ARUP

## Cook Cove Inlet Pty Ltd

# Cooks Cove Planning Proposal

## Flood Risk and Impact Assessment

Final | 6 March 2024



Job number 252942

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# Contents

## Tables

## Figures

## Appendices

# Executive Summary

This report presents a comprehensive and contemporary Flood Impact and Risk Assessment for the Cooks Cove Planning Proposal carried out using Department of Planning and Environment (DPE) guidance, including the *Flood Risk Management Manual: The policy and manual for the management of flood liable land* and the *Flood Impact and Risk Assessment: Flood Risk Management Guide (LU01)*, both prepared by DPE and in force 30 June 2023.

Cooks Cove Planning Proposal seeks to amend Bayside Local Environmental Plan 2021 (BLEP 2021) to rezone and insert planning controls for certain land known as Cooks Cove. The Planning Proposal aims to facilitate the transformation of 36.2 ha of under-utilised and strategically important land at Arncliffe, located to the north of the M5 Motorway and adjacent the western foreshore of the Cooks River.

The project was issued a Gateway Determination by DPE on 5 August 2022 and was placed on public exhibition between 24 April 2023 to 6 June 2023.

In response to the public exhibition, a FIRA was prepared, incorporating full technical responses to all submissions made with respect to flooding. Additional submissions on the FIRA were made by BSC, EHG, SES and TfNSW. Responses to these submissions are presented in Chapter 8. As well, a workshop was held in November 2023 with stakeholders to discuss concerns. The presentations of that workshop and outcomes are also provided in this report (Chapter 9 and Appendix C). In response, a supplementary flooding response to submissions report was provided to DPE on 12 December 2023 which addressed the additional submissions. This was coordinated with a planning-based flooding response prepared by Ethos Urban dated 8 December 2023.

The site is located on a floodplain and adjacent to a river which has been substantially modified in the 1950's to accommodate the airport. This has resulted in a floodplain that does not exhibit natural floodplain behaviour. Based on the absence of flood records and recollections of long-term golf course members, there has not been any flood events in the last 57 years that have resulted in floodwaters passing over Marsh Street into the site.

The site is already zoned for urban purposes and the Cooks Cove Planning Proposal is essentially seeking a revision of controls applying to size and extent of the developable area to achieve a viable redevelopment. Revised controls which are sought by the Planning Proposal will better manage flood risks when compared to the present land use planning provisions for the site.

There are no active floodways identified on the site during a 1% AEP flood event. In rarer flood events, a floodway is evident from Marsh Street to the south-eastern corner of the site.

The key flood risks and their proposed management as part of the Cooks Cove Planning Proposal are listed below.

**Table E1: Management of Residual Flood Risks**

| Flood Risk to be Managed | Management Measures |
|---|---|
| Flood risks to occupants | These risks are minimised due to all developed parts of the site being filled to above the 0.05% (1:2000) AEP flood levels. All floor levels would be above the Probable Maximum Flood. These floor levels would also be 0.6m above the 1% AEP flood levels accounting for a 20% increase in flows and 0.9m sea level rise due to climate change. |
| Flood risks to external property | The Cooks Cove Planning Proposal would not result in adverse flood impacts external to the site. The TfNSW M6/M8 MOC site would not be impacted in a PMF and, hence, the design immunity of the tunnels would remain unchanged. This is made possible through proposed earthworks to enhance flood hazard management, and which offset local flooding impacts through the establishment of the MOC. |

| Flood Risk to be Managed | Management Measures |
|---|---|
| Flood risks to occupants during flood events | Safe access into and from the site would be possible in all floods up to a 0.2% (1:500) AEP flood event. A Shelter-in-Place strategy is proposed for rarer events. However, the site will include significant areas of retail including food outlets, supermarkets supported by emergency power generation infrastructure. Hence, it will be a safe place for isolation for short periods of time for events such as the 1:2000 AEP. |
| Flood risks to occupants requiring evacuation during flood events | The Planning Proposal has been amended since public exhibition in response to concerns relating to flood evacuations. These changes include raising the design of Flora St South to above the 0.2% (1:500) AEP flood levels and including culverts to accommodate the 0.2% (1:500) AEP flows so that there would not be any inundation of Flora Street South up to the 0.2% (1:500) AEP and there would only be H1 hazard (small car accessible) in 0.05% (1:2000) AEP flood. In all floods up to and including the 0.2% (1:500) AEP flood event, the Flood Emergency Classification would be Rising Road Access.<br><br>The key location limiting evacuation in floods rarer than the 0.2% (1:500) AEP is the low point at the intersection of Marsh Street and Flora St South. Here, there would be a short length of road (in the order of 5m) in a 0.05% (1:2000) AEP flood during which H2 hazard (4WD/large car accessible) would be exceeded for 4.5 hours.<br><br>Based on the probabilities of floods occurring in a typical century, the average cumulative time that flood hazards would not permit access to the site would be in the order of 35 minutes.<br><br>Accounting for climate change (i.e. 20% increase in flows and 0.9m sea level rise), this duration would increase to 5.7 hours. Hence, even under these climate change conditions (for 2090), this isolation time would still less than the 6 hours understood to be a benchmark for NSW SES through post exhibition further consultation.<br><br>Hence, it is concluded that the Planning Proposal created no additional burden to emergency management services (recognising that a building with a High Flood Island classification in floods as frequent as a 5% AEP flood would be removed as part of the Planning Proposal). |
| Changing flood risks due to climate change | Floor levels would be 0.6m above the 1% AEP flood levels accounting for a 20% increase in flows and 0.9m sea level rise due to climate change (2090 case). The duration of isolation in 2090 conditions would also be less than six hours. |

# 1. Introduction

## 1.1 Background

Cooks Cove Planning Proposal (PP-2022-1748) was issued a Gateway Determination by the Department of Planning and Environment on 5 August 2022. The proposal seeks to amend Bayside Local Environmental Plan 2021 (BLEP 2021) to rezone and insert planning controls for certain land known as Cooks Cove within the BLEP 2021.

The Cooks Cove Planning Proposal aims to facilitate the long-planned transformation of 36.2 ha of underutilised and strategically important land at Arncliffe, located to the north of the M5 Motorway and adjacent the western foreshore of the Cooks River.

The project seeks a renewed focus on delivering a contemporary logistics and warehousing precinct within a well-connected location, surrounded by enhanced open space provisions. The site forms part of the broader Bayside West 2036 Precincts and generally comprises the footprint of the former Kogarah Golf Club, now in part occupied by a temporary M6 Stage 1 construction compound.

The project was issued a Gateway Determination by DPE on 5 August 2022 and was placed on public exhibition between 24 April 2023 to 6 June 2023.

In response to the public exhibition, a FIRA was prepared, incorporating full technical responses to all submissions made with respect to flooding. Additional submissions on the FIRA were made by BSC, EHG, SES, TfNSW. Responses to these submissions are presented in Chapter 8. As well, a workshop was held in November 2023 with stakeholders to discuss concerns. The presentations of that workshop and outcomes are also provided in this report (Chapter 9 and Appendix C). In response, a supplementary flooding response to submissions report was provided to DPE on 12 December 2023 which addressed the additional submissions. This was coordinated with a planning-based flooding response prepared by Ethos Urban dated 8 December 2023.

## 1.2 Project Context

### 1.2.1 Cooks Cove Master Plan 2022

The Cooks Cove Master Plan 2022, as prepared by Hassell, represents an optimised and refined reference scheme, to guide best practice design and the preparation of detailed planning controls to achieve an attractive precinct with high amenity. This FIRA includes an extract of the September 2023 amendment to the indicative reference scheme as provided at Figure 1,

Key features of the Cooks Cove Master Plan are listed below and shown in Figure 1.

- A net development zone of approximately 15 ha with up to 343,250 $m^2$ Gross Floor Area (GFA) comprising:
    - 290,000 $m^2$ of multi-level logistics and warehousing
    - 20,000 $m^2$ for hotel and visitor accommodation uses
    - 22,350 $m^2$ for commercial office uses
    - 10,900 $m^2$ of retail uses.
- Multi-level logistics with building heights generally up to 5 storeys (approx. 48 m).
- A retail podium with commercial office and hotel above, up to a total of 12 storeys (approx. 51 m).
- Built form of a scale and composition which caters for the generation of approximately 3,300 new jobs.
- A surrounding open space precinct including:

- A highly activated waterfront including the Fig Tree Grove outdoor dining and urban park precinct
- An extension to the Bay to Bay Regional cycle link, ‘Foreshore Walk’, including active and passive recreational uses, together with environmental enhancements
- Master planned and Council-owned ‘Pemulwuy Park’ – with an agreed embellishment outcome of passive open space and environmental enhancements to be delivered in stages post construction of the M6 Stage 1 Motorway.
- Complementary on and off-site infrastructure to be delivered by way of State and Local Voluntary Planning Agreements.


**Figure 1: Proposed Cooks Cove Master Plan 2022 – Source: Hassell**

### 1.2.2 Proposed Planning Controls

The Planning Proposal Justification Report, as prepared by Ethos Urban, details the intention to insert new planning provisions covering the Cooks Cove development zone and adjoining lands, through the amendment of the BLEP 2021, accordingly removing this same area from State Environmental Planning Policy (Precincts—Eastern Harbour City) 2021 (formerly Sydney Regional Environmental Plan No. 33 – Cooks Cove).

Specifically, the Planning Proposal, as updated in September 2023, will include the elements below which also includes minor amendments made as a result of the submissions received:

- Seek new land use zones within the development zone, including a primary SP4 Enterprise zone across the majority of the Kogarah Golf Course freehold land, RE2 Private Recreation zoned foreshore (in part), a C2 Environmental Conservation zone for sensitive biodiversity areas and the foreshore (in part), RE1 Public Recreation passive open space zones and other elements of SP2 Infrastructure (see Figure 2).
- Impose an overall maximum building height of RL51m with appropriate transitions to respond to aviation controls within limited sections of the site and a maximum height of 24m to the north of Marsh Street, to respond to neighbouring developments.
- Limit gross floor area (GFA) to the south of Marsh Street to 340,000 $m^2$, with a further 1.25:1 Floor Space Ratio (circa 3,250 $m^2$ of GFA) to the north of Marsh Street, to achieve the overall intended logistics, commercial, retail and short-term accommodation land uses.
- Other additional permitted uses and site-specific planning provisions.
- Reclassification of Lot 14 DP213314 and Lot 1 DP108492 (Council owned and the subject of Charitable Trusts), initially from ‘community’ to ‘operational’ to ensure appropriate access, improve utility of public open space and to create a contiguous boundary. Following rezoning and subdivision it is subsequently intended that Council reclassify residue RE1 parcels as ‘community’ by resolution.

The proposal is in response to Bayside West Precincts 2036 – Arncliffe, Banksia and Cooks Cove (released August 2018) and the subsequent Ministerial Directions under s9.1 of the EP&A Act, being Local Planning Directions 1.11 Implementation of Bayside West Precincts 2036 Plan and 1.12 Implementation of Planning Principles for the Cooks Cove Precinct.

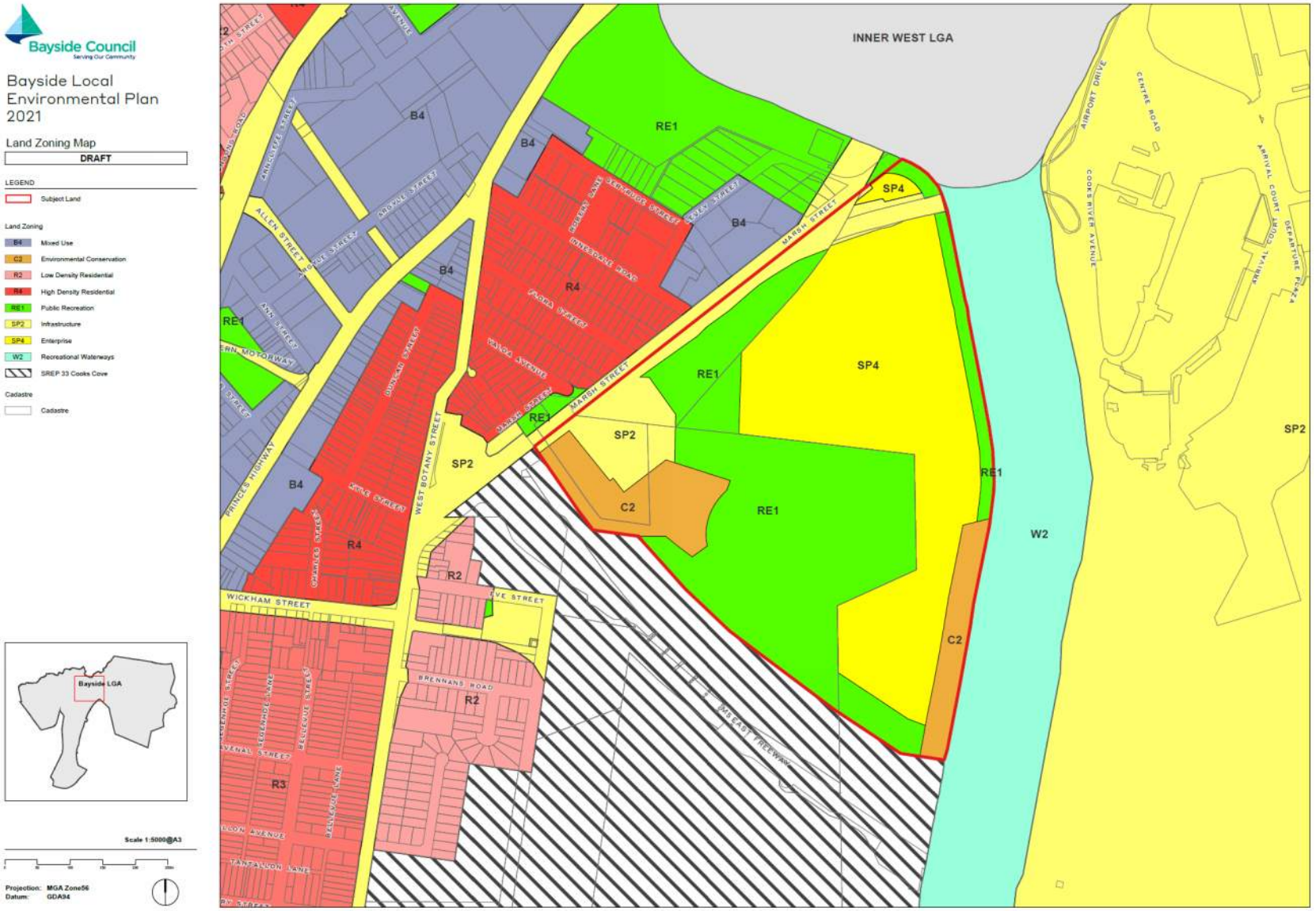



**Figure 2: Proposed Draft Bayside LEP 2021 Zoning Map (September 2023 Update) – Source: Ethos Urban**

## 1.3 FIRA Requirements

This report has been prepared, on behalf of Cook Cove Inlet Pty Ltd, to respond to a request by DPE for a Flood Impact and Risk Assessment consistent with DPE guidance documents (Flood Impact and Risk Assessment: Flood Risk Management Guide LU01, DPE, 2022).

This report follows the chapter headings suggested in table 5 of Appendix A of the Flood Risk Management Guide LU01.

## 1.4 Response to Agency Comments During Public Exhibition

As well, this report aims to address comments raised by SES, DPE (EHG), TfNSW and Bayside Council as a result of the public exhibition process.

**Table 1: List of Comments from Public Exhibition Process and Link to Report Section**

| Agency | Summary of Comment | Location in Report for Response |
|---|---|---|
| DPE (EHG) | Model needs to consider recent guidance from NSW Government and Australian Rainfall and Runoff Guidelines | This FIRA is in response to this comment.<br>All recent NSW guidance has been used in developing this document.<br>Flows are based on ARR 1987 which results in similar but slightly more conservative flows that ARR 2019 (see Section 5.1.4). |
| | Modelling needs to consider impacts of a co-incident overland flow events as well as coastal inundation to consider full risks to the site | The modelling in this FIRA is based on DPE guidance on coincident coastal water levels (see Section 5.1.5) |
| | EHG requires the results from the complete suite of modelling undertaken to assess pre and post development conditions as well as both rainfall and sea level rise impacts, with the 0.5% AEP and 0.2% AEP flood events used as proxies for evaluating sensitivity of the catchment to an increase in rainfall intensity of flood producing rainfall events | This FIRA includes this full suite of AEP's. The 0.2% AEP and 0.5% AEP floods have been assessed. As well, assessments of the five (5) flood events with the effects of climate change (increased rainfall and sea level rise) have been included. |
| | A development of this nature is not compatible with the flood risk and the existing high hazard flood behaviour of the site | The hazard on the site following filling will be low hazard in all floods up to the PMF. |
| | The proponent has not provided EHG with sufficient details relating the flood hazard maps, hydraulic categorisation and duration of inundation/ isolation of the proposed lots as well as the access routes for the full range of flooding events up to the PMF | This FIRA includes flood hazard maps, hydraulic categorisation and duration of inundation/ isolation for the full suite of AEP's. |
| | EHG does not support Private Flood warning systems or Shelter in Place arrangements for new developments. EHG emphasises that any merit-based shelter in place strategies are a matter for the NSW SES as the responsible flood combat agency. This strategy should be referred to the NSW SES for comment | See Shelter-in-Place items for SES below. |
| | The development is incompatible with the flood risk of the site and based on the information provided in this package of works, it is EHG's position that the planning proposal does not satisfy the requirements of the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual | This FIRA provides more detail on the compatibility of the Planning Proposal to the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual (see Chapter 4). |

| | | |
|---|---|---|
| SES | The site is subject to frequent isolation (in 5% AEP flood events) due to flash flooding and is located on a shrinking high flood island. Therefore any future visitors to the site are at risk of driving into floodwater and of secondary emergencies and associated risks with being isolated | The project design has been changed to address this point. Flora Street South has been raised by 0.37m and a large culvert (30m wide) to be constructed under Flora Street South to accommodate the 1:500 AEP flows.<br>There will not be any inundation of the developed parts of the site in all floods up to the 1:2000 AEP flood.<br>Access to and from the developed parts of the site will be possible in all floods up to the 1:500 AEP flood and there would be only a short period of time in rarer floods when the hazard is higher than H1. |
| | To manage the existing flood risk at the site, the planning proposal includes a fill strategy. This is only likely to manage the risk to property adequately, and visitors at the site are still susceptible to the above risks of isolation…This is particularly important, as they are to the north-east of the site, encompassing Gertrude Street Wolli Creek, has historically flooding, for example in March 2022. | The risk of isolation has been addressed by changing the design of the Planning Proposal with significantly improved access at Flora Street South onto Marsh Street.<br>Section 6.10 includes an assessment of the Flood Emergency Classifications that indicates the developed site will be Rising Road access for floods up to and including the 1:500 AEP. |
| | Risk assessment should consider the full range of flooding, including events up to the Probable Maximum Flood (PMF) and not focus only on the 1% AEP flood. The duration of flooding, up to the PMF should also be assessed as the current reference to 2 hour flood durations refer only to the 1% AEP event. This should consider various critical storm durations | This FIRA provides more detail on this matter – see Section 7.4.4. |
| | The site is subject to frequent isolation (in 5% AEP flood events) and located on a shrinking high flood island. As the site is subject to flash flooding, this means evacuation routes would be cut at short notice, limiting the ability for safe evacuation. Ideally the access/egress routes should provide rising road access and/or be passable up to at least a 1 in 500 year local flooding. This standard has been adopted across the Hawkesbury Nepean Valley | Section 6.10 includes an assessment of the Flood Emergency Classifications that indicates the developed site will be Rising Road access for floods up to the 1:500 AEP.<br>The access/egress route provides rising road access and is passable in all floods up to and including the 1:500 AEP flood. |
| | 'Shelter in place' strategy is not an endorsed flood management strategy by the NSW SES for future development, as proposed in the Planning Proposal (s5.2.5). | The Planning Proposal meets all of the requirements of the draft Shelter-in-place Guideline (2023). |
| TfNSW | Impacts for design of M6 UDLP in terms of sports fields, frog pond and park areas | It is likely that TfNSW open space design will change significantly due to discussions with Bayside Council.<br>There is a technical solution which is committed to being implemented by the proponent. However, it is adaptable to the outcome that is likely to be reached between Bayside Council and TfNSW. |
| | Flood paths may necessitate design changes for Pemulway Park | The proposal presented in this FIRA report does include changes to the shape of Pemulway Park. These can be refined at subsequent stages of design. However, it is noted that the TfNSW spoil area on the lease on Lot 1 (which TfNSW plans to |

| | | |
|---|---|---|
| | | convert to Pemulway Park) extends to the western edge of Lot 100.<br>Hence, the flood flows on Lot 1 are diverted completely onto Lot 100 (as designed) leaving no room for the floodplain flows to pass out to the river without flowing completely through Lot 100. This outcome and design are inconsistent with the approval condition B23(h) for the M8 in which TfNSW was required to develop a flood strategy which *"must include but not be limited to…reconsideration of the proposed flood storage along Marsh Street with the intent of incorporating the flood storage requirements of the SSI into the proposed flood storage for the Cooks Cove development".*<br>This issue is fully explored in the flood options assessment documented in Flooding, Stormwater and WSUD Report for the Cooks Cove Planning Proposal (Arup, March 2023). |
| | Design Changes at no cost to TfNSW | Noted and agreed |
| | Model requirements: Bonnie Doon vs. Cooks River and flood events | Mis-understanding by TfNSW that Bonnie Doon local model is used for local runoff and not Cooks River flooding. |
| Bayside Council | PP does not meet 4.3 Flood Prone Land Ministerial Direction | This FIRA includes a table demonstrating compliance to the elements of the Flood Prone Land Ministerial Direction. |
| | Flood path over significant areas of Council land – land will be shaped and maintained as an overland flow path and will limit public access | Frequency of floodwaters in open space parts of Planning Proposal will be low (less than five times a century). The uses of the land will not be compromised by these flows which are not fast nor frequent. The frequency and depth will be similar to that of the current golf course which has successfully operated as active open space for over 60 years on the same site without any hindrance from Cooks River flooding. |
| | Overland flow should be directed between blocks 3B and 3C | This option does not work as the river levels are higher in the river where this proposed outlet is suggested. |
| | Flood report to be updated to reflect DCP now in force | This FIRA includes reference to the current 2022 Bayside DCP (adopted in March 2023) |
| | Flood mapping to be obtained from Arup Flood Model | Section 4.4 now includes reference to the Arup flood modelling for the assessment of hazard on the site. |
| | Assessment of tidal flooding should be included as well as a Sea Level Rise Vulnerability Assessment | Tidal flooding has been assessed in this FIRA and it is not the dominant flood mechanism.<br>A Sea Level Rise Vulnerability Assessment is only possible once detail associated with the drainage from the site has been defined during subsequent stages of approvals. |

## 1.5 Response to Agency Comments Following Public Exhibition

This report also includes responses to the comments raised by SES, DPE (EHG), TfNSW and Bayside Council following the submission of this Flood Impact and Risk Assessment in September 2023.

These comments were provided in November 2023 and further comments were provided by BSC in January 2024. The comments and responses are provided in Sections 8 and 9.

# 2. Background

## 2.1 Study Area

### 2.1.1 Cooks River catchment

The Cooks River catchment has an area of approximately 102 km$^2$. A full description of the catchment including maps can be found in the Cooks River Flood Study (MWH-PB, 2009). The following description is taken from that report with the catchment figure reproduced below in Figure 3:

> *"The catchment has been extensively developed, with many reaches severely altered by developments, and the channel constrained or diverted from its original alignment……*
>
> *The Cooks River has two major tributaries: Alexandra Canal and Wolli Creek. Bardwell Creek forms a tributary of Wolli Creek. Smaller tributaries of the Cooks River include Muddy Creek, Cup and Saucer Creek and Coxs Creek. There are also several unnamed stormwater channels that discharge into the Cooks River…….*
>
> *Much of the main channel of the Cooks River is concrete lined, as is Alexandra Canal and many of the Cooks River's tributaries. Wolli Creek and Bardwell Creek are largely natural waterways."*

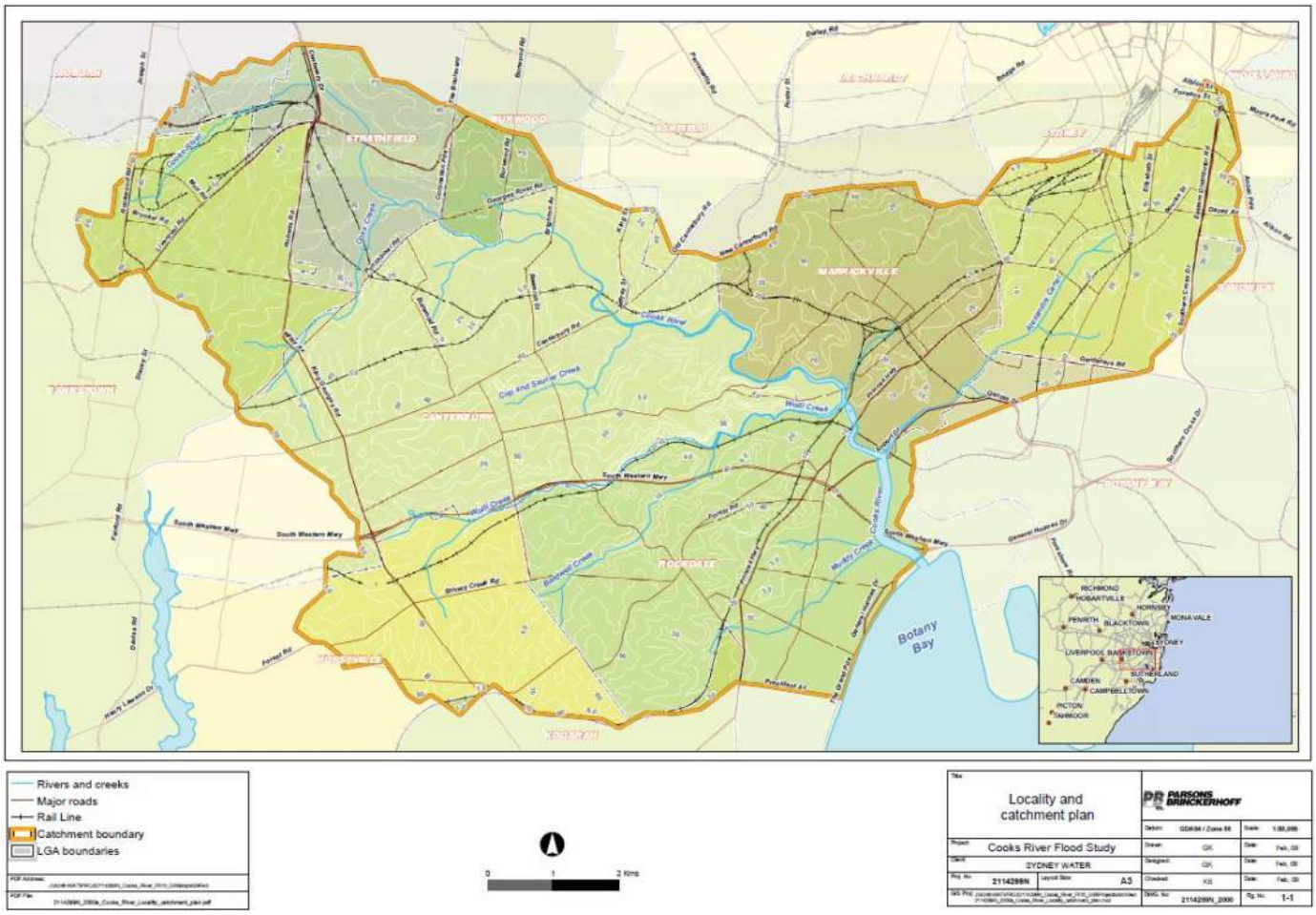



**Figure 3: Cooks River catchment (taken from MWH-PB, 2009)**

### 2.1.2 Cooks Cove

Cooks Cove is located in the suburb of Arncliffe within the Bayside Council Local Government Area (LGA). The site is located to the west of the Cooks River, approximately 10km south of the Sydney Central Business District (CBD). The site enjoys adjacency to key trade-related infrastructure being immediately west of Sydney Kingsford Smith International Airport and approximately 6km west of Port Botany.

Cooks Cove is strategically located within close proximity to a number of railway stations including Banksia, Arncliffe, Wolli Creek and the International Airport Terminal, which vary in distance from the site between 700m and 1.1km. The M5 Motorway, providing regional connectivity to the Sydney Metropolitan area, runs in an east-west direction immediately to the south of the site. The M8 and M6 Motorways are, and will be, constructed in tunnels approximately 60 metres beneath the adjoining Bayside Council 'Trust' lands. The Sydney Gateway project, presently under construction to the immediate north of Cooks Cove and Sydney Airport, will substantially improve future accessibility to the St Peters interchange and the wider M4/M5 WestConnex network, via toll free connections, as well as the Domestic Airport and Port Botany.

The Cooks Cove Development Zone is located to the north of the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS) and is generally bound by the Cooks River to the east and Marsh Street to the north and west. The site is approximately 36.2ha and is owned and managed by a number of landowners, both public and private. Surrounding development includes the Sydney Airport International Terminal precinct, Mercure Sydney Airport, an area of low-density dwellings presently transitioning to medium-high density residential flat buildings, recreation and open space facilities and road and airport related infrastructure.

### 2.1.3 Kogarah Golf Club

Kogarah Golf Club was established in 1928, with the Club occupying the land subject to the Planning Proposal boundary since 1955. At this time, the Cooks River was reconfigured to its current alignment to accommodate the expansion of Sydney Airport. The land presents a highly modified environment, with relatively flat topography, gently moulded fairways and greens, separated by strips of vegetation and man-made water bodies.

The golf course clubhouse, car park and maintenance facilities are located in the northern corner of the site, adjacent the Cooks River. Access is provided via Levey Street. The members of Kogarah Golf Club will relocate from the site in May 2024 to new playing facilities.

### 2.1.4 Arncliffe Motorway Operations Complex

The temporary construction compound for the WestConnex M8 and M6 Stage 1 Motorway tunnelling works was originally established in June 2016. The temporary construction facility occupies approximately 7.5 ha and is expected to remain until 2025.

It should be noted that the WestConnex M8 and M6 Stage 1 Motorway temporary construction facility includes a 2.5m high noise wall that runs the length of Marsh Street. This noise wall forms a barrier that blocks nearly all floodplain flow on the western bank of the Cooks River. This barrier has been in place since approximately 2016 and is likely to be in place until 2025 (so a total of 9 approximately years).

In 2025, the facility will reduce to 1.5 ha to accommodate the permanent Arncliffe Motorway Operations Complex, located in the western corner of the site, adjacent Marsh Street. The complex will house ventilation and water treatment plant and maintenance equipment for both the M6 and M8 sub-grade motorways.

### 2.1.5 Easements and Affectations

The Sydney Desalination Plant pipeline runs through the development zone, north-south adjacent the Cooks River. The pipe has a diameter of 1.8 m and sits within an easement of 6 m to 9 m in width. From south to north the pipeline is constructed in a combination of trench and above ground with mounded cover and then transitions to micro-tunnel and typical depth of circa 11 m.

The Moomba to Sydney Pipeline, containing ethane gas, follows a similar general alignment north-south adjacent the Cooks River. The pipe has a nominal 225 mm diameter, within an easement generally 5m wide and with the pipe located at a depth of 1.2 m to 2.3 m.

## 2.2 Known flood behaviour

### 2.2.1 History of floodplain and river alterations of the Cooks River

The Cooks River and its floodplain have been highly modified over the last 100 years. In the vicinity of the site, the river has been completely re-routed and shortened to accommodate the construction of Sydney Airport in the late 1940's and 1950's.

The earliest aerial image available is presented in Figure 4 below. This image and others further in this section have been taken from the Cooks River Floodplain Risk Management Study and Plan (WMAWater-PB, 2017) which also stated that "the *river channel itself has been highly modified and virtually the entire length of the river has been lined with extensive straightening and realignment*".


**Figure 4: Cooks River 1948 Aerial showing site and original and longer Cooks River route**

It is clear from this image that the site is located on a part of the river that has seen substantial change over the last 60 years.

Figure 5 to Figure 7 present a series of images from this period which show the changes to the river and floodplain. The length of river between the site and the river mouth has shortened from 5.1 km to 2.2 km. As well, it is likely that the capacity of the river channel has significantly increased with these works.

Hence, this floodplain is highly modified, and this is consistent with the modelling outcomes in which the 5% AEP flood (occurring with peak flows coincident with a high tide) does not overtop Marsh Street and enter the site.

The floodplain near the site is only inundated in the 5% AEP flood and then only when assumed that the flood peaks with a very high tide. The anecdotal evidence is that the site has not flooded from the Cooks River in the last 57 years. This behaviour is somewhat atypical and indicates that the river has been constructed with a relatively high capacity (as most rivers break onto the floodplain at about the 50% AEP flood magnitude).

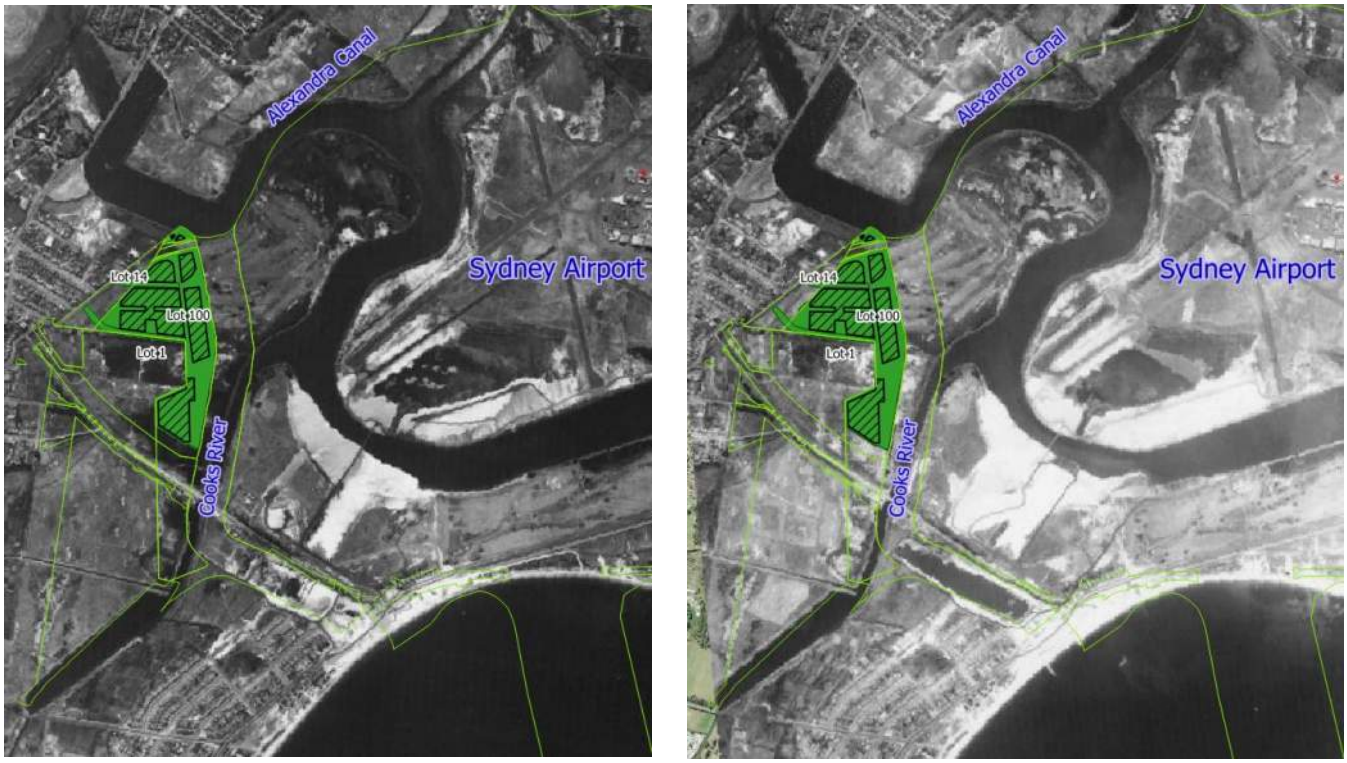



**Figure 5: Cooks River 1948 Aerial (left) and 1949 Aerial (right)**


**Figure 6: Cooks River 1951 Aerial (left) and 1952 Aerial (right)**


**Figure 7: Cooks River 1953 Aerial (left) and Current Aerial (right)**

## 2.3 Flood history

### 2.3.1 Anecdotal Observations of Flooding in Study Area

The Kogarah Golf Course has been operating on the site since the 1950's. The longest serving members of the golf club were contacted. Some of these have been members since the mid 1960's (up to 57 years ago). All 10 of these long-serving members have stated that they have never observed flood waters crossing over Marsh Street.

Hence, it is reasonable to assume that the occurrence of floodwaters breaking out of the Cooks River and passing over Marsh Street into the site is relative uncommon and would occur with a frequency of less than 5% AEP and possibly in the order of 1% AEP to 2% AEP.

This is generally supported by the flood modelling (see Section 5.4). The 5% AEP Cooks River flood with a coincident high tide (HHWS) results in peak flood levels at Cahill Park of 1.65mAHD. This level is sufficient to overtop onto Cahill Park and the nearby low streets of Arncliffe (such as Levey Street and Rockwell Avenue). This results in flood levels of 1.5mAHD in the area of the open channel near Levey Street that is the outlet of the Marsh Street longitudinal drainage system. Following the recent substantial upgrade of the Marsh Street longitudinal drainage system (carried out the last few years), floodwaters are now able to back up under Marsh Street and surcharge the pits on the southern side Marsh Street. This water can then flow onto the golf course. There are no culverts that pass from the golf course under Marsh Street northward towards the open channel.

### 2.3.2 Historical Flooding Observations Further Upstream

Table 2 below is a reduction of a table from Cooks River Floodplain Risk Management Study and Plan (WMAWater-PB, 2017). The FRMS report includes a chapter on flood model calibration to historical flood events. This FMRS does not cover the right bank of the Cooks River floodplain where the site is located.

**Table 2: Historical Flood Levels on Cooks River**

| Location | Feb 1956 | Mar 1958 | Nov 1961 | Jun 1964 | Mar 1983 |
|---|---|---|---|---|---|
| Brighton Avenue | 2.27 | 2.39 | 3.39 | - | 2.38 |
| Canterbury Road | 2.37-2.60 | 2.24 | 2.54-3.9 | 2.22 | 2.13-2.46 |
| Church Street | 2.07 | 1.91 | - | - | 2.07 |
| Wardell Road | 2.12 | 2.10 | 2.64-2.92 | 1.89 | - |
| Illawarra Road | 2.07 | 1.83 | 2.41 | 1.72 | 1.63-1.92 |
| Unwins Bridge | - | - | 2.63 | - | 1.38 |
| Tempe Railway | 1.48 | 1.49 | - | 2.08 | - |
| Princes Highway | 1.32 | 1.40 | - | - | - |

**Notes:** Data obtained from the 1994 Cooks River Floodplain Management Study (Reference 3). On occasions there have been considerable differences between reported levels at the same point for the same flood. This is a common occurrence with flood records and reflects the problems in accurately observing levels under unusual and often difficult conditions.

## 2.4 Emergency management

Currently, the Kogarah Golf Club (i.e. the clubhouse) is the only building on the site (apart from the temporary M6/M8 buildings which have direct access to Marsh St).

As shown in Figure 8 and Figure 9, the clubhouse is isolated in floods that inundate Levey Street which runs under the Marsh Street bridge over the Cooks River (Giovanni Brunetti Bridge). Levey Street has a low flood immunity and a low point at 1.1mAHD and the 5% AEP flood peaks at 1.5mAHD. Hence, the flood immunity is much less than 5% AEP and probably in the order of 20% AEP.


**Figure 8: Aerial showing current emergency access route from Kogarah Golf Clubhouse**

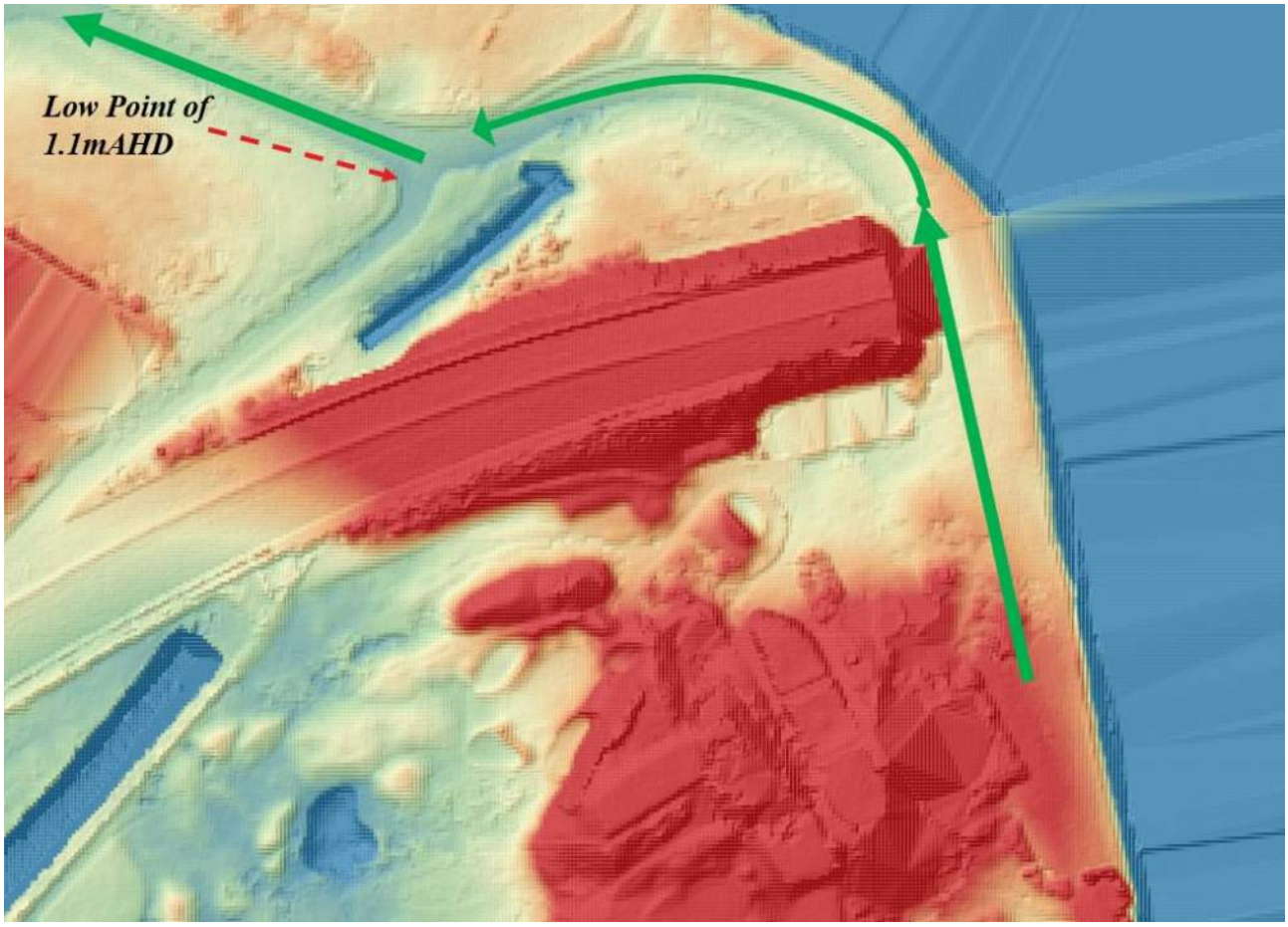



**Figure 9: Terrain showing current emergency access route from Kogarah Golf Clubhouse**

The local Bayside SES unit is located to the south-west of the site (see Figure 41) and would access this area via Marsh St from the south-west. There is flood-free access from the Bayside SES headquarters (Highgate Street, Bexley) to the site until Marsh Street. The south-western end of Marsh St is flood free and at about 7mAHD. From there, it grades gently to the north-east with a low point at the Novotel Hotel area of about 1.45mAHD. The entrance to the M6/M8 MOC site (and the proposed location of the Flora St South connection from the proposal to Marsh St) is at a level of 1.8mAHD. This is the low point at the edge of the carriageway (ie near the gutter).

Once cars can reach Marsh Street at this location and head south-west, there is flood-free access to the suburb of Arncliffe as well as the Princes Highway (including the St Georges Hospital 3.5km away) and the M5 East motorway (eastbound and westbound).

# 3. Available information

## 3.1 Relevant Previous Flood Assessments

### 3.1.1 Flood Studies

The Kogarah Golf Club is located in the lower reach of the Cooks River catchment and within the Bonnie Doon/Eve Street sub-catchment of the Cooks River. A number of flood modelling investigations have been carried out to derive design flood behaviour within the Cooks River catchment.

Presented below is a summary of the investigations undertaken to date which are relevant to the site:

- Cooks River Floodplain Management Study (Webb, McKeown & Associates, 1994);
- Cooks River Bank Naturalisation Data Compilations (Webb, McKeown & Associates, 2007);
- Cooks River Flood Study (MWH-PB, 2009);
- WestConnex New M5 EIS (Lyall & Associates, 2015);
- Bonnie Doon, Eve Street/Cahill Park Pipe & Overland 2D Flood Study, 1st Draft (WMAwater, 2015/2017);
- Cook Cove Flood Impact Assessment (AECOM, 2016);
- WestConnex New M5 (Aurecon Jacobs New M5 Joint Venture, 2016);
- WestConnex New M5 – Local Arncliffe Model (Aurecon Jacobs New M5 Joint Venture, 2016);
- Cooks River Floodplain Risk Management Study and Plan (WMAWater, 2017); and
- F6 Extension Stage 1 EIS – Appendix M Flooding Technical Report, Volume 7 (Lyall & Associates, 2019).

All models listed above utilise surface runoff from a hydrological model to simulate overland flooding, with the exception of the WestConnex New M5 – Local Arncliffe Model (Aurecon Jacobs New M5 Joint Venture, 2016) which only adopts a stage hydrograph boundary to simulate river flooding across the Kogarah Golf Club.

### 3.1.2 TfNSW Flood Models from M6 Stage 1 Detailed Design

The M6 Stage 1 project will include twin tunnels, 4km long, linking the M8 Motorway at Arncliffe to President Avenue at Kogarah and upgrade the intersection of President Avenue and Princes Highway at Kogarah.

Throughout 2022, discussions with TfNSW were held associated with the design of the M6 Stage 1 on land parcels adjoining the Cooks Cove Planning Proposal proposed SP4 Enterprise zone, including the future Arncliffe Motorway Operations Complex. This project is being constructed by a consortium called CGU which includes CIMIC Group's CPB Contractors and UGL, in a joint venture with Ghella.

As an outcome of these discussions, TfNSW provided the TUFLOW flood model that was being used for the design of the M6 Stage 1 project. The details of the origin of this flood model have not been provided to date. However, it is understood that it is a variation of the Sydney Water Cooks River flood model with the river simulated in 2D rather than 1D. The flood model has been used for the design of both the M8 (previously called WestConnex New M5) as well as the M6 Stage 1 projects as both projects share the same facilities site overlapping Lot 14 DP213314, Lot1 DP329283 and Lot 1 DP108492.

This model has been used for sensitivity assessments to understand the magnitude of the impacts using the TfNSW model compared to the Sydney Water model. This is discussed further in Section 7.3 of the Flooding, Stormwater and WSUD Report for the Cooks Cove Planning Proposal (Arup, March 2023).

### 3.1.3 Gateway Determination Flood Mitigations Options Assessment (March 2023)

Cooks Cove Planning Proposal (PP-2022-1748), which was issued a Gateway Determination by the Department of Planning and Environment on 5 August 2022. Condition 1(c) of the Gateway Determination requires preparation of "*an options analysis to clearly outline flood mitigations options available with clear reasoning for the preferred option*."

In response to this condition, a Flooding, Stormwater and WSUD Report for the Cooks Cove Planning Proposal was placed on public exhibition in March 2023. This assessment considered four options that included variations on the footprints of the Cooks Cove proposal and the proposed TfNSW sports fields:

- Option 1: This option includes filling of the Cooks Cove site to its full potential and no changes to the TfNSW works
- Option 2: This option includes reduced filling of the Cooks Cove site and no changes to the TfNSW sports fields to create passive open space
- Option 3: This option includes reduced filling of the Cooks Cove site and removal of the TfNSW sports fields to create ample flow conveyance area
- Option 4: This option includes reduced filling of the Cooks Cove site and modifications to the TfNSW sports fields to create sufficient flow conveyance area

Option 4 was chosen because:

- It achieves compliant afflux;
- It adequately conveys the flows through the site;
- The option includes concessions from the Cooks Cove Planning Proposal as well as requiring some changes to the design of the TfNSW sports fields; and
- It provides a highly beneficial open space outcome that meets the needs of many stakeholders.

This option was then assessed for a range of Cooks River flood events and local Bonnie Doon flood events. Impacts for all events assessed were found to be compliant. A sensitivity analysis was also carried out using the TfNSW Cooks River flood model. The impacts using this flood model were also found to be compliant.

Option 4 (which reflected the Cooks Cove Planning Proposal placed on public exhibition) included construction of the Flora Street South (i.e. the Flora Street extension into the site) at a level of 1.8mAHD. This is a key difference between the proposal assessed in this March 2023 report and this current FIRA which includes a raised Flora Street South to 2.17mAHD.

An assessment of the flood emergency and flood evacuation issues was carried out for the Cooks Cove Planning Proposal (with Flora Street South at 1.8mAHD).

The flood modelling for the Gateway Determination Flood Mitigations Options Assessment was focussed on peak levels and afflux. Hence, a conservative tailwater level of a constant 1.7mAHD was used. The flood assessments have been re-done for this FIRA using DPE guidance on appropriate tailwater levels for estuaries (See Section 5.1.5 for details).

As well, the modelling used in this FIRA include dynamic tidal boundaries that enable more realistic assessments of times of inundation which is a major focus of this FIRA especially in regard to evacuation routes.

## 3.2 Bonnie Doon Local Flood Model

The Flooding, Stormwater and WSUD Report for the Cooks Cove Planning Proposal (Arup, March 2023) included an assessment of the flooding behaviour and impacts using the Bonnie Doon local catchment flood model. This work demonstrated that there are no predicted impacts associated with local flooding. This is because Marsh Street forms a local catchment divide.

The only changes to the local catchment flood behaviour due to the Cooks Cove Planning Proposal are associated with the river flows that passed over Marsh Street as a result of elevated river levels as a boundary condition. Hence, the assessments using this local flood model with coincident high river flood levels provides an overlap (ie a double-up) with the assessments of Cooks River flooding.

To manage this overlap, the pit and pipe network on the floodplain from the Bonnie Doon model has been included in the Cooks River flood model. This has enabled assessments of river flood behaviour and local drainage modelling in the Cooks River flood model.

Figure 10 shows the terrain of the local floodplain and the catchment divide that is formed by the centre of Marsh Street. Hence, local flooding of the streets to the north of Marsh Street does not interact with the site unless the river is flooding. In that situation, it is actually river flood flows that head southward over Marsh Street and into the site.

Figure 11 shows the terrain and pipe network of Marsh Street in more detail of the culvert sizes. The recent upgrade of the Marsh Street longitudinal drainage to convey Marsh Street (northbound) runoff through a large 3.6m wide x 0.45m high RCBC accommodates all road runoff down to 3 x 1050 RCP's which then discharge north to the channel near Levey Street.

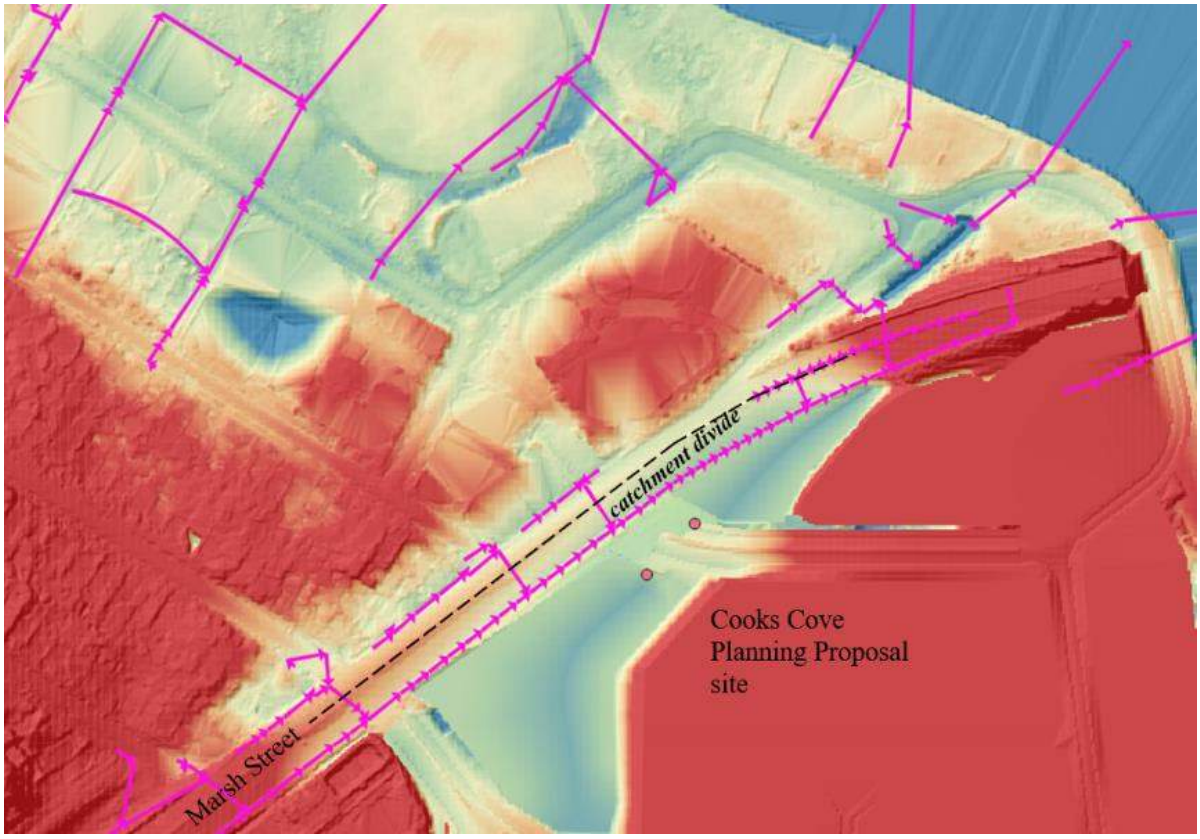


**Figure 10: Terrain of local floodplain showing local catchment divide**

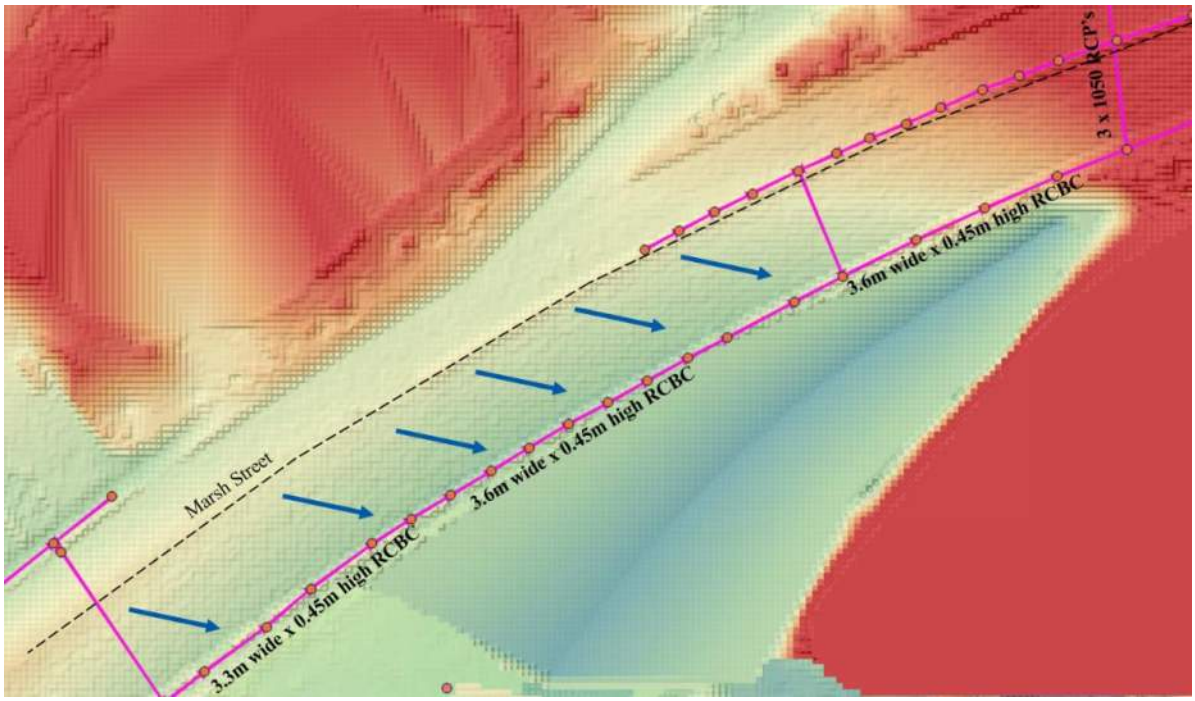



**Figure 11: Terrain of Marsh Street showing local pipe network**

Flood levels from the Bonnie Doon local catchment model are presented in the previous Flooding, Stormwater and WSUD Report (Arup, March 2023). It is clear from that mapping that Bonnie Doon local catchment flooding is not the dominant flood mechanism in any AEP (see Appendix C of that report for flood mapping of this flood mechanism).

The main issue to be addressed to manage flood risks on this site is flood evacuation and flood emergency management during a flood (see Section 7). The roads of the developed part of the site (ie not the open space areas) would be filled to a level 0.4m above the PMF flood levels and floor levels would be 1.3m above the PMF flood levels for the Bonnie Doon local catchment flooding. The hazard at the key evacuation route low point (corner Marsh Street and Flora Street South) is low hazard H1 for this Bonnie Doon local catchment flooding in the PMF.

Hence, this Flood Impact and Risk Assessment has focussed on Cooks River flooding with simulation of the local pit and pipe network as well.

# 4. Flood Related Requirements

The proposed development complies with relevant flood related controls associated with the rezoning and planning of developments. The relevant legislation includes the Environmental Planning & Assessment Act 1979 (EP&A Act) specifically the s9.1 Ministerial Directions (4.1 Flooding), the Bayside Local Environmental Plan 2021 (Bayside LEP) and Bayside Development Control Plan 2022 (Bayside DCP). This section summarises each of these relevant controls and how they relate to the proposed development.

## 4.1 New South Wales Flood Prone Land Policy (from FDM, 2005)

Local Planning Direction 4 (titled Focus area 4: Resilience and Hazards) in the *EP&A Act 1979* includes Clause 4.1 on Flooding which details the objectives and requirements that development in flood prone land must comply with. The direction includes the following objectives for Flood Prone Land:

[1] *(a) to ensure that 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.*

Section 1.1 of the NSW Government's Flood Prone Land Policy (as stated in FDM, 2005) states the following:

*"The primary objective of the New South Wales Flood Prone Land Policy, as outlined below recognises the following two important facts:*

- *flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development; and*
- *if all development application and proposals for rezoning of flood prone land are assessed according to rigid and prescriptive criteria, some appropriate proposal may be unreasonably disallowed or restricted, and equally quite inappropriate proposals may be approved."*

In this context, the merit of the proposal should be reasonably considered in accordance with its location within an identified floodplain. In this report it has been clearly demonstrated that the proposed development would not cause adverse impacts on properties upstream of Marsh Street, and the concept has been developed to appropriately mitigate and manage the risk of flooding at the site in agreement with the NSW Government's Flood Prone Land Policy. Importantly it must also be considered that the Planning Proposal is essentially seeking a revision of controls applying to a site which is already zoned for intensive urban purposes – with a revised extent and suite of controls which will better manage flood risks when compared to the present land use planning provisions for the site.

[4] *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).*

The proposal is consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, as the proposal appropriately manages flood risk and would not result in adverse flooding impacts. This is evident through the detailed flood modelling presented and discussed in this report.

[5] "*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.*

As the development site falls within the flood planning area in the updated LEP maps, assessment of this clause should be considered with consideration of the objectives laid out in the Local Planning Direction 4 (referenced above). These objectives refer to the NSW Flood Prone Land Policy which, as discussed in this section, promotes an approach under which each proposal is considered on its merits. In this context, the merit of the planning proposal should be considered holistically with reasonable consideration given to the merit of the

proposal to develop and not sterilise the subject land. Importantly it must also be acknowledged that the Planning Proposal essentially reduces the quantum of zoned developable land when compared to the existing situation. This approach, together with contemporary flood planning and risk provisions, balances the rezoning of land in the flood planning area in a format which achieves a superior outcome in terms of flood safety.

[6] *A planning proposal must not contain provisions that apply to the flood planning areas which:*

*(a) permit development in floodway areas*

The dominant flood mechanism on the site is flooding from the Cooks River. The Cooks River Flood Study (MWH-PB, 2009) did not map flood function (which includes defining floodways) for the subject site. In regard to local catchment flooding, the Bonnie Doon, Eve Street/Cahill Park Pipe & Overland 2D Flood Study did also not map flood function for the subject site. This is typically completed as part of the Flood Study and Floodplain Risk Management process. However, flood function mapping is presented in this report for the dominant Cooks River flood mechanism (see Figures A-21 to A-25 for the flood function mapping of the base case and Figures B-26 to B-30 for the flood function mapping of the Planning Proposal case). These figures demonstrate that:

- during a 1% AEP flood event in the base case, there are no floodway areas on the site as the golf course does not completely fill to river levels during the 1% AEP flood. At the peak of the flood, there is still inflow from Marsh Street and back-flooding from the river from the south-eastern corner. There is not a continuous flowpath from north to south-east across the site during this flood (this floodway does form in rare floods).
- In the Planning Proposal case, there would not be any floodway areas associated with the developed part of the site as ground floor levels will be above the PMF levels. The floodway parts of the site would be concentrated to the open space parts of Lot 14 and Lot 1.

*(b) permit development that will result in significant flood impacts to other properties*

As has been demonstrated in Chapter 6, the proposal would not result in significant flood impacts to other properties. The Planning Proposal provides sufficient flood storage and flood conveyance through the site to result in no afflux on the urban areas north of Marsh Street. There will be no afflux and no change to the timing of the flooding on the urban areas north of Marsh Street. Hence, there will be no change to the flood function, flood hazards and Flood Emergency Classifications on the urban areas north of Marsh Street.

*(c) permit a significant increase in the development of that land*

As discussed, this clause should be considered in the context of the objectives of the Floodplain Development Manual (2005) and the NSW Flood Prone Land Policy taken from the Flood Risk Management Manual (2023). Although the proposal is located within the existing floodplain, it has been demonstrated that the development can occur whilst appropriately and responsibly managing the risk of flooding (see Chapter 7 for details). As stated previously, the physical area of land zoned for developable purposes will decrease as a result of the Planning Proposal.

*(d) are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services*

The proposal includes features such as a raised Flora Street South (with culverts to accommodate the 0.2% AEP flows) for this very purpose. Access into and out of the site would be possible in all floods up to the 0.2% AEP flood. The current clubhouse would be removed which is located on a High Island and isolated in floods as frequent as a 5% AEP flood. The removal of the clubhouse would reduce the potential requirements for evacuation from this building. In total, the Planning Proposal proposed safety and evacuation measures have been attuned to not overburden emergency services and accordingly will not increase the requirement for government spending on such services. The Planning Proposal would not increase the requirement for government spending on flood mitigation measures.

*(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.*

The proposal is demonstrating compliance with the flood-related requirements of both the DCP 2022 and the Ministerial Local Planning Directions Focus Area 4.1 Flooding and seeking appropriate development consents in agreement with these requirements.

[7] *"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)."*

The proposal would not impose any flood related development controls above the appropriate residential flood planning level. The proposal does not seek any residential land uses. As discussed in this section, the New South Wales Flood Prone Land Policy promotes an approach under which each proposal is considered on its merits.

[8] "*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)."*

As has been demonstrated in this report section, when considered holistically on a merit basis and in accordance with the New South Wales Flood Prone Land Policy and other appropriate guidance and policies referenced in this section, the proposal satisfies the flood-related requirements of both the DCP 2022 and the Ministerial Local Planning Directions Focus Area 4.1 Flooding (discussed below).

## 4.2 Ministerial Local Planning Directions

Ministerial Directions under Section 9.1 of the EP&A Act require plan making authorities to address a range of matters when seeking to rezone land. These are addressed in Local Planning Directions issued by DPE. Of relevance is Focus area 4: Resilience and Hazards and particularly 4.1 Flooding which is addressed in the table below. Note that the below response to Section 9.1 of the EP&A Act is supplemented by an additional detailed response table prepared by Ethos Urban dated 8 December 2023, which provides further justification of compliance with the relevant flooding matters for consideration.

**Table 3: Compliance with Ministerial Directions under Section 9.1 of the EP&A Act**

| **Clauses from Ministerial Local Planning Directions Focus Area 4.1 Flooding** | **Compliance** |
|---|---|
| **Direction 4.1** | |
| (1) A planning proposal must include provisions that give effect to and are consistent with: | |
| (a) the NSW Flood Prone Land Policy, | Refer to Table 4 |
| (b) the principles of the Floodplain Development Manual 2005, | Refer to Table 5 for a list of the principles for flood risk management in New South Wales taken from the most recent Flood Risk Management Manual (DPE, 2023). |
| (c) the Considering flooding in land use planning guideline 2021, and | The Bayside LEP appropriately categorises the land immediately surrounding the Planning Proposal site as a Flood Planning Area (FPA). Accordingly, the Planning Proposal seeks to designate the site as within an FPA.<br>All developable land within the site will be filled to more than 0.5m above the DFE as a baseline conditions, which is not contingent on the Planning Proposal and is consistent with current planning provisions.<br>No Special Flood Considerations apply |
| (d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the | This FIRA has relied upon the Cooks River Flood Study (MWH-PB, 2005) carried out for Sydney Water. |

| Clauses from Ministerial Local Planning Directions Focus Area 4.1 Flooding | Compliance |
|---|---|
| principles of the Floodplain Development Manual 2005 and adopted by the relevant council. | There is no adopted Flood Risk Management Plan that covers this part of the Cooks River floodplain. |
| 2) A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones. | It is acknowledged the Planning Proposal seeks to rezone elements of the site (within the FPA) from recreation to special purpose. However, in doing so this will ultimately result in a reduced quantum of developable area when compared to the current zoning.<br>This approach, together with contemporary flood planning and risk provisions, balances the rezoning of land in the flood planning area in a format which achieves a superior outcome in terms of flood safety. |
| (3) A planning proposal must not contain provisions that apply to the flood planning area which: | |
| (a) permit development in floodway areas, | The floodway areas on the site will be relocated through land reshaping, to new and expanded open space zoned areas within the site. There will not be any development in these relocated floodway areas.<br>The floodway areas of the 'existing situation' (ie the case once TfNSW has constructed the sports fields on the spoil mound and the frog ponds) is on a floodplain that has been heavily modified over the last 70 years and does not resemble a natural floodplain adjacent to a natural river. |
| (b) permit development that will result in significant flood impacts to other properties, | There will not be any impacts to properties external to the site (see Section 6.5). |
| (c) permit development for the purposes of residential accommodation in high hazard areas, | Not applicable as residential land uses are not sought. |
| (d) permit a significant increase in the development and/or dwelling density of that land, | The area is low hazard for the 1% AEP flood and in the case with the development implemented in line with the Planning Proposal, all of the developed land with increased density would be not be inundated in floods up to the 1:2000 AEP and all floor levels would be above the PMF levels. |
| (e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, | Not applicable as these land uses are not sought. |
| (f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent, | Not applicable. |
| (g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or | Section 7 of this report demonstrates that in all floods up to a 1:500 AEP flood event, there is a continuous evacuation route available for entry and egress for occupants and emergency services (apart from a short 3m section of road which would have H2 hazard for 30 minutes).<br>In the 1:2000 AEP flood, there is only a short period of time (4.5 hours) that evacuations would not be possible due to the flood hazard being greater than H2 over a short section of road (5m long). With the exception of that short section of road, the flood hazards into and out of the site would be trafficable by large vehicles and emergency services vehicles. |

| Clauses from Ministerial Local Planning Directions<br>Focus Area 4.1 Flooding | Compliance |
|---|---|
| (h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event. | Not applicable, these land uses are not sought. |
| (4) A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which: | No SFC's identified in Bayside DCP (2022) |
| (a) permit development in floodway areas | No SFC's identified in Bayside DCP (2022) |
| (b) permit development that will result in significant flood impacts to other properties | No SFC's identified in Bayside DCP (2022) |
| (c) permit a significant increase in the dwelling density of that land, | No SFC's identified in Bayside DCP (2022) |
| (d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, | No SFC's identified in Bayside DCP (2022) |
| (e) are likely to affect the safe occupation of and efficient evacuation of the lot, or | No SFC's identified in Bayside DCP (2022) |
| (f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities. | No SFC's identified in Bayside DCP (2022) |
| (5) For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council. | See Section 4.1 for consistency with FRM 2005 and see Table 4 and Table 5 for compliances with the Floodplain Management Manual (DPE, 2023)<br><br>There is no adopted Flood Risk Management Plan that covers this part of the Cooks River floodplain. |
| **Consistency**<br>A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Planning Secretary (or their nominee) that: | |
| (a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or | There is no adopted Flood Risk Management Plan that covers this part of the Cooks River floodplain. |
| (b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or | Not applicable |
| (c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or | The Planning Proposal is supported by this FIRA which has been prepared in accordance with the latest DPE floodplain management guidance. |

| Clauses from Ministerial Local Planning Directions Focus Area 4.1 Flooding | Compliance |
|---|---|
| (d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority. | Not applicable |

**Table 4: Compliance with NSW Flood Prone Land Policy taken from the Flood Risk Management Manual (2023)**

| NSW Flood Prone Land Policy taken from the Flood Risk Management Manual (DPE, 2023) | Compliance |
|---|---|
| Primary objective of the policy is to reduce the impacts of flooding and flood liability on communities and individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. | The Planning Proposal is essentially seeking a revision of controls applying to a site which is already zoned for intensive urban purposes – with a revised extent and suite of controls which will better manage flood risks (e.g filling to above 1:2000 AEP, floor levels above PMF and 1:500 AEP access route) when compared to the present land use planning provisions for the site. |
| **Policy Provisions** | |
| an emphasis on the importance of developing and implementing FRM plans based on an integrated mix of management measures that address the full range of risks to existing and future development | Key flood risk management measures utilised in Planning Proposal are filling to achieve low risks for occupants and provision of a rising road access route. |
| recognition of the potential implications of climate change on flooding behaviour | This FIRA has demonstrated that the impacts of climate change (increased flows and sea level rise) are not significant on this site.<br>The PMF levels would increase by 0.3m which would not create an unsafe situation in the buildings which would have vertical evacuation options.<br>The 1% AEP levels would still be 0.6m below the floor levels (i.e. there will be 0.6m freeboard above the 1% AEP flood levels with 0-.9m sea level rise and 20% increased flows). |
| recognition of the need to consider ways to maintain and enhance riverine and floodplain ecology in the development of FRM plans | No floodplain ecology on the site due its disturbed nature. |
| a floodway definition based on the consideration of the effect of loss of flow conveyance on flood behaviour, hazard and flood damages | Section 6.9 includes floodway definition with consideration of flow conveyance, hazard and flood damages. |
| recognition of the importance of EM in addressing continuing flood risk in the State Emergency Service Act 1989 and NSW State flood plan and the close relationship between EM planning and the FRM process and framework | Chapter 7 is dedicated to the considerations of the needs for emergency management. |
| a flexible merit-based approach to be followed by councils in dealing with the development or redevelopment of flood prone land | Matter for Bayside Council |
| a merit-based approach to the selection of risk-based flood planning levels (FPLs). This recognises the need to consider the risks associated with the full range of flooding, up to and including the probable maximum flood (PMF) | The use of a merit-based approach has led to the adoption of floor levels above the PMF given the possibility of isolation for short periods of time. |
| councils are primarily responsible for the determination of appropriate planning and development controls to manage flood risk relating to development and redevelopment to an acceptable level based on social, economic and ecological, as well as flooding considerations. These controls should be aware of higher level strategies, plans and directions (i.e. state, regional and district) | Matter for Bayside Council |
| explicit recognition that FRM needs to take into account the principles of ecologically sustainable development (ESD) through consideration of relevant government policies and legislation allowing for the | Matter for Bayside Council and agencies |

| | |
|---|---|
| sustainable use of the floodplain as a natural resource. All agencies must comply with the planning and assessment requirements of relevant government policies and legislation associated with the use, development and management of the floodplain | |
| relief from land tax, council rates and water and sewerage rates where vacant land cannot be developed because of its flood prone nature | Not applicable to this site |

**Table 5: Compliance with Principles for Flood Risk Management taken from the Flood Risk Management Manual (2023)**

| **Principles for flood risk management in New South Wales taken from the Flood Risk Management Manual (DPE, 2023)** | **Compliance** |
|---|---|
| Establish sustainable governance arrangements | Not applicable to this site |
| Think and plan strategically | Not applicable to this site |
| Be consultative | The development of this Planning Proposal has included discussions with TfNSW, Bayside Council, DPE and SES over many years. |
| Make flood information available | Not applicable to this site |
| Understand flood behaviour and constraints | This FIRA includes a comprehensive assessment of flood behaviour and the constraints that have led to a Planning Proposal in which over 14,000 $m^2$ has been dedicated to flood conveyance in rare floods. |
| Understand flood risk and how it may change | This FIRA includes a comprehensive assessment of the predicted changes to flood behaviour as a result of this Planning Proposal. |
| Consider variability and uncertainty | This FIRA includes a comprehensive assessment of flood behaviour with climate change. |
| Maintain natural flood functions | This river and floodplain has been highly modified over the last 70 years and has very little natural flood function remaining. |
| Manage flood risk effectively | Chapter 7 of this FIRA demonstrates that all flood risks have been adequately managed |
| Continually improve the management of flood risk | Not applicable to this site |

## 4.3 Bayside Council LEP (2021)

Clause 5.21 of the Bayside Council LEP (2021) addresses flood planning. The three relevant parts of this clause is presented below with a discussion on the compliance to this clause.

*(1) The objectives of this clause are as follows:*

*(a) to minimise the flood risk to life and property associated with the use of land,*

*(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,*

*(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,*

*(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.*

The proposal meets the objectives of Clause 5.21(1) and this is demonstrated in Chapter 6 and Chapter 7 of this report.

*(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development:*

*(a) is compatible with the flood function and behaviour on the land, and*

*(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and*

*(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and*

*(d) incorporates appropriate measures to manage risk to life in the event of a flood, and*

*(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.*

The proposal meets the objectives of Clause 5.21(2) as it is compatible with the flood function and flood behaviour of the site. The compliance relating to flood impacts are presented in Chapter 6 and the compliance relating to safety and evacuation are presented in Chapter 7.

*(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters:*

*(a) the impact of the development on projected changes to flood behaviour as a result of climate change,*

*(b) the intended design and scale of buildings resulting from the development,*

*(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,*

*(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.*

The proposal meets the objectives of Clause 5.21(3) as the floor levels will be set at the PMF levels which would also achieve an outcome in which floor levels are 0.6m above the 1% AEP flood levels in a climate change scenario with 20% increase in flow and a 0.9m allowance for sea level rise. The risk-to-life is minimised through achieving safe refuge on site for short periods in rare floods when evacuation (if required) is not possible. Evacuation from the site would be possible at all times in floods up to and including the 0.2% (1:500) AEP flood event. There would only be short periods (in the order of four hours) when evacuation from the site in a 0.05% (1:2000) AEP flood would not be possible.

## 4.4 Bayside Council DCP 2022

The Bayside Council Development Control Plan (2022) was adopted by Bayside Council on 22 March 2023. A review of the provisions has been carried out for the site and proposal.

Section 3.10 of the DCP addresses Flood Prone Land which states that the "*criteria for proposals potentially affected by flooding are structured in recognition that different controls are applicable to different land uses and flood hazards."*

The flood hazard mapping for the site based on the Bayside Council online mapping is presented in Figure 12. This mapping shows that all of the site, with the exception of some very small areas corresponding to the current open drains on the golf course) is mapped as H1 or H2. Section 3.10.12 of the draft Bayside Council Development Control Plan (2022) lists H1 and H2 to be Low Hazard land.

However, this flood mapping is likely to have been derived from the results of the local catchment flood model (i.e. the Bonnie Doon flood model). Flood hazard associated with Cooks River flooding are more relevant to the flood risk consideration of the site given this type of flooding has the potential to pass high flows through the site in rare floods. Figure 13 shows the flood hazards from the Cooks River flood modelling for the Planning Proposal case (see Chapter 6 for more detail).

Section 6 of this report includes a full description of the flooding behaviour of the Planning Proposal following development of the site. The flood mapping of hazards for the site in its developed form are presented in Appendix B. These maps show that the developed part of the site (i.e. not the open space parts) will have H1 hazard for all floods up to the PMF. This is primarily due to the filling of the site to the 1:2000 AEP levels and having floor levels above the PMF level.

Table 11 from the draft DCP is reproduced below which lists the prescriptive controls for development for Low Hazard land. Based on Table 13 of the draft DCP, the prescriptive controls that apply to residential and commercial/industrial development on this site are listed in Table 1 along with the compliance to these controls.

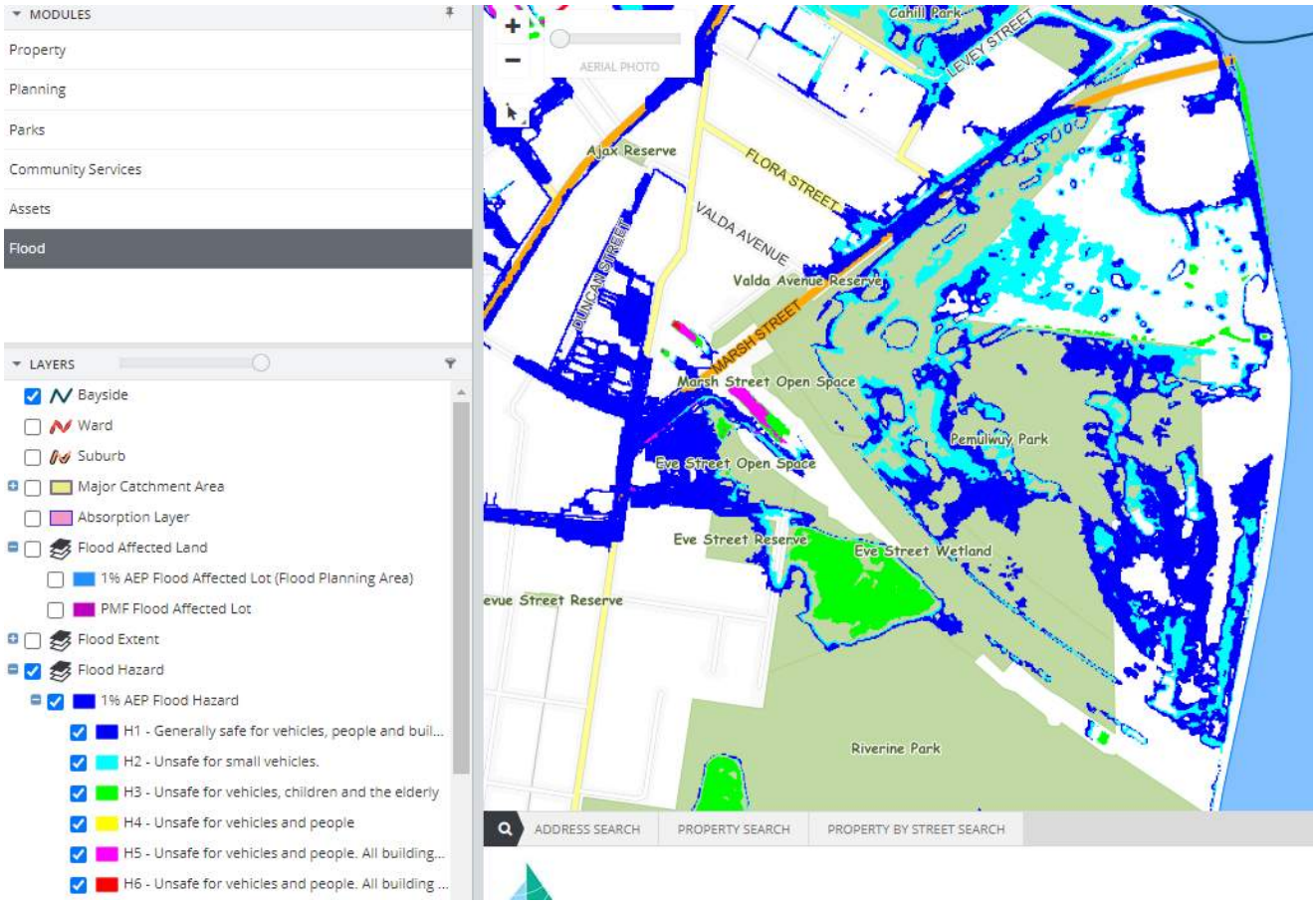



**Figure 12: Bayside Council Flood Hazard Mapping (https://maps.bayside.nsw.gov.au/Intramaps98/?module=Flood)**

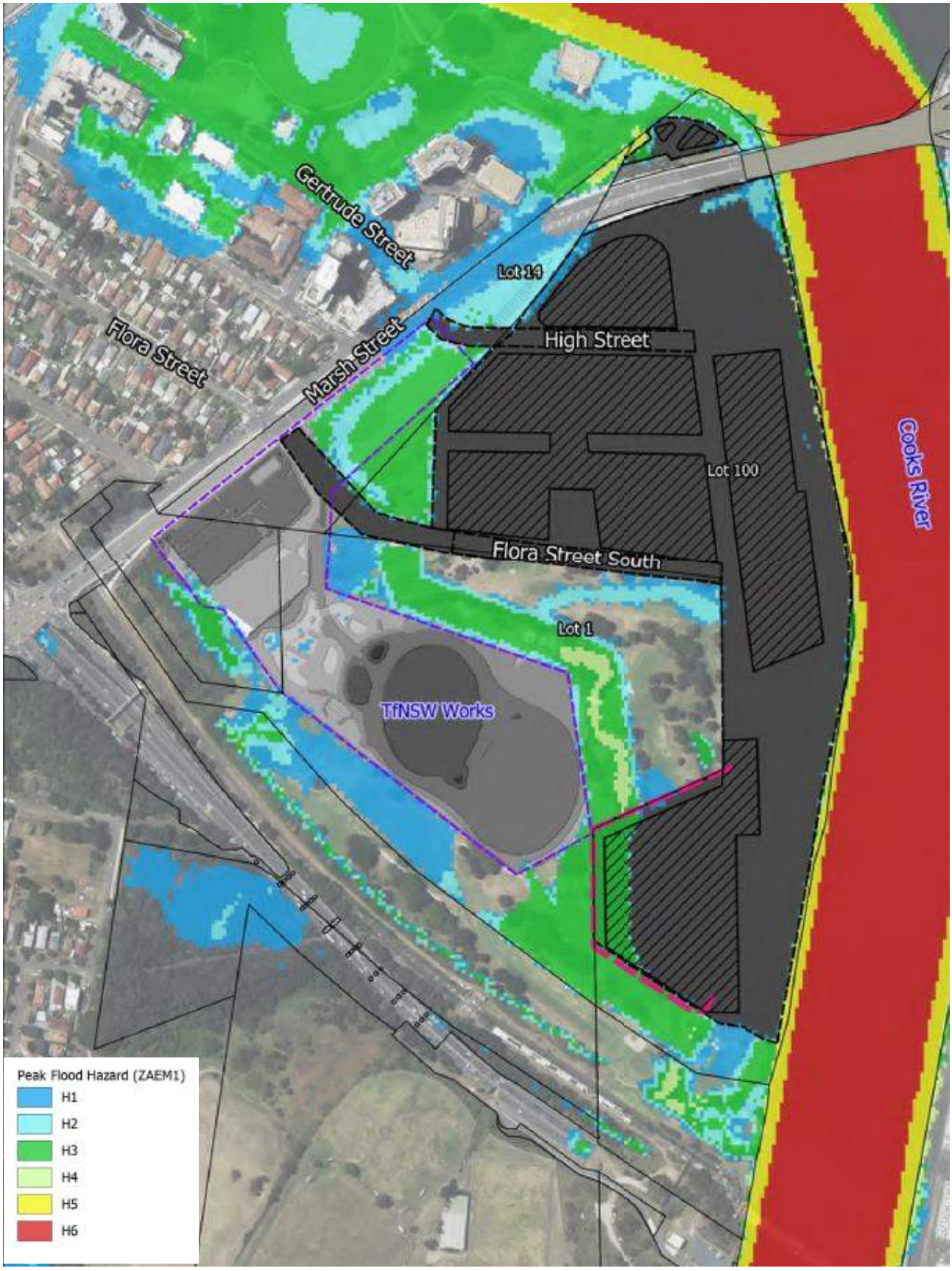



**Figure 13: Flood Hazard Mapping (1% AEP) using updated Cooks River Flood Model (for case with amended Planning Proposal)**

| Planning Consideration | Land Use Category (Development Type) | | | | | |
|---|---|---|---|---|---|---|
| | Critical & Sensitive Uses & Facilities | Subdivision | Residential | Commercial & Industrial | Recreation and non urban | Concessional Development |
| A. Floor level | A2, A3 | G3 | A1, A3 | A1, A3 | A4 | A5 |
| B. Building Components | B2, B3, B4 | | B1, B3, B4 | B1, B3, B4 | B1, B3, B4 | B1, B3, B4 |
| C. Structural Soundness | C2 | | C1 | C1 | C1 | C1 |
| D. Flood Effects | D1 | | D1 | D1 | D1 | D1 |
| E. Car Parking & Driveway Access | E1, E2, E4 | | E1, E2, E3 | E1, E2, E3 | E1, E2, E3 | E1, E2, E3 |
| F. Evacuation | F2 | | F1 | F1 | F1 | F1 |
| G. Management and Design | G2, G4, G5 | | G2, G4, G5 | G2, G4, G5 | G2, G4, G5 | G2, G4, G5 |

**Figure 14: Bayside Council Draft DCP 2022 Table 11 (Low Flood Hazard - Prescriptive Controls for Development)**

**Table 6: Compliance Status with Low Flood Hazard Prescriptive Controls for Development**

| | | |
|---|---|---|
| **Floor Level** | | |
| A1 | Habitable floor levels to be no lower than the 1% AEP flood level plus 0.5m freeboard. | Compliant |
| A3 | Non-habitable floor levels to be no lower than 1% AEP flood level. | Compliant |
| A4 | All floor levels to be at least 300mm above the existing ground level. | Compliant (recreation area only) |
| **Building Components & Method** | | |
| B1 | All structures to have flood compatible building materials (Schedules – Chapter 9.5.3) below the 1% AEP flood level plus 0.5m freeboard. Any part of the building that is erected at or below the 1% AEP flood level + 0.5m freeboard shall be constructed of flood compatible material. | Not applicable |
| B3 | Flow-through open form fencing (louvres or pool fencing) is required for all new fencing and all new gates up to the 1% AEP flood level to allow floodwaters to flow through. | Compliance in subsequent stages of project development |
| B4 | All new electrical equipment, power points, wiring, fuel lines, sewerage systems or any other service pipes and connections must be waterproofed and/or located above the 1% AEP flood level plus 0.5m freeboard.<br>All existing electrical equipment and power points located below the 1% AEP flood level plus 0.5m freeboard within the subject structure must have residual current devices installed that turn off all electricity supply to the property when floodwaters are detected. | Compliance in subsequent stages of project development |
| **Structural Soundness** | | |
| C1 | All new development must be designed and constructed to ensure structural integrity up to the 1% AEP flood level plus 0.5m freeboard, taking into account the forces of floodwater, wave action, flowing water with debris, buoyancy and immersion. Structural certification shall be provided confirming the above. | Compliance in subsequent stages of project development<br><br>Compliance as floor levels above PMF level. |

| | | |
|---|---|---|
| | Where shelter-in-place refuge is required, the structural integrity for the refuge is to be up to the PMF level. Structural certification shall be provided confirming the above. | |
| **Flood Effects Caused by Development** | | |
| D1 | The development must not result in increased flooding elsewhere in the floodplain. A flood assessment report (refer to Schedules – Chapter 9.5.4) shall be provided to demonstrate that the development:<br>• does not divert floodwaters to the detriment of elsewhere on the floodplain.<br>• does not increase flood level or velocity elsewhere on the floodplain.<br>• does not result in a detrimental loss of flood storage.<br>• reduces the existing flood hazard, where possible.<br><br>A flood impact assessment for a site is not required where the flood storage and floodway capacity are retained. For example, a building can be elevated to retain the existing floodway and flood storage to permit the free flow of water under the building. | Compliant (see flood impact assessment in Section 6 of this report)<br><br>Not applicable |
| **Car Parking and Driveway Access** | | |
| E1 | The minimum finished floor level of open car parking spaces or carports shall be at or above natural ground level. A flow-through roller door (or horizontal louvers) is permitted for a carport structure. Carports must be of open design, with at least 2 sides completely open such that flow is not obstructed up to the 1% AEP flood level. Otherwise, it will be considered to be enclosed.<br><br>Open car parking areas shall not be located within a floodway. | Compliant (all car parking above 1% AEP flood levels) |
| E2 | For above ground level garages, the minimum surface level shall be no lower than the 1% AEP flood level. | Compliant (all car parking above 1% AEP flood levels) |
| E3 | Basement garages/storage/car parking, low-level driveways must be physically protected from inundation by floods equal to or greater than the 1% AEP flood level plus 0.5m freeboard. The crest of the driveway shall be located within the property boundary. All access, ventilation, driveway crests and any other potential water entry points to any enclosed car parking shall be above the 1% AEP flood level plus 0.5m freeboard level.<br><br>Council will not accept any options that rely on the electrical, mechanical or manual exclusion of the floodwaters from entering the enclosed carpark for new development. Flood barriers may be accepted for an existing development to improve flood protection. | Compliant (all car parking entrances above 1% AEP + 0.5m flood levels)<br><br>Compliance in subsequent stages of project development |
| **Emergency Response** | | |
| F1 | A qualified civil engineer shall be engaged to prepare an on-site emergency response flood plan is required to detail whether evacuation procedures are required and if so, how they will be initiated, warning signs and preservation of flood awareness as owners and/or occupants change through time. Adequate flood warning systems (such as water level sensors, and alarm stations), signage and exits shall be available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel. The evacuation plan shall be easily accessible to current and future occupants.<br><br>If safe evacuation cannot be achieved within a sufficient response time then a shelter-in-place refuge is required, together with a plan for self-sufficiency for up to 12 hours. This plan must consider as a minimum:<br>• sufficient area for all the occupants, adequate clean water for all occupants;<br>• portable radio with spare batteries;<br>• torch with spare batteries;<br>• first-aid kits;<br>• emergency power; and<br>• a practical means of medical evacuation. | Compliance in subsequent stages of project development<br><br>Shelter-in-place proposed (see Chapter 7)<br><br>Compliance in subsequent stages of project development |

| | | |
|---|---|---|
| | Note that in the event of a flood, occupants would be required to evacuate if ordered by Emergency Services personnel regardless of the availability of a shelter-in-place refuge. | |
| **Management and Design** | | |
| G2 | Storage of materials that may cause pollution or are potentially hazardous during any flood is not permitted below the 1% AEP plus 0.5m freeboard. | Compliant |
| G4 | Where a building is elevated to retain the existing floodway, overland flow path and flood storage, the undercroft area is to remain open to permit the free flow of water under the building. A positive covenant is required. | Not applicable |
| G5 | Pools located within the 1% AEP flood extent are to be in-ground, with coping flush with natural ground level. Where it is not possible to have pool coping flush with natural ground level, it must be demonstrated that the development will result in no net loss of flood storage and no impact on flood conveyance on or from the site. All electrical equipment associated with the pool (including pool pumps) is to be waterproofed and/or located at or above the 1% AEP plus 0.5m freeboard level. All chemicals associated with the pool are to be stored at or above the 1% AEP plus 0.5m freeboard level. | Compliance in subsequent stages of project development |

## 4.5 Afflux Requirements of TfNSW MOC site

The Cooks Cove Planning Proposal has been assessed for flooding impacts on the basis that afflux greater than 10 mm is not likely to be permitted by TfNSW at the M6/M8 operations centre for the probable maximum flood (PMF) event. This is because the operations centre contains critical ventilation infrastructure that connects to the M6/M8 tunnels below.

# 5. Pre-developed modelling and analysis

## 5.1 Cooks River Flood Model

### 5.1.1 Overview

The TUFLOW model developed in the Cooks River Flood Study flood model covers the floodplain of the Cooks River. Figure 15 depicts the TUFLOW hydraulic model layout taken from the Cooks River Flood Study report (MWH-PB, 2009).

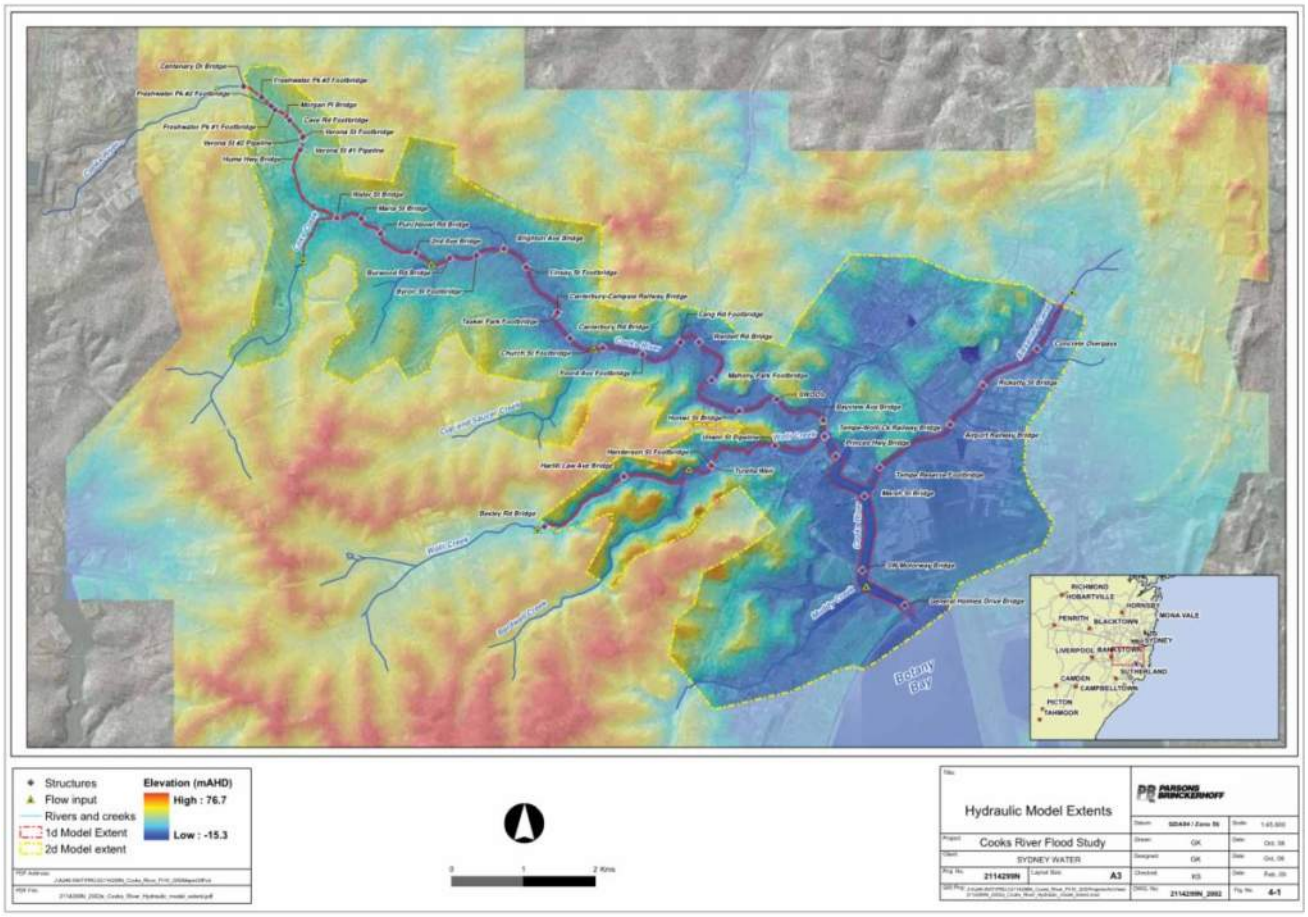



**Figure 15: Cooks River TUFLOW model layout**

The Sydney Water Cooks River Flood Study (MWH-PB, 2009) reported that the 2-hour temporal pattern was found to produce the highest flood levels in the majority of the catchment. Therefore, the 2-hour temporal pattern was adopted to carry out this flooding investigation.

The Sydney Water Cooks River Flood Study includes that the flood model incorporates hydraulic watercourse structures including road bridges, rail bridges, foot bridges and pipelines crossing the Cooks River, Alexandria Canal and Wolli Creek.

### 5.1.2 Summary of Changes Made to the Cooks River Flood Model

A number of changes have been made to the Cooks River Flood Model. Some of the changes are due to the age of the flood model (built in 2009) and the improvements to the flood modelling software. Some of the changes are due to changes in DPE guidance on boundary conditions as well as a need to focus on the duration of flood inundation. As well, there have been a number of developments constructed on the Cooks River floodplain north of Marsh Street as well as the TfNSW Arncliffe Motorway Operation Complex that required

representation in the flood model. New survey and bathymetry has also been incorporated into the flood model as well as improved definition of local topographical details.

The following list summarises the updates incorporated into the flood model:

- Changes to local terrain and drainage associated with the widening of Marsh Street between Valda Avenue and the Giovanni Brunetti Bridge over the Cooks River;
- Some of the larger buildings to the north of Marsh Street were digitised and provided with revised Manning's n roughness values as overland flows from these areas were not reaching the site correctly in the model;
- Existing terrain around the Novotel Hotel (north of Marsh Street) was updated to better reflect existing conditions. There is approximately a 0.9 m difference between the kerb invert on Levey Street and road levels outside the Novotel Hotel;
- Updated ground survey of the golf course was added, which was provided by Cook Cove Inlet Pty Ltd on 4 October 2019;
- The elevation of the TfNSW Arncliffe Motorway Operation Complex has been modelled using the design levels provided by TfNSW. As well, the design of the frog ponds and the proposed sports fields on the current stockpile site have been included in the flood model based on design levels provided by TfNSW. Given that the M8 is now constructed and the M6 Stage 1 is an approved project, these elements were included in the base case terrain.
- A breakline was added to improve accuracy of existing terrain at the south-eastern corner of the golf club;
- The representation of the entrance of the Cooks River at Botany Bay was improved with bathymetry data from 2018 (https://datasets.seed.nsw.gov.au/dataset/marine-lidar-topo-bathy-2018);
- The representation of the drainage line along the southern boundary of the Kogarah Golf Course was improved using the latest available Lidar data (see above) and field measurements of the pipes leading to the river.
- The pit and pipe network in Marsh Street and the area of Arncliffe north of Marsh Street was inserted into the Cooks River flood model to enable more accurate assessments of the time of flood inundation (to enable floodwater trapped in the road to drain back to the river via the drainage network). The existing culverts with flap gate outlets located approximately 80 m north of Marsh Street were also simulated;
- Tailwater conditions as per Section 5.1.5
- The Initial Water Level (IWL) has been set at the same level as the tailwater levels at the start of the flood simulation;
- Culvert losses were updated. Inlet control values for height and width constrictions were changed to 0.6 and 0.9, respectively. Inlet losses for RCBC were changed to 0.4 (as per QUDM for an expected 45 degree wingwall) and
- The Cooks River seawall constructed along the side of Cahill Park, in between the Giovanni Brunetti and Princess Highway Bridges was represented using as-built survey of the seawall (provided by Bayside Council on 15 January 2020).

The existing case scenarios for the current investigation was established after incorporating these changes into the flood models.

### 5.1.3 Hydraulic Model Parameters for Existing Case

The model adopts a seven-metre square grid size and similarly utilises ALS data to establish ground elevations. The terrain over the Kogarah golf Course area was updated for this study to utilise LiDAR flown in 2019.

The ridge associated with the Sydney Water desalination pipeline on the site was included in the model as a 2D_ridgeline to enforce the cell sides to reflect the highest parts of the ridge.

As well, detail was added to the model to represent the drainage features along the southern boundary of the golf course where there is a long drain leading to the river via flap-gated culverts.

Given that the M8 has been constructed and the M6 Stage 1 is an approved project, these elements were included in the base case terrain.

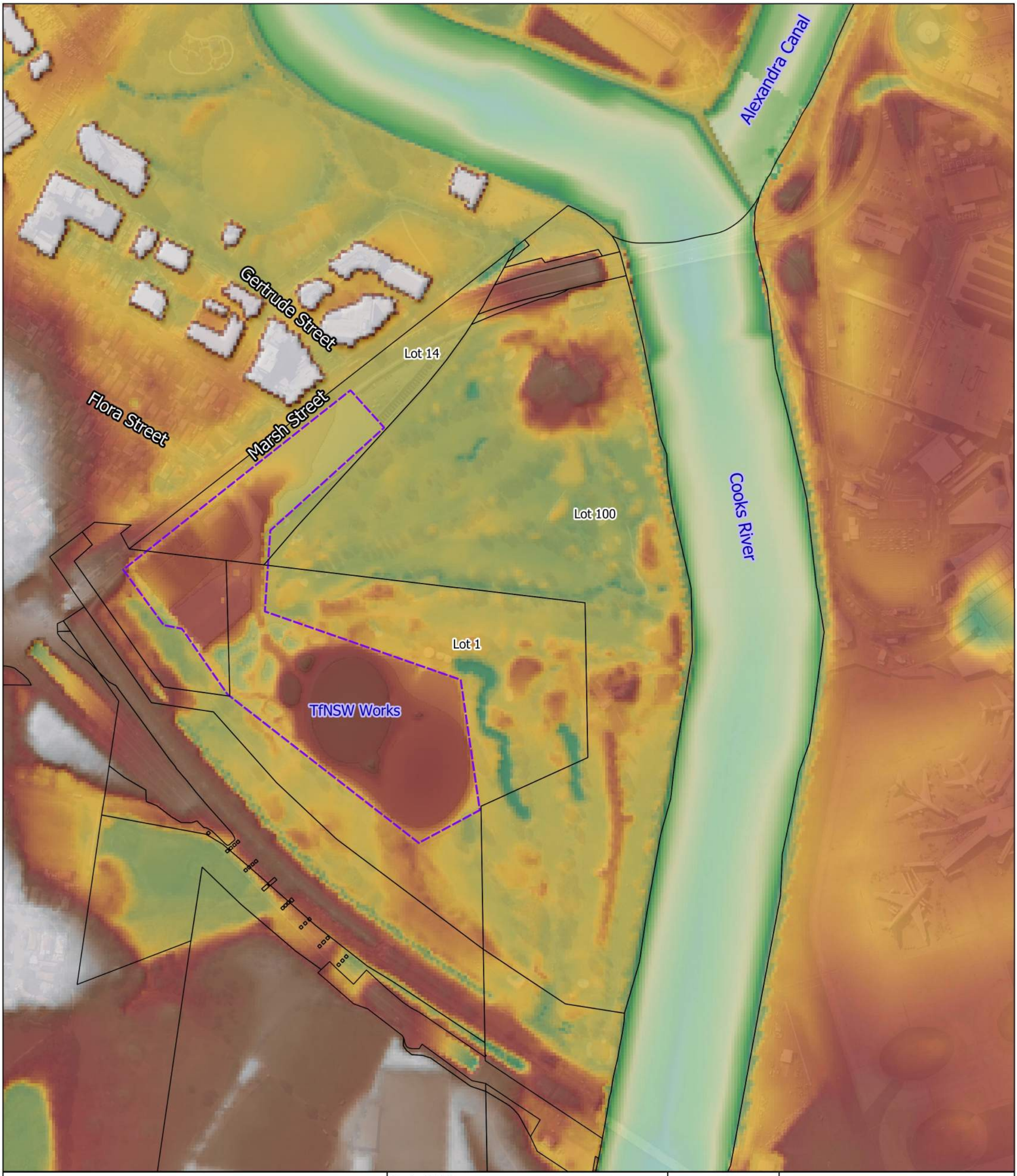
The assumed terrain for the base case scenario is presented in Figure 16. The modelled Manning n values are presented in Figure 17 for the study area and surrounds. The 1D elements includes in the flood model are presented in Figure 18.

### 5.1.4 Hydrological modelling and hydraulic model inflows

The Sydney Water Cooks River Flood Study (2009) used a Watershed Bounded Network Model (WBNM) software program to determine flows within the Cooks River and its tributaries. These inflows were then incorporated into the TUFLOW model at their respective point inlet locations. The inflows are based on rainfall parameters from ARR 1987.

This model sub-catchments and parameters have not been altered for this flood impact and risk assessment. The maps of the sub-catchments are provided in Figure 3-1 of the flood study report (MWH-PB, 2009)

To date, the inflows for this model have not been updated to ARR 2019. However, Section 7.3 of the Gateway Determination Flood Mitigations Options Assessment (Arup, March 2023) provides a comparison between the flows from this model and that used by TfNSW for the M6/M8 works which has been updated to ARR 2019. This indicates that the flows in the river are very similar for ARR 1987 and ARR 2019.




Legend

- Cadastre
- M6/M8 Permanent Facilities

Topography (mAHD)

10

-4

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
Terrain of Cooks River Flood Model for Assumed Base Case

| Job No | Figure No |
|---|---|
| 252942 | 16 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale**
0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

N

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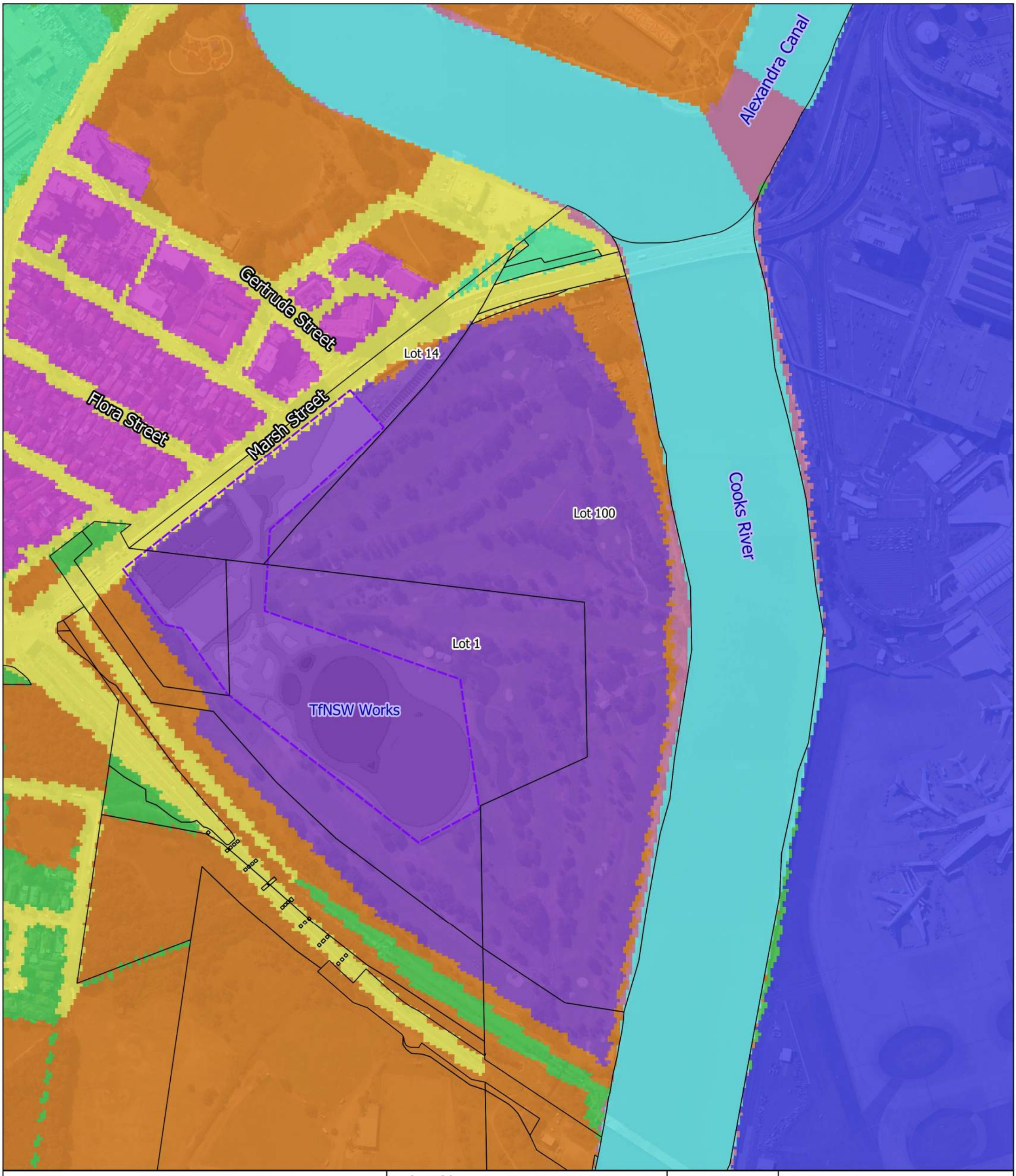
Sources: Google Maps, CNES/Airbus, Landsat/Copernicus, Maxar Technologies




Legend

- Cadastre
- M6/M8 Permanent Facilities

Manning's n

- 0.025
- 0.3
- 0.04
- 0.3
- 0.02
- 0.03
- 0.015
- 0.025
- 0.5

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
Manning n of Cooks River Flood Model for Assumed Base Case

| Job No | Figure No |
|---|---|
| 252942 | 17 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale** 0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

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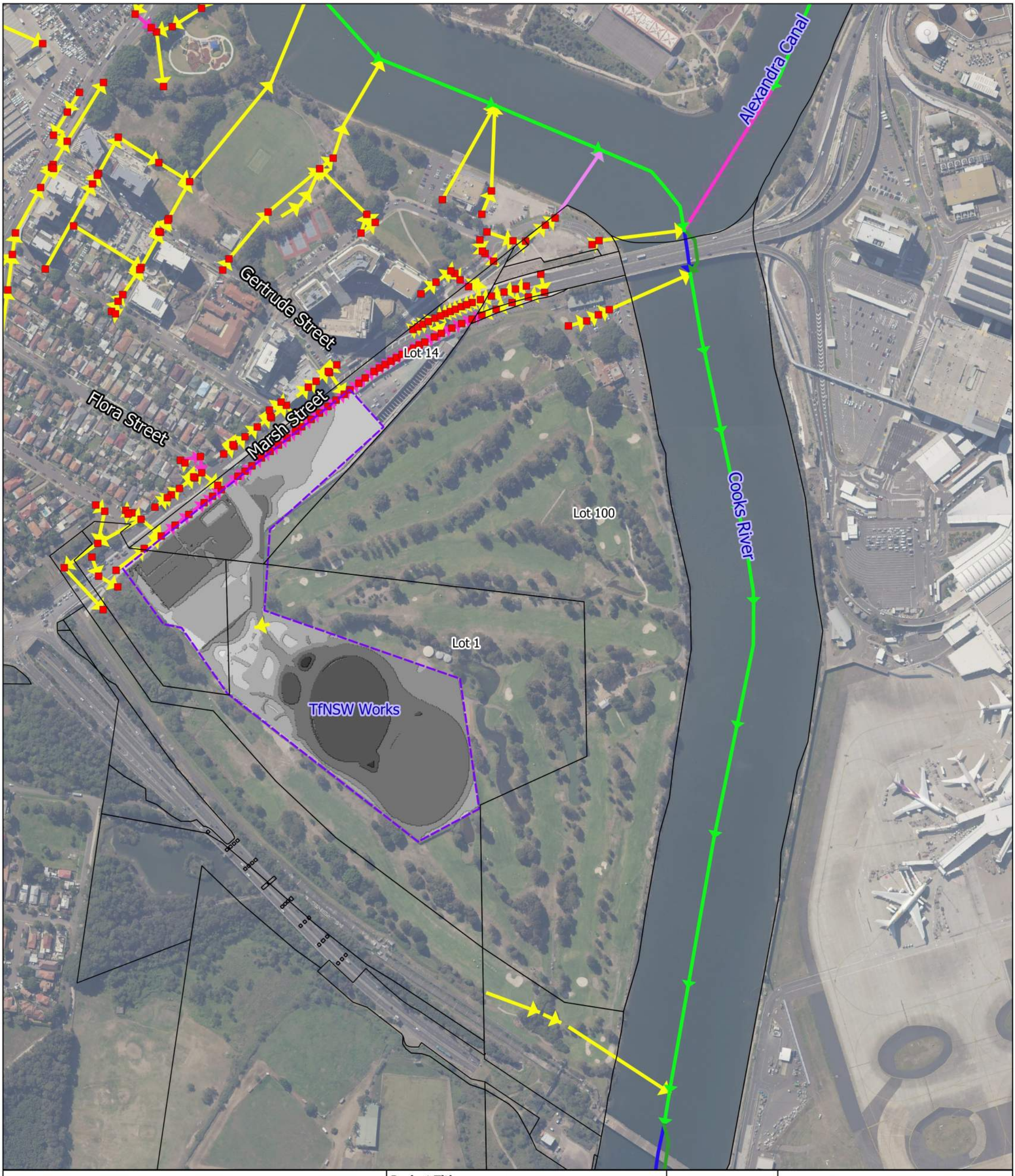


Legend

- Cadastre
- M6/M8 Permanent Facilities
- 1D Pits

1D Network

- Circular Culvert
- Rectangular Culvert
- Open Channel
- Weir Channel
- Connector
- Bridge Structure
- Flap Gated Culvert

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
1D Elements in Cooks River Flood Model for Assumed Base Case

| Job No | Figure No |
|---|---|
| 252942 | 18 |
| **Coordinate System** GDA 1994 MGA ZONE 56 | **Drawing Status** FINAL |

**Scale** 0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

N

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Sources: Google Maps, CNES/Airbus, Landsat/Copernicus, Maxar Technologies

### 5.1.5 Downstream Boundary conditions

The flood study used for the basis of this flood assessment is the Sydney Water Cooks River flood model (2009). This flood study used boundary conditions in Botany Bay of a HHWSS tide level (1.1mAHD) fixed level for all fluvial events including the 1% AEP and PMF.

A tidal inundation case was also simulated with a 1.7mAHD storm surge tidal boundary (with wind stress) and a coincident 50% AEP fluvial event. The report stated that "*a conservative estimate of the 1% AEP water level at the Cooks River entrance can be found by adopting the 1.45 m AHD level at Kurnell and then adding 0.25 m for storm-related effects to the downstream boundary at the Cooks River entrance*."

Since the 2009 flood study, DPE (but under the old name of OEH) has published Floodplain Risk Management Guide: Modelling the Interaction of Catchment Flooding and Oceanic Inundation in Coastal Waterways (OEH, 2015). This guidance *"outlines approaches that can be used to derive ocean boundary conditions and design flood levels for flood investigations in coastal waterways considering the interaction of catchment flooding and oceanic inundation for the various classes of estuary waterways found in New South Wales and likely corresponding ocean boundary conditions."*

The downstream boundaries for this flood assessment have been updated to reflect this guidance. Specifically, the following boundaries have been adopted consistent with Table 5.2 and Table 8.1 of the guidance for a waterway with entrance type A (tidal estuary) that is south of Crowdy Head. The timings of the Botany Bay tidal boundaries were adjusted such that the peak of the storm surge coincide with the peak flows in the river.

**Table 7: Adopted Botany Bay Tidal Boundary Conditions**

| Flood Event | Fluvial Input | Botany Bay Boundary | Peak Level |
|---|---|---|---|
| 5% AEP | 5% AEP flows | HHWS(SS) | 1.25mAHD |
| 1% AEP (envelope)* | 1% AEP flows | 5% AEP tidal | 1.40mAHD |
| | 5% AEP flows | 1% AEP tidal | 1.45mAHD |
| 0.5% AEP | 0.5% AEP flows | 1% AEP tidal | 1.45mAHD |
| 0.2% AEP | 0.2% AEP flows | 1% AEP tidal | 1.45mAHD |
| PMF | PMF flows | 1% AEP tidal | 1.7mAHD** |

** The 5% AEP fluvial inflows with the 1% AEP tidal boundary was found to be lower in all areas of the study area. Hence, the 1% AEP flood was taken as the 1% AEP fluvial inflows with the 5% AEP tidal boundary*

*** The PMF flood was simulated with a tidal boundary peaking at 1.7mAHD to accommodate the possibility of wind stresses (0.25m) on top of the storm surge boundary.*

A flood was also simulated with 1% AEP fluvial inflows and a low tide to assess high velocity situation (as per Table 8.1 of the guidance). This flood does not produce any break-out from the river and, hence, no flooding on or near the site.

### 5.1.6 Climate change assessments

In order to understand the flood behaviour in the future with the predicted effects of climate change, the range of flood events (i.e. 5%, 1%, 0.5%, 0.2% and PMF) were simulated with 20% increase in inflows and 0.9m sea level rise. However, for the PMF flood, only sea level rise was included as the rainfall intensities are already at the physical limit of probability.

### 5.1.7 Average Recurrence Interval of the PMF

The average recurrence interval or probability of the PMF occurring in a catchment can be estimated based on the size of the catchment. Book VI of *Australian Rainfall and Runoff 1998* provides guidance on estimating the probability of a Probable Maximum Precipitation (PMP) event occurring. For the Cooks River catchment, the calculated annual probability of the PMP event that would cause the PMF is 1 in 10 million.

## 5.2 Flooding Mechanisms

Due to its location within the Cooks River catchment, the proposal site has the potential to be subjected to three flooding mechanisms: overland flow from the local stormwater catchment, out of bank/mainstream flooding from the Cooks River, and tidal flooding from Botany Bay that travels up the Cooks River.

In this flood risk and impact assessment report, the primary focus is on the river flooding as this is the dominant flood mechanism. Local catchment flooding does not overtop Marsh Street except when the river is in flood which is actually river flooding. This is discussed further in Section 3.2.

The floodplain engages at about the 5% AEP river flood level. During this flood, floodwaters break out of the river at Cahill Park and flow southward towards Marsh Street. Inundation of the site in this flood only occurs due to floodwaters back-flooding through the Marsh Street pipe drainage and surcharging the roadside pits which then allows flow to pass on to the site. Flows do not pass over Marsh Street until the 1% AEP flood magnitude is reached.

## 5.3 Tidal Inundation Mechanisms

The crest of the riverbank along the right bank of the Cooks River is at or above 1.45mAHD. Hence, the 1% AEP storm surge alone up to this level would not inundate the site.

In a rarer storm surge event with wind stresses included, the river level would peak at 1.7mAHD. This event was simulated without any inflows from the catchment to understand the influence of tidal surge on the site. Peak flood levels on the site were low at 1.3mAHD. These levels are about 0.5m lower than the fluvial 1% AEP flood.

During this storm-surge dominated flood event, the inflow to the site is due to the pit and pipe network on Marsh Steet surcharging (from tidal back-flooding as the area to the north of Marsh Street is inundated with flow from the river. This back-up flows over the Marsh Steet footpath and into the site. Similar to the 5% AEP fluvial flood event, there is no overtopping of Marsh Street into the site.

There is some inundation in the south-eastern corner of the site due to elevated river levels up to 1.7mAHD.

Hence, this flooding mechanism is not expected to be dominant or cause greater flooding impacts than fluvial river flood events.

## 5.4 Existing Case Flood Behaviour

Complete flood modelling results for the existing case are presented in maps in Appendix A. These maps show flood extent, peak flood levels, depths, velocities and hazard across the site and surrounding area. As well, maps of flood function and flood emergency response classification are provided for all flood events assessed. Maps for current climate and those with climate change increases (sea level rise and rainfall increases) are also presented.

A description of the existing case flooding is provided below.

## 5.5 Existing Case Flood Extents and Properties Inundated

Figures A-1 to A-5 show the flood extents and properties inundated for the existing / base case. Properties north of Marsh Street and south of the Princes Highway have been digitised and floor levels have been assumed based on LiDAR data to be at ground level for the purposes of this comparative assessment.

The number of properties flooded in the area north of Marsh Street and south of the Princes Highway are listed below:

- 5% AEP flood = 10 properties
- 1% AEP flood = 29 properties
- 0.5% AEP flood = 44 properties

- 0.2% AEP flood = 47 properties
- Probable Maximum flood = 91 properties

## 5.6 Existing Case Flood Levels and Depths

Figures A-6 to A-10 show the peak flood levels and depths for the existing / base case. These are discussed for each flood event below.

### 5.6.1 5% AEP Existing Flood Event

The flood levels to the north of Marsh Street are 1.5m AHD, with levels dipping to 1.4m AHD as the water comes across Marsh Street. Peak flood depths across the Kogarah Golf course are less than 0.3m (apart from depressions / drains).

### 5.6.2 1% AEP Existing Flood Event

Flood levels to the north of Marsh Street are 1.9m AHD, with levels dipping to 1.7m AHD as the water comes across Marsh Street. The levels at the south-east corner of the site are 1.9m AHD.

The lowest flood levels on the site are those in the middle of the Kogarah Golf course. This is because there are two flood mechanisms at play in this flood. There are flows entering from the north that have passed over Marsh Street. As well, there is floodwaters backing up onto the site from the river at the south-eastern corner. The duration of flooding is not sufficient to fill the entire flooded area and the flood levels do not reach a constant level. Hence, the flood levels do not reach a point in which there is flow from north to south-east. Rather, the flood almost reaches a point where the flood storage on the site is filled.

Peak flood depths across the Kogarah Golf course are less than 0.9m (apart from depressions/ drains).

### 5.6.3 0.5% AEP Existing Flood Event

Water levels in the 0.5% AEP event are essentially a progression from the 1% AEP event with the flooded area in the middle of the site filling up. Flood levels to the north of Marsh Street are 2.1m AHD, with levels dipping to 2.0m AHD as the water comes across Marsh Street. The levels at the south-east corner of the site are 1.9m AHD.

Peak flood depths across the Kogarah Golf course are up to 1.2m deep (not including depressions / drains).

### 5.6.4 0.2% AEP Existing Flood Event

Water levels in the 0.2% AEP event follows a similar pattern to the 0.5% AEP event with more widespread flooding noticeable. Flood levels to the north of Marsh Street are 2.3m AHD, with levels dipping to 2.2m AHD as the water comes across Marsh Street. The levels at the south-east of the site are 2.1m AHD.

Peak flood depths across the Kogarah Golf course exceed 1.2m deep (not including depressions / drains).

### 5.6.5 Probable Maximum Flood

Flood levels to the north of Marsh Street are 3.2m AHD and dip slightly to 3.1m AHD as the water comes across the site.

### 5.6.6 Long Section Plot

A long section plots of peak flood levels is presented in Figure 19. The location of the line used to derive these long sections is presented in the flood level / depth maps in Appendix A.

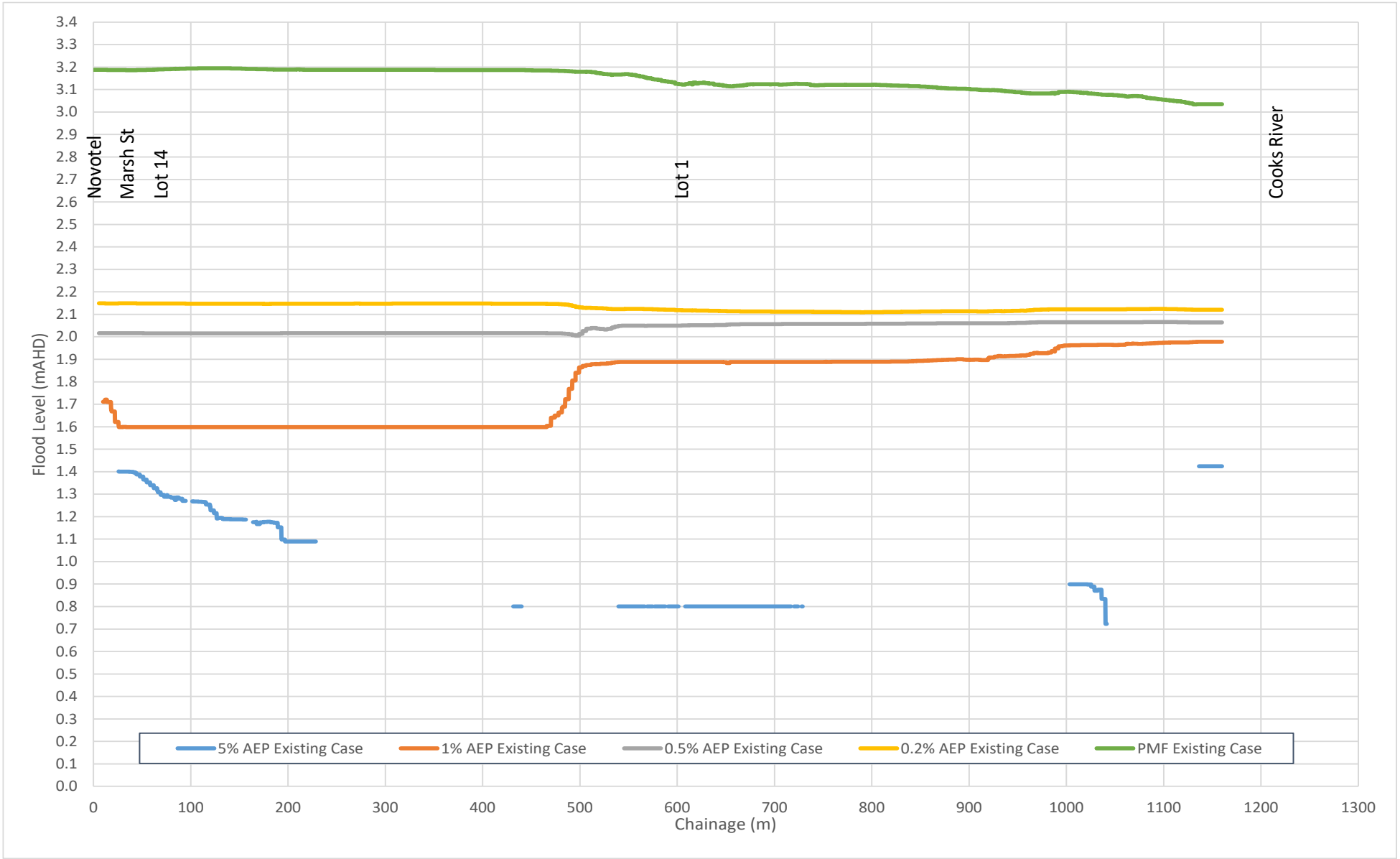


**Figure 19: Existing Case Long Section of Peak Flood Levels**

## 5.7 Existing Case Flood Velocities and Flows

Figures A-11 to A-15 show the peak flood velocities for the existing / base and discussed below:

- For the 5% AEP flood velocities are very low on the site and less than 0.5m/s.
- For the 1% AEP flood velocities are low on the site and generally less than 0.5m/s.
- For the 0.5% and 0.2% AEP flood events, velocities are low on the site and generally less than 0.5m/s with isolated patches up to 1.0m/s.
- For the PMF, velocities are generally less than 1.5m/s with isolated patches up to 2.0m/s

The duration and magnitude of flows through the site are discussed below.

### 5.7.1 5% AEP Existing Flood Event

The modelling indicates that there would be no inflow to the site in a 5% AEP flood due to the low river levels. The only inflow is back-up overflow from the pits in Marsh Street.

### 5.7.2 1% AEP Existing Flood Event

The modelling indicates that there would be about 5 $m^3/s$ passing into the site in a 1% AEP flood (which is about 0.6% of the river flow). The flow at the south-eastern corner of the site is negative flow (8 $m^3/s$ which is about 1% of the river flow) indicating the river is back-flooding into the site to fill up the floodplain storage. At the peak of the flood (approximately 1.8 hours), there is flow over Marsh Street and back-flooding from the river.

Beyond approximately 2 hours into the flood event, the flows begin the drain from the site as the river levels recede to below the flood levels on site. There is only a very short period of time (about 20 minutes) in which there is flow into the site of about 1.5 $m^3/s$ and flow out of the site of a similar magnitude.

Peak velocity-depths across the site are very low and no higher than 0.3$m^2/s$ (except for the lakes areas).

This flood behaviour is consistent with a flood storage area filling from two sources on a floodplain. The hydrographs of inflows (two locations) and outflows (one location) for this flood are presented in Figure 20.

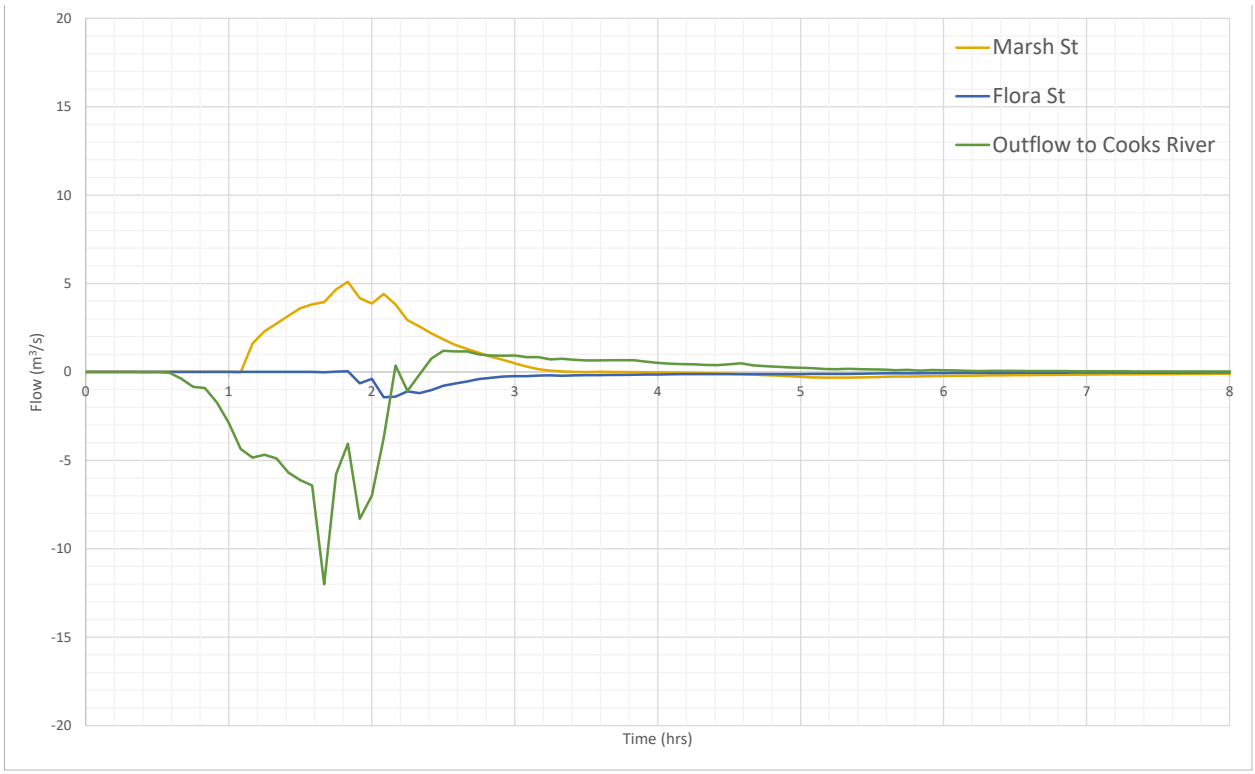


**Figure 20: 1% AEP Existing Case Inflows and Outflows from site**

### 5.7.3 0.5% AEP Existing Flood Event

The modelling indicates that there would be about 12 $m^3/s$ passing into the site in a 0.5% AEP flood. However, at the same time that this inflow peaks, there is still backflow from the river (about 7 $m^3/s$). Only towards the end of the flood event once river levels have peaked is there flow across Marsh Street of about 4 $m^3/s$ and a similar flow exiting the site into the river. The hydrographs of inflows (two locations) and outflows (one location) for this flood are presented in Figure 21.

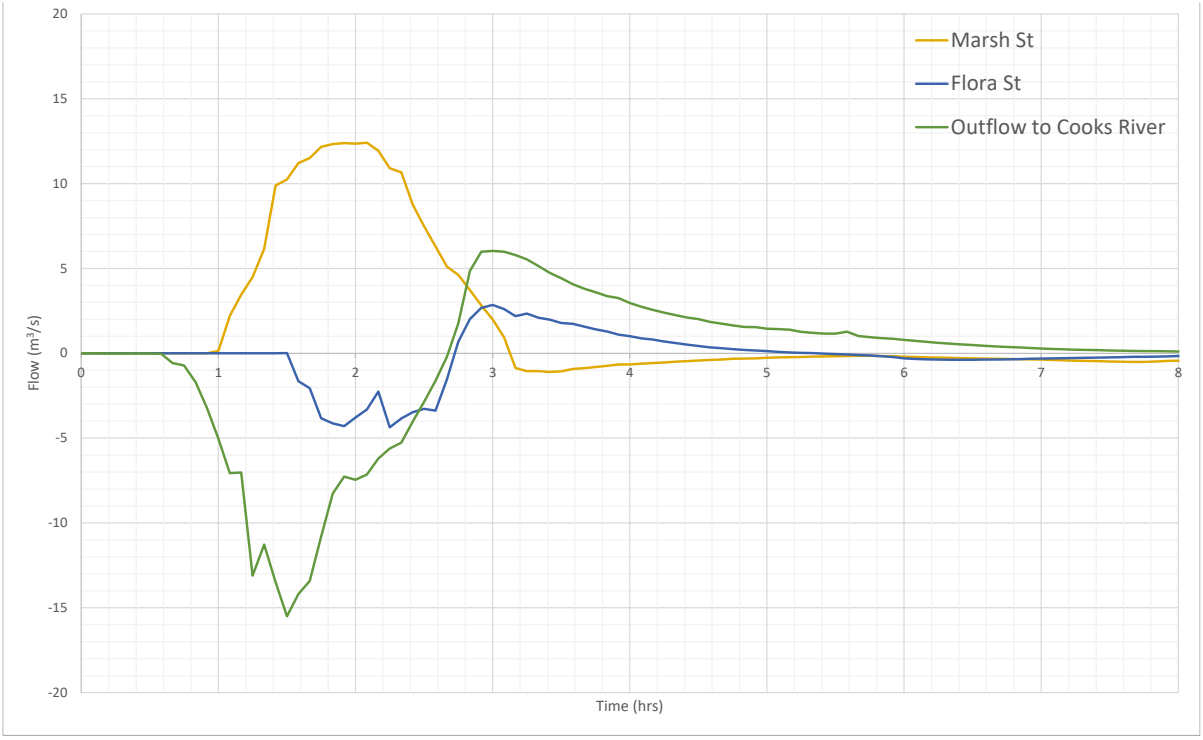


**Figure 21: 0.5% AEP Existing Case Inflows and Outflows from site**

### 5.7.4 0.2% AEP Existing Flood Event

The modelling indicates that there would be about 17 $m^3/s$ passing into the site in a 0.2% AEP flood. The hydrographs of inflows (two locations) and outflows (one location) for this flood are presented in Figure 22.

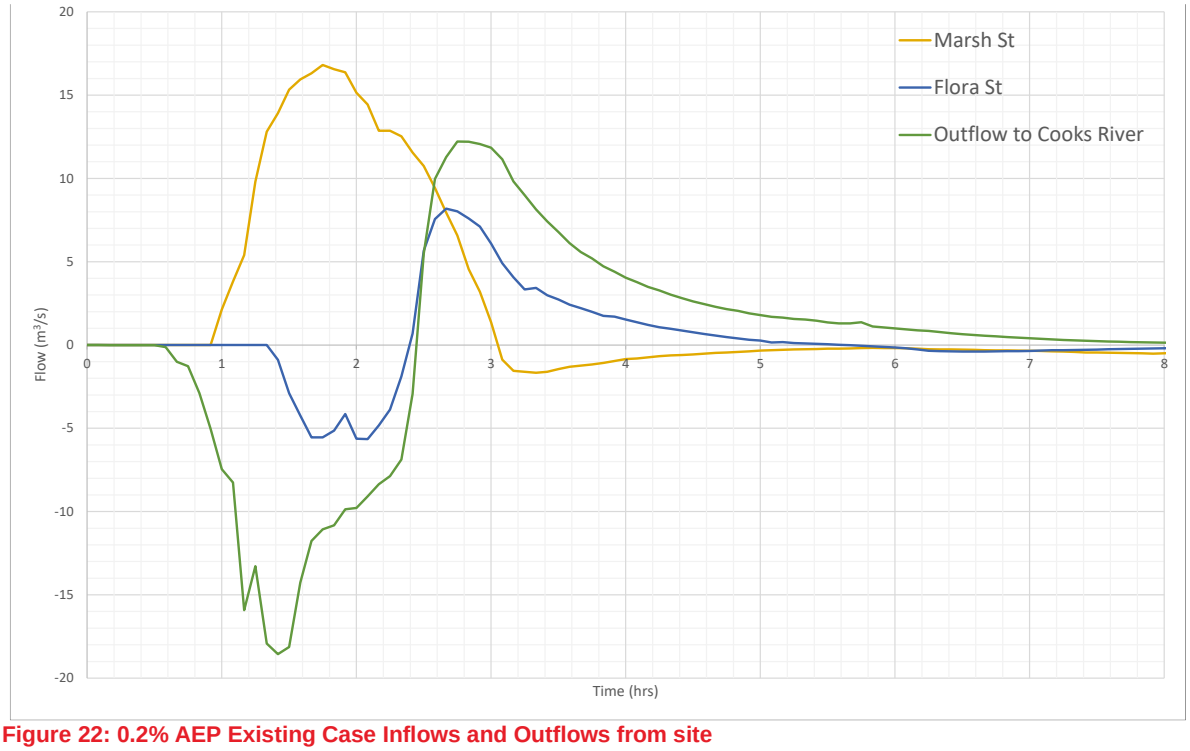


**Figure 22: 0.2% AEP Existing Case Inflows and Outflows from site**

### 5.7.5 Probable Maximum Flood

The modelling indicates that there would be about 170 $m^3/s$ passing into the site in a PMF. The hydrographs of inflows (two locations) and outflows (one location) for this flood are presented in Figure 23.

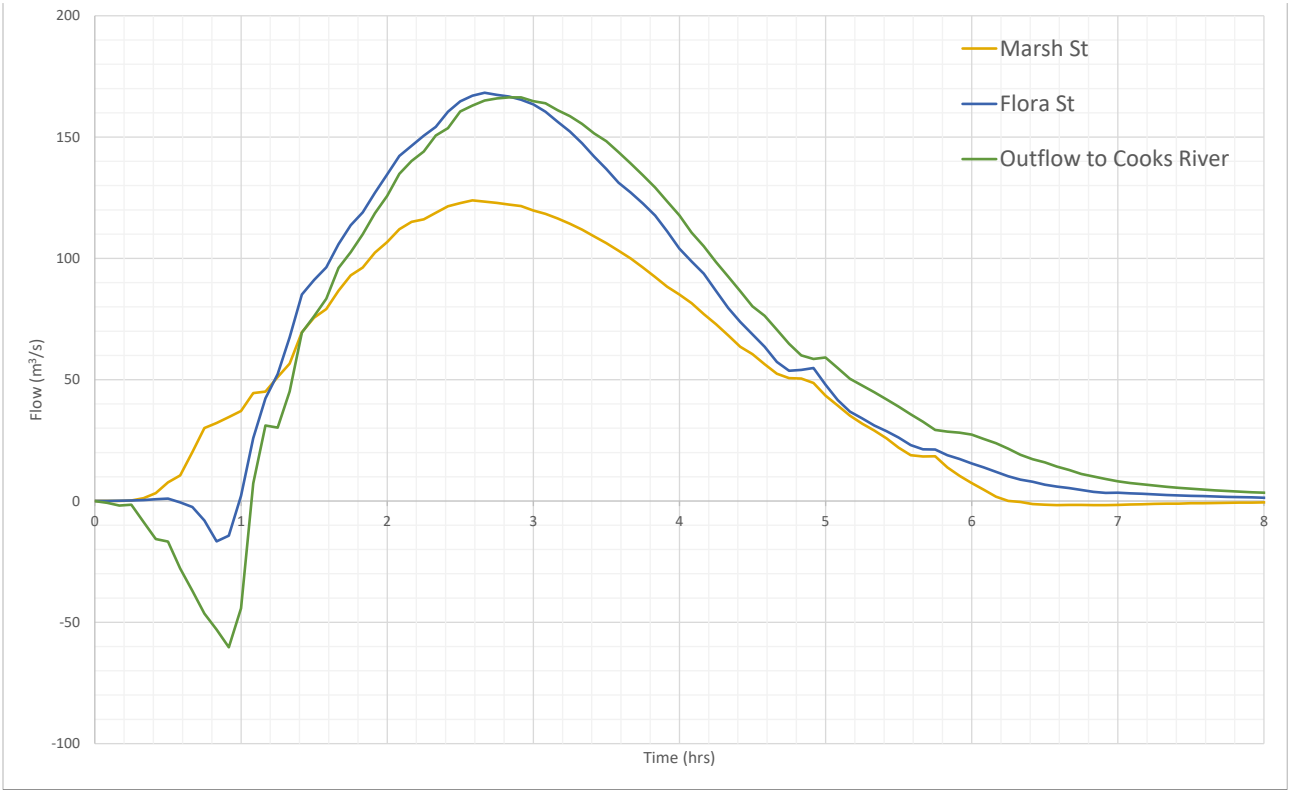


**Figure 23: PMF Existing Case Inflows and Outflows from site**

## 5.8 Existing Case Flood Hazard (AIDR)

### 5.8.1 Flood Hazard Classification

The consideration of potential impacts to risk to life, structural stability and other damages has been assessed based on provisional flooding hazard categorisation.

The Australian Institute for Disaster Resilience (AIDR) released a set of guidelines for responsible management of floodplains in 2017, which cover some of the gaps that may be found in state guidelines.

The document outlines a more comprehensive set of hazard thresholds relating to the vulnerability of the community when interacting with floodwaters.

The set of curves presented in Figure 24 depict six hazard categories based on floodwater velocity-depth relationships.

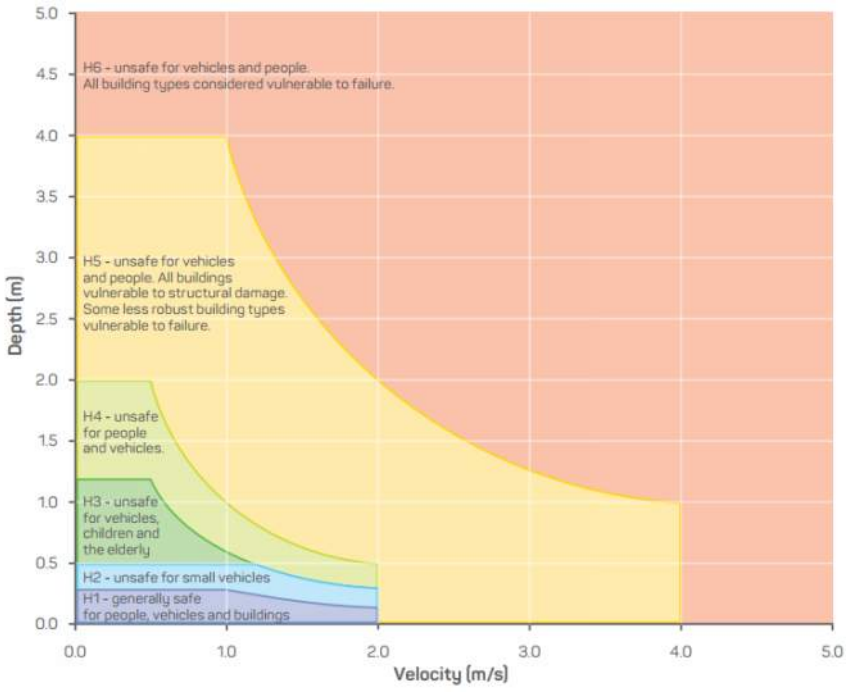


**Figure 24: Hazard classification according to AIDR (2017)**

### 5.8.2 Summary of Flood Hazards for a Range of Flood Events

Figures A-16 to A-20 show the peak flood hazard classifications for the existing / base case and these are discussed below.

- The is only a small amount of inundation primarily on Lot 14 in the 5% AEP flood which is H1 (apart from depression, lakes and drains).
- In the 1% AEP flood the majority of the site is H1, H2 and H3 with some small areas of H4 where the lakes are located. The hazards are strongly dictated by the depths on site as the velocities are low (however, peak velocities occur at much lower depths as the site fills which is consistent with a flood storage areas during the filling phase).
- In the 0.5% AEP flood the majority of the site is H3 due to the depth of the flooding over 0.5m.
- In the 0.2% AEP flood the majority of the site is H3 due to the depth of the flooding over 0.5m and there are some areas of H4 (apart from the lakes which are H5).
- In the PMF flood the majority of the site is H4 with large areas of H5 due to the high flow of over 100 $m^3/s$ passing through the site.

## 5.9 Existing Case Duration of Inundation

Based on the time series plots presented in Section 1.1, the following is a summary of the time of inundation on the site for range of flood events:

- 5% AEP flood = almost no duration of inundation due to the small amount of inflow to the site
- 1% AEP flood = approximately 5 hours of inundation
- 0.5% AEP flood = approximately 7 hours of inundation
- 0.2% AEP flood = approximately 9 hours of inundation
- Probable Maximum flood = approximately 10 hours of inundation

For a discussion on the duration of inundation of emergency access routes, see Section 7.4.4.

## 5.10 Existing Case Flood Function Mapping

Flood function mapping for the site has been carried out for the base / existing case consistent with the guidance supplied by DPE (Flood Function: Flood Risk Management Guideline FB02, 2023).

The identification of the floodway is in the context of the flood behaviour through the site in isolation. However, if the whole river system is considered for the delineation of flood function, then the flows through and into the site would all be flood fringe (with some flood storage) as well over 80% of the flow is contained in the river.

Figures A-21 to A-25 show the flood function mapping for the existing / base case and these are discussed below.

- For the 5% AEP flood, there is only a small volume of water entering the site and this is all flood storage.
- For the 1% AEP, there are flows over Marsh Street and back-flooding from the river (from the south-eastern corner). These flows fill the flood storage on the golf course. The flood levels on the site are never higher than those in the river at the peak of the flood. As the river levels recede, the floodwaters on the site flow out of the site into the river at the south-eastern corner. Flood model testing has confirmed that filling all of this area would result in afflux external to the site. Smaller areas were tested to derive the appropriate Flood Storage area. The remainder of the inundated area is Flood Fringe (as it is not Floodway as there is not a fully active flowpath from north to south-east through the site in this flood event). It should be noted that a large proportion of the original flood storage on the site has been filled as part of the M6/M8 works by TfNSW.

- For the 0.5% AEP, the site is transitioning from Flood Fringe to Floodway. The majority of the flood is dominated by flood storage filling from Marsh Street and from the river (from the south-eastern corner). However, there is still not a fully active flowpath from north to south-east through the site in this flood event. Hence, the inundated areas are mapped as Flood Storage and Flood Fringe.
- For the 0.2% AEP floods, there is a floodway corridor through the middle of the site as the site fills completely and there is a period of time (about 1 hour) when there is positive flow through the site and exiting into the river in the order of 10 $m^3/s$. There are some flood storage areas on the edge of the inundated area that were identified by assessing if filling these areas would result in impacts upstream.
- For the PMF, the floodway zone is similar in size but slightly larger than that for the smaller floods. However, there is no flood storage area.

Flood function mapping for the area north of Marsh Street was not carried out as there are no predicted changes to flood behaviour north of Marsh Street and, hence, no predicted changes to flood function mapping due to the Planning Proposal.

## 5.11 Existing Case Flood Emergency Response Classification

Figures A-26 to A-30 show the Flood Emergency Response Classifications for the existing / base case and these are discussed below. This mapping has been carried out for the single building that exists on the site (Kogarah Golf Course clubhouse). The building is classified as a High Flood Island for all assessed flood events (including the 5% AEP flood) as there is no rising road access in these events and there is access to nearby high land that is above the PMF level.

There was not any value in mapping the Flood Emergency Response Classifications for the urban areas north of Marsh Street as the Planning Proposal does not change the flood behaviour in this area. Hence, the Flood Emergency Response Classifications would remain unchanged.

## 5.12 Effect of Climate Change of Existing Case Flood Behaviour

To assess the effects of climate change on flood behaviour, the DPE guidance documents (Flood Impact and Risk Assessment: Flood Risk Management Guide LU01, DPE, 2022) suggest that *"modelling could assess sensitivity of flood behaviour to changes by using either the 0.5% and/or 0.2% AEP event as an indicator of sensitivity to change in the 1% AEP flood event."*

However, to provide a more robust assessment of the effect of climate change on this site (due to the proximity to the river mouth), a combination of rainfall intensity increase and sea level rise was simulated for the full range of events assessed as shown in Table 8.

**Table 8: Adopted Climate Change Assessments**

| Flood Event | Flow Increase | Botany Bay Level Increase |
|---|---|---|
| 5% AEP | 20% AEP flow increase | 0.9m sea level rise |
| 1% AEP | 20% AEP flow increase | 0.9m sea level rise |
| 0.5% AEP | 20% AEP flow increase | 0.9m sea level rise |
| 0.2% AEP | 20% AEP flow increase | 0.9m sea level rise |
| PMF | No increase | 0.9m sea level rise |

** No changes were made to the PMF flows as these are deemed to be at the upper limit of the possible rainfall*

Figures A-31 to A-35 show the peak flood levels and depths for the existing / base case with climate change.

# 6. Post developed modelling and analysis

## 6.1 Proposed development flood assessment

### 6.1.1 Hydraulic Model Parameters for Existing Case

The flood model was adapted to represent the Cooks Cove Planning Proposal. The terrain of this case is shown in Figure 25. The changes in ground level as a result of the Planning Proposal are shown on Figure 26.

Areas of internal roads will be constructed at 2.5mAHD. Building areas will be constructed to above the PMF level of 3.5mAHD. Flora Street South has been raised in the latest design to 2.17mAHD.

The open space areas on Lot 14 and Lot 1 (as well as the floodway dedicated parts of Lot 100) will have levels varying from 0.8mAHD up to 2.5mAHD. It is currently proposed to remove some of the fill from the proposed TfNSW landscaped area inside the current TfNSW lease area.

However, there is sufficient flexibility in the design that the intrusion into the northern boundary of the TfNSW lease area could be removed (see Section 4.1 of the Response to Submissions report).

The Manning's n for the Planning Proposal model is shown in Figure 27. The open space areas will have a similar Mannings n as those used for the current golf course.

There were also a number of culverts included in the model to represent those required for the design. These include the following (model element location shown in Figure 28):

- 10 x 3.0m wide x 0.75m high RCBC's under Flora Street South
- 8 x 2.1m wide x 0.45m high RCBC's under High Street (Gertrude St extension)
- 4 x 900 RCP's at the south-western corner of the site to allow drainage out of the site following floods (these will be flap-gated to avoid storm surge or tidal inflows)
- 1 x 525 RCP in between Block 2 and Block 3 of the site to accommodate drainage out of the site (this will be flap-gated to avoid storm surge or tidal inflows).

These culverts were changed in the design in response to the issues raised in the submissions relating to evacuation and duration of inundation.


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Development Buildings
- Extent of Development Footprint

Topography (mAHD)

10

-4

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
Terrain of Cooks River Flood Model for Cooks Cove Planning Proposal Case

| Job No | Figure No |
|---|---|
| 252942 | 25 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale**
0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

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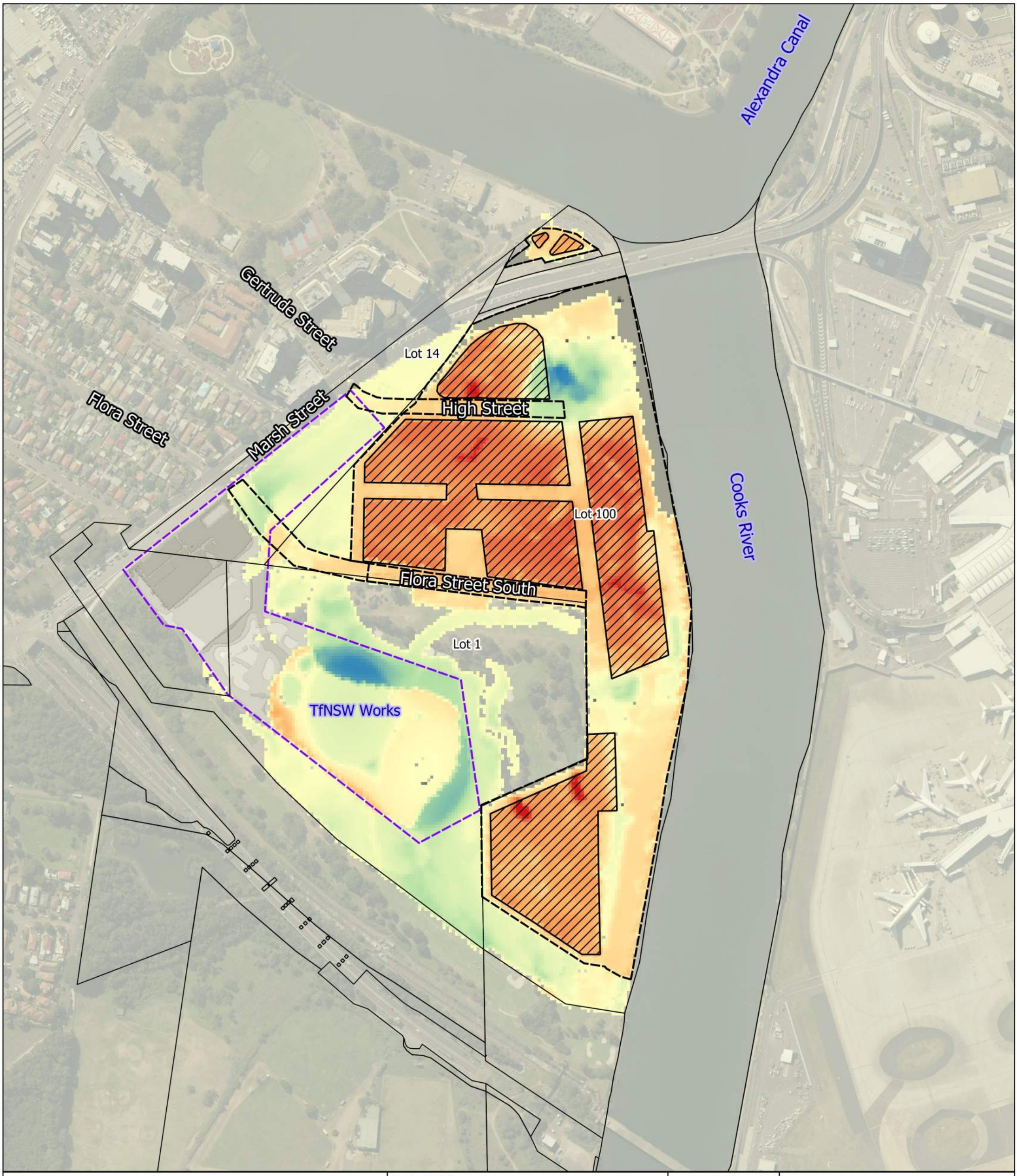
**Disclaimer**



Sources: Google Maps, CNES/Airbus, Landsat/Copernicus, Maxar Technologies




Legend

- Cadastre
- M6/M8 Permanent Facilities
- Development Buildings
- Extent of Development Footprint

Change in Topography for Design Case (m)

4

-4

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
Change in Terrain of Cooks River Flood Model for Cooks Cove Planning Proposal Case

| **Job No** | **Figure No** |
|---|---|
| 252942 | 26 |
| **Coordinate System** GDA 1994 MGA ZONE 56 | **Drawing Status** FINAL |

**Scale**
0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

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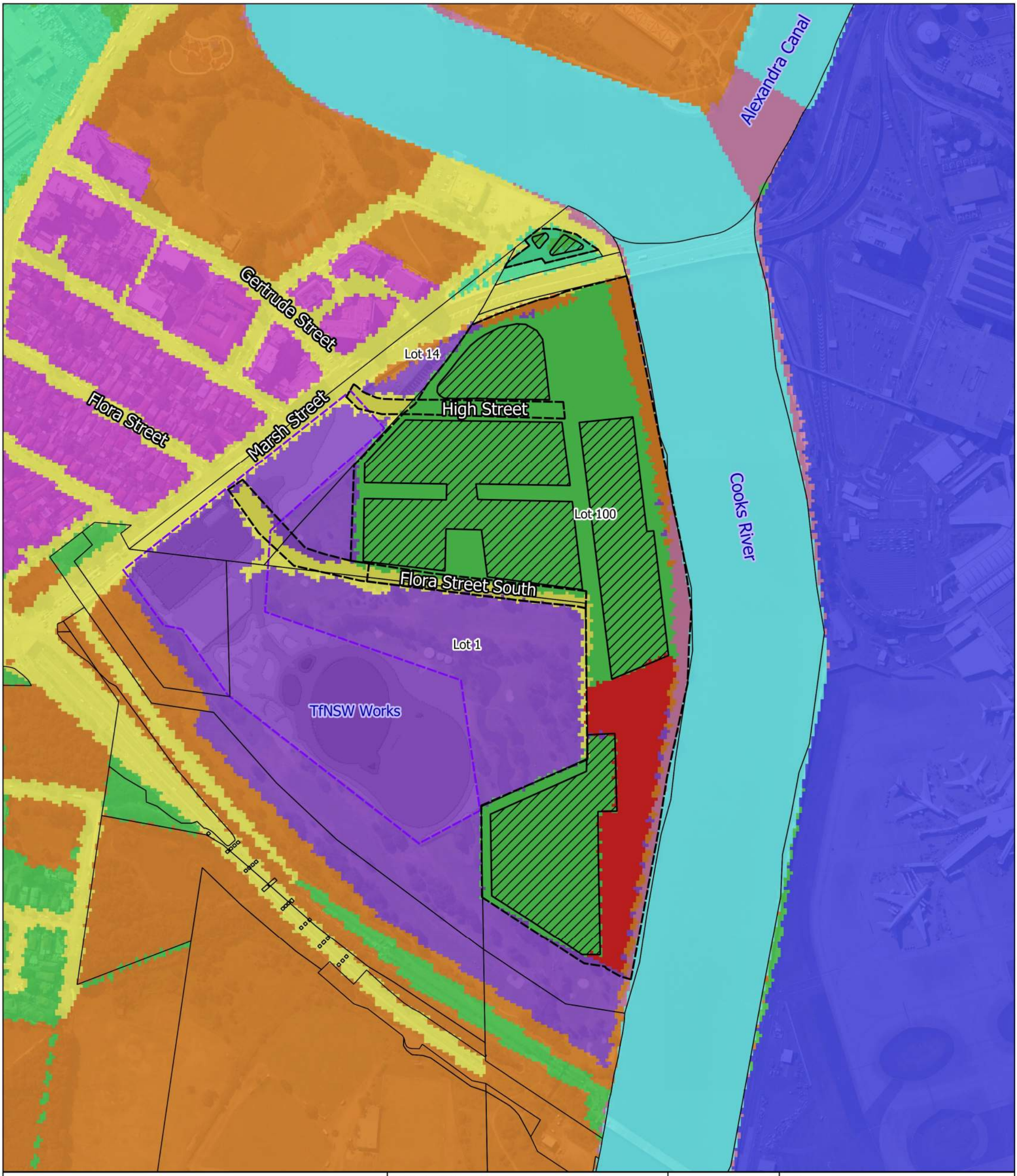


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Development Buildings
- Extent of Development Footprint

Manning's n

- 0.025
- 0.3
- 0.04
- 0.3
- 0.02
- 0.03
- 0.015
- 0.025
- 0.5
- 0.015

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
Manning n of Cooks River Flood Model for Cooks Cove Planning Proposal Case

| Job No | Figure No |
|---|---|
| 252942 | 27 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale** 0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

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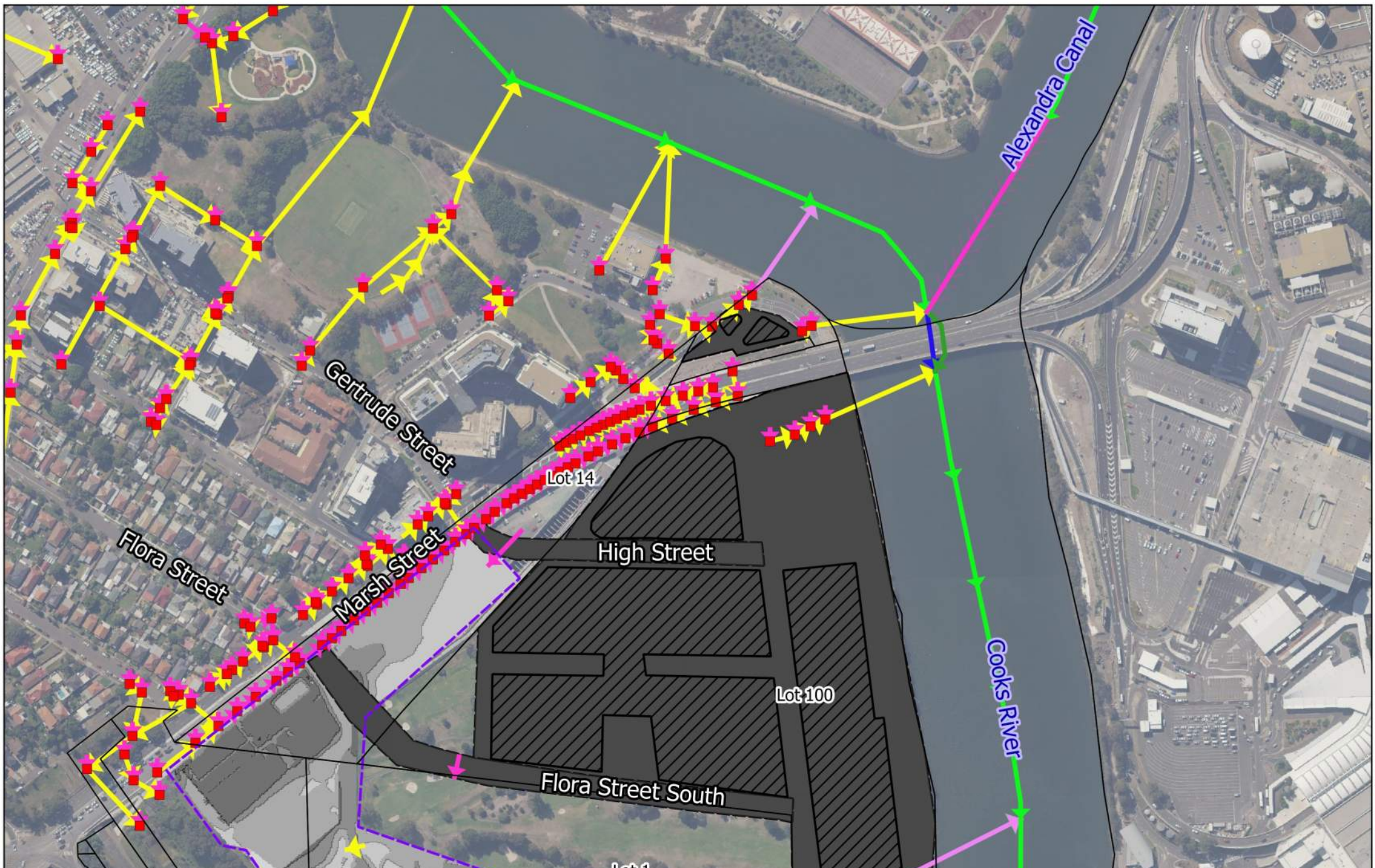


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Development Buildings
- Extent of Development Footprint
- 1D Pits

1D Network

- Circular Culvert
- Rectangular Culvert
- Open Channel
- Weir Channel
- Connector
- Bridge Structure
- Flap Gated Culvert

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
1D Elements in Cooks River Flood Model for Cooks Cove Planning Proposal Case

| Job No | Figure No |
|---|---|
| 252942 | 28 |
| **Coordinate System** GDA 1994 MGA ZONE 56 | **Drawing Status** FINAL |

**Scale** 0 40 80 120 160 200 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

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Sources: Google Maps, CNES/Airbus, Landsat/Copernicus, Maxar Technologies

## 6.2 Planning Proposal Case Flood Behaviour

Complete flood modelling results for the case with the Cooks Cove Planning Proposal constructed are presented in maps in Appendix B. These maps show flood extent, peak flood levels, depths, velocities and hazard across the site and surrounding area.

As well, maps of flood function and flood emergency response classification are provided for all flood events assessed. Maps for current climate and those with climate change increases (sea level rise and rainfall increases) are also presented.

A description of the proposal case flooding is provided in the sections below.

## 6.3 Planning Proposal Case Flood Extents and Properties Inundated

Figures B-1 to B-5 show the flood extents and properties inundated for the Planning Proposal case. The number of properties flooded in the area north of Marsh Street and south of the Princes Highway are listed below:

- 5% AEP flood = 10 properties
- 1% AEP flood = 29 properties
- 0.5% AEP flood = 44 properties
- 0.2% AEP flood = 47 properties
- Probable Maximum flood = 90 properties

There is would not be any change to the number of flooded properties as a result of the Planning Proposal even with the large increase in buildings and floor area on the site proposed as part of the the Planning Proposal. This is primarily due to the setting of floor levels above the PMF levels.

For all floods greater than the 0.2% AEP flood (including the 1:2000 AEP flood), there is one less property flooded due to the Planning Proposal which is the current Kogarah Golf Clubhouse.

## 6.4 Planning Proposal Case Flood Levels and Depths

Figures B-6 to B-10 show the peak flood levels and depths for the Planning Proposal case. Changes to flood levels and depths external to the site are discussed below in Section 6.5.

### 6.4.1 5% AEP Planning Proposal Flood Event

The flood levels to the north of Marsh Street are 1.5m AHD, with levels dipping to about 1.0m AHD on Lot 14 as the water comes across Marsh Street. Peak flood depths across the open space parts of the Planning Proposal are less than 0.3m (apart from depressions / drains).

### 6.4.2 1% AEP Planning Proposal Flood Event

Flood levels to the north of Marsh Street are 1.9m AHD, with levels dipping to 1.5m AHD as the water comes across Marsh Street. The levels at the south-east corner of the site are 1.9m AHD.

The lowest flood levels on the site are those in the open space parts of the Planning Proposal which fill to 1.5mAHD due to the flow passing over Marsh Street. There is no flow back-flooding onto the site due to the proposed 4 x 900 RCP outflow pipes in the south-eastern corner of the site.

The duration of flooding is not sufficient to fill the entire flooded area and the flood levels do not reach a constant level with those north of Marsh Street nor do the levels overtop the land at the south-eastern corner of the site. Hence, the flood levels do not reach a point in which there is flow from north to south. Rather, the flood reaches a point where the flood storage on the site is partially filled.

Peak flood depths across the open space parts of the Planning Proposal are less than 0.9m (apart from depressions/ drains).

### 6.4.3 0.5% AEP Planning Proposal Flood Event

Flood levels in the 0.5% AEP event are essentially a progression from the 1% AEP event with the flooded area in the middle of the site filling up. Flood levels to the north of Marsh Street are 2.1m AHD, with levels dipping to 1.95m AHD as the water comes across Marsh Street. The levels at the south-east corner of the site are just above 2.0m AHD.

Peak flood depths across the open space parts of the Planning Proposal are up to 1.2m deep (not including depressions / drains).

### 6.4.4 0.2% AEP Planning Proposal Flood Event

Flood levels in the 0.2% AEP event follows a similar pattern to the 0.5% AEP event with more widespread flooding noticeable. Flood levels to the north of Marsh Street are 2.3m AHD, with levels dipping to 2.15m AHD as the water comes across Marsh Street. The levels at the south-east of the site are 2.15m AHD. Hence, all of the flood storage on the open space parts of the Planning Proposal are filled and there is flow from north to south.

Peak flood depths across the open space parts of the Planning Proposal exceed 1.2m deep (not including depressions / drains).

### 6.4.5 Probable Maximum Flood for Planning Proposal

Flood levels to the north of Marsh Street are 3.2m AHD and dip slightly to 3.1m AHD as the flood flows traverse through the open space parts of the Planning Proposal. Flood depths in the internal road network would be up to 0.7m.

### 6.4.6 Long Section Plot for Planning Proposal

A long section plots of peak flood levels is presented in Figure 29. The location of the line used to derive these long sections is presented in the flood level / depth maps in Appendix B.

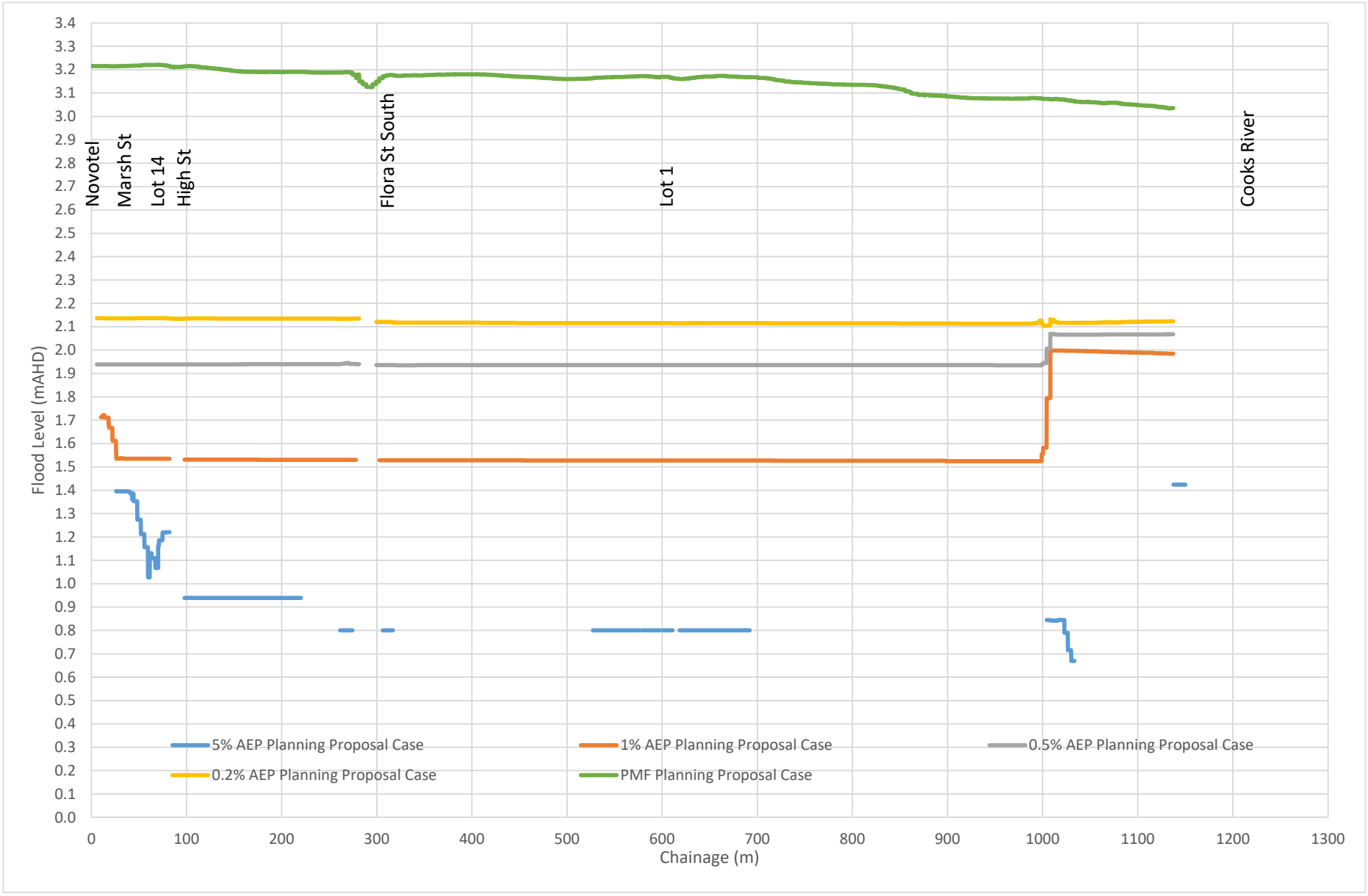



**Figure 29: Planning Proposal Case Long Section of Peak Flood Levels**

## 6.5 Impacts to Flood Levels and Depths due to Planning Proposal

Figures B-11 to B-15 show the afflux (change in flood levels) for the Planning Proposal case.

The proposal would not result in any increases to flood levels external to the site in all floods up to and including the 0.2% AEP flood. Minor decreases would occur in the area to the north of Marsh Street (eg Novotel Hotel area).

In a 0.5% AEP flood, there would be a small area just north of the Novotel Hotel where the flood model indicates an increase of about 12mm. This area is in the parking area of the Novotel Hotel and it is likely that this is a modelling anomaly as an increase here is inconsistent with the flood level decreases predicted nearby.

Note that there would be afflux on the southern boundary of Lot 1 in the order of 180mm in the 0.5% AEP flood and 250mm in the 0.2% AEP flood. This afflux is an artefact of the chosen base case for this assessment which includes the M6/M8 sports fields and frog ponds. These works effectively reduce the ability of flood flows to back up into this area. In the long-term alternative base case prior to 2017, flood waters could backup into this area unimpeded and the flood level in this area was the same as other areas on the golf course. For a very short period of time, when the full extent of the planned TfNSW works are completed, the flood level in this area would drop by about 200mm in these flood events. Then, with the adopted option, floodwaters would be again able to backup into this area unimpeded and the flood level would revert to the flood levels prior to the TfNSW works. Hence, the mapping of afflux showing the difference between the TfNSW works case and the adopted option case indicate an increase here of 180mm/250mm. However, in reality, this increase is actually a reversal of the negative afflux (i.e. reduction in flood levels of 180mm/250mm) that is a result of the M6/M8 sports fields and frog ponds.

## 6.6 Planning Proposal Case Flood Velocities and Flows

The Planning Proposal has been designed to re-direct the flows on the site into a corridor along Lot 14 and between the TfNSW works and the proposed development on Lot 100. Two parts of Lot 100 (each about 7000m$^2$) have been dedicated to allow floodwaters to pass through the site without resulting in upstream impacts.

Figures B-16 to B-20 show the peak velocities for the Planning Proposal case and these are discussed below.

- For the 5% AEP flood velocities are very low on the site and less than 0.5m/s.
- For the 1% AEP flood velocities are low on the site and generally less than 0.5m/s.
- For the 0.5% and 0.2% AEP flood events, velocities are low on the site and generally less than 0.5m/s with isolated patches up to 1.0m/s.
- For the PMF, velocities are generally less than 1.5m/s with isolated patches up to 2.0m/s and some areas over 2.0m/s where flows pass over roads or embankments.

Figure 30 to Figure 34 present the flow hydrographs at the three critical locations as used in Section 5 for the existing case. For the purposes of comparison, the existing case flows are also shown. The flows at Flora Street (South) are the flows over the road (only in PMF) and through the large box culvert.

These plots show that the duration of flooding on the site is generally unchanged. There is a change in the magnitude of flows due to the re-arrangement of the floodway areas and the filling of the site.

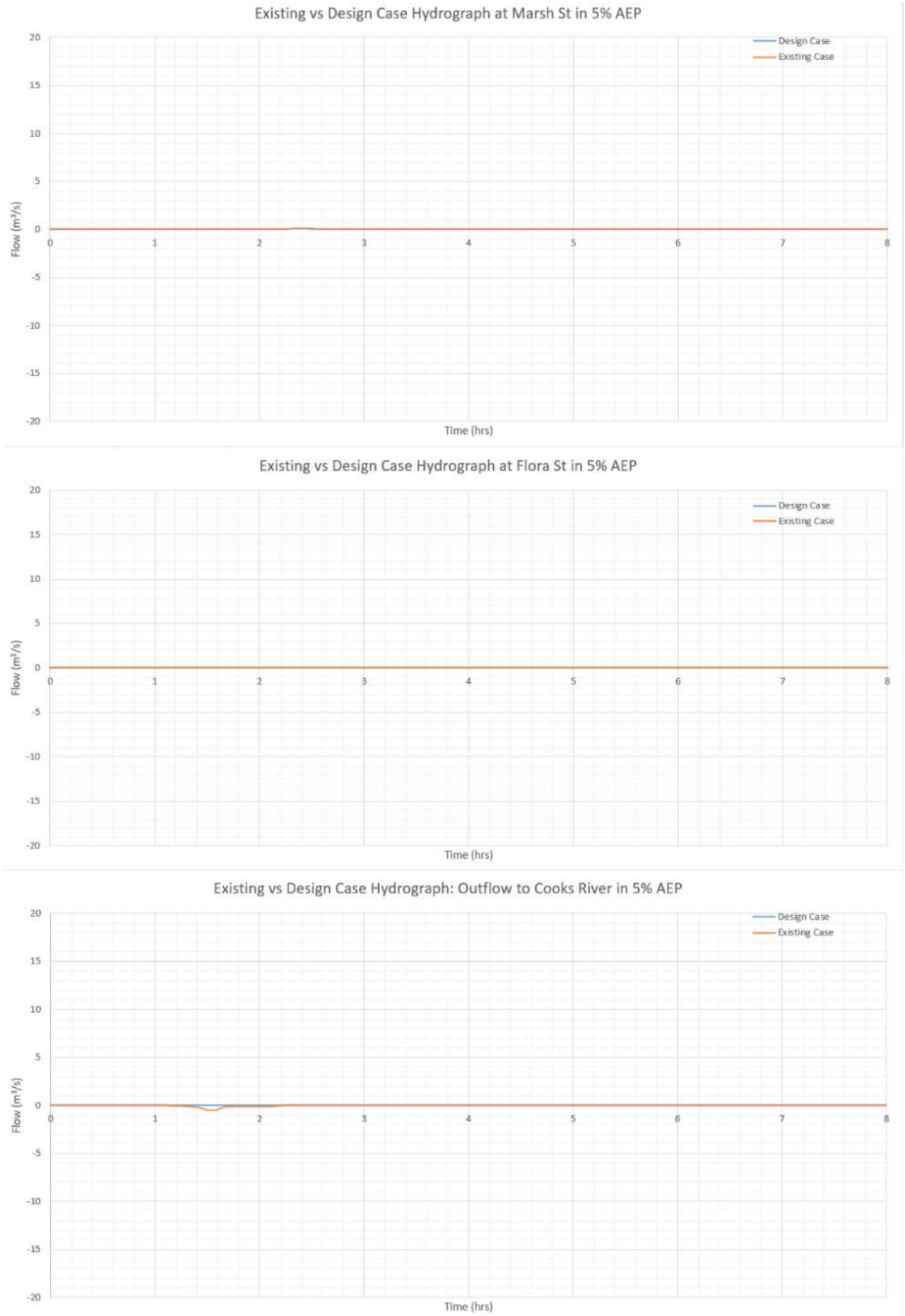



**Figure 30: 5% AEP Flood Flows and Duration of Flows (Existing Case vs Planning Proposal Case)**

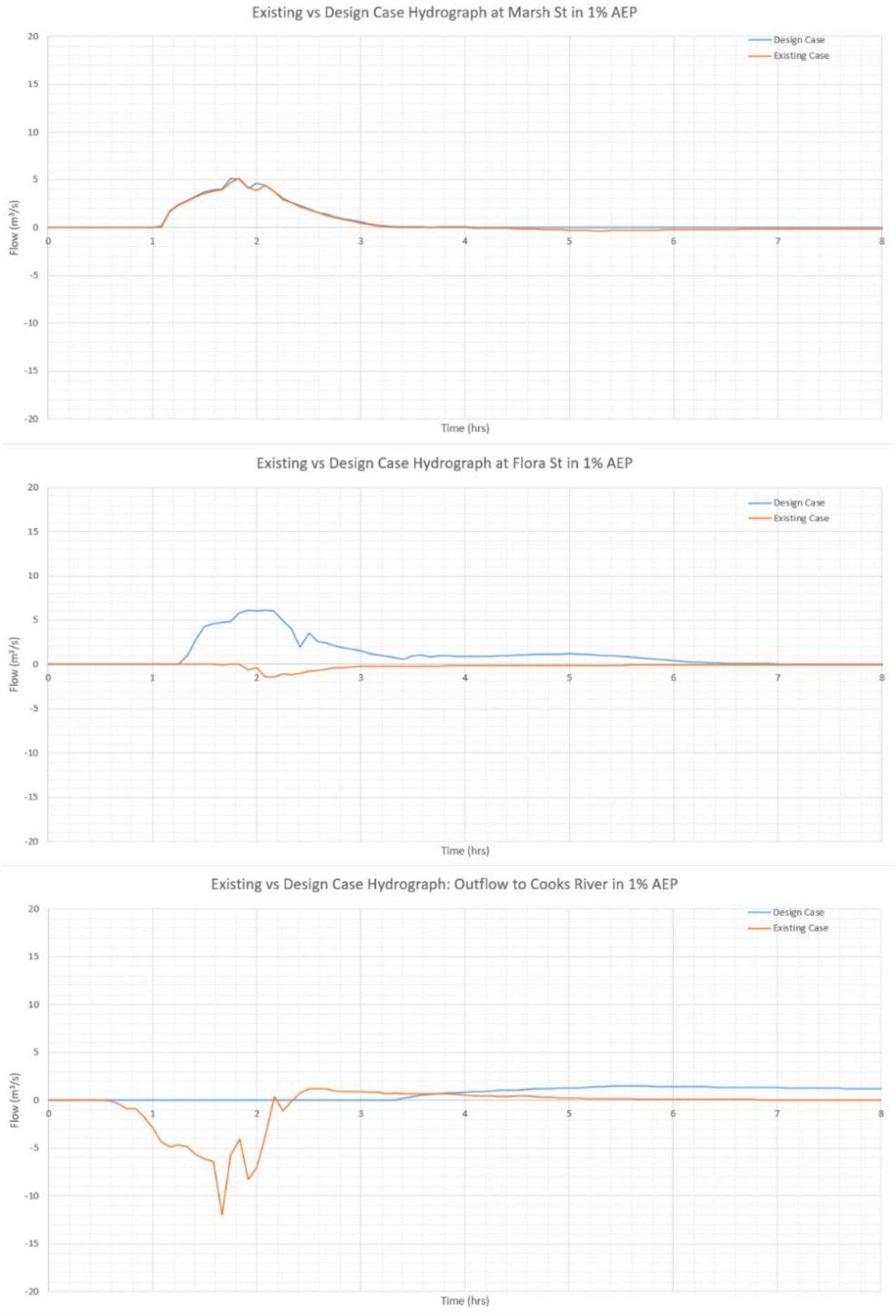



**Figure 31: 1% AEP Flood Flows and Duration of Flows (Existing Case vs Planning Proposal Case)**

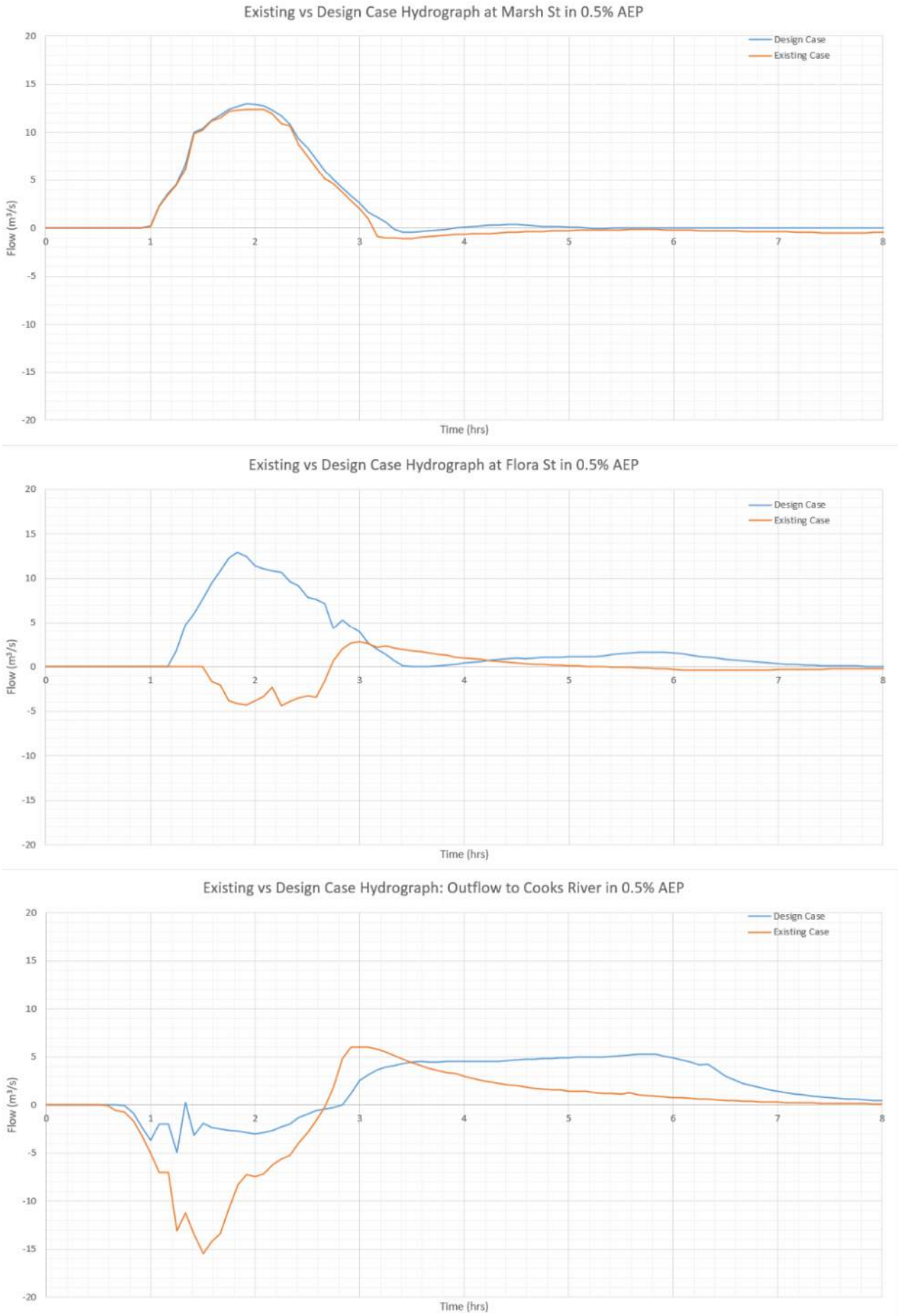



**Figure 32: 0.5% AEP Flood Flows and Duration of Flows (Existing Case vs Planning Proposal Case)**

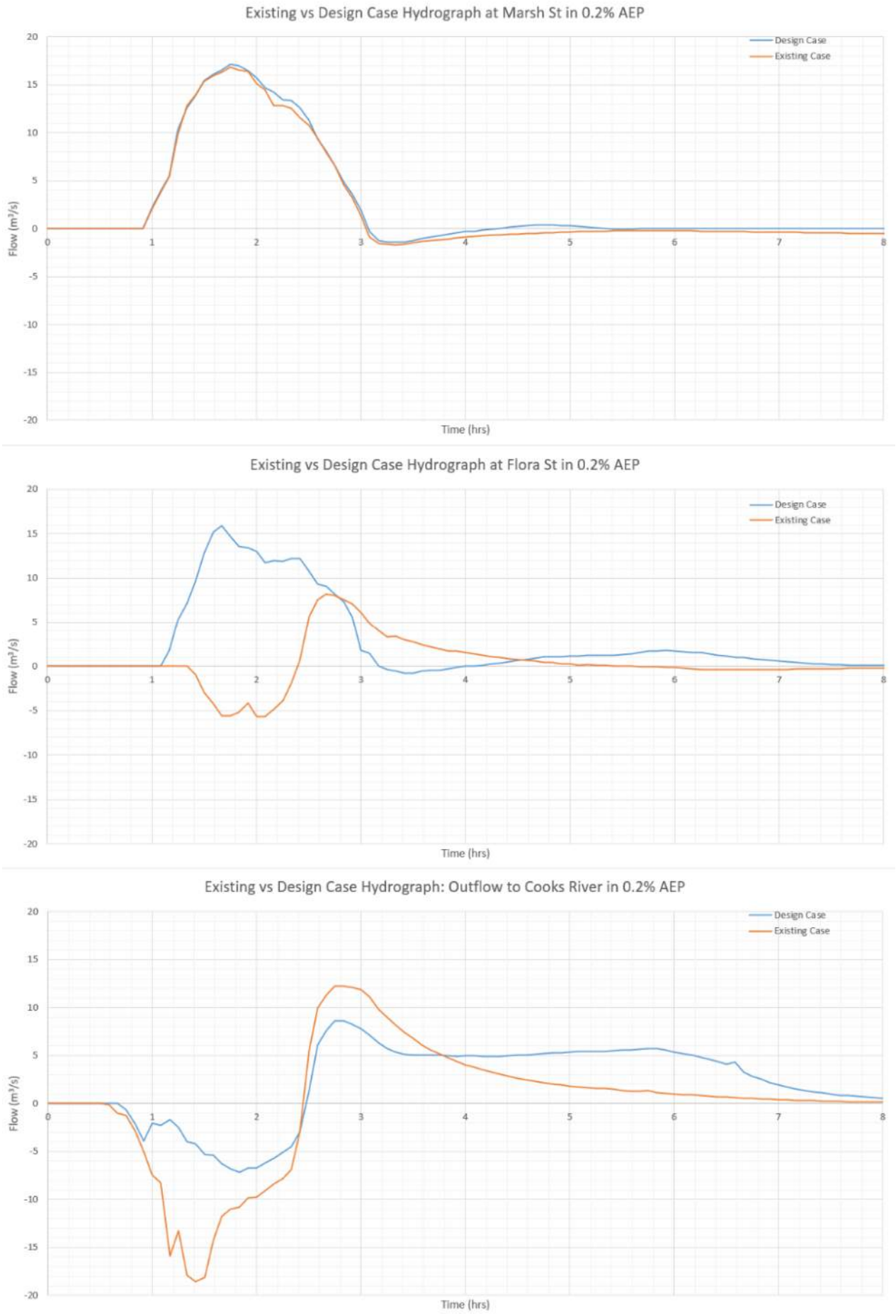
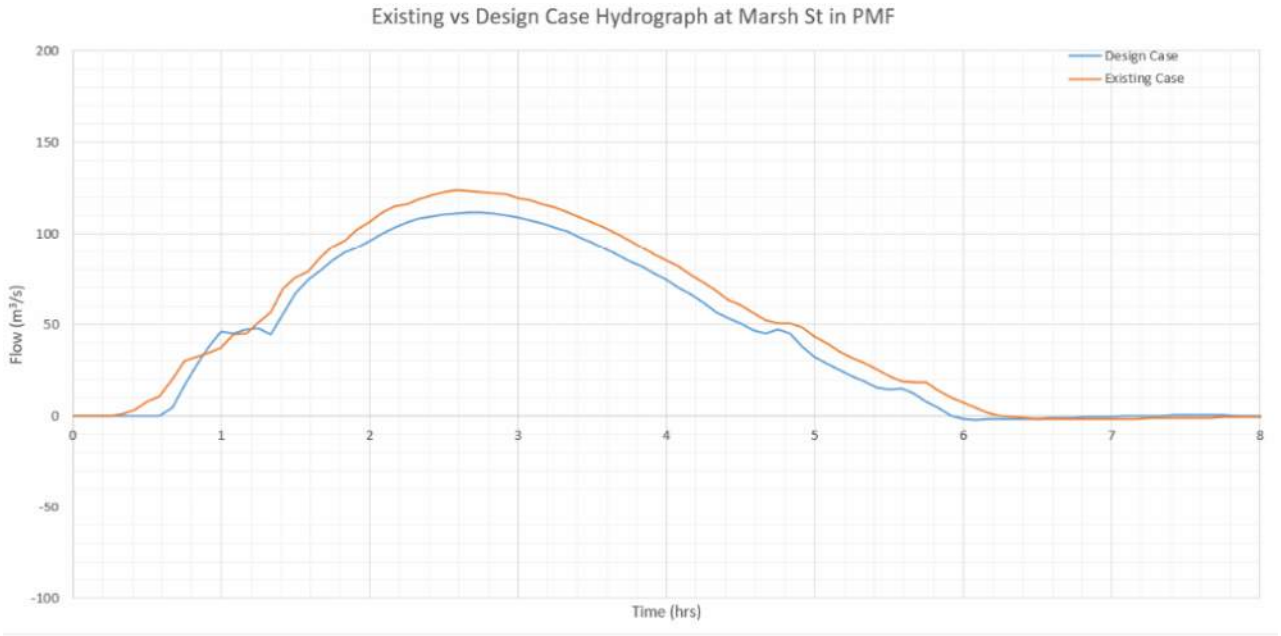
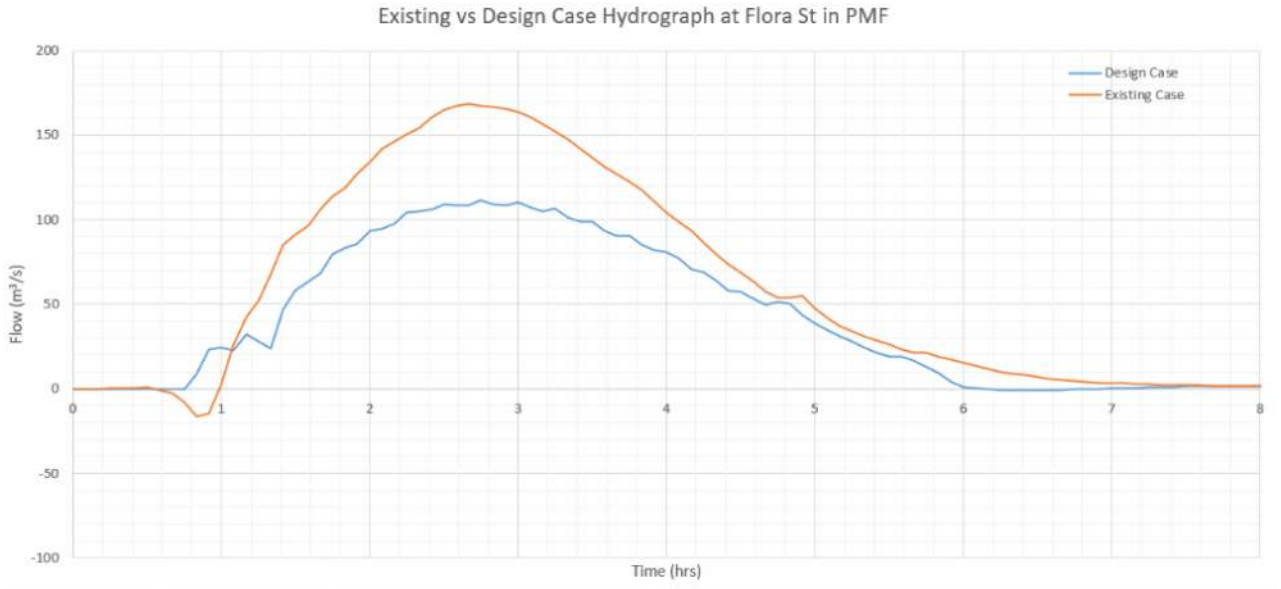



**Figure 33: 0.2% AEP Flood Flows and Duration of Flows (Existing Case vs Planning Proposal Case)**



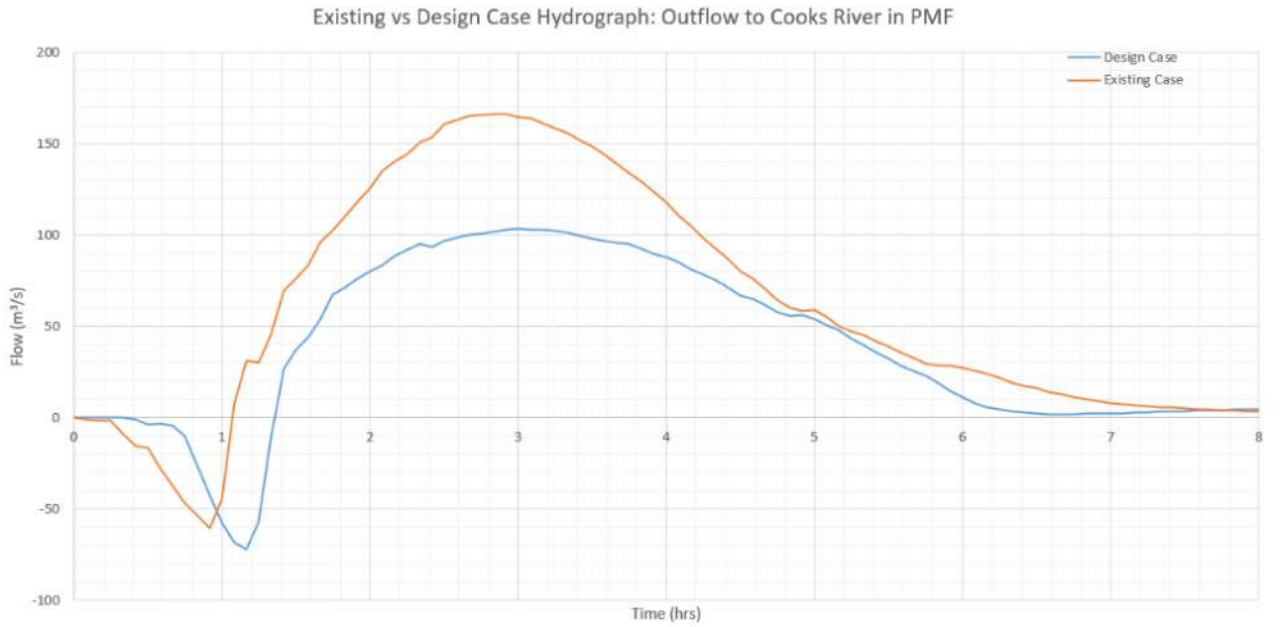




**Figure 34: PMF Flood Flows and Duration of Flows (Existing Case vs Planning Proposal Case)**

## 6.7 Proposal Case Flood Hazard (AIDR)

Figures B-21 to B-25 show the peak flood hazard classifications for the Planning Proposal case and these are discussed below.

- The is only a small amount of inundation primarily on Lot 14 in the 5% AEP flood which is H1 (apart from depression, lakes and drains).
- In the 1% AEP flood the majority of the inundated parts of the site are H2 and H3 with some small areas of H4 where the lakes are located.
- In the 0.5% AEP flood the majority of the inundated parts of the site are H3 due to the depth of the flooding over 0.5m and the flows in the open space areas.
- In the 0.2% AEP flood the majority of the inundated parts of the site are H3 with some areas of H4 (apart from the lakes which are H5).
- In the PMF flood the majority of the site is H5 due to the high flow of over 100 $m^3/s$ passing through the site.

## 6.8 Proposal Case Duration of Inundation

Based on the time series plots presented in Section 6.6, the following is a summary of the time of inundation on the open space parts of the site for range of flood events:

- 5% AEP flood = almost no duration of inundation due to the small amount of inflow to the site
- 1% AEP flood = approximately 5 hours of inundation
- 0.5% AEP flood = approximately 7 hours of inundation
- 0.2% AEP flood = approximately 9 hours of inundation
- Probable Maximum flood = approximately 10 hours of inundation

Based on the time series plots presented in Section 6.6, the following is a summary of the time of inundation on the developed parts of the site (i.e. those with areas with buildings and occupants) for range of flood events:

- 5% AEP flood = no inundation due to areas filled to above 0.05% (1:2000) AEP flood level
- 1% AEP flood = no inundation due to areas filled to above 0.05% (1:2000) AEP flood level
- 0.5% AEP flood = no inundation due to areas filled to above 0.05% (1:2000) AEP flood level
- 0.2% AEP flood = no inundation due to areas filled to above 0.05% (1:2000) AEP flood level
- Probable Maximum Flood = approximately 4 hours of inundation (internal roads only, not floor levels).

## 6.9 Proposal Case Flood Function Mapping

Flood function mapping has been carried out for the base / existing case consistent with the guidance supplied by DPE (Flood Function: Flood Risk Management Guideline FB02, 2023). Figures B-25 to B-30 show the flood function mapping for the Planning Proposal case and these are discussed below.

- In the 5% AEP flood, the inundated areas on the site are flood storage as there is no overtopping of Marsh Street but rather surcharging from the pits in Marsh Street.
- In the 1% AEP flood, the open space parts of the site fill from flows passing over Marsh Street and through Lot 14. These flows are small in regard to the area available for flow and this is reflected in the velocity-depth products which do not exceed $0.3m^2/s$. There is no continuous flowpath from Marsh Street to the river as the outflow to the river does not commence until the inflows over Marsh Street stop. Hence, the area is classified as Flood Fringe and Flood Storage as it does not behave as a floodway and the flows on the site are associated with filling of a flood storage area.

- In the 0.5% AEP flood, there flood behaviour is similar to that of the 1% AEP flood. However, the velocity-depth products exceed 0.3$m^2/s$ over some lengths of the open space areas. Hence, this has been classified as Floodway as there is a period of time (about 30 minutes between time 2.7 hours and 3.2 hours) during which there is flow passing over Marsh Street (about 5$m^3/s$) and flow passing out into the Cooks River. There are other areas of Flood Fringe and Flood Storage in the open space parts of the site.
- In the 0.2% AEP flood, the floodway zone passes along Lot 14 and into the open space of Lot 1 along the alignment of the current lake system. Then the floodway zone continues on to the Cooks River at the southern end of the site. There are other areas of Flood Fringe and Flood Storage in the open space parts of the site.
- In the PMF, the floodway zones are similar to the 0.2% AEP flood but larger and more defined.

## 6.10 Proposal Case Flood Emergency Response Classification

Figures B-31 to B-35 show the Flood Emergency Response Classifications for the Planning Proposal case and these are discussed below.

For all floods up to and including the 0.2% AEP flood, the site is classified as Rising Road Access as there is access from the site onto Marsh Street via flora Street South which will be constructed above the 0.2% AEP flood level and a large culvert constructed to convey the 0.2% AEP flows.

For the 0.05% (1:2000) AEP flood event and the PMF, the site would be classified as High Island as there is access to areas above the PMF flood levels but the access is cut (albeit for a short period of time).

## 6.11 Effect of Climate Change of Proposal Case Flood Behaviour

Figures B-36 to B-40 show the peak flood levels and depths for the Planning Proposal. Figures B-41 to B-45 show the flood impacts for the climate change situation as a result of the Planning Proposal.

In general, the trend of reducing flood levels upstream is also shown in the climate change events. There are minor predicted increases in flood levels beyond the site in the 0.5% AEP and 0.2% AEP floods (with climate change).

# 7. Key risks to be managed

## 7.1 Flood Afflux

In summary of the predicted flood level impacts discussed in Section 6.5, the proposal is likely to provide a net benefit to flood levels for the area to the north of Marsh Street. The benefits of the predicted decreases in flood levels in the more common flood events (5% AEP, 1% AEP and 0.2% AEP) would significantly outweigh the dis-benefits of the impacts in rarer flood events (e.g. 0.2% AEP). This is due to the frequency of the floods with benefits noting that there are on average five (5) flood events with a probability of 1% AEP for every single occurrence of a 0.2% AEP flood event.

Furthermore, there is no predicted increase in flood levels in the PMF for the TfNSW MOC site. Hence, the proposal would not change the likelihood of tunnel inundation for the M6/M8 tunnel system.

Hence, it is concluded that the predicted increases in flood levels due to the proposal are not a key risk requiring management.

## 7.2 Structural Flood Resilience

All buildings within the development precinct would be designed to maintain structural integrity during the maximum force of flows in the PMF, including any potential debris transported by the flood. However, it is unlikely that this requirement will apply to any buildings in the filled part of the site given that all floor levels in this part of the site will be above PMF levels.

Buildings (e.g. toilet buildings) in the open space parts of the site will need to adhere to this requirement.

## 7.3 Flood Risks to Occupants

The main risk requiring management for the proposal is the safety of occupants of the site during flood events. The key mitigation measure for minimising risk to occupants is the setting of high fill and floor levels for the proposed development such that there is no probability of floor inundation and a very low probability of internal road inundation.

It is proposed that all finished floor levels within the Cooks Cove Planning Proposal would be constructed with floor levels of 3.4mAHD. These floor levels will include a 0.6m freeboard above the 1% AEP flood levels with predicted increased rainfall intensities and sea level rise attributed to future climate change effects. These floor levels are also above the current Probable Maximum Flood levels on the site of 3.2mAHD (southern part of site) to 3.3mAHD (northern part of site). Hence, the current Probable Maximum Flood would not inundate floor levels on the site.

Hence, the only flood risks of any note to occupants relate to the need to exit the site during a flood event (ie evacuation). This is discussed in detail below.

## 7.4 Flood Evacuation

Flood evacuation from the site has been considered in the planning of the Cooks Cove Planning Proposal. This is discussed below for the two key evacuation routes and the duration of isolation in rare flood events.

### 7.4.1 Proposed Flood Evacuation Route for Majority of Site

The evacuation route for the planning proposal for all areas south of Marsh Street (i.e. every part except for Block 1) is to use the internal road network (above the 1:2000 AEP flood) and exit along Flora Street South (H1 hazard in a 1:2000 AEP flood) onto Marsh Street.

The key elements of the proposed flood evacuation strategy are as follows:

- For floods up to and including the 0.5% AEP flood event, people can evacuate the site onto Marsh Street at Flora Street South and then south along Marsh Street to high ground. For a range of flood

durations for events up to and including the 0.5% AEP flood, depths would be less than 0.3m at the very low point of this access route and the velocities are very low (backwater area not flowing).

- For floods up to and including the 0.2% AEP flood event, people in large cars and emergency services vehicles can evacuate the site onto Marsh Street at Flora Street South and then south along Marsh Street to high ground. For a range of flood durations for events up to and including the 0.2% AEP flood, depths would be less than 0.5m at the very low point of this access route.

- The flood immunity of the internal road network will be higher than the 1:2000 AEP (0.05% AEP) flood event. All finished floor levels will be constructed above the Probable Maximum Flood levels on the site of 3.2mAHD (southern part of site) to 3.3mAHD (northern part of site). These floor levels would provide at least 0.6m of freeboard to the 1% AEP flood level with climate change (sea level rise and rainfall intensity increase). Hence, the current Probable Maximum Flood would not inundate floor levels on the site.

- For flood larger than the 0.2% AEP flood, people would not be able to evacuate out of the site and a 'shelter-in-place' (SIP) strategy would come into place for the short duration of inundation. In the 1:2000 AEP (0.05% AEP) flood event, the duration that large vehicles would not be able to evacuate from the site is 4 hours. In the PMF, this duration would be up to 7 hours. This strategy is discussed below.

This evacuation route is shown in Figure 41 and is the preferred evacuation route in case of secondary emergencies during a flood. More detail on the duration of inundation and H1/H2 hazard exceedance for this route is presented in Section 7.4.4.

Should evacuation to the nearest hospital be required, the preferred evacuation route is as follows:

- From Flora Street South turn left onto Marsh Street;
- From Marsh Street left turn onto West Botany Street;
- From West Botany Street right turn onto Wickham Street;
- From Wickham Street left turn onto Princes Highway; and
- Continue on Pacific Highway to then turn right onto Gray Street, where the hospital entrance is located.

Based on the Spring Street Drain, Muddy Creek and Scarborough Ponds Catchments Flood Study report (BMT WBM, 2016), localised areas along the Princes Highway may be subject to flooding in a PMF event, with peak flood depths reaching up to 0.5 m on the road. It is also noted that along this route, the duration of inundation to this depth during a PMF event is not expected to exceed 15 minutes, as this was the critical storm duration in the PMF for the upper reaches of the catchment.

### 7.4.2 Proposed Flood Evacuation Route for Block 1

There are two small buildings proposed in Block 1 of the Cooks Cove Planning Proposal. The road access for these buildings is either via Levey Street west onto Marsh Street or under the current access road under Giovanni Brunetti Bridge.

Levey Street westward has a low flood immunity and a low point at 1.1mAHD and the 5% AEP flood peaks at 1.5mAHD. Hence, the flood immunity is much less than 5% AEP and probably in the order of 20% AEP. The access road under Giovanni Brunetti Bridge has a flood immunity of 5% AEP.

If evacuation is required during a flood event to/from the small buildings in Block B1 of the Planning Proposal, this will be possible using a ramp to be constructed to access Marsh Street on the approach to Giovanni Brunetti Bridge. During these flood events, Marsh Street will be closed further west and unimpeded access will be possible onto Marsh Street on the high (above PMF) part of the bridge approach.

This ramp will enable access across the bridge and onto Airport Drive. From there, it will be possible to enter the Sydney Gateway tunnel which is located about 450m north of the bridge. This will provide access to the Sydney motorway network.

The low point on Airport Drive is 2.1mAHD about 250m north of the bridge. This location has the following flood immunity and hazard classifications for a range of floods:

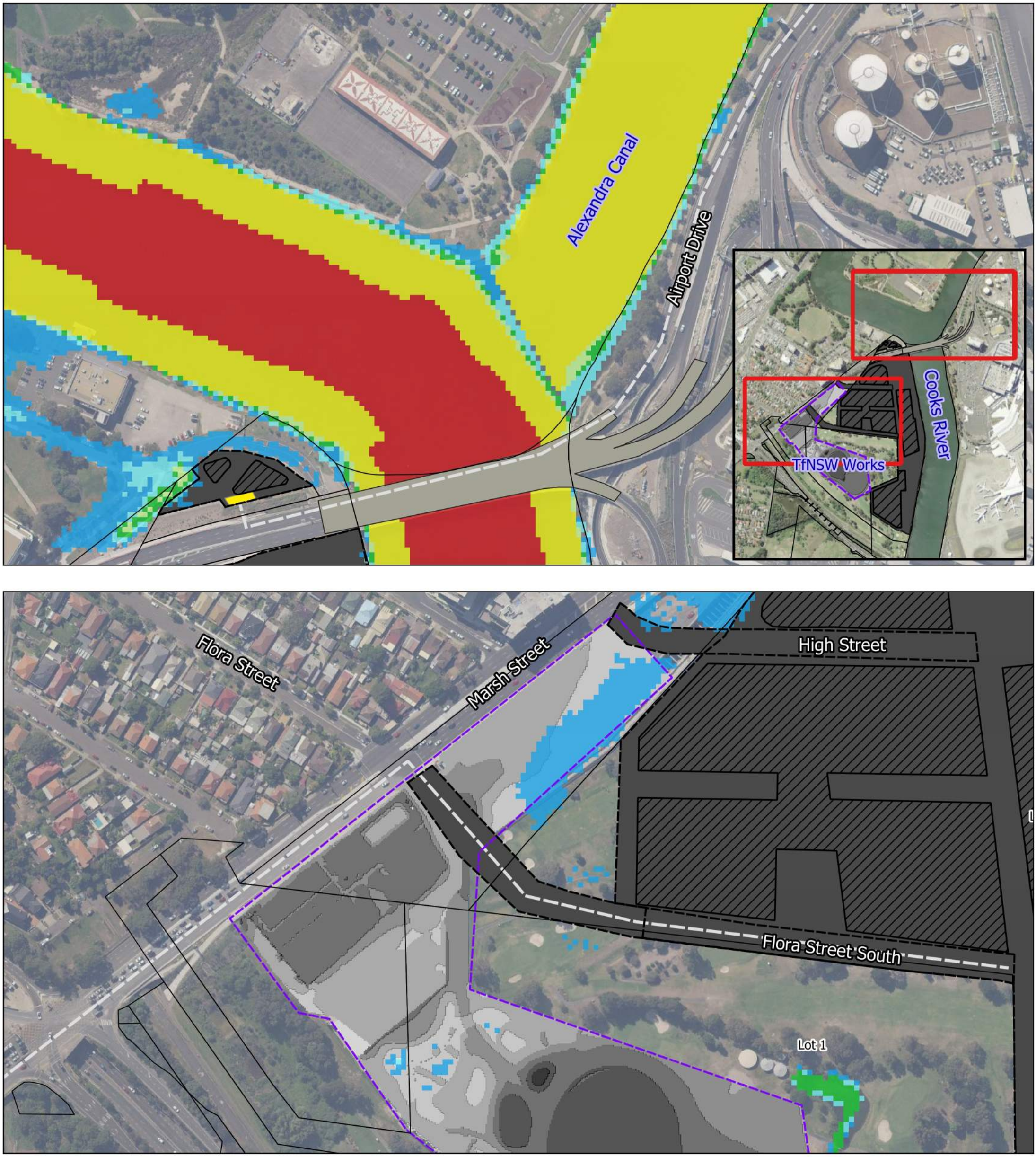
- In all floods up to the 1% AEP flood, there is no floodwater on Airport Drive
- In the 0.2% AEP flood (1:500 AEP), there is 0.2m of floodwater and H1 hazard (so small cars could still evacuate through this route)
- In the 0.05% AEP flood (1:2000 AEP), there is flood depths less than 0.5m that would enable a large car or emergency vehicle to access along Airport Drive with H2 hazard.
- In the PMF, the flood hazard is H4 at the low point and not trafficable for a short period of time (in the order of 4.5 hours for H2 hazard and 5 hours for H1 hazard). In a 24 hour PMF flood, the H2 exceedance time is 6.5 hours.

### 7.4.3 Peak Flood Hazards for Evacuation Routes

Figure 35 to Figure 40 show the flood hazard classifications for the two key locations (i.e. the evacuation route for the majority of the site through the corner of Marsh and Flora South Streets and the evacuation route for the small B1 Block along Airport Drive).

- For the 5% and 1% AEP floods, there is no inundation on either evacuation route.
- For the 0.5% AEP flood, there is a short section (about 3m) of H1 flood hazard on the southern evacuation route at the corner of Marsh Street and Flora Street South.
- For the 0.2% AEP flood, there is a short section (about 10m) of H1 flood hazard on the southern evacuation route at the corner of Marsh Street and Flora Street South.
- In the 0.05% (1:2000) AEP flood, there is a short section (about 20m) of H2 flood hazard on the southern evacuation route at the corner of Marsh Street and Flora Street South. There would be a 270m length of Flora Street South with H1 flood hazard.
- In the PMF, both routes would be cut for a short period by H3 and H4 hazard areas.

The durations of these hazard areas are presented and discussed below in Section 7.4.4.




Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Block B1 Ramp to Marsh St
- Giovanni Brunetti Bridge
- Evacuation Route

Peak Flood Hazard (ZAEM1)

- H1
- H2
- H3
- H4
- H5
- H6

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
5% AEP Planning Proposal Case Peak Flood Hazard for Both Evacuation Route Low Points

| Job No | Figure No |
|---|---|
| 252942 | 35 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale** 0 20 40 60 80 100 m

| Issue | Date | By | Chkd | Appd |
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| A | 19/09/23 | JO | GR | GR |

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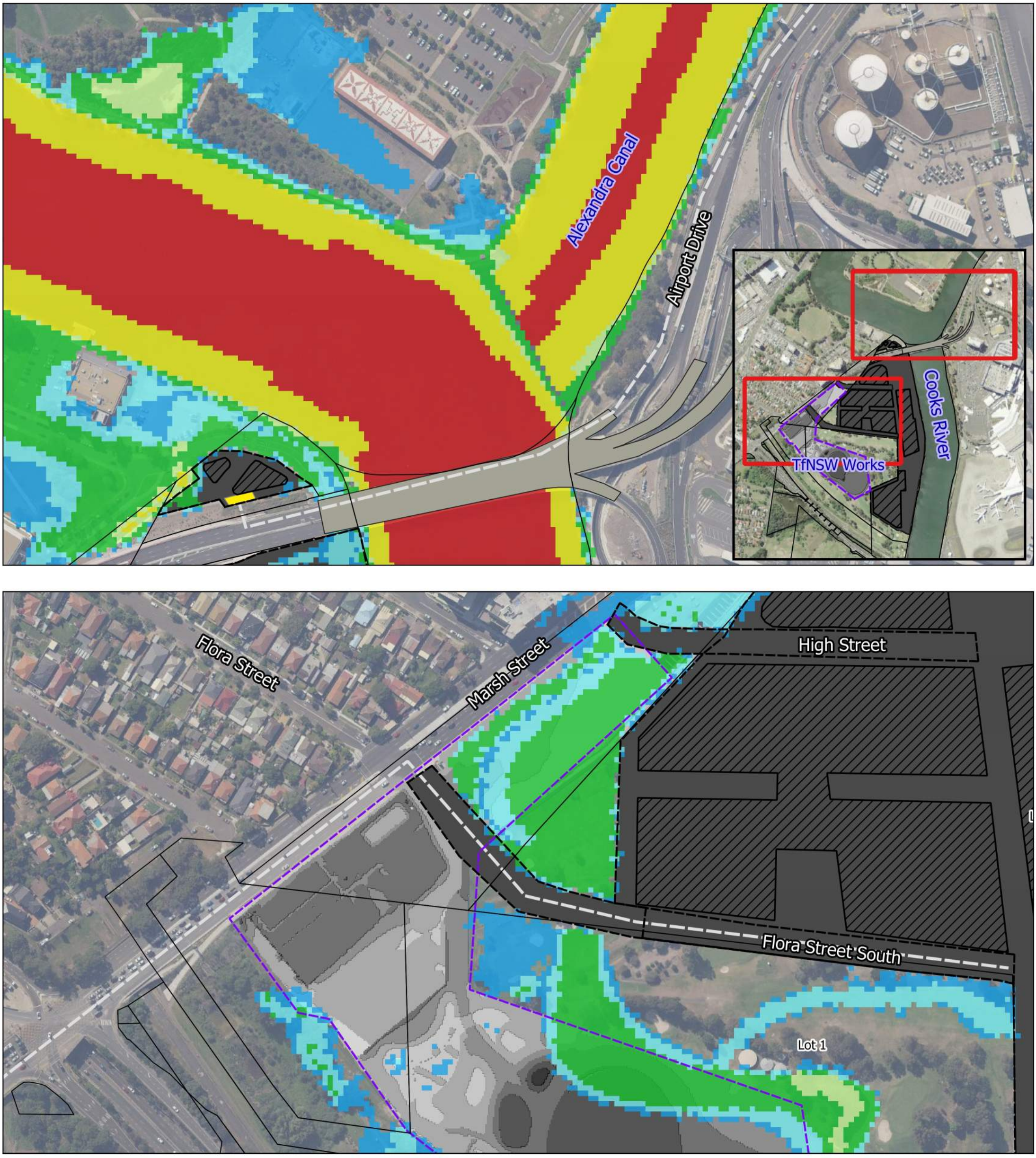


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Block B1 Ramp to Marsh St
- Giovanni Brunetti Bridge
- Evacuation Route

Peak Flood Hazard (ZAEM1)

- H1
- H2
- H3
- H4
- H5
- H6

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
1% AEP Planning Proposal Case Peak Flood Hazard for Both Evacuation Route Low Points

| Job No | Figure No |
|---|---|
| 252942 | 36 |

| Coordinate System | Drawing Status |
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**Scale** 0 20 40 60 80 100 m

| Issue | Date | By | Chkd | Appd |
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| A | 19/09/23 | JO | GR | GR |

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Alexandra Canal

Airport Drive

Cooks River

TfNSW Works

Flora Street

Marsh Street

High Street

Flora Street South

Lot 1

Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Block B1 Ramp to Marsh St
- Giovanni Brunetti Bridge
- Evacuation Route

Peak Flood Hazard (ZAEM1)

- H1
- H2
- H3
- H4
- H5
- H6

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
0.5% AEP Planning Proposal Case Peak Flood Hazard for Both Evacuation Route Low Points

| Job No | Figure No |
|---|---|
| 252942 | 37 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale** 0 20 40 60 80 100 m

| Issue | Date | By | Chkd | Appd |
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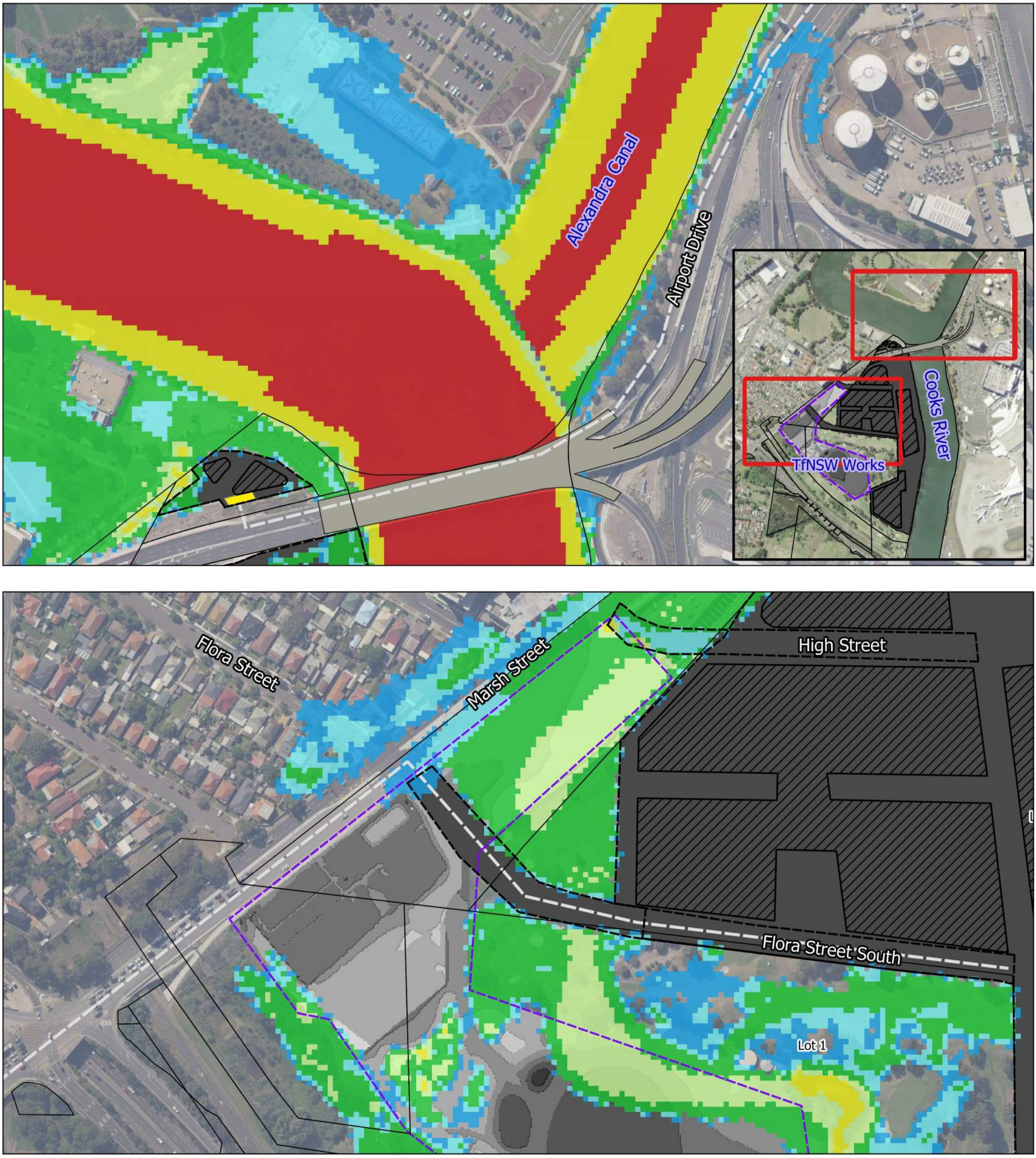


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Block B1 Ramp to Marsh St
- Giovanni Brunetti Bridge
- Evacuation Route

Peak Flood Hazard (ZAEM1)

- H1
- H2
- H3
- H4
- H5
- H6

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
0.2% AEP Planning Proposal Case Peak Flood Hazard for Both Evacuation Route Low Points

| Job No | Figure No |
|---|---|
| 252942 | 38 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale** 0 20 40 60 80 100 m

| Issue | Date | By | Chkd | Appd |
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| A | 19/09/23 | JO | GR | GR |

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Sources: Google Maps, CNES/Airbus, Landsat/Copernicus, Maxar Technologies

Alexandra Canal

Airport Drive

Cooks River

TfNSW Works

Flora Street

Marsh Street

High Street

Flora Street South

Lot 1

Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Block B1 Ramp to Marsh St
- Giovanni Brunetti Bridge
- Evacuation Route

Peak Flood Hazard (ZAEM1)

- H1
- H2
- H3
- H4
- H5
- H6

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
0.05% AEP Planning Proposal Case Peak Flood Hazard for Both Evacuation Route Low Points

| Job No | Figure No |
|---|---|
| 252942 | 39 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale**
0 20 40 60 80 100 m

| Issue | Date | By | Chkd | Appd |
|---|---|---|---|---|
| A | 19/09/23 | JO | GR | GR |

N

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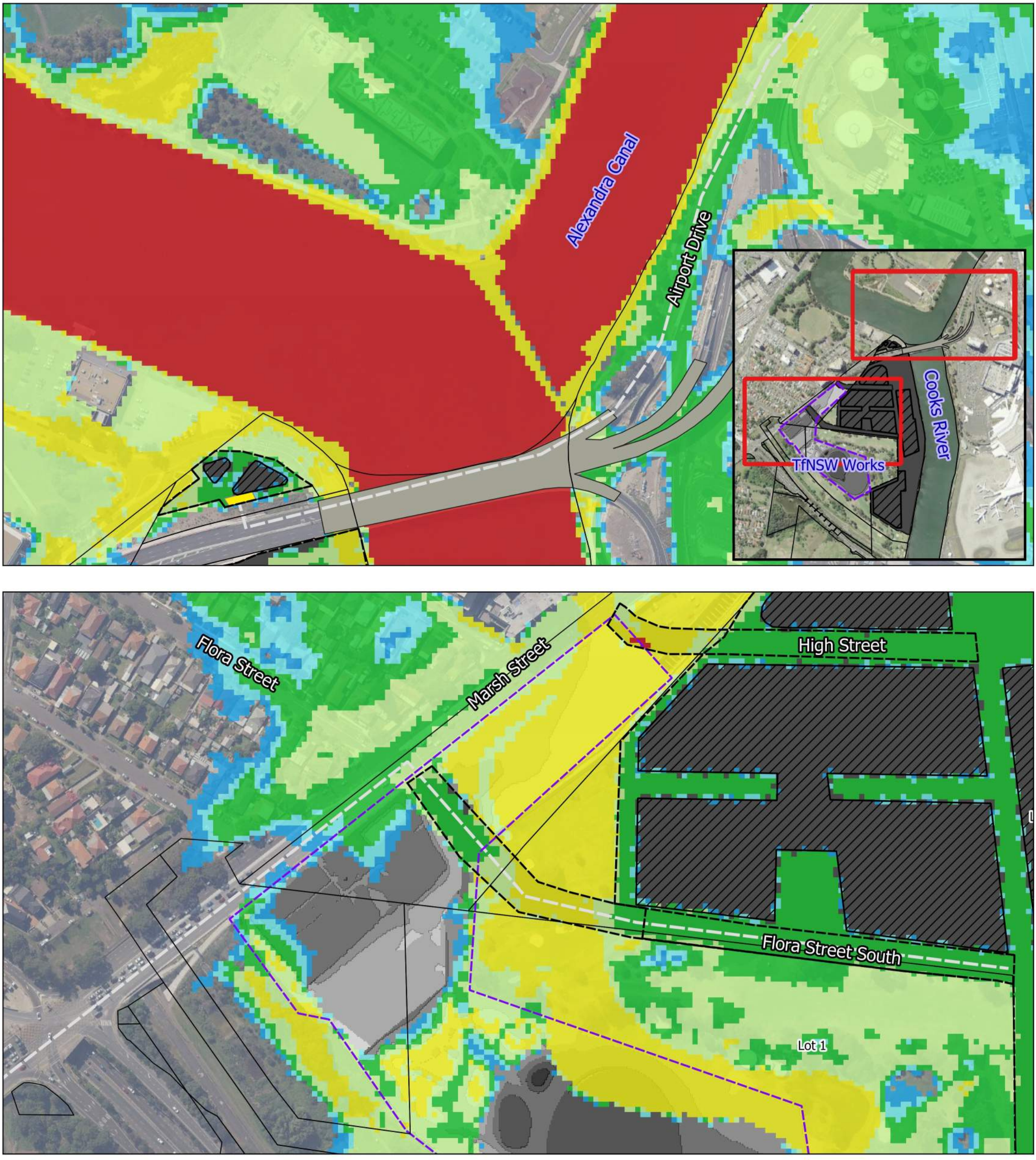


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Block B1 Ramp to Marsh St
- Giovanni Brunetti Bridge
- Evacuation Route

Peak Flood Hazard (ZAEM1)

- H1
- H2
- H3
- H4
- H5
- H6

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
PMF Planning Proposal Case Peak Flood Hazard for Both Evacuation Route Low Points

| Job No | Figure No |
|---|---|
| 252942 | 40 |
| **Coordinate System** GDA 1994 MGA ZONE 56 | **Drawing Status** FINAL |

**Scale** 0 20 40 60 80 100 m

| Issue | Date | By | Chkd | Appd |
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### 7.4.4 Closure Times for a Range of Flood Durations at Marsh St / Flora St intersection

While the critical duration for Cooks River flooding for the study area is 2 hours, it is possible that other longer duration flood events which result in slightly lower levels may result in longer period of inundation. To assess this, the Cooks River flood model was simulated with 2 hour, 9 hour and 24 hour flood events for the range of AEP's assessed.

The 2 hour event is the critical duration (highest flood levels). The 9 hour duration was chosen as it is known that this temporal pattern is often a dominant temporal pattern in the Sydney area (in the ARR 1987 temporal patterns). The 24 hour duration was chosen as a typical long-duration flood event.

The results of the times of closure have been assessed based on varying hazard levels at the key location of the corner of Flora Street South and Marsh Street. This location is key to the assessment as it is the low point in the evacuation route from the site to the south-west. The lowest point of the intersection is 1.80mAHD (essentially in the gutter line of Marsh Street). The level of Flora Street South will be 2.17mAHD (so 370mm higher).

This assessment is slightly more conservative than the TUFLOW flood mapping as there is not a 2D cell at the low point that has a level as low as 1.80mAHD. The lowest 2D cell at the low point is 1.88mAHD.

There is no inundation of the intersection of Flora Street South and Marsh Street in the 5% AEP flood event. So, these assessments were based on floods equal to or larger than the 1% AEP flood.

Table 9 to Table 11 list the durations of inundation, H1 hazard and H2 hazard for a range of AEP's and flood durations for the current climate. It is evident from this data that the duration of flooding is not strongly linked to the flood duration. The longer duration floods typically result in short durations of inundation or hazard exceedance. This is due to the lower levels associated with the longer duration floods.

**Table 9: Duration (h) of Any Inundation at intersection of Flora Street South and Marsh Street (current climate)**

| Annual Flood Probability (%) | 2 hour | 9 hour | 24 hour | Maximum |
|---|---|---|---|---|
| 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.5 | 1.7 | 0.0 | 0.0 | 1.7 |
| 0.2 | 2.5 | 4.1 | 0.0 | 4.1 |
| 0.05 | 5.9 | 5.3 | 5.0 | 5.9 |
| 0 (PMF) | 11.0 | 8.5 | 10.3 | 11.0 |

** Note that the probability of the PMF is estimated to be 0.00001% which is assumed to be close enough to 0% for these assessments.*

**Table 10: Duration (h) of H1 Hazard Exceedance at intersection of Flora Street South and Marsh Street (current climate)**

| Annual Flood Probability (%) | 2 hour | 9 hour | 24 hour | Maximum |
|---|---|---|---|---|
| 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.2 | 0.5 | 0.5 | 0.0 | 0.5 |
| 0.05 | 4.5 | 2.3 | 1.1 | 4.5 |
| 0 (PMF) | 5.0 | 6.4 | 8.1 | 8.1 |

**Table 11: Duration (h) of H2 Hazard Exceedance at intersection of Flora Street South and Marsh Street (current climate)**

| Annual Flood Probability (%) | 2 hour | 9 hour | 24 hour | Maximum |
|---|---|---|---|---|
| 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.05 | 3.8 | 0.8 | 0.0 | 3.8 |
| 0 (PMF) | 4.4 | 5.8 | 8.1 | 8.1 |

Table 12 to Table 14 list the durations of inundation, H1 hazard and H2 hazard for a range of AEP's and flood durations for the 2090 climate (rainfall intensity increase and sea level rise – see Section 5.1.6).

For these assessments, there is a small increase in the durations of inundation or hazard exceedance with increasing flood event duration. However, the trend is weak.

**Table 12: Duration (h) of Any Inundation at intersection of Flora Street South and Marsh Street (2090 climate)**

| Annual Flood Probability (%) | 2 hour | 9 hour | 24 hour | Maximum |
|---|---|---|---|---|
| 1.0 | 5.1 | 6.0 | 5.7 | 6.0 |
| 0.5 | 5.5 | 7.5 | 8.9 | 8.9 |
| 0.2 | 5.7 | 7.3 | 9.4 | 9.4 |
| 0.05 | 5.9 | 8.5 | 10.1 | 10.1 |
| 0 (PMF) | 8.9 | 10.7 | 19.0 | 19.0 |

**Table 13: Duration (h) of H1 Hazard Exceedance at intersection of Flora Street South and Marsh Street (2090 climate)**

| Annual Flood Probability (%) | 2 hour | 9 hour | 24 hour | Maximum |
|---|---|---|---|---|
| 1.0 | 3.3 | 1.8 | 2.0 | 3.3 |
| 0.5 | 3.9 | 4.6 | 5.8 | 5.8 |
| 0.2 | 4.1 | 4.3 | 6.2 | 6.2 |
| 0.05 | 4.5 | 5.5 | 6.9 | 6.9 |
| 0 (PMF) | 6.7 | 8.5 | 10.6 | 10.6 |

**Table 14: Duration (h) of H2 Hazard Exceedance at intersection of Flora Street South and Marsh Street (2090 climate)**

| Annual Flood Probability (%) | 2 hour | 9 hour | 24 hour | Maximum |
|---|---|---|---|---|
| 1.0 | 2.5 | 0.0 | 0.0 | 2.5 |
| 0.5 | 3.2 | 3.9 | 4.5 | 4.5 |
| 0.2 | 3.4 | 3.6 | 5.0 | 5.0 |
| 0.05 | 3.8 | 4.9 | 6.0 | 6.0 |
| 0 (PMF) | 6.1 | 7.9 | 9.6 | 9.6 |

Based on this data, it is possible to calculate the average annual duration of inundation or hazard exceedance by using similar techniques used for calculating average annual flood damages (see DECC Floodplain Risk Management Guideline: Residential Flood Damages, 2007). In this way, a true assessment of risk can be provided which accounts for the consequences (i.e. inundation or hazard exceedance) and the probability in a quantitative manner.

However, the calculated durations are very short as floods do not occur every year. It is more meaningful to express these durations as the average cumulative duration of inundation or hazard exceedance for a typical century of flooding behaviour.

Using this technique, the following average cumulative durations were calculated:

- Total cumulative duration of inundation for 100 years is 2.5 hours;
- Total cumulative duration of H1 hazard exceedance for 100 years is 0.8 hours;
- Total cumulative duration of H2 hazard exceedance for 100 years is 0.6 hours.

The following conclusions can be drawn from this assessment:

1. For a 1:2000 AEP flood, the maximum duration of inundation at this key location is 5.9 hours. However, small cars would still be able to access and leave the site for 2.1 of those 5.9 hours.
2. For a 1:2000 AEP flood, the maximum duration of H1 exceedance is 4.5 hours.

3. For a 1:2000 AEP flood, the maximum duration of H2 exceedance (i.e. large cars and emergency vehicles) is in the order of four (4) hours.
4. The most probable estimate of the duration of inundation at this key location over a typical century of flooding is 2.5 hours.
5. The most probable estimate of the duration of H2 exceedance at this key location over a typical century of flooding is 0.8 hours (about 45 minutes).
6. The most probable estimate of the duration of H2 exceedance at this key location over a typical century of flooding is 0.6 hours (about 35 minutes).
7. With the effect of climate change (and largely due to the 0.9m sea level rise assumption), the most probable estimate of the duration of H2 exceedance at this key location over a typical century of flooding is less than six hours (5.7h).

### 7.4.5 Flood Warning Systems

Flood warning systems have proven to significantly reduce risk to life and damages if sufficient warning time is provided.

The Bureau of Meteorology is responsible for issuing flood warnings on major river systems and the NSW State Emergency Services (SES) is responsible for disseminating this information to the local community. An assessment is then carried out to determine whether implementation of evacuation procedures should be undertaken. Sufficient warning time allows the community to move cars and goods above the likely peak level of floodwaters as well as to evacuate to higher ground. Notwithstanding, the effectiveness of the flood warning depends on a number of factors:

- Maximum potential warning time before arrival of flooding;
- Skill and knowledge of the operator to efficiently gather rainfall and stream gauge information and then adequately disseminate this information to relevant authorities; and
- The community response to the flood warning.

The fast response nature of the local catchment and Cooks River catchments result in limited available flood warning time for critical events. Although major floods can be forecast based on large weather systems, flooding in localised areas and small catchments can be challenging to forecast for government agencies.

As a result, the SES has not implemented a flood warning system within the local catchment nor for the Cooks River catchment. Although stream gauging stations are available in the Cooks River, they are not currently used for flood warnings. However, flood depth boards are located in specific areas of the catchments and actual flooding information is made available to the SES.

While a warning system is not in place, an education and flood awareness program could be implemented to increase the community's awareness of the local flood risk and appropriate flood response behaviour. This could include flood evacuation officers designated for each development lot. These officers would be appropriately trained in evacuation procedures and would be responsible for notifying staff and visitors about flood evacuation procedures.


Legend

- Cadastre
- M6/M8 Permanent Facilities
- Extent of Development Footprint
- Development Buildings
- Evacuation Route

Peak Flood Depth (m)

- <= 0.30
- 0.30 - 0.60
- 0.60 - 0.90
- 0.90 - 1.20
- > 1.20

**Project Title**
Cooks Cove Planning Proposal

**Drawing Title**
0.2% AEP Peak Flood Depth and Evacuation Route for Cooks Cove Planning Proposal Case

| Job No | Figure No |
|---|---|
| 252942 | 41 |

| Coordinate System | Drawing Status |
|---|---|
| GDA 1994 MGA ZONE 56 | FINAL |

**Scale** 0 100 200 300 400 500 m

| Issue | Date | By | Chkd | Appd |
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## 7.5 Shelter-in-Place Strategy for rare floods

As discussed above, occupants will be able to enter and exit the site in all floods up to a 0.2% (1:500) AEP flood. For rarer floods, there will be a short period of time (less than six hours) in which entry and exit from the site would not be possible due to the flood hazards. Only in these rarer floods is the shelter-in-place strategy proposed to manage the flood risks to the occupants.

In January 2023, the Department of Planning and Environment released a draft shelter-in-place guideline for discussion and comment (DPE, 2023). The guideline includes the following text that is relevant to the application of this strategy to the Cooks Cove Planning Proposal:

- *"Planning for flood emergencies requires an understanding of the full range of flood behaviour up to the probable maximum flood (PMF)."*
- *"In some situations, attempting to evacuate may be worse than not evacuating. This is especially the case where flash flooding leaves very little time for evacuation and can result in isolation with very little notice. This is where there can be a role for shelter-in-place approaches".*
- *"When SIP is appropriate:*
    - *SIP is an emergency management response, especially when the flood warning time and flood duration are both less than six hours (typically called flash floods).*
    - *These flooding events are dangerous because of the short timeframes, as well as the flood speed and depth.*
    - *Under such circumstances, evacuation via vehicle may not possible. SIP is the last resort evacuation option for development in greenfield and infill areas"*
- *"The department proposes the following when considering whether to apply SIP controls, noting that evacuation off-site is always preferrable. If this cannot be achieved, then SIP may be used if:*
    - *The duration for flood inundation is less than six hours*
    - *The development is not located in an area of high-risk (eg, floodways and H5 or H6 flood hazard areas)*
    - *Access to on-site systems to provide power, water and sewerage services during and beyond the event for the full range of flooding*
    - *The location of storage of food, water and medical emergency for SIP purposes should be above the PMF level and available during and beyond the event for the full range of flooding*
    - *SIP floor level is above PMF*
    - *SIP provides a minimum floor space per person*
    - *SIP must be structurally safe and accessible during floods up to the PMF."*

In regard to the matters listed above, the following is noted specific to the Cooks Cove Planning Proposal:

1. The consideration of flood behaviour for all floods up to the PMF has been a key part of this flood assessment and flood evacuation strategy.
2. The duration of flood inundation has been considered when developing the emergency management strategy for the precinct. This is discussed further in regard to the key evacuation routes in Section 7.4.
3. Due to the H2 hazard of the corner of Marsh Street and Flora Street South in floods greater / rarer than the 0.2% (1:500) AEP flood, evacuation is not possible for these flood events and shelter-in-place is the only viable option.
4. The proposed development will comprise mixed-use facilities including hotel and short-stay accommodation, retail and dining, commercial office, warehousing and logistics, and recreational and community facilities. The site will also include significant areas of retail including food outlets, supermarkets. Hence, it will be a safe place for isolation for short periods of time.
5. The Cooks Cove Planning Proposal meet all of the seven conditions and requirements listed above for shelter-in-place to the applied.

# 8. Responses to Submissions on September 2023 FIRA

The following sections were prepared in response to additional submissions made by key agencies on the September 2023 FIRA. These responses were originally included in a report to DPE dated 12 December 2023. These are replicated below for completeness.

## 8.1 Response to SES Submission

### 8.1.1 Response to Summary of SES Submission

***Comment: Note and appreciate that the that modelling has now been undertaken for events up to and including the Probable Maximum Flood (PMF)***

Comment noted. This full range of flood events enables a more complete assessment of the flood risks associated with the Cooks Cove Planning Proposal. However, it still needs to be noted that these floods (e.g. 0.05% AEP, PMF) are defined by their attributed probability and that this probability needs to be accounted for in any risk assessment.

***Comment: Note and appreciate that the proposed road changes for Flora Street South accommodate 1:500 AEP flows***

Comment noted. It was identified in discussions with SES that the preferred direction for evacuations would be to the south and SES access would be from the south which offers a more direct connection to SES facilities. Hence, the concept civil design has been amended to provide this access for all floods up to the 0.2% (1:500) AEP flood.

***Comment: Reiterate that 'Shelter in place' strategy is not an endorsed flood management strategy by the NSW SES for future development, and note that any SES Warnings for the area will override private arrangements.***

Comment noted. Shelter in Place is not the default strategy for emergency management for the Cooks Cove Planning Proposal. In all floods up to the 0.2% / 1:500 AEP flood, the strategy is to evacuate (if needed) via Flora Street South onto Marsh Street. This amendment has been made in response to feedback received from the public exhibition process.

Only if a flood rarer than the 0.2% / 1:500 AEP flood occurs (unlikely in the 100 year design life of this project) would there be a need to rely upon Shelter in Place for a short period of time. Refer to the FIRA which further addresses the acceptability of this outcome.

***Comment: Recommend seeking further advice from the Biodiversity Conservation Division of the Department of Planning and Environment regarding climate change, particularly in relation to the 0.9m sea level rise in the NSW Sea Level Rise Policy Statement (DECCW, 2009) instead of 0.8m in the current modelling.***

It is confirmed that the sea level rise allowance should have been 0.9m instead of the 0.8m used in the original September 2023 FIRA. This is discussed in Section 8.1.3.

***Comment: Recommend considering tsunami evacuation as part of any emergency response plan, noting that this site is within the Tsunami Evacuation Area.***

This is noted and appropriate strategies will be incorporated into the emergency response plan to be developed in subsequent stages of the project development, including at the Development Application stage.

### 8.1.2 Consideration against Ministerial Section 9.1 Directions (4.1)

***Comment: The consent authority will need to ensure that the planning proposal is considered against the relevant Ministerial Section 9.1 Directions, including 4.1 – Flooding and is consistent with the NSW Flood Prone Land Policy as set out in the Flood Risk Management Manual 2023 (the Manual) and supporting guidelines, including the Support for Emergency Management Planning***

The consent authority is directed towards the FIRA on this matter. The Cooks Cove Planning Proposal has been considered in detail against the Ministerial Section 9.1 Directions, including 4.1 (see Table 3 of the FIRA) and the NSW Flood Prone Land Policy (see Table 4 of the FIRA and supplementary response from Ethos Urban).

The information in the FIRA and this document demonstrate that the Cooks Cove Planning Proposal meets all of the requirements of the Ministerial Section 9.1 Directions: Focus Area 4.1 and has been demonstrated to be consistent with the NSW Flood Prone Land Policy.

### 8.1.3 Principles Outlined in the Support for Emergency Management Planning Guideline

**Principle 1**

***Any proposed Emergency Management strategy should be compatible with any existing community Emergency Management strategy.*** *Any proposed Emergency Management strategy for an area should be compatible with the evacuation strategies identified in the relevant local or state flood plan or by the NSW SES. As per the Bayside Local Flood Plan4, evacuation is the NSW SES's primary response strategy for managing the population at risk of flooding.*

It is confirmed that evacuation is the primary response strategy for managing the population at risk of flooding for the Cooks Cove Planning Proposal. For all floods up to the 0.2% (1:500) AEP flood, occupants of the site can exit the site onto Marsh Street and drive south to high ground.

For rarer floods, occupants of the site would need to remain on site for a short period of time (in the order of hours) prior to flood levels receding to enable access to Marsh Street.

The Emergency Management strategy has been tailored to the existing community strategies by creating of high flood immunity access to the south where the local Bayside SES is located as well as access to local hospitals.

**Principle 2**

***Decisions should be informed by understanding the full range of risks to the community.*** *Decisions relating to future development should be risk-based and ensure Emergency Management risks to the community of the full range of floods are effectively understood and managed.*

SES has requested further information on the anecdotal evidence that the site has not flooded from the Cooks River in the last 57 years. This evidence is not inconsistent with the SES observations that the area around Gertrude Street (northeast of the site) has flooded in the recent past (e.g. March 2022).

The flooding in Gertrude Street is likely to be due to either local catchment flooding (for a different local catchment to that of the project site, as Marsh Street is a local catchment divide) or elevated Cooks River flood levels causing river break out into this low part of Wolli Creek.

In either case, that type of flooding would not necessarily result in flooding of the Cooks Cove site. Floodwaters would need to overtop Marsh Street and flow southward onto the site. The flood modelling suggests that this only occurs in floods larger than the 1% AEP flood. However, the design floods simulated in this circumstance are somewhat conservative as there is an assumed coincident storm surge (also occurring simultaneously with a high tide) in Botany Bay.

In the absence of a storm surge in Botany Bay (simultaneously occurring at high tide), the frequency of Cooks River floods that are large enough to overtop Marsh Street is low and with a probability of much less than 1% AEP.

SES has also requested that an assumed sea level rise scenario for 2100 of 0.9m be assessed. It is agreed that the 0.8m sea level rise used in the FIRA was inconsistent with the NSW Sea Level Rise Policy Statement (2009).

Flood modelling has confirmed that the use of a 0.9m sea level rise instead of a 0.8m sea level rise only raises flood levels on the site by 0.035m (35mm). The minor influence of changes to the sea level rise value is due to the relatively steep flood gradient at the trained mouth of the Cooks River.

Hence, the conclusions drawn in the FIRA relating to the flood performance of the Cooks Cove Planning Proposal with sea level rise are still valid. The proposed floor levels would still be more than 0.5m above the 1% AEP flood levels with 0.9m sea level rise and 20% increased rainfall intensities, which is able to be addressed further at the DA stage.

SES state that "*tidal influence is also likely to contribute to flood risk at the site*" and that "*the site is situated within the Tsunami Evacuation Zone*". The lowest parts of the Cooks Cove Planning Proposal would be 2.17mAHD (the road level for Flora Street South onto Marsh Street). This level is still more than 1.0m above the highest astronomical tide (HAT) level for Botany Bay.

In regard to tsunami, that risk is noted, and that hazard will be included in the development of the Emergency Management Strategy at the DA stage.

**Principle 3**

***Development of the floodplain does not impact on the ability of the existing community to safely and effectively respond to a flood.*** *The ability of the existing community to effectively respond (including self-evacuating) within the available timeframe on available infrastructure is to be maintained. It is not to be impacted on by the cumulative impact of new development.*

The expected population that would be working at the site under the Cooks Cove Planning Proposal indicative reference scheme is (3,300 people) which is significantly less than the expected population under the current zoning of Trade and Technology (11,000 people). Hence, the Cooks Cove Planning Proposal represents a significant reduction in the possible population exposed to the risks of isolation (which are low risks anyway).

Hence, the existing community could be considered to include all currently zoned land and the Cooks Cove Planning Proposal would provide an improvement to that situation, including those arising from the implementation of flood mitigation strategies and improvements to be delivered to road infrastructure on Marsh Street and Flora Street East

**Principle 4**

***Decisions on redevelopment within the floodplain does not increase risk to life from flooding.*** *The preferred Emergency Management approach is evacuation, where evacuation capacity and capability has been demonstrated as the most effective strategy to manage Emergency Management risks*.

It is confirmed that evacuation is the primary response strategy for managing the population at risk of flooding for the Cooks Cove Planning Proposal. For all floods up to the 0.2% (1:500) AEP flood, occupants of the site can exit the site onto Marsh Street and drive south to high ground.

**Principle 5**

***Risks faced by the itinerant population need to be managed.*** *Any Emergency Management strategy needs to consider people visiting the area or using a development.*

It is agreed and noted that the Emergency Management Strategy will need to recognise the needs of any itinerant population in the hotel accommodation or other visitors to the site.

**Principle 6**

***Recognise the need for effective flood warning and associated limitations.*** *An effective flood warning strategy with clear and concise messaging understood by the community is key to providing the community an opportunity to respond to a flood threat in an appropriate and timely manner.*

It is agreed and noted that the Emergency Management Strategy will need to include clear and unambiguous messaging that is accessible to the whole population at risk.

**Principle 7**

***Ongoing community awareness of flooding is critical to assist effective emergency response.*** *In terms of the current proposal, the flood risk at the site and actions that should be undertaken to reduce the potential*

*risk to life should be clearly communicated to all site users, for example through signage and emergency drills, during and after the construction phase.*

It is agreed and noted that the Emergency Management Strategy will need to include elements such as signage and the conduct of emergency drills during and post construction.

## 8.2 Response to EHG Submission

### 8.2.1 Flood Function comments

**Technique used to define flood functions**

In regard to EHG's query on the technique used to define flood functions, the following is provided:

- For floodway definition, the conveyance technique was used (consistent with DPE Guideline FB02)
- For flood storage definition, the encroachment technique was used (consistent with DPE Guideline FB02)
- For flood fringe, this was defined as being that inundated land that is not flood way nor flood function (consistent with DPE Guideline FB02)

It is worth noting that the principle of defining natural floodplain floodways and flood storage areas is a very important step in managing flood risk on a floodplain that is generally in its natural state. However, the lower Cooks River and its floodplain is almost entirely man-made and was constructed in the middle part of the 20$^{th}$ century.

Hence, the value in defining and preserving floodways in a non-natural floodplain requires consideration in this instance. This is discussed further below.

**Influence of Muddy Creek flooding on Cooks Cove site**

EHG indicates that the flood behaviour from Muddy Creek (and its tributaries) is critical for the flood assessment of this site.

To provide clarity on this matter:

- there is no evidence that the site could be affected in any way from the Muddy Creek catchment as it is located downstream of the site;
- the land between the site and Muddy Creek is at an elevation of 7mAHD and will not be overtopped by Muddy Creek or Cooks River flooding in all events up to a PMF;
- The Cooks River flood model includes representation of the Muddy Creek floodplain (including Spring Drain and Scarborough Ponds) and the flows from the Muddy Creek catchment.

Figure 42 shows the location of Muddy Creek (including Spring Drain and Scarborough Ponds) in relation to the Cooks Cove site.

In summary of this matter, the Muddy Creek catchment has no influence on the flooding behaviour of the site. The local inflows from this catchment are already accounted for in the Cooks River flood assessments.

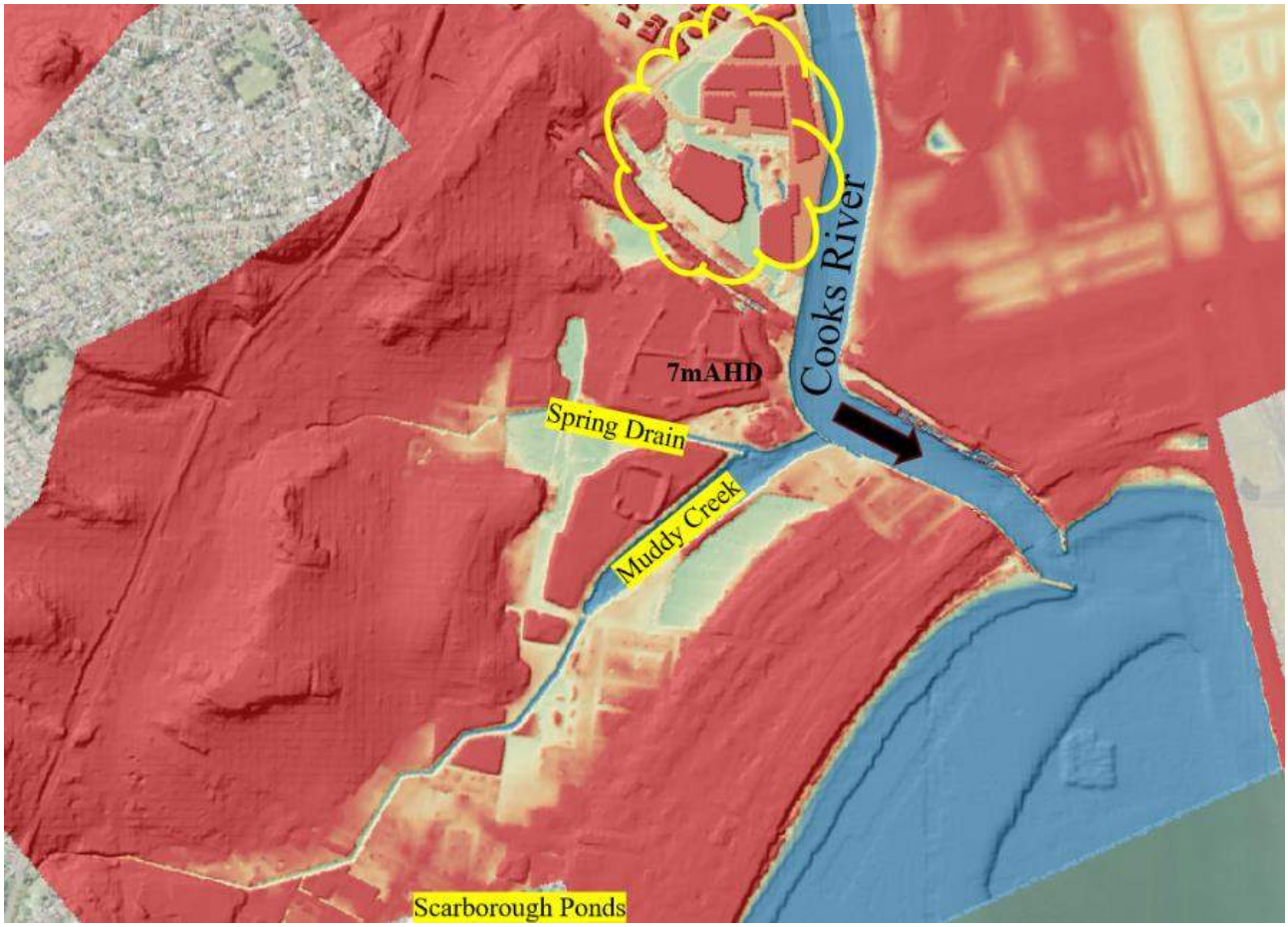


**Figure 42: Muddy Creek Location Relative to Cooks Cove site**

## Development filling floodway and Principle 8 of FRM (2023)

EHG states the opinion that the Cooks Cove Planning Proposal works against Principle 8 of FRM (2023) in that it involves filling and redirection of flows in a floodway.

For clarity on this matter, the relevant parts of Principle 8 of FRM (2023) are preproduced below (with bold emphasis added).

> ***Principle 8: Maintain natural flood functions***
>
> *Understanding the **natural flow conveyance and storage function** of the floodplain is important for effective flood risk management.*
>
> *Maintaining the conveyance of floodway areas and the capacity of storage areas can limit the impacts of change to the floodplain and associated flood risk to the existing community. In local overland flooding, maintaining flowpaths is important to enable water to flow from the catchment into waterways. **If flowpaths are partially or fully blocked by development or fill, alternative flowpaths may form, with potentially detrimental impacts to the community**. In addition, identifying and maintaining local flowpaths is an important aspect of managing local overland flooding.*

In response to the EHG comment on this matter:

- Principle 8 is clearly focused on maintaining the "*natural flow conveyance and storage function of the floodplain".* Hence, the Cooks River is a highly modified and constructed river and floodplain, the natural flood functions are no longer present due to these modifications.
- It is worth noting that the floodways in this site only become active in floods larger than the 0.5% (1:200) AEP flood and Bayside Council has never mapped nor identified floodways on this site.

- The Cooks Cove Planning Proposal would result in a scenario where "*flowpaths are partially or fully blocked by development or fill".* However, it needs to be recognised that the capacity of the flowpaths is to be retained in a nearby location. Principle 8 goes on to state that in this scenario *"alternative flowpaths may form, with potentially detrimental impacts to the community".* However, the flood assessments for a range of floods from small floods up to the PMF has demonstrated that the altering of this floodway can be achieved without any detrimental impacts to the community. There are no adverse impacts upstream or downstream and the hazards on the site are consistent with public open space usage. Hence, the Cooks Cove Planning Proposal is not inconsistent with the requirements or intent of Principal 8.

### 8.2.2 Climate Change comments

***Comment: EHG recommends testing the impacts of SLR with the 50th percentile value for SSP 8.5 of 1.3m the 95th percentile value for SSP 8.5 of 2.4m.***

The recommended EHG sea level rise values of 1.3m and 2.4m would appear inconsistent with the current NSW Sea Level Rise Policy statement value of 0.9m for 2100. The FIRA has used a value of 0.8m for sea level rise and that value should have been 0.9m. The consequences on the Cooks Cove Planning Proposal of using 0.9m for sea level rise are minor / negligible and discussed in Section 8.1.3.

Figure 43 and Figure 44 below show the extent of tidal inundation (no flooding) due to a high tide with sea level rise of 1.3m and 2.4m respectively. It is apparent in these scenarios that large parts of Arncliffe and a long section of Marsh Street would be largely under water. This would occur regularly in this scenario (i.e. twice a day). Further, key parts of Sydney Airport would be under water, which would impact significantly on the purpose of the development, which is to support trade related enterprises.

Hence, it is highly improbable that these scenarios would be permitted to eventuate without some type of intervention or mitigation (e.g. raising of seawalls, tidal gates, raising of Marsh Street). The key element to note is even in the EHG nominated 2.4m sea level rise scenario, the ground floors of all buildings in the Cooks Cove site would not be inundated in a Highest Astronomical Tide.

In conclusion, assessing sea level rise values of 1.3m and 2.4m would add no value to the assessment of flood risks for this site if it is assumed that this occurs in isolation.

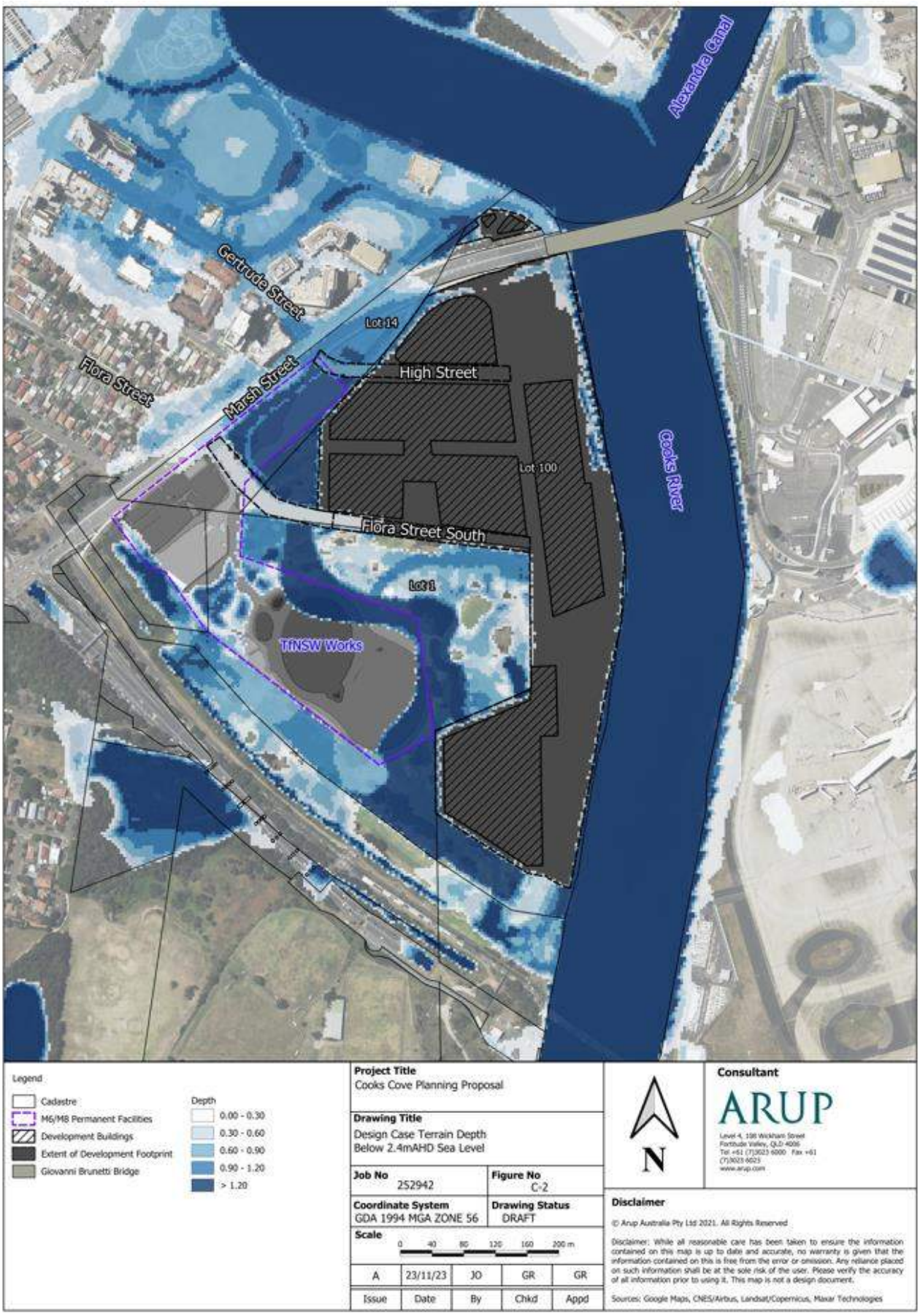


**Figure 43 Tidal Inundation (no flooding or storm surge) with 1.3m SLR**

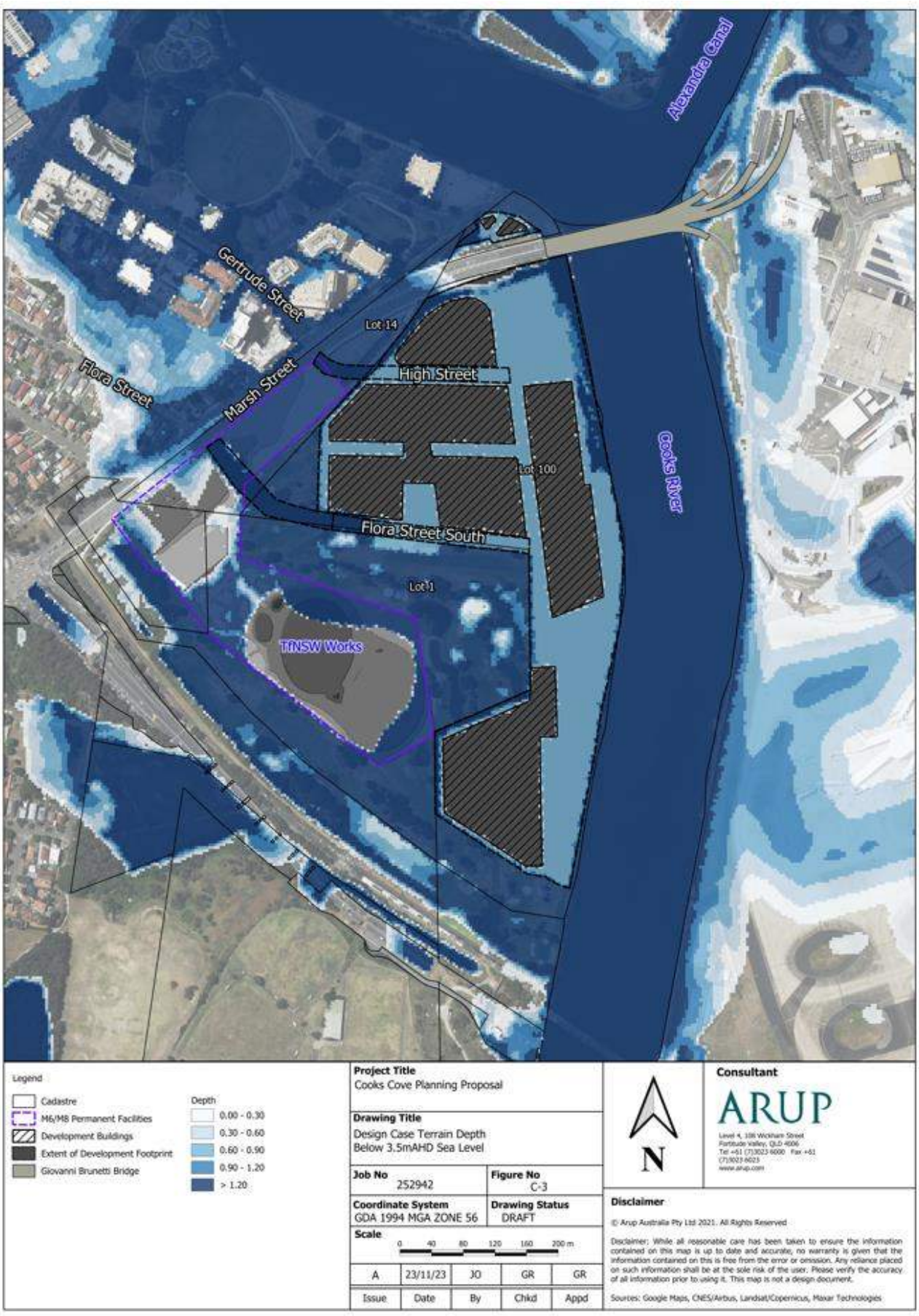


**Figure 44 Tidal Inundation (no flooding or storm surge) with 2.4m SLR**

### 8.2.3 Duration of Inundation comments

***Comment: The maximum duration of flooding should be established using the long duration PMF storms per the Generalised Southeast Australia Method***

In summary, EHG is requesting further assessments of the PMF to understand the possible duration of isolation that would occur in a PMF event (1:10,000,000 AEP).

The techniques used in the FIRA to estimate hydrographs for the PMF were somewhat conservative. It is likely that the use of the Generalised Southeast Australia Method would lead to slightly shorter durations of isolation.

However, the key point here is that there is no disagreement that the duration of isolation for a PMF flood would be in the order of 8 hours to 12 hours for the current climate and up to 20 hours for the climate change scenario (with sea level rise).

This consequence needs to be assessed in conjunction with the probability of this event (1:10,000,000 AEP or a 1 in 100,000 chance during the 100 year life of the project). The consequences of this event are that people would be isolated in buildings for half a day to one day with access to communications, food and water.

In summary, the technical risk-based approach as presented in the FIRA provides a sound basis for assessment of the risks (i.e. consequences and probability) associated with durations of isolation. The assessment concluded that the risks associated with very rare floods are low and acceptable.

### 8.2.4 Flood Emergency Management comments

***Comment: Sheltering in place for new development is generally not supported by DPE, EHG nor SES.***

This comment would appear to be inconsistent with DPE's Draft Shelter-in-place Guideline (2023) which states:

> *"SIP in infill developments is being approved on an ad hoc basis (part of a merit-based assessment of each development), while it is not considered an acceptable flood management approach in greenfield areas or large-scale urban renewal."*

The Cooks Cove Planning Proposal is neither greenfield (the land is currently zoned Trade and Technology) nor large-scale urban renewal.

The expected population that would be working at the site under the Cooks Cove Planning Proposal indicative reference scheme is (3,300 people) which is significantly less than the expected population under the current zoning of Trade and Technology (11,000 people). Hence, the Cooks Cove Planning Proposal represents a significant reduction in the possible population exposed to the risks of isolation (which are low risks anyway).

The Cooks Cove Planning Proposal relies upon evacuation as the primary emergency management approach for all floods up to the 0.2% (1:500) AEP flood. Hence, in the unlikely event of a rarer flood (i.e. it is not likely that such an event occurs in the 100 year design life of this project), then SIP would be employed.

The Cooks Cove Planning Proposal meets all of the seven requirements listed in DPE's Draft Shelter-in-place Guideline (2023) – see Section 7.5 of the FIRA.

### 8.2.5 Riparian Zone comment

***Comment: The Response to Submissions report shows the width of the amended riparian zone ranges from 20 – 100m. However, as stated in EHG's previous comments, the Cooks River is a 4$^{th}$ order stream that requires a 40m riparian buffer (on each side of the waterway) under the BAM.***

Within this precinct, the following watercourses values were identified as being significant in regard to riparian corridor purposes:

- Conveying flood flows and controlling the direction of flood flows
- Providing bed and bank stability and reducing bank and channel erosion

- Providing recreational uses.

For context, the following advice on this matter from Cumberland Ecology is provided:

> *Although it is agreed that the Cooks River (identified as a Diversion Canal on Lot 7 DP 1050923) requires the mapping of a 40 m riparian buffer under the Biodiversity Assessment Method, there is no requirement under the Biodiversity Assessment Method to avoid impacts within this area. There is also nothing in the Biodiversity Method that requires this 40m buffer to be revegetated. The Biodiversity Assessment Method only requires the impacts within this 40 metre buffer to be considered at the time of the preparation of a Biodiversity Development Assessment Report (BDAR) at the Development Application stage.*

The proposal seeks to enhance the values listed above by providing biodiversity enhancements including:

- Water quality improvements by trapping sediment, nutrients and other contaminants within the development zone.
- A diversity of habitats for terrestrial, riparian and aquatic plants (flora) and animals (fauna), with an expansion of suitable plant species.
- Maintaining connectivity between wildlife habitats
- A well-designed interface or buffer between developments and waterways
- Maintaining the flood conveyance of the current terrain as evidenced by the flood modelling outcomes (i.e. no upstream afflux)

To achieve these enhancements, the design has been amended to incorporate a number of features and enhancements to the foreshore. These are documented in the Cooks Cove Urban Design Report Addendum A (reproduced here as Figure 45).

Key features of this proposal include:

- A 40 m wide corridor through the Marshland Parts of the foreshore (see Figure 46)
    - Providing for ecological improvements far superior to which presently exist along the Cooks River and Muddy Creek within the vicinity of the precinct.
    - The zone includes zones for semi-aquatic planting that is protected from wave and current action in the main channel.
    - Zones of large trees that can provide habitat.
    - Connectivity back to the existing pond network to the west to provide habitat connectivity.
- A natural precinct that interfaces with the SP4 Enterprise zones (see Figure 47).
    - Providing for superior recreational use through the integration of walking and regional grade active transport paths to a foreshore which is not presently publicly accessible.
    - A general design which is largely comparable to that recently undertaken by Bayside Council for the interface with the Cooks River in nearby Cahill Park
    - This zone provides opportunities for mangrove planting along the foreshore, similar to those located on the foreshore at Caringbah in the Sharks League facility redevelopment.
    - Zones for larger planting and habitat.
- An urban interface zone that reflects the values of the norther portion of the precinct as a central urban hub (see Figure 48).
    - A design which welcomes the adjacent residential community through to the water's edge to enjoy enhanced connectivity, amenity and recreation outcomes.
    - These steps include planting and other opportunities for intertidal ecosystems.
    - Large trees to provide a comfortable environment by natural means, as well as habitat opportunities.

As such, the proposal presents an opportunity to enhance the biodiversity and other watercourse values associated with the site.

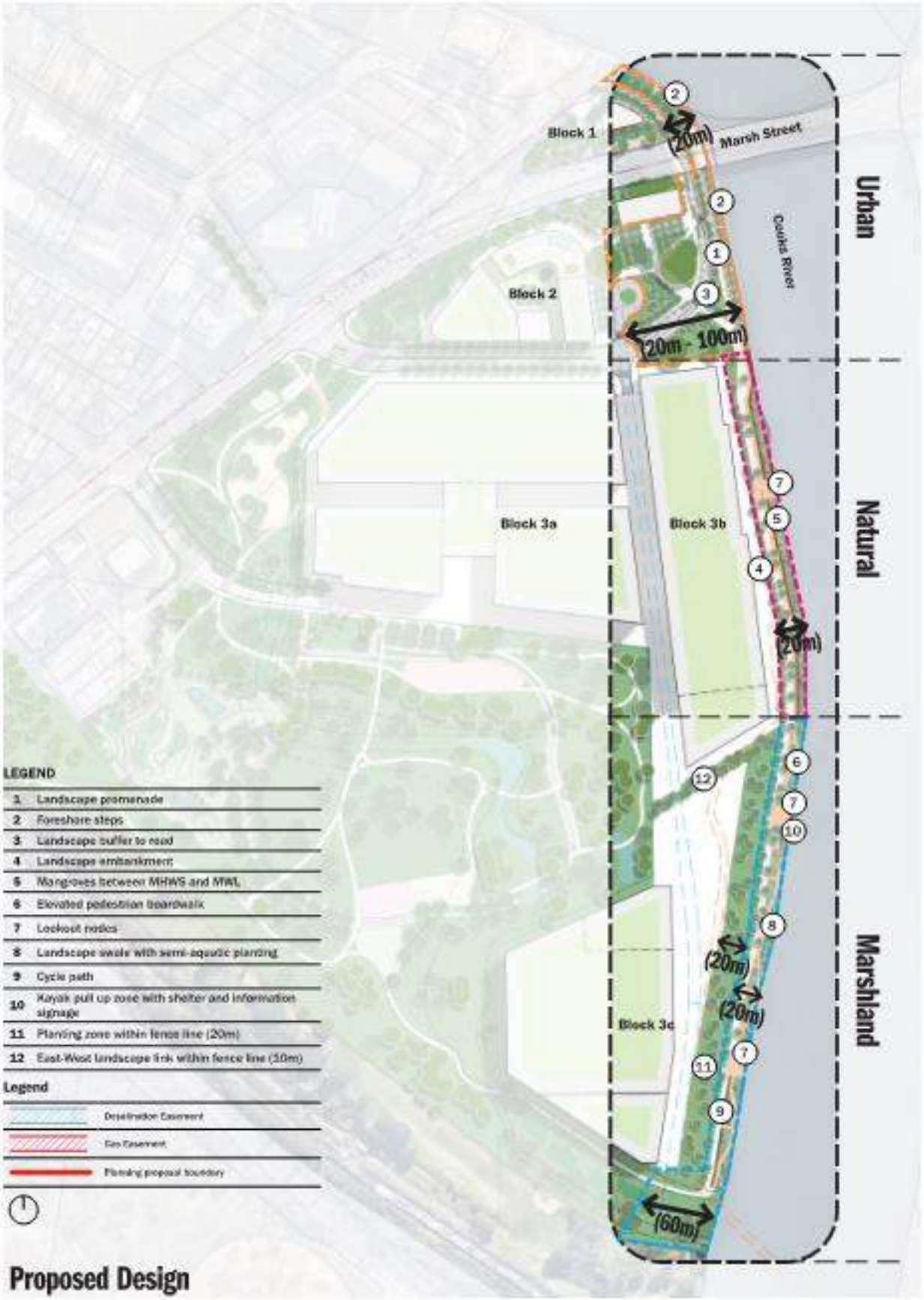


**Figure 45 Proposed Cooks Cover Urban Design Masterplan**

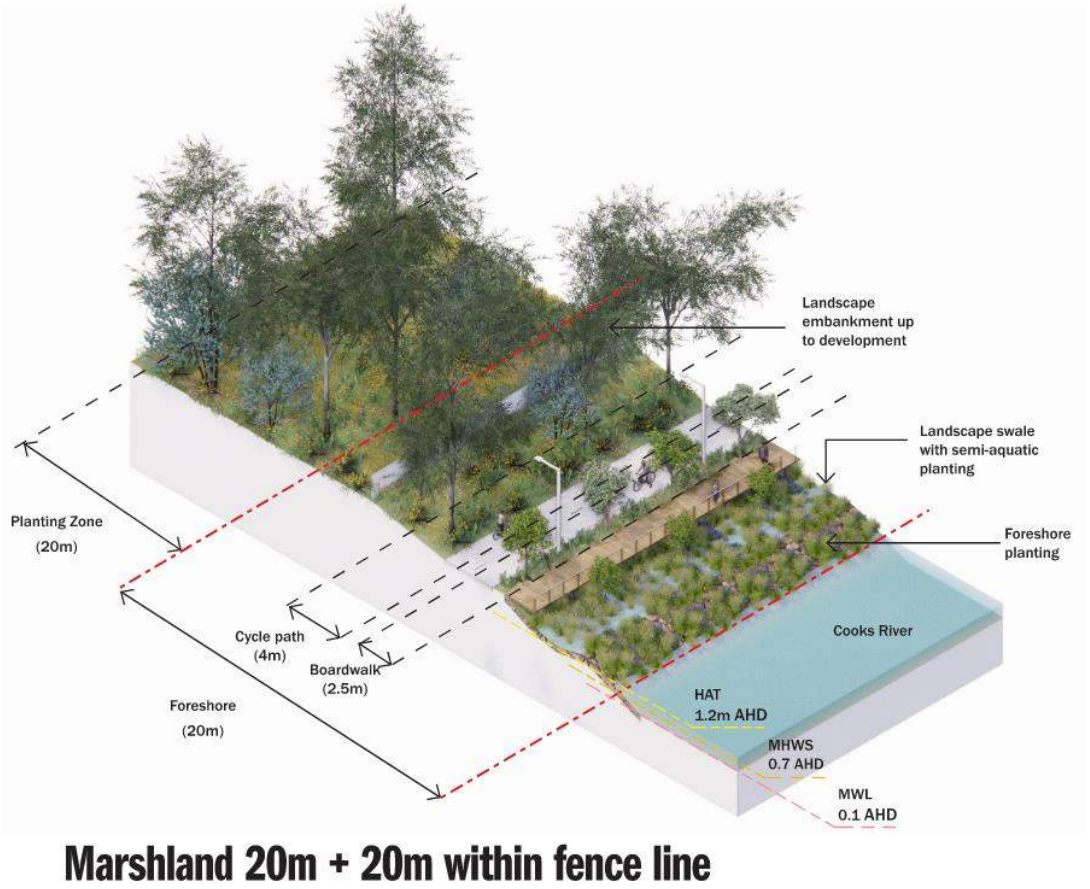


**Figure 46 Marshland Foreshore Treatment**

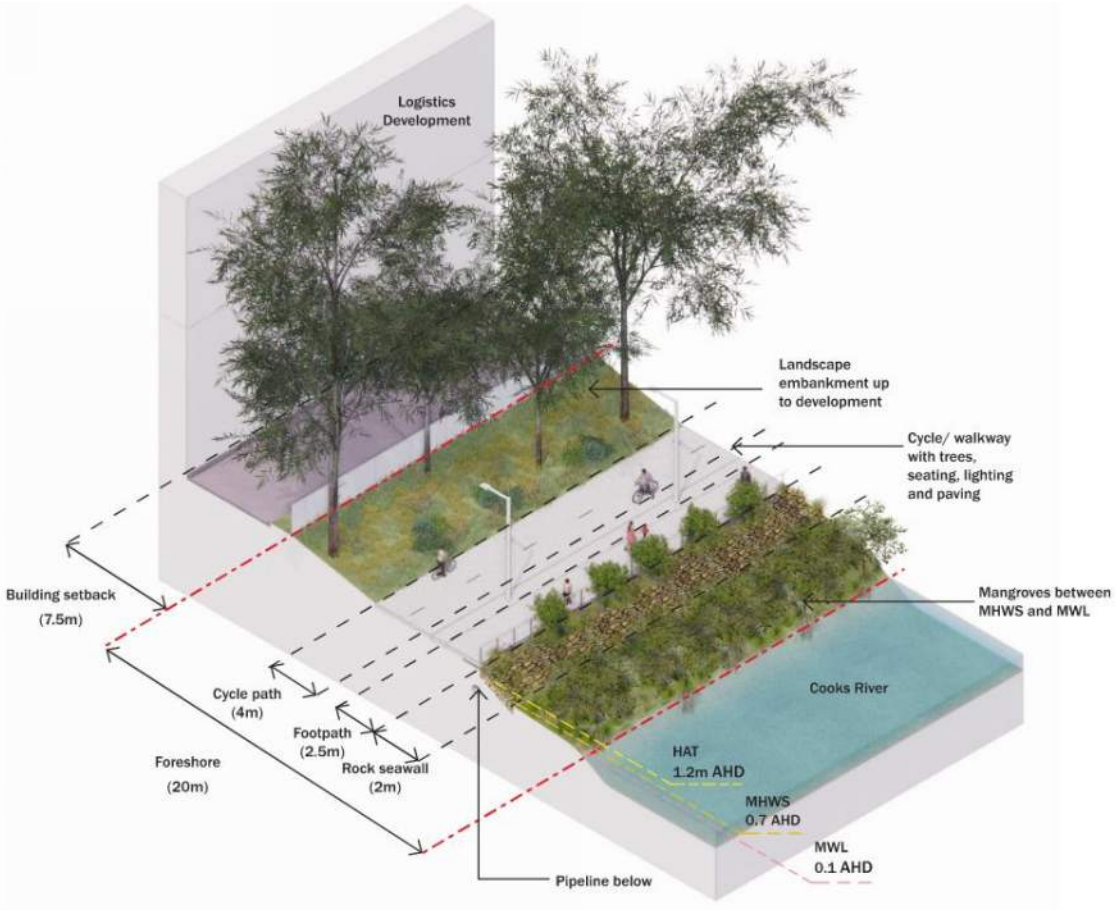


**Figure 47 Natural foreshore treatment**

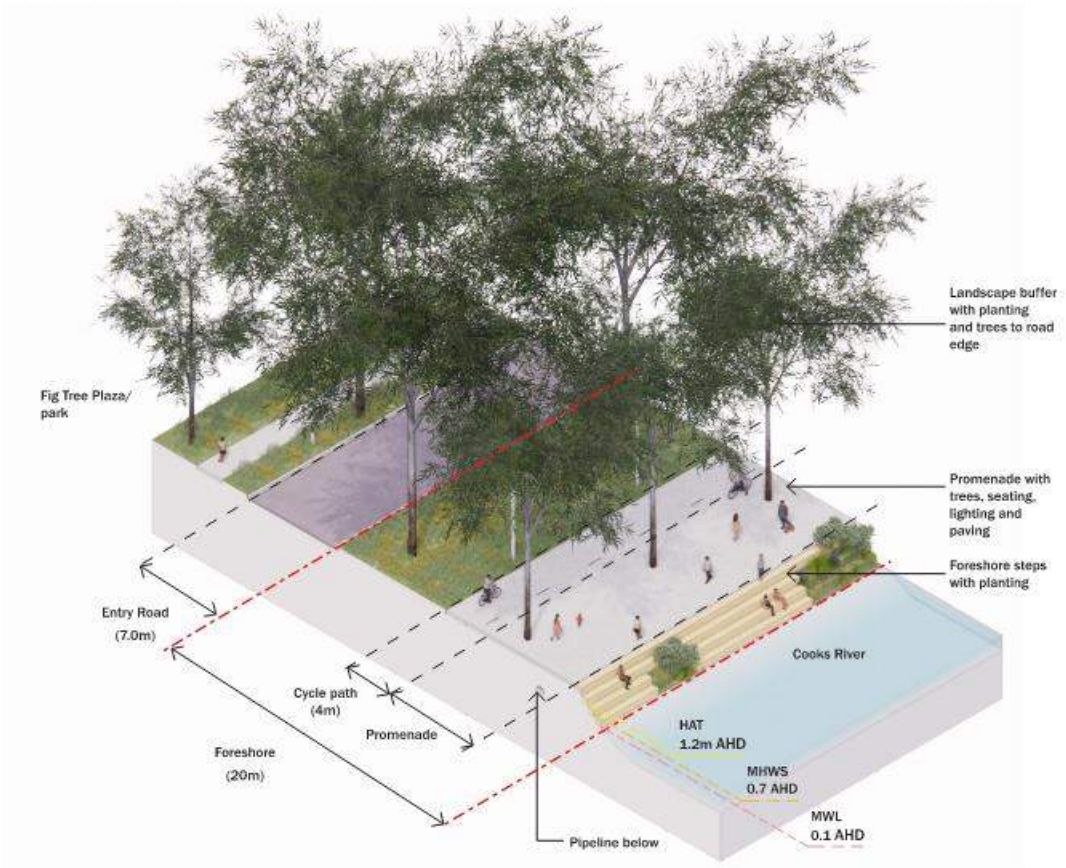


**Figure 48 Urban Foreshore treatments**

## 8.3 Response to BSC Submission

### 8.3.1 BSC Summary Comment

***Comment: Flooding, Stormwater Management & Water Sensitive Urban Design (WSUD) – Flood mitigation and stormwater management must be reviewed to ensure surrounding public land will not be burdened by the impacts generated by the development. This includes overland flow during significant flood events that currently passes through the golf course proposed to be diverted onto Council's land.***

For clarity on this matter, the flooding / overland flow is only associated with Cooks River flooding that overtops the banks of the Cooks River and then overtops Marsh Street. There would not be any stormwater from the Cooks Cove Planning Proposal discharged into the future council open space, it is intended to be treated on site and would flow into the Cooks River.

There have been further discussions with Bayside Council (BSC) relating to the accommodation of more of the overland flowpath on Lot 100 rather than Lot 1. This is achievable through the construction of an undercroft under the Block 3C buildings.

It needs to be noted that floods will only infrequently overtop the banks of the Cooks River and then overtop Marsh Street to flow through the future council open space. This would only occur in floods rarer than the 5% AEP flood (based on a conservative assumption that a storm surge in Botany Bay occurs and peaks at the same time). Further, duration of inundation for each flood event would be short and in the order of a few hours.

Hence, it is likely that the total combined duration of inundation of the future council open space would be in the order of 10 hours per century. This is 0.0011% of the time (i.e. one hour every 90,000 hours).

Note that this frequency of flow across Lot 1 is not changed by the Cooks Cove Planning Proposal. This frequency is fixed by the level of Marsh Street.

The design has been amended to avoid intrusion into the Pemulwuy Park area to accommodate the flood flowpath. In this revised design, the only potential intrusion into the Pemulwuy Park area would be a small area of 400m$^2$. This design change has been made to address Council's concerns regarding the integrity of the Pemulwuy Park area.

### 8.3.2 Overland Flow Comment

***Comment: Flood Planning & Stormwater Management – We retain our objection to the proposed overland flow path over Council land. The diversion of overland flow around the development site over Council land is not acceptable unless the consequential impact on the enjoyment of Council's land by the community is minimal.***

For context, currently the Cooks River flood flows pass through Lot 14 and Lot 100 and Lot 1 prior to flowing back into the Cooks River. This will still be the situation with the Cooks Cove Planning Proposal.

This is a repeat of the issue listed above relating to the enjoyment of the land being diminished by having flow pass over it for 10 hours per century. Further, the frequency of flow across Lot 1 is not changed by the Cooks Cove Planning Proposal

It should also be noted that the Cooks Cove Planning Proposal has been significantly adjusted to accommodate flows on Lot 100 at three (3) critical pinch points as shown in Figure 49 below.

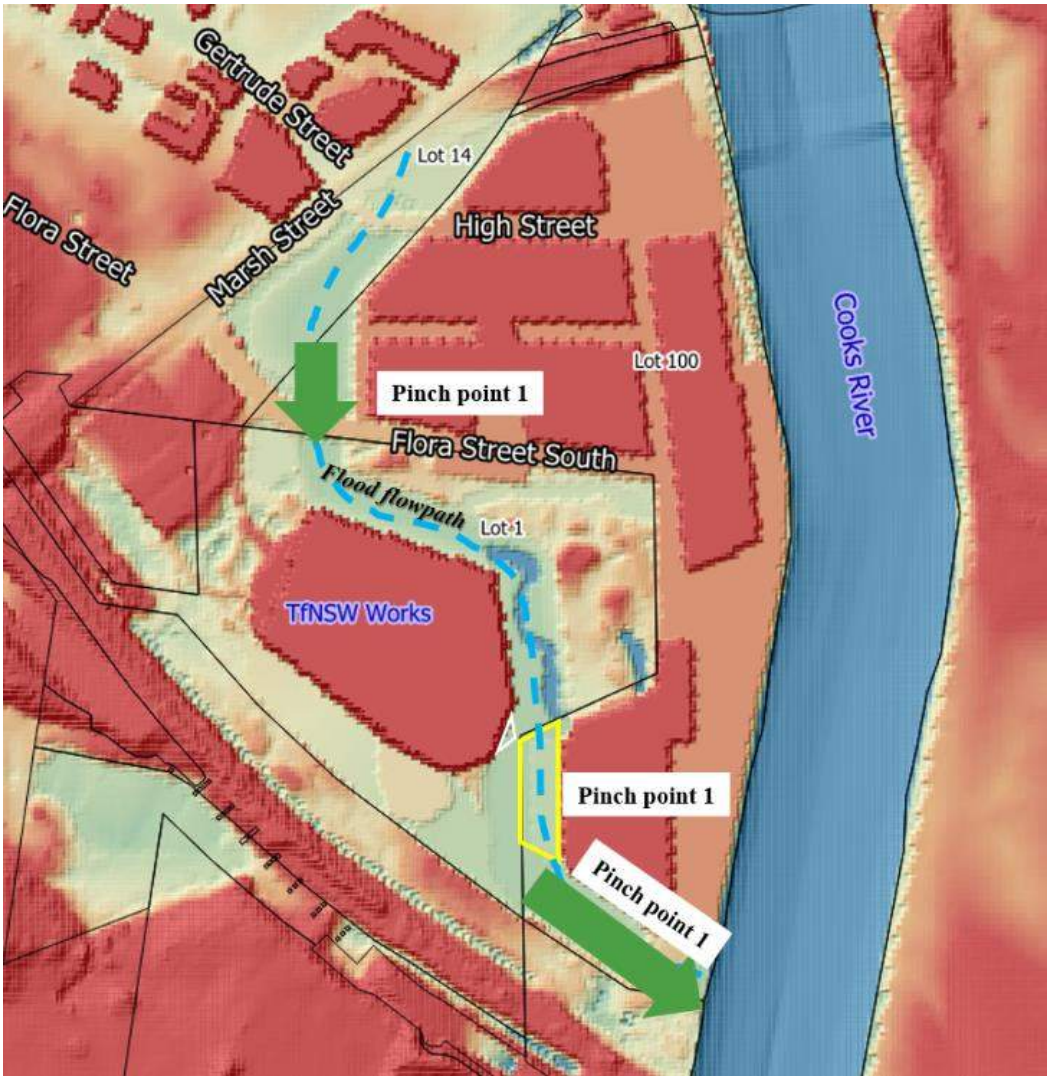


**Figure 49 Cooks Cove Planning Proposal Lot 100 Flow Accommodation**

### 8.3.3 Ministerial Direction 4.1 Comment

***Comment: Council's is not yet satisfied that the proposal meets the requirements of Ministerial Direction 4.1 – Flooding.***

We believe that this issue has been sufficiently addressed in the FIRA to meet the needs of this stage of the planning process. See Table 3 of FIRA which provides a list of the elements of the direction and how the Cooks Cove Planning Proposal meets each element. The information in the FIRA and this document demonstrate that the Cooks Cove Planning Proposal meets all of the requirements of the Ministerial Section 9.1 Directions: Focus Area 4.1. Also refer to supplementary response from Ethos Urban with regards to a full Ministerial Direction response.

### 8.3.4 Coincidental Flooding Comment

***Comment: Council's engineers have confirmed they are not satisfied that coincidental flooding including tidal inundation has been adequately addressed.***

The FIRA has used current DPE guidance on this matter. The flood assessments presented in the FIRA are based on flood events with coincident fluvial flooding and tidal / storm surge events.

We believe that this issue has been sufficiently addressed in the FIRA to meet the needs of this stage of the planning process.

### 8.3.5 Emergency Management Comment

***Comment: Council's engineers have confirmed that the evacuation/emergency management strategy (flood risk management) is not considered to be adequate, with the following issues outstanding:***

***Comment: The revised report has not met the EHG and SES comments regarding disagreement with a shelter in place strategy for the development.***

Issues relating to emergency management have been raised by SES and are discussed in their submission. It would appear from the SES submission that SES *"note and appreciate that the proposed road changes for Flora Street South accommodate 1:500 AEP flows"*. However, it is noted that SES also state that they are not supportive of the shelter in place strategy.

DPE's Draft Shelter-in-place Guideline (2023) states:

> *"SIP in infill developments is being approved on an ad hoc basis (part of a merit-based assessment of each development), while it is not considered an acceptable flood management approach in greenfield areas or large-scale urban renewal."*

The Cooks Cove Planning Proposal is neither greenfield (the land is currently zoned Trade and Technology) nor large-scale urban renewal.

The expected population that would be working at the site under the Cooks Cove Planning Proposal is (3,300 people) is significantly less than the expected population under the current zoning of Trade and Technology (11,000 people). Hence, the Cooks Cove Planning Proposal represents a significant reduction in the possible population exposed to the risks of isolation (which are low risks anyway).

The Cooks Cove Planning Proposal relies upon evacuation as the primary emergency management approach for all floods up to the 0.2% (1:500) AEP flood. Hence, in the unlikely event of a rarer flood (i.e. it is not likely that such an event occurs in the 100 year design life of this project), then SIP would be employed.

The Cooks Cove Planning Proposal meets all of the seven requirements listed in DPE's Draft Shelter-in-place Guideline (2023) – see Section 7.5 of the FIRA. Hence, we believe that the proposed emergency management approach is technically robust and consistent with DEP guidance.

***Comment: The assessment looking at different hazard levels and comments regarding "large vehicles" being able to traverse H2 flood waters is not appropriate, as this dismisses SES advice of not entering flood waters.***

SES has not raised this as an issue and *"note and appreciate that the proposed road changes for Flora Street South accommodate 1:500 AEP flows"*.

It should also be noted that SES uses large vehicles (ie Land Cruiser 4WD) for emergency access that can safely drive through H2 hazard flow.

***Comment: The evacuation route assessment (external to the site) uses only the peak duration, as this is all based on peak flood depths from other flood studies. Noted this is what is reported in the flood study report however the peak event is not necessarily producing the longest duration of road access being cut.***

The FIRA assessments on durations of inundation considered a range of flood durations including the critical duration (i.e. that which produces the peak flood levels). The FIRA focussed on the longest duration of inundation which is a conservative approach. Hence, this comment is not a correct reflection of the FIRA assessment.

***Comment: The feasibility of a ramp to Marsh Street should be considered based on its proposal as an evacuation route. The practicality of this ramp is questionable, and as it is a key consideration of this planning proposal, it should not be deferred to the detailed design stage.***

It is not agreed that the practicality of this ramp is questionable as it is a commonly used approach to accessing higher roads. There is sufficient space for suitable grades. Further detail can be addressed at the subsequent stages of design, but the concept is relatively uncomplicated and sound.

***Comment: The "6 hour" SIP is exceeded in numerous instances for inundation of the Marsh Street evacuation route considering climate change***

This is true only for the PMF in the current climate and events rarer than the 1:2000 AEP for the climate change scenario. These floods cannot be referred to as 'instances' in the way that they are floods that have a similar probability. The floods are defined by their rarity. So, unless the probability is considered in the context of the duration of inundation, these assessments become meaningless. For context, for every PMF flood 'instance', there would be 5,000 events larger than the 1:2000 AEP flood. For every 1:2000 AEP flood 'instance', there would be 20 events larger than the 1:100 or 1% AEP flood.

***Comment: Council's engineers have confirmed they are not satisfied with the Proponent's response to issues raised regarding Stormwater and WSUD as the updated ARUP report purely focuses on flooding***.

The FIRA was a flood impact assessment so focussed on flooding. The issues raised on stormwater and WSUD can be resolved at subsequent approval stages. BSC has not identified any outcomes / concepts of the CCPP that would not enable suitable measures to be introduced at the subsequent approval stages. Stormwater and WSUD provisions will be addressed through the site-specific DCP, which has been drafted by the Proponent and is under review by BSC to appropriately address these detailed matters.

### 8.3.6 Riparian Zone comment

***Comment: We maintain that the riparian buffer zone should be consistent with DPE's 'Guideline for riparian corridors on waterfront land' along the entire length of the foreshore. A setback of 40m must be provided unless otherwise justified with evidence that a reduction will not pose a negative impact upon the watercourse.***

Within this precinct, the following watercourses values were identified as being significant in regard to riparian corridor purposes:

- Conveying flood flows and controlling the direction of flood flows
- Providing bed and bank stability and reducing bank and channel erosion
- Providing recreational uses.

The proposal seeks to enhance the values listed above by providing biodiversity enhancements including:

- Water quality improvements by trapping sediment, nutrients and other contaminants within the development zone.

- A diversity of habitats for terrestrial, riparian and aquatic plants (flora) and animals (fauna), with an expansion of suitable plant species.
- Maintaining connectivity between wildlife habitats
- A well-designed interface or buffer between developments and waterways
- Maintaining the flood conveyance of the current terrain as evidenced by the flood modelling outcomes (i.e. no upstream afflux)

To achieve these enhancements, the design has been amended to incorporate a number of features and enhancements to the foreshore. These are documented in the Cooks Cove Urban Design Report Addendum A (reproduced here as Figure 50).

Key features of this proposal include:

- A 40 m wide corridor through the Marshland Parts of the foreshore (see Figure 51)
    - Providing for ecological improvements far superior to which presently exist along the Cooks River and Muddy Creek within the vicinity of the precinct.
    - The zone includes zones for semi-aquatic planting that is protected from wave and current action in the main channel.
    - Zones of large trees that can provide habitat.
    - Connectivity back to the existing pond network to the west to provide habitat connectivity.
- A natural precinct that interfaces with the SP4 Enterprise zones (see Figure 52).
    - Providing for ecological improvements far superior to which presently exist along the Cooks River and Muddy Creek within the vicinity of the precinct.
    - A general design which is largely comparable to that recently undertaken by Bayside Council for the interface with the Cooks River in nearby Cahill Park
    - This zone provides opportunities for mangrove planting along the foreshore, similar to those located on the foreshore at Caringbah in the Sharks League facility redevelopment.
    - Zones for larger planting and habitat.
- An urban interface zone that reflects the values of the norther portion of the precinct as a central urban hub (see Figure 53).
    - A design which welcomes the adjacent residential community through to the water's edge to enjoy enhanced connectivity, amenity and recreation outcomes.
    - These steps include planting and other opportunities for intertidal ecosystems.
    - Large trees to provide a comfortable environment by natural means, as well as habitat opportunities.

Each of these zones is intended to enhance the watercourse values applicable to the site while facilitating the overall planning objectives for the site.

As such, the proposal presents an opportunity to enhance the biodiversity and other watercourse values associated with the site.

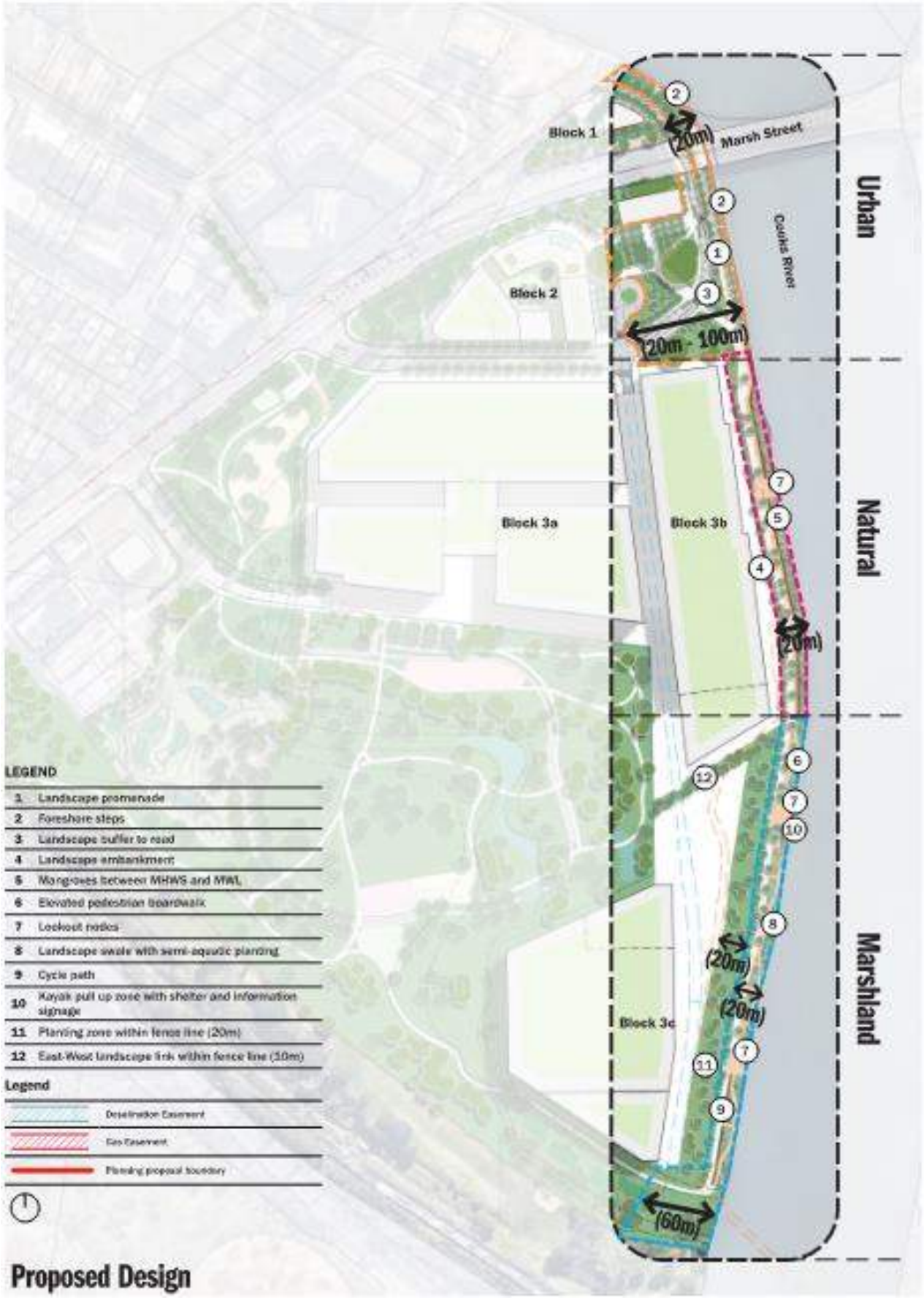


**Figure 50 Proposed Cooks Cover Urban Design Masterplan**

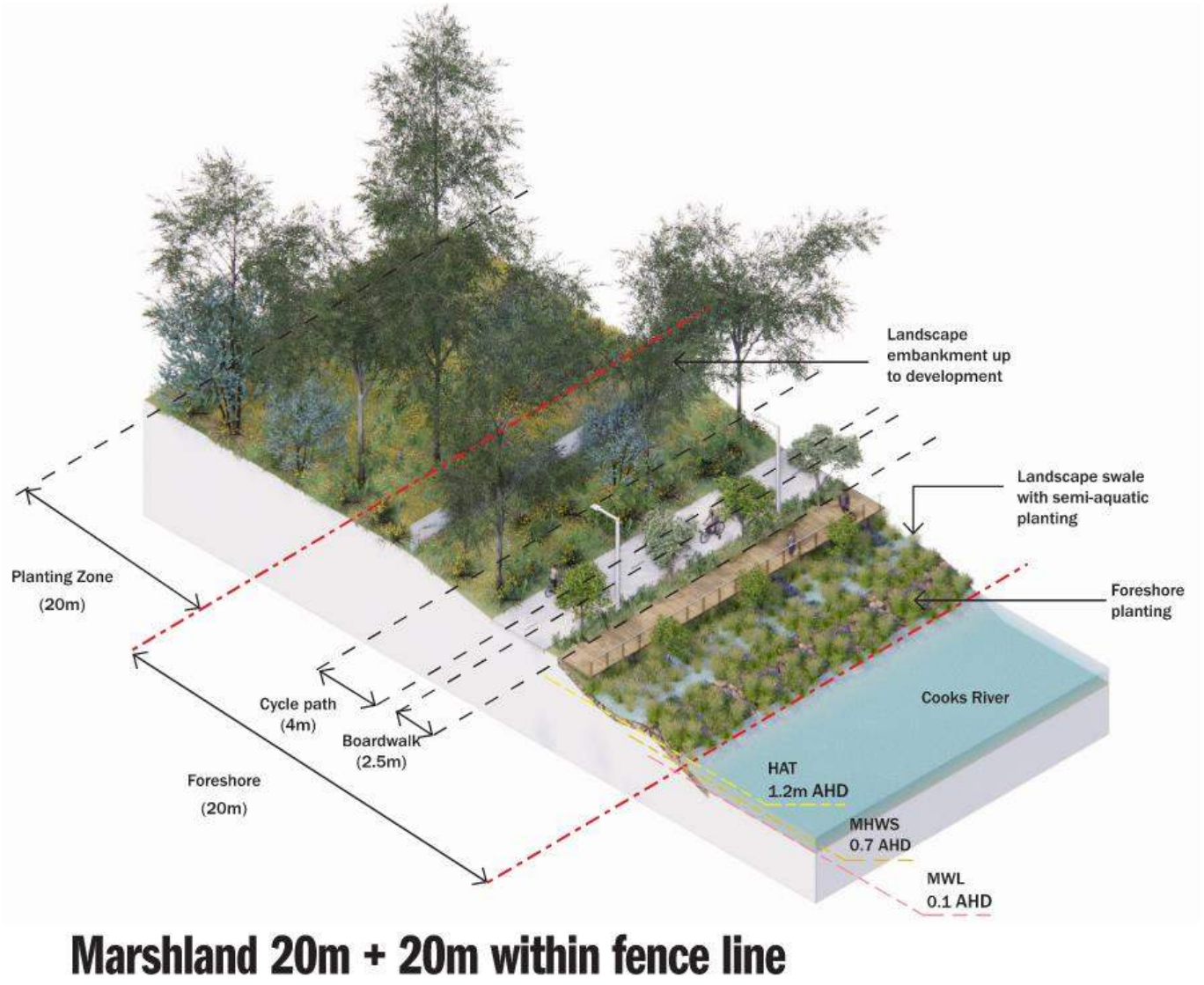


**Figure 51 Marshland Foreshore Treatment**

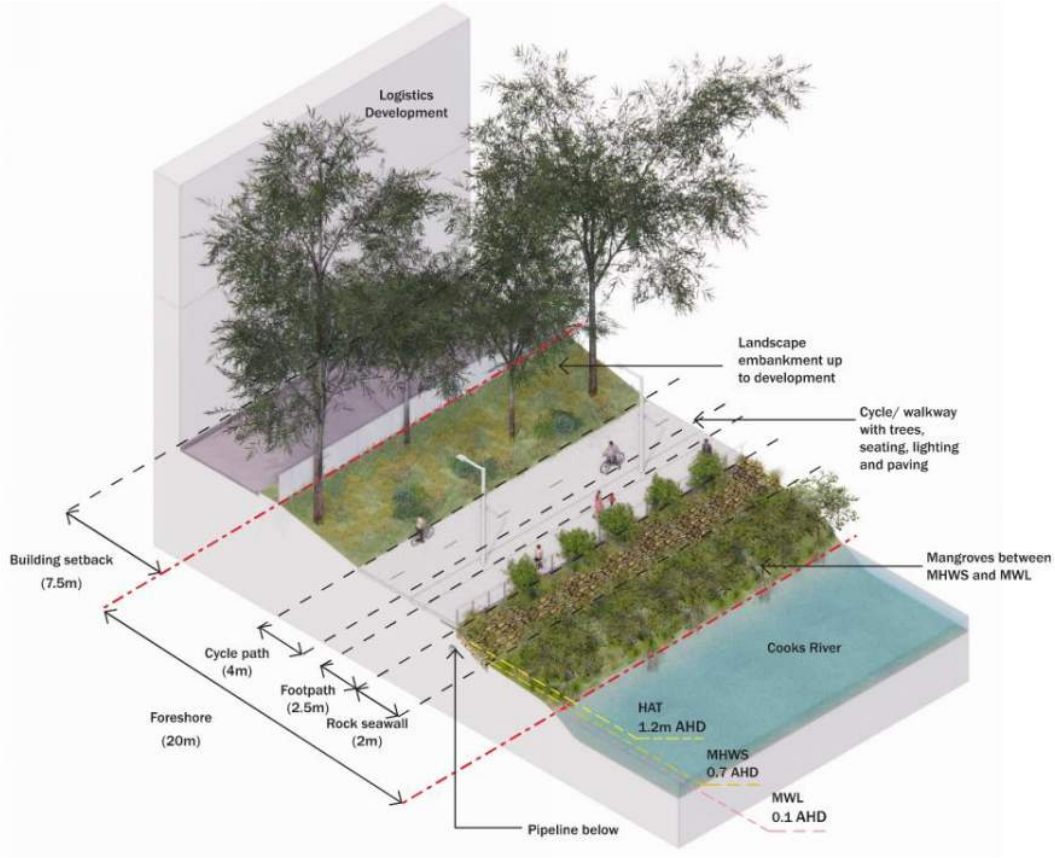


**Figure 52 Natural foreshore treatment**

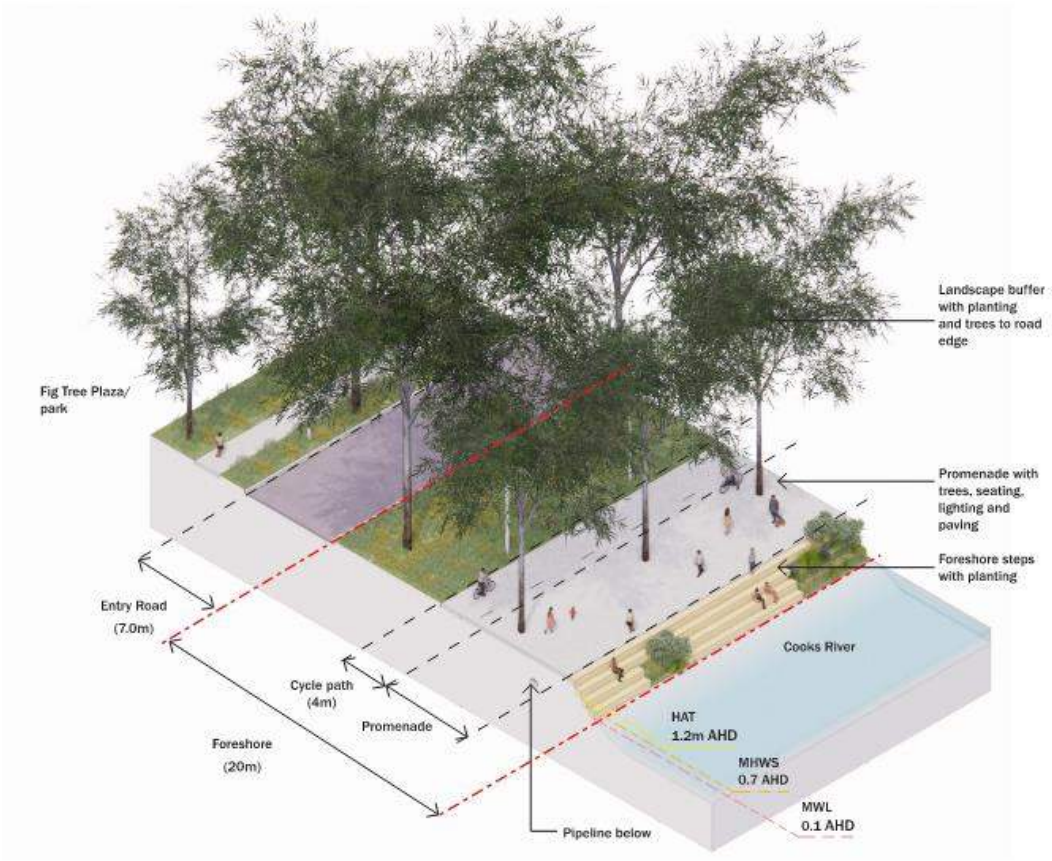


**Figure 53 Urban Foreshore treatments**

## 8.4 Response to TfNSW Submission

### 8.4.1 Comment #3

***Comment: CCI's proposed flood management strategy maintains status quo to Option 4 as exhibited, and requires significant redesign work or retrospective redesign and construction to the M6 Arncliffe Parklands open space as supported by Bayside Council. Option 4 is also in conflict with Bayside Council's concerns re: diversion or concentration of an overland flow path across Council owned land.***

Since the submission of the FIRA, an alternative proposal has been prepared that aims to accommodate the flood flows on land outside of the M6 Arncliffe Parklands / land forming part of the Urban Design Landscape Plan (UDLP). This has been made possible through the introduction of an undercroft under the Block 3C building.

As well, the requirement to change the design of the M6 Arncliffe Parklands on the northern boundary has been removed.

The overall outcome is that there would only be a small area of about 400m$^2$ of the M6 Arncliffe Parklands (under 1% of the area) that would require re-design. The only need for the re-design of this small area is to manage the risks associated with debris blockage on the security fence surrounding the site.

# 9. Workshop with Stakeholders on 27/11/2023

## 9.1 27/11/2023 Workshop

On 27th November, 2023, a workshop was held with stakeholders (DPE Agile Planning, EHG, TfNSW, BSC) on the proposal. The workshop provided an opportunity to discuss the planning proposal and the concerns of stakeholders.

## 9.2 Information Pack Outcomes from 27/11/2023 Workshop

Appendix C.1 includes the PowerPoint slides used in the 27/11/2023 Stakeholder Workshop. Following the workshop, further flood assessments were carried out on a proposed undercroft option. The revised flood impact maps for this option are presented in Appendix C.2.

Appendix C.3 presents the flood impacts for the proposed undercroft option with climate change (0.9m sea level rise). Appendix C.4 presents the resulting flood hazards for the proposed undercroft option. Appendix C.5 presents the resulting flood velocities for the proposed undercroft option.

## 9.3 Responses to Further BSC Comments after Stakeholder Workshop

Agile Planning (DPE) provided a number of additional comments from BSC (ref email to Boyd Properties and Ethos Urban on 19th January 2024). The parts of the email requiring responses are repeated below with the response.

### 9.3.1 Council concerns regarding changes to flood hazard on BSC land

***Comment:***

> However, Agile considers that the following matter raised by Council will require a response from CCI's flood consultants demonstrating how the Section 9.1 Direction can be met:
>
> - *The flood hazard must be reduced on Council land. The entire proposal is reliant on filling too much of the site and increasing the flood hazard on Council land from H3 to H4/H5 which is not an acceptable outcome for the community. The applicant should investigate measures to reduce the flood risk on Council's land compared to existing conditions. By reducing the fill on the development site, the displacement of floodwaters can be reduced which is necessary to reduce flood hazard on Council's land. The construction methodology for Block 3 should be reconsidered as excessive fill is not appropriate.*

To understand the chronology of the changes to flood hazard on Lot 1 and Lot 14 (Council's land), a set of maps is provided in Appendix D. These show the flood hazards for three cases:

- Pre 2017 (which is generally the case that existed for about 65 years from early 1950's onwards, including urban development surrounding the site, construction of the Giovanni Brunetti Bridge and widening of Marsh Street, to when TfNSW started works of the M6 and M8 projects)
- 2017-2025 (the interim case with the TfNSW compound and park areas filled over the top of the previous lakes and flood flowpaths)
- 2025 onwards (the case with TfNSW compound, Pemulwuy Park and Cooks Cove development)

These maps help demonstrate a few matters:

1. Lot 1 and Lot 14 always had high hazard flow (H4/H5) areas until the TfNSW filling which moved the flow onto CCI's Lot 100
2. The resulting H5 areas generally coincide with long-standing golf course lakes (see discussion on depth below) but there was a defined flowpath on Lot 1 (now filled)

As well, the flood maps for the Cooks Cove Case (design case) show that the resulting flood hazards for the total public open space outcome within the Planning Proposal boundary is actually a far better outcome than the large majority of public open space areas, in general terms. Further justification is provided as follows:

1. The flood immunity is low (about 2% AEP) compared to flood immunities of most public open space (usually about 10% AEP or higher).
2. About 20% of the public open space area within the Planning Proposal boundary is above the PMF, which is considered to be a significant positive and a rare outcome for public open space in general.
3. There is safe access to and from the public open space area within the Planning Proposal in all floods up to the 1:500 AEP. The Planning Proposal provides a mechanism to provide this safe access which does not exist in the current planning provisions.
4. The duration of the high hazard flow with the Planning Proposal is short (in the order of a few hours per century) and is in specially designed and managed locations.
5. By way of example, the hazards on the flooded parts of Lot 1 and Lot 14 are no different to that on nearby Cahill Park.
6. The high hazard areas (H4/H5) only occur in floods rarer than a 0.2% AEP (1:500 AEP) flood. Hence, the chance that these hazards occur in the next 100 years is about 1 in 5. The most likely outcome over the next 100 years is that this area would experience some areas of H3 flow for about two hours (in the whole century).

### 9.3.2 Council concerns regarding changes impacts to other properties

***Comment:***

> In particular, Direction 4.1 (3)(b) states that *"a planning proposal must not contain provisions that... permit development that will result in significant flood impacts to other properties,"*. Accordingly, Agile requests that CCI's flood consultants provide advice as to potential future mechanisms that would reduce the flood hazard on Council land, and/or how the 'consistency' mechanism in the 9.1 Direction for flooding can be achieved.

In response to DPHI Agile's request to "*provide advice as to potential future mechanisms that would reduce the flood hazard on Council land*", we provide the following.

Firstly, it needs to be noted that the some of the high hazard land for some floods on Council land is due to the depth of flooding in the lakes. The hazard ratings are based on an assessment of depth, velocity and depth-velocity product. But part of the hazard rating is based purely on depth. For example, any floodwater (even backwater / still water with no velocity) that has a depth of more than 1.2m will be H4 and any water depth of more than 2m will be H5. Hence, lakes with a standing depth of say 1m would start at H3 and become H5 with only 1m of additional floodwater.

Hence, the mapping showing H5 areas on Lot 1 could be reduced in future designs by filling of the existing golf course lakes which may not be required to be as deep as they currently are (as they were designed for golf course irrigation storage).

Secondly, another future design could include a focus on ensuring simple, safe access from the flood-prone parts of Lot 14 and Lot 1 to the safe refuge of the adjacent land above the PMF. The Cooks Cove development will result in large areas of land with roads above the PMF. The TfNSW Pemulwuy Park will be above the PMF. Access to these areas would be facilitated by flat grades (less than 5%) and potentially gentle ramping where required.

Thirdly, the detailed design could provide signage to these flood refuge areas in the event of a flood event in which people find themselves on the lower parts of Lot 1. The rates of floodwater rise are slow (refer to flood animations previously provided) and, as previously documented, the longest distance to walk to high ground is 200m and this could be covered in 6 minutes at very slow walking speed of 2km/h. The rate of floodwater rise in that 6 minutes would be about 0.1m.

Fourthly, there could be opportunities to reduce the hazard on the Lot 1 area by reducing the capacity of the flowpath. This would be achieved through the further cooperation of TNSW to understand whether minor

afflux is acceptable within non-sensitive areas of the TfNSW Arncliffe MOC. This would require a more technical process to understand and test flooding impact against specific infrastructure and plant within the MOC facility. This is capable of being further addressed in the detailed design phase post rezoning.

### 9.3.3 Council concerns regarding consistency with 9.1 Direction

***Comment:***

> Council's engineers have particularly noted the following principles require resolution to be consistent with the 9.1 Direction:
>
> - ***Principle 8: Maintain natural flood functions:*** *Flood storage areas have been removed and replaced with a high hazard flood way in Council land.*
> - ***Principle 9: Manage Flood Risk Effectively:*** *This principal requires Council to limit increases in flood risk to new development. This proposal results in high hazard areas forming and an increase of risk due to an increase in population in a flood prone area.*

In regard to the issue of demonstrating consistency with these two principles:

**Principle 8:**

As demonstrated in Section 2.2 of the FIRA, there are not any natural flood functions on this floodplain due to the highly modified and man-made nature of the Cooks River (physically diverted / channelised in the 1950s) and its floodplain.

However, it is worth noting that the case documented as the existing case is actually an interim case that will exist for about 9 years (2017 to 2025). The long-term base case (1950 to 2017) shows that there were always high hazard flow areas (H4/H5) on Lot 1 and Lot 14. It is important to note that the length of duration for the Cooks Cove Planning Proposal exceeds this interim period, with the Planning Proposal originally lodged in 2017.

As discussed above, the hazards on the public open space areas are only high in rare flood events and the likely outcome over the next century is that there would be about two hours of H3 flow.

We have also identified above future methods for reducing the hazards on Lot 1 and Lot 14 subject to the detailed design process post rezoning and subject to the further cooperation of Bayside Council and TfNSW as key stakeholders.

**Principle 9:**

It is important that the full text of Principle 9 is understood. The overall aim of Principle 9 is that related to managing the flood risk in an effective manner – not just limiting increases in flood risk:

> *"Effective management of flood risk to the community requires a* ***flexible merit-based approach to decision-making****. This supports sustainable use and development of the floodplain ……..Management also needs to consider social, economic, ecological and cultural factors, together with* ***community aspirations for the use of flood prone land****."*
>
> *"****Decisions to place new development in the floodplain generally increase flood risk****. This may be due to the risk to the new development and its users, or it may relate to the impacts the development may have on flood behaviour or flood and EM risks to the existing community. Consistent with the policy, a merit-based approach is recommended in developing and implementing strategic planning through local strategic planning statements (LSPSs), planning instruments such as local environmental plans (LEPs), and development control plans (DCPs). This involves considering the risks outlined above to limit the potential for increases in flood losses and risks in areas proposed for new development."*

As discussed above, the overall outcome for the community in regard to public open space is an area with relatively low flood risks compared to most public open space areas and one which is further augmented by the Planning Proposal compared to the current arrangements.

The Cooks Cove Planning Proposal will result in a reduced gross development footprint (zoned SP4 Enterprise) of approximately 18 hectares and a net development footprint of 14.3 hectares. This has been arrived at through land dedications of some 1.6ha to effectively address regional flooding matters within the boundary of the Planning Proposal.

Despite the larger footprint of the current Trade and Technology zoning, which has a maximum floorspace of 270,000sqm, a different typology of logistics and warehousing under the Cooks Cove Planning Proposal has allowed an increase in overall floorspace to 343,250sqm. However, the indicative reference scheme which is considered 'highest and best use' for the purpose of technical analysis of the Planning Proposal, is expected to reduce the population to approximately 3,300 workers, primarily to less worker intensive trade-related logistics buildings which are now intended to be realised within Cooks Cove.

Further commentary in respect to the planning related outcomes of the flood solution proposed are provided in correspondence prepared by Ethos Urban dated 8 December 2023. The FIRA has demonstrated that the working population on the Cooks Cove site can be accommodated in buildings that are above the PMF and have safe access in all floods up to the 1:500 AEP and short durations where shelter-in-place would be required in rarer flood events.

Through the site-specific DCP process for Cooks Cove, of which Council is a key stakeholder, planning provisions envisioned by the proponent are intended to significantly enhance the flood safety and management regime within the site, including the public open space area. For instance, a key objective of future development is captured in an objective proposed as follows:

> *"To ensure Cooks Cove provides appropriate flood mitigation solutions to regional stormwater flows which enhances public safety and protection of critical infrastructure."*

Supporting additional provisions require a 'Flood Evacuation Strategy' for the development precinct which will give effect to the above objective.

### 9.3.4 Council requests for improved cross-sections

***Comment:***

Further, we request the following information to be included as part of updated advice:

- The appendices which included the complete set of flood maps were not provided with the presentation information package.
- The sections of the channel in Council land were not sufficient to identify grades and the channels built form.

The inability to identify the 'channels built form' on the cross sections is probably due to the fact that there is no identifiable channel proposed. The side slopes are very flat (in the order of 3%) which is hard to discern on the ground. Hence, there is no channel proposed – just flat grades across Lot 1.

Gradients are now shown on the cross-sections in Appendix E. The cross-sections have been deliberately created with equal vertical and horizontal axis scales so that the slopes observed are actual slopes. The red gradient numbers are areas requiring excavation / change and green gradient numbers are existing golf course grades. As a comparative guide, football/cricket ovals are usually built at 2% and wheelchair / accessibility ramps are between 7% and 10%. Many of these areas would appear flat to most people.

This area will also be comprehensively embellished with soft landscaping to an appropriate outcome, with a funding commitment to this process made by the proponent. The final detailed design will be subject to the Council-led landscaping process for Pemulwuy Park of which a general vision has been portrayed by Hassell in Cook Cove's Urban Design and Landscape Plan, which was prepared in consultation with Bayside Council.

# 10. Conclusions and Recommendations

## 10.1 Conclusions

The following conclusions are drawn from this flood risk and impact assessment:

- The site is located on a floodplain that has undergone substantial change over the last 70 years and it bears little resemblance to the original river and floodplain;
- The Planning Proposal is essentially seeking a revision of controls applying to a site which is already zoned for intensive urban purposes – with a revised extent and suite of controls which will better manage flood risks when compared to the present land use planning provisions for the site;
- The developed part of the site (not the open space areas) will be filled to a minimum of 2.5mAHD for the internal road network (above 1:2000 AEP flood levels);
- The floor levels will be at 3.4mAHD which includes a 0.6m freeboard above the 1% AEP flood levels with predicted increased rainfall intensities and sea level rise attributed to future climate change effects;
- These floor levels are also above the current Probable Maximum Flood levels on the site of 3.2mAHD (southern part of site) to 3.3mAHD (northern part of site). Hence, the current Probable Maximum Flood would not inundate floor levels on the site;
- Following filling on the site (which does not result in any adverse impacts external to the site), the flood hazards on the site are low for all floods up to the 0.05% (1:2000) AEP flood;
- There will not be any adverse changes to flood behaviour beyond the site boundary;
- The key risk to be managed on the site is associated with emergency management and possible evacuation during rare flood events;
- If evacuation is required during a flood event, access to/from to the majority the site is available to/from the south-west across Flora Street South which will be constructed above the 0.2% (1:500) AEP flood levels (so no inundation in that event). In a 1:2000 AEP flood, there will be shallow (H1 hazard) flow across this road;
- For a 1:2000 AEP flood, the maximum duration of H2 exceedance (i.e. large cars and emergency vehicles) at the intersection of Marsh Street and Flora Street South is in the order of four (4) hours;
- If evacuation is required during a flood event to/from the small buildings in Block B1 of the Planning Proposal, this will be possible using a ramp to be constructed to access Marsh Street. During these flood events, Marsh Street will be closed further west and unimpeded access will be possible onto Marsh Street on the high (above PMF) part of the bridge approach;
- The most probable estimate of the duration of H2 exceedance at the key location (i.e. the Marsh Street / Flora Street South intersection) over a typical century of flooding is 0.6 hours (about 35 minutes);
- With the effect of climate change (and largely due to the 0.9m sea level rise assumption), the most probable estimate of the duration of H2 exceedance at this key location over a typical century of flooding is less than six (6) hours;
- Shelter-in-Place will be relied upon in floods rarer than the 0.2% (1:500) AEP flood event as the duration of isolation is short (less than 6 hours);
- The site will include significant areas of retail including food outlets, supermarkets supported by emergency power generation infrastructure. Hence, it will be a safe place for isolation for short periods of time.

## 10.2 Recommendations

This flood impact and risk assessment has identified that the flood risks associated with the Cooks Cove Planning Proposal are able to be managed.

The following key recommendations are made to manage these flood risks:

1. Floor levels are to be set at the above the PMF levels at 3.4mAHD.
2. The internal road network is to be above 2.5mAHD (above the 1:2000 AEP flood level).
3. Flora Street South is to be set at 2.17mAHD to allow the 0.2% (1:500) AEP flood to pass under the road.
4. A shelter-in-place strategy is to be used to manage the residual flood risks to occupants in floods larger than the 0.2% AEP flood.
5. The further stages of developing the design of the Cooks Cove Planning Proposal needs to recognise and work with the above features.

# 11. Reliance statement

The sole purpose of this flood impact and risk assessment report, flood models and the associated services performed by Arup is to assess the flooding compliance of the Cooks Cove Planning Proposal in accordance with the scope of services set out in the contract between Arup and Cook Cove Inlet Pty Ltd.

In preparing this report and flood models, Arup has relied upon, and presumed accurate, information (or confirmation of the absence thereof) provided by Bayside Council, Sydney Water, TfNSW, Cook Cove Inlet Pty Ltd and other sources. Except as otherwise stated in the report, Arup 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.

Arup derived the data from information sourced from the above parties and/or available in the public domain at the time or times outlined in the report. These data include:

- The Cooks River mainstream channel flood model, provided by Sydney Water
- The M8 and M6 Stage 1 permanent operations facility areas and changes made to local ground and road levels as part of these works, provided by TfNSW
- Ground survey for the golf course, provided by Cook Cove Inlet Pty Ltd.

The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in the report. Arup has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report and flood models. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in the report, to the extent permitted by law.

All flood models, whether numerical, analytical or physical, rely on a set of assumptions and requirements to accurately simulate the flow conditions. As no model will provide an exact representation of the complexity of the actual flow, it is important for engineers to understand these assumptions, as they form the limitations of that method. Ignoring or violating these assumptions and limitations or failing to critically analyse the model will produce inaccurate results.

No responsibility is accepted by Arup for use of any part of this report in any other context. This modelling data has been prepared on behalf of, and for the exclusive use of Cook Cove Inlet Pty Ltd, and is subject to, and issued in accordance with, the provisions of the contract between Arup and Cook Cove Inlet Pty Ltd. Arup accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

# 12. References


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# Appendix A: Existing Case Flood Maps