KINCOPPAL- ROSE BAY
CNR NEW SOUTH HEAD ROAD & VAUCLUSE ROAD,
ROSE BAY

State Significant Development Application

Revision 2

May 2021

Job No.: 19949

Contents

1. Introduction

This report has been prepared in response to the Secretary's Environmental Requirements (SEARs) in relation to flooding and drainage for the proposed development.

The report will address the issues raised in item number 17 under Concept Proposal and item numbers 8 and 11 under Stage 1 works of the SEARS. The issues raised in items number 8 and 17 (relating to flooding and coastal hazards) that this report will respond to include; description of the flood assessment and modelling, flood behaviour for range of storm events, and the impacts on the proposed development.

The issues raised in item 11 (related to drainage) include; measures to minimise operational water quality, methods of drainage without impacting on the downstream properties, impacts on the development on water quality and on hydrology.

1.1 Site Context

The Kincoppal Rose Bay school consists of a junior school, senior school and the senior boarding which is located south-west of Vaucluse Road. The sports field and MTC building is located north-east of Vaucluse Road in Rose Bay. The school re-development site, however, is within the junior and senior schools which are located at the south-west of Vaucluse Road. An aerial photo of the overall site is shown in Figure 1 below.

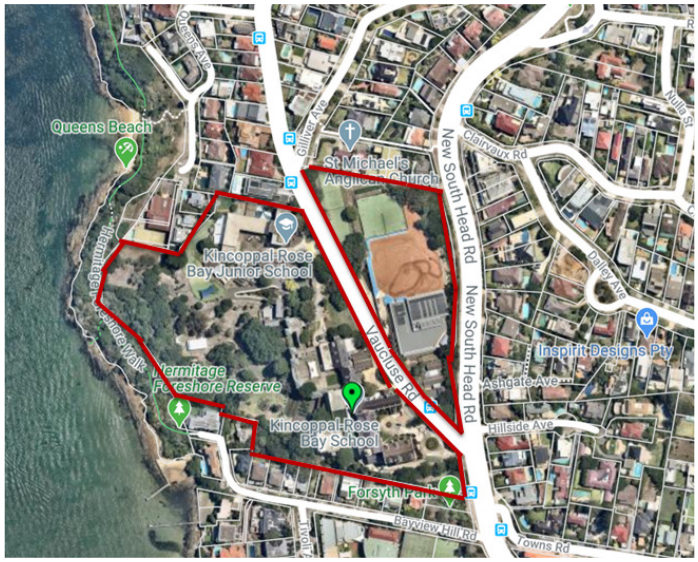


Figure 1: Aerial View of the Site

2. Flood Assessment

2.1 Existing Flood Studies

In relation to the existing flood studies in item 8 of SEARs, Henry and Hymas obtained a copy of Woollahra Municipal Council's Flood study report for Rose Bay (prepared by WMA water) on their website.

The Flood study catchment comprises of areas within the suburbs Bellevue Hill and Rose Bay with a very small portion of the suburb Vaucluse included. This is shown in Figure 2 below and the overall study area shown in Appendix A. The majority of the flood study, however, covers Rose Bay and Bellevue Hill sub-catchments and also New South Head Road.

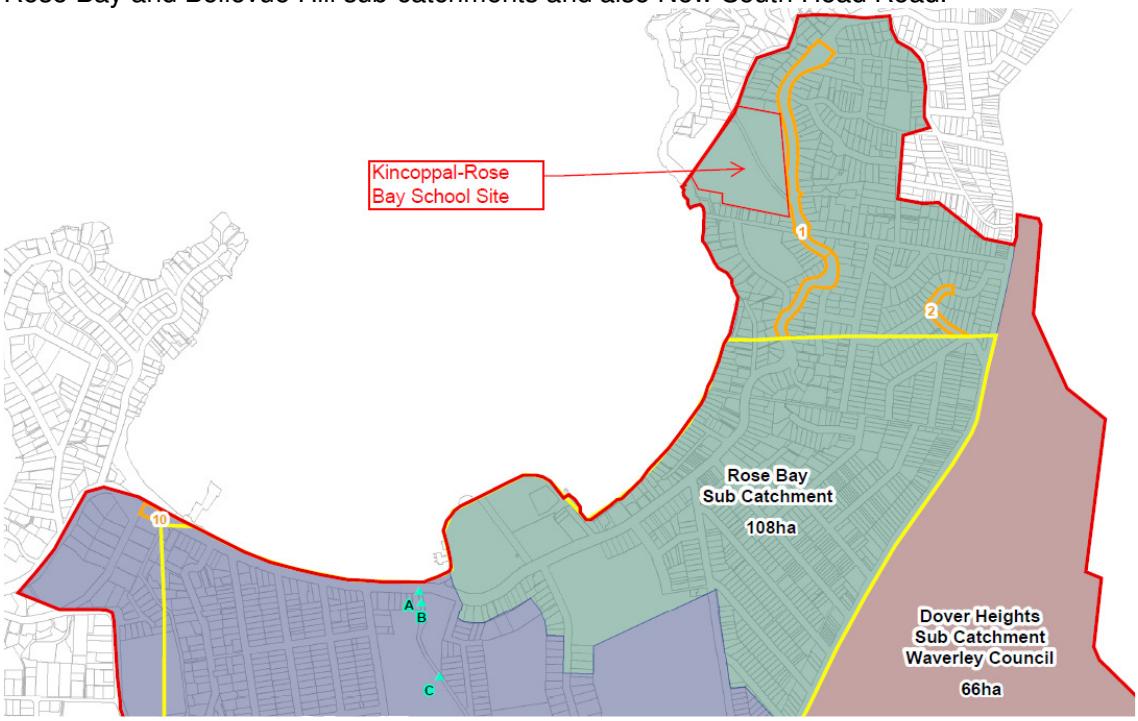


Figure 2: Flood Study Catchment Area

It is understood that New South Head Road captures and conveys the majority of the overland flow from the upper eastern catchment of approximately of 8.56 Ha. The overland flow path is understood to be along the eastern side of New South Head Road along the kerb and gutter. According to the flood study for Rose Bay, the overland flow for the New South Head Road is in the range of between 5 m^3/s and 10m^3/s in the 100 year ARI storm event. It is also assumed that New South Head Road will wholly contain the overland flow. The overland flows (Figure 6 of Rose Bay Flood study) are shown in Appendix A.

In regards to the Floodplain Development Manual (NSW Government 2005), it is our understanding that the site is not identified as flood prone land, is not in a flood planning area, is not considered to be in a flood way or flood storage area and does not have a flood hazard categorisation on the basis that the site is not within the 100 year or PMF for a mainstream watercourse or catchment.

Furthermore, a checklist on the impacts on the proposed development on flood behaviour is tabulated below:

SEARs COMMENT	H&H RESPONSE
Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure	No impact due to no change to the catchment nor the overland flow paths.
Consistency with Council floodplain risk management plans.	Yes, in so far as we have considered the flooding information provided in the Rose Bay Floodplain Risk Management Study.
Consistency with any Rural Floodplain Management Plans.	N/A as the site is not rural.
Compatibility with the flood hazard of the land.	N/A as the site is not within the 100 year or PMF extent of a mainstream catchment therefore is not considered to have a flood hazard category.
Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land.	Overland flow paths and the associated hydraulic functions are not affected by the proposed development.
Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	The development does not affect the inundation of the floodplain as there are no impacts on the existing overland flow path that would lead to changes to floodplain inundation.
Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses	There would be no increase in the risk of erosion or destruction of riparian vegetation in so far as the site is within an urbanised catchment and there are no changes to any existing overland flow path as a result of the development.

2.2 Flood assessment of the site re-development area

Since the site is not shown to be flood affected by the major overland flow down New South Head Road, this report will provide assessment of the localised overland flow path along Vaucluse Road, prior to the proposed redevelopment. As shown in Figure 3 below and Appendix A, the peak overland flow running along Vaucluse Rd has a maximum flow rate of $1m^3/s$.

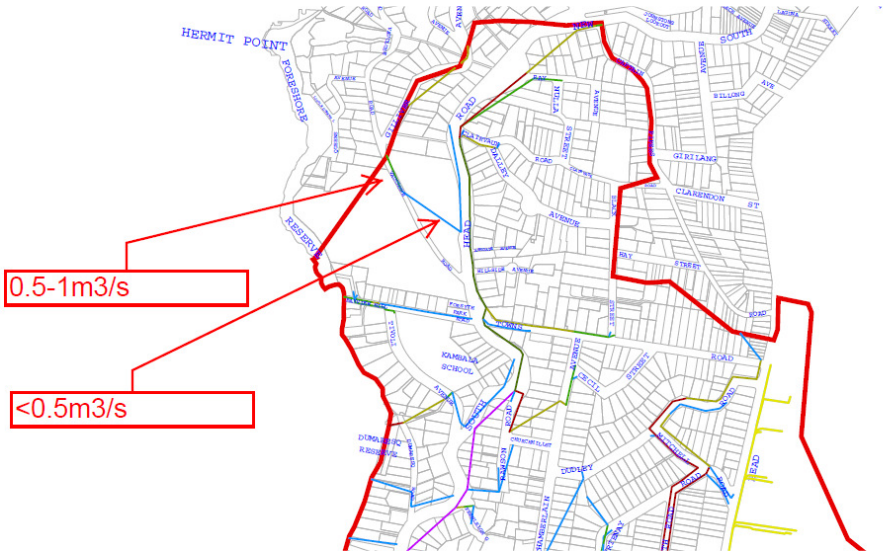


Figure 3: Peak overland flows in 100 year ARI (taken from Rose Bay flood study by WMA water)

Using SIX Maps online, the upstream catchment of the site was assessed to determine the upstream catchment for the overland flow along Vaucluse Road. As shown below in Figure 4, the upstream catchment is bounded by the eastern edge of New South Head Road, the eastern side of Vaucluse Road and part of the existing sports field to the north. The total catchment area is approximately 1.59 hectares (Ha).

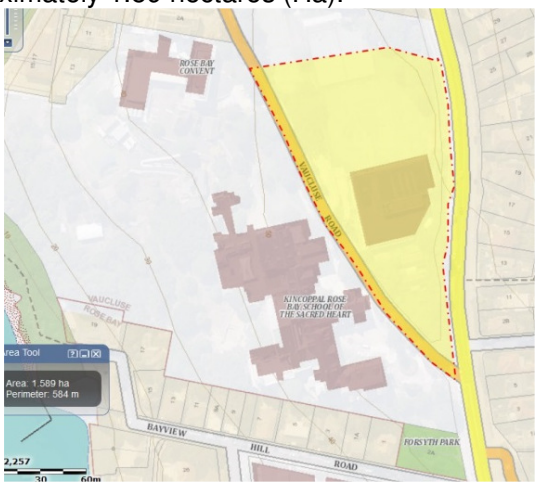


Figure 4 Catchment Area to the proposed re-development area

It is understood that as part of the SEARs, that a description of the flood assessment and modelling for determining the design flood levels for the 5% AEP and 1% AEP storm events is required. In addition, this report will also look at design flood for storm event 0.2%AEP and 0.5 % AEP for climate change which are considered as the extreme events.

The catchment flow for the storm events is calculated using DRAINS modelling and are tabulated in the below table. This was found to be somewhat consistent with the flow rates determined in the Rose Bay Flood Study report.

Storm Event	Flow (m3/s)
5% AEP	0.46
1% AEP	0.874
0.5% AEP	0.948
0.2% AEP	1.07

Table 1 Overland Flow rates calculated from DRAINS

2.3 Hydraulic Modelling and Impacts

According to SEARs enquiry item number 8, it is required to assess the impacts on the proposed development at the storm events mentioned above.

Hydraulic modelling was undertaken to assess the impacts to the site from of the overland flow path in Vaucluse Road.

Vaucluse Road has a constant cross fall from the western side of the road to the kerb and gutter along the eastern side. This makes the north eastern site boundary (for the junior and senior school area) a ridgeline to overland flow path. This changes to a two-way crossfall further north at Vaucluse Rd beyond the northern end of the school site.

In order to understand whether the overland flow reaches the ridgeline at the boundary to the site (both of pre and post developed), a channel flow calculation was undertaken to determine the flow depth. A cross section through the existing driveway of the senior school and to the driveway of the eastern side is shown below in Figure 5.

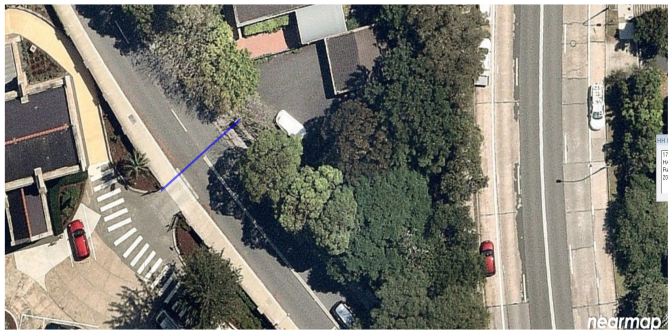


Figure 5 Section through existing driveway of the senior school

The levels for the driveway, kerb inverts and the centre line are taken from the survey. The RLs at the eastern side of Vaucluse Road, however, is based on linear extrapolation. Based on a site investigation, the existing eastern driveway, on the other side of Vaucluse Rd, opposite of the senior school driveway is understood to be falling towards the road.

Based on the channel flow calculations, the resulting flow depths at the critical section are tabulated below in Table 2:

Storm Event	Flow depth (mm)
5% AEP	117
1% AEP	150
0.5% AEP	155
0.2% AEP	164

Table 2 Calculated Flow depths

As shown in the table above, the flow depths indicate that runoff down Vaucluse Rd and will not enter the site for all storm events up to and including the 0.2% AEP at the critical section of the senior school driveway.

The figures below show the flow depth for 0.2% AEP storm event.

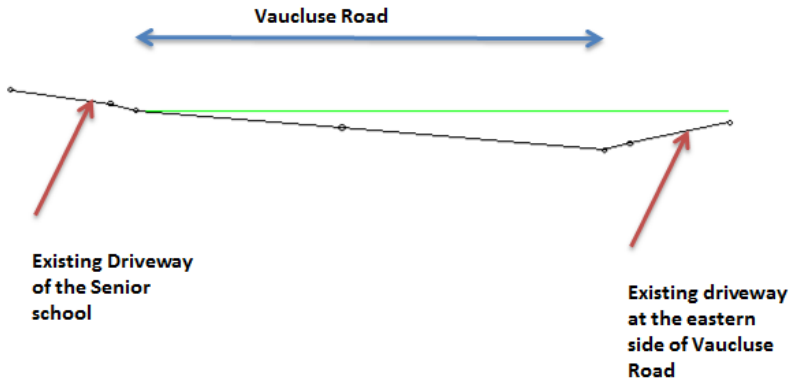


Figure 6 Typical Overland Flow Section

FLOWRATE	1.07 m3/s	LFP Flow	0.0 m3/s
Normal Water Surface Elevation	53.4748	m	
Max. Depth	0.184803	m	
Normal Flow Velocity	0.8702	m/s	
Surface Flow Width	10.6964	m	
Total Energy	53.5134	m	
Velocity Depth Product	0.1608	m.m/s	
Froude Number	0.674	Subcritical Flow	
Critical Flow Depth	53.4541	m	
Critical Flow Velocity	1.0429	m/s	

Properties

Flow X-Area	1.2287 m2	Wetted Perimeter	10.7438 m
Hydraulic Radius	0.1144 m	Compound n	0.0148

Figure 7 Overland Flow Calculations

In addition to the above, it is understood that the most critical section is from the junior school's driveway to Vaucluse Road. As shown in Figure 8 below, the crossover for the junior school entry falls to the site from the Vaucluse Road kerb alignment. The flow depth for the 0.2% AEP

year is 161 mm. In order to prevent overland flow from entering the school, it is proposed to construct a bund at the driveway at a level of RL50.56.

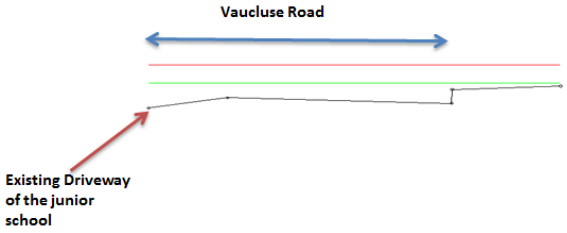


Figure 8 Section through the driveway at junior school

FLOWRATE	1.07 m3/s	LFP Flow	0.0 m3/s
Normal Water Surface Elevation	50.5112	m	
Max. Depth	0.1612053	m	
Normal Flow Velocity	1.4688	m/s	
Surface Flow Width	9.5585	m	
Total Energy	50.6212	m	
Velocity Depth Product	0.2368	m.m/s	
Froude Number	2.797	Supercritical Flow	
Critical Flow Depth	50.5436	m	
Critical Flow Velocity	1.0095	m/s	
Properties			
Flow X-Area	0.7363 m2	Wetted Perimeter	9.6234 m
Hydraulic Radius	0.0765 m	Compound n	0.015

Figure 9 Overland Flow Calculations at junior school driveway

2.4 Climate Change

This section of the report addresses item 17 of the SEARs (concept design). Climate change has become a major environmental concern over the last 20 years. With the increasing amounts of greenhouse gases being released to the atmosphere due to human activity, the average earth surface temperature has been rising. As such, this may be affecting the climate and sea level.

Climate change has the potential to alter flood levels as a result of increased rainfall intensity and increase in receiving water levels (i.e. sea levels). The Rose Bay Flood Study has taken into account possible sea level rise and based off CSIRO modelling, indicate an upper limit rise of 0.91m by 2090 and 2100. This rise puts the tailwater/100year ARI flood level at 1.91mAHD.

As the site itself is located above 50mAHD (Figure 10), it is reasonable to say the potential effects of climate change along with the sea level rise will have negligible effect on the site.

Figure 10: 100 year ARI flood map

Changes in climate will result in changes in the frequency, intensity, spatial extent, duration,and timing of extreme weather and climate events, and may lead to unprecedented extreme weather and climate events (IPCC, 2012).

Climate change may also affect and raise the intensity of rainfall. In order to determine and calculate the water quantity through the development site, the Intensity Frequency Data (IFD) was obtained which is readily available from the Bureau of Metoerology (BOM) website. The calculation of water quantity will be further discussed in Section 3.2 of the report. These IFD data (design rainfalls) were derived from observed rainfall data for Australia. While the 2016 design rainfalls do not include the effects of future climate change, in order to deal with uncertainty, particularly with design flood estimation, the typical situation is that the catchment modelling system is calibrated to data from a few selected flood events, and the calibrated model is then extrapolated using design rainfall estimates (which itself is an extrapolation of observed rainfall data, Book 2, Chapter 3) to provide estimates of the 1% or 0.5% Annual Exceedance Probability flood. Both these type of approaches introduce significant uncertainties in estimates of the design flood (ARR,2019).

2.5 Community Emergency Management

In regards to safety emergency measures, the site does not adversely affect flooding below and impacts of climate change are therefore likely to be minimal. The current school emergency response plan will not need to be amended as a result of the proposed works.

3. Drainage

This section addresses the issues raised in item number 11 of the SEARs.

The management of stormwater quantity and quality is to be designed in accordance with Part E2 - Stormwater and Flood Risk Management of the Woollahra Development Control Plan (DCP) 2015.

The objective of stormwater management is to provide stormwater controls, which ensure that the proposed development does not adversely impact on the stormwater flows and water quality of waterways within, adjacent and downstream of the site.

In section 2.4 of Council's DCP Part E2 Stormwater and Flood Risk Management it is stated that regardless of the development type properties within the Council's OSD exemption area are not required to install OSD. Kincoppal Rose Bay school lies within the Council's OSD exemption area. As such OSD is not required.

However, it is understood that the proposed re-development for senior school which includes an internal road and bus parking bay will create additional runoff to an existing stormwater system. This will create additional concentrated flows to the existing stormwater system. As such we have elected to control the additional runoff via an OSD system.

For the Junior School redevelopment at the northern end of the site, there is no change in the roof-form or impervious area and as such, no amendments to the existing inground drainage system are proposed.

For the Early Learning Centre (ELC), the discharge from the building will be to an existing freely discharging headwall outlet within the site. Since the are no capacity limitations as a result of these works, no OSD is proposed to deal with the additional runoff.

3.1 Key Issues

The key issues and the proposed mitigation measures to be implemented as part of the proposed development are as follows:

- **Stormwater Quantity-** The increased impervious surfaces (such as roads, roofs, driveways, etc) associated with the development will result in an increase in peak stormwater flows from the site during storm events. In order to cater for the stormwater flow increase, on-site stormwater detention (OSD) tanks have been designed at under the driveway for senior school within the site. The site stormwater system has been designed to safely convey the flows through the site and within the capacity of the downstream system. The design and operation of the proposed stormwater system is described in Section 3.2 below.

- **Stormwater Quality** - Urban developments have the potential to increase gross pollutants, sediments, hydrocarbons and nutrient concentrations in stormwater runoff. To limit impact on the downstream water quality, water quality measures at source and end of line treatments will be provided. Section 3.3 further describes the specific implementation of these measures for the proposed development.

3.2 Stormwater Quantity

3.2.1 Existing Drainage System

The overall site, for the junior and senior schools, predominantly falls towards the west towards Rose Bay.

3.2.2 Proposed Drainage Systems

The drainage system for the proposed development has been designed to collect concentrated flows from impervious surfaces such as the new driveway for junior school, the ELC and the internal road for the existing site and from the senior school.

The proposed drainage system includes:

- A network of piped minor drainage system to collect runoff from the site.
- An overland flow path to convey major flows.
- An OSD tank to help reduce the peak discharge from the site due to the increased flows resulting from an increased impervious area where the downstream capacity s restricted.

3.2.3 Data Source

The rainfall and IFD (Intensity - Frequency - Duration) data used in DRAINS modelling are from Bureau of Meteorology website.

	2ARI	50ARI		
1hr	41.34(mm/hr)	88.2(mm/hr)	**G**	0
12hr	8.28(mm/hr)	16.8(mm/hr)	**F2**	4.29
72hr	2.5(mm/hr)	5.02(mm/hr)	**F50**	15.87

Table 3: IFD data used for the rainfall generation

3.2.4 On-Site Stormwater Detention Tank

In section 2.4 of Stormwater and Flood Risk management of Council's DCP, the OSD is to be sized in accordance with storage/discharge relationship specified in the document.

As mentioned previously, the proposed internal road and bus parking bay will generate additional runoff. This will create an additional concentrated flow to the existing stormwater system. The storage/discharge relationship specified in the Council document may not be effective in managing the increased flows. As such the OSD is to be designed to best suit industry practice and to ensure post developed flow do not exceed predeveloped.

The OSD system has been modelled using the DRAINS software and limit the discharge of stormwater flow to the five-year ARI greenfield. For approximately 670 m^2 of impervious area, the preliminary OSD size is 11 m^3.

3.3 Stormwater quality

Urban developments have the potential to increase gross pollutants, sediments, hydrocarbons and nutrient concentrations in stormwater runoff. As per section 2.3 of the part E2 Stormwater and Flood Risk management of Woollahra Council DCP 2015, it is noted that all properties with connections to Sydney Harbour, waterways and open watercourses will require a stormwater treatment.

To limit the impact on the downstream water quality, water quality measures at the source and end of line-treatments will be provided. Water quality treatments have been provided as per Council's Stormwater Management specifications. The additional runoff from the proposed internal driveway and bus parking to the existing stormwater system is to be treated through the use of OceanGuards and Ocean Protect Stormfilter cartridges within the OSD tank.

OceanGuards are to be installed in surface inlet pits areas to prevent any gross pollutants / fine sediments leaving the site via the piped system and remove the hydrocarbons, oil & grease.

Ocean Protect Stormfilter cartridges are to be installed in a chamber built into the OSD tank. This secondary treatment device is used to treat a majority of the nutrients (phosphorus and nitrogen) being generated on site.

For the ELC, a single Ocean Protect Stormfilter cartridge will be provided in a pit prior to the headwall discharge point.

As per Woollahra Council DCP 2015, the pollutant removal target rates for the water quality treatment system to achieve are tabulated in Table 4. The proposed stormwater treatment has been modelled using the MUSIC software and the results have been tabulated in Table 5.

Pollutant	% post development reduction target
Total Suspended Solids	85
Total Phosphorous	65
Total Nitrogen	45
Gross Pollutants	90

Table 4: Removal rates required

Pollutant	Reduction Rate High School	Reduction Rate ELC
Total Suspended Solids	96.9%	86.8%
Total Phosphorous	83.6%	79.4%
Total Nitrogen	60.2%	51.7%
Gross Pollutants	100%	100%

Table 5: Resultant Removal Rates

As can be seen from the above table, the proposed treatment is successful in achieving Council's pollutant removal rates removal target rates.

4. Conclusion

The report has addressed the enquiries related to flooding and drainage. This includes the hydraulic assessment of the overland flow path, the water quality treatment and management of stormwater quantities.

Appropriate stormwater management practices will be implemented that minimise the impact of development on the existing stormwater system in terms of water quality whilst ensuring safe and efficient conveyance of runoff.

Whilst it is inevitable that the development will have an impact of the existing landform and stormwater runoff characteristics due to earthworks, change of land-use and changes in impervious areas; by providing a safe and efficient design, and implementing appropriate

measures during construction and operation of the development, it can be ensured that there will be minimal impact on the existing environment as a result of the proposed development.

5. References

- Wmawater - Woollahra Municipal Council, Rose Bay Catchment Flood Study, Final Report, September 2010
- New South Wales Government - Floodplain Development Manual, April 2005
- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019.
- Part E2 - Stormwater and Flood Risk Management of the Woollahra Development Control Plan (DCP) 2015.
- Bureau of Meteorology – bom.gov.au

6. Appendix A

FIGURE 1
STUDY AREA

Rose Bay
Sub Catchment
108ha

Dover Heights
Sub Catchment
Waverley Council
66ha

Bellevue Hill
Sub Catchment
209ha

North Bondi
Sub Catchment
Waverley Council
133ha

1
2
3
4
5
6
7
8
9
10

A
B
C
F
G
H
J
L
M

N

0 250 500 m

Catchment Boundary
2D Hydraulic Model Extent
1D Hydraulic Model Extent
Open Channel Section - A (Refer to Table 2)
1 Reach Numbers Refer to Figure 7

J:\Jobs\27002\Arcview\Maps\FloodMapping\Figure1_StudyArea.mxd

FIGURE 6a

PEAK OVERLAND FLOWS
100y ARI

28.9 (m^3/s)

8.2 (m^3/s)

Flows shown within this area do NOT include inflows from Waverly Council LGA

Study Area

Flow (m3/s)

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- > 20
- EXCLUDED Flows from Waverley Council

N

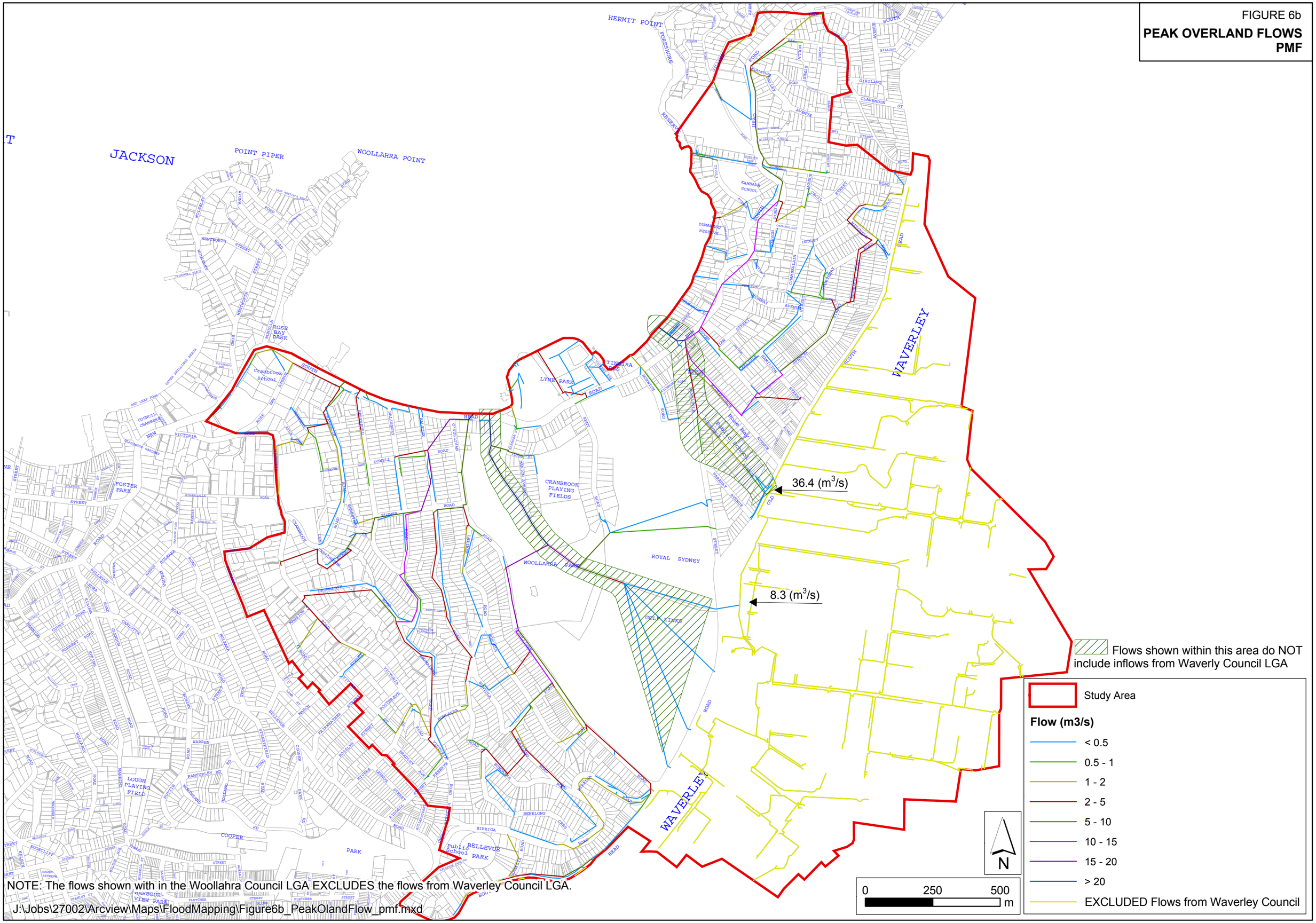
0 250 500 m

NOTE: The flows shown with in the Woollahra Council LGA EXCLUDES the flows from Waverley Council LGA.

J:\Jobs\27002\Arcview\Maps\FloodMapping\Figure6a_PeakOlandFlow_pmf.mxd

FIGURE 6b

PEAK OVERLAND FLOWS
PMF



NOTE: The flows shown with in the Woollahra Council LGA EXCLUDES the flows from Waverley Council LGA.

J:\Jobs\27002\Arcview\Maps\FloodMapping\Figure6b_PeakOlandFlow_pmf.mxd

FIGURE 13

100 YEAR ARI FLOOD DEPTHS AND CONTOURS

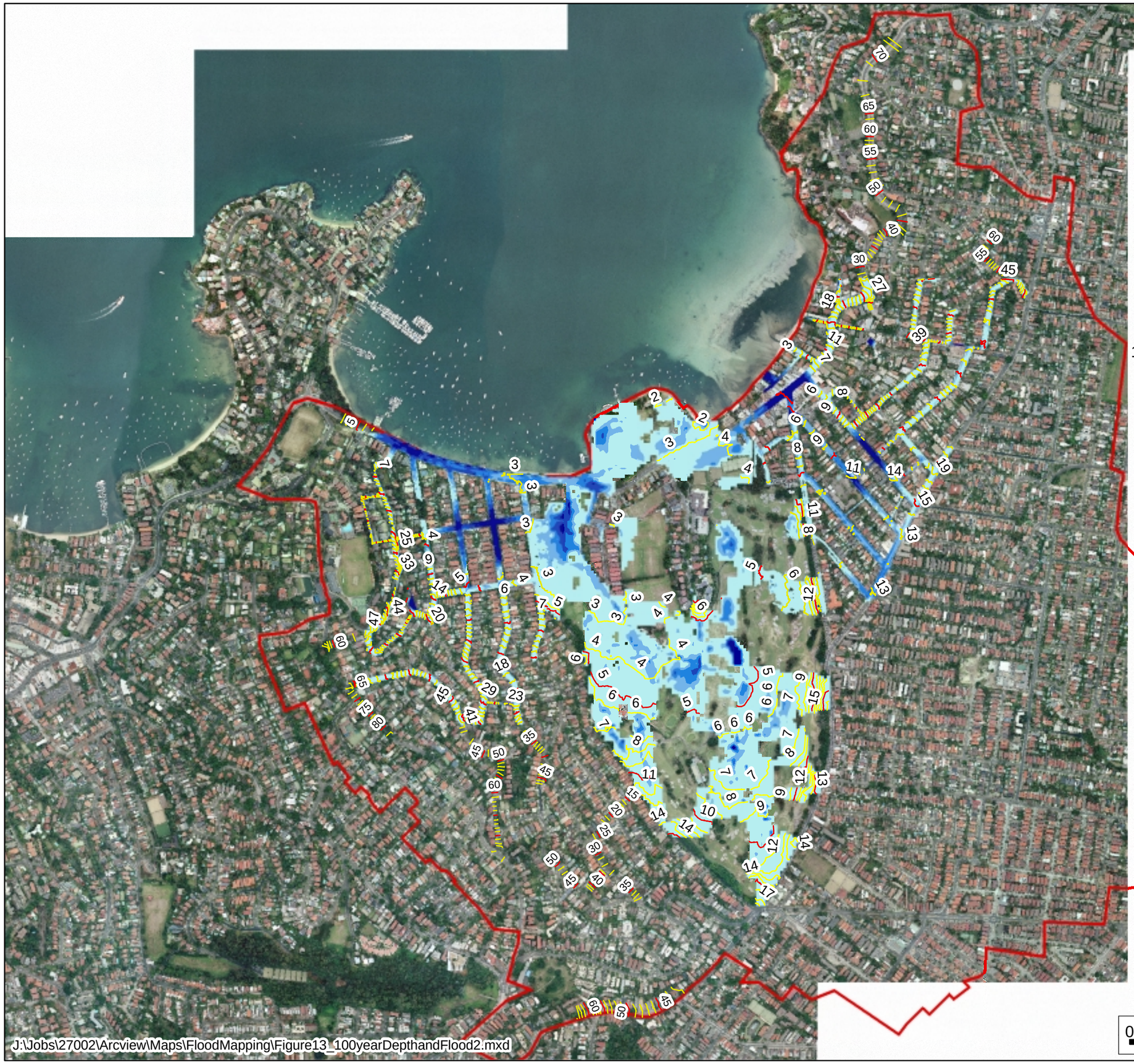


FIGURE 13b

BELLEVUE HILL

100 YEAR ARI FLOOD DEPTHS AND CONTOURS

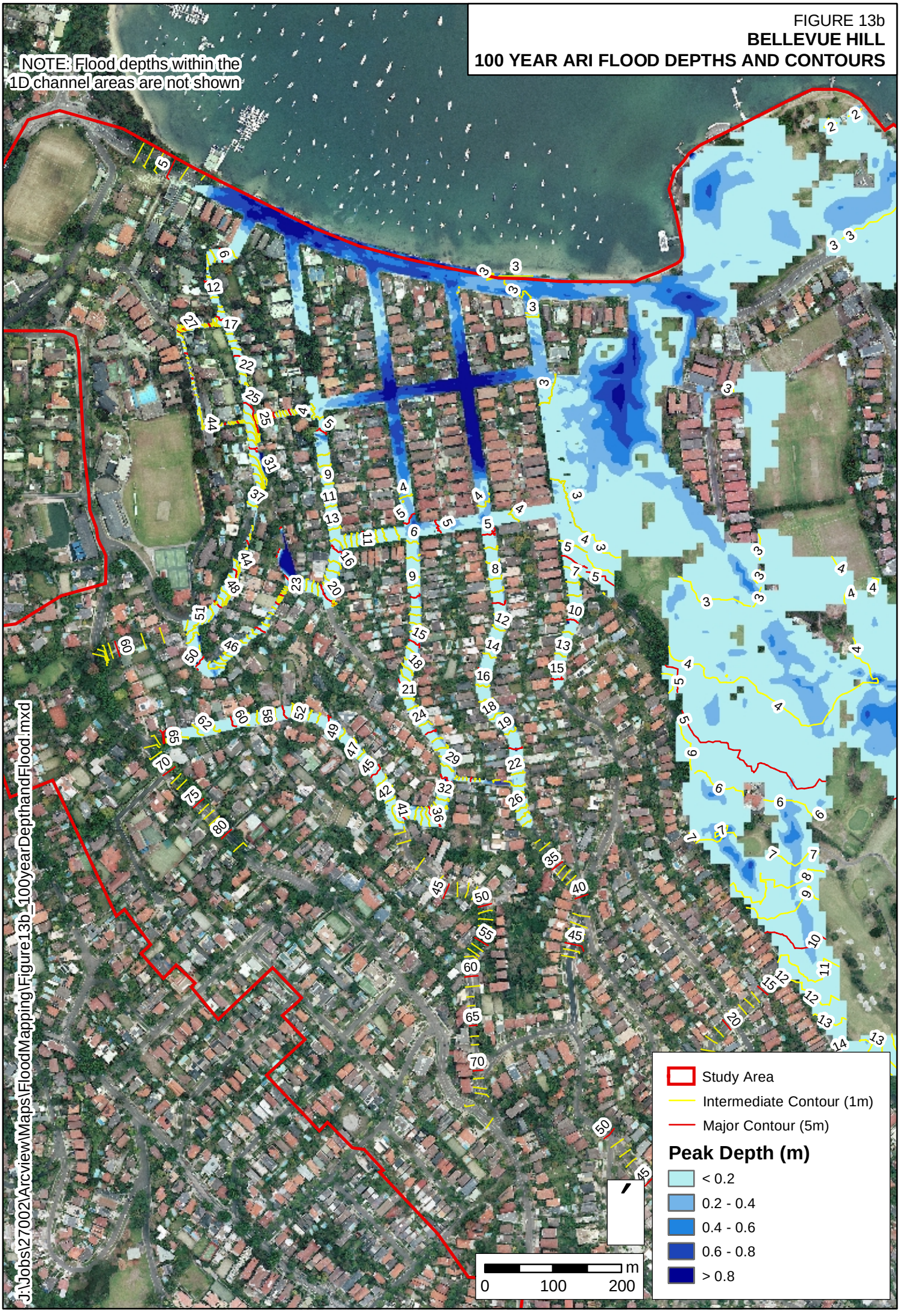


FIGURE 13c

CENTRAL AREA
100 YEAR ARI FLOOD DEPTHS AND CONTOURS

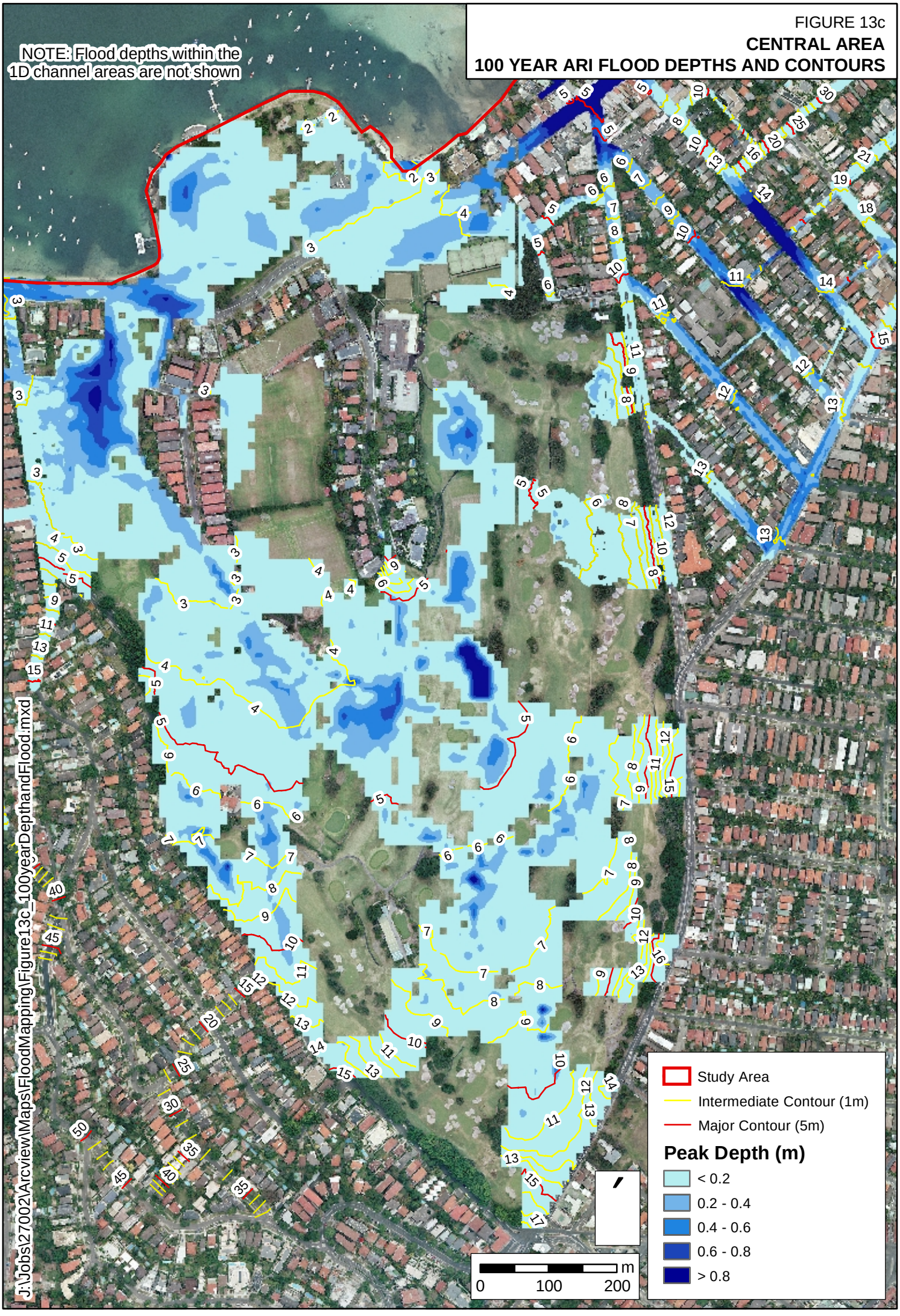



FIGURE 13d
ROSE BAY
100 YEAR ARI FLOOD DEPTHS AND CONTOURS
NOTE: Flood depths within the 1D channel areas are not shown
J:\Jobs\27002\Arcview\Maps\FloodMapping\Figure13d_100yearDepthandFlood.mxd
Study Area
Intermediate Contour (1m)
Major Contour (5m)
Peak Depth (m)
< 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
> 0.8
0
100
200
m