# Botany Bay and Foreshore Beach Floodplain Risk Management Study and Plan

Bayside Council

## Final Floodplain Risk Management Study and Plan

Rev E

27 November 2020

# Botany Bay and Foreshore Beach Floodplain Risk Management Study and Plan

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## Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to undertake a floodplain risk management study for the Botany Bay Foreshore Beach stormwater catchments, in accordance with the scope of services set out in the contract between Jacobs and Bayside Council (the Client). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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## Contents

# Foreword

The primary objective of the New South Wales Government's Flood Prone Land 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, wherever possible. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

| | | |
|---|---|---|
| 1. | **Data Collection** | Involves compilation of existing data and collection of additional data |
| 2. | **Flood Study** | Determines the nature and extent of the flood problem |
| 3. | **Floodplain Risk Management Study** | Evaluates management options in consideration of social, ecological and economic factors relating to flood risk with respect to both existing and future development |
| 4. | **Floodplain Risk Management Plan** | Involves formal adoption by Council of a plan of management for the floodplain |
| 5. | **Implementation of the Plan** | Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood preparedness, environmental rehabilitation, ongoing data collection and monitoring by Council |

Bayside Council is undertaking this study for the Botany Bay and Foreshore Beach catchment to identify and to develop measures to address the existing, the continuing and the future flooding risk to people and development in the catchment in accordance with the NSW Government's *Floodplain Development Manual*.

This study represents Stages 1, 2, 3 and 4 of the management process and was prepared for Council by Jacobs. This report is the Final Floodplain Risk Management Study and Plan Report for the project.

Bayside Council's Floodplain Risk Management Committee has overseen and provided input into the preparation of this study. The committee consists of representatives from the community, Council officers and representatives, NSW Government Department of Planning, Industry and Environment (DPIE), State Emergency Service (SES) and Sydney Water.

# Executive Summary

### Introduction

The Botany Bay and Foreshore Beach Catchment is located within the Bayside Council local government area, and includes parts of the suburbs of Botany, Pagewood and Banksmeadow. The catchment is situated at low elevations with flat relief. Refer to Figures 2.1 and 2.2. Flooding in the catchment occurs as a result of runoff collecting within low points on the ground surface, with drainage of these locations being impeded by a constrained stormwater drainage system. The poor drainage conditions are exacerbated by the low ground elevations and the influence of elevated ocean levels, coinciding with rainfall events, in Botany Bay to which the catchment drains. The low elevation of parts of the catchment mean that areas are also susceptible to tidal inundation during dry weather conditions and high tide and elevated ocean level events such as storm surge, in addition to future sea level rise.

Bayside Council ("Council") commissioned Jacobs to prepare a floodplain risk management study and plan (FRMSP) for the Botany Bay Foreshore Beach Catchment. Key objectives of this study are to:

- Update available hydrologic and hydraulic modelling to estimate flooding conditions for a range of design events based on current flooding analysis guidelines.
- Identify and assess structural and non-structural mitigation measures to manage flood risk.
- Review existing planning, policy and emergency management for gaps and inconsistencies relating to floodplain planning, then develop proposed amendments to address residual flood risk.
- Prioritise the works and measures, including economic and multi criteria appraisal of options.
- Develop an implementation program for recommended works and measures including timing, responsibility and sources of funding.
- Conduct consultation with the community and key stakeholders throughout the study to obtain information and intelligence for input into the study. Gauge the perceptions of the community on flooding matters. Obtain feedback on the findings and recommendations of the study.

To assist with the reading of this report, a glossary of terms is provided in Section 14.

### Mechanisms of Flooding

The Botany Bay and Foreshore Beach catchment is mainly affected by the following two flooding mechanisms:

- Overland flooding: This occurs as a result of intense rainfall over the catchment causing runoff which flows overland and collects within low points on the ground surface, which are then drained by the stormwater system. Overland flooding can also occur due to the stormwater system capacity being exceeded, resulting in flows surcharging to the surface.
- Tidal and oceanic inundation: The low elevation of parts of the catchment mean that areas are also susceptible to inundation caused by very high astronomical tides (i.e. king tides), in addition to elevated oceanic level events (e.g. due to storm surge and other oceanic water level phenomena) and combinations of these factors. The elevated tide and ocean levels cause water in Botany Bay to back up existing trunk drainage pipes, which then surcharge via stormwater pits onto low lying areas in the catchment.

Flooding events can be caused by coinciding overland flooding and tidal/oceanic inundation events.

Mainstream flooding, resulting from rising floodwaters in main watercourses such as Mill Pond/Botany Wetlands or the Cooks River, is not a significant influence on flooding in the study area. Flooding from Mill Pond does not spill into the study area in up to the 1% annual exceedance probability (AEP) event, and there are only minor overflows during the Probable Maximum Flood (PMF).

### Historic Flooding

Catchment flooding has occurred a number of times in the study area, although specific details are limited. Council and Sydney Water records identified that an approximately 1% AEP event occurred in March 1975. Since then the largest flood event was in March 1977 (20%, or 1 in 5, AEP), while subsequent events were up to 1 exceedances per year (EY), i.e. 1 year average recurrence interval (ARI), including the June 2010, June 2012 and April 2013 events. The 24 March 2014 event was estimated as less than a 0.5EY (i.e. 2 year ARI) event. Residents have reported historic flooding at a number of locations including Hale Street roundabout, The Esplanade and Botany Road near the Botany Golf Course. Flooding was described as extensive though generally shallow. In some locations flooding caused cars in roadways to float and also disrupted traffic. A number of locations were also reported to be subject to tidal inundation during king tides.

### Assessment of Existing Flooding

An assessment of existing flooding conditions has been undertaken which provided an update of the previous Botany Bay Foreshore Beach Catchment Flood Study (BMT WBM, 2015). Numerical modelling was undertaken using the TUFLOW software, which was calibrated to the March 2014 and March 1977 rainfall flood events, and the January 2014 tidal flooding event. A number of updates were made to the 2015 Flood Study as a part of this project to align the assessment with the latest, recently released industry guidance on design flood estimation. This included adoption of ARR 2016 guidelines to estimate design rainfall depths, temporal patterns and blockages of hydraulic structures, current guidance on ocean tailwater conditions, representation of buildings as solid obstructions to flood flow, inclusion of new developments and missing stormwater networks.

Existing flooding conditions were analysed for a range of flood events including the 20%, 5% 2%, 1%, 0.5% and 0.2% AEP and probable maximum flood (PMF) events. Flood depth mapping for the 20%, 5% and 1% AEP and PMF events is presented in this report. The PMF extent as shown on Figure B.4 represents the full extent of the floodplain in the study area. The stormwater drainage system for the study area consists of pits, pipes and open channels which convey rainfall runoff generated from the catchment into Mill Stream. Once the capacity of the stormwater drainage system is exceeded, overland flooding occurs on low-lying areas during significant flood events. Peak flood depth maps for all modelled design flood events for the study area are presented in Appendix C. Note that local drainage problems have been excluded from the mapping by filtering out flood depths less than 0.05m. The following observations are made from the maps:

- A number of roads (e.g. Botany Road, Wilson Street, Pemberton Street, Hale Street, Lord Street, etc.) within the study area are impacted up to 0.5m depth of flooding in the 20% AEP catchment flood event which reflects inadequate capacities of stormwater network within the study area. The stormwater drainage capacity is lower than the 20% AEP event. High tailwater conditions which restrict the outflow from the drainage network into Botany Bay are also a significant influence on flooding conditions in the lower portions of the study area.
- The majority of roads within the study area are impacted in the 5% AEP event and almost half of the properties located within the study area are subject to yard flooding. The maximum depth of flooding on roads is up to 1m which would impact on access to several properties and result in extensive damage to vehicles and infrastructure within the road corridors and would be a significant hazard to the road users.
- In the 2% AEP event, additional properties are subject to yard flooding and the maximum depth of flooding on roads is increased to over 1m.
- About 400 residential properties and 200 commercial properties are likely to experience above floor flooding in the 1% AEP event.
- About 900 residential properties and 300 commercial properties are likely to experience above floor flooding in the PMF event. The maximum flood depth on roads is up to 3.5m on the Booralee Street, with typical depths of 0.5 to 2m on other roads.

Flow velocities are high in a number of overland flow paths running through properties and particularly on roads.

- Typical flow velocities are 0.25 – 1m/s in the 20% AEP event, 0.25 – 1.2m/s in the 5% AEP event, and 0.25 - 1.25m/s in the 1% AEP event.

- High flow velocities (>1m/s) occur in a limited number of localised areas on roads and properties for the 1% AEP design event (e.g. Rochester Street, Wilson Street, Bay Street). High velocity flows have the potential to knock over pedestrians, move vehicles and cause damage to property even at shallow flow depths.
- Peak flow velocities for the 0.5% AEP event are approximately 1.5m/s and for the 0.2% AEP event the peak velocity is up to 1.7m/s.
- In the case of the PMF event, peak velocities are as high as 3m/s at a number of locations (e.g. Rochester Street, Wilson Street, Bay Street, Pemberton Street, Cranbrook Street, Banksia Street).

Durations of flooding are expected to be 18 – 24 hours in events up to the 1% AEP particularly in the lower points of the study area. Durations of flooding are expected to be prolonged (several days) in the PMF due to the large volumes of floodwater ponding in trapped low points and the poor drainage conditions.

Tidal inundation due to king tides and storm surge with no catchment flooding for current climate and sea level conditions would reach a maximum level of approximately 1.45m AHD and affect Bay Street, Erith Street, Hale Street, McFall Street, Luland Street and Booralee Street in the north-western portion of the study area, with typical depths of flooding of approximately 0.3m. The extent significantly increases with future sea level rise in up to the year 2100 to also include Byrne Street, Underwood Street, Ramsgate Street, The Esplanade, Chelmsford Avenue, Dent Street and parts of Botany Road, with inundation depths of 0.4 – 1m in affected areas. Refer to Figure 10.2.

Provisional flood hazard mapping was prepared for the 20%, 5% and 1% AEP and PMF events based on the hydraulic analysis in the TUFLOW model (refer to Figures B.1 – B.4 in Appendix B). The flood hazard mapping based on the direct flood modelling outputs is denoted provisional and does not reflect the “true” flood hazard to take into consideration evacuation, isolation and other emergency management aspects. In assessing the true flood hazard, considerations have been made about aspects and characteristics of flooding and the flooding problem including the size of flood, rate of rise, effective warning times, risk to life, flood hazard at the dwelling, duration of flooding and emergency access. True flood hazard mapping was also prepared and is presented in this report (refer to Figures B.5 – B.8 in Appendix B). The hydraulic categories, delineating floodway, flood storage and flood fringe areas (refer to Figures B.9 – B.12 in Appendix B), in addition to the emergency response classification of communities is also presented (refer to Figures B.13 and B.14 in Appendix B).

**Climate change impacts on flooding**

The study area’s low elevations mean that flooding in the lower reaches is expected to be sensitive to future climate change impacts, in particular sea level rise. Previous guidance from the NSW Government recommended considering a 0.4m rise in sea level from current (1990) levels for the year 2050, and 0.9m rise for the year 2100 in assessing the impact of climate change on flooding. These projections are based on research by the Intergovernmental Panel on Climate Change (IPCC) and were refined for the Australian region.

The effects of future sea level rise on the 1% AEP events were estimated in TUFLOW as a sensitivity assessment, based on a 0.4m increase in sea level, and a 0.9m increase in sea level. The existing climate 1% AEP design rainfalls were simulated and coincided with a 5% AEP ocean water level as per the design flood simulations. The change in flood levels is mapped on Figures D.9 and D.10 in Appendix D. In summary:

- In the catchment low-point around Hale Street, flood levels increase by 0.34m with 0.4m sea level rise, and by 0.8m with 0.9m sea level rise
- In the low-point at Chelmsford Avenue and The Esplanade, flood levels increase by 0.1m with 0.4m sea level rise, and by 0.23m with 0.9m sea level rise
- No change in flood levels on the residential properties in Dent Street with o.4m sea level rise and 0.05m increase with 0.9m sea level rise.

The assessment was based on existing catchment development and drainage infrastructure conditions. The impacts to flooding in the study area are attributed primarily to the high tailwater levels preventing drainage of the low points when coinciding with a catchment rainfall event, and to a lesser degree due to backflow of the water from Botany Bay.

The effects of increased rainfall intensity on the 1% AEP events due to climate change were also. The change in flood levels is mapped on Figures D.11 and D.12 in Appendix D. In summary:

- In the catchment low-point around Hale Street, flood levels increase by 0.09m with 10% increase in rainfall intensity, and by 0.17 – 0.26m with 24% increase in rainfall intensity
- In the low-point at Chelmsford Avenue and The Esplanade, flood levels increase by 0.08m with 10% increase in rainfall intensity, and by 0.14 with 24% increase in rainfall intensity
- Around Pemberton Street low point, flood levels increase by 0.09m with 10% increase in rainfall intensity, and by 0.22 with 24% increase in rainfall intensity
- Around Salisbury Street and Cranbrook Street low point, flood levels increase by 0.06m with 10% increase in rainfall intensity, and by 0.27 with 24% increase in rainfall intensity
- Around Rochester Street low point, flood levels increase by 0.02m with 10% increase in rainfall intensity, and by 0.1 with 24% increase in rainfall intensity
- Around William Street and Aylesbury Street low point, flood levels increase by 0.05m with 10% increase in rainfall intensity, and by 0.08 with 24% increase in rainfall intensity
- Around Bay Street, Rose Street, Ivy Street and Daphne Street, flood levels increase by 0.06m with 10% increase in rainfall intensity, and by 0.12 with 24% increase in rainfall intensity
- Around Dent Street, flood levels increase by 0.03m with 10% increase in rainfall intensity, and by 0.09 with 24% increase in rainfall intensity.

**Impacts to the Community**

The impacts of flooding to the community were quantified. A count of properties and buildings affected by above-floor flooding resulting for tidal, oceanic and catchment flooding are summarized in Table 1.

Table 1: Count of properties and dwellings with above-floor flooding

| Event | Property flooding* | | Above-floor flooding | |
|---|---|---|---|---|
| | Residential | Commercial/ Industrial | Residential | Commercial/ Industrial |
| Tidal inundation – King Tide (1.25m AHD)**. No catchment flooding | 0 | 1 | 0 | 1 |
| Ocean inundation – storm surge (5% AEP design ocean level 1.4m AHD). No catchment flooding | 0 | 12 | 0 | 12 |
| Ocean inundation – storm surge (1% AEP design ocean level 1.45m AHD). No catchment flooding | 0 | 16 | 0 | 16 |
| 20% AEP catchment flooding | 1,655 | 134 | 214 | 134 |
| 5% AEP catchment flooding | 1,656 | 159 | 320 | 159 |
| 1% AEP catchment flooding | 1,657 | 203 | 415 | 203 |
| PMF catchment flooding | 1,667 | 304 | 933 | 304 |

* Depths above 0.05m. Includes those with above-floor flooding

** High High Water Spring (Solstice Spring) design tide level of 1.25m AHD, as specified in OEH (2015) is adopted as the "king tide" level.

Flood affectation of properties is relatively insensitive to the increasing rarity of flooding events. This is attributed to the flat terrain of the study area, relatively shallow nature of flooding and generally poor drainage conditions. Flooding is typically resultant from catchment inflows with tidal backflows up the drainage system having a minor contribution in the lower areas of the study area.

Sensitive properties and critical infrastructure have been identified in the catchment. Certain types of properties may require specific evacuation considerations due to the vulnerability of its occupants, such as schools and pre-schools, and aged care facilities. Critical infrastructure (water supply systems and distribution systems, wastewater systems and sewer distribution facilities, electricity substations, etc.) and emergency services centres (SES, police, fire stations, hospitals and ambulance centres etc.) impacted by flooding may have effects on the recovery and functioning of the community following a flood event.

A review of land zoning indicates a number of existing childcare centres which are flood-affected with high hazard flooding in the PMF and with some affected by high hazard flooding in the 1% AEP event. The three schools in the study area are mainly affected by low hazard flooding in up to the PMF in the main built areas of the school grounds. The schools' land use is considered compatible with the flood hazard. The Heritage Botany Aged Care Facility is mostly not flooded or affected by low hazard flooding in the PMF event and is considered mostly compatible with the flood hazard. Some areas of the aged care facility are affected by higher hazard flooding which poses a flood risk to residents. Development of a flood management plan for the facility and for affected child care centres should be considered to manage the flood risk to residents and occupants.

Flood damages have been estimated in the study area, and are primarily attributed to residential dwellings that are impacted by overland flooding. Commercial and industrial properties contribute about 15% to the total average annual damages (AAD). The residential AAD for the study area is $11.5 million. The commercial/ non-residential AAD is $1.8 million. There are 618 residential and non-residential properties that are estimated to experience above floor flooding for the 1% AEP event. In the PMF, 1,237 properties are estimated to experience above floor flooding. Refer to Table 7-3 and Table 7-4 for the residential and non-residential property flood damages, respectively, for various flood events. While flood damage estimates for the study area are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

**Review of Existing Emergency Planning**

The existing local emergency planning arrangements in the study area were reviewed. There is currently no specific flood warning system for flash flooding in the study area. Emergency response and evacuation considerations were reviewed. Flooding in the study area may generally be considered to be flash flooding in nature with rapid rates of rise, fast catchment hydrologic response and no warning time. Durations of flooding are expected to be up to 18 – 24 hours in events up to the 1% AEP particularly in the lower points of the study area. Durations of flooding are expected to be prolonged (several days) in the PMF due to the large volumes of floodwater ponding in trapped low points and the poor drainage conditions.

Coordinated evacuation to flood refuges prior to a flood event is not a practical solution due to the minimal warning time and flashy nature of flooding. Local evacuation, whereby residents observe flooding and respond by moving to higher ground, may be feasible although it requires a high level of awareness of the flooding conditions and flood-free zones. However, the flat terrain of the study area means that identification and access to flood-free zones is likely to be difficult, and some areas which are flood-free in the 1% AEP may be affected to depths greater than 1m in rarer events up to the PMF. There is also risk of a flood occurring during night time during which the residents may not be awake to observe and respond to flooding.

Given minimal warning time and limited practicality of evacuation before or during a flood event, for existing developments, it might be appropriate for residents to shelter in place in the dwelling which is structurally sound in a flood event up to the PMF flood event, however this is subject to the investigation by SES as part of the Bayside Local Flood Plan. SES will review whether shelter in place is appropriate as a primary response in these circumstances.

The factors described above and the constraints on planned evacuation places emphasis on the importance of flood education and awareness within the community. A proposed flood education and awareness program should encourage residents to be familiar with the flooding conditions at and in the vicinity of their property to help them plan and prepare for a flood.

**Assessment of Flood Risk Management Measures**

One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing and future flood risk in the study area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts.

The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories as described below:

- Property modification measures involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions);
- Response modification measures involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness); and
- Flood modification measures involve modifying the behaviour of the flood itself (for example, trunk drainage improvements; construction of a levee to exclude floodwaters from an area or flood retarding/detention basins to store floodwaters and reduce peak outflows).

A range of non-structural flood risk management measures were assessed for suitability. Property modification measures reviewed included voluntary house purchase, voluntary house raising, flood proofing and flood compatible design but were not considered suitable. Amendments to planning instruments and controls (LEP, DCP, rezoning) were also investigated and recommendations made regarding these measures. Response modification measures which are recommended included flood depth signage on roads, updates to emergency management and planning, flood education and awareness and site specific flood plans. Development of a flash flood warning system for the study area is not recommended as there is no warning time in the occurrence of a flood event in the study area.

A total of 19 structural options i.e. flood modification measures, including combinations of options, were identified and assessed as options for implementation in the short term. These included detention basins, local and trunk drainage upgrades and backflow prevention devices on drainage lines. Each option was analysed in the TUFLOW hydraulic model. This long list of options was shortlisted, based on the modelled hydraulic performance, to 10 options (including combinations) for further assessment. A summary of the hydraulic performance and the cost-benefit assessment of the 10 options are provided in Table 2.

Detailed evaluation of these options was undertaken considering improvements to flood behaviour and flood damages, resultant flooding impacts, costs and economic feasibility, social, environmental, emergency management and flood safety and administrative aspects. The detailed evaluation informed the selection of the recommended options for inclusion in the Floodplain Risk Management Plan.

Table 2 Summary of Selected Flood Modification Options for Detailed Evaluation

| Option | Location | Description | Constraints and Impacts<br>Plus other comments | Hydraulic Benefits<br>*And Negative Impacts if Any* | Savings in Flood Damages<br>(50 years life, 7% Discount Factor) | Cost of Works | Benefit Cost Ratio (BCR) |
|---|---|---|---|---|---|---|---|
| Option 2c | Detention Basin- Booralee Park | • Removal of informal embankment along western side of Jasmine Street<br>• Lowering the base of the park by 1m<br>• 300mm low flow outlet pipe connected to existing drainage network | • The park would be subject to more frequent flooding and for longer durations<br>• May not be acceptable to community<br>• Likely disturbance/removal of vegetation including EECs<br>• Disturbance of cricket pitches, soccer field and other park facilities<br>• High groundwater table may result in park being frequently waterlogged<br>• Potential for unrecorded Aboriginal sites/items in south-western portion of park<br>• Dam safety issues need to be considered | • Reductions in flood levels up to 0.13m in 5% AEP event, and 0.15m in 1% AEP, on Daniel Street<br>• Reductions in flood levels up to 0.03m in 5% AEP event, and 0.30m in 1% AEP, on Rose Street<br>• Reductions in flood levels up to 0.08m in 5% AEP event, and 0.30m in 1% AEP, on Bay Street and Jasmin Street<br>• 28 less properties with above floor flooding in 1% AEP event.<br>• Five less properties with above floor flooding in 5% AEP event<br>• One property with above floor flooding in 5% AEP event which is flood free in the existing scenario<br>• Flood hazard changes from H3 to H1 on Daniel Street and Ivy Street in both 1% and 5% AEP events, on Daphne Street for 1%AEP event only. | $1.5M | $1.1M | 1.4 |
| Option 4a | Drainage Augmentation- around Bay Street | • Augmented drainage line along Ivy Street, Rose Street, Hickson Street, Bay Street and Botany Road | • Disruption to major arterial road during construction. Likely closure of major road with traffic diverted via local roads<br>• Limited space for construction activities on footpath<br>• Potential clash with existing utilities (Ausgrid cables, Telstra networks, NBN facilities, Jemena high pressure gas main, RMS traffic signal cable). Significant number of main drainage lines already in place<br>• Likely closure of driveways to existing properties<br>• Likely disturbance/removal of vegetation | • Increase in flood levels up to 0.02m in 5% AEP event, and 0.08m in 1% AEP, on downstream of Bay Street<br>• Reductions in flood levels up to 0.38m in 5% AEP event, and 0.31m in 1% AEP, on Rose Street<br>• Reductions in flood levels up to 0.10m in 5% AEP event, and 0.40m in 1% AEP, on upstream of Bay Street<br>• Reductions in flood levels up to 0.06m in 5% AEP event, and 0.10m in 1% AEP, on Botany Road<br>• 26 less properties with above floor flooding in 1% AEP event<br>• Five less properties with above floor flooding in 5% AEP event<br>• Two properties with above floor flooding in 5% AEP and 1% AEP event which are flood free in the existing scenarios<br>• Flood hazard changes from H2 to H1 on Rose Street and Ivy Street in both 1% and 5% AEP event<br>• Flood hazard changes from H3 to H1 on Hickson Street flood in 1% AEP event. | $0.8M | $14.2M | 0.05 |
| Option 7a | Drainage Augmentation- around Pemberton Street | • Drainage duplication near junction of Pemberton Street and Mahroot Street | • Limited space for construction activities on footpath<br>• Potential clash with existing utilities (Ausgrid cables, Telstra networks, NBN facilities, Jemena high pressure gas main).<br>• Likely closure of driveways to existing properties<br>• Works on private property, which will require micro-tunnelling | • Reductions in flood levels up to 0.08m in 5% AEP event, and 0.09m in 1% AEP, on Pemberton Street and Mahroot Street<br>• Reductions in flood levels up to 0.02m in 5% AEP event, and 0.08m in 1% AEP, on Rancom Street<br>• Reductions in flood levels up to 0.05m in 5% AEP event, and 0.03m in 1% AEP, on Sir Joseph Bank Street<br>• Four less properties with above floor flooding in 1% AEP event<br>• Six less properties with above floor flooding in 5% AEP event<br>• Two properties with above floor flooding in 1% AEP event which are flood free in the existing scenarios | $3.2M | $12.9M | 0.25 |

| Option | Location | Description | Constraints and Impacts<br>Plus other comments | Hydraulic Benefits<br>*And Negative Impacts if Any* | Savings in Flood Damages<br>(50 years life, 7% Discount Factor) | Cost of Works | Benefit Cost Ratio (BCR) |
|---|---|---|---|---|---|---|---|
| | | | | • Flood hazard becomes H1 on a large part of Pemberton Street and Mahroot Street in both 1%AEP and 5%AEP events. | | | |
| Option 8 | Drainage Augmentation-William Street | • Upgrade of stormwater system in William Street (2x600mm pipe) | • Limited space for construction activities on footpath<br>• Potential clash with existing utilities (Ausgrid cables, Telstra networks, NBN facilities, Jemena high pressure gas main) | • Reduction in flood levels up to 0.14m in 5% AEP event, and 0.07m in 1% AEP, on William Street<br>• Reductions in flood levels up to 0.13m in 5% AEP event, and 0.06m in 1% AEP, on Aylesbury Street<br>• 29 less properties with above floor flooding in 1% AEP event.<br>• 25 less properties with above floor flooding in 5% AEP event<br>• One property with above floor flooding in 5% AEP event which is flood free in the existing scenario<br>• Flood hazard becomes H1 on a part of William Street and Aylesbury Street in both 1%AEP and 5%AEP events. | $3.9M | $1M | 4 |
| Option 11 | Drainage Augmentation Option 8 plus near Pemberton Street and Clevedon Street | • Option 8 plus<br>• Drainage duplication near Pemberton Street and Clevedon Street | • Limited space for construction activities on footpath<br>• Potential clash with existing utilities (Ausgrid cables, Telstra networks, NBN facilities, Jemena high pressure gas main)<br>• Likely closure of driveways to existing properties<br>• Works on private property, which will require micro-tunnelling | • Increase in flood levels up to 0.08m in 1% AEP, on Clevedon Street<br>• Reduction in flood levels up to 0.18m in 5% AEP event, and 0.09m in 1% AEP, on William Street<br>• Reductions in flood levels up to 0.18m in 5% AEP event, and 0.07m in 1% AEP, on Aylesbury Street<br>• 33 less properties with above floor flooding in 1% AEP event.<br>• 30 less properties with above floor flooding in 5% AEP event<br>• Two properties with above floor flooding in 5% AEP which are flood free in the existing scenarios<br>• Flood hazard becomes H1 on a part of William Street and Aylesbury Street in both 1%AEP and 5%AEP events. | $4.8M | $13M | 0.37 |
| Option 13a | Drainage Augmentation-Dent St | • New culverts to drain water into the existing pond<br>• Connect pond with existing outlets to drain water into Botany Bay + local backflow deivices | • Likely disturbance/removal of vegetation including EECs<br>• Potential clash with existing utilities (Ausgrid cables, Caltex pipe/Jemena high pressure gas main)<br>• Potential environmental issue<br>• Likely closure of park entrance<br>• Potential for unrecorded Aboriginal sites/items in Sir Joseph Banks Park | • Reductions in flood levels up to 0.2m in 5% AEP event, and 0.23m in 1% AEP, on Dent Street<br>• 12 less properties with above floor flooding in 1% AEP event<br>• 16 less properties with above floor flooding in 5% AEP event<br>• Flood hazard becomes H1 on a significant part of Dent Street in both 1%AEP and 5%AEP events. | $1M | $1.7M | 0.59 |
| Option 16 | Combined option | • Option 13a<br>plus<br>• Option 1: Backflow prevention devices for all outlets | • Similar to Option 13a plus 4 backflow prevention devices<br>• | • Reductions in flood levels up to 0.2m in 5% AEP event, and 0.23m in 1% AEP, on Dent Street<br>• 13 less properties with above floor flooding in 1% AEP event<br>• 16 less properties with above floor flooding in 5% AEP event<br>• Flood hazard becomes H1 on a significant part of Dent Street in both 1%AEP and 5%AEP events. | $1.4M | $2.1M | 0.67 |
| Option 17 | Combined option | • Combination of Option 1, Option 4a and Option 12<br>• (Option 12 consists of Augmented drainage line at Hale Street and Booralee Street. Refer to | • Similar to Option 4a and Option 12 plus 4 backflow prevention devices | • Increase in flood levels up to 0.02m in 5% AEP event, and 0.07m in 1% AEP, on downstream of Bay Street<br>• Reductions in flood levels up to 0.32m in 5% AEP event, and 0.4m in 1% AEP, on Rose Street | $1.4M | $27.7M | 0.05 |

| Option | Location | Description | Constraints and Impacts<br>Plus other comments | Hydraulic Benefits<br>*And Negative Impacts if Any* | Savings in Flood Damages<br>(50 years life, 7% Discount Factor) | Cost of Works | Benefit Cost Ratio (BCR) |
|---|---|---|---|---|---|---|---|
| | | Appendix E for more details) | | • Reductions in flood levels up to 0.14m in 5% AEP event, and 0.40m in 1% AEP, on Bay Street<br>• Reductions in flood levels up to 0.05m in 5% AEP event, and 0.09m in 1% AEP, on Botany Road<br>• Reductions in flood levels up to 0.08m in 5% AEP event, and -0.02m in 1% AEP, on Hale Street<br>• 26 less properties with above floor flooding in 1% AEP event<br>• Seven less properties with above floor flooding in 5% AEP event<br>• Two properties with above floor flooding in 5% AEP and 1% AEP event which are flood free in the existing scenarios<br>• Flood hazard changes from H2 to H1 on Rose Street and Ivy Street in both 1% and 5% AEP events and on Daniel Street and Daphne Street in 1%AEP event only<br>• Extent of flood hazard of H1 increases on Booralee Street, Hale Street and Luland Street in both 1%AEP and 5%AEP events | | | |
| Option 18 | Combined option | • Combination of Option 4a and Option 12 | • Similar to Option 4a and Option 12 | • No significant change in flood behaviour compare to Option 17 | $1.5M | $27.4M | 0.05 |
| Option 19 | Combined option | • Combination of Option 2c, Option 4a and Option 12 | • Similar to Option 2c, Option 4a and Option 12 | • Increase in flood levels up to 0.03m in 5% AEP event, and 0.02m in 1% AEP, on downstream of Bay Street<br>• Reductions in flood levels up to 0.32m in 5% AEP event, and 0.6m in 1% AEP, on Rose Street<br>• Reductions in flood levels up to 0.2m in 5% AEP event, and 0.57m in 1% AEP, on Bay Street<br>• Reductions in flood levels up to 0.06m in 5% AEP event, and 0.10m in 1% AEP, on Botany Road<br>• Reductions in flood levels up to 0.08m in 5% AEP event, and 0.05m in 1% AEP, on Hale Street<br>• 36 less properties with above floor flooding in 1% AEP event<br>• 11 less properties with above floor flooding in 5% AEP event<br>• Two properties with above floor flooding in 5% AEP and 1% AEP event which are flood free in the existing scenarios<br>• Flood hazard changes completely to H1 on Rose Street, Ivy Street and Daniel Street in both 1% and 5% AEP events.<br>• Extent of flood hazard of H1 increases on Booralee Street, Hale Street and Luland Street in both 1%AEP and 5%AEP events. | $2M | $28.3M | 0.07 |

**Floodplain Risk Management Plan**

A number of structural mitigation options were assessed but most of them were found to be infeasible due to high costs and relatively low improvements to flooding conditions and flood damages. Detention Basin-Booralee Park (Option 2c) and Drainage Augmentation- William Street (Option 8) are two structural options which were found to be economically feasible due to Benefit-Cost Ratio (BCR) values above 1.0. The recommended management measures relate to the development planning and policy, emergency planning, public education and awareness and implementation of feasible structural mitigation options to manage the flood risk in the catchment.

Residents in the Dent Street neighbourhood raised several concerns regarding flooding issues in their street. While Drainage Augmentation- Dent St (Option 13a, and Option 16 with backflow devices) is not found to be economically feasible based on savings in property flood damages, this does not preclude the upgrade of the drainage system to mitigate flooding as significant number of properties are impacted by above floor flooding around Dent Street is in a high hazard zone (H3- unsafe for vehicles, children and the elderly) in 1% annual exceedance probability (AEP) flood event. Option 13a has therefore been included on the grounds of improvements to high hazard flooding. Further, the damages to vehicles and infrastructure is not included in the economic assessment and their inclusion would likely justify the nomination of this option based on economic feasibility. Detailed investigation (e.g. survey of existing utilities) would be required to further investigate the feasibility of this option.

Option 16, which includes installation of backflow devices at 4 trunk drainage outlet locations on top of Option 13a, is also recommended in the Floodplain Risk Management Plan to protect against oceanic (tidal and storm surge) flooding from backflow up the trunk drainage for existing climate conditions. Installation of backflow devices is recommended at 5 additional outlets in the long term to protect against oceanic flooding under future sea level rise scenario. This has not been included in the Floodplain Risk Management Plan.

The majority of recommended management measures relate to development planning and policy, land use, emergency planning and management by agencies and private operators, public education and awareness in order to manage the flood risk in the catchment.

The Floodplain Risk Management Plan, which outlines an implementation program for the proposed measures, is provided in Table 3. The Plan can be progressively implemented with an anticipated timeframe of 3-5 years for high priority options and 5-10 years for medium priority options. Estimated costs and responsibilities for implementation are indicated. The DPIE administer the NSW Government’s Floodplain Risk Management Program which provides grant funding to local councils for eligible studies and works, including detention basins and major drainage augmentation works. The funding is on a 2 (state) to 1 (Bayside Council) basis. The Plan is presented pictorially on Figure 1.

Community consultation including public exhibition was undertaken on the Draft FRMSP in October 2020 prior to update and adoption of the Final Plan by Council.

**Management of Future Climate Change Flood Risks**

The Floodplain Risk Management Plan includes measures which have the objective of managing the existing flood risk in the first instance. Additional measures, excluded from the current Plan, should be considered in future updates of the Plan to progressively address the changing flood risks as a result of future climate change. These may include:

Backflow devices on 5 additional trunk drainage outlets (as discussed in Section 10.1.1.1)

- Floodwater pumping facilities (as discussed in Section 10.2.4)
- Further improved and modified drainage infrastructure, if these become feasible in the future
- Revision design flood levels and of flood planning levels, minimum floor levels and other relevant development controls related to design flood levels. Flood studies would need to be updated to reflect new information on rainfall, sea level and flooding conditions, in line with Council’s climate change and sea level rise policies (as discussed in Section 4.3.2).

Council has committed to identify and respond to emerging hazards and risks associated with local climate change and this would be appropriately done in relation to flooding with the planned periodic reviews of the FRMP.

Table 3 Botany Bay and Foreshore Beach Floodplain Risk Management Plan

| Measure ID | Measures considered | Responsibility | Initial Cost | Ongoing Cost | Features of the Measure | Recommended Priority Rankings |
|---|---|---|---|---|---|---|
| FM1 | **Option 2c**<br>Detention Basin-Booralee Park | Council | $1.1M | Up to $5K p.a. Inspection/ maintenance of basin outlet, basin sides. | • Removal of embankment along western side of Jasmine Street<br>• Lowering the base of the park by 1m<br>• 300mm low flow outlet pipe connected to existing drainage network<br>• Feasibility study should be undertaken to assess if raised embankment (Option 2b- raising the existing embankment)) is preferred due to contaminated soil and other issues. | **Medium** – would significantly improve flood immunity in the surrounding area.<br>Option to be further investigated following feasibility assessment (Option FM1A) in relation to site contamination to determine best design strategy for a detention basin. |
| FM1A | Feasibility study for Booralee Park detention basin | Council | $100K | N/A | • A feasibility study should be undertaken to assess if raised embankment (Option 2b) is preferred over a lowered basin bed (Option 2c) due to contaminated soil and other issues. There is a risk of potential soil contamination based on historic usage of the park area. Soil contamination investigation is required.<br>• Aboriginal heritage investigation is also recommended as a part of the feasibility study. There is high potential for unrecorded Aboriginal artefacts in south-western portion of the park.<br>• Dam safety issues and design requirements need to be scoped. Consultation with Dam Safety NSW to be undertaken as required. | **High –** feasibility assessment should be undertaken in the near future for this high priority option |

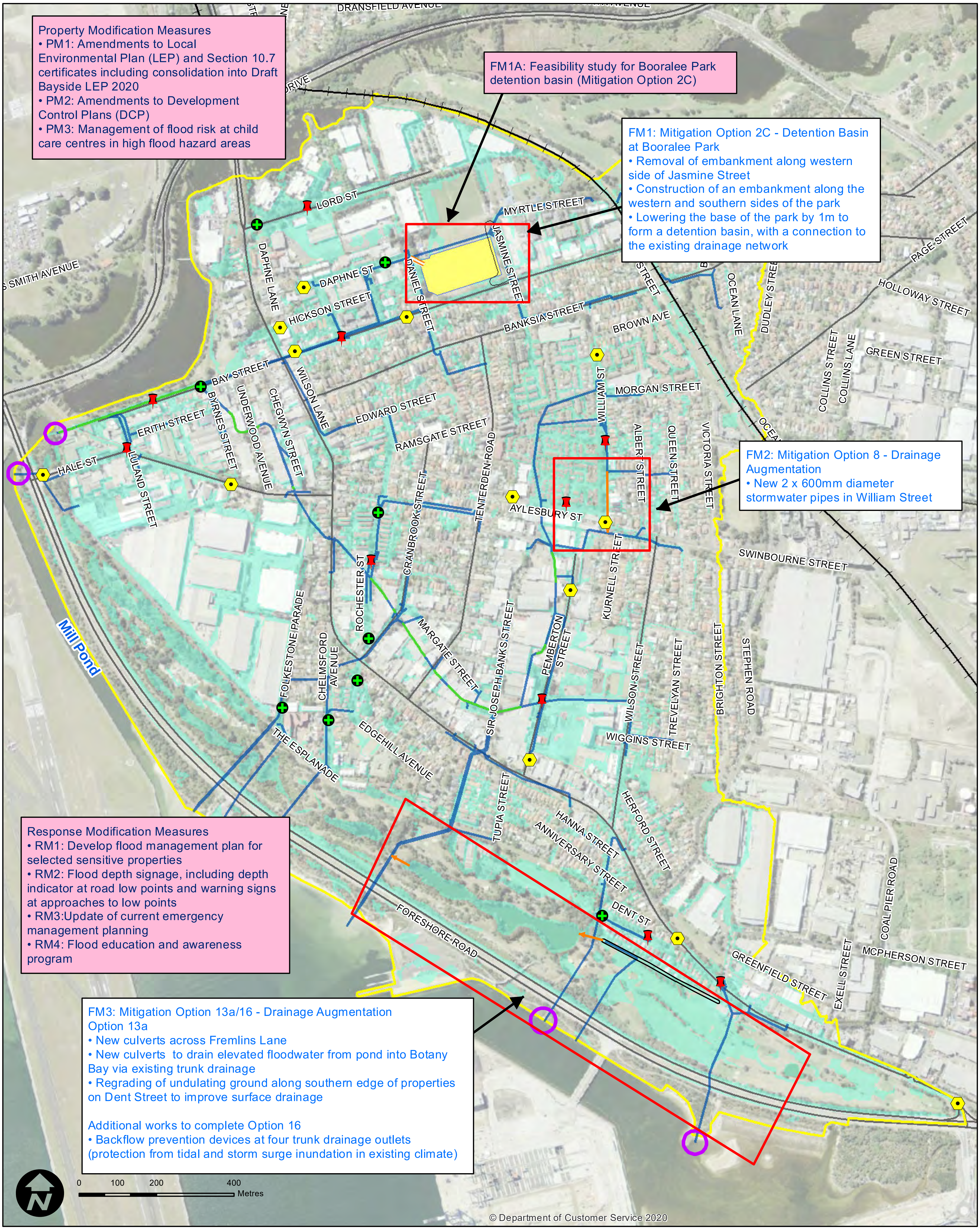
| Measure ID | Measures considered | Responsibility | Initial Cost | Ongoing Cost | Features of the Measure | Recommended Priority Rankings |
|---|---|---|---|---|---|---|
| FM2 | **Option 8**<br>Drainage Augmentation- William Street | Council | $1M | Up to $5K p.a. Inspection/ maintenance of drainage inlets | • Upgrade of stormwater system in William Street (2x600mm pipe) | **Medium** – would significantly improve flood immunity in the surrounding area. |
| FM3 | **Option 13a/16**<br>Drainage Augmentation- Dent St<br>+ installation of backflow devices at 4 outlets | Council | $1.5M (Dent Street drainage augmentation)<br>+$220K (tbackflow devices) | Up to $5K p.a. Inspection/ maintenance of drainage | Install Option 13a<br>• New culverts to drain water into the existing pond<br>• Connect pond with existing outlets to drain water into Botany Bay with backflow prevention devices.<br>• Requires detailed scoping and design study including proximity locating of major gas line and BIP groundwater treatment network.<br>Install Option 1 backflow devices at 4 locations for protection from tide/storm surge for existing climate/ sea levels to complete Option 16. | **Medium** – although relatively low benefit-cost ratio it would significantly improve flood immunity and flood hazard in the surrounding area. |
| PM1 | Amendments to LEP and Section 10.7 certificates | Council | Council staff costs | N/A | LEP amendments shall be consistent with the requirements of the applicable Environmental Planning Instrument and Development Control Plan, to enable flood risks to be reduced and managed.<br>Section 10.7 certificates to notate properties which are affected by flooding as identified in the Botany Bay and Foreshore Beach floodplain risk management study. | **High –** ensure planning documents are consistent and utilize the most up to date flood information. |

| Measure ID | Measures considered | Responsibility | Initial Cost | Ongoing Cost | Features of the Measure | Recommended Priority Rankings |
|---|---|---|---|---|---|---|
| PM2 | Amendments to DCP | Council | Council staff costs | N/A | Bayside Council is currently reviewing the DCP (as of June 2020). Recommendations for inclusion/ amendment relating to management of flood risk are provided below:<br>• Consideration should be made for consolidating all flood planning controls under a specific section for Flood Liable Land or in a separate Flood Policy instrument.<br>• It is recommended that a flood planning level of 1% AEP + 0.5m freeboard be adopted, in line with flood planning provisions in draft Bayside LEP. The 0.5m freeboard is commensurate with the flood risk in the study area.<br>• The inclusion of provisions specifying minimum floor levels for critical facilities should be considered. Typically the minimum floor level of such development is the PMF level.<br>• The flood hazard and hydraulic categories mapping is to be consulted by Council in the planning and approval of proposed developments for flood-affected lots. Developments are not to be approved on high hazard or floodway areas.<br>• Council should consider inclusion of requirements for flood compatible design in the development controls.<br>• Inclusion of a fence policy whereby fences should not be constructed in floodways. Where this is | **High –** ensure planning documents are consistent and provide clarity and utilize the most up to date flood information. |

| Measure ID | Measures considered | Responsibility | Initial Cost | Ongoing Cost | Features of the Measure | Recommended Priority Rankings |
|---|---|---|---|---|---|---|
| | | | | | unavoidable fences are to be of open construction that will not restrict the flow of floodwater. | |
| PM3 | Management of flood risk at child care centres in high flood hazard areas | Council (advocacy only), property operator (funding and implementation) | Cost to be borne by property operator | N/A | • Council should consult with the owners/operators of the Hippo's Friends Child Care Centre and Botany Bay Preschool regarding the flood risk to these properties. During the consultation Council should advocate for provision of suitable flood refuge spaces above PMF level on the properties if further assessment of the properties identifies no suitable spaces. The owner/operator should then consider redevelopment to provide flood refuge spaces. | Consultation with owner/operator is **high priority**.<br>Implementation of redevelopment is considered **medium priority**, subject to stakeholder willingness and capacity to redevelop. |
| RM1 | Develop flood management plan for selected sensitive properties | Council (advocacy only), property operator (funding and implementation), SES (advice) | Cost to be borne by property operator | N/A | • Council should consider consultation with the Heritage Botany Aged Care Facility regarding management of flood risk on the site. Development of a flood management plan for the site should be considered.<br>• Similar plans should be considered for Hippo's Friends Child Care Centre and Botany Bay Preschool. The plans should contain procedures for evacuation of children to flood-safe spaces within the property if possible.<br>• Emergency and evacuation procedures for Childcares shall include the flood risk management and emergency procedure. | **High** – need to communicate flood risks to significant stakeholders in the floodplain. |

| Measure ID | Measures considered | Responsibility | Initial Cost | Ongoing Cost | Features of the Measure | Recommended Priority Rankings |
|---|---|---|---|---|---|---|
| RM2 | Flood depth signage | Council | **Static depth indicator and warning signs**<br>$5K per sign, 19 signs<br>**Flashing warning light signs**<br>$100K per sag location incl. dual independent systems at each location. 13 signs | $5-10K p.a. | • Flood depth signage (x10) at key road low points<br>• Flood depth and hazard warning signs (x9) ahead of the road low points to warn of possible flooding ahead<br>• Flashing light warning signs are recommended at 5 key high hazard locations (main roads and high risk locations) (x13 flashing signs).<br>• The signs serve as depth indicators and warning of flooding ahead during a flood event to reduce occurrences of people driving into floodwaters, in addition as a passive reminder of flooding risk.<br>• Flood depth indicator and signage requirement is to be consistent with the outcome of Hawkesbury Nepean and Georges River Floodplain Risk Management Strategy. | **High** – aims to directly modify driver response to flood hazard during a flood event.<br>Static signs are a low cost measure which also improves flood safety and flood awareness at each location. |
| RM3 | Update of current emergency management planning | SES | SES costs | SES costs | • It is recommended that the findings of this flood study are incorporated into the development of the Bayside Local Flood Plan, such as locations of roads being cut by flooding, locations of sensitives properties, emergency response classification, flood hazards.<br>• Incorporate the information on flood behaviour and hazards from this study into SES internal operations.<br>• The Bayside Local Flood Plan will be developed as part of the review cycle of the EMPLAN (2021). | High – incorporate into the 3 yearly review cycle of EMPLAN (due 2021), including development of Bayside Local Flood Plan. |

| Measure ID | Measures considered | Responsibility | Initial Cost | Ongoing Cost | Features of the Measure | Recommended Priority Rankings |
|---|---|---|---|---|---|---|
| RM4 | Flood education and awareness program | Council, SES | $50K | Staff costs | Measures may include:<br>• Promotion of FloodSafe brochures to help residents understand the flood risk and prepare their property and personal plans for a flooding event.<br>• Flood depth signage in selected road locations (cost covered in measure RM2). Flood depth indicator and signage requirement is to be consistent with the outcome of Hawkesbury Nepean and Georges River Floodplain Risk Management Strategy.<br>• Provide flood mapping on an interactive mapping portal on Council's website for easier viewing. Provide graphic on website showing catchments in Botany Bay where studies have been completed.<br>• Promotion and support for SES information events.<br>• Enhanced messaging on flood risk on Council's floodplain management webpage.<br>• Promotion of flood proofing measures should also be included in flood education and awareness programs<br>• The program should be reviewed on a regular (e.g. 2 yearly) basis. | **High** – community awareness is likely to significantly improve flood preparedness, reduce flood damages and reduce flood response and risk to people. |




## Legend

Proposed Mitigation

Flood sign (Measure RM2)
- Depth indicator
- Flashing light warning sign
- Static warning sign

- New stormwater pipes
- Backflow prevention devices
- Detention basin
- Existing open channels
- Existing stormwater networks
- Study area
- 1% Annual Exceedance Probability Flood Extent

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:9,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Recommended Floodplain Risk Management Plan | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | Figure 1 | |
| DRAWN AI | CHECK LC | DATE 25/11/2020 | PROJECT # IA190100 |

# 1. Introduction

## 1.1 General

The Botany Bay Foreshore Beach Catchment is located within the Bayside Council local government area, and includes parts of the suburbs of Botany, Pagewood and Banksmeadow. The catchment is situated at low elevations with flat relief. Overland flooding in the catchment occurs as a result of runoff flowing overland and collecting within low points on the ground surface, with drainage of these locations being impeded by a constrained stormwater drainage system. The poor drainage conditions are exacerbated by the low ground elevations and the influence of elevated ocean levels, coinciding with rainfall events, in Botany Bay to which the catchment drains. The low elevation of parts of the catchment mean that areas are also susceptible to tidal inundation during dry weather conditions and high tide and oceanic level events.

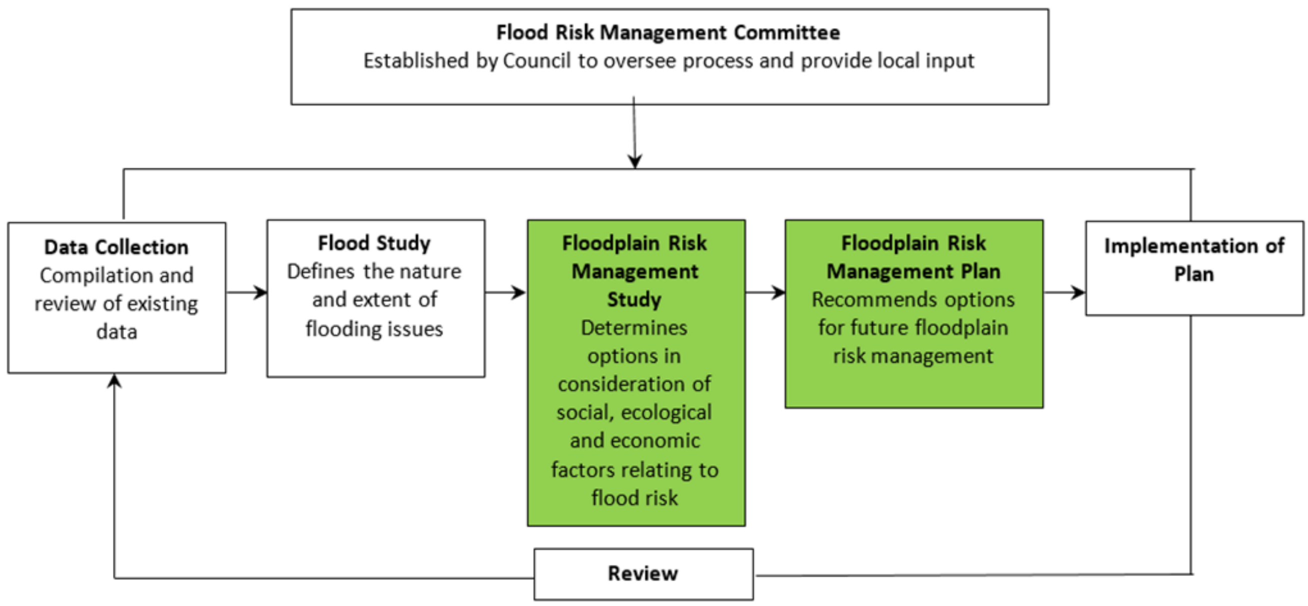
Bayside Council ("Council") commissioned Jacobs to prepare a floodplain risk management study and plan for the Botany Bay Foreshore Beach Catchment. This report is the Floodplain Risk Management Study and Plan (FRMSP) which defines the flooding behaviour and its impact on the community, identifies and appraises potential management measures to reduce existing and future flood risk. Based on the study findings, a list of prioritised measures for consideration and implementation by Council has been prepared.

## 1.2 Floodplain risk management

Council is responsible for managing the existing, continuing and future flood risk for its Local Government Area (LGA). The floodplain risk management planning process, as set out in the *Floodplain Development Manual* (NSW Government, 2005) has a number of steps which are illustrated in Figure 1.1.

The Flood Risk Management Committee (FRMC) for Council was established in 2018 and includes a number of Council Representatives, staff from the Office of Environment and Heritage (OEH), the NSW State Emergency Services (SES), in addition to local stakeholders including community representatives.

Figure 1.1 Floodplain Risk Management Process



## 1.3 Purpose of this study

Objectives of the study include:

- Update available hydrologic and hydraulic modelling to estimate flooding conditions for a range of design events based on current flooding analysis guidelines.
- Identify and assess structural and non-structural mitigation measures to manage flood risk.
- Review existing planning, policy and emergency management for gaps and inconsistencies relating to floodplain planning, then develop proposed amendments to address residual flood risk.
- Prioritise the works and measures, including economic and multi criteria appraisal of options.
- Develop an implementation program for recommended works and measures including timing, responsibility and sources of funding.
- Conduct consultation with the community and key stakeholders throughout the study to obtain information and intelligence for input into the study. Gauges the perceptions of the community on flooding matters. Obtain feedback on the findings and recommendations of the study.

## 1.4 Structure of this report

This report is structured accordingly:

- Section 2 – Summary of the physical setting, history of flooding and social, environmental and heritage aspects of the catchment.
- Section 3 – Discusses previous studies and relevant available information and data on flooding and hydrology in the catchment.
- Section 4 – Summary of relevant State and local government policies and planning framework.
- Section 5 – Summary of consultation activities undertaken for the study.
- Section 6 – Describes flood behaviour and flood hazard.
- Section 7 – Impacts of flooding on the community including high hazard properties, flood damages, land use compatibility, evacuation considerations.
- Section 8 – Overview of existing flood emergency planning.
- Section 9 – Outline of management measure types and review of property and response modification measures.
- Section 10 – Discussion of shortlisted mitigation options nominated for detailed assessment, and evaluation of options.
- Section 11 – Floodplain Risk Management Plan.
- Section 12 – Acknowledgements.
- Section 13 – Literature cited in this report.
- Section 14 – Definition of terms used in this report.

# 2. Study Area

## 2.1 Catchment description

The study area is located within the Bayside Council Local Government Area (LGA) as shown in Figure 2.1. The study area, approximately 5.4km$^2$, is bounded by Sydney Airport to the west, Southern Cross Drive and Eastlakes Golf Course to the north, Stephen Road to the east and Botany Bay to the south.

The study area is quite flat, with the exception of a low-lying ridge line located on the eastern boundary of the catchment. This leads to generally poor surface drainage conditions. The catchment generally slopes in a south-westerly direction toward the Botany Bay foreshore, with a ridge of sand hills preventing direct surface drainage to the Bay. A northwest-southeast chain of ponds/wetlands are located along much of Sir Joseph Banks Park, towards the bottom end of the catchment. The catchment is a highly modified landscape, comprising high-density residential, commercial and industrial development. It also includes major roads (Botany Road and Foreshore Road) as well as a section of freight railway line. Refer to Figure 2.2 for the catchment terrain.

## 2.2 Existing land use and development

The study area contains a diverse range of land uses under the Botany Bay Council Local Environmental Plan (LEP) 2013. The study area includes the following land zones:

- IN1 General Industrial
- R2 Low Density Residential
- R3 Medium Density Residential
- B1 Neighbourhood Centre
- B2 Local Centre
- B4 Mixed Use
- B5 Business Development
- B7 Business Park
- SP1 Special Activities
- SP2 Infrastructure
- RE1 Public Recreation

The middle and eastern section of the study area is generally occupied by low and medium density residential land uses. Areas zoned industrial are located mainly in the far-western end of the study area, with some areas in the south-eastern corner of the study area. Business park and business development land uses are interspersed within the residential and industrial areas in the mid and northern sections of the study area. There are large areas of open space along the south-eastern section of the study area comprising the Botany Golf Course. Other open space areas include parks and reserves in the study area. Special purpose zoned areas include schools and infrastructure. Refer to the land use zoning map on Figure 2.3.


Legend

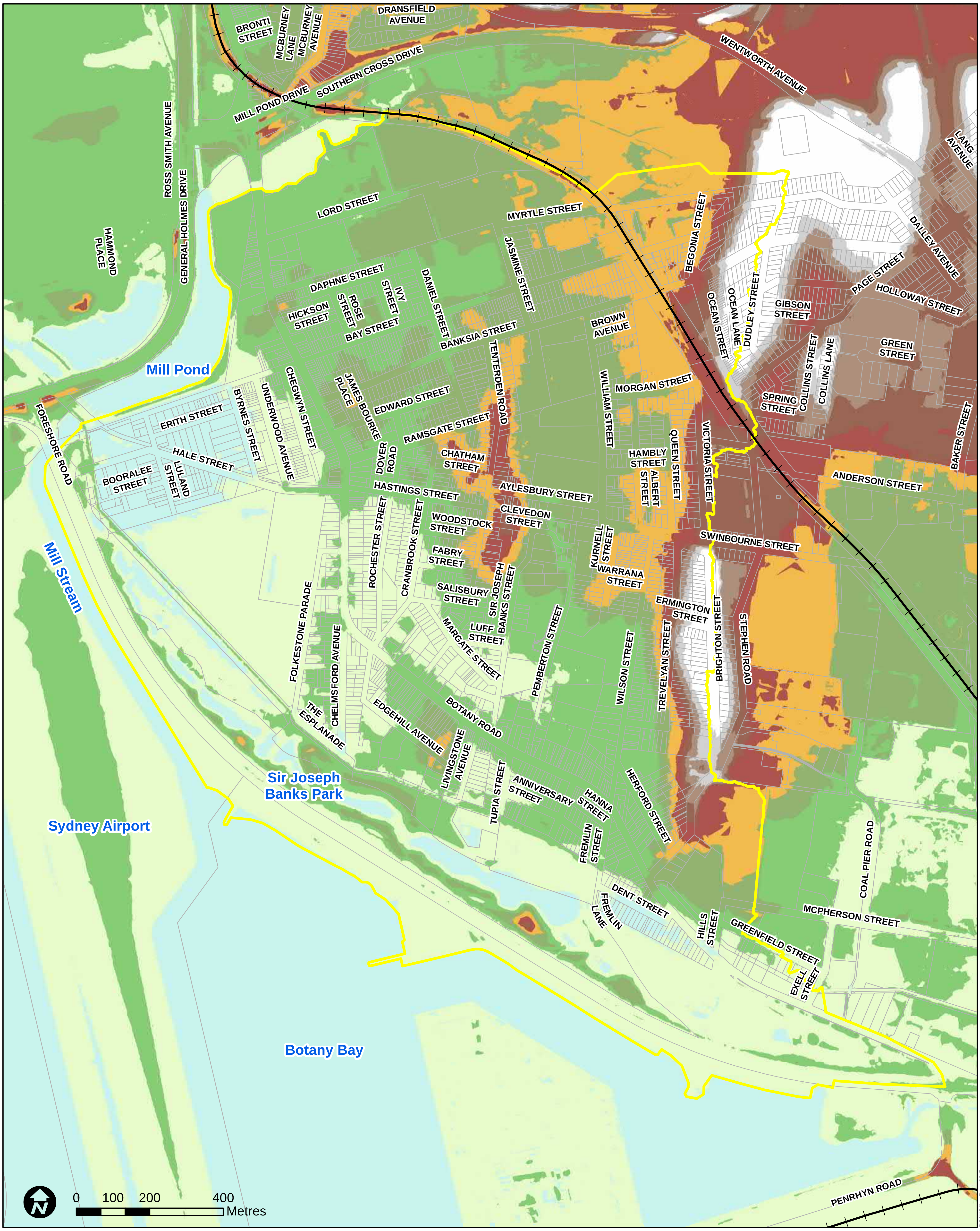
- Study area
- Rail
- Roads

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Study Area | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 2.1 | REV 2 VER 1 |
| CHECK AH | DATE 4/04/2020 | | |




Legend

- Rail
- Study area
- Cadastre

Land Elevation (mAHD)

- <=2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- 14 to 16
- 16 to 18
- >18

JACOBS

Data Sources: Bayside Council

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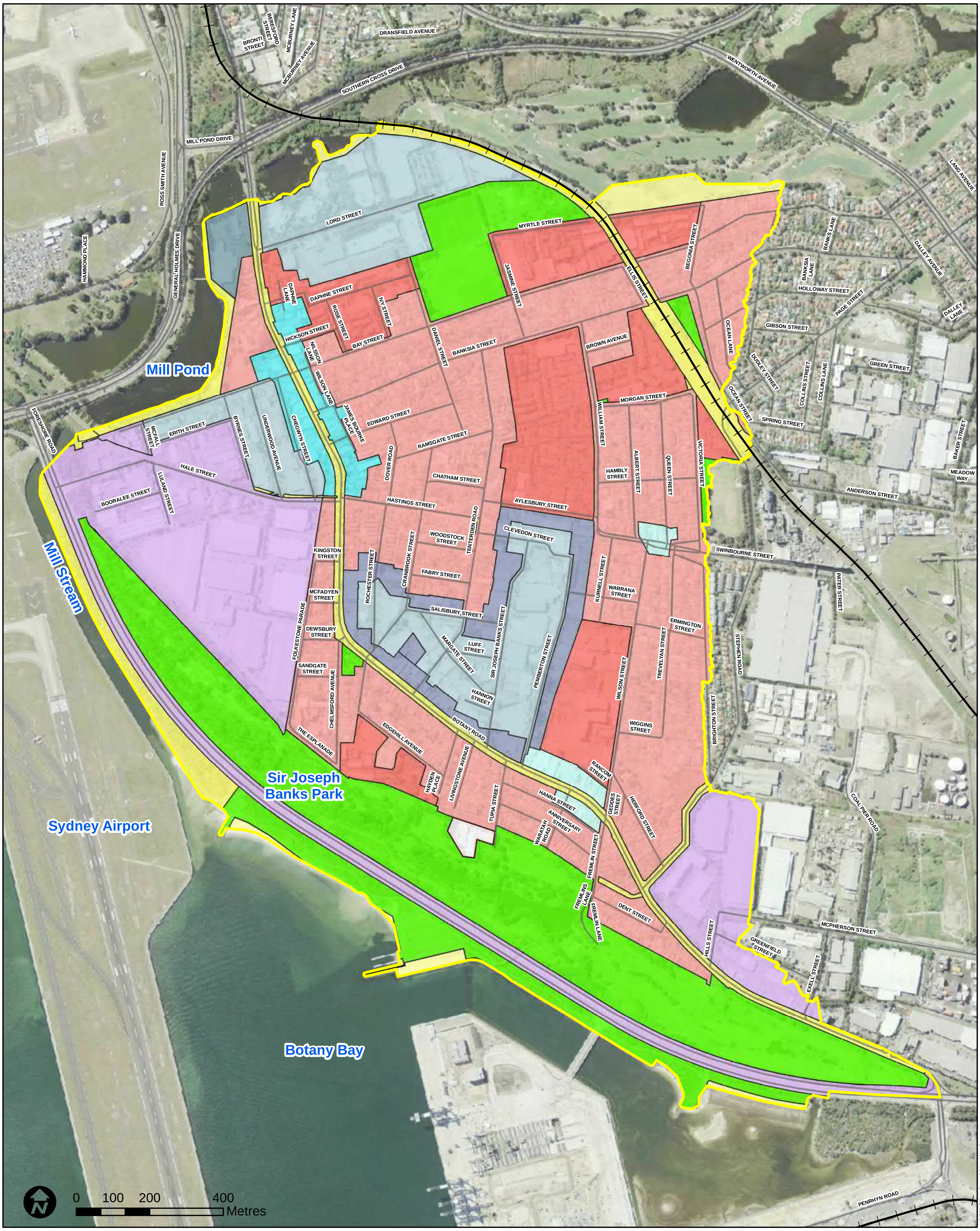
| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Terrain of the Study Area | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 2.2 | REV 2 VER 1 |
| CHECK AH | DATE 4/04/2020 | | |




Legend

- Study area
- Roads
- Rail

Land Use Zoning

- Neighbourhood Centre
- Local Centre
- Mixed Use
- Business Development
- Business Park
- Deferred Matter
- General Industrial
- Low Density Residential
- Medium Density Residential
- Public Recreation
- Special Activities
- Infrastructure

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Land Use Zoning | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 2.3 | REV 1 VER 1 |
| CHECK AH | DATE 1/04/2020 | | |

## 2.3 Flooding mechanisms

The Botany Bay and Foreshore Beach catchment is mainly affected by the following two flooding mechanisms:

- Overland flooding: This occurs as a result of intense rainfall over the catchment causing runoff which flows overland and collects within low points on the ground surface, which are then drained by the stormwater system. Overland flooding can also occur due to the stormwater system capacity being exceeded, resulting in flows surcharging to the surface.
- Tidal and oceanic inundation: The low elevation of parts of the catchment mean that areas are also susceptible to inundation caused by very high astronomical tides (i.e. king tides), in addition to elevated oceanic level events (e.g. due to storm surge and other oceanic water level phenomena) and combinations of these factors. The elevated tide and ocean levels cause water in Botany Bay to back up existing trunk drainage pipes, which then surcharge via stormwater pits onto low lying areas in the catchment.

Flooding events can be caused by coinciding overland flooding and tidal/oceanic inundation events.

Mainstream flooding, resulting from rising floodwaters in main watercourses such as Mill Pond/Botany Wetlands or the Cooks River, is not a significant influence on flooding in the study area. Flooding from Mill Pond does not spill into the study area in up to the 1% AEP event, and there are only minor overflows during the PMF (refer to Section 3.1.2).

## 2.4 Drainage conditions

The study area is generally flat and generally slopes in a south-westerly direction towards Botany Bay. While the catchment is generally highly modified, the natural land surface has formed a number of drainage low points across the study area in which runoff accumulates and ponds, causing flooding issues. Historically, stormwater drainage was constructed including a trunk drainage line consisting of pipes, culverts and open channels to follow the natural drainage direction, running to the north-west to an open channel which drains to Mill Pond. Most local drainage networks were connected to this trunk drainage line. This arrangement presumably increased conveyance of floodwaters and contributed to flooding of low-lying areas in the north-western section around Hale Street and Bay Street.

In the 1980s, bulkheads were installed on the Sydney Water trunk drainage line in the vicinity of Sir Joseph Banks Street and Rochester Street to limit flows being conveyed to the Hale Street/Bay Street area. The main trunk drainage was diverted southward from upstream of the bulkheads to directly discharge to Botany Bay. Other drainage modifications were made which resulted in an interlinked drainage network with multiple main connections and discharge points, rather than drainage via a traditional main trunk branch and local feeder branches.

The low-lying and flat nature of the study area has heavy reliance on this drainage system with limited flow capacity, hence flooding issues occur in frequent storm events when the system capacity is exceeded. Essentially, much of the study area acts as a “bath tub” which depends on this drainage system to discharge any floodwaters to Botany Bay. Additionally, the interlinked nature of the overall drainage system means that changes in one part of the system could influence flooding in another area.

Flooding is usually characterised by short, intense events with little or no warning time. Catchment runoff is conveyed in part via the original trunk drainage line towards the north-western portion of the catchment to Mill Stream, with a higher portion of the drainage occurring via the newer trunk drainage pipes to the south-west directly to Botany Bay. However, discharge to the receiving waters is constrained by the drainage system and/or elevated water levels in Botany Bay. The southern portions of the catchment close to Foreshore Road and the north-west part of the catchment are at increased risk of flooding due to the combination of flooding from both rainfall runoff and tidal events.

Future sea level rises are likely to exacerbate the flooding issues. A large proportion of the industrial area in the vicinity of Bay Street lies below an elevation of 2.3m AHD, which is the level of the 5% AEP ocean level of 1.4m AHD plus 0.9m sea level rise (projected for the year 2100), which puts it at direct risk from inundation in storm surge events during projected climate change scenarios. Many areas would also be affected from tidal inundation during the highest astronomical tide of approximately 2.05m AHD under projected sea level rise in the year 2100.

## 2.5 Historic flood events

Information on historic flood events in the study area is limited. Council and Sydney Water records identified that an approximately 1% annual exceedance probability (AEP) event occurred in March 1975. Since then the largest flood event was in March 1977 (20% AEP, or 1 in 5 AEP), while subsequent events were up to 1 exceedances per year (EY), i.e. 1 year average recurrence interval (ARI), including the June 2010, June 2012 and April 2013 events. The 24 March 2014 event was estimated as less than a 0.5EY (i.e. 2 year ARI) event.

## 2.6 Social profile

Social characteristics of the study area are a key consideration for the floodplain risk management study. The Australian Bureau of Statistics (ABS) census 2016 summarised in Table 2-1 indicates the following information on the population in the study area.

Table 2-1: Census Data for Botany Statistical Area Level 2. source: ABS 2016 Census Basic Community Profile

| Item | Statistic |
|---|---|
| **Selected Person Characteristic** | |
| Total Persons | 10,817 |
| Aged 14 years and under | 20.6% |
| Aged 65 years and over | 11.9% |
| Aboriginal/Torres Strait Islander | 2.7% |
| Australian born | 63.1% |
| Born overseas | 30.5% |
| Speaks English only at home | 68.4% |
| Speaks other language and speaks English not well/not at all/not stated | 2.7% |
| Other languages spoken at home (% of people) | Cantonese (2%)<br>Mandarin (2%)<br>Greek (2%)<br>Indonesian (2%)<br>Spanish (2.9%) |
| Completed Year 12 | 46.6% |
| Completed Year 10 | 14.1% |
| Did not go to school | 0.4% |
| **Selected Medians & Averages** | |
| Median age | 36 |
| Median total household income ($/weekly) | $2,028 |
| Median mortgage repayment ($/monthly) | $2,600 |
| Median rent ($/weekly) | $520 |
| Average household size | 2.8 |

| Item | Statistic |
|---|---|
| **Dwelling Structure** | |
| Separate house | 30.4% |
| Semi-detached etc | 24.3% |
| Flat, unit, apartment | 37.3% |
| Other dwelling | 0.9% |
| **Tenure Type by Dwelling Structure** | |
| Fully owned | 23.4% |
| Mortgaged | 40.0% |
| Rented | 33.4% |
| Other tenure type | 0.5% |
| Tenure type not stated | 2.8% |
| **Household Composition** | |
| Family households | 75.4% |
| Single (or lone) person households | 20.4% |
| Group households | 4.2% |
| **Type of Internet Connection** | |
| Internet not accessed from dwelling | 11.7% |
| Internet accessed from dwelling | 85.5% |
| Not stated | 2.8% |

| Item | Statistic |
|---|---|
| **Number of Motor Vehicles by Dwellings** | |
| Dwellings with 0 motor vehicles | 7.7% |
| Dwellings with 1 motor vehicles | 36.6% |
| Dwellings with 2 motor vehicles | 38.7% |
| Dwellings with 3+ motor vehicles | 13.6% |
| Number of motor vehicles not stated | 3.5% |

| Item | Statistic |
|---|---|
| **Selected Labour Force and Education % of total labour force or % of persons aged 15 years and over** | |
| Total unemployed | 3.9% |
| Total labour force | 68.2% |

* Remainder not stated.

The census data is a snapshot of the population characteristics. Key attributes include:

- About 32% of the population are children or retirees/elderly (>65 years old). Children and elderly may require assistance during a flood. Elderly may have difficulties with recovery following a flood, particularly if they are part of the nearly 20% of the population in single person households.
- About 3% of the population speak a language other than English at home and speak English not well or not at all. This suggests that the use of English in flood warnings and messages, such as brochures and signage, would generally be adequate for the large majority of the community. Multi-language brochures could be considered to communicate flood messaging for the remaining members of the community with no fluency in English. Interpretation services may also be required during emergencies and also for effective public education strategies outside of emergency situations. The most common languages spoken at home, other than English, is Mandarin, Cantonese, Indonesian, Greek and Spanish (about 2% each).
- Very few persons did not attend school, and a high proportion completed Year 12 or higher. This indicates relatively high education levels and a capacity to absorb technical information (if well written).
- 89% of dwellings are stated to own a vehicle. NSW Evacuation Guidelines makes recommendations that evacuees be encouraged to make their own way to a safer location, seek accommodation and assistance from family and friends or insurance companies where possible and the high rate of ownership of vehicles would generally enable this.
- Over 63% of dwellings are fully owned or mortgaged. Home ownership status may affect the willingness to participate in property modification measures.
- 37% of households are in flats/apartments which are typically multi-storey. Given the nature of flooding in the study area those dwellings on the first floor or above are unlikely to have their habitable space directly affected by above-floor flooding, although ground floor or basement storage spaces may be affected. About 55% of dwellings are in houses or semi-detached dwellings which are typically single storey in the study area and which may be vulnerable to flooding of habitable spaces.
- The census indicates that about 86% of households accessed internet from the dwelling (i.e. via home internet). It is reasonable to assume that virtually all households have smartphones which have mobile access to the internet. Therefore, there would be a high rate of accessibility to information on flooding on websites of Council and other agencies such as BOM and SES, including warnings and messages in the lead-up to and during storm events.
- The median total household income of $2,028 per week is high compared to the NSW average of $1,486. This does not necessarily suggest that the economic ability of households to recover from flooding events is high, as the median monthly mortgage is also high ($2,600 compared to NSW median of $1,986) and earnings may be significantly tied up in these repayments. Flood damages may be relatively high due to higher value of possessions.

- A high rate of employment may mean that a large proportion of the population are in the workplace and not at their property during a flood event. This may limit their ability to self-help during a flood event to minimise property damage.

## 2.7 Natural environment

### 2.7.1 Overview

The study area is situated within the Eastern Beaches Sub-catchment of the Sydney Metropolitan Catchment which occupies an area of approximately 1,860km$^2$, extending offshore to include state waters up to the three nautical mile limit (DPI, 2019).

The study area is highly urbanised with limited terrestrial native biodiversity values. As such, the study area principally comprises an interconnected network of streets, buildings, and industrial parks; which generally contain planted both native and exotic vegetation.

Vegetated areas within the study area include a narrow strip of coastal vegetation bounding the foreshore of Botany Bay, and extensive areas within Sir Joseph Banks Park. The Park is a feature of environmental significance especially from an inner southern Sydney perspective, providing a large vegetated open space within heavily urbanised areas in Botany and Banksmeadow.

The western and central portions of the Park are the main vegetated areas and were a narrow coastal dune and intertidal sand flat until the expansion of Port Botany in the late 1970s. These works included dredging of the Botany Bay sands which was used to reclaim the land that now forms the western and central precincts of the reserve, and construction of Foreshore Drive. The reclaimed land was designed by renown Sydney based landscape architect, Bruce Mackenzie, and is a good example of 1970s Australian landscape architecture using native species to recreate natural dune systems, wetlands and coastal environments, and innovative landscape construction techniques. The vegetation profiles within the park include open grass, dunes, Eucalyptus Woodland/Coastal Scrub Heath vegetation areas and wetlands. The wetlands and chain of ponds were formed by exposing the water table of the Botany Aquifer. Although the wetlands suffer from generally poor water quality with overgrowth of weed species, they provide valuable habitat for many native birds and aquatic species and are surrounded with stands of native trees and edge species in areas (Thompson Berrill Landscape Design, 2019).

The pond water levels within Sir Joseph Banks Park respond naturally to fluctuating water table levels. Any proposed flood mitigation measures need to consider the potential effects on overland and subsurface flows which may impact on the pond wetlands.

Kamay Botany Bay National Park and Towra Point Nature Reserve are located approximately 5.5km south-east of the study area, both of which have significant biodiversity and conservation values.

### 2.7.2 Protected species

Table 2-2 presents a summary of threatened species identified within the study area, which have been listed as vulnerable to critically endangered under the *NSW Threatened Species Conservation Act 1995* (TSC Act) and/ or the *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The list of species identified within  is derived from review of information contained within the NSW Office of Environment and Heritage (OEH) Threatened Biodiversity database and NSW Bionet Atlas, and consists only of species which have been sighted. A number of additional threatened flora and fauna species listed under the EPBC Act (1999) have been identified as 'likely to occur within the area', however no confirmed sightings have been identified through the NSW OEH Threatened Biodiversity database or NSW Bionet Atlas. Accordingly, the preliminary impact assessments have focused only on those species that have confirmed sightings.

Table 2-2 Commonwealth and NSW listed threatened species that have been sighted in the study area (OEH, 2019)

| Class | Common Name | Scientific name | NSW Status – TSC Act 1995 | Commonwealth Status – EPBC Act 1999 |
|---|---|---|---|---|
| Amphibia | Green and Golden Bell Frog | *Litoria aurea* | Endangered | Vulnerable |
| Aves | Superb Fruit-Dove | *Ptilinopus superbus* | Vulnerable | |
| Aves | Pied Oystercatcher | *Haematopus longirostris* | Endangered | |
| Aves | Greater Sand-plover | *Charadrius leschenaultii* | Vulnerable | Vulnerable |
| Aves | Sanderling | *Calidris alba* | Vulnerable | |
| Aves | Curlew Sandpiper | *Calidris ferruginea* | Endangered | Critically Endangered |
| Mammalia | Grey-headed flying fox | *Pteropus poliocephalus* | Vulnerable | Vulnerable |
| Mammalia | Southern Myotis | *Myotis macropus* | Vulnerable | |
| Mammalia | Large Bent-winged Bat | *Miniopterus orianae oceanensis* | Vulnerable | |
| Flora | Sunshine Wattle | *Acacia terminallis subsp. terminalis* | Endangered | Endangered |

#### 2.7.2.1 Birds (Aves)

It is expected that any structural floodplain management measures that may be proposed are unlikely to cause permanent adverse impact to those sensitive bird species that have been identified within the study area. Nevertheless, the design and placement of structural floodplain measures within the catchment or study area should consider impacts on the presence of the identified sensitive bird species. As such, further detailed design should include an environmental assessment to determine the potential presence and extents of nesting and/or foraging sites to further inform potential impacts.

#### 2.7.2.2 Mammals (Mammalia)

The mammalian species that have been identified as present within the study area are protected bat and flying-fox species. It is expected that any structural floodplain management measures that may be proposed are unlikely to cause a significant impact to any of these species, due to their high mobility. Nevertheless, the design and placement of structural floodplain measures should consider the presence of these identified sensitive mammalian species. As such, further detailed design should include an environmental assessment to determine the potential presence and extents of nesting and/or foraging sites to further inform potential impacts.

#### 2.7.2.3 Amphibians (Amphibia)

The species that has been identified as present within the study area comprises the Green and Golden Bell Frog, which commonly inhabit coastal and near coastal locations within NSW. Structural floodplain management measures may have the potential to adversely impact Green and Golden Bell Frog through alteration of flow regimes and/or clearing of native vegetation within the study area.

The design and placement of structural floodplain measures should consider the presence of the identified sensitive amphibian species. As such, further detailed design should include an environmental assessment to determine the potential presence and extents of Green and Golden Bell Frog habitat to further inform potential impacts.

#### 2.7.2.4 Flora

The Sunshine Wattle (*Acacia terminallis subsp. Terminalis*) has been identified as being present within the study area. As such, design and placement of structural floodplain measures should consider the presence of this species and further detailed design may require a species-specific environmental survey to determine the presence of the Sunshine Wattle within the footprint area.

### 2.7.3 Endangered ecological communities

Vegetation mapping available through the NSW Sharing and Enabling Environmental Data (SEED) portal indicates that vegetation is limited to the following plant communities:

- Coast Banksia - Coast Wattle dune scrub of the Sydney Basin Bioregion and South East Corner Bioregion – adjacent to the Botany Bay foreshore;
- Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion – adjacent to the Botany Bay foreshore (identified in Table 2-3 above);
- Banksia heath on aeolian sands of eastern Sydney suburbs, Sydney Basin Bioregion – adjacent to Stephen Road and Mill Stream;
- Old-man Banksia - she-oak - Red Bloodwood heathland on coastal sands, southern Sydney Basin Bioregion – adjacent to Mill Stream; and
- Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion – adjacent to Mill Stream.

The design and placement of any structural floodplain management measures should consider the presence of the existing EECs (though limited in extent). EECs in addition to those listed above may occupy the bushland areas that are situated within Sir Joseph Banks Park or in the wetland areas along the foreshore of Botany Bay. Site-specific ecological surveys should be undertaken to formally identify EECs that may be present within the footprint area should be conducted as part of the detailed design stage.

## 2.8 Heritage

An understanding of heritage issues is required in addressing floodplain risk management for the study area. Heritage items provide information on the social and cultural context of the floodplain and their location is an important consideration for floodplain mitigation measures.  Any flood mitigation works needs to consider impact on Aboriginal and non-Aboriginal heritage, and the presence of heritage items has been considered in the identification and assessment of mitigation options. Additional heritage assessment would need to be undertaken in the further design of recommended mitigation options

An online search of the State Heritage Inventory was undertaken. The Inventory is a list of heritage items in New South Wales including Aboriginal Places, State Heritage Register, Interim Heritage Orders, State Agency Heritage Registers and Local Environmental Plans.

The Botany Water Reserves (SHR 1317) is the only identified heritage item listed under the NSW Heritage Act in the vicinity of the study area. It comprises remnant natural wetland which provided water supply during the early period of settlement in Sydney, and includes Mill Stream and Mill Pond. Existing drainage structures discharge into this water feature. Proposed measures should avoid impacting on the characteristics of this feature. The management of this heritage item is covered in part in Botany Wetlands Plan of Management 2018-2028 (Sydney Water, 2018).

There are approximately 80 items identified in the register listed by Council and by State government agencies, refer to Table 2-3.There are no Aboriginal Places listed in the OEH register under the National Parks and Wildlife Act in the study area.

An Aboriginal heritage item (AHIMS item 45-6-0629) is identified within the study area as being the only item listed in AHIMS within the former City of Botany area (Gondwana Consulting, 2011). It is recorded as an "enclosed shelter" with "burial/s, midden and shelter with deposits". In general the aeolian sand dunes at Botany Wetlands are considered a high-risk landscape which may indicate the existence of previously unidentified Aboriginal objects (Sydney Water, 2018). This also applies to the sand dune areas within Sir Joseph Banks Park and the south-western corner of Booralee Park (Gondwana Consulting, 2011). Additional heritage assessment would need to be undertaken in the further design of recommended mitigation options within these and other locations.

Sir Joseph Banks Park is listed as a local heritage item and is subject to the Sir Joseph Banks Park Conservation Management Plan (Thompson Berrill Landscape Design, 2019). Any proposed flood mitigation works within the Park should consider and be consistent with the Conservation Management Plan.

Development consent is required prior to altering heritage items; this includes demolishing or moving, altering the building by making structural changes, disturbing or excavating archaeological sites, disturbing or excavating an Aboriginal place of heritage significance, erecting a building on the land or subdividing the land where a heritage item is located.

Table 2-3 Non-Aboriginal Heritage Items in Study Area

| Item name | Address | Suburb | LGA | Information source |
|---|---|---|---|---|
| Alignment Pin, Botany | Botany Road, SW cnr Fremlin Street | Botany | Botany Bay | SGOV |
| Banksmeadow Public School | Brighton Street | Botany | Botany Bay | LGOV |
| Boarding House (front buildings) | 1443 Botany Road | Botany | Botany Bay | LGOV |
| Booralee Park | Bounded by Sydenham Railway Line and Daniel, Bay, Lord, Myrtle and Jasmine Streets | Botany | Botany Bay | LGOV |
| Botany Fire Station | 1-3 Banksia Street | Botany | Botany Bay | LGOV |
| Botany Fire Station | 3 Banksia Street | Botany | Botany Bay | SGOV |
| Botany Public School (c.1869) | Botany Road | Botany | Botany Bay | LGOV |
| Botany Town Hall and Council Chambers | 1423 Botany Road | Botany | Botany Bay | LGOV |
| Botany Township | | Botany | Botany Bay | LGOV |
| Botany Township Heritage Conservation Area | Botany Township Botany Road | Botany | Botany Bay | LGOV |
| Botany Uniting Church | 1355 Botany Road | Botany | Botany Bay | LGOV |
| Botany Water Reserve | Southern Cross Drive, Wentworth Avenue and Heffron Road | Botany, Pagewood, Eastlakes and Kensington | Botany Bay | SGOV |
| Botany Water Reserves | | | | LGOV |
| Canary Island Date Palms (Phoenix canariensis) | 23 Byrnes Street | Botany | Botany Bay | LGOV |
| Captain Cook Hotel | 1114 Botany Road | Botany | Botany Bay | LGOV |
| Commercial / Residential Building | 1226 Botany Road | Botany | Botany Bay | LGOV |
| Corner Store - Alto | 50 - 52 Bay Street | Botany | Botany Bay | LGOV |
| Electricity Substation No. 153 | 14 Byrnes Street | Botany | Botany Bay | SGOV |
| Electricity Substation No. 153 | 14 Byrnes Street | Botany | Botany Bay | LGOV |

| Item name | Address | Suburb | LGA | Information source |
|---|---|---|---|---|
| Electricity Substation No. 340 | 3 William Street | Botany | Botany Bay | SGOV |
| Electricity Substation No. 340 | 3 William Street | Botany | Botany Bay | LGOV |
| Finnies Buildings | 1094-1098 Botany Road | Botany | Botany Bay | LGOV |
| Former Headmasters Residence (Banksmeadow Public School) | 60 Brighton Street | Botany | Botany Bay | LGOV |
| Hippo's Friends Child Care Centre | 1082 Botany Road | Botany | Botany Bay | LGOV |
| House | 1447 Botany Road | Botany | Botany Bay | LGOV |
| House | 8 Banksia Street | Botany | Botany Bay | LGOV |
| House | 47 Banksia Street | Botany | Botany Bay | LGOV |
| House | 145 Bay Street | Botany | Botany Bay | LGOV |
| House | 147 Bay Street | Botany | Botany Bay | LGOV |
| House | 50 Tenterden Road | Botany | Botany Bay | LGOV |
| House | 54 Tenterden Road | Botany | Botany Bay | LGOV |
| House | 16 Tenterden Road | Botany | Botany Bay | LGOV |
| House | 31 Cranbrook Street | Botany | Botany Bay | LGOV |
| House | 35 Cranbrook Street | Botany | Botany Bay | LGOV |
| House | 37 Cranbrook Street | Botany | Botany Bay | LGOV |
| House | 2 Woodstock Street | Botany | Botany Bay | LGOV |
| House | 1365 Botany Road | Botany | Botany Bay | LGOV |
| House | 84 Tenterden Road | Botany | Botany Bay | LGOV |
| House | 135 Bay Street | Botany | Botany Bay | LGOV |
| House | 6 Banksia Street | Botany | Botany Bay | LGOV |
| House | 16 Bay Street | Botany | Botany Bay | LGOV |
| House | 19 Bay Street | Botany | Botany Bay | LGOV |
| House | 7 Banksia Street | Botany | Botany Bay | LGOV |
| House - Helena | 1424 Botany Road | Botany | Botany Bay | LGOV |
| House (The White House) | 151 Bay Street | Botany | Botany Bay | LGOV |
| House Group | 165-179 Bay Street | Botany | Botany Bay | LGOV |
| House Group | 10-14 Bay Street | Botany | Botany Bay | LGOV |
| House Group | 21-23 Salisbury Street | Botany | Botany Bay | LGOV |
| House Group | 1268-1270 Botany Road | Botany | Botany Bay | LGOV |
| House Group | 63-65 Tenterden Road | Botany | Botany Bay | LGOV |
| House Group | 45-57 Bay Street | Botany | Botany Bay | LGOV |
| House Group | 1158-1168 Botany Road | Botany | Botany Bay | LGOV |
| John Brotchie Kindergarten | 1361 Botany Road | Botany | Botany Bay | LGOV |
| Memorial Park | 814 Botany Road | Mascot | Botany Bay | LGOV |
| Memorial Park | 814 Botany Road | Botany | Botany Bay | LGOV |
| New Market Hotel | 889 Botany Road | Rosebery | Botany Bay | LGOV |
| New Market Hotel | 889 Botany Road | Botany | Botany Bay | LGOV |
| Police Station (circa 1871) | 1441 Botany Road | Botany | Botany Bay | LGOV |
| Port Botany Revetment Wall | Prince of Wales Drive | Port Botany | Randwick | SGOV |
| Post Office (c.1923) | 2 Banksia Street | Botany | Botany Bay | LGOV |

| Item name | Address | Suburb | LGA | Information source |
|---|---|---|---|---|
| Presbyterian Church of Australia and Manse | 1561-1563 Botany Road | Botany | Botany Bay | LGOV |
| Residential Building | 16 The Esplanade | Botany | Botany Bay | LGOV |
| Sandstone Kerb, Botany | Botany Road, NW & NE cnr Wilson Street | Botany | Botany Bay | SGOV |
| Sewage Pumping Station No 60 (SP0060) | McFall Street | Botany | Botany Bay | SGOV |
| Sewer Vent | Tenderden Road | Botany | Botany Bay | SGOV |
| Sir Joseph Banks Hotel (c.1840), Former | 23 Anniversary Street | Banksmeadow | Botany Bay | LGOV |
| Sir Joseph Banks Hotel (c.1920) | 1354 Botany Road | Botany | Botany Bay | LGOV |
| Sir Joseph Banks Park | Fremlin | Botany | Botany Bay | LGOV |
| St. Matthews Anglican Church (1862) | 1331 Botany Road | Rosebery | Botany Bay | LGOV |
| Streetscape - Verge plantings of Canary Island Date Palm | Northern side of Bay Street | Botany | Botany Bay | LGOV |
| Streetscape - Verge plantings of Canary Island Date Palm | Brighton Street | Botany | Botany Bay | LGOV |
| Streetscape - Verge plantings of Canary Island Date Palm, Brown Avenue, Botany | Brown Street | Botany | Botany Bay | LGOV |
| Streetscape - verge plantings of Canary Island Date Palms (and Hoop Pines) | Swinbourne Street (between William and Queen Streets) | Botany | Botany Bay | LGOV |
| Sydney Water Corporation - Sewer Vent | Tenterden Road | Botany | Botany Bay | LGOV |
| Sydney Water Corporation Sewage Pumping Station SP0060 | McFall Street | Botany | Botany Bay | LGOV |
| Terrace Group | 42-54 Daphne Street | Botany | Botany Bay | LGOV |
| Weatherboard House Group | 18-20 Erith Street | Botany | Botany Bay | LGOV |
| Botany Bay Hotel | 1807 Botany Road | Banksmeadow | Botany Bay | LGOV |
| Commercial Building | 1619 Botany Road | Banksmeadow | Botany Bay | LGOV |
| Former Headmasters Residence (Banksmeadow Public School) | 60 Brighton Street | Botany | Botany Bay | LGOV |
| Long Jetty, Botany Bay | Foreshore Road | Banksmeadow | Botany Bay | SGOV |
| Main Administration Building | Beauchamp Street | Banksmeadow | Botany Bay | LGOV |
| Pier Hotel | 1751 Botany Road | Banksmeadow | Botany Bay | LGOV |
| Port Botany Old Government Wharf Remains | Port Botany | Banksmeadow | Unincorporated Waterway | SGOV |
| Sandstone Kerb from Golf Course, Botany Road, Banksmeadow | Botany Road | Banksmeadow | Botany Bay | SGOV |
| Sir Joseph Banks Hotel (c.1840), Former | 23 Anniversary Street | Banksmeadow | Botany Bay | LGOV |

# 3. Review of Available Information

## 3.1 Previous studies

### 3.1.1 Botany Bay Foreshore Beach Catchment Flood Study (BMT WBM, 2015)

BMT WBM undertook a flood study for the Botany Bay Foreshore Beach Catchment in 2015. The study is the most recent flood study and was undertaken to define the nature and extent of flooding within the study area. The study represented catchment conditions at 2015 and utilised Australian Rainfall and Runoff (ARR) 1987 methodologies to estimate rainfall runoff.

The study involved the application of direct rainfall to estimate catchment rainfall and runoff. The direct rainfall was applied in an integrated one-dimensional (1D) /two-dimensional (2D) TUFLOW hydraulic model. The hydraulic model was calibrated and validated to three historic flood events, namely events on the 24$^{th}$ March 2014 (correspond to smaller than a 2 year ARI event), 2$^{nd}$ January 2014 (no rain, tidal event) and 4$^{th}$ March 1977 (correspond to a 5 year ARI event).  The design flood events modelled include the 20%, 10%, 5%, 2%, 1% and 0.5% AEP and the PMF event. An assessment on the impact of climate change was also undertaken.

The hydraulic model developed as part of the 2015 Flood Study forms the baseline model for this floodplain risk management study.

### 3.1.2 Mascot, Rosebery & Eastlakes Flood Study (WMAwater, 2015)

WMAwater undertook a flood study for the Mascot, Rosebery and Eastlakes catchment area in 2015. The study area covers a part of the northern side of the study area including Mill Stream and Mill Pond. The aim of the study was to assess the flood behaviour in Mascot, Rosebery and Eastlakes catchment for various design flood events. Results from the WMAwater (2015) study were adopted to update water levels in Mill Pond in this current study's flood modelling.

The study identified that flooding in Mill Pond would not spill into the Botany Bay and Foreshore Beach study area in up to the 1% AEP. There would be only minor overflows into the current study area during the Mill Pond PMF event.

### 3.1.3 Springvale Drain and Floodvale Drain Flood Study (BMT WBM, 2014)

BMT WBM conducted a flood study for the adjacent Springvale Drain and Floodvale Drain catchment, using a direct rainfall method to assess design flood behaviour in the study area. The Floodvale Drain catchment is located immediately east of the current study area. Flow from this catchment overtops Botany Road at the west of Botany Golf Club, when the capacity of Floodvale Drain system is exceeded. This overtopping flow was represented as an inflow hydrograph in the Botany Bay Foreshore Beach Catchment Flood Study (BMT WBM, 2015).

### 3.1.4 Springvale Drain and Floodvale Drain Floodplain Risk Management Study (WMAwater, 2017)

WMAwater conducted a floodplain risk management study for Springvale Drain and Floodvale Drain catchment in 2017. This Floodplain Risk Management Study focused on the floodplain management issues faced by the study area and investigated potential mitigation options to manage the flood risk.

### 3.1.5 Hydrologic and Hydraulic Study – Botany Wetlands – Volume 1 report (SMEC, 1992)

SMEC conducted this hydrologic and hydraulic study of Botany Wetlands from downstream of Gardeners Road to its outlet in Botany Bay for the Water Board. This drainage line is located along the outside of the north-western border of the current study area and includes the Mill Stream and Mill Pond waterways, and drains a large catchment area comprising a significant proportion of eastern Sydney up to Centennial Park and Oxford Street in the north, Waverley, Randwick and Kingsford in the east and Moore Park to Zetland in the west.

The 10%, 2% and 1% AEP flood levels and flood behaviour were defined for the existing catchment. Important for the current study is that it was found for all events up to the 1% AEP, existing catchment flooding is within the formed watercourses and do not affect the existing development. That is, water does not break from the levee banks training the major flow path. Cross catchment flows from the Botany Wetlands do not need to be considered in this current study.

## 3.2 Available data

### 3.2.1 LiDAR data

The 2013 Light Detection and Ranging (LiDAR) dataset used in the 2015 Flood Study was reviewed against an online database of LiDAR data (http://elevation.fsdf.org.au). The LiDAR data used in the 2015 Flood Study is the latest available LiDAR dataset for the study area.

### 3.2.2 Aerial photographs

The NSW aerial imagery captured in 2018 and held by Spatial Services of NSW Government was utilised to update building footprints.

### 3.2.3 Hydraulic structures

Drawings and schematics of two stormwater diversion works for the study area were provided by Sydney Water. These included details of the bulkheads constructed at Sir Joseph Banks Street and at Rochester Street and the associated pipe network.

Design drawings for three-groyne option for foreshore beach erosion stabilization were provided by Port Authority. These drawings included longitudinal and cross-sectional profiles indicating the various levels and extents of groynes and pipe outlets.

A culvert runs along the open channel at the end of Bay Street near Mill Stream. Details of the culvert were approximated based on site photographs, LiDAR data and satellite imagery.

A triple pipe outlet near Mill Stream lookout parking bay (refer to Figure 3.1) was not included in previous flood study (BMT WBM 2015). An investigation undertaken by Council reveals that this pipe outlet is affected by frequent sand blockage due to tides and no further information on this outlet was available. Details of this pipeline were obtained for its inclusion in modelling in this study.

Figure 3.1: Triple pipe outlet near Mill Stream lookout parking bay

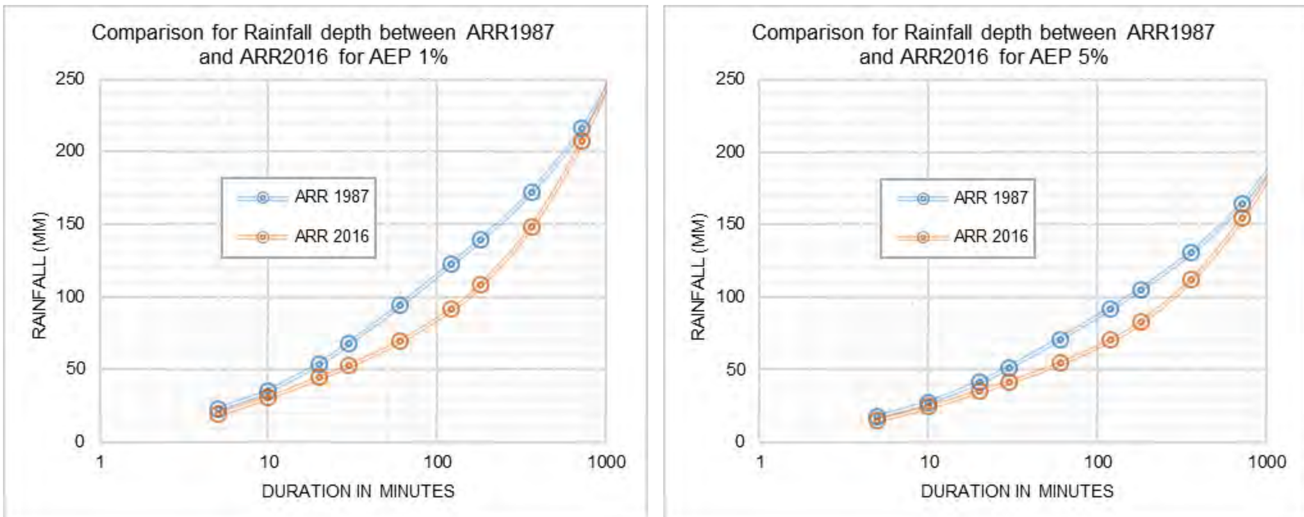
An as-built drawing of 27 -31 William Street culvert was received from Council at the end of this present study. The drawing shows that the size of the culvert at 27-31 William Street is 1830mm x 620mm which increases to 2440mm x 620mm before joining with the downstream culvert. The present study is developed based on previously available data which is 700mm circular pipe at 27 -31 William Street, which has a significantly lower flow capacity.

The updated drainage structure information could not be incorporated into the modelling in this study due to project time constraints. It is recommended to undertake sensitivity of the new culvert information at 27 -31 William Street; this culvert can have significant impact on the flood behaviours in the surrounding areas. The culvert is show in the Figure 3.2 in red.


Figure 3.2: Location of 27 -31 William Street culvert

### 3.2.4 Rainfall data

The ARR 2016[1] Data Hub was accessed to derive design rainfall inputs using ARR 2016 guidelines. The Data Hub also includes links to relevant data sources, including the Bureau of Meteorology Design Rainfall Data System which is used to source Intensity Frequency Duration (IFD) design rainfall depths. Data was extracted at the centroid of the study area. The ARR 2016 rainfall depths are compared with ARR 1987 rainfall depths which were adopted in previous flood study (BMT WBM 2015). The ARR 2016 rainfall depths are less than the ARR 1987 rainfall depth for all durations in the 1% AEP and 5% AEP events as shown in Figure 3.3.




[1] The draft revisions were referred to as ARR 2016, and finalised during 2019 and now referred to as **ARR 2019** revisions. The ARR 2016 terminology is retained in this report.

Figure 3.3: ARR 2016 and ARR 1987 rainfall depths for 1% and 5% AEP events

### 3.2.5 Stream gauge

No stream gauges are located within the study area.

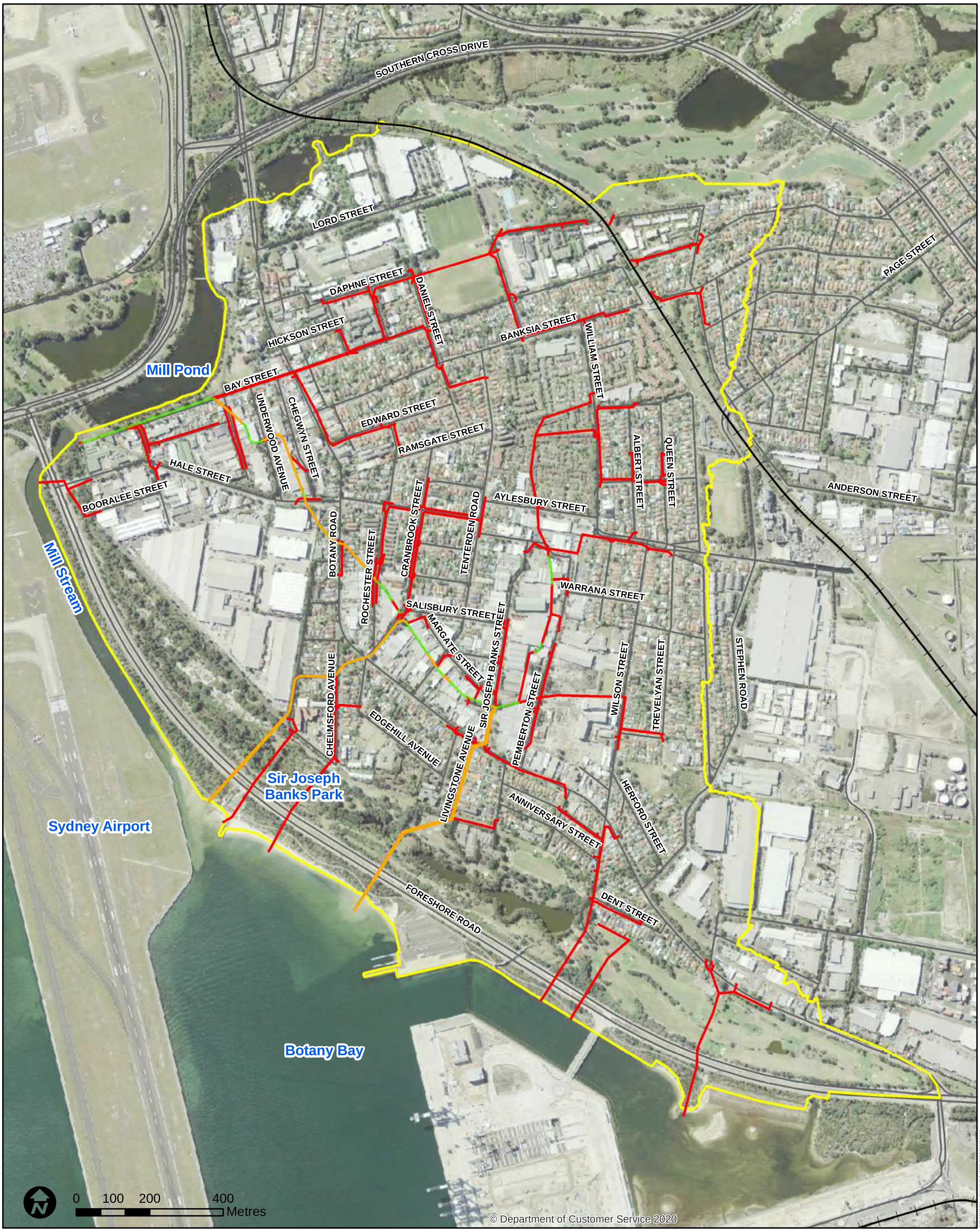
### 3.2.6 Hydraulic model

The hydraulic model for the 2015 Flood Study was developed using TUFLOW modelling software. The TUFLOW model was reviewed as part of this study and key outcomes from the model review are provided in Table 3-1.

Table 3-1: Key findings and recommendations from the TUFLOW model review

| Item | Description | Model updates |
|---|---|---|
| Topography and 2D model grid | A 1m digital elevation model based on LiDAR data captured in 2013 was used to define the 2m x 2m 2D grids for the TUFLOW model. Breaklines were defined in the TUFLOW model to represent linear topographical features such as levees and gullies. | No changes were recommended. The latest available LiDAR data was used in the model (refer to Section 3.2.1) and the 2m x 2m 2D grid was considered a reasonable representation of terrain for the study area. |
| Land use | Based on a review of the most recent aerial photographs, land use represented in the TUFLOW model is generally consistent with the current land use. However, there are a few isolated areas where the land use was not accurately defined and where urban developments occurred after completion of the 2015 Flood Study. | Land use for the isolated areas and recent urban developments were incorporated in the updated TUFLOW model. |
| Manning's n | Depth varying Manning's n roughness values were adopted for the entire TUFLOW model domain including residential and commercial properties. | Residential and commercial buildings were represented as solid obstructions to flow in the updated TUFLOW model. Adopted Manning's n values for the remaining areas are considered acceptable. |
| Representation of buildings | Buildings were represented in the TUFLOW model with depth varying Manning's n values. Based on a review of the most recent aerial photographs, a few buildings within the study area were not represented in the TUFLOW model and a small number of recent urban developments have taken place. | Updates to the model included the missing buildings and recent urban developments based on building outlines digitised from SIX maps referred to in Section 3.2.2.<br>Change the representation of building to solid objects for a better representation of flood behaviour in the vicinity of buildings. |
| Stormwater network | Pits and pipes were represented in the TUFLOW model with unlimited pit inlet capacity. Known changes to the pipe network since the completion of the 2015 Flood Study includes extended pipe outlets along Foreshore Road. Information on these extended pipe outlets was provided by Council. In addition, Sydney Water provided | Updates of the stormwater network included the data referred to in Section 3.2.3. |

| Item | Description | Model updates |
|---|---|---|
| | details on two bulkheads located at Sir Joseph Banks Street and Rochester Street. | |
| Blockage | Two blockage scenarios were assessed which included 50% blockage of pipes, covered channels and bridges and no blockage of pits and open channels, and 0% blockage of all hydraulic structures. | Updates of the blockage scenario were made based on ARR 2016 guidelines (mix of 25% and 50% blockage, depending on pipe size). Assessment was also made of 0% blockage of all hydraulic structures and derive a maximum envelope of flooding conditions from the combination of the two scenarios.<br>Refer to Figure 3.4. |
| Inflow boundaries | A direct rainfall approach was adopted in the TUFLOW model based on ARR 1987 design rainfall data. | ARR 2016 design rainfall data was used to define the direct rainfall inputs in the updated TUFLOW model. |
| Tailwater boundaries | A static water level of 0.69m AHD was adopted in tidal areas for all design flood events. Static water levels of 1.35m AHD and 3.5m AHD were defined at Botany Road along the northern boundary of the study area and in Mill Pond respectively for all design flood events. | Tidal boundaries were updated based on the Floodplain Risk Management Guide – Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways (OEH, 2015). Tailwater levels at Botany Road and in Mill Pond were updated based on information sourced from the Mascot, Rosebery & Eastlakes Flood Study (WMAwater, 2015). |
| Storm duration | The TUFLOW model was run for 25 minute and 2 hour storm burst duration for all AEP events which were identified as the critical bursts during the 2015 Flood Study. | The updated TUFLOW model was run for a range of storm burst durations in line with ARR 2016 guidelines. |




Legend

- Rail
- Study area
- Roads

ARR 2016 Blockage

- 25%
- 50%
- Open channels (0%)

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Pipe Blockages Based on ARR 2016 | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 3.4 | REV 2 VER 1 |
| CHECK AH | DATE 25/06/2020 | | |

#### 3.2.7 Property database

A number of residential and commercial properties were identified as being at risk of flooding in the 2015 Flood Study. A database of these properties was developed as part of this floodplain risk management study. Properties located within the 0.5% AEP flood extent as defined by the 2015 Flood Study are included in the database. The following information is estimated for each property located within the study area:

- Property ground elevations extracted from the LiDAR data based on the maximum ground level within a 1m buffer of the building polygon;
- Floor heights above ground level estimated using the Google Street View images captured between 2015 and 2018 and during a site inspection on 13th July 2018. The floor height data is added to the ground elevation data to estimate the building floor level. For the purpose of this study, floor heights which could not be estimated by visual inspection or Google Street View imagery are assumed to be located 0.15m above ground level; and
- Property type (commercial or residential) based on LEP data, Google Street View images and site visit notes.

## 3.3 Site inspection and floor level validation

A site inspection was undertaken on 13th July 2018. The purpose of the site inspection was to gain a further understanding of the catchment characteristics, the nature of existing development and hydraulic conditions (including flow patterns, drainage arrangements, hydraulic features, etc.) in known flooding areas mapped in the 2015 Flood Study.

The site inspection was also used to validate floor heights assumed from Google Street View and to estimate floor heights for the buildings which could not be identified using Google Street View.

# 4. Flood Policies and Planning Controls

## 4.1 Background

This section provides an overview on the NSW flood risk management framework, and existing policies and planning controls applicable to the study area and recommends additional controls to be considered for the study area.

## 4.2 NSW flood risk management framework

### 4.2.1 Objectives and approach

The primary objective of the NSW Flood Risk Management (FRM) framework, as expressed within the NSW Flood Prone Land Policy (Floodplain Development Manual (FDM) 2005, page 1), is as follows:

"*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 wherever possible*."

Within the scope of this report, the relevance of the above objective is primarily to ensure that future redevelopment within the study area does not lead to increased flood risk to property and persons, and that the planning controls proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risk.

### 4.2.2 NSW FRM policy and guidelines

The NSW Flood Prone Land Policy, as identified within Section 1.1 of the FDM, places the primary responsibility for flood risk management on local councils. This provides the opportunity for FRM to be integrated within council's normal planning processes.

The NSW Flood Prone Land Policy and the FDM provide a platform for the management of floodplains following a risk management approach. The FDM provides guidance on how to implement the NSW Flood Prone Land Policy. The FDM requires the level of flood risk acceptable to the community to be determined through a process overseen by a committee comprised of local elected representatives, community members and state and local Government officials (including the SES).

The ultimate outcome is the preparation of a Floodplain Risk Management Plan (FRMP), which is a plan formally adopted by a local council in accordance with the NSW Flood Prone Land Policy. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.

### 4.2.3 2007 flood planning guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the *Environmental Planning and Assessment Act 1979* (EP&A Act) and *Environmental Planning and Assessment Regulation 2000* (Regulation) was issued by the Department of Planning in a Circular (PS 07-003) dated 31 January 2007. The Flood Planning Guideline issued by the Minister relates to this package of directions and changes to the EPA Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the Floodplain Development Manual (2005). The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 1% AEP plus freeboard as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 1% AEP plus freeboard may be subject to an "exceptional circumstance" justification being agreed to by the Department of Planning, Industry and Environment and the Department of Planning Industry and Environment prior to the exhibition of a Draft LEP or Draft DCP.

The "Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual" defines Standards for Flood Controls for Residential Development. Whilst the flood used to define the residential FPL is a decision of Council, FDM highlights that FPLs for typical residential development would be based around the 1% AEP plus an appropriate freeboard (typically 0.5m).

### 4.2.4 2020 Draft Updates to Flood Prone Land Package

Significant flood events, like those in Brisbane in 2011 and those more recently in NSW show the importance of managing flood risk up to and beyond the 1% AEP flood and considering flood risks up to the probable maximum flood level. This will build resilience in communities located on floodplains and reduce the extent of property damage and potential loss of life from severe to extreme flooding throughout NSW.

The NSW Department of Planning Industry and Environment has been working to update the Flood Prone Land Package (including the 2007 flood planning guideline – refer to Section 4.2.3) which provides advice to councils on considering flooding in land use planning and consists of:

A proposed amendment to schedule 4, section 7A of the Environmental Planning and Assessment Regulation 2000

A revised planning circular

A revised local planning direction regarding flooding issued under section 9.1 of the Environmental Planning and Assessment Act 1979

Revised Local Environmental Plan flood clauses

A new guideline: Considering Flooding in Land Use Planning (2020)

- Revoking the Guideline on Development Controls on Low Flood Risk Areas (2007).

The proposed updates promote the effective consideration of flood risk in land use planning, which involves developing an understanding of the full range of flood behaviour up to the Probable Maximum Flood (PMF) and considering this in management of flood risk.

The proposed local planning direction has been revised to remove the need to obtain exceptional circumstances to apply flood-related residential development controls above the 1% AEP flood event.

The proposed updates support the principles of the Floodplain Development Manual and provide advice to local councils on land use planning within flood-prone land. It provides councils greater flexibility in defining the areas to which flood-related development controls apply, with consideration of both defined flood events (used to set flood planning levels) and low probability/high-consequence flooding. In addition, it allows for land requiring controls related to regional evacuation consideration to be identified. The Floodplain Development Manual states that a defined flood event (DFE) of the 1% AEP, or a historic flood of similar scale, plus a freeboard should generally be used as the minimum recommended level for setting residential FPLs. Councils proposing a different FPL are required to demonstrate the merits of this approach through the FRM process.

The consultation period for the updated Flood Prone Land Package concluded on 25 June 2020. Further information is expected from the NSW Department of Planning, Industry and Environment in due course.

### 4.2.5 Relationship with EP&A Act

The plan-making processes under the EP&A Act, such as for the preparation of Local Environmental Plans (LEPs) and Development Control Plans (DCPs), operate independently of the preparation of FRMPs under the FDM. While these two processes could be overlapped, it has been the usual practice to undertake the processes separately. Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EP&A Act.

## 4.3 Existing policies and planning controls

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding relates to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations. In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state-imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the FRM planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

### 4.3.1 State Environmental Planning Policies

State Environmental Planning Policies (SEPPs) are planning policies which deal with State wide matters of environmental planning significance. They are prepared in accordance with the EP&A Act by the NSW Department of Planning and Environment and approved by the Minister. Clause 1.19 of the Exempt and Complying Development Codes SEPP has been amended so that land identified as 'flood control lot' is no longer excluded from the application of the General Housing Code. Instead, specified development and development standards have been added to the General Housing Code in Clause 3.36 of the Exempt and Complying Development Codes SEPP (2008) for development on flood control lots. The development standards have been designed to ensure that complying development is not allowed on those parts of flood control lots which are defined as being floodways, flood storage areas, a flow path, a high flood hazard area or high flood risk area.

Hydraulic hazard and hydraulic categories across the study area are identified in this study. A number of existing properties are surrounded by floodway and/or high flood hazard areas and during future development assessment and planning the hazard and hydraulic categories maps should be consulted to ensure that developments are not approved on high hazard or floodway areas. Refer to Appendix C for 1% AEP flood hazard and hydraulic category mapping, including floodways and flood storages.

**Recommendation**

The flood hazard and hydraulic categories mapping is to be considered by Council in the planning and approval of proposed developments for flood-affected lots. Proposed developments are not to be approved on high hazard or floodway areas.

### 4.3.2 Climate change and sea level rise policies

Climate change is expected to have adverse impacts upon sea levels and rainfall intensities, both of which may have a significant influence on flood behaviour at specific locations. In the case of the study area, both rainfall intensities and sea level rise will have a wide influence on flooding. The study area is generally above 3m AHD, with areas at lower elevations down to 1.5m AHD. Hence flood levels at the developed areas are expected to be influenced by ocean tides to some degree with tidal inundation also occurring in the current climate on very high tides. Such flooding behaviour is expected to increase in frequency and magnitude under climate change conditions.

Scientific data regarding the effect of climate change on rainfall intensities is not sufficiently advanced to provide specific guidance for the assessment of flood risk. No relevant planning benchmarks have been adopted by the NSW Government relating to rainfall intensity changes. However, NSW Government guidelines recommend the undertaking of a sensitivity analysis, which assumes nominal increases in rainfall intensities.

Bayside Council recognises that increased rainfall intensity and sea level rise (SLR) due to climate change, may make flooding and drainage issues more significant in Bayside. Council is committed to working with its community to identify and respond to emerging hazards and risks associated with local climate change.

#### 4.3.2.1 Botany Bay Council's Sea Level Rise Policy

The following policy was adopted by the former Botany Bay City Council and currently remains in effect:

- Council will consider the effect of climate change when determining development applications.
- Council will consider climate change in preparation of planning instruments, policies and flood studies.
- Council will apply the 2009 Sea Level Rise Policy benchmarks of 0.4m above Australian Height Datum (AHD) by 2050 and 0.9m above AHD by 2100 relative to a 1980 – 1999 reference period in preparation of planning instruments, policies and flood studies. In implementation of this policy position Council will utilise the Sydney Coastal Councils Sea Level Rise Maps that have been prepared for the Botany Bay Local Government Area.
- Council will continue to monitor, review and manage the risks associated with sea level rise relating to local government functions. Council will review the above benchmarks if and when the NSW Government recommends a new level under its planning policies, guidelines, or manuals, and/or in the light of new scientific evidence.

### 4.3.3 Section 9.1(2) Directions

Ministerial directions pursuant to section 9.1(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood prone land and has the following two objectives:

*(a) To ensure that the development of flood prone land is consistent with the NSW Government’s Flood Prone Land Policy and the principles of the Floodplain Development Manual, 2005.*

*(b) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.*

The Direction applies to all councils that contain flood prone land when an LEP proposes to “*create, remove or alter a zone or provision that affects flood prone land*.” In such cases, the Direction requires draft LEPs to ensure the following:

1. *A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*

2. *A 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.*

3. *A planning proposal must not contain provisions that apply to the flood planning areas which:*

    a. *permit development in floodway areas,*

    b. *permit development that will result in significant flood impacts to other properties,*

    c. *permit a significant increase in the development of that land,*

    d. *are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or* *e. permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*

*4. 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).*

*5. For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

#### 4.3.4 Local Environmental Plan 2013

The former Botany Council did not have provisions in the Botany Bay LEP 2013 for flooding controls. Bayside Council is currently preparing a new LEP document which will include flood planning control for all the catchments in Bayside LGA.

#### 4.3.5 Development Control Plan

As of June 2020, Bayside Council is currently in the process of reviewing the Development Control Plan which is expected to be adopted later in 2020. At the time of this study the Botany Bay Development Control Plan 2013 (DCP 2013) is the current planning instrument.

DCP 2013 provides detailed guidelines to guide the design and assessment of development applications for land covered by Botany Bay LEP 2013. Part 10 – Stormwater Management Guidelines specifies in **Section 8 – Finished Floor Levels** – that all new developments should comply with the following minimum criteria:

i. For a site within Council's identified flood area or within the vicinity of Council or Sydney Water drainage easement/reserve or stormwater drainage system (including open/covered channel, watercourse and underground drainage pipes/culverts), the finished floor levels shall be minimum 500mm (habitable buildings/structures) and 300mm (non-habitable buildings/structures, such as garages, ramps to the basement car parking area) above the estimated 1% AEP flood level.

ii. For developments associated only with extension of a single dwelling where this requirement may create a major problem, Council will consider lowering the criteria, depending on the size of the proposed extension and its proposed use.

iii. For a site falls toward the streets and not affected by overland flow path and flooding, the finished floor level of the habitable area shall be minimum 300mm above the top of kerb fronting the site.

iv. For site falls to the rear and not affected by overland flow path and flooding, the finished floor level of the habitable area shall be minimum 300mm above the highest natural surface RL directly adjoining the proposed floor.

v. For site with belowground basement, the crest levels of ramps and steps at the entry points shall be minimum of 300mm above the following:

   - 1% AEP flood level where such is known; or
   - top of kerb adjacent to the layback; or
   - overflow RL from any on-site stormwater systems; and

vi. The raising of floor levels, or any site levels, shall not create or exacerbate flooding on any other private or public properties, including public roads and open space.

Stormwater Management Guidelines require a flood study or overland flowpath assessment identifies on the basis of the following requirements:

- For sites with upstream catchments of less than 5ha, a detailed overland flow path assessment is required. The proposed finished floor levels of habitable buildings/structures and non-habitable buildings/structures (including garage, ramps to the basement car parking area etc.) shall be minimum 300mm and 100mm above the 1% AEP floodwater levels respectively.
- For sites with upstream catchments greater than 5ha, a detailed flood study is required. The proposed finished floor levels of habitable buildings/structures and non-habitable buildings/structures (including garage, ramps to the basement car parking area etc.) shall be minimum 300mm and 100mm above the 1% AEP floodwater level respectively (i.e. same requirement as for sites with less than 5ha catchment).

Hence, there is inconsistency in the minimum freeboard above 1% AEP flood level for finished habitable floor levels in the document, with Section 11 specifying 300mm freeboard for sites with upstream catchments greater than 5ha, while Section 8 specifies 500mm. It is also unclear where the overland flooding freeboard of 300mm would apply, and where the general flooding freeboard of 500mm would apply, for habitable floor levels.

There are no provisions in the DCP for minimum floor levels for critical facilities such as hospitals, police, fire and ambulance stations and SES depots.

The DCP and Stormwater Management Guidelines also specify that the impacts of climate change on flooding must be considered in flood studies and overland flow path studies conducted for proposed developments.

The DCP includes specific sections for Botany South (Part 9B) and Wilson – Pemberton Precinct (Part 9C) which are both in the study area. These include flooding-related controls for minimum floor levels (500mm and 300mm above 1% AEP flood level for habitable and non-habitable floors, respectively), structures/filling within the flood extent, maintaining flood storage and open fencing in overland flow areas.

### 4.3.6 Section 10.7 Certificates

Bayside Council, under the provisions of Section 10.7 of the Environmental Planning and Assessment Act 1979 issue Certificates which are also known as planning certificates. The certificate provides information on flooding conditions on the property, planning controls (including flood planning controls) and any development restrictions which may apply to a particular parcel of land within the Council area. They are usually required upon the sale or purchase of a property.

# 5. Community Consultation

## 5.1 Overview

Community consultation is an important part of the flood study and floodplain risk management study process. Its objectives are to inform the community about the study, gather information on experiences of flooding in the study area and provide an opportunity for the community to communicate their concerns about flooding issues.

## 5.2 Consultation in previous Botany Bay Foreshore Beach Catchment Flood Study (BMT WBM, 2015)

This current study builds on the previous Botany Bay Foreshore Beach Catchment Flood Study (BMT WBM, 2015) during which community consultation was undertaken, including informing the community of the study via a media release and information website, and gathering of community information via a community questionnaire.

In summary, a total of 50 completed questionnaires (including electronic responses) were received out of the 4,300 letters delivered, representing a response rate of just 1%. On average the respondents have lived in the area for 32 years.

Comments relating to flood behaviour were utilised in the model calibration process. The community responses rarely indicated any specific rainfall events that resulted in flooding across the catchment, but rather, the information received identified certain areas of the study area where flooding occurs on a regular basis. A key event which was identified through the consultation was the March 2014 rainfall event.

A total of 24 community respondents have experienced some degree of flooding within the grounds of their property, two of which experiencing flooding above floor level. The key catchment areas which have community reports of flooding are summarised below.

**Hale Street Roundabout**

Hale Street near Luland Street received a number of reports of flooding. The Community identified that this area is subject to flooding from rainfall events and also from high tides.

**The Esplanade**

The Esplanade near Chelmsford Avenue received a number of reports of flooding. One report stated that flooding caused a car to float.

**Tupia Street**

The intersection of Tupia Street and Anniversary Street received a number of reports of extensive though shallow flooding. Some reports indicated blockages may contribute to the flooding.

**Botany Road near the Golf Course**

Flooding is reported to occur on Botany Road near the Botany Golf Course. This has been reported by residents and also community members who notice the road disruption.

## 5.3 Public exhibition

The Final Draft FRMSP was placed on public exhibition in October 2020 on Council's website, refer to Appendix H. Submissions were received from the community via Council's Have Your Say online consultation portal, email and phone. A total of 19 unique submissions were received and responses are provided, refer to Table H-1 in Appendix H.

# 6. Existing Flood Environment

## 6.1 Flooding assessment

The Botany Bay and Foreshore Beach Floodplain Risk Management Study - Flood Study Update (Jacobs, July 2019) was undertaken as a part of this study and provided an update of the previous Botany Bay Foreshore Beach Catchment Flood Study (BMT WBM, 2015). The TUFLOW hydraulic model used in this current study to define flooding behaviour was originally developed by BMT WBM (2015) and calibrated to the March 2014 and March 1977 rainfall flood events, and the January 2014 tidal flooding event.

A number of updates were made to the 2015 Flood Study to align the assessment with the latest, recently released industry guidance on design flood estimation. This included adoption of ARR 2016 guidelines to estimate design rainfall depths, temporal patterns and blockages of hydraulic structures, DPIE’s guidance on tailwater conditions, representation of buildings as solid obstructions to flood flow, inclusion of new developments and missing stormwater networks. Property fencelines were considered in the modelling with an increased Mannings n value for property blocks.

Flooding behaviour in the Flood Study Update (Jacobs, 2019) and as presented in this floodplain risk management study report was assessed for existing climate and sea level conditions.

## 6.2 Flood behaviour

### 6.2.1 Flood depths

The stormwater drainage system for the study area consists of pits, pipes and open channels which convey rainfall runoff generated from the catchment into Mill Stream. Once the capacity of the stormwater drainage system is exceeded; overland flooding occurs on low-lying areas during significant flood events. Peak flood depth maps for all modelled design flood events for the study area are presented in Appendix C. Note that local drainage problems have been excluded from the mapping by filtering out flood depths less than 0.05m. The following observations are made from the maps:

- A number of roads (e.g. Botany Road, Wilson Street, Pemberton Street, Hale Street, Lord Street, etc.) within the study area are impacted up to 0.5m depth of flooding in the 20% AEP catchment flood event which reflects inadequate capacities of stormwater network within the study area. The stormwater drainage capacity is lower than the 20% AEP event. High tailwater conditions which restrict the outflow from the drainage network into Botany Bay are also a significant influence on flooding conditions in the lower portions of the study area.
- The majority of roads within the study area are impacted in the 5% AEP event and almost half of the properties located within the study area are subject to yard flooding. The maximum depth of flooding on roads is up to 1m which would impact on access to several properties and result in extensive damage to vehicles and infrastructure within the road corridors and would be a significant hazard to the road users.
- In the 2% AEP event Additional properties are subject to yard flooding and the maximum depth of flooding on roads is increased to over 1m.
- About 400 residential properties and 200 commercial properties are likely to experience above floor flooding in the 1% AEP event.
- About 900 residential properties and 300 commercial properties are likely to experience above floor flooding in the PMF event. The maximum flood depth on roads is up to 3.5m on the Booralee Street, with typical depths of 0.5 to 2m on other roads (refer to Table 6-1).

The maximum flood depths are summarised by road in Table 6-1 for the 20%, 5% and 1% AEP and PMF events.

Twenty-one (21) locations (refer to Figure 6.1) are selected for reporting flood depths at specific locations within the study area. These locations are the same locations used in the 2015 Flood Study for reporting flood levels. Modelled flood depths for all modelled events at 21 locations are presented in Table 6-2.

Table 6-1: Maximum flood depths on roads

| Road name | Maximum Flood Depth (m) | | | |
|---|---|---|---|---|
| | 20% AEP | 5% AEP | 1% AEP | PMF |
| Foreshore Road | 0.1 | 0.2 | 0.2 | 0.3 |
| Tupia Street | 0.5 | 0.6 | 0.6 | 1.1 |
| Jasmine Street | 0.4 | 0.5 | 0.6 | 0.9 |
| Dover Street | 0.3 | 0.3 | 0.3 | 0.6 |
| Clevedon Street | 0.4 | 0.5 | 0.8 | 1.6 |
| Anniversary Road | 0.5 | 0.6 | 0.7 | 1.1 |
| Stephen Road | 0.3 | 0.3 | 0.3 | 0.4 |
| Wilson Street | 0.5 | 0.5 | 0.6 | 1.0 |
| Pemberton Street | 0.6 | 0.8 | 0.9 | 1.9 |
| Mcfall Street | 0.5 | 0.7 | 1.0 | 3.2 |
| Botany Road | 0.8 | 0.7 | 0.8 | 1.6 |
| The Esplanade | 0.3 | 0.6 | 0.7 | 2.2 |
| Hill Street | 0.5 | 0.6 | 0.7 | 1.7 |
| Bay Street | 0.6 | 0.7 | 0.8 | 3.1 |
| Booralee Street | 0.7 | 0.9 | 1.2 | 3.5 |
| Tenterden Road | 0.3 | 0.3 | 0.3 | 0.5 |
| William Street | 0.6 | 0.7 | 0.8 | 1.4 |
| Margate Street | 0.3 | 0.4 | 0.4 | 1.2 |
| Hambly Street | 0.6 | 0.7 | 0.8 | 1.3 |
| Banksia Street | 0.3 | 0.3 | 0.4 | 0.7 |
| Aylesbury Street | 1.2 | 1.3 | 1.4 | 1.9 |
| Nilsson Lane | 0.2 | 0.3 | 0.5 | 1.4 |
| Daniel Street | 0.2 | 0.3 | 0.4 | 1.1 |
| Cranbrook Street | 0.2 | 0.4 | 0.5 | 1.7 |
| Hickson Street | 0.7 | 0.9 | 1.1 | 2.0 |
| Luland Street | 0.6 | 0.8 | 1.1 | 3.4 |
| Daphne Street | 0.2 | 0.5 | 0.6 | 1.5 |
| Daphne Lane | 0.4 | 0.5 | 0.5 | 0.5 |
| Rochester Street | 0.6 | 0.8 | 1.0 | 1.9 |
| Folkestone Parade | 0.3 | 0.4 | 0.7 | 2.3 |
| Dent Street | 0.8 | 1.0 | 1.1 | 2.0 |
| Rose Street | 0.7 | 0.9 | 1.1 | 2.0 |
| Lord Street | 0.8 | 1.0 | 1.1 | 1.2 |
| Erith Street | 0.2 | 0.3 | 0.6 | 3.0 |
| Byrnes Street | 0.3 | 0.3 | 0.4 | 2.7 |
| Salisbury Street | 0.3 | 0.4 | 0.6 | 1.8 |
| Hale Street | 0.5 | 0.7 | 1.0 | 3.2 |

| Road name | Maximum Flood Depth (m) | | | |
|---|---|---|---|---|
| | 20% AEP | 5% AEP | 1% AEP | PMF |
| Chegwyn Street | 0.6 | 0.6 | 0.7 | 1.4 |
| Chelmsford Avenue | 0.7 | 0.9 | 1.0 | 2.6 |
| Edgehill Avenue | 0.7 | 0.8 | 0.8 | 1.6 |
| Hanna Street | 0.2 | 0.3 | 0.4 | 0.8 |
| Morgan Street | 0.2 | 0.3 | 0.3 | 0.9 |
| Livingstone Avenue | 0.6 | 0.7 | 0.8 | 1.4 |
| Queen Street | 0.4 | 0.4 | 0.4 | 0.8 |
| Wiggins Street | 0.3 | 0.4 | 0.4 | 0.9 |
| Fremlin Road | 0.4 | 0.4 | 0.4 | 1.2 |
| Edward Street | 0.3 | 0.3 | 0.3 | 0.4 |
| Fremlins Lane | 0.1 | 0.3 | 0.4 | 1.3 |
| Exell Street | 0.2 | 0.2 | 0.4 | 0.7 |
| Ivy Street | 0.4 | 0.6 | 0.7 | 1.6 |


Legend

- Study Area
- Rail
- Roads
- Reporting Locations

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | |
|---|---|
| SCALE | 1:10,000 A3 |
| SHEET | 1 of 1 GDA 1994 MGA Zone 56 |
| TITLE | Selected locations to investigate for peak flood levels |
| PROJECT | Botany Bay Foreshore Beach FRMS |
| CLIENT | Bayside Council |
| DRAWN PK | PROJECT # IA190100 |
| CHECK AH | DATE 15/04/2020 |
| MAP # | Figure 6.1 |
| REV VER | 2 1 |

Table 6-2: Peak flood depths at selected locations

| ID | Location | Peak flood depth (m) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 20% AEP | 5% AEP | 2% AEP | 1% AEP | 0.5% AEP | 0.2% AEP | PMF |
| 101 | Rancom Street | 0.17 | 0.22 | 0.23 | 0.24 | 0.27 | 0.63 | 1.43 |
| 102 | Tupia Street | 0.47 | 0.57 | 0.61 | 0.63 | 0.63 | 0.66 | 1.03 |
| 103 | Corner of Anniversary and Tupia Street | 0.52 | 0.62 | 0.66 | 0.67 | 0.68 | 0.71 | 1.08 |
| 104 | Livingstone Avenue | 0.50 | 0.65 | 0.73 | 0.77 | 0.81 | 0.93 | 1.34 |
| 105 | Corner of Esplanade and Chelmsford Avenue | 0.65 | 0.91 | 1.03 | 1.04 | 1.08 | 1.12 | 2.57 |
| 106 | Edgehill Avenue | 0.66 | 0.74 | 0.79 | 0.80 | 0.82 | 0.83 | 1.54 |
| 107 | Booralee Street | 0.62 | 0.82 | 1.06 | 1.11 | 1.20 | 1.28 | 3.37 |
| 108 | Corner of Hale and Luland Street | 0.59 | 0.80 | 1.03 | 1.09 | 1.17 | 1.26 | 3.35 |
| 109 | Chegwyn Street | 0.72 | 0.78 | 0.84 | 0.83 | 0.85 | 0.87 | 1.59 |
| 110 | Rochester Street | 0.65 | 0.81 | 0.93 | 1.00 | 1.02 | 1.11 | 1.93 |
| 111 | William Street | 0.59 | 0.68 | 0.76 | 0.77 | 0.81 | 0.85 | 1.31 |
| 112 | Queen Street | 0.26 | 0.31 | 0.36 | 0.34 | 0.39 | 0.42 | 0.71 |
| 113 | Rose Street | 0.68 | 0.92 | 1.04 | 1.09 | 1.15 | 1.21 | 1.99 |
| 114 | Daphne Street | 0.20 | 0.44 | 0.56 | 0.61 | 0.67 | 0.74 | 1.51 |
| 115 | Aylesbury Street | 1.21 | 1.29 | 1.37 | 1.38 | 1.42 | 1.46 | 1.90 |
| 116 | Clevedon Street | 0.37 | 0.46 | 0.73 | 0.73 | 0.81 | 0.86 | 1.57 |
| 117 | Wilson Street | 0.37 | 0.43 | 0.47 | 0.47 | 0.50 | 0.53 | 0.89 |
| 118 | Pemberton Street | 0.59 | 0.73 | 0.82 | 0.89 | 0.97 | 1.10 | 1.89 |
| 119 | Corner of Edward Street and Dover Road | 0.18 | 0.22 | 0.24 | 0.24 | 0.27 | 0.29 | 0.51 |
| 120 | Banksia Street | 0.57 | 0.68 | 0.74 | 0.74 | 0.77 | 0.79 | 1.04 |
| 121 | Dent Street | 0.82 | 0.97 | 1.03 | 1.10 | 1.13 | 1.19 | 2.04 |

### 6.2.2 Flow velocity

A summary of flow velocities for the simulated design events is below:

- Flow velocities are high in a number of overland flow paths running through properties and particularly on roads.
- Typical flow velocities are 0.25 – 1m/s in the 20% AEP event, 0.25 – 1.2m/s in the 5% AEP event, and 0.25 - 1.25m/s in the 1% AEP event.
- High flow velocities (>1m/s) occur in a limited number of localised areas on roads and properties for the 1% AEP design event (e.g. Rochester Street, Wilson Street, Bay Street).
- Peak flow velocities for the 0.5% AEP event are approximately 1.5m/s and for the 0.2% AEP event the peak velocity is up to 1.7m/s.
- In the case of the PMF event, peak velocities are as high as 3m/s at a number of locations (e.g. Rochester Street, Wilson Street, Bay Street, Pemberton Street, Cranbrook Street, Banksia Street).

### 6.2.3 Durations of inundation

The durations of inundation at key drainage low points are summarised in Table 6-3. Refer to Figure 6.1 for locations. Durations of inundation are up to 18 – 24 hours in the 1% AEP event and several days for the PMF.

Table 6-3: Peak durations of flooding at selected locations

| ID | Location Name | Critical Storm Duration (mins) | | | | Duration of Flooding (>0.1m depth) | |
|---|---|---|---|---|---|---|---|
| | | 20% AEP | 5% AEP | 1% AEP | PMF | 1% AEP | PMF |
| 106 | Edgehill Avenue | 540 | 540 | 360 | 90 | 18hrs | Several days |
| 108 | Corner of Hale and Luland Street | 540 | 540 | 540 | 90 | 22hrs | Several days |
| 109 | Chegwyn Street | 540 | 540 | 360 | 90 | 18hrs | Several days |
| 111 | William Street | 540 | 540 | 360 | 60 | 18hrs | Several days |
| 121 | Dent Street | 540 | 540 | 540 | 90 | 18hrs | Several days |

## 6.3 Flood hazard

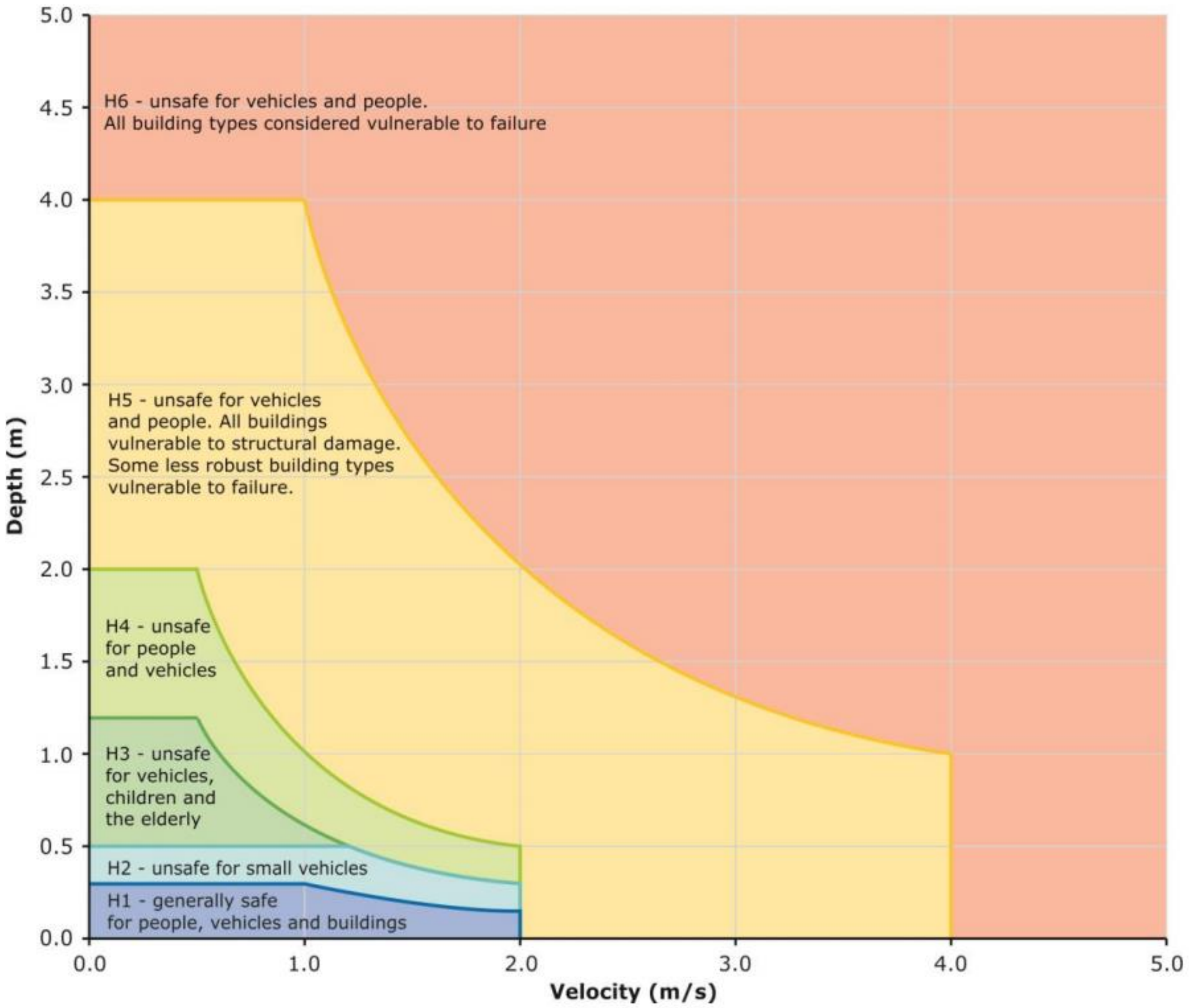
### 6.3.1 Provisional flood hazard

Flood hazard mapping was prepared for all the simulated design event on the basis of recent research undertaken into the hazard that flooding poses and the vulnerability of the public and assets when interacting with floodwaters. A combined flood hazard classification is presented in *Australian Disaster Resilience Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017a) and *Guideline 7-3 Flood Hazard* (AIDR, 2017b) based on this research, and is illustrated in Figure 6.2. The flood hazard categories according to the AIDR definition are:

- H1 – Generally safe for people, vehicles and buildings;
- H2 – Unsafe for small vehicles;
- H3 - Unsafe for vehicles, children and the elderly;
- H4 - Unsafe for people and vehicles;
- H5 - Unsafe for people and vehicles. Buildings require special engineering design and construction; and
- H6 – Unsafe for people or vehicles. All buildings types considered vulnerable to failure.

The flood hazard classification provides guidance on flood hazard thresholds to different members of the community (e.g. children and elderly) and different assets (small versus larger vehicles, standard versus specialised engineered buildings).

Figure 6.2 General flood hazard vulnerability curves, Australian Institute for Disaster Resilience (AIDR) definition. Reproduced from Figure 6 in *Guideline 7-3: Flood Hazard* (AIDR, 2017b)




### 6.3.2 True flood hazard

The flood hazard mapping based on the direct flood modelling outputs as shown on Figure 6.2 is denoted provisional and does not reflect the "true" flood hazard to take into consideration evacuation, isolation and other emergency management aspects. In assessing the true flood hazard, considerations have been made about aspects and characteristics of flooding and the flooding problem including the size of flood, rate of rise, effective warning times, risk to life, flood hazard at the dwelling, duration of flooding and emergency access. A qualitative assessment is made in Table 6-4.

Table 6-4 Consideration of flooding aspects in defining the True Flood Hazard in the Study Area

| Criteria | Weighting | Comments |
|---|---|---|
| Size of flood, increment in flooding between AEP events | Low | Relatively shallow depths of flooding on properties. Typically, there is a small increment in flood depths between flood AEPs up to the 1% AEP. Relatively small increment in depth (average less than 0.6m) between the 1% AEP and PMF on properties. |

| Criteria | Weighting | Comments |
|---|---|---|
| Flood awareness in the community | Moderate | Moderate level of awareness in the community about flooding and drainage issues in moderate to high frequency flood events based on historic flooding and as reflected in community questionnaire responses. Likely low awareness of rare (1% AEP) and PMF extents and hazard. Likely consistent level of awareness across the study area – provisional flood hazard not modified to reflect this factor. |
| Depth of floodwaters | Moderate | Most properties are generally affected by relatively shallow overland flooding. A limited number of properties (< 10% of impacted properties) would be impacted by high depth (>0.5m) in the 1% AEP event.<br><br>In the PMF a number of dwellings are exposed to very high flood hazard conditions. |
| Risk to life, flood hazard at dwelling | High | While the flood hazard at dwellings is generally low in up to the 1% AEP event, there are a number of properties with very high flood hazard (H5) in the PMF which may make these locations unsuitable for shelter-in-place. The flood hazard has been updated for the PMF to reflect the true hazard. |
| Effective warning and evacuation times | High | No effective warning or evacuation time due to nature of flash flooding. This factor is consistent across the study area – provisional flood hazard not modified to reflect this factor. |
| Evacuation difficulties | Moderate/ High | A number of properties would experience high depths of flooding above floor levels in the PMF event, to depths of 0.6m above flood.<br><br>Given the nature of flooding in the catchment, flood events may catch residents unaware and, in their dwellings, particularly if a flood event occurred during night. The flooding effectively renders the dwelling as a flood island as it becomes surrounded by floodwaters.<br><br>There are vulnerable properties (child care, schools, aged care facilities) which are significantly affected by flooding. Provisional flood hazard is updated to represent true hazard to the vulnerable properties. |
| Rate of rise of floodwaters | High | No effective warning or evacuation time due to nature of short duration of flooding. This factor is consistent across the study area – provisional flood hazard not modified to reflect this factor. Any affected dwellings would be captured in the provisional high hazard mapping already. |
| Effective flood access | Moderate to High | Most roads are subject to low to medium hazard and are expected to be trafficable in up to the 1% AEP. There are several roads including Wilson Street, Dent Street, William Street and Lord Street are hazardous in 1% AEP events and hence flood access is restricted on these roads.<br><br>A number of roads have high hazard flow conditions in the PMF event which would be unsafe for access to properties. Some dwellings are affected by high hazard flooding particularly in the PMF and access to and from the dwelling is hampered by high hazard flooding in the overland access route or roads (H3 or greater). The flood hazard extents have been modified to reflect this true hazard. |

The qualitative assessment above necessitates the flood hazard mapping to be updated to reflect the true flood hazard. Flood hazard update patches are overlaid on the provisional flood hazard to indicate the following basis for upgrade to high hazard:

- High hazard – potential flood access issues. Resulting from difficulty on local evacuation from the building due to high hazard (H3 or greater) between building and flood-free road, or road access cut-off nearby.
- High hazard – potential risk to life and very high flood hazard (H5 or greater) at the dwelling or building. Possible significant damage to building and risk if sheltering in place.
- High hazard – vulnerable and sensitive properties affected and hence the hazard needs to be upgraded.

The true flood hazard mapping for the 20%, 5% and 1% AEP and PMF events is mapped in Appendix C.

## 6.4 Hydraulic categories

Three flood hydraulic categories are identified in the *Floodplain Development Manual* (NSW Government, 2005):

- Floodway, where significant discharge of water occurs during floods and blockage could cause redirection of flows. Generally characterised by relatively high flow rates; depths and velocities;
- Flood storage, characterised by relatively deep areas of floodwater and low flow velocities. Floodplain filling of these areas can cause adverse impacts to flood levels in adjacent areas; and
- Flood fringe, areas of the floodplain characterised by shallow flows at low velocity.

There is no firm guidance on hydraulic parameter values for defining these hydraulic categories, and appropriate parameter values may differ from catchment to catchment. For example, the minimum threshold flows and depths which might define a floodway in an overland flow catchment may be markedly lower than those for a large river due to the different scale of flooding.

For the purposes of this study, the hydraulic categories were defined as per the criteria in Table 6-5, which were also adopted in the 2015 Flood Study.

Table 6-5 Hydraulic categories criteria

| Hydraulic Category | Criteria | Description |
|---|---|---|
| Floodway | Velocity * Depth > 0.25 m2/s AND Velocity > 0.25 m/s<br>OR<br>Velocity > 1.0 m/s. | Areas and flow paths where a significant portion of floodwaters are conveyed during a flood. |
| Flood Storage | NOT Floodway<br>AND Depth > 0.2 m | Floodplain areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks. |
| Flood Fringe | NOT Floodway<br>AND Depth < 0.2 m | Areas that are low velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour. |

The hydraulic categories mapping is presented in Appendix C.

The following observations are made from the maps:

- The western end of Bay Street is classified as floodway in the 20% AEP event. Sections of Hale Street, Wilson Street, Botany Road, William Street and Pemberton Street are categorised as flood storage areas in the 20% AEP event.

- Additional roads are classified as having floodway areas in the 5% AEP and 1% AEP events including Booralee Street, Rochester Street, Wilson Street, Ermington Street, Swinbourne Street, Aylesbury Street, Banksia Street and Edgehill Avenue.
- Floodways are typically located within road reserve and open space areas up to and including the 0.2% AEP event. Floodways are also located in the open trunk drainage channels.
- Almost all roads within the study area are classified as floodway in the PMF event.

## 6.5 Comparison between this study and the 2015 Flood Study

Key differences in flood modelling between this study and the 2015 Flood Study include the following:

- Updated works for the stormwater system is included in the updated TUFLOW model which were not included in the 2015 Flood Study.
- The 2015 Flood Study adopted high hydraulic roughness (Manning's n) parameter values for building footprints. However, buildings were assumed to be solid obstructions and blocked out in this study. Therefore, it is expected that conveyance capacities of the overland flow paths would be reduced due to blocking-out buildings which would result in increased flood levels. Blocking out of buildings would also have the effect of reducing available floodplain storage, resulting in additional increases in flood levels.
- The 2015 Flood Study adopted 50% blockage for all stormwater pipes. Whereas, in this study, variable blockage factors are adopted as per ARR 2016 guidelines. This is likely to impact on flood behaviour.
- Critical storm durations and temporal patterns adopted in this study are based on ARR 2016 guidelines.
- The 2015 Flood Study adopted rainfall depths and storm temporal patterns for design events as per ARR 1987, however, ARR 2016 rainfall depths are adopted in this study.

A change in modelled flood behaviour is expected due to the above differences in key input data adopted in this study and the 2015 Flood Study. Flood impact maps identifying the spatial extent and the degree of change in the peak water levels for all modelled flood events within the study area between this flood study and the 2015 Comparisons with the Flood Study (BMT WBM 2015) are presented in Appendix D. Following key observations are made from the figures:

- There are no major changes in overland flow paths, however, there are considerable changes in flood extents and depths of flooding which result from updates made to the TUFLOW model used in this study.
- Peak flood levels estimated in this study are generally higher than flood levels adopted in the 2015 Flood Study. However, flood levels in the open channel downstream of Pemberton Street are reduced due to representation of additional Sydney Water's bulkhead in the TUFLOW model.
- Peak flood levels are slightly higher in the 2015 Flood Study than this study north of Banksia Street, north of Hale Street and around Cranbrook Street.
- Peak flood levels for the PMF event estimated in this study are generally 0.3m higher than the 2015 Flood Study. PMF levels are higher than 0.5m in this study between Wilson Street and Pemberton Street.
- A comparison of flood levels for selected locations (refer to Figure 6.1) represented in Table 6-6 which shows that the maximum reduction in flood level occurs at location 101 and the maximum increase in flood level (up to 1m) occurs at locations 107 and 108 in the PMF event.

Table 6-6: Difference in peak flood levels at selected locations

| ID | Location | Difference in Peak Flood Level (Updated Flood Study – 2015 Flood Study), m | | | |
|---|---|---|---|---|---|
| | | 20% AEP | 5% AEP | 1% AEP | PMF |
| 101 | Rancom Street | -0.37 | -0.59 | -0.71 | -0.29 |
| 102 | Tupia Street | -0.04 | 0.01 | 0.03 | 0.10 |
| 103 | Corner of Anniversary and Tupia Street | -0.04 | 0.01 | 0.03 | 0.10 |
| 104 | Livingstone Avenue | 0.09 | 0.07 | 0.02 | 0.04 |
| 105 | Corner of Esplanade and Chelmsford Avenue | 0.06 | 0.00 | 0.00 | 0.49 |
| 106 | Edgehill Avenue | 0.04 | 0.06 | 0.07 | 0.25 |
| 107 | Booralee Street | -0.09 | -0.02 | 0.12 | 1.00 |
| 108 | Corner of Hale and Luland Street | -0.09 | -0.02 | 0.12 | 1.01 |
| 109 | Chegwyn Street | 0.10 | 0.12 | 0.13 | 0.72 |
| 110 | Rochester Street | -0.13 | -0.18 | -0.29 | 0.05 |
| 111 | William Street | 0.04 | 0.06 | 0.08 | 0.24 |
| 112 | Queen Street | -0.03 | -0.01 | -0.02 | 0.17 |
| 113 | Rose Street | -0.13 | -0.03 | 0.00 | 0.30 |
| 114 | Daphne Street | -0.13 | -0.03 | 0.01 | 0.29 |
| 115 | Aylesbury Street | 0.23 | 0.19 | 0.18 | 0.26 |
| 116 | Clevedon Street | -0.01 | -0.06 | 0.04 | 0.30 |
| 117 | Wilson Street | 0.04 | 0.05 | 0.05 | 0.28 |
| 118 | Pemberton Street | 0.16 | 0.21 | 0.29 | 0.57 |
| 119 | Corner of Edward Street and Dover Road | -0.04 | -0.04 | -0.05 | 0.06 |
| 120 | Banksia Street | -0.10 | -0.06 | -0.06 | 0.06 |
| 121 | Dent Street | 0.00 | 0.04 | 0.10 | -0.16 |

*Note: "-" sign means decrease in flood level. "+" sign refers to an increase in flood level.*

## 6.6 Sensitivity assessment

A number of scenarios were modelled to assess the sensitivity of flooding behaviour to possible changes in drainage and development conditions.

### 6.6.1 Stormwater infrastructure blockage

Sensitivity of flooding to the ARR 2016 design blockages on the stormwater infrastructure is investigated by comparing ARR 2016 blockage results with zero blockage results. Adopting ARR 2016 blockage produces higher flood levels inside the study area except a small part between William Street and Tenterden Road.

- Flood levels in 5% AEP for ARR 2016 blockage scenarios increased by 0.2m or more in Hale Street, Bay Street, Rose Street, Jasmin Street, Rochester Street, Dent Street, Livingstone Street and Tupia Street and increased by about 0.1m in William Street, Pemberton Street Margate Street and Edgehill Avenue.

- Flood level also increases in those areas in 1% AEP for ARR 2016 blockage scenarios but usually slightly lower than 5% AEP flood levels. The flood impact mapping for this sensitivity assessment scenario is presented in Appendix D.

### 6.6.2 Approved works on the floodplain

The design flood modelling represented infrastructure and building footprints prior to 2018. After 2018, a number of developments and drainage works were approved and implemented which could influence the flood behaviour of the study area.

In 2016, Council proposed drainage upgrades included new road drainage and new kerb and guttering in Aylesbury Street, constructed by Council. Due to clashes with existing utilities the installation of underground drainage was deferred and only kerb and guttering installed. For the purposes of the sensitivity testing the full set of underground drainage and kerb and guttering was modelled.

The sensitivity modelling for approved work indicate that the drainage upgrades in Aylesbury Street do not have significant impact on reduction on the flood level in the surrounding areas.

Additionally, a major development is currently underway between Pemberton Street and Wilson Street and is referred to as Wilson Pemberton Street Precinct (Ref: Part 9C Wilson Pemberton Street Precinct, Development Control Plan, City of Botany Bay). This area was adopted as open area in the design flood model. The new drainage works and the Wilson Pemberton Street Precinct development were included in the sensitivity assessment modelling for the 5% and 1% AEP flood events. The results are compared with the design flood model results. Flooding impacts (increase in flood levels) are summarised below:

- Rancom Street sag point (up to 0.5m in the 5% AEP event and up to 0.6m in 1% AEP due to development finished levels being raised above pre-development ground levels);
- Pemberton Street and Mahroot Street (up to 0.11m in 5% AEP and up to 0.07m in 1% AEP);
- Margate Street and Sir Joseph Banks Street (up to 0.06m in 5% AEP and up to 0.02m in 1% AEP);
- Hannon Street (up to 0.04m in 5% AEP);
- Rochester Street (up to 0.012m in 5% AEP and 1% AEP) and
- Livingstone Avenue (up to 0.02m in 5% AEP and up to 0.012m in 1% AEP).
- The increased flooding also results in increased flow along Wilson Street, resulting in 0.02m increase in the 5% AEP flood levels in Dent Street.

Underground detention and absorption systems were installed as a part of this development. These were not assessed in the flood model to check the impacts of these features. It is expected that the impacts would be minor, as these systems are designed to cater for the development itself and not for overall and external catchment flooding.

The flood impact mapping for this sensitivity assessment scenario is presented in Appendix D.

### 6.6.3 Cumulative impacts of development

Most of the study area is fully developed as per the Local Environmental Plan (LEP) except an open area adjacent to the Banksmeadow Public School which is defined as R2 (low density residential area) in the LEP. Therefore, to assess the cumulative impact, an ultimate developed case model was produced assuming residential development for the area. A Manning's n value of 0.35, the average roughness values for residential blocks as per ARR2016, was adopted to represent the residential development. The ultimate developed case model also includes the new/approved developments at the Wilson Pemberton Street Precinct (as described in Section 6.6.2). The model was simulated for the 5% and 1% AEP flood event. The changes in flood behaviour including changes in flood levels are described below based on flood impact mapping presented in Appendix D.

- The development of the open area adjacent to the Banksmeadow Public School to low density residential (as per LEP) may result in increased flood levels by up to 0.02m in the 5% AEP event and up to 0.03m in the 1% AEP.

- Similar to the development flooding impacts described in Section 6.6.2, significant increases in flood level occur at a sag point in Rancom Street with up to 0.5m in the 5% AEP event and up to 0.6m in 1% AEP event occurring, due to Wilson Pemberton Street Precinct development finished levels being raised above pre-development ground levels. There are also increases in flood levels in Pemberton Street and Mahroot Street (up to 0.11m in 5% AEP and up to 0.07m in 1% AEP); Margate Street and Sir Joseph Banks Street (up to 0.06m in 5% AEP and up to 0.02m in 1% AEP); Hannon Street (up to 0.04m in 5% AEP); Rochester Street (up to 0.02 in 5% AEP) and in Livingstone Avenue (up to 0.02m in 5% AEP and up to 0.01m in 1% AEP). These impacts are attributed to the approved footprint of the proposed development, assumed to be solid obstructions, in addition to modified ground levels, displacing the ponded floodwaters in this location. No upgraded drainage or other mitigation was modelled in association with this development.

### 6.6.4 Bulkhead removal

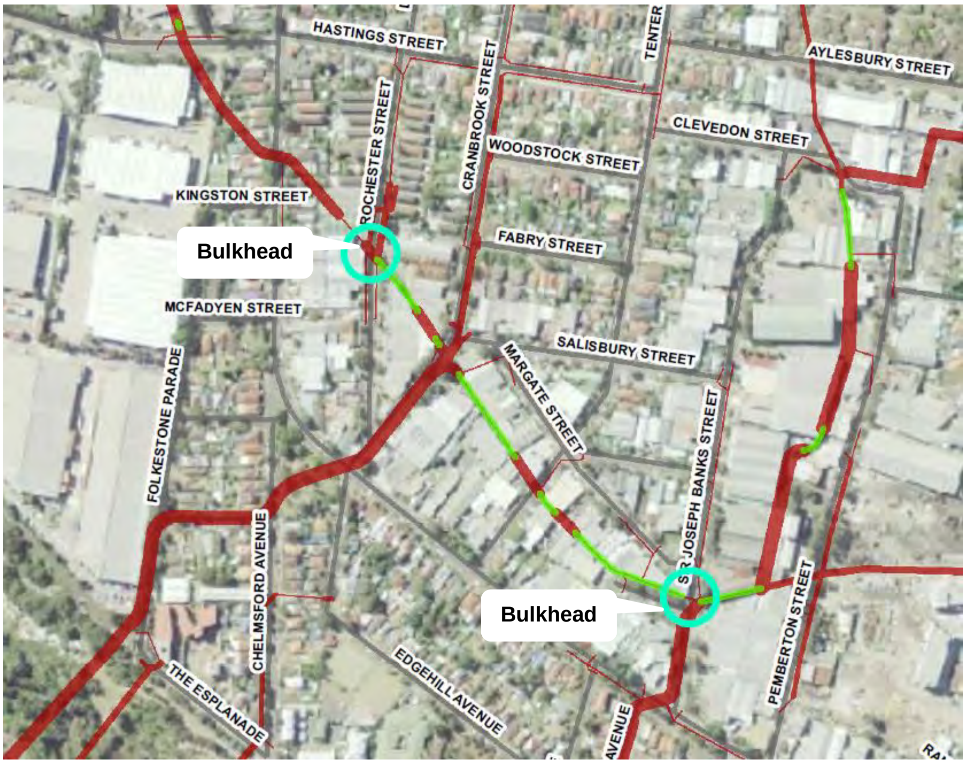
The removal of the two existing bulkheads on the Sydney Water trunk drainage system was assessed as a sensitivity test on request from Sydney Water, as a stakeholder and asset owner of trunk drainage infrastructure in the study area. The existing bulkheads consist of small diameter (200 – 375mm) pipe connections between larger (approximately 2m wide) trunk drainage culverts. The bulkhead removal testing involved enlarging the small pipes with large size culverts equivalent to the upstream and downstream drainage. The locations of the bulkhead removal are shown on Figure 6.3. The intention of this sensitivity testing was to investigate the impacts or benefits of restoring the original trunk drainage patterns by removal of the bulkheads.

Removal of the bulkheads results in typical increases in the 1% and 5% AEP flood levels of +0.05m in Bay Street, with further increases of up to +0.02m in the 5% AEP event and 1% AEP event in Rose Street, Hale Street and Booralee Street. There are reductions in flood levels up to -0.07m in the 5% AEP event and 1% AEP event in Rochester Street and up to -0.03m decease in Cranbrook Street.

Opening up of the drainage constraint at the bulkhead locations reduces the flow and volume being directed into the trunk drainage lines which run southward to discharge directly to Botany Bay. Instead, the flows are retained in the trunk drainage line which runs westward, resulting in higher tailwater conditions in the trunk lines and reduced drainage performance of the local network servicing the area around Hale Street.

The flood impact mapping for this sensitivity assessment scenario is presented in Appendix D.

Figure 6.3 Locations of bulkheads removal



## 6.7 Flood Planning Levels and Flood Lot Tagging

Tagging and mapping of the 1% AEP and PMF flood lots has been prepared on behalf on Council by another consulting company. It is documented in the report Flood Planning Level Project 2020 (WMAwater, 2020) prepared for Bayside Council. The property tagging used the outputs from catchment wide flood studies within the Bayside Council LGA to define flood affection for the 1% AEP and PMF design events, for the Botany Bay and Foreshore Beach catchment and for other catchments in Bayside LGA.

The methodology developed for the lot-based tagging system involved an initial automated GIS-tagging analysis followed by a comprehensive process of desktop review and ground truthing. This methodology was developed to provide a consistent approach to identifying flood liable properties within the Bayside Council LGA, which takes into account the range of modelling approaches employed in catchment wide flood studies within the LGA. Properties were classified as tagged or not tagged based on their risk of flood affectation in the modelled design events and the reason for this classification was added to the property tagging database.

The 1% AEP and PMF tagged flood lots is provided in Figure B.15 and Figure B.16 in Appendix B. The property tagging denotes those properties where flood-related development controls apply. Additional property tagging was produced for the 1% AEP event under 0.4 m and 0.9 m sea level rise scenarios.

The flood planning levels consider a 0.5m freeboard above the 1% AEP flood level, which is a typical provision for setting habitable floor levels for flooding in NSW. Consideration of the sensitivity of flood levels to potential uncertainties in hydraulic conditions (such as hydraulic roughness, blockage of hydraulic structures and increased flooding due to climate change) indicates some sensitivity in the flood levels. The adopted 0.5m freeboard is considered appropriate to provide a factor of safety above the design 1% AEP flood levels to account for these uncertainties in the hydraulic conditions, and provide a buffer against climate change increases in flooding.

## 6.8 Climate Change Impacts to Flooding

The study area's low elevations mean that flooding in the lower reaches is expected to be sensitive to future climate change impacts, in particular sea level rise. Previous guidance from the NSW Government recommended considering a 0.4m rise in sea level from current (1990) levels for the year 2050, and 0.9m rise for the year 2100 in assessing the impact of climate change on flooding. These projections are based on research by the Intergovernmental Panel on Climate Change (IPCC) and were refined for the Australian region.

The effects of future sea level rise on the 1% AEP events were estimated in TUFLOW as a sensitivity assessment, based on a 0.4m increase in sea level, and a 0.9m increase in sea level. The existing climate 1% AEP design rainfalls were simulated and coincided with a 5% AEP ocean water level as per the design flood simulations. The change in flood levels is mapped on Figures D.9 and D.10 in Appendix D. In summary:

- In the catchment low-point around Hale Street, flood levels increase by 0.34m with 0.4m sea level rise, and by 0.8m with 0.9m sea level rise
- In the low-point at Chelmsford Avenue and The Esplanade, flood levels increase by 0.1m with 0.4m sea level rise, and by 0.23m with 0.9m sea level rise
- In the vicinity of Dent Street,

With 0.4m sea level rise, flood levels are not increased on the residential properties but increase by 0.04m in the golf course to the south

With 0.9m sea level rise, flood levels increase by 0.05m on the residential properties and increase by 0.19m in the golf course to the south.

The assessment was based on existing catchment development and drainage infrastructure conditions. The impacts to flooding in the study area are attributed primarily to the high tailwater levels preventing drainage of the low points when coinciding with a catchment rainfall event, and to a lesser degree due to backflow of the water from Botany Bay.

The effects of increased rainfall intensity on the 1% AEP events due to climate change were also assessed in TUFLOW by comparing the 0.5% and 0.2% AEP design flood levels with the 1% AEP flood level. The 0.5% AEP event represents a 10% increase in rainfall depth from the 1% AEP event, and the 0.2% AEP event represents a 24% increase in rainfall depth from the 1% AEP event. The change in flood levels is mapped on Figures D.11 and D.12 in Appendix D. In summary:

- In the catchment low-point around Hale Street, flood levels increase by 0.09m with 10% increase in rainfall intensity, and by 0.17 – 0.26m with 24% increase in rainfall intensity
- In the low-point at Chelmsford Avenue and The Esplanade, flood levels increase by 0.08m with 10% increase in rainfall intensity, and by 0.14 with 24% increase in rainfall intensity
- Around Pemberton Street low point, flood levels increase by 0.09m with 10% increase in rainfall intensity, and by 0.22 with 24% increase in rainfall intensity
- Around Salisbury Street and Cranbrook Street low point, flood levels increase by 0.06m with 10% increase in rainfall intensity, and by 0.27 with 24% increase in rainfall intensity
- Around Rochester Street low point, flood levels increase by 0.02m with 10% increase in rainfall intensity, and by 0.1 with 24% increase in rainfall intensity
- Around William Street and Aylesbury Street low point, flood levels increase by 0.05m with 10% increase in rainfall intensity, and by 0.08 with 24% increase in rainfall intensity
- Around Bay Street, Rose Street, Ivy Street and Daphne Street, flood levels increase by 0.06m with 10% increase in rainfall intensity, and by 0.12 with 24% increase in rainfall intensity
- Around Dent Street, flood levels increase by 0.03m with 10% increase in rainfall intensity, and by 0.09 with 24% increase in rainfall intensity.

Measures to mitigate against the impacts of climate change to flooding would be required on top of any mitigation options to manage existing climate flooding risks. Further discussion is provided in Section 11.4.

# 7. Impacts of Flooding

## 7.1 Property impacts

### 7.1.1 Catchment flooding

The flood modelling results were compared to building and property details including floor levels. Above-floor flooding at properties is mapped on Figure 7.1 and Figure 7.2 for the 5% and 1% AEP events, respectively. The property type (residential, commercial etc.) is also shown. The mapping indicates the spatial distribution and density of flooding impacts to properties.

Above-floor flooding is expected to incur significantly greater flood damages to the building and contents compared to yard (i.e. below floor level) flooding. The map indicates the spatial distribution of properties with above-floor flooding and their relative vulnerability, with properties affected in frequent events such as the 20% AEP event being more vulnerable than those affected only in rarer events such as the 1% AEP.

### 7.1.2 Ocean inundation

#### 7.1.2.1 Property Impacts

Property floor levels, up to 4m AHD, are mapped on Figure 7.3 to show the vulnerability of properties to ocean inundation. The map shows location of buildings with low floor levels, with a number of buildings in the Bay Street/Hale Street industrial area having floor levels below 1.45m AHD, which is the 1% AEP ocean level at Sydney. The mapping also shows properties with building floor levels below 2.35m AHD, which is the 1% AEP ocean level plus 0.9m sea level rise, which is forecast for the year 2100 under IPCC projected climate change scenario. These buildings include additional commercial/industrial properties around Hale Street and Bay Street, in addition to residential properties in the low-lying area around Dent Street, in the south-eastern part of the study area. Note this is a simplified assessment of tidal inundation vulnerability based on ground and floor levels only.

#### 7.1.2.2 Road Impacts

Tidal inundation due to king tides and storm surge with no catchment flooding for current climate and sea level conditions would reach a level of 1.45m AHD in the 1% AEP ocean level conditions and affect Bay Street, Erith Street, Hale Street, McFall Street, Luland Street and Booralee Street in the north-western portion of the study area.

### 7.1.3 Property Flood-Affectation

A count of properties and buildings affected by above-floor flooding and by high hazard flooding is provided in Table 7-1. The table summarises the properties affected as shown on Figure 7.1 to Figure 7.2 for the properties affected by 5% AEP and 1% AEP catchment flooding.

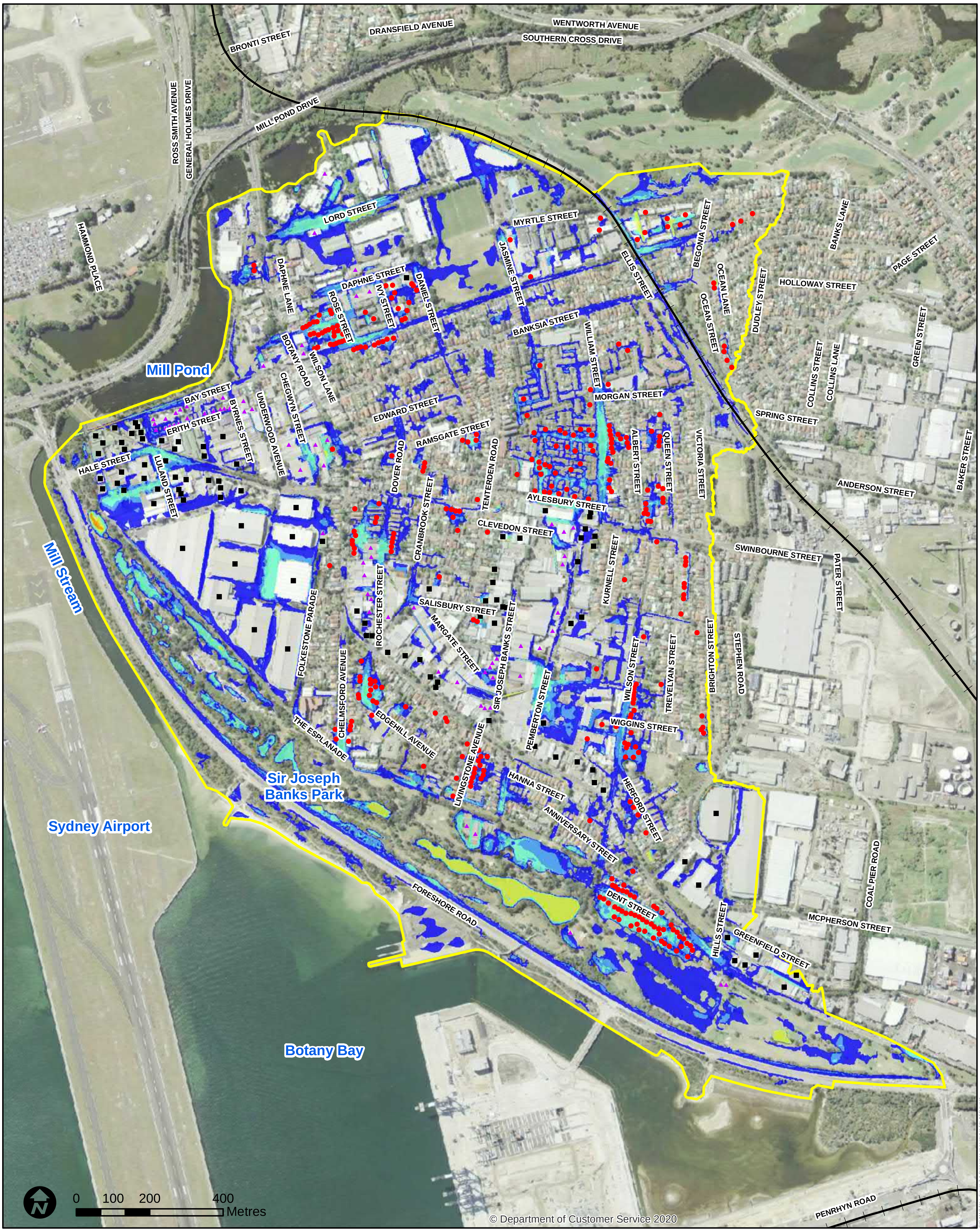
Note that the property count for the tidal inundation scenarios (no catchment flooding) was undertaken based on hydraulic modelling with the dynamic tidal boundaries imposed in the model, rather than a simplified assessment based on ground level and floor level of each property. The hydraulic modelling approach accounts for the flow constraints posed by the trunk drainage pipes and culverts discharging to Botany Bay.

Table 7-1: Count of properties and dwellings with above-floor flooding

| Flood event | Property flooding* | | Above-floor flooding | |
|---|---|---|---|---|
| | Residential | Commercial/ Industrial | Residential | Commercial/ Industrial |
| Tidal inundation – King Tide (1.25m AHD)**. No catchment flooding | 0 | 1 | 0 | 1 |
| Ocean inundation – storm surge (5% AEP design ocean level 1.4m AHD). No catchment flooding | 0 | 12 | 0 | 12 |
| Ocean inundation – storm surge (1% AEP design ocean level 1.45m AHD). No catchment flooding | 0 | 16 | 0 | 16 |
| 20% AEP catchment flooding | 1,655 | 134 | 214 | 134 |
| 5% AEP catchment flooding | 1,656 | 159 | 320 | 159 |
| 1% AEP catchment flooding | 1,657 | 203 | 415 | 203 |
| PMF catchment flooding | 1,667 | 304 | 933 | 304 |

* Depths above 0.05m. Includes those with above-floor flooding

** High High Water Spring (Solstice Spring) design tide level of 1.25m AHD, as specified in OEH (2015) is adopted as the “king tide” level.

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Legend

- Study area
- Rail

Impact Properties (above-floor)

- Commercial
- Industrial
- Residential

Flood Hazard

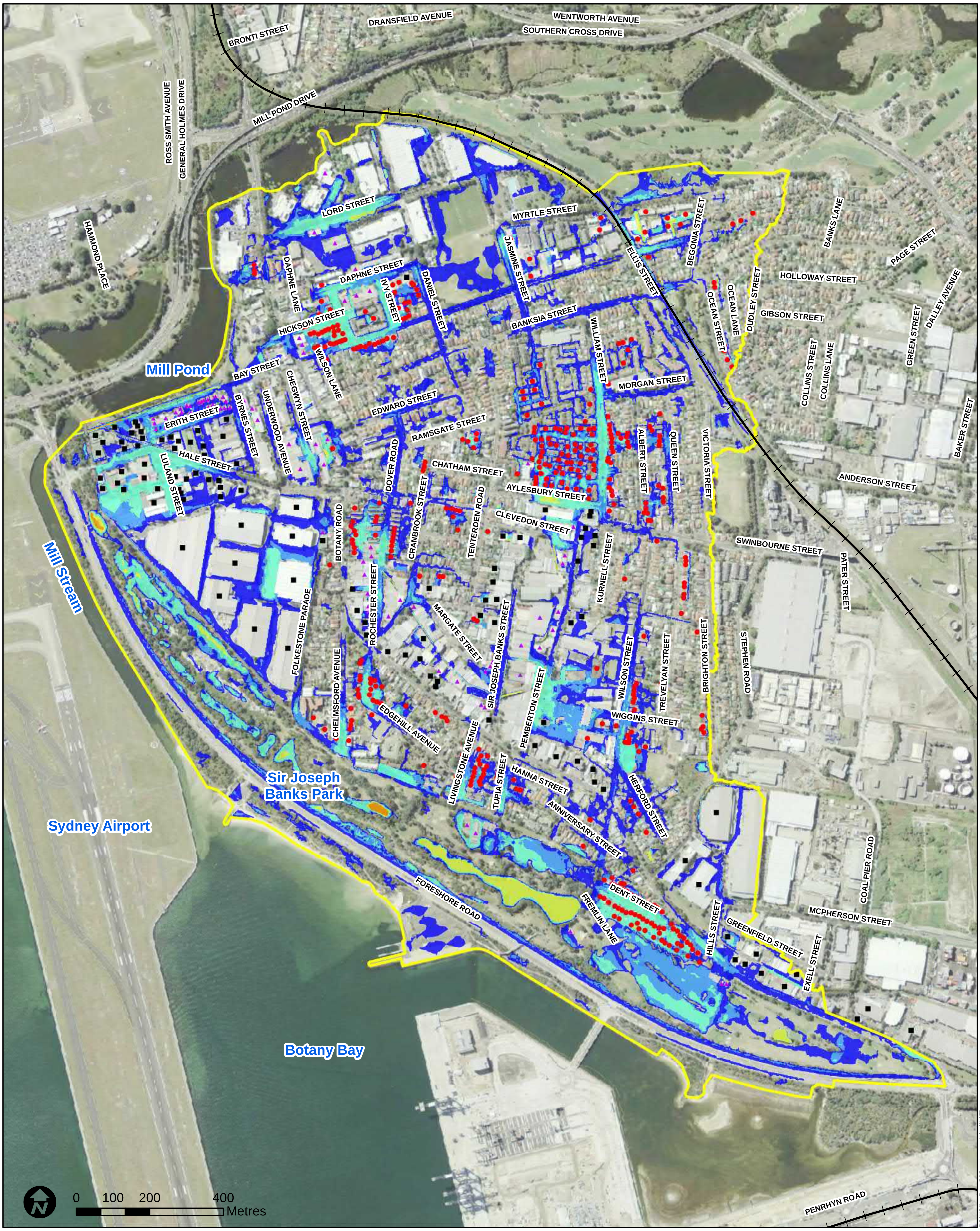
- H1 - No restrictions
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6 - Not suitable for people, vehicles or buildings

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Buildings Impacted in the 5% AEP Event | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 7.1 | REV 2 VER 1 |
| CHECK AH | DATE 19/06/2020 | | |




Legend

Rail

Study area

Impact properties (above-floor)

- Commercial
- Industrial
- Residential

Flood Hazard

- H1 - No restrictions
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction
- H6 - Not suitable for people, vehicles or buildings

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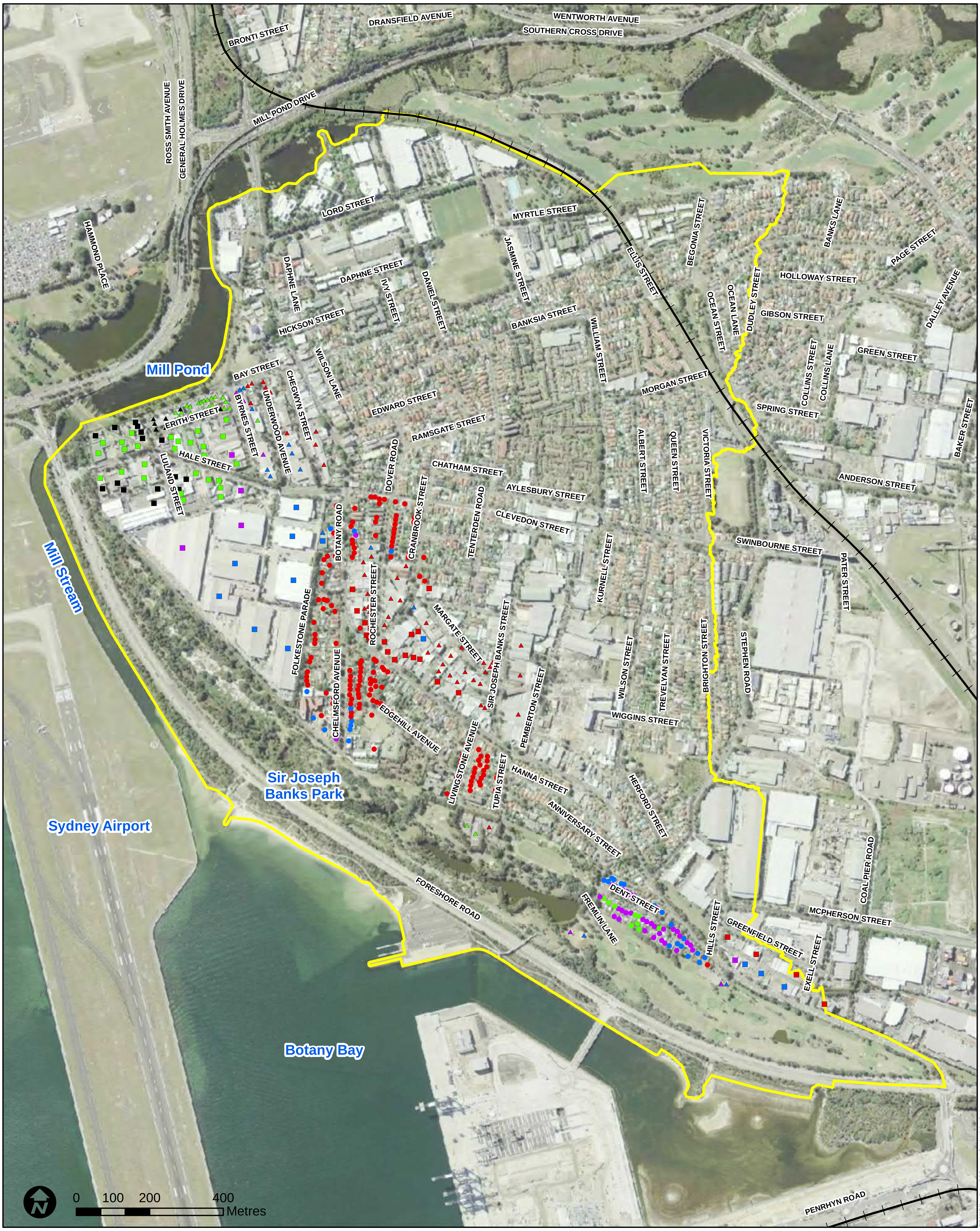
| | | |
|---|---|---|
| SCALE | 1:10,000 | A3 |
| SHEET | 1 of 1 | GDA 1994 MGA Zone 56 |
| TITLE | **Buildings Impacted in the 1% AEP Event** | |
| PROJECT | Botany Bay Foreshore Beach FRMS | |
| CLIENT | Bayside Council | |
| DRAWN PK | PROJECT # IA190100 | MAP # **Figure 7.2** REV 2 VER 1 |
| CHECK AH | DATE 3/04/2020 | |




Legend

| | | |
|---|---|---|
| Rail | Properties floor level (mAHD) | Properties type |
| Study area | <1.45 | Commercial |
| | 1.45 - 1.95 | Industrial |
| | 1.95 - 2.35 | Residential |
| | 2.35 - 2.85 | |
| | 2.85 - 4 | |
| | >4 (not shown) | |

JACOBS

Data Sources: Bayside Council

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| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Properties Floor Level Classification | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 7.3 | REV 2 VER 1 |
| CHECK AH | DATE 3/04/2020 | | |

7.2

## 7.2 Mapping and Assessment of Sensitive Properties

Sensitive properties and critical infrastructure have been identified in the catchment. Certain types of properties may require specific evacuation considerations due to the vulnerability of its occupants, such as schools and pre-schools, and aged care facilities. Critical infrastructure (water supply systems and distribution systems, wastewater systems and sewer distribution facilities, electricity substations, etc.) and emergency services centres (SES, police, fire stations, hospitals and ambulance centres etc.) impacted by flooding may have effects on the recovery and functioning of the community following a flood event.

The sensitive properties and critical infrastructure identified in the study area are mapped on Figure 7.4. The flood hazard in the PMF event is mapped on the figure. Sensitive properties and infrastructure which are flood-affected include:

- Botany Public School: Mostly low hazard (H1, H2) in PMF. Some yard areas up to high to very hazard (H4, H5) in PMF. Localised areas in yards up to moderate hazard (H3) in 1% AEP.
- Hippo's Friends Child Care Centre: Areas of H3 moderate hazard in 1% AEP and H5 very high hazard in the PMF.
- John Brotchie Memorial Nursery School: rear yard area H3 moderate hazard in PMF. Building not affected.
- Botany Bay Preschool: H3 moderate hazard in 1% AEP, and H4 high hazard (depths to 1.2m) in the PMF.
- All Star Early Learners: H1 low hazard in PMF.
- Edward Street Early Learning Centre: H1 low hazard in PMF.
- St Bernard's Catholic Primary School: Mostly H1 low hazard in PMF, localised up to H3 moderate hazard.
- Heritage Botany Aged Care Facility: mostly H1-H2 low hazard in PMF, areas of H3 moderate hazard in low-lying sections in southern portion of site, particularly around south-eastern villas (five villas affected by H3). Depths to 0.8m in the PMF. One villa affected by H3 moderate hazard in the 1% AEP event.
- Banksmeadow Public School: Mostly low hazard (H1, H2) in PMF. Localised areas in yard low points up to high hazard (H4) in PMF. Localised areas in yards up to moderate hazard (H3) in 1% AEP.
- Three Sydney Water sewer pumping stations (SP0060, SP0074, SP0075).

Note that H3 moderate flood hazard conditions are unsafe for children and the elderly.

Most of the high hazard areas affecting these properties is due to active flood flows which are expected to occur in quick response to rainfall events. Therefore, it is likely that there is no effective warning time to allow evacuation of these properties. Shelter-in-place may be appropriate, although. This is subject to the investigation by SES as part of the Bayside Local Flood Plan. SES will review whether shelter in place is appropriate as the primary response option given the warning timeframes.

## 7.3 Review of land use planning

The current land zoning as per LEP 2013 is mapped on Figure 2.3. As previously mentioned, land use in the study area is a mixture of low and medium density residential, business/commercial and industrial land uses. Note that the Draft Bayside LEP 2020 is on public exhibition at the time of preparation of this study and will supersede the LEP 2013.

The assessment of sensitive properties in Section 7.2 indicates a number of existing childcare centres which are flood-affected with high hazard flooding in the PMF and with some affected by high hazard flooding in the 1% AEP event. There is incompatibility between the land use and flood hazard. Flood management plans are a preferred option for these properties (see discussion later in this section). Provision of safe, flood-free refuge on these properties in addition to potential evacuation procedures and external flood refuge locations should also be investigated.

The three schools in the study area are mainly affected by low hazard flooding in up to the PMF in the main built areas of the school grounds. The land use is considered compatible with the flood hazard.


Legend

- Study area

Sensitive Properties

- Aged care
- Emergency services
- Preschool and day care
- School
- Sewer pumping station

PMF Event Flood Hazard

- H1 - No restrictions
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for people and vehicles
- H5 - Unsafe for people or vehicles. Buildings require special engineering design/construction
- H6 - Not suitable for people, vehicles or buildings

JACOBS

Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Sensitive Properties | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 7.4 | REV 2 VER 1 |
| CHECK AH | DATE 6/08/2020 | | |

The Heritage Botany Aged Care Facility is mostly not flooded or flooded up to H2 low hazard in the PMF event and is considered mostly compatible with the flood hazard. Development of a flood management plan for the facility should be considered to manage the flood risk to residents. Relocation of vulnerable residents from the five affected villas from the H3 flood hazard area (PMF event) could be considered and these villas repurposed to lower risk uses.

Flood management plans could also be considered for Hippo's Friends Child Care Centre and Botany Bay Preschool. Council should consider consultation with the facility on managing the flood risk on the sites. The Hippo's Friends site appears to include a two-storey building with second floor above PMF level and which could potentially be used as a flood refuge. The Botany Bay Preschool site appears to be single storey only. These issues should be considered in the flood management plan.

There are properties currently with floodway areas in the 1% AEP event on the lot, confined to within trunk drainage channels. These properties do not require rezoning. Other planning controls such as minimum floor levels and development away from floodways and trunk drainage channels in addition to response measures would be adequate to address flood risk at existing and future development.

**Recommendation**

Council should consider consultation with the Heritage Botany Aged Care Facility regarding management of flood risk on the site. Development of a flood management plan for the site should be considered. A similar plan could be considered for Hippo's Friends Child Care Centre and Botany Bay Preschool.

## 7.4 Flood damages assessment

### 7.4.1 Overview

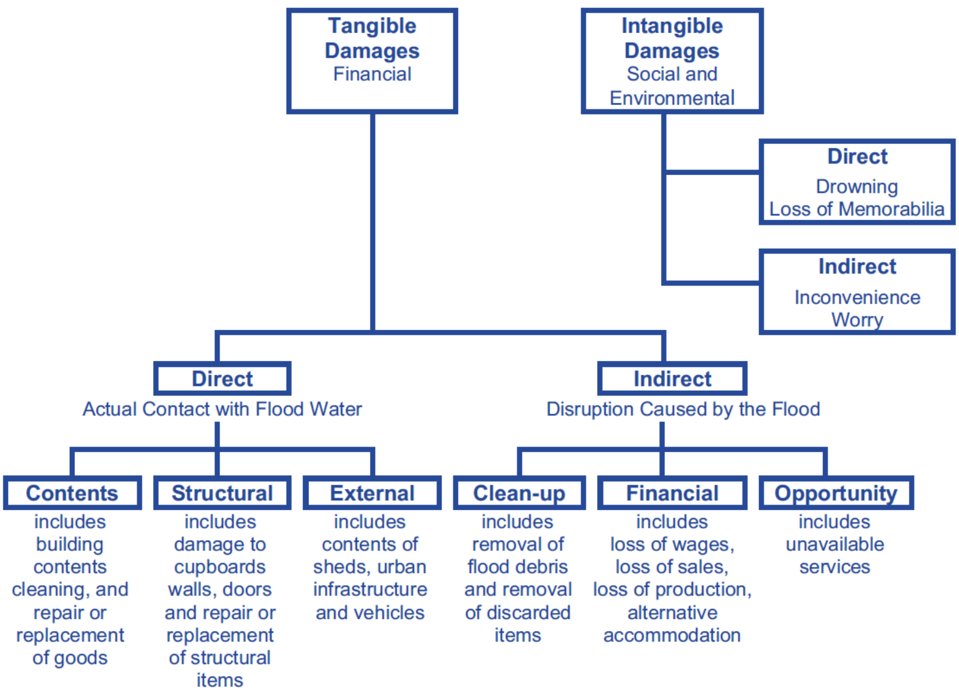
Flood events may cause damage to property with significant costs to property owners and insurers. The damage may occur due to floodwaters affecting the building façade and interior (weatherboard exterior, gyprock interior walls, carpets), electrical wiring and building contents and other property outside the dwelling (vehicles, contents of sheds and garages, etc). Structural damage to the dwelling can also occur due to extreme flood hazard conditions.

The cost of flooding is estimated to identify the magnitude of the event to a community, and subsequently provide a benchmark for the viability of potential measures for mitigating the impacts of flooding. This section describes the estimation of flood damage costs in the study area, focussing on residential and commercial properties.

### 7.4.2 Flood damages categories

The type of damages associated with floods is shown in Figure 7.5 (*Floodplain Development Manual¸ NSW Government 2005*). The cost of damage caused by floods may include tangible and intangible components. Tangible damage costs include the direct material damage and rebuilding costs to existing homes, property and infrastructure, and also the indirect costs associated with the social disruption of the floods, such as: clean-up; lost income during and after the flood event; and the cost of alternative accommodation for people displaced by the floods. A monetary value can be readily placed on the direct damages, which are the focus of this assessment.

Figure 7.5 Types of Flood Damage




Other social and environmental damages to which a monetary value cannot be placed are intangible damages, which include emotional stress of the flood event, injury and loss of life. While these damages cannot readily be incorporated into an economic feasibility assessment of mitigation options, it is still important to consider the potential for these intangible damages, particularly if there is an elevated risk of loss of life.

### 7.4.3 Estimation of direct tangible flood damage costs

#### 7.4.3.1 Property information

Residential and commercial properties were identified and characterised based on knowledge and site observations of the study area.

Residential house types in the study area are a mixture of one and two storey houses. In floodplains with deep flooding (riverine floodplains) two storey houses would experience a second increment of flood damages as floodwaters rise and affect the second storey. Flooding in the study area is typified by overland flows, affecting up to the first storey of the house only. For the purposes of this assessment all houses were assumed to be single storey.

Flood damages are estimated based on flood depth in relation to building floor level. Floor levels above ground level were estimated based on visual inspection. Where this was not possible, floor levels were assumed to be 0.15m above the highest ground level (obtained from LiDAR data) at the building. The applicable flood level at each building for each event AEP for flood damages estimation purposes was assumed to be at a representative point exposed to overland flows at the building.

#### 7.4.3.2 Residential property damages

Residential flood damages guidelines and a calculation spreadsheet was developed by the NSW Office of Environment and Heritage (OEH, 2016b). The calculation spreadsheet includes a representative stage-damage curve derived for typical house types in the study area to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth, for a suite of annual exceedance probability events ranging from the 20% AEP event up to the PMF. These values are then summed to provide a total damage for each flood event analysed. The AEP of the PMF in the study area is assumed to be 1 in 10,000,000.

The stage-damage curves assume some flood damages for flood levels below the floor level. A minimum damage value of $12,060 (2019 dollars) is assumed to occur at a level 0.5m below the floor level. This approach accounts for flood damages to parts of the dwelling and property below the floor level and ensures that damages are not underestimated.

Various input parameters are used to define the flooding and location characteristics which derive a location specific damage curve. The parameters adopted for the study area are presented in Table 7-2.

The DECCW stage-damage curves within the spreadsheet were originally derived for late 2001 dollar values, and have been updated using an Average Weekly Earnings (AWE) factor to the current day values. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). The most recent AWE value from the Australian Bureau of Statistics (ABS, 2019) at the time of the assessment was November 2018, however, this resulted in a multiplication factor on 2001 dollars of 2.37, which was significantly out of step from the factor value derived from November 2017 AWE of 1.76 and from previous recent years. On this basis, a factor of 1.8 was assumed for up to August 2019 to keep in trend with AWE increases for the years prior to November 2017.

Table 7-2 Input parameters for damage calculations

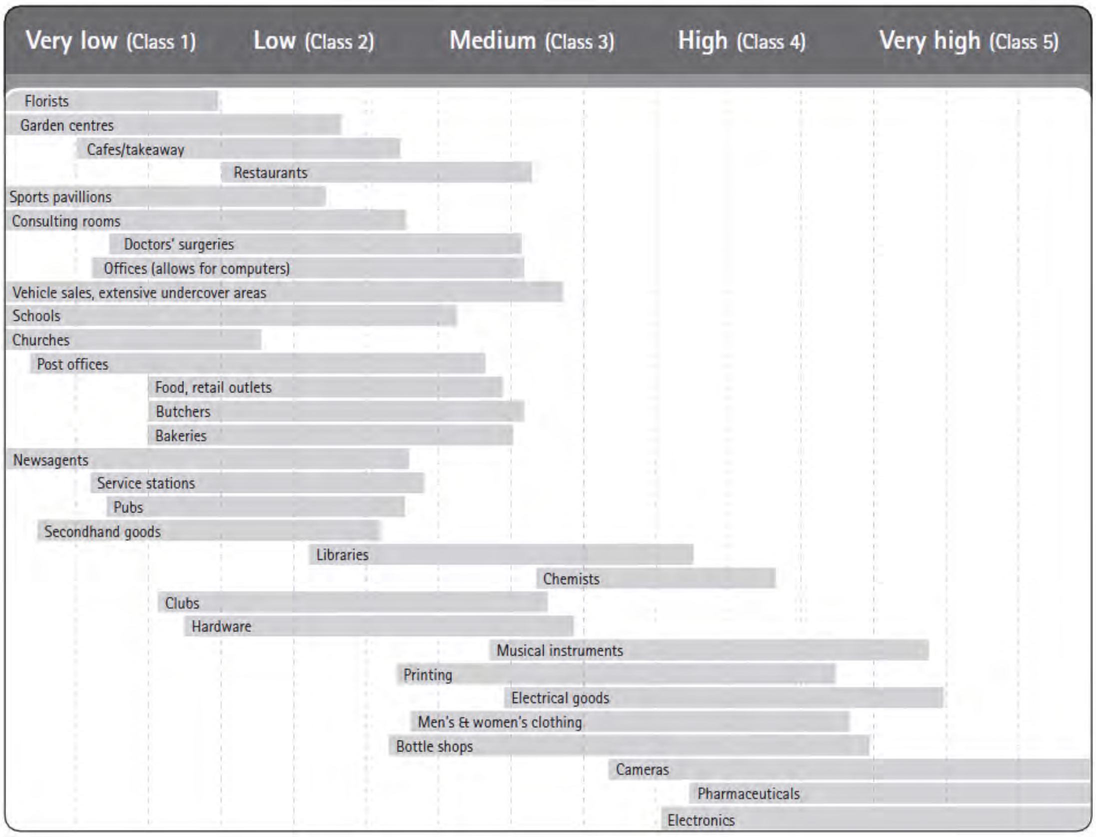
| Parameter | Value | Comment |
|---|---|---|
| Regional Cost Variation Factor | 1.0 | Appropriate value for a major city (Sydney) and surrounds |
| Post flood inflation factor | 1.4 | |
| Typical duration of immersion | 4 hours | |

| Parameter | Value | Comment |
|---|---|---|
| Building damage repair limitation Factor | 0.92 | Averaged value between suggested values for short (0.85) and long (1.0) duration flooding. |
| Typical free-standing house size | 140m$^2$ | |
| Contents damage repair limitation Factor | 0.83 | Averaged value between suggested values for short (0.75) and long (1.0) duration flooding. |
| Effective warning time (hrs) | 0 | Flooding in the study area is mainly due to local catchment rainfall-runoff. No prior warning from stream gauges. No relevant stream gauges for the study area.<br>Only marginal improvement in damages cost when effective warning time is increased to 1 hour as a sensitivity assessment |
| Level of flood awareness | Low | Flood warning times are nil and it is assumed that residents are typically not aware of potential damage of flood waters and the measures to minimise damages (e.g. elevated storage of goods). |

#### 7.4.3.3 Commercial property damages

No information on commercial property flood damage costs in NSW was found during a literature search. The most relevant information obtained was published in the Queensland Government Natural Resources and Management Department's *Guidance on the Assessment of Tangible Flood Damages* (2002). This document contains flood damage curves for commercial properties over a range of property footprint areas and degrees of susceptibility to flooding and is based on information published in *ANUFLOOD: A Field Guide* (Centre for Resource and Environmental Studies (Australian National University), 1992). Different types of commercial and non-residential properties were assigned a susceptibility rating, as illustrated in Figure 7.6.

Figure 7.6 Damage categories for commercial properties (reproduced from *Guidance on the Assessment of Tangible Flood Damages* (Qld. Government, 2002)




The stage-damage data were factored up by a value of 1.8 from late 2001 dollars to current values based on Average Weekly Earnings (AWE), similar to the approach adopted for the residential flood damages.

An additional multiplication factor of 1.6 was applied based on guidance in *Rapid-Appraisal Method (RAM) for Floodplain Management* (Victorian Government Natural Resources and Environment, 2000), which suggests that the ANUFLOOD values are underestimated and should be increased by 60%.

The results of the commercial and non-residential property flood damages assessment are provided in Section 7.4.3.5.

#### 7.4.3.4 Damages to utilities and infrastructure

Utilities and infrastructure in the study area which are susceptible to flooding include roads and other public infrastructure such as sewage pumping stations, electrical transformer boxes, etc.

The potential cost of damage to roads is difficult to estimate for the study area, as the nature of flooding in a significant portion of study area is typically due to relatively shallow, short-duration flows, although road damage is possible for roads conveying higher velocity flows.

The roads damages guidance published in the references cited in this study are based on longer-duration mainstream flooding damages and hence are likely to significantly overestimate the flood damages to roads in the study area. Hence these costs have not been included in this assessment.

The damages to other infrastructure and utilities were not estimated as these damages are unlikely to be reduced by potential mitigation options, and hence, are inconsequential to the feasibility assessment of the mitigation options.

#### 7.4.3.5 Damage assessment results

The most convenient way to express flood damage for a range of flood events is by calculating the Annual Average Damage (AAD). The AAD is equal to the total damage caused by all floods over a long period of time divided by the number of years in that period. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options.

The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the rarer catastrophic floods.

Table 7-3 and Table 7-4 summarises the residential damages and the commercial/non-residential damages, respectively. The residential and commercial property flood damages include direct damages to property such as structural, external and contents damage, and indirect damages such as clean up costs and accommodation/ loss of rent costs. Infrastructure damage, vehicular damage and intangible damages are not included.

The flood damages here are "potential flood damages", which may be reduced with increased flood awareness and preparedness in the community. The Net Present Value of the flood damages assumes a 7% discount rate over a 50 year life, as per the OEH (2016b) guidelines. The damages are in 2019 dollar values.

Table 7-3 Estimated tangible flood damages for residential properties

| Event | Number of properties flooded above floor level | Estimated Flood Damage |
|---|---|---|
| 20% AEP | 214 | $30.6M |
| 5% AEP | 320 | $35.1M |
| 2% AEP | 391 | $39.3M |
| 1% AEP | 415 | $40.1M |
| 0.5% AEP | 468 | $42.5M |
| 0.2%AEP | 503 | $45.2M |
| PMF | 933 | $72.4M |
| **AAD** | | **$11.5M** |

Table 7-4 Estimated tangible flood damages for non-residential and commercial properties

| Event | Number of properties flooded above floor level | Estimated Flood Damage |
|---|---|---|
| 20% AEP | 134 | $3.4M |
| 5% AEP | 159 | $5.7M |
| 2% AEP | 193 | $9.8M |
| 1% AEP | 203 | $11.3M |
| 0.5% AEP | 209 | $14.2M |
| 0.2%AEP | 222 | $19.3M |
| PMF | 304 | $159.1M |
| **AAD** | | **$1.8M** |

#### 7.4.4 Summary

Flood damages in the study area is primarily attributed to residential dwellings that are impacted by overland flooding. Commercial and industrial properties contribute about 15% to the total AAD. The residential AAD for the study area is $11.5 million. The commercial/non-residential AAD is $1.8 million.

There are 618 residential and non-residential properties that are estimated to experience above floor flooding for the 1% AEP event. In the PMF, 1,237 properties are estimated to experience above floor flooding.

While flood damage estimates for the study area are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

# 8. Local Emergency Planning Context

## 8.1 Local flood and emergency plan

Having a local flood plan is important for the community and State Emergency Service (SES) and other emergency services to be prepared when there is a flood. The plan would outline preparedness measures and the response to flooding in the area. The strategies and personnel responsible for their implementation would be detailed along with the plan for recovery afterwards. A local flood plan may prove to be a valuable resource in times of flood in order to coordinate a strategy to reduce flood risks.

A Local Flood Plan (LFP) does not currently exist for the study area. This document typically describes the risk to the community, outlines roles and responsibilities for the SES and supporting agencies and describes how the SES would manage flood events. A broader Bayside Local Emergency Management Plan (EMPLAN) applies to the study area and identifies the range of hazards as having risk of causing loss of life, property, utilities, services and/or the community's ability to function within its normal capacity. It lists flooding as having a "likely" likelihood rating with moderate consequences, and gives it a medium/high priority rating. It denotes NSW SES as having primary responsibility for managing a flood emergency. EMPLAN addresses aspects on prevention, preparation, response and recovery in relation to the identified hazards for the LGA.

The EMPLAN is reviewed and updated on a three yearly basis. SES advises that a new Bayside LFP, covering flood emergency management in Bayside LGA, will be developed in the next review cycle, due in 2021. It is recommended that the findings of this flood study are incorporated into the development of the Bayside Local Flood Plan, such as locations of roads being cut by flooding, locations of sensitives properties.

## 8.2 Flood warning systems

As the study area is not connected to or influenced by any river system, there is currently no flood warning system, including any stream gauging, specific to the study area. Flash flooding is the primary contributor to the flooding issues in the study area and is likely to result almost immediately after the occurrence of heavy rainfall with little to no warning time.

General sources of real time information currently available during the event of a flood are:

- Bureau of Meteorology (BOM)
- State Emergency Service (SES).

BOM issues forecasts and warnings of possible flood events across Australia in the form of generalised flood warnings (Flood Watch) that flooding is occurring or is expected to occur in a particular region, including flash flooding and riverine flooding. Severe Thunderstorm Warnings and Severe Weather Warnings are also issued when significant weather is expected to occur in certain areas and which may cause flash flooding. Detailed Severe Thunderstorm Warnings are issued for specific thunderstorms which are occurring in metropolitan areas including locations expected to be affected and the time of affectation. These warnings are relevant to the study area and are posted on BOM's website www.bom.gov.au/warnings/nsw. These warnings are also disseminated via social media by BOM and community groups, and announced on local radio stations. Some insurance companies also relay Severe Thunderstorm Warnings and Severe Weather Warnings by SMS to their customers located in the area affected.

BOM also issues Flood Warnings of minor, moderate or major flooding in areas where specialised warning systems have been installed, although these are generally for main river flooding such as along the Georges River and Cooks River and are not directly relevant to the study area.

SES uses information provided by the BOM and assists in communication flood warnings and recommendation on what action communities should take before, during and after flood events.

## 8.3 Emergency response classification mapping

Flood emergency response is an important outcome of the Floodplain Risk Management Process. It is anticipated that SES will use the information contained in this section to update the local flood plan. Areas within the study area have been classified based on the floodplain risk management *Guideline 7-2 Flood Emergency Response Classification of the Floodplain* (AIDR, 2017b). The classification indicates the relative vulnerability of different areas of the catchment and considers the ability to evacuate certain parts of the community. The categories are identified as per the definitions in Table 8-1. In summary, these include:

- FEO – Flooded area, with an Exit Route via Overland Escape
- FER – Flooded area, with an Exit Route via Rising Road
- FIE – Flooded Area, Isolated with an Area Elevated Above flood event of interest
- FIS – Flooded Area, Isolated and Fully Submerged
- NIC – Not Flooded, Indirect Consequences.

Mapping of the classification is provided in Appendix C for the 1% AEP and PMF. The classification is based on review of the flood model and indicates the capacity to evacuate from a certain location at the peak of the flood.

Table 8-1 Flood emergency response classifications (from Table 1 in AIDR, 2017b)

| Primary Classification | Description | Secondary Classification | Description | Tertiary Classification | Description |
|---|---|---|---|---|---|
| Flooded (F) | The area is flooded in the flood event of interest | Isolated (I) | Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater/ impossible terrain as waters rise during a flood event. These areas are likely to lose electricity, gas, water, sewerage and tele-communications during a flood. | Submerged (**FIS**) | Where all the land in the isolated area will be fully submerged after becoming isolated. |
| | | | | Elevated (**FIE**) | Where there is a substantial amount of land in isolated areas elevated above the flood event of interest. |
| | | Exit Route (E) | Areas that are not isolated in the flood event of interest and have an exit route to community evacuation facilities (located on flood-free land) | Overland Escape (**FEO**) | Evacuation from the area relies upon overland escape routes that rise out of the floodplain. |
| | | | | Rising Road (**FER**) | Evacuation routes from the area follow roads that rise out of the floodplain. |
| Not Flooded (N) | The area is not flooded in the flood event of interest | | | Indirect Consequence (**NIC**) | Areas that are not flooded but may lose electricity, gas, water, sewerage, tele-communications and transport links due to flooding. |
| | | | | Flood free | Areas that are not flood affected and are not affected by indirect consequences of flooding. |

In the 1% AEP event, there are a number of blocks of "FIS", flooded, isolated and fully submerged. These blocks are centred around the main flood ponding areas and low points in the study area and reflect the high depths of flooding in these areas. Also present are areas of "FER", flooded with an escape route via rising road, and "FEO", flood-affected with overland escape route, to adjoining areas which are classified "NIC", areas which not flooded but experience the indirect consequences of flooding.

During the PMF a large portion of the study area is rated as "FIS" reflecting the widespread areas of deep flooding, with depths of 1 – 2m common. Another large portion is rated "FIE" which reflects the area being isolated for an extended duration of time in the PMF. Other areas are rated FER, FEO and NIC which reflect the ability to access out of indirectly affected, un-flooded areas.

## 8.4 Flood evacuation and emergency access considerations

Flooding in the study area may generally be considered to be flash flooding in nature with rapid rates of rise, fast catchment hydrologic response and no warning time. Durations of flooding are expected to be up to 18 – 24 hours in events up to the 1% AEP particularly in the lower points of the study area. Durations of flooding are expected to be prolonged (several days) in the PMF due to the large volumes of floodwater ponding in trapped low points and the poor drainage conditions.

The maximum flood depths in the roads are summarised in Table 6-1. All roads have sections which are flooded to depths of at least 0.3m in the 1% AEP event. Such depths are likely to cause cars to float. Access in and out of flooded properties via these roads during a flood event may be hazardous and pose a risk to residents if they attempt to evacuate to offsite flood-free refuges. Most locations in the study area are expected to be accessible by large emergency vehicles and trucks in up to the 1% AEP event, which would be able to pass through water depths of up to 0.5m. There would be some locations which would not be accessible due to depths exceeding 0.5m. Flood depths in the PMF are 1m or more in most roads which will be inaccessible to such vehicles.

The minimum response time for emergency services to coordinate and undertake a response is in the range of one hour, which exceeds the time between high intensity rain falling and the onset of flooding, due to the flashy nature of flooding. Hence coordinated evacuation to flood refuges is not a practical solution. Given minimal warning time and limited practicality of evacuation before or during a flood event, for existing developments, it might be appropriate for residents to shelter in place in the dwelling which is structurally sound in a flood event up to the PMF flood event, however this is subject to the investigation by SES as part of the Bayside Local Flood Plan. SES will review whether shelter in place is appropriate as a primary response in these circumstances.

Local evacuation, whereby residents observe flooding and respond by moving to higher ground, may be feasible although it requires a high level of awareness of the flooding conditions and flood-free zones. However, the flat terrain of the study area means that identification and access to flood-free zones is likely to be difficult, and some areas which are flood-free in the 1% AEP may be affected to depths greater than 1m in rarer events up to the PMF. There is also risk of a flood occurring during night time during which the residents may not be awake to observe and respond to flooding.

# 9. Floodplain Risk Management Measures

## 9.1 Overview

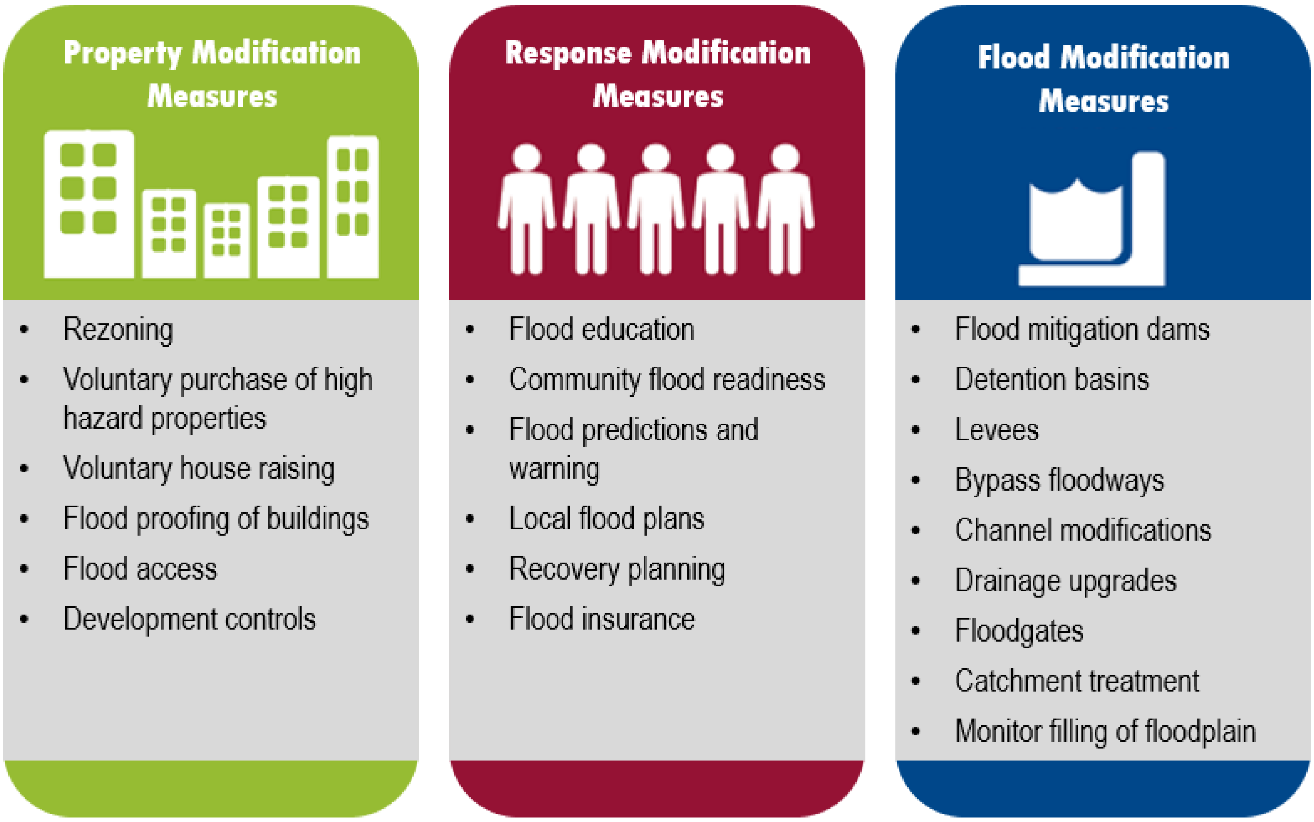
One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing and future flood risk in the study area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts.

The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories as described below:

- Property modification measures involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions);
- Response modification measures involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness); and
- Flood modification measures involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area or flood retarding/detention basins to store floodwaters and reduce peak outflows).

Examples of measures falling under the three categories are outlined in Figure 9.1. Some of these measures may or may not be appropriate in a particular catchment, depending on factors such as the flooding behaviour and patterns of development.

Figure 9.1 Floodplain Risk Management Measures *(Source: Floodplain Development Manual, 2005)*




The approach for identifying and modelling assessment of potential flood mitigation options is discussed in Section 10. Property modification and response modification measures are discussed in this report section.

## 9.2 Property modification measures

### 9.2.1 Voluntary purchase of high hazard properties

Voluntary purchase of high flood hazard properties may be considered in order to eliminate the potentially high risk of loss of life and damage to property from these areas by physically removing the dwellings at risk to hazardous flood conditions.

OEH has prepared Guidelines for Voluntary Purchase Schemes (OEH, 2013b). This describes the eligibility criteria for NSW Government funding for VP schemes, which include:

- no other feasible flood risk management options are available to address the risk to life at the property;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties are located either 1) within high hazard areas where there is a significant risk to life for occupants and those who may have to evacuate or rescue them, 2) within a floodway where the removal of the house may be part of a floodway clearance program aimed to reduce the significant impacts caused by the existing development on flood behaviour elsewhere in the floodplain, or 3) within the footprint of a proposed flood mitigation measure or where a flood mitigation measure may result in a significant increase in flood risk to a house that cannot be protected.

The current best practice on flood hazard categorisation (refer to Section 6.2.3) has progressed on from a simplified “low” and “high” rating referred to in the VP schemes guidelines, and defines flood hazard conditions with safety thresholds for people, vehicles and buildings. For the purposes of identifying properties potentially eligible for VP, an H5 (buildings require special engineering design and construction) or H6 (all buildings types considered vulnerable to failure) flood hazard rating is assumed to be required.

There are 9 properties (refer to flood hazard mapping in Appendix C) which are significantly impacted by a H4 flood hazard rating in the 1% AEP event, meaning flooding conditions are unsafe for people and vehicles. However, there are no properties impacted by a H5 or H6 flood hazard rating in the 1% AEP event where there is significant risk of damage or failure of buildings due to floodwaters. A voluntary purchase scheme is therefore not considered further.

### 9.2.2 Voluntary house raising

Voluntary house raising has long been a traditional response to flooding in New South Wales, as demonstrated by the number of raised houses in frequently flooded urban areas such as Lismore and Fairfield (Floodplain Development Manual, 2005). There are advantages associated with house raising which are noted as follows (Frost and Rice, 2003).

- A reduction of flood damages due to personal items being stored above the nominated flood level
- A reduction in danger to personal safety and a reduction in the cost of potentially needing to evacuate residents
- Potentially cost-effective alternative to voluntary purchase, with positive social outcomes (i.e. home owners who have strong sentimental value on their properties can remain in the same location).

Some of the disadvantages include:

- Residents’ concern over security and privacy due to an open, exposed ground floor
- Accessibility issues for the elderly or people with a disability
- Following raising, residents may develop a false sense of security from impacts. This can result in a belief that they will not be impacted by flooding or reluctance to evacuate when required.
- Over time and when flooding has not occurred, residents may be inclined to utilise the ground floor and converting it to a habitable area.

OEH has prepared *Guidelines for Voluntary House Raising Schemes* (OEH, 2013a). This describes the eligibility criteria for NSW Government funding of VHR schemes including:

- not located in floodways;
- limited to areas of low flood hazard;
- the suitability of individual houses for raising;
- residential properties and not commercial and industrial properties;
- buildings were approved and constructed prior to 1986;
- properties cannot be benefiting substantially from other floodplain mitigation measures;
- VHR should generally return a positive net benefit in damage reduction relative to its cost (benefit–cost ratio greater than 1).

Inclusion of a property in a voluntary house raising scheme places no obligation on the owner to sell the property or on the council or NSW Government to fund the purchase of the property. Owner participation in the scheme is voluntary and there are limitations on the availability of funding.

Whilst house raising can be considered for a range of building types, it is easiest and cheapest for timber-framed houses clad with non-masonry materials. A large proportion of houses in the study area which area flood-affected are of single or double brick construction which are considered costly and impractical for raising.

Due to the factors outline above, a voluntary house raising program is not considered feasible as a mitigation measure for dwellings within the study area.

### 9.2.3 Flood proofing and flood compatible design of individual buildings

Flood compatible design refers to the design and construction of buildings with appropriate water-resistant materials such that flood damage to the building itself (structural damage) and possibly its contents, is minimised should the building be inundated. *Reducing Vulnerability of Buildings to Flood Damage* (Hawkesbury-Nepean Floodplain Management Steering Committee, 2007) provides a comprehensive discussion of the various options for building design to minimise the impact of flooding. These include structural and architectural design and building materials, in addition to design considerations such as setting of electrical equipment above flood levels to reduce risk of their damage. A list of suitable flood-compatible building materials is provided in Appendix G.

Flood compatible design measures should be considered for inclusion in development controls. There is currently no provision in the DCP for such measures. Promotion of types of flood proofing measures should also be undertaken as a part of flood awareness and readiness improvement programs (refer Section 9.3.4).

Flood proofing of residential properties can also refer to implementing external measures such as walls or landscaping to redirect flows away from and around vulnerable parts of the house, such as doorways and other entry points. It is generally a measure that can be pursued by individual property owners in low hazard areas to prevent above floor inundation. Given the nature of development in the catchment, this option is not considered feasible due to potential diversion of flows to neighbouring properties and resultant impacts.

**Recommendation**

- Council should consider inclusion of requirements for flood compatible design in the development controls.
- Promotion of flood proofing measures should also be included in flood education and awareness programs.

#### 9.2.4 Planning and development controls

##### 9.2.4.1 General

Land use planning and development controls are an essential element in managing flood risk and the most effective way of ensuring future flood risk is managed appropriately. Planning controls including flood planning levels, flood related development control plans and restrictions on permissible types of development in different parts of the floodplain are recommended to ensure that development in the study area occurs in an appropriate manner in relation to flooding.

##### 9.2.4.2 Application of Current Planning Instruments

Bayside Council's existing LEP 2013 and DCP 2015, in addition to the Draft LEP 2020 and Draft DCP 2020, have a role in future planning for development within the study area and the entire Bayside LGA. Application of these planning instruments in conjunction with the outcomes of this study will help to guide development within the study area which is compatible with the flooding conditions.

**Recommendation**

For future planning of flood prone land, Council shall consider identification of prescriptive flood planning controls based on the type of the development and the flood hazard classification, or order to identify suitability of development and ability to intensify existing use can be assessed.

For future flood planning control (LEP and DCP), Council shall consider developments which are compatible to the flood hazard of the land. This is to ensure the land uses and essential services are appropriately sited and designed in recognition of potential floods.

##### 9.2.4.3 Amendments to LEP

Any amendment to the Environmental Planning Instrument applying to the land will need to consider an assessment against any flood planning controls contained in that instrument, the applicable Development Control Plan, relevant NSW flood planning policies, and the broader NSW statutory planning framework.

The applicable Environmental Planning Instrument and/or Development Control Plan include mapping of flood affected land, enabling linkage between Council's flood studies and flood planning controls.

**Recommendation**

LEP amendments shall be consistent with the requirements of the applicable Environmental Planning Instrument and Development Control Plan, to enable flood risks to be reduced and managed.

##### 9.2.4.4 Amendments to Section 10.7 Certificates

The Section 10.7 certificates currently provide information on flooding on the properties such as 1% AEP flood levels and flood planning levels as these are relevant to future redevelopment of the property and also promote awareness of flooding conditions on the property with the landowner. The certificates should continue to provide this level of information.

##### 9.2.4.5 Amendments to DCP

Bayside Council is currently reviewing the DCP (as of June 2020). Recommendations for inclusion/ amendment relating to management of flood risk are provided below.

**Recommendation**

A flood planning level of 1% AEP + 0.5m freeboard is recommended to be adopted, for consistency with DPIE model provisions for flood planning. This would also resolve the identified inconsistency in the specified minimum freeboard above 1% AEP flood level for finished floor levels between Section 8 and Section 11 of Botany Bay DCP 2013 Part 10 – Stormwater Management Guidelines, and provide a uniform 0.5m freeboard across the study area. Currently a 0.3m freeboard is applicable for areas affected by "overland flooding" as defined by Botany Bay DCP 2013. Amendment to a 0.5m freeboard for overland flood areas would also provide ongoing future protection from increased flood levels due to climate change in the upstream sections of the study area.

The inclusion of provisions specifying minimum floor levels for critical facilities should be considered. Typically the minimum floor level of such development is the PMF level or higher.

Consideration should be made for consolidating all flood planning controls under a specific section for Flood Liable Land or in a separate Flood Policy instrument.

Inclusion of a fence policy should be considered whereby fences should not be constructed in floodways. Where this is unavoidable fences are to be of open construction that will not restrict the flow of floodwater. This would be consistent with the current Rockdale DCP 2011, which applies in other parts of Bayside LGA.

Separate DCPs for overland flooding and mainstream flooding are not required for this study area, as the study area is primarily affected by overland flooding and with minimal or not impact from mainstream flooding.

#### 9.2.4.6 Rezoning

Review of the current land zoning in the study area and the existing potentially flood-sensitive properties indicates that there is some incompatibility between the existing sensitive land uses and the flood hazard in up to the PMF. However, it is recognised that rezoning of land may in effect sterilise the use of that land and hence is not a recommended option. Other measures which improve the flood risk at these properties, such as flood management plans and redevelopment to provide flood-free refuges, are preferred.

### 9.2.5 Redevelopment

Redevelopment could be considered for the Hippo's Friends Child Care Centre and Botany Bay Preschool properties to provide flood-safe spaces on the property which would as refuges during a flood event, if assessment of the property indicates the current buildings are not suitable for refuge. This may entail rebuilding on the site with appropriate structural design for flooding including a second floor above the PMF level (depths of 1.2m). This option would avoid the loss of each property as a valuable community service in the longer term, but would be disruptive to the operation of each centre during redevelopment. As the centres appear to be privately operated there is no obligation on the owner/operator to proceed with a redevelopment. It is assumed the operator would need to bear the cost which is a disincentive, but there may be additional funding options available. Any future redevelopment instigated by the owner would need to meet minimum floor levels for critical facilities according to Council's development controls and should not increase the development density from existing conditions, which has the potential to increase flood risk due to increased population exposed to flooding.

**Recommendation**

Council should advise the owners/operators of the Hippo's Friends Child Care Centre and Botany Bay Preschool regarding the flood risk to these properties. Council should advocate for provision of suitable flood refuge spaces on the properties if further assessment of the properties identifies no suitable spaces. The owner/operator should then consider redevelopment to provide flood refuge spaces. Flood refuge space shall be above PMF flood level.

## 9.3 Response modification measures

### 9.3.1 Flood warning systems

The study area includes local catchments and overland flow paths where flash flooding may occur. Flash flood catchments are those defined as catchments in which less than six hours may elapse between heavy rainfall and flooding. Flash flooding usually results from relatively short intense bursts of rainfall, commonly from thunderstorms. This is problematic in urban areas where drainage systems may not cope. Flash floods tend to be quite local and it is difficult to provide effective warning because of their rapid onset. The reasons for this have been outlined identified for flash flood catchments as follows (McKay, 2004, 2008):

- Flash floods are less predictable than larger scale flooding. Rainfall over small catchments is usually not well predicted by numerical weather prediction models
- For flash floods, there is insufficient time to develop reliable flood warnings and for effective the dissemination and response to the flood warnings. More rapid user response is required, which necessitates specialised communication systems and a high level of public flood awareness
- A reliance on rainfall triggers increases the frequency of false alarms
- The use of main river level triggers does not allow sufficient time for response.

As discussed in Section 8.2, it is not possible for BOM to issue specific predictions for flash flood catchments. More importance is placed on the role of the SES and other agencies to interpret the regional warnings which are provided by BOM to warn the community of the potential road closures and damage as a result of predicted storms and flash floods.

Given the issues and challenges discussed above, the development of a flash flood warning system for the study area is not recommended.

### 9.3.2 Flood depth signage on roads

A number of road crossings are affected by significant flooding. Flood depth signage is recommended for key locations primarily to warn drivers of the flood hazard during a flood event and reduce occurrences of people driving into floodwaters. Flood depth signage may also act as a passive reminder to residents of the potential for flooding in their neighbourhood streets.

Figure 9.2 shows proposed locations for road flood depth signage, selected based on flood hazard rating of H3 and higher in the 1% AEP flood event at road low points. The signage is proposed at the road low points in addition to at the edges or before main ponding areas to give motorists advanced warning of road flooding ahead. This includes on Foreshore Road at the intersection with Hale Street, where there is no chance to perform a U-turn out of Hale Street once a motorist has performed a turn into Hale Street.

Flood depth signage may consist of:

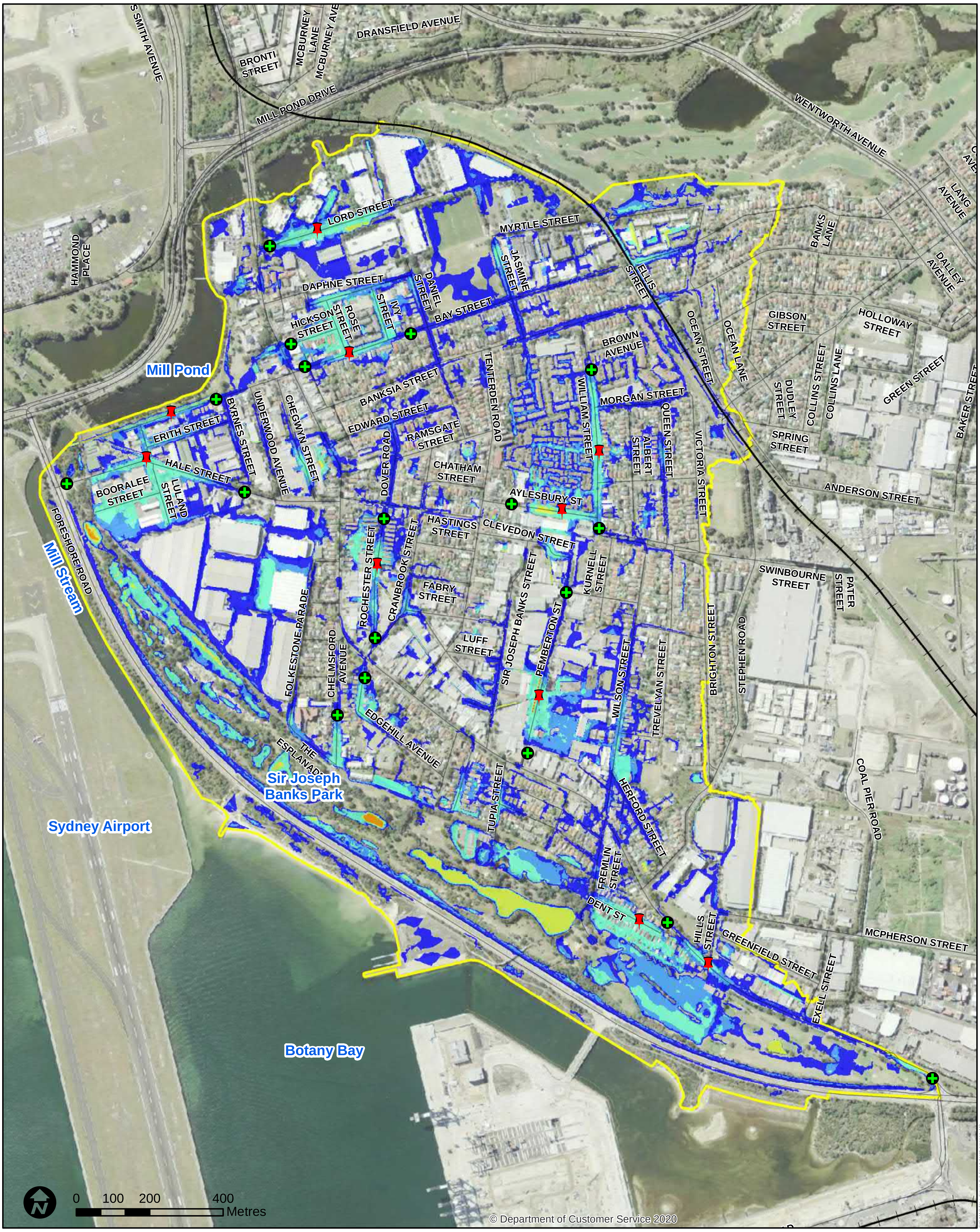
- Static depth signs which are partially “buried” to reflect the maximum depth at the sag point. This would be the typical treatment, or
- Flashing light signs at key locations such as on Foreshore Drive entry to Hale Street. Alternatively, the signage could be integrated with the traffic lights at this intersection. For example, a green turning arrow is not to be provided when the road is flooded. Flashing light signs would rely on telemetered depth gauges to be installed.

Flashing light signage around Hale Street roundabout are also proposed and would also function to warn motorists of tidal inundation on the road during king tide events.

For the purposes of the FRMSP, static depth and warning signs have been assumed for implementation. A total of 10 depth indicators at road ponding sag points, and an additional 22 signs at the approaches to the sag points are recommended as shown on Figure 9.2.

**Recommendation**

It is recommended that flood depth signage be installed at and at the approaches to key road sag points as a warning of the flood hazard during a flood event and reduce occurrences of people driving into floodwaters, in addition as a passive reminder of flooding risk.




## Legend

| | |
|---|---|
| Roads | Flood Hazard (1% AEP) |
| Rail | H1 - No restrictions |
| Study area | H2 - Unsafe for small vehicles |
| **Flood Warning Signage** | H3 - Unsafe for vehicles, children and the elderly |
| Depth sign | H4 - Unsafe for people and vehicles |
| Warning sign | H5 - Unsafe for people or vehicles. Buildings require special engineering design and construction |
| | H6 - Not suitable for people, vehicles or buildings |

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Data Sources: Bayside Council

LIMITATIONS: This mapping is based on data provided by the Bayside Council. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

| | | | |
|---|---|---|---|
| SCALE | 1:10,000 | | A3 |
| SHEET | 1 of 1 | | GDA 1994 MGA Zone 56 |
| TITLE | Locations for Flood Warning Signage | | |
| PROJECT | Botany Bay Foreshore Beach FRMS | | |
| CLIENT | Bayside Council | | |
| DRAWN PK | PROJECT # IA190100 | MAP # Figure 9.2 | REV 2 VER 1 |
| CHECK AH | DATE 25/06/2020 | | |

#### 9.3.3 Update of Emergency Planning and Management

As discussed in Section 8.1 flood emergency planning is currently addressed in the Bayside Local Emergency Management Plan (EMPLAN), and a new Bayside Local Flood Plan will be developed as a part of the EMPLAN review cycle, due in 2021. Findings from this study including key flooding areas, roads which become cut-off by flooding and the emergency response classification mapping should be incorporated into the new Bayside Local Flood Plan.

**Recommendation**

It is recommended that Bayside Local Flood Plan be prepared incorporating the findings of this study.

#### 9.3.4 Flood education, awareness and readiness

Flood education and awareness should be promoted throughout the study area. Measures may include information brochures in English and multi-lingual including promotion of NSW SES FloodSafe brochures and website (http://www.floodsafe.com.au/). Additionally, Council or SES may run educational workshops or distribute information sheets to help people plan and prepare for a flood.

The flood education and awareness program should encourage residents to be familiar with the flooding conditions at and in the vicinity of their property to help them plan and prepare for a flood. Section 10.7 certificates issued by Council could also be used to inform property owners about flood risk to their properties, where there are flood studies completed within Bayside LGA.

Additionally, Council’s floodplain management web page and social media could be further developed to enhance the messaging on flood risk and flood preparation. This may include flood mapping on an interactive mapping portal on the website itself rather than links to the flood study reports and mapping, where it can be difficult for community members to navigate through often lengthy technical reports. Information on, or links to external websites (SES, floodsafe, etc), should be included for advice for residents on how to prepare for flooding.

Some Councils provide a list of road closed to flooding during flood events (and roads recently opened as the flooding recedes) on their website and social media. This warns road users and encourages them to find alternative routes and reduce the number of drivers encountering flooded roads and potentially driving into floodwaters. However, due to the generally short duration of flash flooding there may be limited applicability of this measure in the study area given the time required for Council staff to confirm flooding conditions and roads cut and the time required for the online messages to be initially posted and then updated.

A flood education and awareness program should be developed by Council which outlines and schedules various flood education methods to be implemented (e.g. brochures, news articles highlighting previous flooding, SES events, Council web pages etc.). The program should be reviewed on a regular (e.g. 2 year) cycle to assess the effectiveness of the program, reinvigorate flood awareness in the community and plan the roll-out of new flood information as it becomes available.

**Recommendation**

It is recommended that Council develops a flood education program to promote flood awareness and readiness in the community. Measures may include:

- Promotion of FloodSafe brochures to help residents understand the flood risk and prepare their property and personal plans for a flooding event.
- Flood depth signage

- Section 10.7 certificates continue to inform property owners about flood risk to their properties
- Provide flood mapping on an interactive mapping portal on Council's website for easier viewing
- Promotion and support for SES information events
- Enhanced messaging on flood risk and flood preparedness on Council's floodplain management webpage.

The program should be reviewed on a regular (e.g. 2 yearly) basis.

#### 9.3.5 Site-Specific Flood Management Plans

Most of the property occupied by Heritage Botany Aged Care Facility is not flooded or flooded up to H2 low hazard in the PMF event. The lower south-eastern corner including five villas are affected by H3 flood hazard and depths to 0.8m in the PMF. One villa is affected by H3 moderate hazard in the 1% AEP event.

Development of a flood management plan for the facility should be considered to manage the flood risk to residents. Relocation of vulnerable residents from the five affected villas from the H3 flood hazard area (PMF event) could be considered and these villas repurposed to lower risk uses. Otherwise, the flood management plan should consider and address monitoring of rainfall and flooding conditions, document appropriate procedures for flood response including movement of elderly residents out from flooded areas, etc.

Plans should also be developed for the Hippo's Friends Child Care Centre and Botany Bay Preschool, which experience high hazard flooding in the 1% AEP event and greater. The plans would address the flood risk on the existing sites and provide procedures on monitoring of weather and resulting flooding conditions, and evacuation of children to flood-safe spaces on the property, such as second floor of existing buildings if adequate. Assessment of the suitability of the buildings as flood refuges should be undertaken by SES.

**Recommendation**

Council should advise the Heritage Botany Aged Care Facility regarding management of flood risk on the site. Development of a flood management plan for the site should be considered.

Similar plans should be considered for Hippo's Friends Child Care Centre and Botany Bay Preschool. The plans should contain procedures for evacuation of children to flood-safe spaces within the property if possible.

Preparation of the flood management plans would be the responsibility of the owner/operator of each facility, with support from SES and Council as required.

#### 9.3.6 Improved flood evacuation response and procedures

Flood evacuation is under the control of the SES and the SES needs to update the current evacuation planning based on information presented in this report, in particular the emergency response mapping shown in Appendix C which indicates vulnerable properties and road cut-off locations in the 1% AEP and PMF events.

**Recommendation**

It is recommended that the SES updates the current emergency planning, such as development of a Local Flood Plan or update of the EMPLAN, based on information presented in this FRMSP and from supporting flood studies.