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# Flood Impact and Risk Assessment

*for*

## 488-492 Old South Head Road and 30 Albemarle Road, Rose Bay

*for* Woolworths Group

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# Contents

# Acronyms

| | |
|---|---|
| AEP | Annual Exceedance Probability |
| AHD | Australian Height Datum |
| ALS | Airborne Laser Survey (LiDAR) |
| ARI | Average Recurrence Interval |
| ARR2019 | Australian Rainfall and Runoff 2019 |
| BoM | Bureau of Meteorology |
| CC | Climate Change |
| DCP | Development Control Plan |
| DTM | Digital Terrain Model |
| FERP | Flood Emergency Response Plan |
| FERC | Flood Emergency Response Category |
| FPL | Flood Planning Level |
| Ha | Hectares – Measure of Area |
| IFD | Intensity-Frequency-Duration Rainfall |
| LGA | Local Government Area |
| LiDAR | Light Detection and Ranging Terrain Data (also see ALS) |
| m | Measure of length / height / distance (metres) |
| m AHD | Meters above Australian High Datum |
| m/s | Measure of velocity (metres per second) |
| $m^3/s$ | Measure of flow rate (cubic metres per second) |
| PMF | Probable Maximum Flood |
| PMP | Probable Maximum Precipitation |
| RFI | Request for Information |
| TUFLOW | A 1D and 2D hydraulic modelling software |
| WC | Waverley Council |
| WMC | Woollahra Municipal Council |

# Introduction

Northrop Consulting Engineers have been engaged by Woolworths Group to prepare a Flood Impact and Risk Assessment for the proposed development at 488-492 Old South Head Road and 30 Albemarle Avenue, Rose Bay, herein referred to as the subject site or the site. The subject site locality is presented in **Figure 1** overleaf.

This Flood Impact and Risk Assessment (FIRA) aims to review the impact potential development at the subject site has on existing flood behaviour within the subject site and adjacent properties. This FIRA has been prepared to support the Planning Proposal submission to the NSW Department of Planning, Housing and Infrastructure (DPHI) (PP-2022-731).

The Planning Proposal seeks to enable an additional permitted use and set a maximum permissible height of 14.5m at 30 Albemarle Avenue, and set a maximum Gross Floor Area, when the two lots are developed together.

It is important to note that this FIRA has been prepared to present a hypothetical developed case solution. It has been prepared to demonstrate a workable flooding solution can be achieved on the subject site. It is anticipated flood mitigation measures will be further resolved in concert with the progression of the design during future project phases.

This FIRA has been prepared in response to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) Request for Information (RFI) dated 15 May 2024 (Ref: DOC24/245706). The RFI was received following Public Exhibition of the Planning Proposal at 488-492 Old South Head Road and 30 Albemarle Avenue, Rose Bay (PP-2022-731).

This assessment has been prepared with the consideration of the following guidelines and documents:

- Minister for Planning Local Planning Directions, in particular Focus Area 4.1 (Flooding);
- Woollahra Local Environmental Plan (LEP) 2014.
- Woollahra Development Control Plan (DCP) 2015.
- NSW Flood Risk Management Manual (NSW DPHI 2023).
- Flood Risk Management Guideline LU01 – Flood Impact and Risk Assessment (NSW DPIE, 2023)
- Flood Risk Management Guideline EM01 – Support for Emergency Management Planning (NSW DPHI, 2023)
- Australian Rainfall and Runoff 2019 Guidelines (AR&R 2019).
- Australian Rainfall and Runoff Project 15: Two-Dimensional Modelling in Urban and Rural Floodplains (2012).
- The Draft Shelter in Place (SIP) guideline prepared by the NSW Department of Planning, Housing and Infrastructure (DPHI) and dated December 2022.
- The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method" (BoM, 2003).

This assessment has been prepared with consideration to the following existing studies and data.

- Flood Assessment for the Planning Proposal at 488-492 Old South Head Road & 30 Albemarle Avenue, Rose Bay prepared by Northrop Consulting Engineers and dated the 3rd of March 2022, herein referred to as the *"Original FIRA (Northrop, 2022)"*.
- The Draft Waverley LGA Flood Study prepared by BMT and dated August 2019, herein referred to as the *"Waverley Flood Study (BMT, 2019)"*.
- Rose Bay Catchment Flood Study prepared by WMAwater and dated September 2010, herein referred to as the *"Rose Bay Flood Study (WMAwater, 2010)"*.
- Rose Bay Floodplain Risk Mnagemnet Study and Plan prepared by WMAwater and dated January 2014, herein referred to as the "*Rosebay FRMSP (WMAwater, 2014)"*.

PERCIVAL PARK
COLLINS AVENUE
ST MARY MAGDALENE
IAN STREET
ROSE BAY POST OFFICE
MCAULEY PRIMARY SCHOOL
IAN LANE
CARLISLE STREET
HAMILTON STREET
SPENCER STREET
OLD SOUTH HEAD ROAD
PRINCESS STREET
PRINCESS GARDENS
GILBERT STREET
PORTLAND STREET
WOOLLAHRA SAILING CLUB
ROSE BAY TOWERS RETIREMENT VILLAGE
NEW SOUTH HEAD ROAD
TINGIRA RESERVE
PANNERONG RESERVE
ST ANDREW'S PRESBYTERIAN CHURCH
ROBERTS STREET
NORWICH ROAD
RICHMOND ROAD
TENNIS COURTS
TENNIS COURTS
SPENCER LANE
WILBERFORCE AVENUE
SPENCER LANE
DOVER ROAD
SHORT LANE
BLAKE STREET
Swimming Pool
TENNIS COURTS
BOWLING GREEN
ROSE BAY PUBLIC SCHOOL
NORWICH LANE
STRICKLAND STREET
VICTORY STREET
CAFFYN PARK
ROYAL SYDNEY GOLF CLUB (THE)
ROSE BAY-VAUCLUSE UNITING CHURCH
ALBEMARLE LANE
ALBEMARLE AVENUE
CRANBROOK JUNIOR SCHOOL
KENT ROAD
NEWCASTLE STREET
ROSE BAY
GILBERT STREET
BEAUMONT STREET
BANGALLY ROAD
FARADAY AVENUE
LIVERPOOL STREET
ROSE BAY
HARDY STREET
LYONS STREET
REGIS ROSE BAY
ONSLOW STREET
WALLANGRA ROAD
CONSULATE-GENERAL OF THE REPUBLIC OF KIRIBATI
ONSLOW STREET RESERVE
GREEK ORTHODOX CHRISTIAN CHURCH OF ST GEORGE
ROSE BAY
CHALEYER STREET
THE AVENUE
ROSE BAY SECONDARY COLLEGE
WILLIAM STREET
KIPPARA ROAD
NARELLE STREET
OWEN STREET

16/9/2024 A3 X:\PROJECTS\SYDNEY\2024 Jobs\488 Albemarie Avenue\Figures\240912 - PP\QGIS_Project.qgz

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**Legend**

Site Boundary

0 70 140 Metres

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# Figure 1

**Subject Site Locality**

Rosebay Woolworth
488-492 Old South Head Rd

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# Methodology

This Flood Risk and Impact Assessment has been undertaken generally using the following procedure:

- Desktop review of available previous investigations and information including design plans, LiDAR and survey data, stormwater infrastructure information, land use classifications and boundary conditions.
- Modification of the original Waverley Flood Study TUFLOW model (BMT, 2019) to include Rose Bay and additional catchment in the vicinity of the subject site. This has been performed in response to a request from the DPHI to consider the use of the Waverley Flood Study TUFLOW model (BMT, 2019) for the purposes of the FIRA.
- Inclusion of site-specific elements into the Existing Case TUFLOW model such as detailed survey, landscape walls and buildings based on aerial imagery and observations made during a site investigation.
- Modification of the Existing Case TUFLOW hydraulic model to include an indicative development layout at the subject site, creating the Developed Case scenario.
- Comparison of the existing and indicative developed case results to review the impact potential future development may have on the existing flood behaviour on-site and in adjacent properties.
- Review of potential future development at the site with respect to the flood related NSW Ministerial Direction, the Principles of the NSW Floodplain Risk Management Manual (2023), Woollahra Municipal Council Local Environmental Plan and Development Control Plan.

This study has been prepared with consideration to the following plans and reports:

- Detailed survey prepared by LTS and dated August 2020

This report has been prepared for Planning Proposal submission to the NSW Department of Planning, Housing and Infrastructure (DPHI).

# Subject Site

The subject site is located at Rose Bay and include the parcels of land at 488-492 Old South Head Road and 30 Albemarle Avenue, Rose Bay otherwise known as Lot 1 DP1009799 and Lot 30 DP4567.

The subject site is bordered by commercial properties to the north-east, residential properties to the north-west, Old South Head Road to the south-east and Albemarle Avenue to the south-west. The site has an area of approximately 2257m$^2$ and is relatively flat with terrain levels ranging form approximately 11.89m AHD to 12.55m AHD and generally falling at a grade of 1% towards the north-western corner of the site.

The existing land use includes a decommissioned service station at 488-492 Old South Head Road and a residential property at 30 Albemarle Avenue. The decommissioned service station has been recently converted to a Woolworths direct to boot shopping facility with vehicular access / egress via both Old South Head Road and Albemarle Avenue.

The existing site frontages are presented in Photos 1 and 2 below:


**Photo 1 – 488-492 Old South Head Road Frontage (Looking South, 2024)**


**Photo 2 – 488-492 Old South Head Road Frontage (Looking North-West, 2024)**


**Photo 3 – 30 Albemarle Avenue Frontage (Google Maps 2021), Looking North-West towards the Site**

## Flooding Mechanisms

The subject site is affected by overland flow derived by the local upstream catchment.

The upstream catchment extends approximately 1km east and north-east of the subject site, towards the upper reaches of Rose Bay and Dover Heights. The catchment area upstream of the site is approximately 0.8km$^2$.

Downstream of the subject site, the catchment continues in a north-westerly direction before discharging into Sydney Harbour at Rose Bay Beach approximately 700m downstream.

The upstream catchment is largely urbanised with the trunk drainage network limited to the below ground stormwater network and the road network. Upstream flows are conveyed via a below ground trunk stormwater network which extends north along Old South Head Road and east up Onslow Street.

Flows that exceed the capacity of the below ground network, run overland through Council's road reserve, before combining at the intersection of Old South Head Road and Albemarle Avenue (adjacent to the subject site). Terrain grades at the intersection of Old South Head Road and Albemarle Avenue at Albemarle Avenue are relatively flat with overland flow directly upstream of the site ponding before continuing down Albemarle Avenue.

The subject site is not burdened by a direct channel or Council below ground infrastructure, however flows that exceed the capacity of the existing Sydney Water's Trunk drainage network in Albemarle Avenue and the capacity of the road reserve are observed to spill onto the site during flood events.

With the high urbanisation and relatively small upstream catchment, overland flow flooding is expected be representative with flash flooding whereby flood water is expected to rise and fall quickly with the potential for limited available warning time prior to a flood event.

# Planning Proposal

The Planning Proposal received gateway determination in February 2024 and was placed on Public Exhibition by DPHI from 2nd of April 2024 to 7th of May 2024. In summary, the exhibited Planning Proposal sought the following amendments to the Woollahra LEP 2014:

- Insert a new clause in Schedule 1 Additional permitted uses to permit retail premises at 30 Albemarle Avenue, provided it is as part of a shop top housing development at 488-492 Old South Head Road.
- Create a new local provisions clause that applies only if 488-492 Old South Head Road and 30 Albemarle Avenue are developed together that: Allows a maximum Gross Floor Area (or GFA) of 3,720m² on 488-492 Old South Head Road and 480m² on 30 Albemarle Avenue.
- Permit a maximum Height of Building of 14.5m at 30 Albemarle Avenue.

The revised indicative development concept to accompany the Planning Proposal involves the demolition of existing structures on the site and the construction of a four (4) storey mixed use building, incorporating a 2 storey Supermarket on ground and level 1, 14 residential apartments, a substantial ground level landscaped separation zone to the west and basement car parking.

It is important to note that this FIRA has been prepared to present a hypothetical developed case solution. It has been prepared to demonstrate a workable flooding solution can be achieved on the subject site. It is anticipated flood mitigation measures will be further resolved in concert with the progression of the design during future project phases. The indicative development concept submitted with this Planning Proposal was utilised to demonstrate the acceptable flooding outcome.

Please refer to the indicative concept plans prepared by PBD Architects for further details.

# Model Parameters

The Waverley Flood Study (BMT, 2019) TUFLOW model has been used for the purposes of the analysis. The TUFLOW model has been provided by Waverley Council under a license agreement for the purposes of the analysis.

It is noted that the Waverley Flood Study (BMT, 2019) TUFLOW model has been both truncated (reduced) and extended for the purposes of the analysis. The extent of the updated TUFLOW model is presented in Figure 2.

With the increased extent of the TUFLOW model, the model hydrology and hydraulic characteristics have also been extended. Below provides a summary of the model updates that have been made for the purposes of the analysis. For a summary of any parameters not discussed below, please refer to the Waverley Flood Study (BMT, 2019).

## Hydrological Model

The hydrological model over the extents of the existing Waverley Flood Study (BMT, 2019) remain unchanged when compared to the original Waverley Flood Study (BMT, 2019). For the extended areas of the model, a Rainfall on Grid (RoG) approach has been adopted.

The Waverley Flood Study (BMT, 2019) presents a comparison between the XP-RAFTS hydrology and the RoG methodology (see Section 5.5). The comparison shows a “good correlation” between the two methods and as such, RoG is considered an acceptable method for the purposes of the analysis.

It is noted that pre-burst rainfall depths have not been applied over the RoG section of the model which is consistent with the approach adopted by the Waverley Flood Study (BMT, 2019).

The input data for the RoG extent of the model consists of rainfall intensity-frequency-duration (IFD) depths, rainfall losses and rainfall temporal patterns. These are summarised in greater detail below.

### Burst Rainfall

The Intensity-Frequency-Duration (IFD) rainfall depths were obtained from the Waverley Flood Study (BMT, 2019) and are summarised in the below Table 3. Note that, only the critical durations / patterns determined by the Waverley Flood Study (BMT, 2019) have been used for the analysis.

**Table 1 - IFD Rainfall Depths (BMT, 2019)**

| Duration (min) | 1EY (mm) | 10% AEP (mm) | 1% AEP (mm) | 0.2% AEP (mm) | PMP (mm) |
|---|---|---|---|---|---|
| **15** | - | - | - | - | 180 |
| **20** | 19.2 | 34.0 | 50.4 | 62.0 | - |
| **30** | - | - | - | - | 260 |
| **45** | 27.0 | 47.2 | 70.4 | 86.5 | - |
| **90** | 34.8 | 60.5 | 91.1 | 111.0 | 540 |

Areal reduction factors have not been applied to the rainfall depths which is consistent with the approach adopted by the Waverley Flood Study (BMT, 2019).

### Rainfall Losses

For the purposes of the RoG modelling methodology, rainfall losses were applied to the land use and reduced based on the percentage impervious. Only the land use beneath the RoG portion of the model included rainfall losses. Please refer to Figure 2 for the extent of RoG hydrology.

The Waverley Flood Study (BMT, 2019) notes a typical 20mm Initial Loss and 2mm/hr Continuing Loss was adopted for pervious areas while, 2mm initial and 0mm/hr continuing loss was adopted for impervious catchments.

The following Table 2 presents a summary of the loss rates adopted over the RoG section of the model for each land use.

**Table 2 - Rainfall Losses**

| Landuse | Impervious Fraction (%) | Initial Loss (mm) | Continuing loss (mm/hr) |
|---|---|---|---|
| **Waverley Flood Study (BMT, 2019)** | 0% | 20.0 | 2.0 |
| **Waverley Flood Study (BMT, 2019)** | 100% | 2.0 | 0.0 |
| **Buildings** | 100% | 2.0 | 0.0 |
| **High Density Lots** | 90% | 2.0 | 0.2 |
| **Low Density Lots** | 40% | 12.0 | 1.2 |
| **Parks** | 0% | 20.0 | 0.0 |
| **Roads** | 100% | 2.0 | 0.0 |
| **Beach** | 0% | 20.0 | 0.0 |

The Waverley Flood Study (BMT, 2019) hydrology (XP-RAFTS) was used over the original model extents.

### Temporal Patterns

The latest ARR2019 temporal patterns for the “East-Coast South” region were applied to ARR 2019 design storm depths for the 1EY - 0.2% AEP.

The Generalised Short Duration Method (GSDM) and procedures outlined in the Publication *“The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method”* (BOM, 2003) were used to develop design storm pattern for the Probable Maximum Flood (PMF).

These temporal patterns remain consistent with those adopted by the original Waverley Flood Study (BMT, 2019).

## Hydraulic Model

As previously mentioned, the hydraulic model adopted for the purposes of the analysis is the Waverley Flood Study (BMT, 2019) TUFLOW model, which has been truncated and extended for the purposes of this analysis.

TUFLOW version 2018-03-AD with HPC GPU module has been used for the purposes of the analysis which is consistent with the version used by the Waverley Flood Study (BMT, 2019).

**Two-Dimensional Grid Extent and Size**

The two-dimensional grid extends to approximately Raleigh and Rodney Reserves to the east, the Avenue to the south, Royal Sydney Golf Club and Rose Bay Beach to the west and Towns Road the North.

The TUFLOW model was run with a two-meter grid size which is consistent with the Waverley Flood Study (BMT, 2019).

Please refer to Figure 2 for the adopted model extent.

**Boundary Conditions**

Inflows over the existing Waverley Flood Study (BMT, 2019) catchment remain unchanged when compared to the original Waverley Flood Study (BMT, 2019) TUFLOW model. As previously mentioned, a RoG methodology has been adopted over the parts of the model that were extended downstream of the site.

To accommodate the updated model extent, revised outlet boundary conditions were entered into the model. A free outfall head boundary has been entered into the two-dimensional model along the northern, and southern boundaries. Similarly, a free outfall outlet has been entered into the model at Rose Bay Golf Course. Flow from these catchments is expected to continue to drain away from the site and are low enough so as to not influence flood levels at the subject site.

Similarly, at the main catchment outlet (at Rose Bay Beach), an outlet head boundary with a tailwater height of 0.5m has been added to the model. Due to the height of the site, (>RL 10m AHD), tailwater effects due to sea level rise or offshore storm surges are not expected to significantly influence flood levels at the site.

Please refer to Figure 2 for the location of the adopted model boundary conditions.

**Terrain**

Base Model / Existing Case

Terrain data used in the development of the TUFLOW model is based on the original terrain used for the Waverley Flood Study (BMT, 2019). Modifications to the original Waverley Flood Study (BMT, 2019) model terrain generally involve the inclusion of detailed survey and manual terrain modifications made to include landscape walls, buildings and developed case terrain.

Landscape walls have been entered manually into the TUFLOW terrain, along the frontage of Albemarle Street. This is based on observations made during a site investigation and review of Google Street View, which present raised landscape walls along the frontages of the majority of properties along Albemarle Street. The height of landscape walls varies between 0.3 - 1.8m and have been estimated using Google Street View and from observations made during the site visit.

In addition, terrain levels over buildings have been raised by 1m (based on aerial imagery) along Albemarle Avenue. The approach to include landscape walls and buildings along major flow paths is consistent with the methodology adopted by the Waverley Flood Study (BMT, 2019).

Some additional minor amendments have also been made to the existing raised building extents presented within the extent of Waverley Flood Study (BMT, 2019). This was performed to better reflect aerial imagery and to include additional areas where major overland flow paths were observed.

Developed Case

Manual terrain amendments have also been made to the model for the developed case scenario. A storage tank has been modelled beneath the Ground Floor level while the proposed basement driveway has been raised assuming it will prevent flows from entering.

Modelled terrain levels for the Existing and Developed Case Scenarios are presented in Figure 2 and Figure 3, respectively.

**Hydraulic Structures**

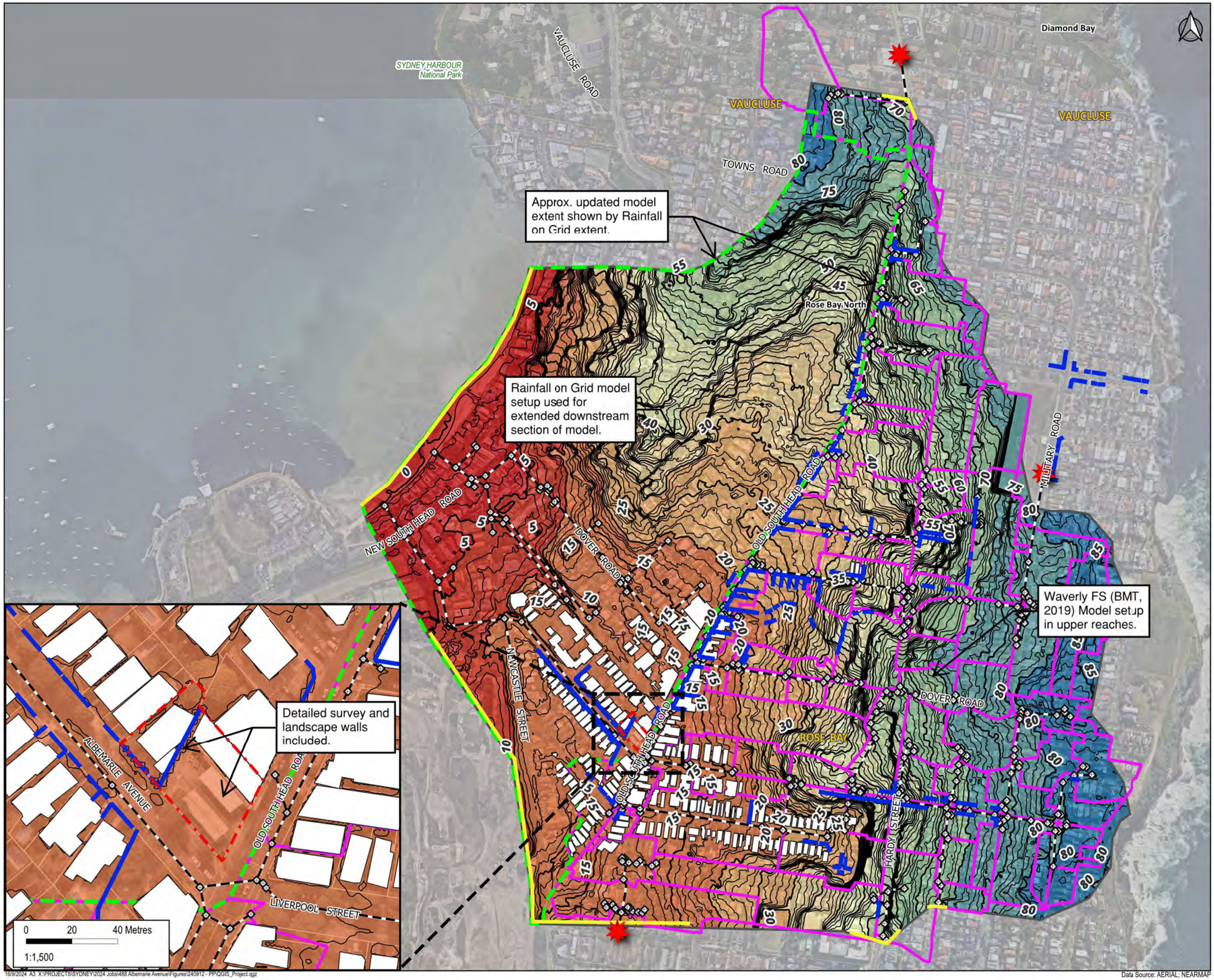
Base Model / Existing Case

Hydraulic structures included in the TUFLOW model are presented in Figure 2 and are based on those adopted in the Waverley Flood Study (BMT, 2019). Over the section of the model that has been extended, hydraulic structures have been based on the continuation of existing structures presented in the Waverley Flood Study (BMT, 2019) as well as information contained in the Rose Bay Flood Study (WMAwater, 2010).

Modelled blockage conditions are consistent with the design scenarios adopted by the Waverley Flood Study (BMT, 2019) namely 25% for on-grade pits and 50% for sags.

Developed Case

Developed case stormwater infrastructure includes a flood tank on the subject site with a suspended ground flood level above. The modelled flood tank has an assumed soffit of 12.7m AHD and 10% blockage within the Tank. Above the soffit level, 100% blockage factor has been adopted to represent the ground floor and upper levels. A minor connection from the proposed flood tank to the existing Sydney Water Trunk line running beneath Albemarle Avenue. For the purposes of the analysis, this has been modelled indicative as a 600mm RCP.




## Legend

- Site Boundary
- Raised Buildings
- RAFTS Inflows
- Rainfall on Grid Extent
- TUFLOW Model Extent
- Outlet Boundary
- Fences / Walls
- Terrain Contours (1m)
- Terrain Contours (5m)
- Pipes / Culverts
- Pits / Headwalls
- 1D Outlets

**Terrain (m AHD)**

- <= 5.0
- 5.0 - 10.0
- 15.0 - 20.0
- 25.0 - 30.0
- 35.0 - 40.0
- 45.0 - 50.0
- 55.0 - 60.0
- 65.0 - 70.0
- 75.0 - 80.0
- > 85.0

0 100 200 Metres

1:6,800

# Figure 2

**Existing Case**
**Model Setup and Terrain**

Rosebay Woolworth
488-492 Old South Head Rd

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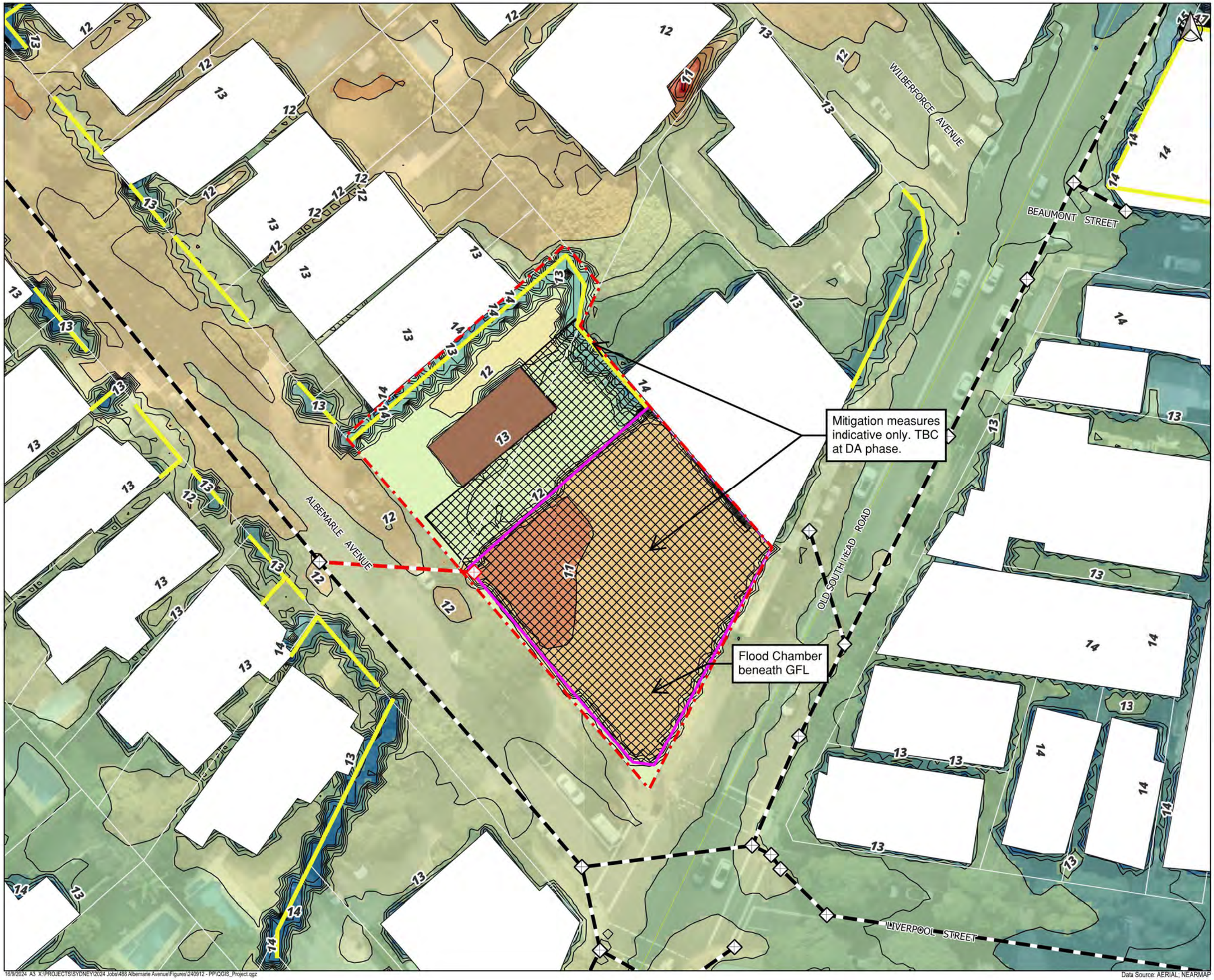


**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Suspended Building
- Flood Tank
- Fences / Walls
- Terrain Contours (250m)
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Ex. Pits / Headwalls
- Dev. Headwall

**Terrain (mAHD)**

- <= 10.5
- 10.5 - 11.0
- 11.0 - 11.5
- 11.5 - 12.0
- 12.0 - 12.5
- 12.5 - 13.0
- 13.0 - 13.5
- > 13.5

0 8 16 Metres

1:500

# Figure 3

**Developed Case**
**Model Setup and Terrain**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP

### Catchment Roughness and Building Representation

Hydraulic roughness for the existing and developed case scenarios is presented in the following Figure 4 and Figure 5. Roughness values were based on those used by the Waverley Flood Study (BMT, 2019). The following Table 3 presents the surface roughness values adopted for each land use.

**Table 3 – Land use Roughness (Manning's)**

| Land use | Roughness (Manning's) |
|---|---|
| Parks | 0.035 |
| Roads | 0.020 |
| Low Density Lots | 0.040 |
| Medium Density Lots | 0.060 |
| High Density Lots | 0.060 |
| Dense Vegetation | 0.080 |
| Beach | 0.030 |
| Paved | 0.020 |
| Water Body | 0.025 |
| Buildings | 0.900 |

As mentioned previously, existing buildings in the vicinity of the site and within critical flow paths have been raised in the flood model representing 100% flow obstructions. This methodology is consistent with the Waverley Flood Study (BMT, 2019).

Similarly, the proposed driveway has been blocked out of the model assuming flows could not enter this area during flood events.

Rainfall losses applied over landuse for Rainfall on Grid section of model

SYDNEY HARBOUR National Park

VAUCLUSE ROAD

VAUCLUSE

Diamond Bay

TOWNS ROAD

Rose Bay North

NEW SOUTH HEAD ROAD

DOVER ROAD

OLD SOUTH HEAD ROAD

MILITARY ROAD

NEWCASTLE STREET

ROSE BAY

HARDY STREET

ALBEMARLE AVENUE

LIVERPOOL STREET

0 20 40 Metres

1:1,500

## Legend

- Site Boundary
- Rainfall on Grid Extent
- TUFLOW Model Extent

**Roughness (Mannings)**

- Parks (0.035)
- Roads (0.020)
- Low Density Lots (0.040)
- High Density Lots (0.060)
- Dense Vegetation (0.080)
- Beach (0.030)
- Paved (0.020)
- Water Bodies (0.025)
- Buildings (0.90)
- Med Density Lots (0.060)

0 100 200 Metres

1:6,800

# Figure 4

**Existing Case**
**TUFLOW Roughness**

Rosebay Woolworth
488-492 Old South Head Rd

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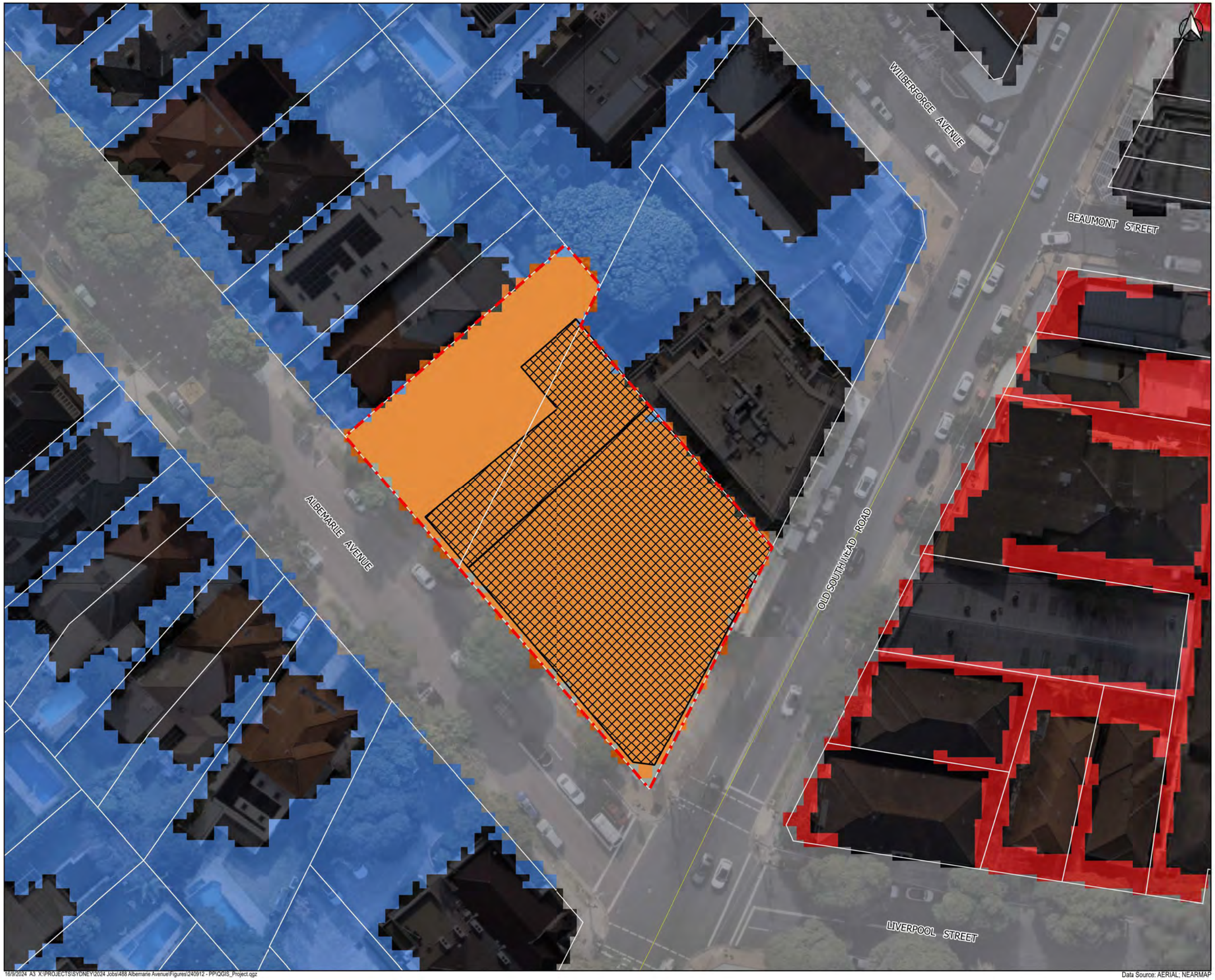


**Legend**

- Site Boundary
- Suspended Building

**Roughness (Mannings)**

- Parks (0.035)
- Roads (0.020)
- Low Density Lots (0.040)
- High Density Lots (0.060)
- Dense Vegetation (0.080)
- Beach (0.030)
- Paved (0.020)
- Water Bodies (0.025)
- Buildings (0.90)
- Med Density Lots (0.060)

0 8 16 Metres

1:500

# Figure 5

**Developed Case**
**TUFLOW Roughness**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP

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# Results

## Critical Duration

The critical durations outlined in the Waverley Flood Study (BMT, 2019) have been considered for this analysis. The following Table 4 presents the storm events that have been considered herein.

**Table 4 - Modelled Critical Events**

| Duration (min) | 1EY | 10% AEP | 1% AEP | 0.2% AEP | PMP |
|---|---|---|---|---|---|
| **15** | - | - | - | - | GSDM |
| **20** | 4445 (TP01) | 4383 (TP01) | 4359 (TP01) | 4359 (TP01) | - |
| **30** | - | - | - | - | GSDM |
| **45** | 4545 (TP01) | 4478 (TP01) | 4362 (TP01) | 4362 (TP01) | - |
| **90** | 4606 (TP06) | 4597 (TP09) | 4465 (TP03) | 4465 (TP03) | GSDM |

The results presented in Appendix A are based on a maximum envelope of each event presented in the above Table 4 for each return interval presented above.

## Model Validation

A comparison of the 1% AEP results observed by the Waverley Flood Study (BMT, 2019) and the flood modelling presented herein is presented in the following Figure 6.

The results presented in Figure 6 below demonstrate generally no change between the two models in the upper reaches of the catchment. This confirms model elements in the original Waverley Flood Study (BMT, 2019) generally remain unchanged.

Increased flood levels are observed around Old South Head Road by the modelling presented herein when compared to the Waverley Flood Study (BMT, 2019). This is expected to be due to a combination of amendments made to the raised building extents around Old South Head Road, updated Rainfall on Grid hydrology, inclusion of detailed survey, as well as different tailwater conditions when compared to the Waverley Flood Study (BMT, 2019).

As mentioned above, some minor amendments have been made to the modelled buildings in the vicinity of the subject site to better reflect aerial imagery and observations that are made on-site. Similarly, landscaped walls have been included, particularly down Albemarle Avenue, which are based on observations made on-site as well as Google Street View.

Similarly, a free outfall tailwater condition has been assumed by the Waverley Flood Study (BMT, 2019) at the model outlet (approx. 30m downstream of the site) which is observed to influence flood levels at the subject site.

Although increased flood levels are observed around the subject site when compared to the Waverley Flood Study (BMT, 2019) results, the model provides a better representation of likely site flood conditions and can be considered conservative when compared to the Waverley Flood Study (BMT, 2019) results. This is due to the site specific elements added into the model (landscape walls, detailed survey etc) and is considered conservative as the flood levels are higher in comparison.

Blue line = extent of Waverly FS (BMT, 2019)

Increases up to approx. 100-200mm around site. Expected to be due to inclusion of detailed survey, updated walls / buildings and modified model boundary

Changes due to updated wall and building extents

No changes in upper reaches of catchment (consistent with Waverly FS (BMT, 2019)

0 20 40 Metres
1:1,500

0 100 200 Metres
1:6,800

**Legend**

- Site Boundary
- Raised Buildings
- TUFLOW Model Extent
- Pipes / Culverts
- Pits / Headwalls

**Depth Difference (m)**

- <= -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.02
- -0.02 - -0.01
- -0.01- 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.5
- 0.05 - 0.10
- 0.10 - 0.50
- >0.50

# Figure 6

**Existing Case Model Verification**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP

## Existing Case Behaviour

Maximum modelled water depth and elevation maps for the Existing case 1EY, 10% AEP, 1% AEP and PMF design storm events are presented in **Figures A1, A3, A5 and A8** of Appendix A respectively.

Flood hazard conditions for the Existing case 1EY, 10% AEP, 1% AEP and PMF design storm events are also presented in Figures **A2, A4, A6 and A9** of Appendix A, respectively.

Flood hazard conditions have been assessed based on the latest AR&R 2019 hazard categories as presented in Figure 7 below. Flood hazard conditions for the Regional Catchment 1% AEP and PMF design storm events are presented in Figures C4 and C6 of Appendix A, respectively.

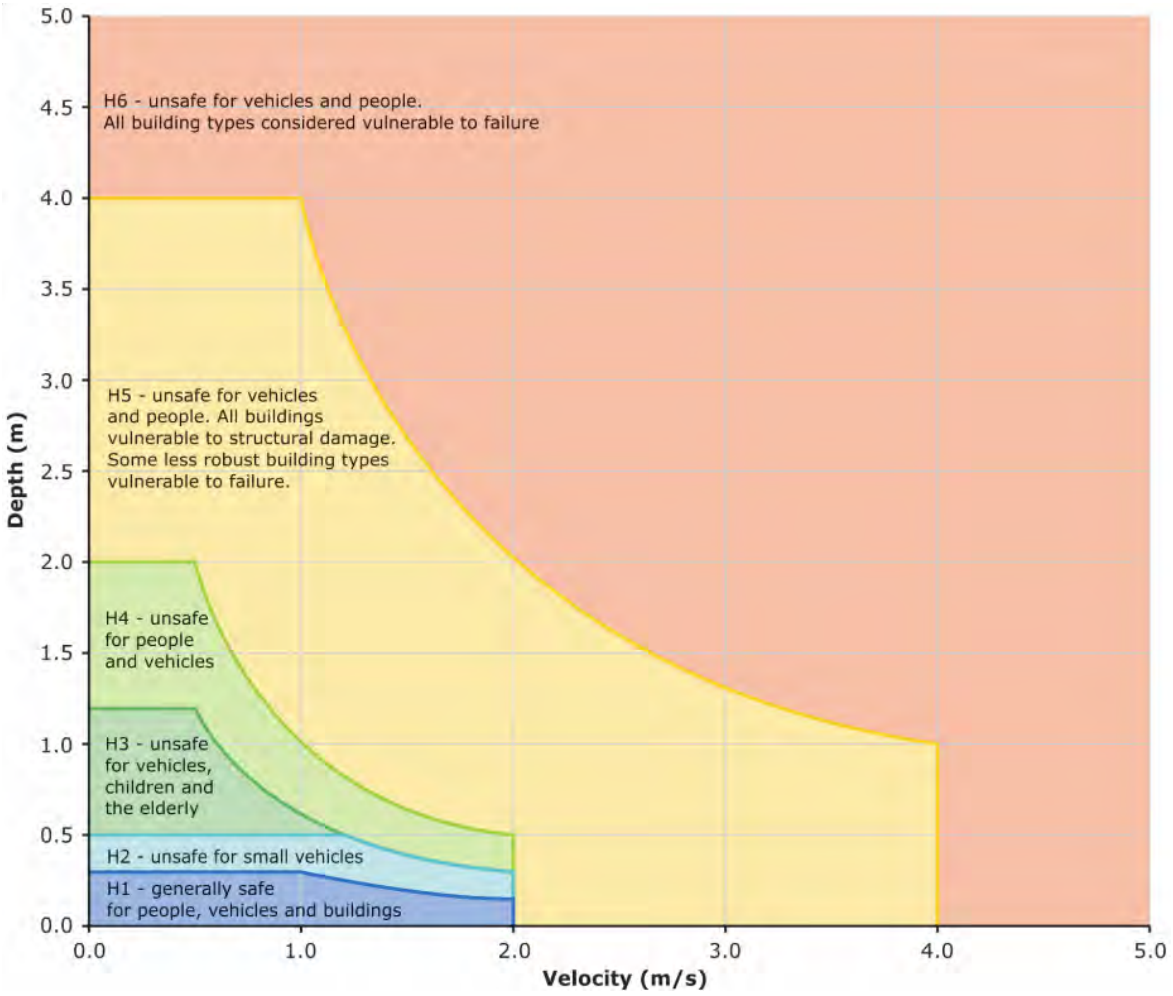


**Figure 7 - Flood Hazard Categories (ARR 2019)**

Flood hydraulic categories for the Existing case 1% AEP and PMF design storm events are presented in Figures **A7 and A10** of Appendix A, respectively. Hydraulic categories are based on those adopted by the Waverley Flood Study (BMT, 2019), reproduced below.

**Table 5 - Hydraulic Categories for 1% AEP (Waverley FS; BMT, 2019)**

| Category | Flood Behaviour | Definition |
|---|---|---|
| **Floodway** | Velocity * Depth > 0.2 | Areas and flow paths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections) |
| **Flood Storage** | Velocity * Depth < 0.2 and Depth > 0.5m | Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks. |
| **Flood Fringe** | Velocity * Depth < 0.2 and Depth < 0.5m | Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour |

**Table 6 - Hydraulic Categories for PMF (Waverley FS; BMT, 2019)**

| Category | Flood Behaviour | Definition |
|---|---|---|
| **Floodway** | Velocity * Depth > 0.4 | Areas and flow paths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections) |
| **Flood Storage** | Velocity * Depth < 0.4 and Depth > 0.5m | Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks. |
| **Flood Fringe** | Velocity * Depth < 0.4 and Depth < 0.5m | Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour |

The following Table 7 presents as summary of the existing case flood behaviour across the subject site for all modelled return events.

**Table 7 - Summary of Existing Case Flood Behaviour**

| Return Interval | Depth (m) | Elevation (m AHD) | Hazard (ARR 2019) | Category |
|---|---|---|---|---|
| **1EY** | 0 – 0.13 | 11.98 – 12.50 | H1 | - |
| **10% AEP** | 0 – 0.30 | 12.00 – 12.65 | H1 | - |
| **1% AEP** | 0.1 – 0.5 | 12.00 - 12.75 | H1 - H2 | Flood Fringe |
| **PMF** | 0.7 - 1.2 | 12.59 – 13.55 | H3 - H5 | Flood Storage to Floodway |

## Developed Case Flood Behaviour

Maximum modelled water depth and elevation maps for the Developed case 1EY, 10% AEP, 1% AEP and PMF design storm events are presented in **Figures B1, B3, B5 and B8** of Appendix A respectively.

Flood hazard conditions for the Developed case 1EY, 10% AEP, 1% AEP and PMF design storm events are also presented in Figures **B2, B4, B6 and B9** of Appendix A, respectively.

Flood hydraulic categories for the Developed case 1% AEP and PMF design storm events are presented in Figures **B7 and B10** of Appendix A, respectively.

The following Table 8 presents as summary of the Developed case flood behaviour across the subject site for all modelled return events.

**Table 8 - Summary of Developed Case Flood Behaviour**

| Return Interval | Depth (m) | Elevation (m AHD) | Hazard (ARR 2019) | Category |
|---|---|---|---|---|
| **1EY** | 0 – 0.60 | 12.00 – 12.50 | H1 and H3 (in tank) | - |
| **10% AEP** | 0 – 1.5 | 12.20 – 12.65 | H1 and H4 (in tank) | - |
| **1% AEP** | 0.0 – 1.7 | 12.40 - 12.66 | H1 and H5 (in Tank) | Flood Fringe to Floodway (in tank) |
| **PMF** | 0.8 – 2.6 | 13.20 – 13.48 | H3 to H5 (in Tank) | Flood Storage to Floodway |

## Flood Effects

Development flood effects during the 1EY, 10% AEP, 1% AEP and PMF design storm events is presented in Figures **C1, C2, C3 and C4** of Appendix A, respectively.

The results shown in Figures **C1-C3** of Appendix A, demonstrate the potential for future development to reduce flood depths in the vicinity of the subject site. During the 1% AEP, Figure **C3** of Appendix A shows a decrease of up to 180mm in Albemarle Avenue and Old South Head Road, directly adjacent to the subject site.

During the PMF event, an increase of up to 200mm is observed in Albemarle Avenue which dissipates as flows continue in a north-westerly direction down the street. A commensurate decrease of up to approximately 120mm is also observed in Old South Head Road which propagates into upstream properties. This demonstrates a potential benefit to upstream properties and roads as a result of the proposed development.

It is important to note that the PMF design storm event is an extremely rare event with a nominal $10^{-7}$ AEP (1 in 10 million) chance of occurring. It is not typically used to guide development and generally, the greatest concern during an event of this nature is reviewing how the residual risk to life can be managed. The risk to life is typically assessed using the flood hazard conditions with Figure **C5** of Appendix A presenting a comparison of the Existing and Developed flood hazard conditions during the PMF event. The results show negligible change in hazard conditions with the extent of H5 hazard in Albemarle Avenue (in the vicinity of the observed increase) largely the same pre and post development. A reduction in H5 hazard is observed in Faraday Avenue demonstrating some benefit to flood hazard conditions in the vicinity of the proposed development.

# Discussion

## Climate Change Sensitivity

A review of potential impacts due to climate change has been performed herein. The 0.2% AEP has been used as a proxy to climate change with a comparison between the 0.2% AEP and 1% AEP presented in Figure **D1** of Appendix A.

The results show there is the potential for increased flood depths around the subject site that range between approximately 50mm to 150mm, during potential future rainfall conditions. With the proposed development to be protected up to the PMF, these increases are not expected to influence the proposed mitigation measures at the site.

## Duration of Hazard

The following Table 9 and Table 10 presents the expected duration of existing hazard conditions at both Old South Head Road and Albemarle Street. The results presented in Table 9 and Table 10 are based on the critical durations considered herein. Existing case flood hazard conditions have been assessed as they are expected to present the longest period of hazard, due to the reductions observed in Old South Head Road during the developed case scenario.

Note that the 1EY and 10% AEP events have not been considered for the analysis as it is expected access and egress remains possible to and from the site during these events. Access and egress to and from the site is expected to be possible during the peak of these events, via Old South Head Road (i.e. Max H1 hazard observed in Figure A4 of Appendix A).

**Table 9 - Duration of Hazard (1% AEP)**

| Location | Greater than H1 (mins) | Greater than H2 (mins) | Greater than H3 (mins) | Greater than H4 (mins) |
|---|---|---|---|---|
| **Old South Head Road Frontage** | 20mins | Max H2 | Max H2 | Max H2 |
| **Albemarle Road Frontage** | 30mins | <10mins | <10mins | Max H4 |

**Table 10 - Duration of Hazard (PMF)**

| Location | Greater than H1 (mins) | Greater than H2 (mins) | Greater than H3 (mins) | Greater than H4 (mins) |
|---|---|---|---|---|
| **Old South Head Road Frontage** | 100mins | 80mins | 70mins | 10mins |
| **Albemarle Road Frontage** | 110mins | 100mins | 90mins | 80mins |

Review of Table 9 and Table 10 shows “non-trafficable” hazard conditions are expected to last approximately 20 minutes during the 1% AEP and 100 minutes during the PMF. It is noted that although non-trafficable conditions are expected, pedestrian access (i.e. max H2 hazard) is expected to remain possible via Old South Head Road.

## Evacuation, Refuge and Risk to Life

The above analysis of the duration of hazard conditions suggests there is the potential for access and egress, to and from the site (by vehicle) to become difficult for a period of approximately 20 minutes during the 1% AEP and 100 minutes during the PMF.

It is noted that access / egress is only expected to be limited during the peak of the event and access and egress is expected to be possible prior to and preceding the event. Similarly, as noted above, pedestrian and large vehicle access / egress during emergencies is expected to remain available via Old South Head Road during a 1% AEP design storm event.

As there is the potential for isolation of the site, future development at the site is to be designed to enable on-site refuge. This means that future development shall ensure sufficient space remains available for all occupants to Shelter-In-Place on the site at a location that is away from the flood hazard. Similarly, future buildings on the subject site that are to be used for on-site refuge shall be designed to withstand PMF flood forces to ensure the building remains safe for occupants within during a worst-case flood event.

Evacuation is recommended as the primary flood emergency response at the site and shall only proceed if time permits. In the event where sufficient warning time is not available for evacuation, occupants of the facility shall seek refuge within the upper levels of the building (as a means of last resort). This is facilitated in the design with the 2-storey supermarket connected by both fire stairs and a travellator while the residential facilities are proposed at or above Level 1 (which is already above the PMF). This Flood Emergency Response Strategy is consistent with the recommendations presented in the Draft SIP guidelines (DPHI, 2022).

With the primary strategy as early evacuation and the available secondary opportunity for shelter in place, the proposal is not expected to adversely impact existing evacuation routes or create an additional impost on emergency services.

Behavioural measures noted above can be introduced through the development of education and awareness programs for occupants of the facility. Education and awareness programs can be developed and maintained through the preparation of a Flood Emergency Response Plan (FERP) which can be prepared prior to Construction Certificate phase and once a development layout is finalised.

Through the proposed hard engineered flood mitigation measures recommended herein (i.e. flood protection of the building to the PMF) and the soft behaviour measures (such as the preparation of a Flood Emergency Response Plan), the flood risk on the subject site can be minimised.

With the introduction of on-site refuge, future development has the potential to reduce flood risk by changing the Flood Emergency Response Category (FERC) from a **Low Flood Island** under existing conditions to a **High Flood Island** during developed conditions. Providing the users on the site the opportunity to retreat to higher ground directly reduces the risk to life on the site.

Similarly, the proposal has the potential to reduce flood risk at the site by introducing an itinerant use (i.e. retail) at ground floor level in lieu of residential (as per existing conditions at 30 Albemarle Avenue). This reduces the flood risk on the site as occupants are less likely to remain on the ground floor level in the event of a flood, given upper level refuge opportunities and valuable / irreplaceable items associated with the residential uses will be stored in the upper levels.

# Planning Proposal Compliance

## Ministerial Direction

The following Table 11 demonstrates how the proposed development addresses the flood related Ministerial Direction (4.1 – Flooding) as outlined in Section 9.1(2) of the Environmental Planning and Assessment Act 1979 which came into effect in July 2021.

**Table 11: Response to Ministerial Direction (4.1 – Flooding)**

| Item | Development Control | Response |
|---|---|---|
| **4.1.1** | **A planning proposal must include provisions that give effect to and are consistent with:** | |
| (a) | The NSW Flood Prone Land Policy | The latest NSW Flood Prone Land Policy presented in the Floodplain Risk Management Manual (2023) promotes a merits-based approach and highlights flood prone land as a valuable resource, with rezoning to involve an objective assessment and review of local considerations.<br>An objective assessment and merits-based assessment is sought for the Planning Proposal with the proposal demonstrating an opportunity to improve flood conditions and reduce flood risk on the site through future development. |
| (b) | The principles of the Floodplain Development Manual 2005 (2023). | A response to the principles of the NSW Floodplain Risk Management Manual (2023) is presented in the below Table 12. |
| (c) | The Considering Flooding in Land Use Planning Guideline 2021 | The full range of flood events, up to and including the PMF have been considered herein.<br>Additional Special Flood Considerations outlined in the Considering Flooding in Land use Planning Guideline 2021 have not been adopted in the Woollahra Local Environmental Plan (2014) and are therefore are not applicable. |
| (d) | Any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 (2023) and adopted by the relevant council | The original FIRA (Northrop, 2022) was prepared using the Woollahra Council adopted Rose Bay Flood Study (WMAwater, 2010) and Rose Bay FRMS&P (WMAwater, 2014).<br>A review of these studies determined that they do not preclude the potential for development at the subject site, rather promote the use of flood mitigation measures.<br>Additional modelling has been prepared herein which is based on the Waverley Flood Study (BMT, 2019).<br>The Principles of the latest Floodplain Risk Management Manual (DPHI, 2023) have been addressed in Table 12 below. It is noted the |

| Item | Development Control | Response |
|---|---|---|
| | | Principles of the Floodplain Risk Management Manual (DPHI, 2023) encourage a merit-based assessment with respect to flood prone sites. |
| **4.1.2** | A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Business, Industrial or Special Purpose Zones. | The Planning Proposal does not seek to rezone land as noted by this clause. |
| **4.1.3** | **A planning proposal must not contain provisions that apply to the flood planning area which:** | |
| (a) | Permit development in floodway areas | The results presented herein demonstrate the subject site is not affected by Floodway hydraulic conditions during the Defined Flood Event (i.e. the 1% AEP).<br>Similarly, the results presented herein demonstrate potential future development at the subject site has the capacity to improve flood behaviour in adjacent properties. |
| (b) | Permit development that will result in significant flood impacts to other properties. | The results presented in the Flood Effects section of this report demonstrates potential future development at the subject site does not create a significant adverse impact in adjacent properties. |
| (c) | Permit development for the purposes of residential accommodation in high hazard areas | The results presented herein demonstrate the subject site is not affected by high hazard flood behaviour during the Defined Flood Event (i.e. the 1% AEP).<br>The planning proposal has the potential to reduce flood risk at the site by changing the Flood Emergency Response Category (FERC) from a Low Flood Island to a High Flood Island with provision for refuge on site at a level above the PMF.<br>Similarly, the proposal has the potential to reduce flood risk at the site by introducing an itinerant use (i.e. retail) at ground floor level in lieu of residential (under existing conditions). This reduces risk as occupants are less likely to remain on the ground floor in the event of a flood as it is not a place of residence, rather a place of occupation. |
| (d) | Permit a significant increase in the development and/or dwelling density of that land | The planning proposal does not propose a significant increase in potential development or residential accommodation on the site. As such, the proposal does not result in increased |

| Item | Development Control | Response |
|---|---|---|
| | | residential population or visitation to a high-risk area that will increase reliance on emergency services.<br>The site currently operates as a direct to boot retail service at ground level, and a residential dwelling, with the zoning remaining unchanged across the site. It is unlikely to significantly increase government spending on emergency services due to its location within an existing built-up area and the currently permitted uses. Additionally, the new building will have significantly greater flood resilience and provide refuge above the PMF which currently does not exist. |
| (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, | These uses are not proposed as part of the planning proposal. |
| (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 | The planning proposal is not expected to alter existing complying development pathways available / not available at the subject site. |
| (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. | Development on the subject site will protect future infrastructure to a level at or above worst-case flood levels. This is expected to reduce site vulnerability to flood damage when compared to existing infrastructure on the site.<br>Similarly, to enable refuge on-site, the proposed building will be designed to withstand flood forces during the worst case PMF event. Both of these elements demonstrate a significant improvement with respect to infrastructure and community flood resilience.<br>In addition to the above, development on the site provides an opportunity to improve warnings available and awareness for users (i.e. improved communication and preparation of a FERP).<br>Future development is expected to have established mitigation processes which will limit the requirement for emergency management from government services. |

| Item | Development Control | Response |
|---|---|---|
| (h) | Permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event | The proposed development includes a retail business and residential facilities. These uses are not expected to require storage of hazardous materials. |

## Principles of the NSW Floodplain Risk Management Manual (2023)

The guiding principles and a response to each principle of the NSW Floodplain Risk Management Manual (2023) is presented in the following Table 12.

**Table 12 - Principles of the NSW Floodplain Risk Management Manual (2023)**

| Principle | Definition | Response |
|---|---|---|
| 1 | **Establish sustainable governance arrangements** | Governance arrangements as discussed by the Manual (2023) are largely with respect to providing all levels and disciplines of government the opportunity to provide advice and commentary with respect to the proposal.<br>This has been achieved through the planning proposal assessment and review process and is expected to continue through future project phases. |
| 2 | **Think and plan strategically** | The preparation of this FIRA is expected to provide strategic guidance for future project phases.<br>Strategically, future development on the subject site has the potential to reduce flood risk and enhance flood readiness for the users. |
| 3 | **Be consultative** | Similar to Principle 1, this principle has been achieved through the planning proposal assessment and review process. Various government departments and agencies have been and will continue to be engaged during the Planning Proposal and future Development Application project phases. |
| 4 | **Make flood information available** | Flood information for the purposes of the Planning Proposal is presented herein. Additional information is also contained in the Rose Bay Flood Study and Waverley Flood Study (BMT, 2019).<br>This flood information will also be provided to future occupants of the site through the preparation of a Site-Specific Flood Emergency Response Plan (FERP). The preparation of a FERP directly responds to this Principle by:<br>• informing users about flooding and subsequently influence their decision making.<br>• Making users aware of how to respond to a flood threat and to heed the advice of relevant government and EM personnel during floods<br>• Informs users of site flood behaviour so they can take out appropriate insurances to cover their risks. |

| Principle | Definition | Response |
|---|---|---|
| | | It is recommended future users of the property be made aware of the existing flood risk on the site prior to signing a lease agreement. |
| 5 | **Understand flood behaviour and constraints** | Flood behaviour for the full range of events has been assessed and is presented herein.<br>Impacts relating to development on the site have been assessed previously with the results highlighting the potential for improvements on the site and in adjacent properties.<br>Flood behaviour for the future site layout and use is expected to be confirmed during future development approval phases. |
| 6 | **Understand flood risk and how it may change** | Flood behaviour for the full range of events has been assessed and presented herein.<br>Changes in flood behaviour due to climate change are not expected to significantly alter design outcomes for the site with the Ground Floor Finished Floor Level noted in the previous approval (and by the DCP) to be protected up to the PMF level.<br>Climate Change conditions can be further reviewed during a future Development Application submission, as necessary. |
| 7 | **Consider variability and uncertainty** | Cumulative impacts created by changing catchment conditions, such as adjacent development, is typically assessed by Local Government Council's as development occurs. Council will then typically assess development impact on a case-by-case basis and review cumulative impacts based on their knowledge of other nearby development at the time of approval.<br>The Flood Effects section of this report demonstrates the capability for development at the site to improve flood conditions in adjacent properties. This demonstrates a feasible solution with respect to potential cumulative impacts and changing catchment conditions.<br>The NSW Flood Prone Land Policy (2023) outlines a number of additional provisions that are necessary to achieve the aforementioned primary objective. Included in the policy provisions is the below statement:<br>*"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)"*<br>The Manual (2023) also highlights that different Flood Planning Levels apply to different types of development. And states:<br>*"Determining the FPL for typical residential development should generally start with a DFE of the 1% AEP flood plus an appropriate freeboard (typically 0.5 m)."*<br>The Planning Proposal incorporates a conservative approach with respect to protecting the proposed residential spaces from flood |

| Principle | Definition | Response |
|---|---|---|
| | | water. This is recognised by the allocation of residential spaces in the upper levels of the building which are well above the 1% AEP + 500mm. Retail facilities are proposed on the ground floor space which are considered an itinerate use and one of the lowest risk uses from a flooding perspective (when compared to other more permanent / vulnerable uses). The proposed retail use is also provided across two storeys which enables a rising route evacuation pathway within the building. |
| 8 | **Maintain natural flood functions** | There are no natural or classified watercourses across the subject site.<br>Flood behaviour across the site is recognised as low flood hazard (H1/H2) during the Defined Flood Event (i.e. the 1% AEP design storm event).<br>Development on the subject site has the potential to increase flood storage and improve the overall management of overland flow across the site and in adjacent properties. |
| 9 | **Manage flood risk effectively** | This principle identifies five elements that lead to informed decisions. These are summarised below, with a response to each element also provided.<br>**1. Managing flood risk to the existing community**<br>A range of flood risk management measures will be introduced for the proposed development, generally in accordance with Local Government requirements.<br>**2. Limiting increases in flood risk related to new and modified development.**<br>Development on the subject site has the potential to reduce flood risk on the subject site by changing the site FERC from a Low Flood Island to High Flood Island.<br>**3. Establishing or improving EM arrangements and planning for floods**<br>The preparation of the FERP and construction of future buildings on the site to be protected to a level at or above the PMF will enhance available Emergency Management arrangements when compared to existing conditions on the site. This is achieved by reducing the time and distance for users to find safe refuge, educates users of the risks and formalises flood emergency response measures.<br>**4. Considering flood risk when constructing or upgrading infrastructure**<br>Flood risk on the site has been reviewed herein and is expected to continue to be analysed during future project phases.<br>**5. Considering the influence of existing and proposed infrastructure on community flood resilience**<br>The existing facility is expected to be located beneath the 10% AEP design storm event. As such, the vulnerability of the existing |

| Principle | Definition | Response |
|---|---|---|
| | | facility is high with the potential for over-floor flooding and damage to building materials. In addition, the capacity of the existing facility to withstand flood forces is also unknown and may be susceptible to failure during a major or extreme flood event. As such, the current facility is not expected to provide opportunity to seek refuge on-site and evacuation is likely the more feasible emergency response measure.<br>Development on the subject site will protect future infrastructure to a level at or above worst-case flood levels, significantly reducing the site vulnerability to flood damage. Similarly, to enable refuge on-site, the proposed building will be designed to withstand flood forces during the worst case PMF event. Both of these elements demonstrate a significant improvement with respect to infrastructure and community flood resilience.<br>In addition to the above, development on the site provides an opportunity to improve warnings available for users (i.e. water level gauge/s and improved communication). |
| 10 | **Continually improve management of flood risk** | Development on the site presents an opportunity to improve existing site flood conditions with enhanced hard, engineered, and soft, behavioural, flood mitigation and management measures.<br>Further improvements may be recognised during future Development Applications as a final site use and layout is recognised. |

## Local Environmental Plan

The flood related Woollahra Local Environmental Plan (LEP) 2014 items and response to each item are presented in the following Table 13.

**Table 13 - Woollahra Local Environmental Plan (2014)**

| Item | Development Control | Response |
|---|---|---|
| **5.21 (a)** | **The objectives of this clause are as follows:** | |
| (a) | to minimise the flood risk to life and property associated with the use of land | The planning proposal is not expected to increase the flood risk to life and property on the subject site.<br>As mentioned above, the planning proposal and future development has the potential to reduce flood risk by changing the FERC from a Low Flood Island to High Flood Island (through the provision of on-site refuge).<br>Similarly, future development will preclude flood water from entering the building for events up to and including the PMF and as such reduces the potential for property damage and risk to life due to flooding. |

| Item | Development Control | Response |
|---|---|---|
| (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 | Low flood hazard conditions (H1/H2) are observed across the subject site during the existing case Defined Flood Event (i.e. the 1% AEP) scenario.<br>Similarly, flood fringe flow behaviour is identified across the site during the Defined Flood Event.<br>Climate change conditions have the potential to raise flood levels in the order of 50 - 150mm during the DFE. With future development expected to be designed to preclude flood waters up to the PMF design storm event, future climate conditions are not expected to significantly, adversely affect flood mitigation measures and flood risk at the subject site. |
| (c) | to avoid adverse or cumulative impacts on flood behaviour and the environment | The modelling presented herein demonstrates that future development of the site is not expected to significantly, adversely impact flood behaviour in adjacent properties. |
| (d) | to enable the safe occupation and efficient evacuation of people in the event of a flood. | Future development at the site is expected to incorporate appropriate flood mitigation measures to enable the safe occupation and efficient evacuation of people in the event of a flood.<br>Early evacuation, if time permits, is recommended as the primary flood emergency response measure for the site. On-site refuge is also expected to be available as a secondary measure (and means of last resort). This flood emergency strategy limits loading on existing evacuation routes.<br>It is also noted that the proposal does not propose a significant increase in residential accommodation on the site when compared to current zoning conditions. |
| **5.21 (b)** | **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 | Low flood hazard conditions (H1/H2) are observed across the subject site during the existing case Defined Flood Event (i.e. the 1% AEP) scenario.<br>Similarly, flood fringe flow behaviour is identified across the site during the Defined Flood Event. |

| Item | Development Control | Response |
|---|---|---|
| (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 | The modelling presented herein demonstrates the proposed development is not expected to significantly, adversely impact flood behaviour in adjacent properties. |
| (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 | Future development at the site is expected to incorporate appropriate flood mitigation measures to enable the safe occupation and efficient evacuation of people in the event of a flood.<br>Early evacuation, if time permits, is recommended as the primary flood emergency response measure for the site. On-site refuge is also expected to be available as a secondary measure (and means of last resort). This flood emergency strategy limits loading on existing evacuation routes.<br>It is also noted that the proposal does not propose a significant increase in the capacity of residential accommodation on the site when compared to current zoning conditions. |
| (d) | incorporates appropriate measures to manage risk to life in the event of a flood | The planning proposal and future development has the potential to reduce flood risk by changing the FERC from a Low Flood Island to High Flood Island (through the provision of on-site refuge).<br>Similarly, future development shall include mitigation measures that preclude flood water from entering the building for events up to and including the PMF.<br>In addition to hard engineered flood mitigation measures, soft behavioural measures are also recommended such as the preparation of a Flood Emergency Response Plan which will assist educate and improve flood awareness. The FERP can be prepared prior to Construction Certificate phase. |
| (e) | will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses. | The modelling presented herein demonstrates the proposed development is not expected to significantly, adversely impact flood behaviour in adjacent properties.<br>There are no identified defined or open water courses in the vicinity of the subject site. |
| 5.21 (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 | The modelling presented herein demonstrates the proposed development is not expected to |

| Item | Development Control | Response |
|---|---|---|
| | behaviour as a result of climate change | significantly, adversely impact flood behaviour in adjacent properties.<br>With the proposed development to be protected up to the PMF, increases due future climate conditions are not expected to influence the proposed mitigation measures at the site. |
| (b) | the intended design and scale of buildings resulting from the development, | The modelling presented herein demonstrates future development at the site has the capacity to not significantly, adversely impact flood behaviour in adjacent properties.<br>As a result, the scale of development is considered appropriate from a flood impact perspective. |
| (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, | The planning proposal and future development has the potential to reduce flood risk by changing the FERC from a Low Flood Island to High Flood Island (through the provision of on-site refuge).<br>Similarly, future development shall include mitigation measures that preclude flood water from entering the building for events up to and including the PMF.<br>In addition to hard engineered flood mitigation measures, soft behavioural measures are also recommended such as the preparation of a Flood Emergency Response Plan which will assist educate and improve flood awareness. The FERP can be prepared prior to Construction Certificate phase. |
| (d) | the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion. | The planning proposal is not expected to influence the existing potential to modify, relocate or remove buildings on the site or in adjacent properties. |

## Woollahra Development Control Plan

The proposed development has been assessed based on the flooding related controls outlined in Councils Development Control Plan, in particular Chapter E2 Section E2.3 – Flood Risk Management Controls.

Modelling presented herein assumes the ground floor level retail space is suspended above the flood storage tank with a Finished Floor Level (FFL) located at a minimum of the 1% AEP + 500mm. From the modelling presented herein, this corresponds to a level of approximately 13.2m AHD – up to approximately 0.6 - 1.2m above the existing surface levels in the adjacent road verge.

All residential spaces are proposed to be located in the upper levels of the facility and as such, are located well above the necessary 1% AEP + 500mm minimum level for habitable floors.

Although the ground floor FFL is sited at the 1% AEP + 500mm, floodwalls and flood gates are also proposed around the façade to prevent flood water ingress into the building for events up to and including the Probable Maximum Flood event. The intent is to maintain flood protection to the basement levels for events up to and including the PMF.

Given the high depths, of up to approximately 1.0m observed in both Old South Head Road & Albemarle Avenue adjacent to the subject site, finding a balance between flood protection and street activation is difficult. This balance is expected to be further fine-tuned at Development Application phase.

It is important to note that this FIRA has been prepared to present a hypothetical developed case solution. It has been prepared to demonstrate a workable flooding solution can be achieved on the subject site. It is anticipated flood mitigation measures will be further resolved in concert with the progression of the design during future project phases.

The following Table 14 demonstrates how the proposed development in its current form, achieves the remaining flood related requirements of Council's DCP.

**Table 14 - Additional Flood Related Controls (DCP Part E2.3.4) and the Development Response**

| Item | Development Control | Response |
|---|---|---|
| | **General Requirements** | |
| C1 | All structures have flood compatible building components below the 100 Year ARI level plus 0.5m freeboard. | Future development at the site is expected to have capability to protect building components up to the PMF event. |
| C2 | All electrical equipment (e.g. air conditioners and pool pumps) is located or protected to above the 100 Year ARI level plus 0.5m freeboard. | Future development at the site is expected to be able to protect internal electrical components up the PMF flood event. |
| C3 | All storage areas such as shelving are above the 100 Year ARI level plus 0.5m freeboard. | Future development at the site is expected have capacity to protect storage areas up the PMF flood event. |
| C4 | The structure is built to withstand the forces of floodwater, debris and buoyancy up to and including the 100 Year ARI level plus 0.5m freeboard. | With the provision for on-site refuge on the site, flood forces up to the PMF are to be considered. It is anticipated this will be assessed at detailed design phase, however, given the type of structure proposed, flood forces are not expected to be limiting in design. |
| C5 | Reliable evacuation access for pedestrians is provided from the lowest habitable floor area to a refuge area above the PMF level and designed to withstand PMF water forces. | Future development at the site is expected to be able to provide protection to the ground floor level up to the PMF event. Additional refuge is available in the upper level. |

| Item | Development Control | Response |
|---|---|---|
| C6 | Suitable flood protection (e.g. a crest up before descent on an access driveway) is provided within the subject site. Council will not generally allow alteration to existing levels on the public road or its property to achieve flood protection. | Protection to the basement level during events up to and including the PMF is recommended. This can be achieved through flood façade walls, inclusion of flood gates, raising the GF FFL and the appropriate driveway crest. |
| | **Fencing** | |
| C7 | Fencing is constructed in a manner which does not change the nature or level of flood waters in the area. Fencing is of a permeable/open type design, however, existing solid fences may be replaced by new solid fences. | Fencing is expected to be reviewed during future project phases. |
| C8 | Fencing is adequately constructed so as to withstand the forces of floodwaters. | Fencing is expected to be reviewed during future project phases. |
| C9 | The flood impact of the development is considered to ensure that the development will not increase flood effects elsewhere. Where a significant change in use of the site is proposed, a flood impact assessment is required. | Fencing is expected to be reviewed during future project phases.<br>The modelling presented herein demonstrates future development is not expected to significantly, adversely impact flood behaviour in adjacent properties. |
| | **Overland Flow Paths** | |
| C10 | All overland flow paths are free of structures which prevent the free passage of overland flow | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C11 | All overland flow paths are designed to convey the 1 in 100 ARI event. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C12 | All existing overland flow paths are maintained and the hydraulic capacity of the openings between buildings is maintained. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C13 | Overland flow paths are provided on all properties that have upstream contributing catchments of 1,000m or greater. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C14 | All overland flow paths are designed to a low hazard classification if possible. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |

| Item | Development Control | Response |
|---|---|---|
| C15 | Overland flow paths are designed such that they do not increase velocity or concentrate water on any adjacent property. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C16 | In overland flow paths, fencing is generally not be permissible. However, in low and medium flood risk precincts permeable/open type fences may be approved where it can be demonstrated that there will be no adverse impact on flooding to the subject land or surrounding properties. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C17 | Any structure located in an overland flow path is designed to be structurally sound in all flood events. A flood study may be required. Structures are designed by a suitably qualified practitioner. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C18 | If an overland flow path is not achievable, a 1 in 100 ARI drainage system may be accepted as an alternative. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| | Overland flow paths are grass turfed. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C19 | In (sandy) areas with high-risk erosion potential, overland flow paths are designed to limit velocity and/or protect against scour. | Site Overland Flow Paths and the local drainage network are expected to be reviewed at Development Application and Detailed Design phase. |
| C20 | Where an applicant cannot increase EPLs to take into account the sea level rise planning benchmarks, Council may consider imposing time-limited consent to provide the potential to remove, replace or adapt development in the future. | Not applicable. |
| | **Time Limit Consents** | |
| C21 | Properties within a high flood risk precinct are unsuitable for all development (except alterations and additions (only) developments) unless a Flood Risk Management Report has been prepared, by a suitably qualified practitioner, outlining appropriate risk management measures. | Low flood hazard conditions (H1/H2) are observed across the subject site during the existing case Defined Flood Event (i.e. the 1% AEP) scenario.<br>Similarly, flood fringe flow behaviour is identified across the site during the Defined Flood Event. |

| Item | Development Control | Response |
|---|---|---|
| | | Flood mitigation measures are proposed as outlined above. |
| | **High Flood Risk Precincts** | |
| C22 | Buildings or structures constructed in high flood risk precincts are designed to withstand the PMF event. | Future development is expected to be designed to withstand flood forces. |
| C23 | No new fencing of any type is permitted in high flood risk precincts unless it can be demonstrated, by a suitably qualified practitioner, that there will be no adverse impact on<br>flooding to the subject land or surrounding properties. | Response as per Item C7. |
| C24 | No new fencing of any type is permitted in high flood risk precincts unless it can be demonstrated, by a suitably qualified practitioner, that there will be no adverse impact on<br>flooding to the subject land or surrounding properties. | Response as per Item C7 |
| | **Medium Flood Risk Precincts** | |
| C25 | Properties within a medium flood risk precinct are generally unsuitable for critical and sensitive use development. Such developments will be considered on their merits, taking into account any proposed risk management measures. | The proposed development is not considered a critical or sensitive use and therefore this item is not applicable. |
| C26 | In medium flood risk precincts, impervious and continuous fencing is not permissible unless it can be demonstrated that there will be no adverse impact on flooding to the subject land or surrounding land. | As per Item C7. |
| | **Low Flood Risk Precincts** | |
| C27 | For critical and sensitive developments in low flood risk precincts, all habitable and non-habitable floor levels are no lower than the PMF flood level. | The proposed development is not considered a critical or sensitive use and therefore this item is not applicable. |
| C28 | For critical and sensitive developments in low flood risk precincts, all structures have flood compatible building components below the PMF flood level. | The proposed development is not considered a critical or sensitive use and therefore this item is not applicable. |

| Item | Development Control | Response |
|---|---|---|
| C29 | For critical and sensitive developments in low flood risk precincts, the applicant is to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including the PMF flood level. | The proposed development is not considered a critical or sensitive use and therefore this item is not applicable. |
| C30 | Where a property is outside of the four flood plains, but identified as flood prone, a site specific assessment is required. A flood analysis may be requested to determine the level of flood risk and to allow the setting of FPLs. | A site-specific assessment is presented herein. |

# Response to RFI

Following submission of the original FIRA (Northrop, 2022) a Request for Further Information (RFI) was received from the DCCEEW. The DCCEEW RFI (ref: DOC24/245706) was dated 15 May 2024 and was in response to the Exhibition of Planning Proposal – 488-492 Old South Head Road and 30 Albemarle Avenue, Rose Bay (PP-2022-731)

**Table 15 - Response to DCCEW RFI (15 May 2024)**

| Department Theme | Response |
|---|---|
| Consistency with the Ministerial Direction 4.1 | Please see Table 11 for a response to the flood related Ministerial Directions.<br>Similarly, the Principles of the NSW Flood Risk Management Manual (2023) have been addressed in Table 12. |
| Increase of residential land use in a high hazard area and NSW Planning Circular PS24-001. | Low flood hazard conditions (H1/H2) are observed across the subject site during the existing case Defined Flood Event (i.e. the 1% AEP) as shown in Figure A6 of Appendix A.<br>Similarly, flood fringe hydraulic behaviour is observed across the site during the Defined Flood Event as shown in Figure A7 of Appendix A.<br>Furthermore, residential accommodation is permitted under the current zoning. The proposed rezoning does not result in any significant increase in residential accommodation on the site (see separate analysis for further information). Therefore, the rezoning does not result in increased residential population or visitation to a high-risk area that will increase reliance on emergency services<br>The site currently operates as a direct to boot retail service at ground level, it is unlikely to significantly increase government spending on emergency services due to its location within an existing built-up area. Additionally, the new building will have significantly greater flood resilience and provide refuge above the PMF which currently does not exist.<br>The primary flood emergency response measure for the site is evacuation (if time permits) while, Shelter in Place is proposed as a means of last resort. This is consistent with the NSW Draft Shelter in Place guidelines (DPHI, 2022). This strategy is consistent with the existing site conditions and is not expected to change due to the Planning Proposal.<br>Future development at the site has the potential to reduce existing flood risk on the site by changing the FERC classification from a low flood island to high flood island, through the provision for on-site refuge. Providing the users on the site the opportunity to retreat to higher ground directly reduces the risk to life on the site. |
| Flood planning | The indicative concept scheme is conceptual to validate the planning controls. More detailed flood mitigation measures and operational aspects are expected to be resolved at the Development Application phase.<br>A FERP can be prepared on the site to ensure occupants in the lower levels of the facility evacuate into to the upper levels of the facility above the flood levels. |

| Department Theme | Response |
|---|---|
| Adequacy of FIRA | This updated FIRA has been prepared in response to this item.<br>The modelling presented herein demonstrates future development is not expected to significantly adversely impact flood behaviour in adjacent properties. |
| Potential for very large losses to occur | The proposed rezoning does not substantially increase the developable floor space at risk to flooding. Therefore, the risk of loss due to flooding has not been increased through the planning proposal and associated LEP amendments. |

# Conclusion

A Flood Impact and Risk Assessment Report has been prepared for the Planning Proposal at 488-492 Old South Head Road and 30 Albemarle Avenue, Rose Bay, NSW.

The Planning Proposal received gateway determination in February 2024 and was placed on Public Exhibition by DPHI from 2nd of April 2024 to 7th of May 2024. In summary, the exhibited Planning Proposal sought the following amendments to the Woollahra LEP 2014:

- Insert a new clause in Schedule 1 Additional permitted uses to permit retail premises at 30 Albemarle Avenue, provided it is as part of a shop top housing development at 488-492 Old South Head Road.
- Create a new local provisions clause that applies only if 488-492 Old South Head Road and 30 Albemarle Avenue are developed together that: Allows a maximum Gross Floor Area (or GFA) of 3,720m² on 488-492 Old South Head Road and 480m² on 30 Albemarle Avenue.
- Permit a maximum Height of Building of 14.5m at 30 Albemarle Avenue.

The revised indicative development concept to accompany the Planning Proposal involves the demolition of existing structures on the site and the construction of a four (4) storey mixed use building, incorporating a 2 storey Supermarket on ground and level 1, 14 residential apartments, a substantial ground level landscaped separation zone to the west and basement car parking.

Updated flood modelling has been prepared herein, based on the latest modelling prepared by the Waverley Flood Study (BMT, 2019). It was concluded that the proposed development is not affected by high hazard flood behaviour and is not affected by floodway hydraulic behaviour during the Defined Flood Event (i.e. the 1% AEP). Similarly, future development at the site has the capability to not create a significant adverse impact to the existing flood behaviour on the subject site and on the properties surrounding the subject site.

Furthermore, flood risk on site during the developed case has been minimised through adoption of necessary flood mitigation measures such as protection of the development up to the PMF, the provision of vertical and horizontal evacuation opportunities and the preparation of a FERP to formalise flood emergency measures and educate occupants of the flood risk.

In addition, a review of flood related legislation and Engineering and Development controls has been undertaken with a response to each of these requirements presented herein. The analysis concludes that development at the site has the capability to satisfy the requirements set out by the legislation and controls.

Low flood hazard conditions (H1/H2) are observed across the subject site during the existing case Defined Flood Event (i.e. the 1% AEP) as shown in Figure A6 of Appendix A.

Similarly, flood fringe hydraulic behaviour is observed across the site during the Defined Flood Event as shown in Figure A7 of Appendix A.

Furthermore, residential accommodation is permitted under the current zoning. The proposed rezoning does not result in any significant increase in residential accommodation on the site (see separate analysis for further information). Therefore, the rezoning does not result in increased residential population or visitation to a high-risk area that will increase reliance on emergency services

The site currently operates as a direct to boot retail service at ground level, it is unlikely to significantly increase government spending on emergency services due to its location within an existing built-up area. Additionally, the new building will have significantly greater flood resilience and provide refuge above the PMF which currently does not exist.

The primary flood emergency response measure for the site is evacuation (if time permits) while, Shelter in Place is proposed as a means of last resort. This is consistent with the NSW Draft Shelter in Place guidelines (DPHI, 2022). This strategy is consistent with the existing site conditions and is not expected to change due to the Planning Proposal.

Future development at the site has the potential to reduce existing flood risk on the site by changing the FERC classification from a low flood island to high flood island, through the provision for on-site refuge. Providing the users on the site the opportunity to retreat to higher ground directly reduces the risk to life on the site.

The proposed rezoning does not substantially increase the developable floor space at risk to flooding. Therefore, the risk of loss due to flooding has not been increased through the planning proposal and associated LEP amendments.

We commend our findings to the Department for their review.

## Limitation Statement

Northrop Consulting Engineers Pty Ltd (Northrop) has been retained to prepare this report based on specific instructions, scope of work and purpose pursuant to a contract with its client. It has been prepared in accordance with the usual care and thoroughness of the consulting profession for the use by Woolworths Group. The report is based on generally accepted practices and standards applicable to the scope of work at the time it was prepared. No other warranty, express or implied, is made as to the professional advice included in this report.

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## Document Register

| Rev | Status | Prepared | Approved | Date |
|---|---|---|---|---|
| **1** | DRAFT | LG | | 18/09/2024 |
| **A** | Approval | LG | LG | 02/10/2024 |
| **B** | Approval | LG | LG | 04/10/2024 |

# Appendix A – Flood Figures

ALBEMARLE AVENUE

WILBERFORCE AVENUE

BEAUMONT STREET

OLD SOUTH HEAD ROAD

LIVERPOOL STREET

FARADAY AVENUE

**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

**NOTE: Flood depths <50mm not shown**

# Figure A1

**Existing Scenario**
**Flood Depth and Elevation**
**1EY Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP


**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Flood Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure A2

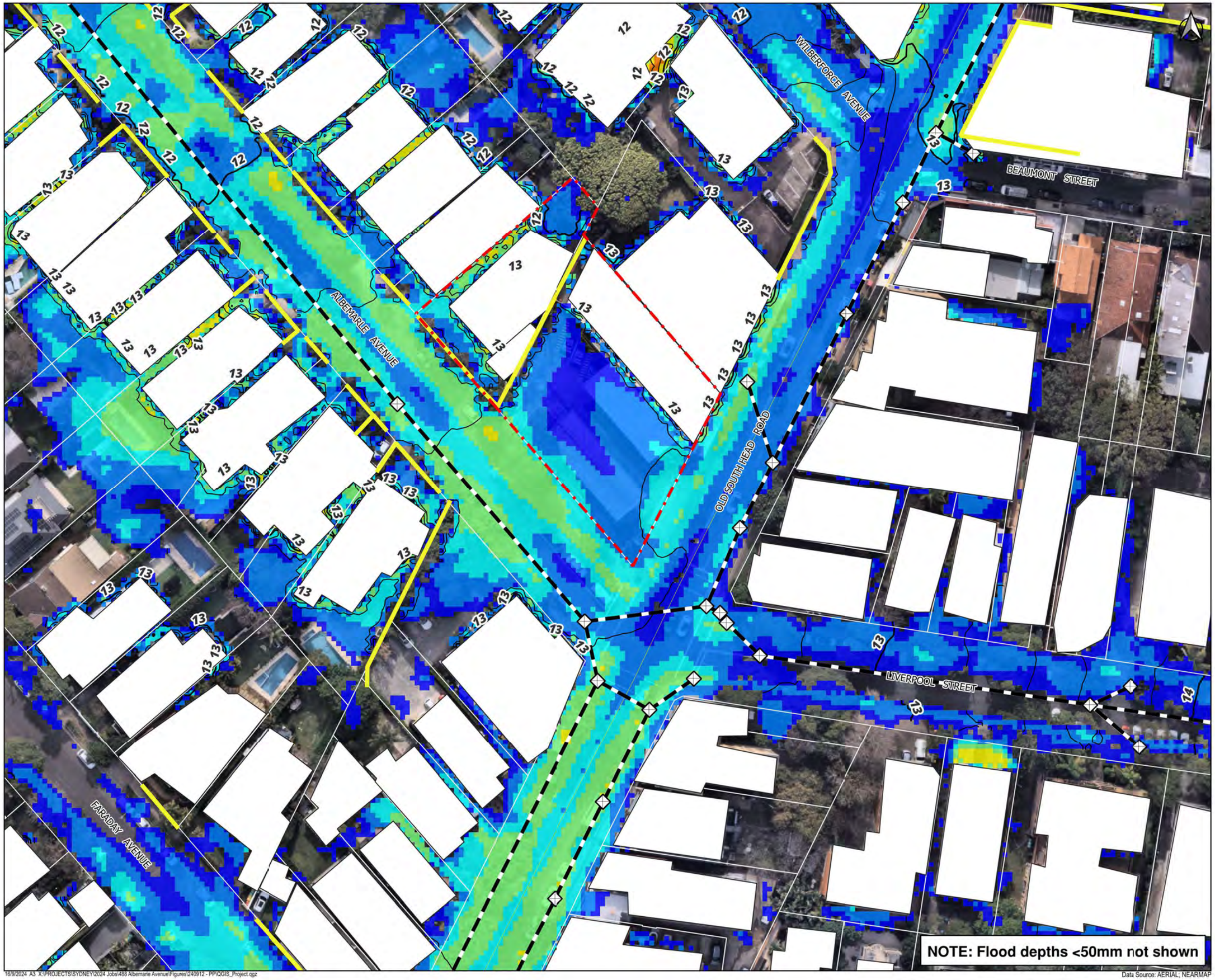
**Existing Scenario**
**Flood Hazard (ARR 2019)**
**1EY Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

# Figure A3

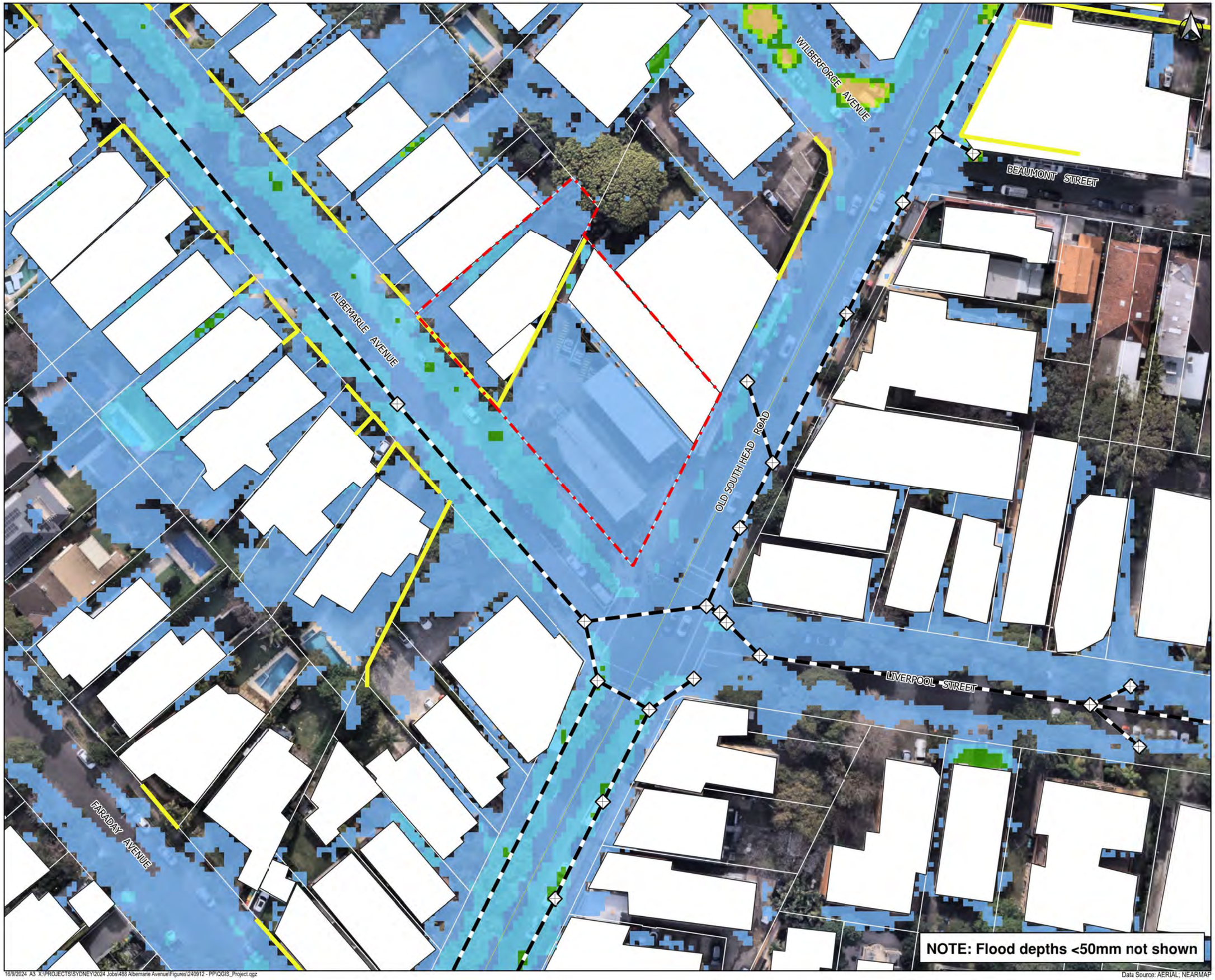
**Existing Scenario**
**Flood Depth and Elevation**
**10% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Flood Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure A4

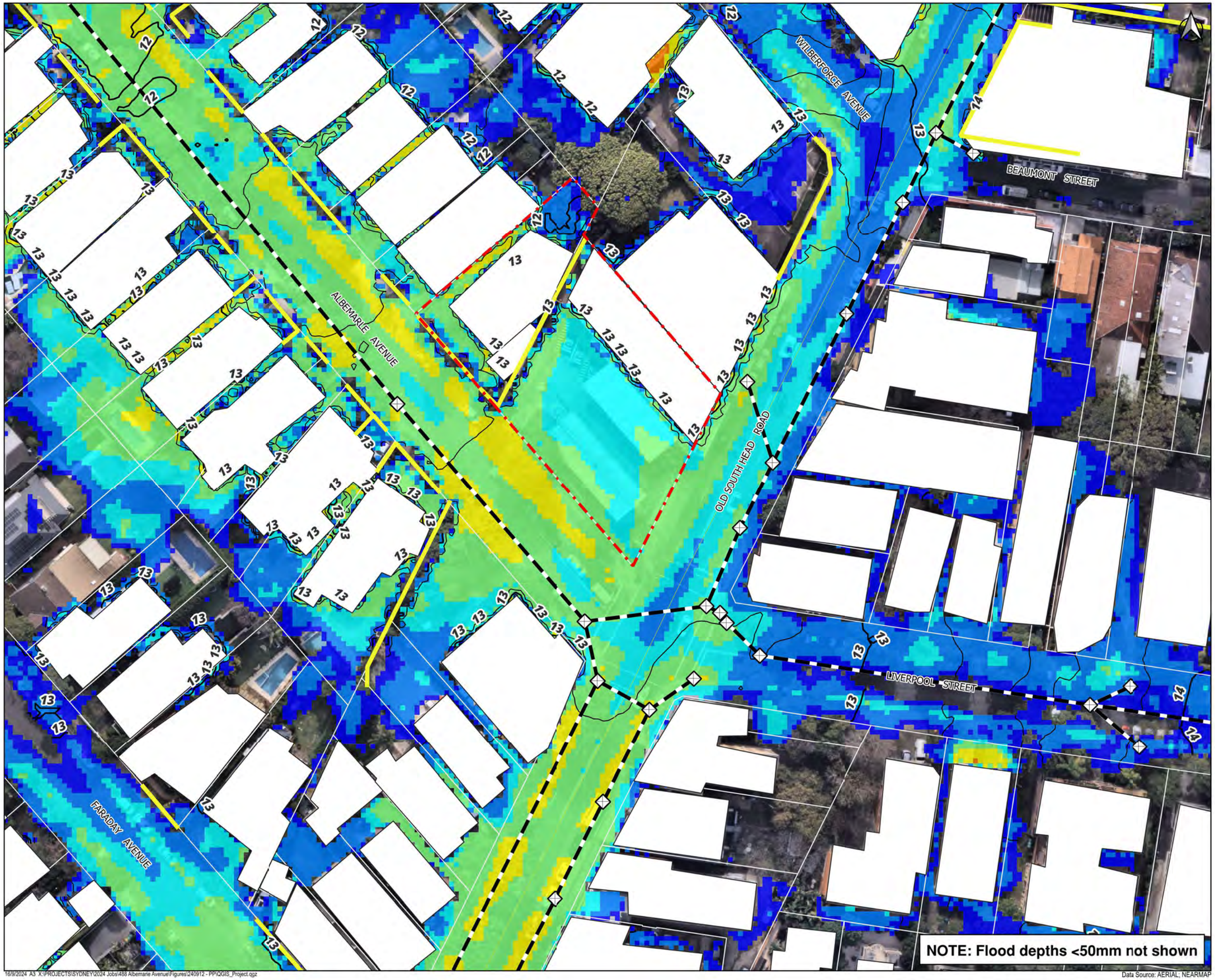
**Existing Scenario**
**Flood Hazard (ARR 2019)**
**10% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

## Figure A5

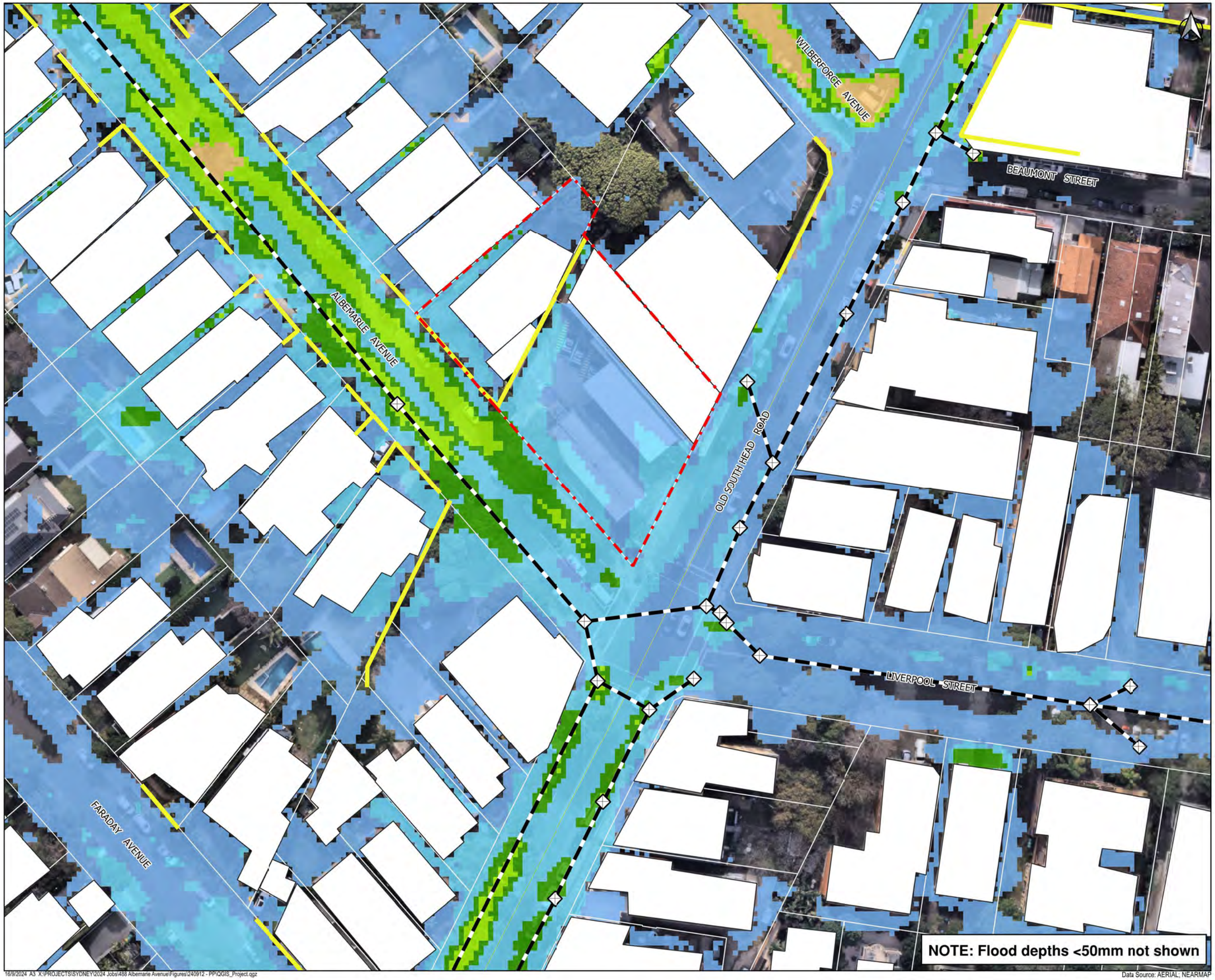
**Existing Scenario**
**Flood Depth and Elevation**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Flood Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure A6

**Existing Scenario**
**Flood Hazard (ARR 2019)**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP


**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 10 20 Metres

1:700

# Figure A7

**Existing Scenario**
**Hydraulic Category**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP

ALBEMARLE AVENUE
WILBERFORCE AVENUE
BEAUMONT STREET
OLD SOUTH HEAD ROAD
LIVERPOOL STREET
FARADAY AVENUE

**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

**NOTE: Flood depths <50mm not shown**

# Figure A8

**Existing Scenario**
**Flood Depth and Elevation**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP


**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Flood Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure A9

**Existing Scenario**
**Flood Hazard (ARR 2019)**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP


**Legend**

- Site Boundary
- Raised Buildings
- Fences / Walls
- Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Pits / Headwalls

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 10 20 Metres

1:700

# Figure A10

**Existing Scenario**
**Hydraulic Category**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP

ALBEMARLE AVENUE

WILBERFORCE AVENUE

BEAUMONT STREET

OLD SOUTH HEAD ROAD

LIVERPOOL STREET

FARADAY AVENUE

Depths in Flood Chamber beneath GFL

NOTE: Flood depths <50mm not shown

**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

**Figure B1**

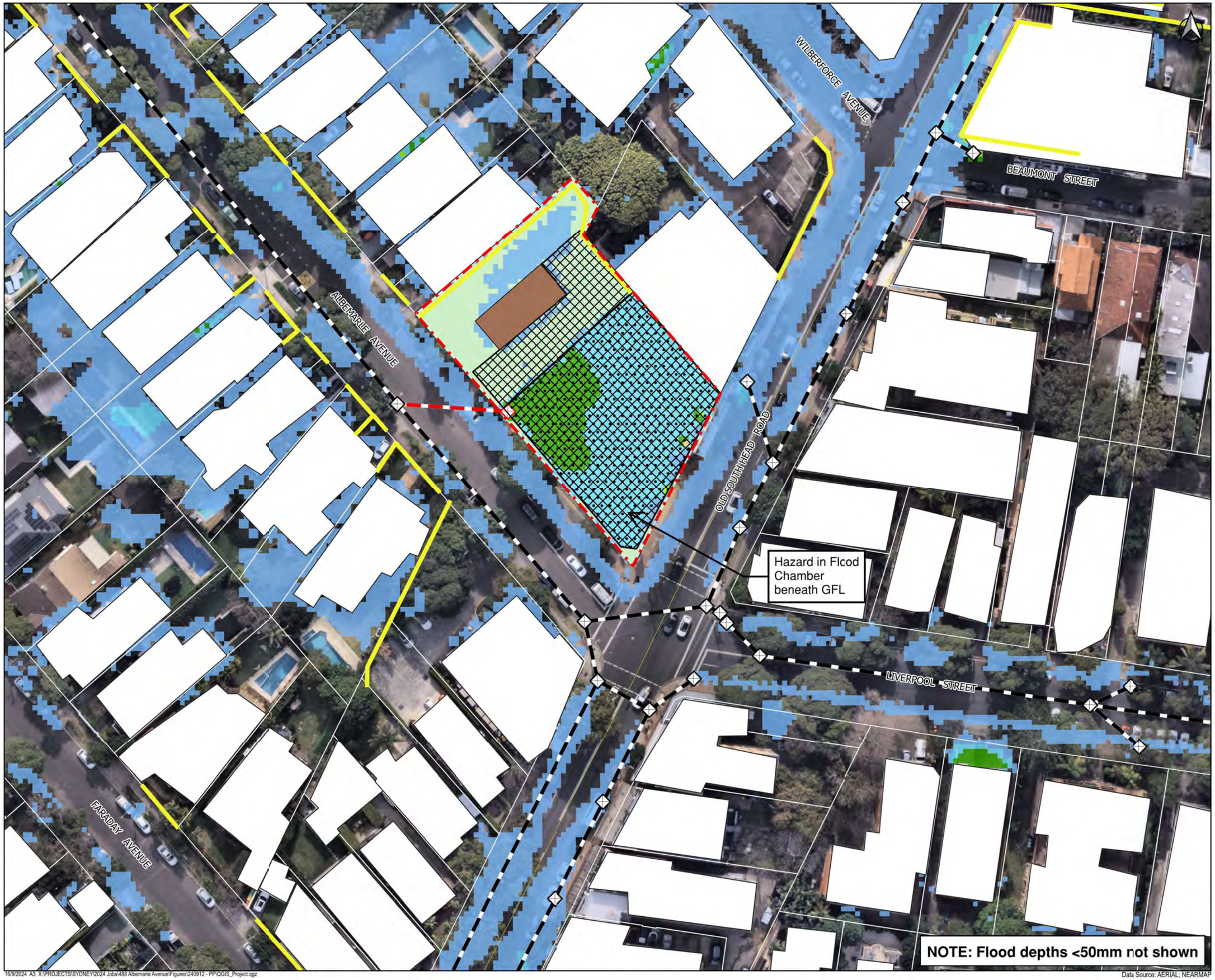
**Developed Scenario**
**Flood Depth and Elevation**
**1EY Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP

16/9/2024 A3 X:\PROJECTS\SYDNEY\2024 Jobs\488 Albemarie Avenue\Figures\240912 - PP\QGIS_Project.qgz

Data Source: AERIAL: NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure B2

**Developed Scenario**
**Flood Hazard (ARR 2019)**
**1EY Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP

ALBEMARLE AVENUE
WILBERFORCE AVENUE
BEAUMONT STREET
OLD SOUTH HEAD ROAD
LIVERPOOL STREET
FARADAY AVENUE

Depths in Flood Chamber beneath GFL

NOTE: Flood depths <50mm not shown

## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

# Figure B3

**Developed Scenario**
**Flood Depth and Elevation**
**10% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP

ALBEMARLE AVENUE

WILBERFORCE AVENUE

BEAUMONT STREET

OLD SOUTH HEAD ROAD

LIVERPOOL STREET

FARADAY AVENUE

Hazard in Flood Chamber beneath GFL

NOTE: Flood depths <50mm not shown

**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure B4

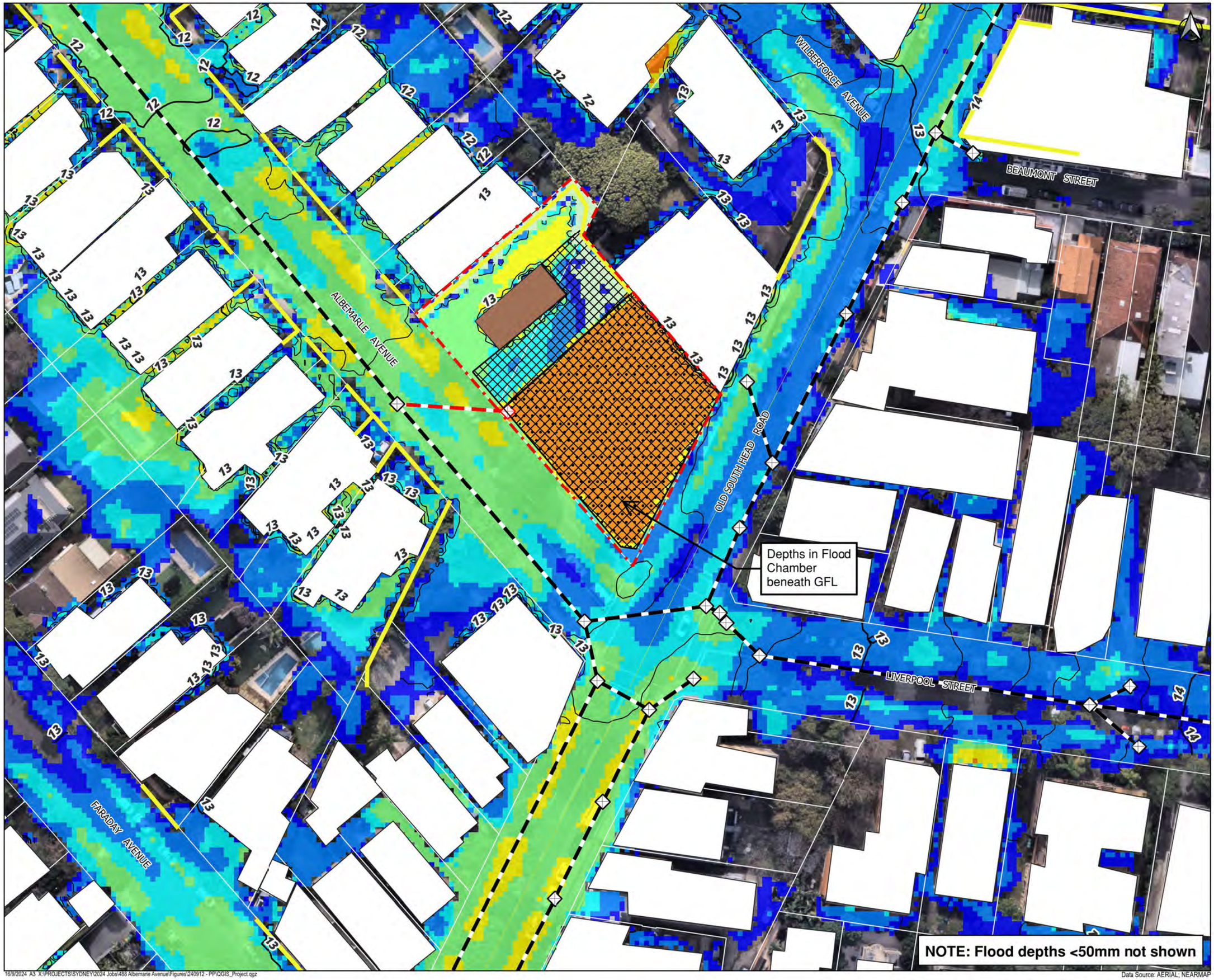
**Developed Scenario**
**Flood Hazard (ARR 2019)**
**10% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

# Figure B5

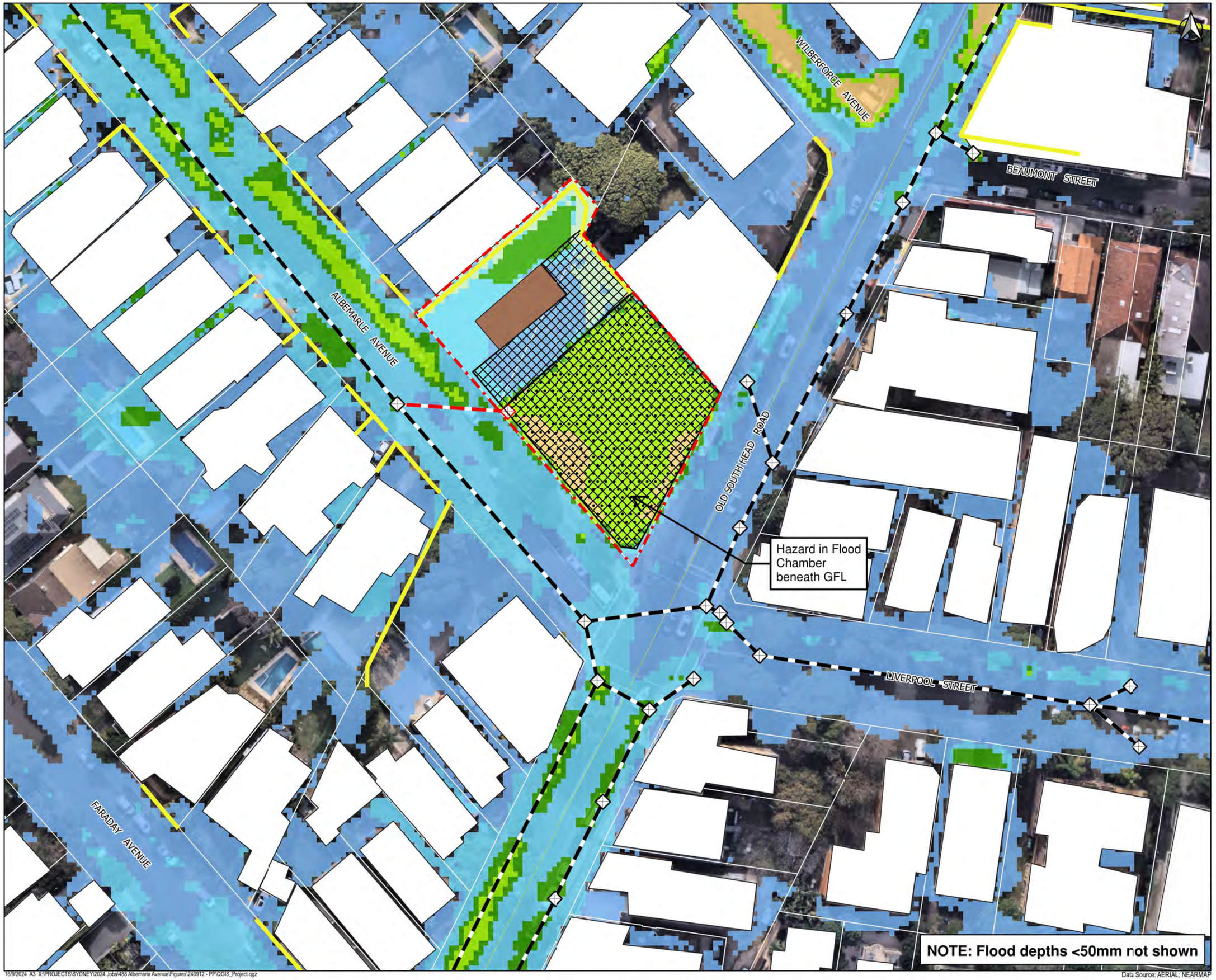
**Developed Scenario**
**Flood Depth and Elevation**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP




**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hazard (ARR 2019)

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

0 10 20 Metres

1:700

**Figure B6**

**Developed Scenario**
**Flood Hazard (ARR 2019)**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP

ALBEMARLE AVENUE

WILBERFORCE AVENUE

BEAUMONT STREET

OLD SOUTH HEAD ROAD

LIVERPOOL STREET

FARADAY AVENUE

Category in Flood Chamber beneath GFL

NOTE: Flood depths <50mm not shown

**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 10 20 Metres

1:700

# Figure B7

**Developed Scenario**
**Hydraulic Category**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP

ALBEMARLIE AVENUE

WILBERFORCE AVENUE

BEAUMONT STREET

OLD SOUTH HEAD ROAD

LIVERPOOL STREET

FARADAY AVENUE

Depth in Flood Chamber beneath GFL

NOTE: Flood depths <50mm not shown

## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Depth (m)

- Less than 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

0 10 20 Metres

1:700

# Figure B8

**Developed Scenario**
**Flood Depth and Elevation**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP

ALBEMARLE AVENUE

WILBERFORCE AVENUE

BEAUMONT STREET

OLD SOUTH HEAD ROAD

LIVERPOOL STREET

FARADAY AVENUE

Hazard in Flood Chamber beneath GFL

NOTE: Flood depths <50mm not shown

**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hazard (ARR 2019)

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

0 10 20 Metres

1:700

# Figure B9

**Developed Scenario**
**Flood Hazard (ARR 2019)**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP

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Data Source: AERIAL: NEARMAP


**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

0 10 20 Metres

1:700

# Figure B10

**Developed Scenario**
**Hydraulic Category**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP

Decreases downstream up to approx. 80mm

## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Ex. Pits / Headwalls
- Dev. Headwall

Depth Difference (m)

- <= -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.02
- -0.02 - -0.01
- -0.01- 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.5
- 0.05 - 0.10
- 0.10 - 0.50
- >0.50

0 50 100 Metres

1:3,000

# Figure C1

**Development Flood Effects**
**Flood Depth Difference**
**1EY Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP

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Data Source: AERIAL: NEARMAP

Decreases downstream up to approx. 60mm

Decreases up to approx. 130mm

PERCVAL PARK
COLLINS AVENUE
ST MARY MAGDALENE
IAN STREET
ROSE BAY POST OFFICE
MCAULEY PRIMARY SCHOOL
IAN LANE
CARLISLE STREET
SPENCER STREET
OLD SOUTH HEAD ROAD
ROBERTS STREET
ROSE BAY TOWERS RETIREMENT VILLAGE
NEW SOUTH HEAD ROAD
VICKERY AVENUE
TINGIRA RESERVE
ROSE BAY RSL CLUB T/AS CLUB ROSE BAY
PANNERONG RESERVE
ST ANDREW'S PRESBYTERIAN CHURCH
NORWICH ROAD
RICHMOND ROAD
TENNIS COURTS
TENNIS COURTS
WILBERFORCE AVENUE
SPENCER LANE
HAMILTON STREET
BLAKE STREET
DOVER ROAD
SHORT LANE
STRICKLAND STREET
BOWLING GREEN
Swimming Pool
NORWICH LANE
ROSE BAY PUBLIC SCHOOL
ROYAL SYDNEY GOLF CLUB (THE)
ROSE BAY
NEWCASTLE STREET
ALBEMARLE LANE
ALBEMARLE AVENUE
ROSE BAY-VAUCLUSE UNITING CHURCH
OLD SOUTH HEAD ROAD
BEAUMONT STREET
KENT ROAD
LIVERPOOL STREET
LIVERPOOL STREET
REGIS ROSE BAY
ONSLOW STREET
ONSLOW STREET RESERVE
GREEK ORTHODOX CHRISTIAN CHURCH OF ST GEORGE

## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Ex. Pits / Headwalls
- Dev. Headwall

Depth Difference (m)

- <= -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.02
- -0.02 - -0.01
- -0.01- 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.5
- 0.05 - 0.10
- 0.10 - 0.50
- >0.50

0 50 100 Metres

1:3,000

# Figure C2

**Development Flood Effects**
**Flood Depth Difference**
**10% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP

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Data Source: AERIAL: NEARMAP


## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Ex. Pits / Headwalls
- Dev. Headwall

Depth Difference (m)

- <= -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.02
- -0.02 - -0.01
- -0.01- 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.5
- 0.05 - 0.10
- 0.10 - 0.50
- >0.50

0 50 100 Metres

1:3,000

# Figure C3

**Development Flood Effects**
**Flood Depth Difference**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL: NEARMAP


## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Ex. Pits / Headwalls
- Dev. Headwall

Depth Difference (m)

- <= -0.50
- -0.50 - -0.10
- -0.10 - -0.05
- -0.05 - -0.03
- -0.03 - -0.02
- -0.02 - -0.01
- -0.01- 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.5
- 0.05 - 0.10
- 0.10 - 0.50
- >0.50

0 50 100 Metres

1:3,000

# Figure C4

**Development Flood Effects**
**Flood Depth Difference**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP

EXISTING CASE

DEVELOPED CASE

H5 hazard

H5 hazard

Reduction in H5 hazard

## Legend

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Major Contours (1m)
- Minor Controus (200mm)
- Ex. Pits / Headwalls
- Dev. Headwall

Hazard (ARR 2019)

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

0 40 80 Metres

1:2,500

**Figure C5**

**Flood Effects**
**Flood Hazard (ARR 2019)**
**PMF Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP

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Data Source: AERIAL; NEARMAP


**Legend**

- Site Boundary
- Raised Buildings
- Driveway (Raised)
- Tank (Indicative)
- Suspended Building (Indicative)
- Fences / Walls
- Ex. Pipes / Culverts
- Dev. Pipes / Culverts
- Ex. Pits / Headwalls
- Dev. Headwall

Depth Difference (m)

- <0.01
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.150
- 0.150 - 0.300
- >0.30

0 10 20 Metres

1:700

# Figure D1

**Developed Scenario**
**Climate Change**
**Flood Depth Difference**
**1% AEP Flood Event**

Rosebay Woolworth
488-492 Old South Head Rd

NORTHROP



Data Source: AERIAL; NEARMAP