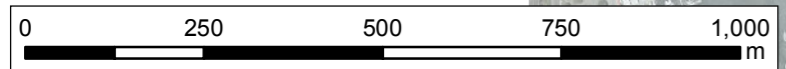
Note: Flood depths modelled as less than 0.1m are not displayed

FIGURE 3
PEAK FLOOD DEPTH
PMF EVENT

J:\Jobs\113046\ArcGIS\ArcMaps\FRMS&P_Report\BW\FRMPI\Figure03_Peak_Flood_Depth_PMF.mxd



- Study Area
- Depth (m)**
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- > 1

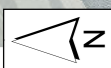
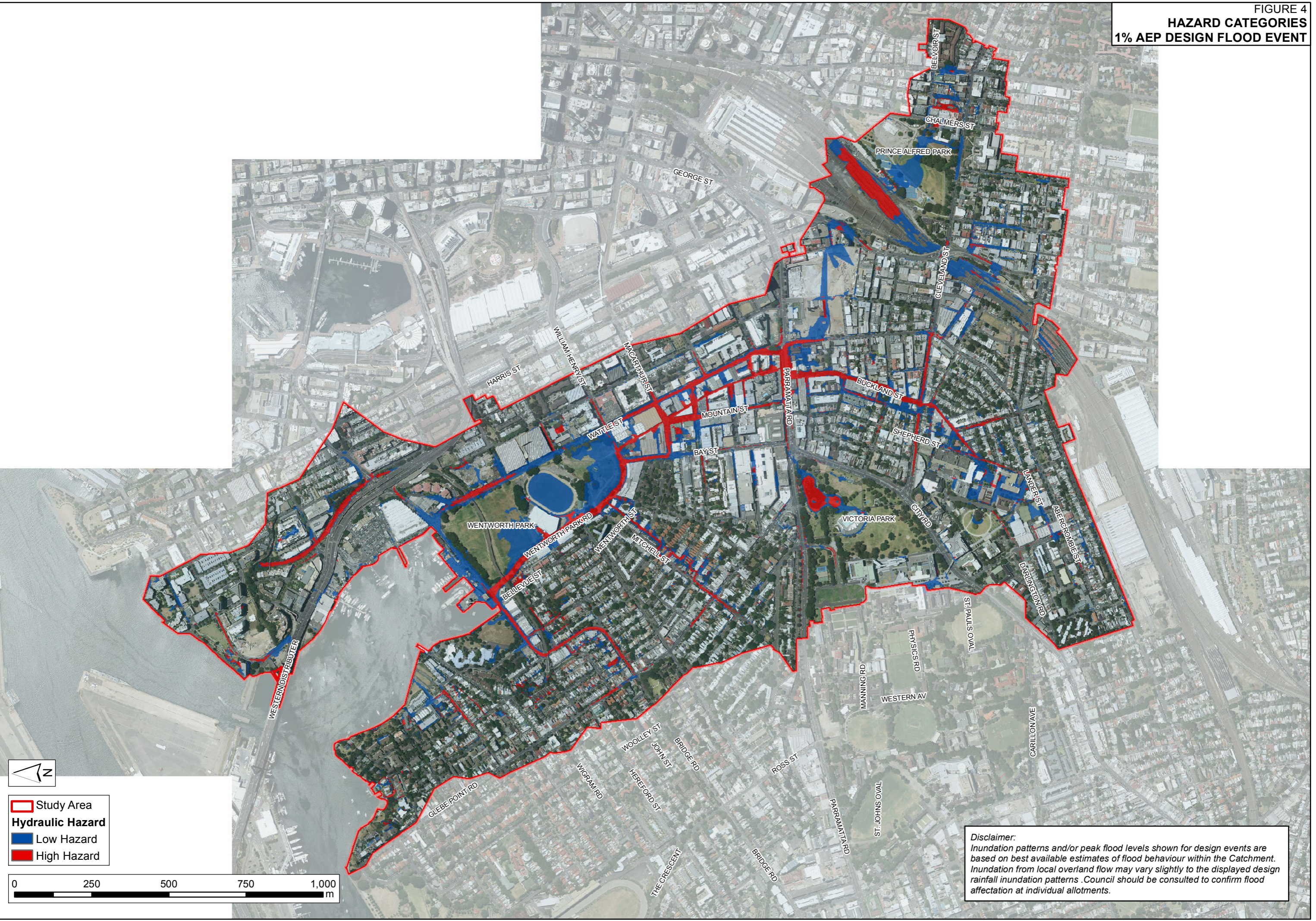


Disclaimer:
Inundation patterns and/or peak flood levels shown for design events are based on best available estimates of flood behaviour within the Catchment. Inundation from local overland flow may vary slightly to the displayed design rainfall inundation patterns. Council should be consulted to confirm flood affectation at individual allotments.

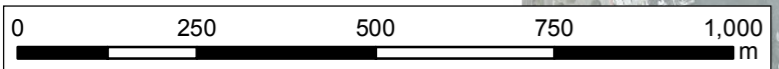
Note: Flood depths modelled as less than 0.1m are not displayed

FIGURE 4
HAZARD CATEGORIES
1% AEP DESIGN FLOOD EVENT

J:\Jobs\111021\GIS\ArcMaps\BWDraft_Report_Figs\Figure27_Hazard_Categories_002y.mxd

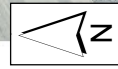
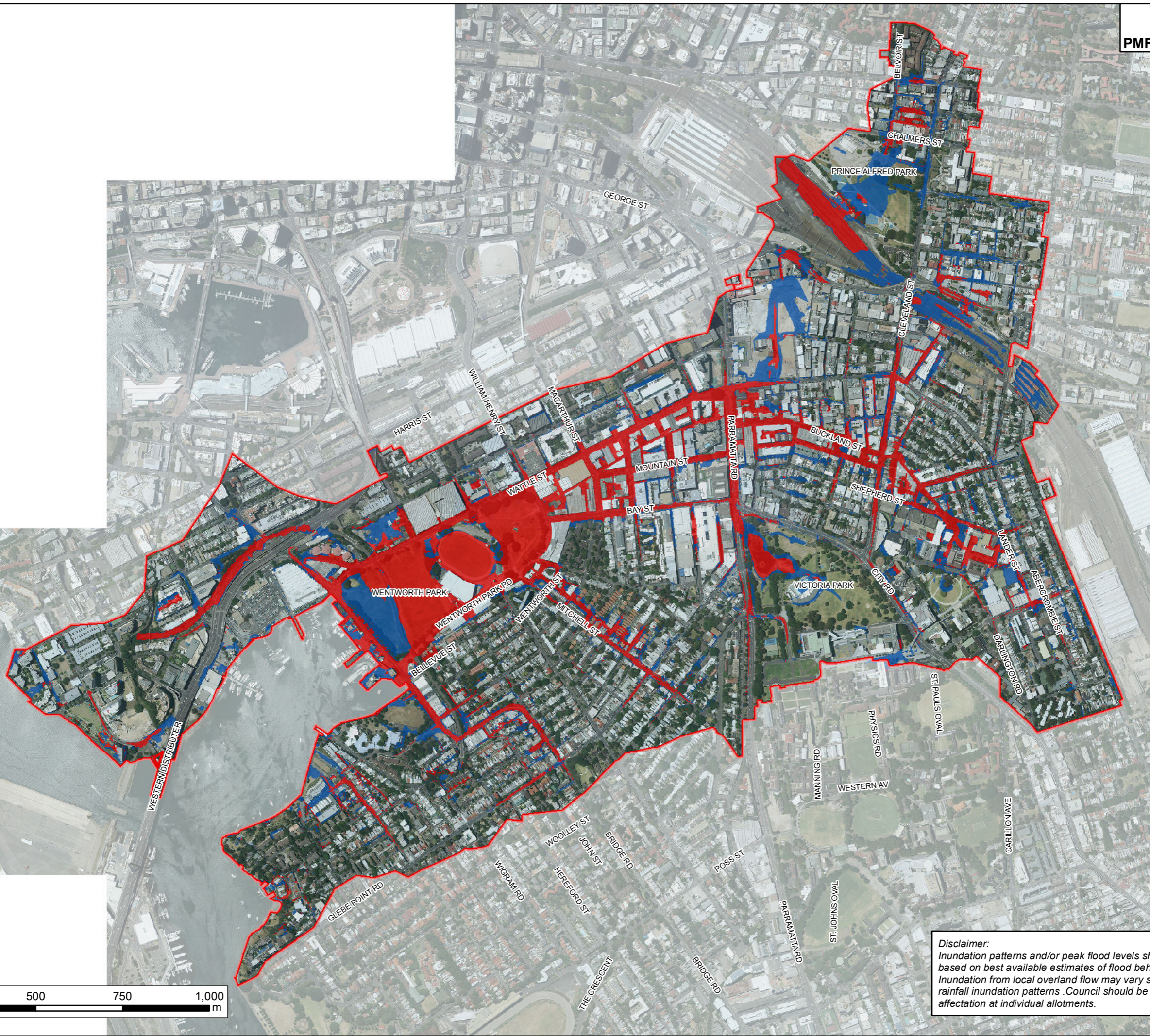


- Study Area
- Hydraulic Hazard**
- Low Hazard
- High Hazard

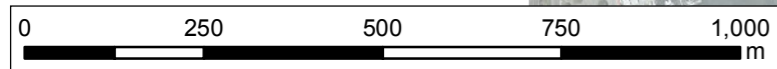


Disclaimer:
Inundation patterns and/or peak flood levels shown for design events are based on best available estimates of flood behaviour within the Catchment. Inundation from local overland flow may vary slightly to the displayed design rainfall inundation patterns. Council should be consulted to confirm flood affectation at individual allotments.

FIGURE 05
HAZARD CATEGORIES
PMF DESIGN FLOOD EVENT



- Study Area
- Hydraulic Hazard**
- Low Hazard
- High Hazard



Disclaimer:
Inundation patterns and/or peak flood levels shown for design events are based on best available estimates of flood behaviour within the Catchment. Inundation from local overland flow may vary slightly to the displayed design rainfall inundation patterns. Council should be consulted to confirm flood affectation at individual allotments.

FM-BB01 Additional Drainage and Detention Basin
Add drainage pipe along Belvoir St and drain to a detention basin in Prince Alfred Park

FM-BB07 Drainage Upgrade and Underground Storage
Upgrade capacity of trunk drainage between Wentworth Park and Cleveland St and put an underground storage tank under the council depot

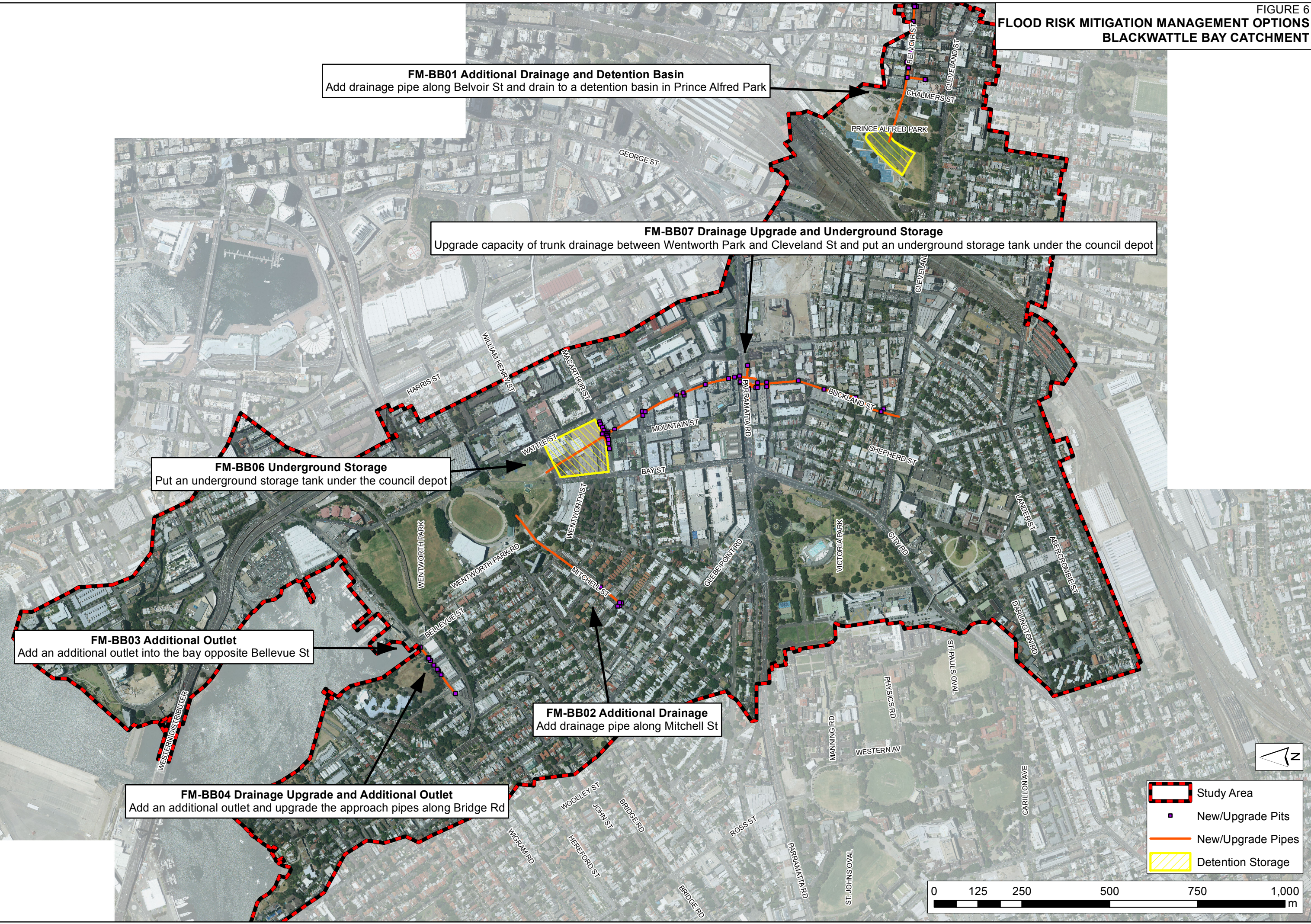
FM-BB06 Underground Storage
Put an underground storage tank under the council depot





FM-BB03 Additional Outlet
Add an additional outlet into the bay opposite Bellevue St

FM-BB02 Additional Drainage
Add drainage pipe along Mitchell St

FM-BB04 Drainage Upgrade and Additional Outlet
Add an additional outlet and upgrade the approach pipes along Bridge Rd

J:\Jobs\113046\ArcGIS\ArclMaps\FRMS&P_Report\BW\FRMPI\Figure06_Flood_Risk_Mit_Management_Options_BW.mxd



-  Study Area
-  New/Upgrade Pits
-  New/Upgrade Pipes
-  Detention Storage

