Appendix T

Flooding report

Sydney Metro West

Parramatta Over and Adjacent Station Development Flooding Report

Appendix T

September 2022

NSW GOVERNMENT

sydney METRO

Document Number: SMWSTEDS-SMD-SN600-WA-RTP-044001

REVISION	DATE	SUITABILITY CODE	TEAMBINDER DOCUMENT NUMBER	TB REVISION
E	12/09/2022	S4	SMWSTEDS-SMD-SN600-WA-RPT-044001	E

Approval Record

FUNCTION	POSITION	NAME	DATE
Author	Principal Engineer	Sachi Canning	12/09/2022
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Approver	EDS Metro West Lead	Adrian Garnero	20/09/2022

Amendment Record

DATE	REVISION	AMENDMENT DESCRIPTION	AUTHOR
22/10/2021	A	Initial issue	Sachi Canning
14/01/2022	B	Second Issue	Sachi Canning
07/04/2022	C	Third Issue	Sachi Canning
14/06/2022	D	Fourth Issue	Sachi Canning
12/09/2022	E	Final issue	Sachi Canning

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Glossary

Term	Definition
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding.
ARR	Australian Rainfall and Runoff (ARR) is a national guideline document used for the estimation of design flood characteristics in Australia. Reference is made to either ARR1987 (3rd edition) or ARR2019 (4th edition) as specified
ASD	Adjacent site development.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected flood event. For example, floods with a discharge as great as or greater than the 20-year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. Also refer to Average Exceedance Probability (AEP), which is the industry standard terminology for definition of design flood events
Catchment	The land area draining through the mainstream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
CBD	Central business district
Concept and Stage 1 CSSI Approval	SSI-10038 (approved 11 March 2021), including all major civil construction works between Westmead and The Bays, including station excavation and tunnelling, associated with the Sydney Metro West line
Concept SSDA	A concept development application as defined in section 4.22 of the EP&A Act. It is a development application that sets out the concept for the development of a site, and for which detailed proposals for the site or for separate parts of the site are to be the subject of a subsequent development application or applications
CSSI	Critical state significant infrastructure
Continuing flood risk	The risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure
DPE	Department of Planning and Environment
Exceedances per year (EY)	The number of times a flood event is likely to occur or be exceeded within any given year
EP&A Act	Environmental Planning and Assessment Act 1979
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks
Existing flood risk	The risk a community is exposed to due to its location on the floodplain.
Future flood risk	The risk a community may be exposed to due to new development on the floodplain
Hydraulic modelling	Hydraulic modelling uses the rainfall, catchment and watercourse topography to predict flood behaviour including flood levels, flood extents, flood velocities and the duration of inundation in the catchment and watercourse

Term	Definition
Hydrologic modelling	Hydrologic modelling refers to the conversion of the design rainfall and runoff into flow hydrographs that are applied to the hydraulic model to define flood depths, flood extents, velocities and hazards for a range of design storms
Hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
IFD	Intensity-frequency duration
LGA	Local government area
Matter of national environmental significance (MNES)	A matter of national environmental significance (MNES) protected by a provision of Part 3 of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
MIKE11	MIKE11 is an industry standard computer program used to simulate 1D hydraulics, developed by the Danish Hydrology Institute.
OSD	Over station development
PLR	Parramatta Light Rail
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. The PMF defines the extent of flood prone land, that is, the floodplain
Rain on grid hydraulic model	In these studies, hydrological assessment has been incorporated directly into the hydraulic models, rather than employing a separate hydrological model to derive flow hydrographs. Along with topographic information and model parameters reflecting the catchment and watercourse, flood behaviour including flood levels, flood extents, flood velocities and the duration of inundation in the catchment and watercourse can be predicted
RCP	Representative concentration pathways
SEARs	Secretary's Environmental Assessment Requirements.
SRD SEPP	State Environmental Planning Policy (State and Regional Development) 2011
SSD	State significant development.
Stage 2 CSSI Application	Application SSI-19238057, including major civil construction works between The Bays and Hunter Street Station
Stage 3 CSSI Application	Application SSI-22765520, including rail infrastructure, stations, precincts and operation of the Sydney Metro West line
Sydney Metro West	Construction and operation of a metro rail line and associated stations between Westmead and the Sydney CBD as described in section 1.1
The site	The site which is the subject of the Concept SSDA
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia
TUFLOW Classic	TUFLOW classic is the original TUFLOW solver which uses a 2nd order implicit finite difference solution. It uses a fixed timestep. The Classic solver's turbulence model is dependent on cell size with a fixed timestep
TUFLOW HPC	The TUFLOW HPC (Heavily Parallelised Compute) solver uses a 2nd order explicit finite volume solution. TUFLOW HPC has increased stability with an adaptive timestep compared with Classic. The HPC model uses an updated turbulence scheme, which is cell size insensitive
WSPAJV	WSP Aurecon Parramatta Light Rail Infrastructure Joint Venture

Executive summary

This Flooding Assessment report supports a Concept State Significant Development Application (Concept SSDA) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Concept SSDA is made under Section 4.22 of the EP&A Act.

Sydney Metro is seeking to secure concept approval for an over station development (OSD) and adjacent station development (ASD) on the Parramatta metro station site (referred to as the 'proposed development'). The proposed development will comprise three new commercial office buildings (Buildings A, C, D), and one new residential building (Building B).

The Concept SSDA seeks consent for a building envelope and mixed-use purposes, maximum building height, a maximum gross floor area (GFA), pedestrian and vehicular access, circulation arrangements and associated car parking, and the strategies and design parameters for the future detailed design of the proposed development.

This Flooding Assessment report identifies and responds to relevant state and local government policy, and statutory planning instruments in support of the Concept SSDA. In accordance with the Secretary's Environmental Assessment Requirements (SEARs), a flooding assessment has been undertaken to determine any potential hydraulic impacts from the proposed development and assess flooding immunity requirements for the proposed development. A response to the appropriate SEARs has been included. Assessments have been undertaken based on relevant Commonwealth, State and Local Government guidelines.

Hydraulic flood models developed for Transport for NSW for the adjacent Parramatta Light Rail were adopted and adapted for use in assessing the flooding for the proposed development site. The proposed developed permanent works are based on indicative design concept of the proposed development site.

The assessment has been undertaken based on information available when this report was written and will need to be updated as the design progresses.

1 Introduction

1.1 Sydney Metro West

Sydney Metro West will double rail capacity between Greater Parramatta and the Sydney Central Business District (CBD), transforming Sydney for generations to come. The once in a century infrastructure investment will have a target travel time of about 20 minutes between Parramatta and the Sydney CBD, link new communities to rail services and support employment growth and housing supply.

Stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD).

Sydney Metro West station locations are shown in Figure 1-1.

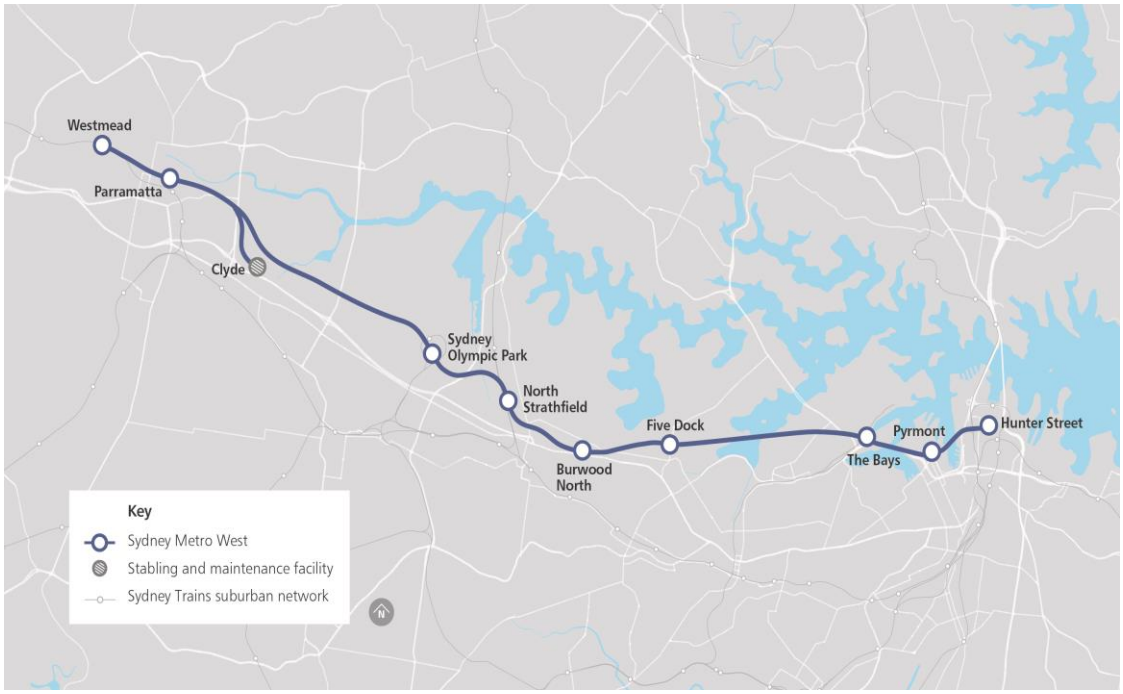

Figure 1-1 Sydney Metro West

1.2 Background and planning context

Sydney Metro is seeking to deliver Parramatta metro station under a two-part planning approval process. The station fit-out infrastructure is to be delivered under a Critical State Significant Infrastructure (CSSI) application subject to provisions under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), whereas the over and adjacent station developments are to be delivered under a State Significant Development (SSD) subject to the provisions of Part 4 of the EP&A Act.

1.2.1 Critical State Significant Infrastructure

The State Significant Infrastructure (SSI) planning approval process for the Sydney Metro West metro line, including delivery of station infrastructure, has been broken down into a number of planning application stages, comprising the following:

- Concept and Stage 1 CSSI Approval (SSI-10038) – All major civil construction works between Westmead and The Bays including station excavation, tunnelling and demolition of existing buildings (approved 11 March 2021)

- Stage 2 CSSI Application (SSI- 19238057) – All major civil construction works between The Bays and Sydney CBD (approved 24 August 2022)
- Stage 3 CSSI Application (SSI- 22765520) – Tunnel fit-out, construction of stations, ancillary facilities and station precincts between Westmead and Hunter Street Station, and operation and maintenance of the Sydney Metro West line (under assessment, lodged).

1.2.2 State Significant Development Application

The SSD will be undertaken as a staged development with the subject Concept State Significant Development Application (Concept SSDA) being consistent with the meaning under section 4.22 of the EP&A Act and seeking conceptual approval for a building envelope, land uses, maximum building heights, a maximum gross floor area, pedestrian and vehicle access, vertical circulation arrangements and associated car parking. A subsequent Detailed SSDA is to be prepared by a future development partner which will seek consent for detailed design and construction of the development.

1.3 Purpose and scope

This Flooding Assessment report supports a Concept State Significant Development Application (Concept SSDA) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the EP&A Act. The Concept SSDA is made under Section 4.22 of the EP&A Act.

This report has been prepared to specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the Concept SSDA on 22 February 2022 which states that the Environmental Impact Statement is to address the requirements shown in Table 1-1.

Table 1-1 SEARs and where this is addressed in this SSD report

Key issue	SEARs	Addressed in
6. Public Space	Illustrate the integration between station infrastructure and the development including public domain works that are needed to support the uses of the SSD (e.g. access, flood mitigation, open space, etc).	Section 5.
14. Flooding Risk	Identify any flood risk on-site having regard to adopted flood studies, the potential effects of climate change, and any relevant provisions of the NSW Floodplain Development Manual.	
	Assess the impacts of the development, including any changes to flood risk on-site or off-site, and design solutions and operational procedures to mitigate flood risk where required.	

2 The site and proposal

2.1 Site location and description

The subject application is in the Parramatta CBD, in the City of Parramatta Local Government Area (LGA). It is within the city block bounded by George Street, Church Street, Smith Street, and Macquarie Street.

The site presents a 164m long frontage to Macquarie Street, 125m frontage to George Street, 48m frontage to Church Street, and 15.5m frontage to Smith Street (in the form of Macquarie Lane).

The site location is shown in Figure 2-1.

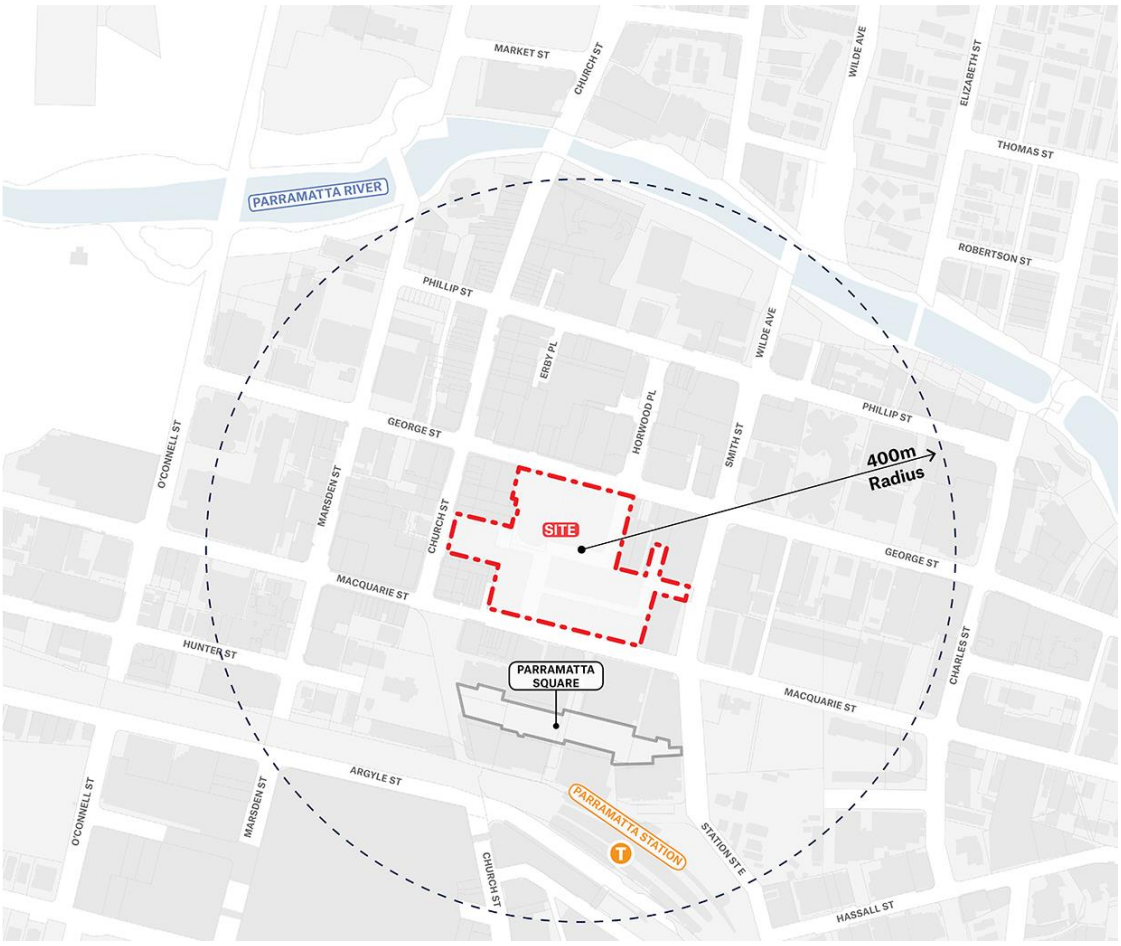

Figure 2-1 Paramatta metro station precinct location

As described in Table 2-1, the site comprises fourteen (14) different allotments of varying sizes. It is irregular in shape, with a total area of approximately 24,899m^2.

Table 2-1 Site legal description

Street address	Legal Description
41-59 George Street	Lot 10 in DP858392
45A George Street	Lot 2 in DP701456
61B George Street	Lot 1 in DP607181
71 George Street	Lot 100 in DP607789
220 Church Street	Lot 1 in DP1041242
222 Church Street	Lot 1 in DP702291
232 Church Street	Lot 1 in DP651992
236 Church Street	Lot 1 in DP128437
238 Church Street	Lot 2 in DP591454
48 Macquarie Street	Lot B in DP394050
58-60 Macquarie Street	Lot 1 in DP399104
62-64 Macquarie Street	Lot AY in DP400258
68 Macquarie Street	Lot 1 in DP711982
70 Macquarie Street	Lot E DP 402952
72 Macquarie Street	Lot 3 in DP218510
74 Macquarie Street	Lot H in DP405846

2.2 Overview of this proposal

The Concept SSDA will seek consent for four building envelopes as detailed in Table 2-2 and Figure 2-2 below.

Table 2-2 Parramatta metro station proposed development overview

Item	Description
Building use	**Building A:** Commercial and retail **Building B:** Residential and retail **Building C:** Commercial **Building D:** Commercial and retail
Building Height (Number of storeys)	**Building A:** 38 storeys **Building B:** 33 storeys **Building C:** 26 storeys **Building D:** 25 storeys
Gross Floor Area (m²)	**Building A:** 78,700 **Building B:** 20,000 **Building C:** 35,950 **Building D:** 55,350 **TOTAL: 190,000**
Car parking spaces	455

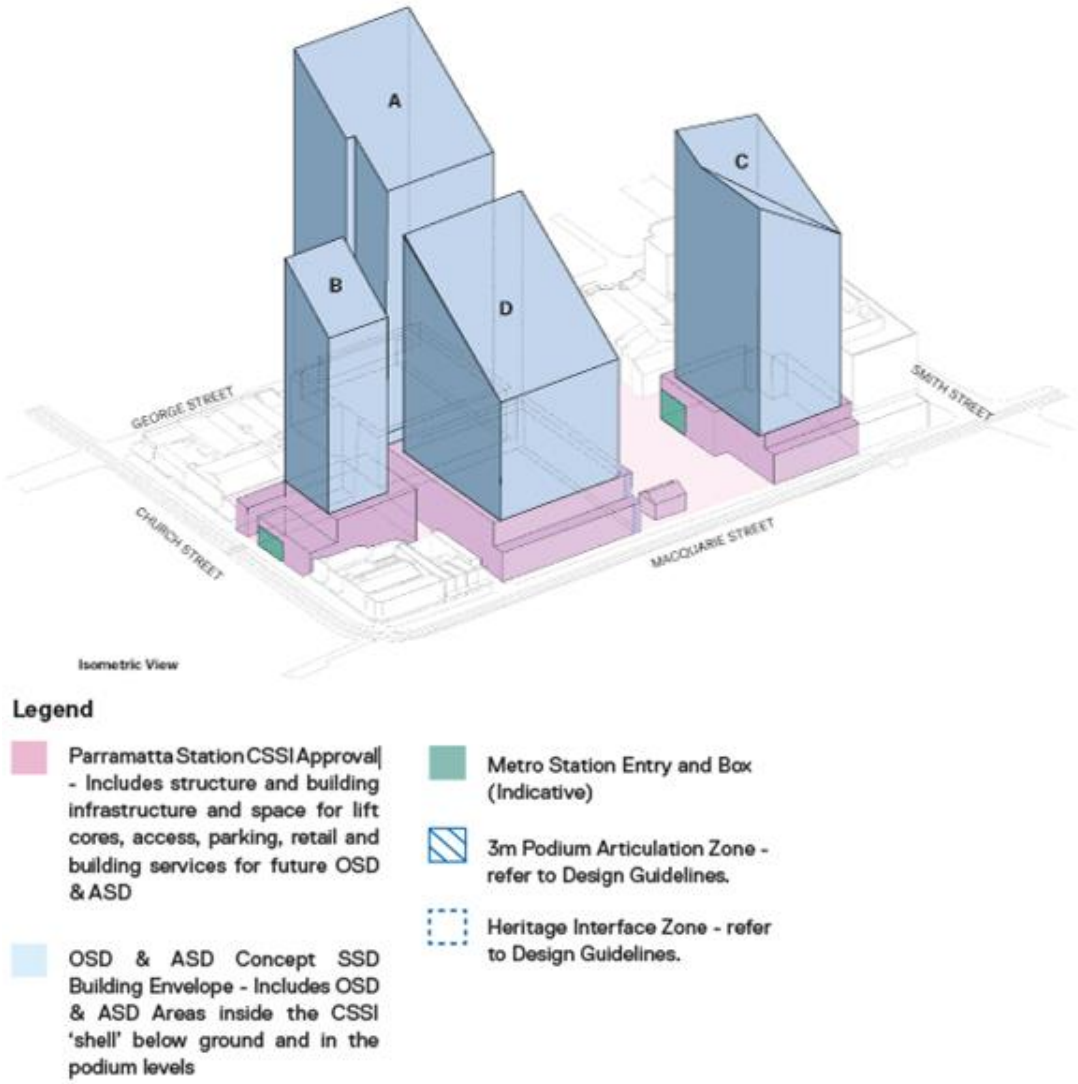

Figure 2-2 Proposed Concept SSDA development and CSSI scope

3 Scope of assessment

This Flooding Assessment has been undertaken to satisfy the planning requirements of the State Significant Development Guidelines and the SEARs. This report's scope is to summarise existing flooding conditions and detail upgrades, infrastructure and protection measures required to satisfy the relevant flooding standards. Assessment of the potential impacts of the proposed development on flooding which considers flood events up to the Probable Maximum Flood (PMF) is provided and focuses on:

- potential increases in flood risk and flood affectation on adjacent properties and assets as well as potential impacts to any emergency management arrangements
- land use compatibility in relation to flood hazard
- compatibility with Council floodplain risk management in terms of safe velocities and depths for pedestrians and vehicles
- where required mitigation and management measures have been identified.

3.1 Assessment criteria

The flooding assessment has been undertaken to satisfy State and Local Government guidelines. These include ARR2019, the NSW Floodplain Development Guidelines (NSW Government, 2005), Australian Institute for Disaster Resilience (2017), and Parramatta development Control Plans (City of Parramatta, 2011). The flood criteria applicable to this study are set out below:

- Sydney Metro West tunnels and other critical infrastructure would be protected from the PMF or be 0.5 metres above the one per cent Annual Exceedance Probability (AEP) flood level (whichever is greater)
- the one per cent AEP flood event (1% AEP flood event) and the five per cent AEP flood event (5% AEP flood event) will incorporate allowances for climate change impacts including:
    - Design for permanent infrastructure completed as part of this study would incorporate allowance for climate change consistent with Representative Concentration Pathways (RCP) 8.5 in the year 2100. The RCP8.5 refers to the upper range projection of greenhouse gases concentrations in the atmosphere as adopted by the Intergovernmental Panel on Climate Change in 2014 for the assessment of climate change impacts.
    - rainfall intensity uplift of 21.3% representing RCP8.5 in accordance with Australian Rainfall and Runoff 2019 (ARR2019).
- minimise increases in flood levels due to temporary and permanent infrastructure completed by this study during flood events up to and including the 1% AEP flood event. Not worsen flooding on properties or infrastructure up to the 1% AEP climate change flood event. Not worsen is defined as:
    - a maximum increase in flood levels of 50 mm
    - a maximum increase in time of inundation on one hour
    - no increase in potential soil erosion and scouring from any increase in flow velocity.
- dedicated evacuation routes would not be adversely impacted in flood events up to and including the PMF event
- basements within the floodplain to be protected from all flooding up to and including the PMF event.

3.2 Assumptions, dependencies and constraints

The assumptions, dependencies and constraints for the proposed development are based on the indicative design concept (refer Appendix H in the EIS).

These have been used in developing the flooding design, additionally they have been used in detailing design work that is required in future detailed design stages.

4 Baseline investigations

4.1 Existing site description

The proposed development site is a heavily urbanised commercial area in the heart of Parramatta CBD. Horwood Place is a bi-directional single lane road which is aligned through the site connecting George Street to the north and Macquarie Street to the south. There is a high point approximately half-way along the road at RL 10.66. Horwood Place provides access to several small commercial stores and provides access to the existing multi-storey car park.

Key roads near the proposed development site include O'Connell Street (sub-arterial road), Macquarie Street (collector road), Pitt Street (sub-arterial road), George Street (collector road) and Church Street (collector road). O'Connell Street operates in both directions north of Macquarie Street, and south of Macquarie Street it operates in the southbound direction only. Macquarie Street operates one-way in an eastbound direction. Prior to November 2019, George Street operated one-way in an eastbound direction however was recently converted to two-way operation between O'Connell Street and Harris Street as part of network modifications to accommodate Parramatta Light Rail (Stage1).

The existing topography is relatively flat, with a predominant fall towards the north-east for stormwater discharge into the Parramatta River. Elevations vary across the site from approximately RL 8.5 to RL10.8.

4.2 Catchment and topography

The Upper Parramatta River catchment is a hilly, highly urbanised catchment that discharges through the west of Sydney and flows into Sydney Harbour at the confluence of Lane Cove River. The river has a catchment area of approximately 110 square kilometres upstream of the subject site. The Parramatta River catchments and site location are shown on Figure 4-1. The waterway through the Parramatta CBD reach of the river is lined by parks and other public spaces and the waterway flows through several structures including four large bridges and the Marsden Street and Charles Street weirs.

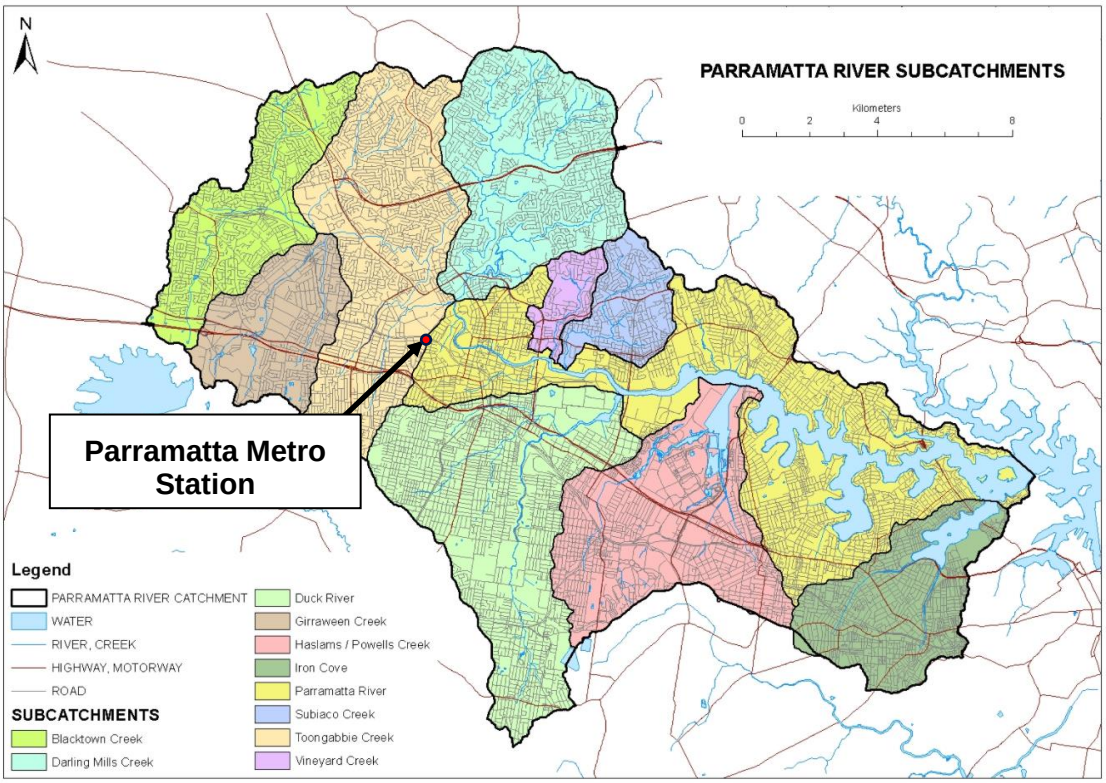

Figure 4-1 Parramatta River sub-catchments (Parramattariver.org.au)

The Parramatta CBD floodplain extends approximately 650 metres to the south of Parramatta River before sloping up towards Mays Hill. The proposed development site is about 300 metres to the south of the Parramatta River, downstream of the Charles Street weir. The local catchment is highly developed and primarily drains through the piped stormwater network to the Parramatta River. The local CBD topography and trunk drainage network, based on the proposed PLR design, is presented in Figure 4-2. The site is located on a local high point within the Parramatta River floodplain. The main flooding constraint on the site and the surrounding area is related to mainstream flooding during extreme flood events in excess of the 1% AEP flood event. During these extreme events Horwood Place, which bisects the site, may act as a flood flow path.

There are no major overland flow paths from the local catchment that discharge through the proposed development site. There is an elevated regional rail line to the south of the site, which splits the upper and lower catchment, which is highlighted on Figure 4-2. The area to the south of the rail line primarily drains via the trunk drainage to the north-west of the site, with the area between the rail line and the site draining via the trunk drainage to the south-east of the site. A ‘convict drain’ built under Parramatta during the 1820’s previously drained the catchment. Since 1930s parts of the drain had collapsed or purposely infilled and has been bypassed with cement piping (Higginbotham, 1983). The location of the convict drain is also shown on Figure 4-2. The existing buildings on the site drain into the adjacent streets and collect in the local street drainage.

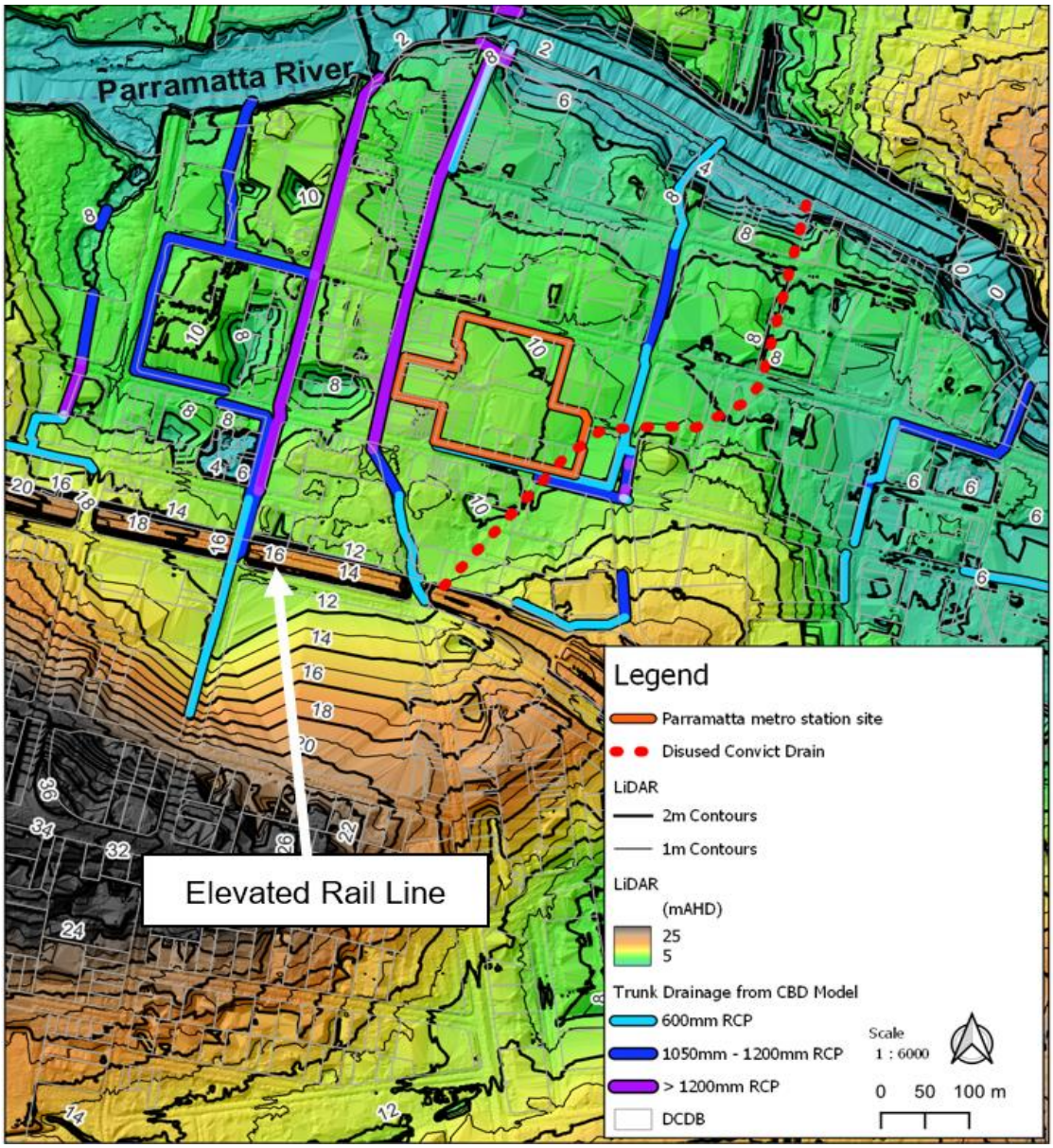

Figure 4-2 Parramatta CBD local topography and trunk drainage

4.3 Existing flood conditions

Potential for serious flooding in the Parramatta catchment from the Parramatta River on the surrounding urban floodplain was recognised in the early 1970s with a major flood mitigation strategy being carried out. During this time extensive urban development was occurring in the catchment. In the late 1980's the catchment experienced a series of rainfall events resulting in major flooding. In 1986 and 1988 the two largest floods occurred during this period, with their magnitudes being estimated to be a 1.7% (1 in 60) AEP and 3.3% (1 in 30) AEP, respectively. Prior to these floods, the largest flood on record occurred in 1914, which was estimated to be a 2.5% (1 in 40) AEP flood event. During the floods in the 1980s many properties that had never been flooded before were inundated above floor level, for some properties this occurred more than once (Bewsher, 2003).

The historic record from the Briens Road water level gauge (site number 213005) was sourced from WaterNSW. The gauge was installed at the site in 1979. The water level gauge record is presented in Figure 4-3. The record captures the large floods in the late 1980s and some recent minor flooding in February 2020. The gauge location and site location are presented in Figure 4-4.

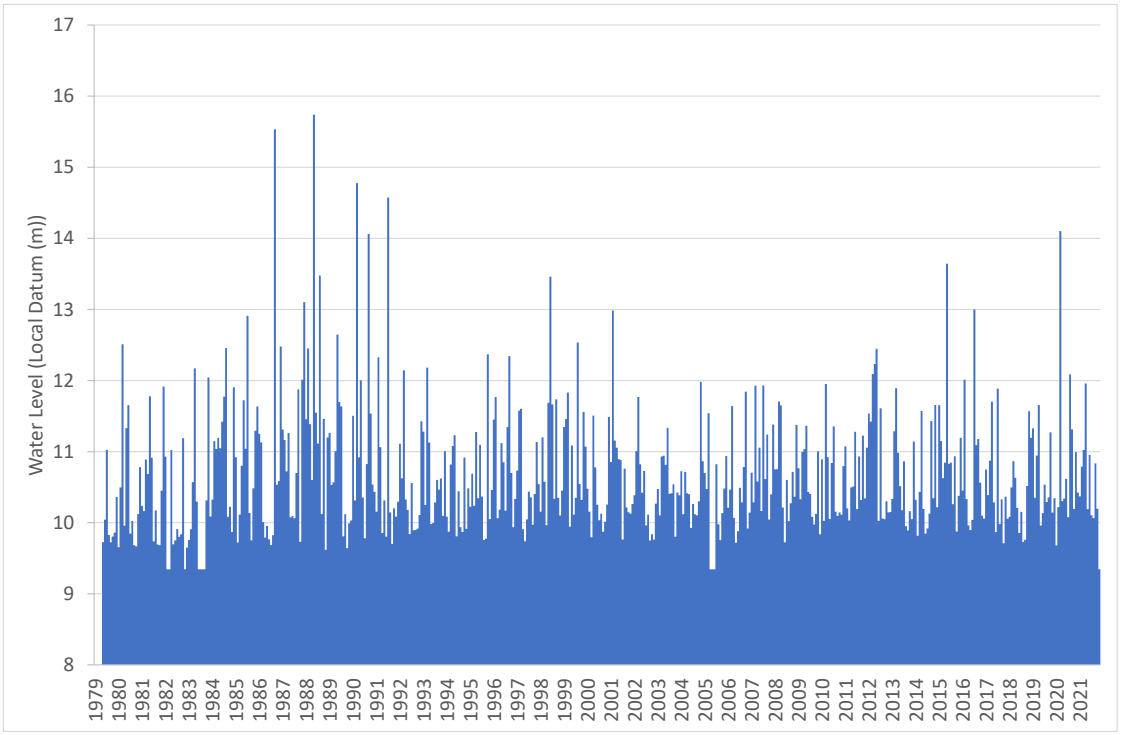

Figure 4-3 Monthly maximum water surface level (Parramatta River at Toongabbie Briens Road Gauge Number 213005)

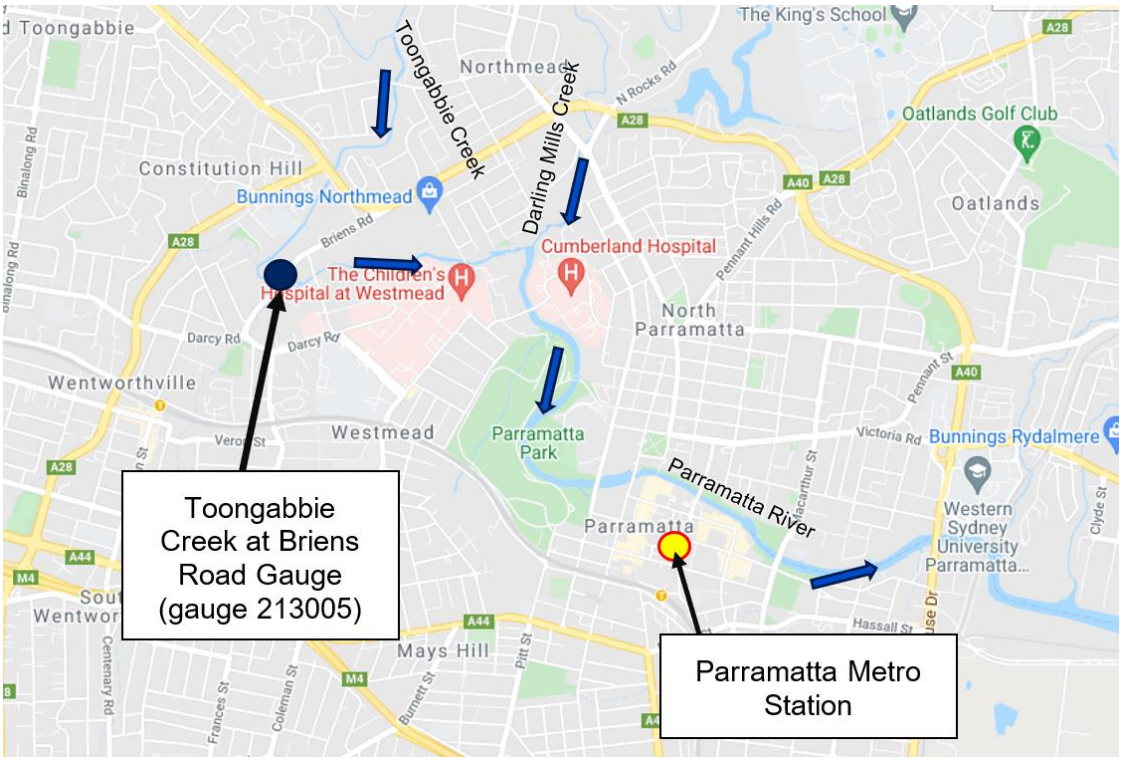

Figure 4-4 Parramatta River at Toongabbie Briens Road (Gauge No. 213005) Location

The Parramatta River Catchment Trust and four local council areas within the Upper Parramatta River catchment have made progress in addressing flood threats since 1989. The mitigation devices used to reduce flooding included detention basins within the upper catchment and widening of some waterways to increase conveyance and reduce flood levels. These measures reduced the chance of above floor flooding, particularly within the Parramatta CBD. The Parramatta CBD is now protected from flooding from the Parramatta River in the 1% AEP flood event (UPRCT, 1999). This is also shown on the City of Parramatta flood risk portal available online.

Some parts of the CBD are subject to flooding from local runoff. Evidence of localised nuisance type flooding adjacent to the proposed development site were noted following a brief, but intense rainfall event on 3 March 2017. Photos supplied to ARUP by Transport for NSW showing gutter flow in Macquarie Street during this event are presented in Figure 4-5 and Figure 4-6. These figures show the nature of flooding in the streets adjacent to the site area up to a 1% AEP flood event.

Figure 4-5 Flow in gutter at Smith Street looking south towards Macquarie Street intersection (Source: ARUP (2017))

Figure 4-6 Flow in gutter along the southern side of Macquarie Street looking east toward Horwood Place intersection (Source: ARUP (2017))

5 Assessment

5.1 Flood model development

5.1.1 Hydraulic model background

The TUFLOW hydraulic flood models adopted for the assessment of the proposed development site were originally developed for Transport for NSW by ARUP as part of the Parramatta Light Rail (PLR) Stage 1 Environmental Impact Statement. The local TUFLOW model adopted a 2-metre grid resolution to simulate the Parramatta River floodplain and local stormwater catchment. Parramatta River discharge was extracted from a calibrated MIKE11 flood model developed for the Parramatta River. The model development is documented in the Upper Parramatta River Catchment Floodplain Risk Management Study (Bewsher, 2003). Local catchment inflows were input using the rain on grid approach using Australian Rainfall and Runoff 2019 methods. The model was used to assess design events up to the 1% AEP flood, with the inclusion of climate change. A similar model with a larger model extent and grid size of 4-metre was adopted to undertake modelling of the PMF event. The larger model was required to cater for the wider floodplain that is inundated during this extreme flood event.

The TUFLOW models developed by ARUP were then adopted by the WSP Aurecon Parramatta Light Rail Infrastructure Join Venture (WSPAJV) for further assessment of the PLR development. The model was subsequently updated as part of the 80% detailed design of the enabling works for the light rail. The updates included further development of the existing conditions model to include updated pit inlet rating curves, blockage factors and minor updates to the stormwater network. The hydraulic models were used to assess the existing and proposed PLR design, which included the 3D alignment, drainage network upgrades and flood mitigation measures. A detailed background to the development of the models is available in the Parramatta Light Rail State 1 Flood Assessment Report (WPAJV, 2020).

THE WSPAJV models were used to undertake assessment of the subject site. The adopted local model extent, boundaries, drainage network and buildings are presented in Figure 5-1. The model includes several developments that were proposed, yet to be completed at the time of model development, including the following:

- Parramatta Light Rail
- Parramatta Square
- Macquarie Towers residential development
- Riviera Apartments.

The PLR includes changes to the local topography and considerable additional drainage, which has been included in the design. The existing and new proposed PLR drainage, as outlined in the PLR Flood Assessment Report (WSPAJV, 2020), is presented in Figure 5-1. A map with the proposed development site and drainage focused on the area of interest is presented in Figure 5-2.

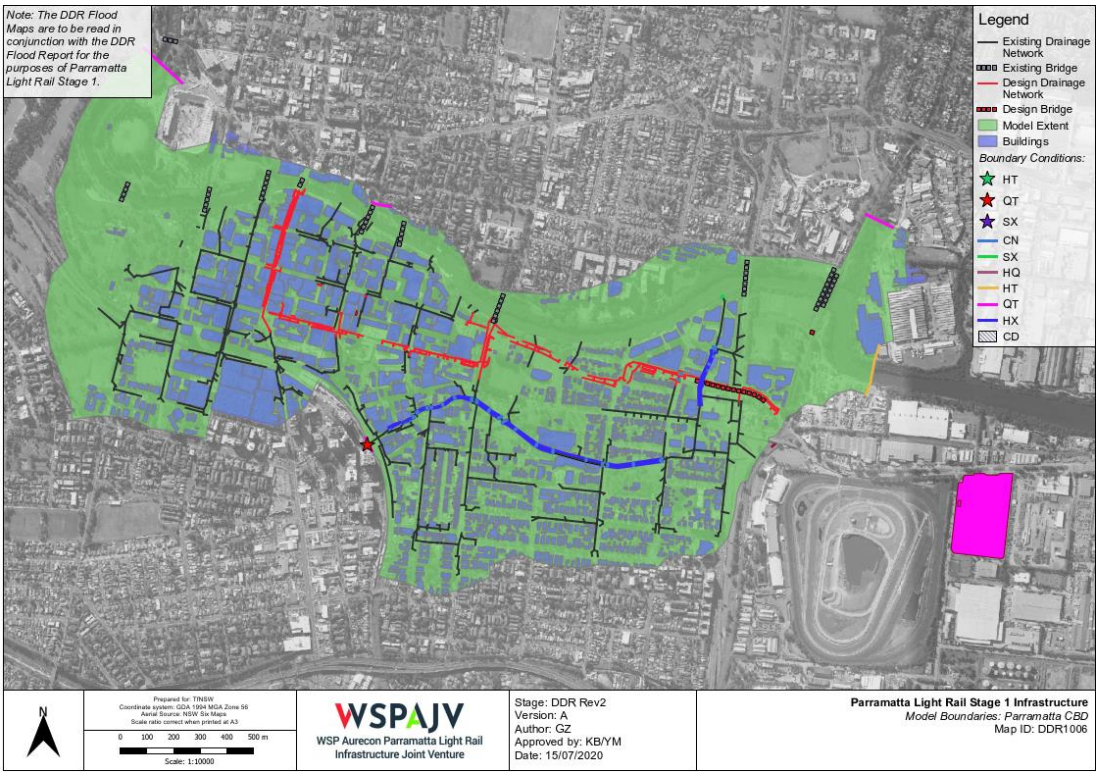

Figure 5-1 Parramatta metro station hydraulic model layout

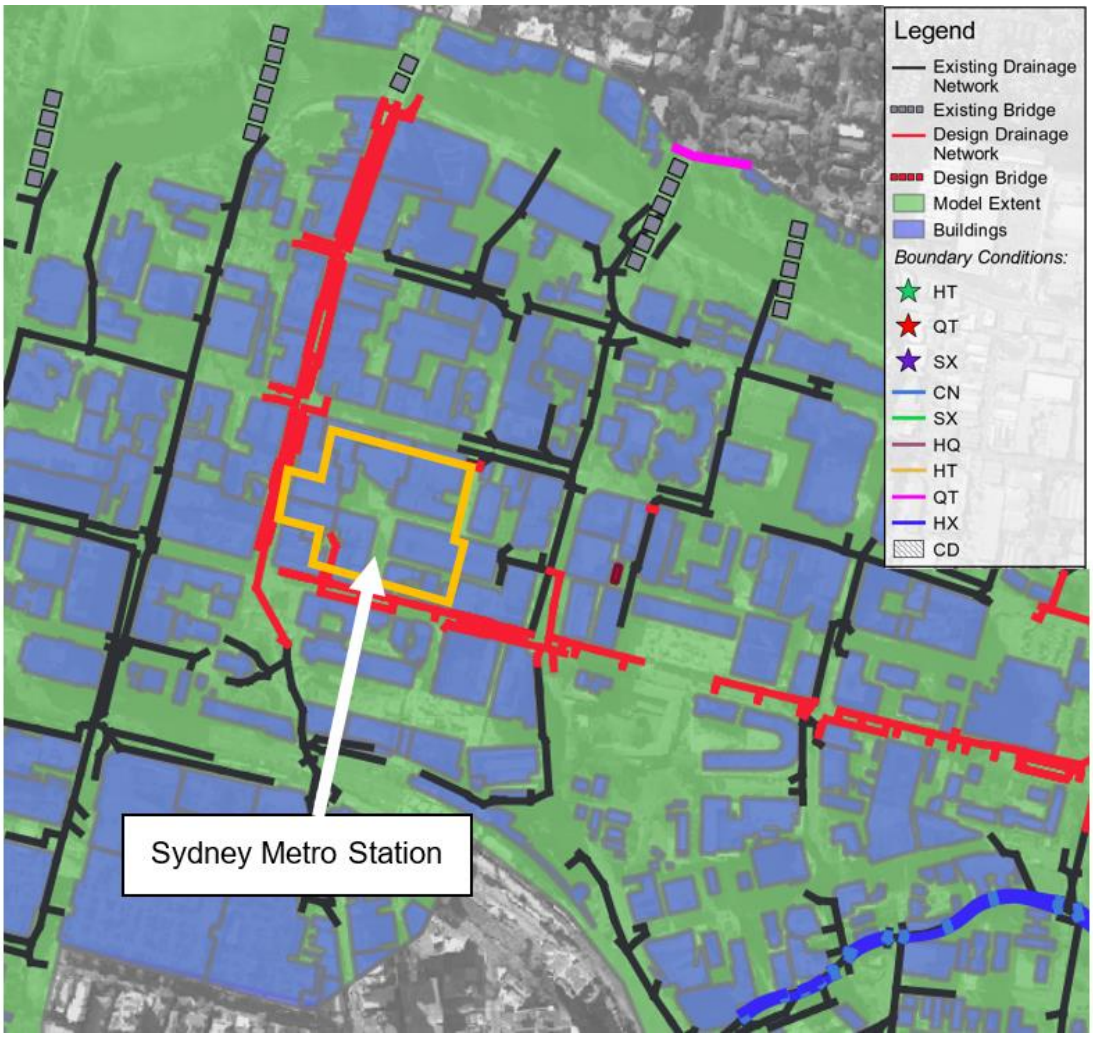

Figure 5-2 Parramatta OSD and ASD location and model drainage

5.1.2 Hydraulic model configuration

The aim of the assessment it to estimate the impact the proposed development will have on flooding and determine design flood levels to set floor levels and flood immunity requirements. The baseline conditions include Building B and Building C. The model includes the existing buildings located at the proposed building locations. Therefore, it has been assumed there is no change in building footprint between the baseline and proposed developed scenario. A map showing the proposed developed topography and building locations is shown in Figure 5-3. The proposed developed site plan is presented in Figure 5-4.

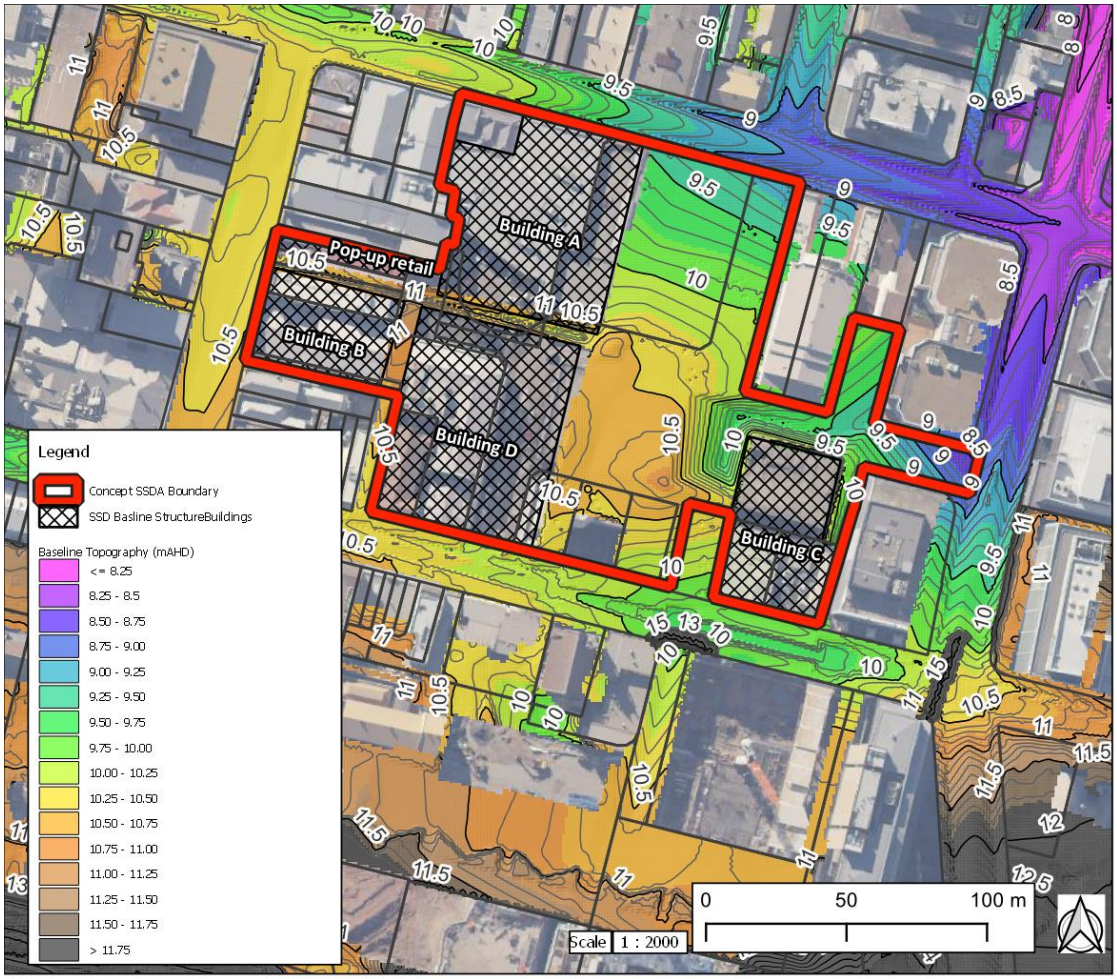

Figure 5-3 Proposed developed site model configuration

Figure 5-4 Proposed developed site plan

5.1.3 Hydraulic model flood scenarios

The hydraulic model was used to simulate the 5% and 1% AEP flood events with the inclusion of 21.3% climate change and the PMF flood event. The climate change allowance is based on guidance in Australian Rainfall and Runoff 2019, as outlined in the Sydney Metro West Climate Change Projections memorandum (Jacobs, 2020).

As outlined in section 5.1.1, the Parramatta riverine inflows are based on discharge estimates from the calibrated MIKE11 one dimensional model used in the Upper Parramatta Flood Study. The local overland flow model was based on the same model using ARR2019 rainfall information and modelled using the direct rainfall methodology. The TUFLOW model was used to determine the critical duration and temporal patterns for the proposed development site.

5.2 Climate and rainfall

The site is located in Western Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.5 to 28.6 degrees Celsius, and a monthly average minimum range of 6.2 to 17.7 degrees Celsius. Annual average rainfall total is 966 mm/year with the monthly variation as indicated in Figure 5-5 (Bureau of Meteorology, Parramatta North (Masons Drive)).

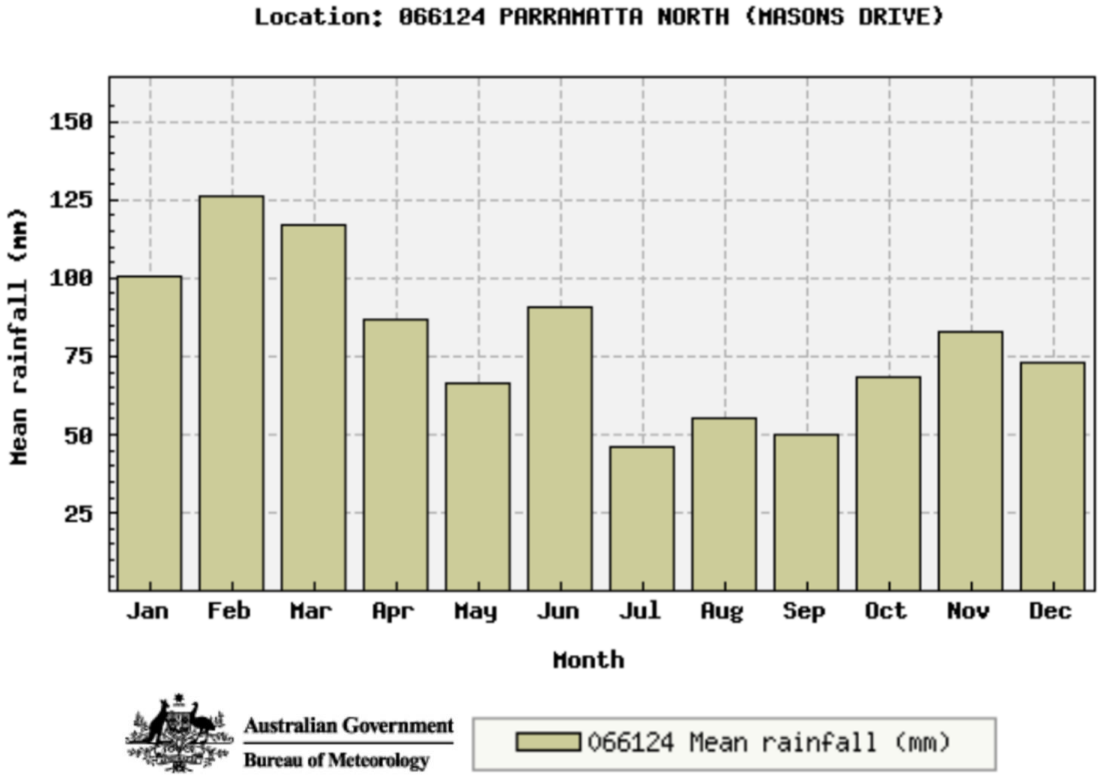

Figure 5-5 Monthly rainfall statistics Parramatta station north (Masons Drive)

Rainfall Intensity-Frequency-Duration (IFD) for the TUFLOW hydraulic model was extracted from the Bureau of Meteorology website based on ARR2016 rainfall estimates for Parramatta (latitude -33.81, longitude 151.009). The IFD rainfall depths are presented in Table 5-1.

Table 5-1 Parramatta ARR2016 Rainfall Information-Frequency-Duration

Duration	63% AEP	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
5 min	7.42	8.15	10.5	12.0	13.6	15.7	17.4
10 min	11.7	13.0	17.1	19.8	22.4	25.9	28.6
15 min	14.7	16.3	21.3	24.7	28	32.3	35.6
20 min	16.8	18.7	24.3	28.2	31.9	36.8	40.5
25 min	18.6	20.5	26.6	30.8	34.8	40.2	44.2
30 min	20.0	22.0	28.5	32.9	37.2	42.8	47.2
45 min	23.3	25.5	32.6	37.5	42.3	48.8	53.8
1 hour	25.7	28.1	35.6	40.9	46.1	53.2	58.8
1.5 hour	29.4	32.0	40.4	46.3	52.2	60.4	66.9
2 hour	32.4	35.2	44.4	50.9	57.5	66.7	74.1
3 hour	37.2	40.5	51.3	59.0	67.0	78.2	87.2
4.5 hour	43	47.0	60.3	70.0	80.0	93.9	105
6 hour	47.9	52.7	68.5	80.0	91.9	109	122
9 hour	56.1	62.3	83.0	98.1	114	135	153
12 hour	63	70.5	95.7	114	133	159	180

5.3 Hydraulic model results

5.3.1 Results summary

The model was used to simulate the three design events noted in section 5.1.3, these are the 5% AEP climate change, 1% AEP climate change and PMF flood events. The flood depth with water surface level contours and hazard mapping are presented in Appendix A. The flood hazard for the site has been classified using the Australian Institute for Disaster Resilience, (2017) scheme. The hazard classifications are based on a combination of flow velocity and flood depth as shown on the diagram in Figure 5-6.

The hazard conditions shown in the figure are defined below:

- H1: Generally safe for vehicles, people and buildings
- H2: Unsafe for small vehicles
- H3: Unsafe for vehicles, children and the elderly
- H4: Unsafe for vehicles and people
- H5: Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6: Unsafe for vehicles and people. All building types considered vulnerable to failure.

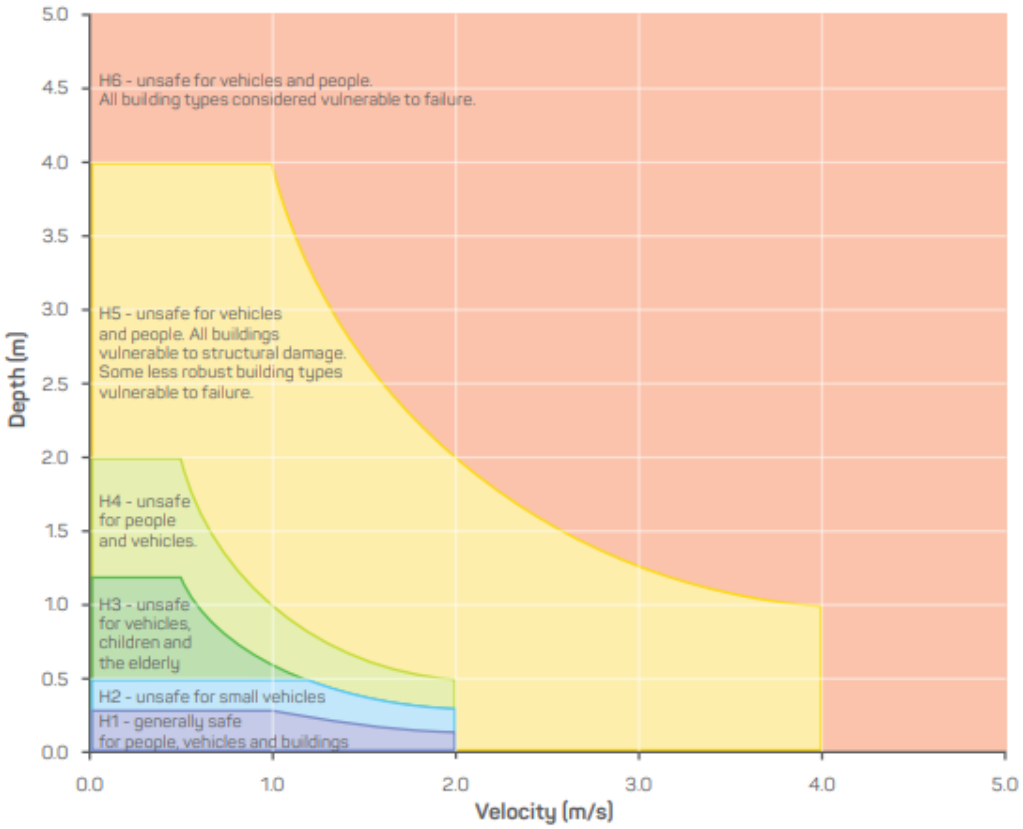

Figure 5-6 Flood Hazard Classifications

A summary of the flooding conditions for the proposed development site and surrounding area are as follows:

5% AEP climate change and 1% AEP climate change flood events:

- Much of the stormwater is captured in the stormwater inlets and piped drainage in the streets surrounding the proposed development site and conveyed to the Parramatta River along the trunk drainage, which was shown previously in Figure 4-2. There is minor street flooding, similar to the flooding shown in Figure 4-5 and Figure 4-6.
- The proposed development site is not affected by any overland flow paths in the 5% AEP or 1% AEP climate change flood events. The site is located on a local highpoint within the Parramatta CBD floodplain.
- Stormwater flow along the gutters in Smith Street at the east of the site discharges north toward George Street and continues east along George Street.
- Stormwater flow along the gutters in George Street discharges east toward Smith Street, with the flow continuing north along Smith Street and further west along George Street.
- There is localised ponding of water at the intersection of George Street and Smith Street. The maximum depth of the stormwater is 0.23 metres and 0.27 metres in the 5% AEP climate change and 1% AEP climate change flood events, respectively.
- There is localised ponding at the east of the site at the intersection of Macquarie Lane and Smith Street. The maximum depth of the stormwater is 0.13 metres and 0.15 metres in the 5% AEP climate change and 1% AEP climate change flood events, respectively.
- Flood hazard in the 5% AEP climate change and 1% AEP climate change flood events in the surrounding streets is low, with the area predominantly being H1 category with localised areas of H2. Evacuation and site access is readily available during these flood events.

PMF Event:

- in the PMF event, the area of the proposed development site is inundated by floodwaters from local and Parramatta River catchments with a maximum flood depth in excess of 1.5 metres across much of the site.
- the PMF level at the western extent of the site near Church Street and the western extent of the station box is 12.45 metres AHD. At the eastern extent of the near Smith Street the PMF level is 10.62 metres AHD.
- due to the substantial flood depths and flow velocities in excess of 3 metres per second during the PMF event the flood hazard in the adjacent streets are high in many of the streets with a H5 or H6 hazard classification.
- there are no evacuation routes available in the PMF event.

There are ongoing development options and changes being considered for the end state design of the proposed development. Further stormwater and flooding analysis will be undertaken as part of the Detailed SSDA/s.

5.3.2 Hydraulic result discussion

The results of the flood assessment show the proposed development is not susceptible to flooding up to and including the 1% AEP climate change event. During the PMF flood event the site is heavily affected by floodwater that has broken the banks of the Parramatta River.

In terms of flood impacts, the proposed Buildings A and D will replace existing buildings and are unlikely to result in any changes to flood behaviour up to the PMF event. The proposed development will therefore fulfill the SEARs that the proposed development will minimise adverse impacts on existing flooding characteristics and avoids or minimises the risk, infrastructure flooding or flooding hazards during construction and operation. The proposed Buildings A and D will require flood barriers over the lower areas of the building site. This may result in a minor reduction in flood storage volume compared the current conditions. This may result in minor increases in the PMF flood level, which have not been captured in this flood modelling.

Responses to the SEARs for flooding for the proposed development are in Table 5-2.

Table 5-2 Response to SEARs

SEARs	Response
Item 6. Public Space Illustrate the integration between station infrastructure and the development including: Any impact of the SSD on surrounding public domain Public works that are needed to support the uses of the SSD (e.g. Access, flood mitigation, open space)	The proposed development will include new buildings to be located where existing buildings are currently standing. Therefore, it has been assumed there is no change in building footprint between baseline and proposed development conditions and therefore no impact of the proposed development on surrounding public domain. More details included in Section 5.1.2. Public domain works associated with the Parramatta metro station will be carried out under the Stage 1 CSSI approval (SSI 10038) and Stage 3 Application (SSI-227-65520). Flood planning criteria for the required flood immunity is outlined in Section 3 along with the relevant guidelines upon which they are based. The results presented in Section 6 and flood assessment maps are premised on the basis that flood protection measures would be employed where necessary to ensure the Parramatta metro station would continue to experience the requisite flood immunity at all access points. Therefore, a number of access points in the proposed development will experience additional flood protection over and above City of Parramatta Council requirements in order to prevent flood water from entering the station.
Item 14a. Flooding Risk Identify any flood risk on-site having regard to adopted flood studies, the potential effects of climate change, and any relevant provisions of the NSW Floodplain Development Manual.	A review of available flood studies has been undertaken and discussed in section 4.3. Previous studies and modelling undertaken as part of this assessment show the site is flood free up to the 1% AEP climate change event, however, is impacted by extreme flooding such as the PMF event. This is consistent with the modelling undertaken as part of this assessment and discussed in Section 5. Climate change has been considered and included in the analysis. The effect of climate change adopting RCP8.5 estimates an increase in rainfall intensity of 21.3% (Jacobs, 2020). Assessment has been undertaken as detailed in the NSW Floodplain Development Manual.
Item 14b. Hydraulic Impacts Assess the impacts of the development, including any changes to flood risk on-site or off-site, and detail design solutions and operational procedures to mitigate flood risk where required.	The proposed development will include new buildings to be located where existing buildings are currently standing. Therefore, it has been assumed there is no change in building footprint between baseline and proposed development. More details included in Section 5.1.2. Measures to mitigate flood risk include flood barriers to ensure floodwaters up to the PMF event will not inundate basement areas and Parramatta metro station. More details included in Section 6.

6 Mitigation measures

6.1 Consultation

Due to the preliminary nature of the civil design so far, consultation has been limited. More thorough co-ordination and consultation will be required in future detailed design stages to ensure the design is compliant with each authority and stakeholder requirements. Sydney Metro would undertake detailed engagement consistent with the Undertaking Engagement Guidelines for State Significant Projects with the City of Paramatta Council in relation to flooding risk associated with this proposal.

6.2 Flood planning levels

The proposed development site is only affected by flooding during extreme flood events, such as the PMF event. Flood events up to the 1% AEP climate change event result only in localised ponding in the streets adjacent to the site.

Building B, C and D are connected to the underground Parramatta metro station. The guidelines note the station requires flood protection from either the 1% AEP climate change event (with the inclusion of 0.5 metres freeboard), or the PMF event, whichever is higher. For the subject site the PMF event is greater than 0.5 metres above the 1% AEP climate change event and is therefore the controlling level. The design and flood mitigation measures for podiums for Building B,C and D will be delivered under the Stage 3 CSSI application.. These flood mitigation measures will be required to ensure flooding cannot reach the Parramatta metro station up to the PMF event. They will likely include flood barriers at the ground floor level of the proposed buildings to ensure the floodwaters do not enter the basements of the metro station via ingress routes such as lift shafts or stairs. These barriers will be developed as part of the detailed design.

The basement of Building A is not connected to the underground Parramatta metro station however, in line with design principle P.14 of the Parramatta DCP the basement is required to be protected from all flooding events up to the PMF event. Flood barriers are being considered for the basement and building entries to stop the ingress of floodwater into the basement areas up to the PMF flood level. Figure 6-1 shows the PMF flood level at selected locations throughout the proposed development site.

Commercial spaces within Building A, B, C and D which are not directly connected to the external frontage of the building will be protected from flooding events up to the PMF event. Commercial spaces not connected to the internal portions of the buildings will not be required to be protected from the PMF event. The Parramatta DCP notes commercial premises are required to have a floor level set to be above the 1% AEP flood with the inclusion of 0.5 metres freeboard. The 1% AEP flood level in the Parramatta River upstream Church Street, to the north of the site, is approximately 7.1 metres AHD, which is below the lowest elevation of the site, which is approximately 8.9 metres AHD. The flooding at the site is considered nuisance stormwater rather than riverine flooding. The Parramatta DCP does not include guidance for floor levels in relation to local stormwater flooding. For local stormwater flooding a freeboard of 0.3 metre freeboard above internal overland flow paths has been adopted for the Sydney Metro West project area. Internal flow path elevations will be determined during detailed design.

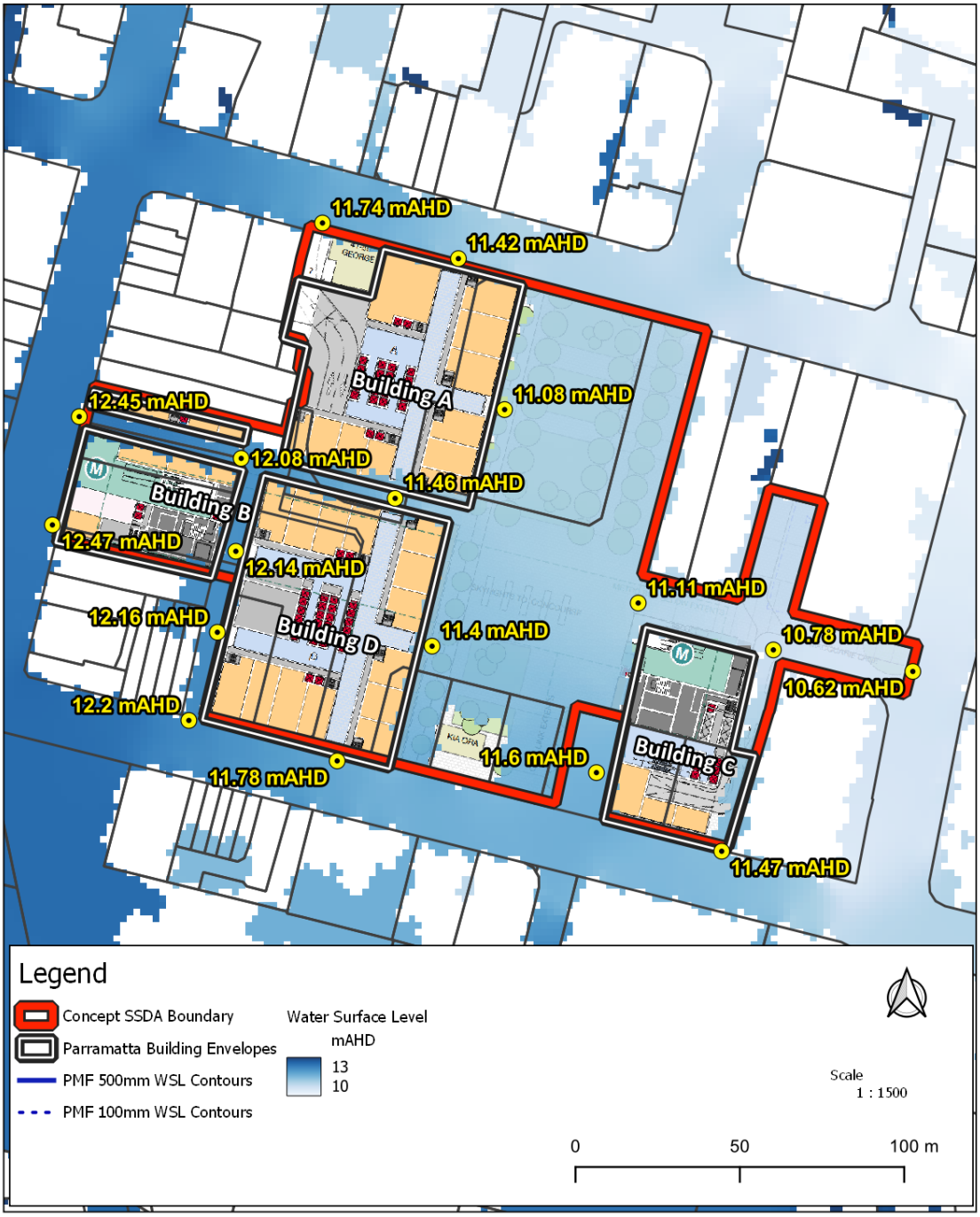

Figure 6-1 PMF Levels at the proposed site

Where flood barrier mitigation measures are proposed, they will be employed such that:

- flood waters would be prevented from entering the basement
- flooding risk associated with lifts, loading dock entry and other service access arrangements would be managed
- operations, maintenance and replacement plans would be developed to ensure that these measures continue to be in full working order for the life of the proposed development.

6.3 Emergency response

Emergency management arrangements would need to be developed to manage flood risks to people and vehicles accessing the location during extreme flood events. Egress arrangements would need to consider flood hazard in nearby streets particularly where active flood measures are employed. They would need to be designed to ensure that the inclusion of flood barriers at relevant access points does not interfere with the egress strategy.

Evacuation of the basement areas and commercial/retail tenancies within the above ground structures will be considered and will be managed through the detailed design phase of the SSD.

The nature of flooding from Parramatta River can be considered flash flooding with river rise generally occurring within hours of heavy rainfall. This will need to be considered as part of flood emergency management plans for the proposed development site to ensure sufficient warning time can be provided for occupied areas including retail levels where the occupants will need to move into elevated areas.

The flood hazard is most appropriately managed by commercial/retail operators with a shelter in place strategy. The flooding duration is estimated to take several hours. Any residual risk to the commercial/retail spaces will require an operational flood emergency response plan. The plan would, at a minimum, confirm the most appropriate response strategy, nominate shelter locations or muster points, plot the recommended evacuation routes, consider the timeline to execute the plan, identify trigger conditions for initiating the plan, and assign specific responsibilities. This emergency management response should consider flooding up to the PMF event. The plan should be prepared in consultation with the local State Emergency Service (SES) and other emergency services and the final plan communicated to the occupants of the buildings.

7 Conclusion

This report summarises the assessment of flooding associated with the proposed development. Hydraulic flood models developed for Transport for NSW for the adjacent Parramatta Light Rail were adopted and adapted for use in assessing the flooding for the proposed development site. The proposed buildings will replace existing buildings. Therefore, there will be no meaningful change in flood behaviour through the site and the baseline and proposed developed scenarios have been assumed to be the same.

The results of the assessment show the proposed development location is not affected by overland or riverine flooding up to the 1% AEP climate change flood event. The proposed development site is affected by riverine flooding in extreme events, such as the PMF flood event, with significant flood depths and flood hazard affecting the site and in adjacent streets.

Within Buildings B, C and D, which are connected to the Parramatta metro station, flood protection up to the PMF event is required to ensure there is no flood ingress into the metro station or basement areas. Building A includes a basement that is separate from the Parramatta metro station. The entry to Building A or any internal areas that may allow water ingress into the basement area are required to also be protected up to the PMF event. Flood barriers or other mechanisms will be adopted to ensure the areas connected to the basements and the Parramatta metro station remain flood free up to the PMF event.

Commercial spaces not connected to the internal portions of the buildings, where there is no possible ingress of flood water to the Parramatta metro station or basements, will not be required to be protected from the PMF event. The flood levels of these external facing commercial spaces should consider a 0.3 metre freeboard above internal flow paths.

There is a potential hazard to people and vehicles accessing the proposed development site during the PMF event due to high flood hazard. This will need to be managed through the Sydney Metro West Construction Environmental Management Framework in extreme floods. Consultation has been undertaken with The City of Parramatta on flooding at the site, including flood evacuation routes and the use of active flood protection measures.

A response to the applicable SEARs is included in 0. This assessment complies with relevant planning requirements and SEARs, including:

- Hydraulic modelling has been undertaken for the 5% and 1% AEP flood events with an appropriate increase in rainfall adopted to reflect climate change projections to the year 2100, based on ARR2019. The PMF event has also been assessed. The PMF flood levels at the site for the proposed developed scenario is outlined in section 6.2.
- modelling shows there will be no worsening of flooding on properties or infrastructure up to the 1% AEP climate change flood event
- dedicated evacuation routes will not be adversely impacted by flood events up to and including the PMF event in the proposed developed scenario
- Flood protection up to the PMF event have been noted for the proposed development areas connected to the Parramatta metro station and the Building A basemen. External commercial/retail areas not connected to these internal areas should adopt a 0.3 metre freeboard above internal overland flow paths.

- responses to the appropriate SEARs have been prepared and outline required flood immunity levels for the building entrances and mitigation measures which may be adopted.

Further stormwater and flooding analysis for the detailed design of the proposed development will be undertaken as part of the future Detailed SSDAs.

8 References

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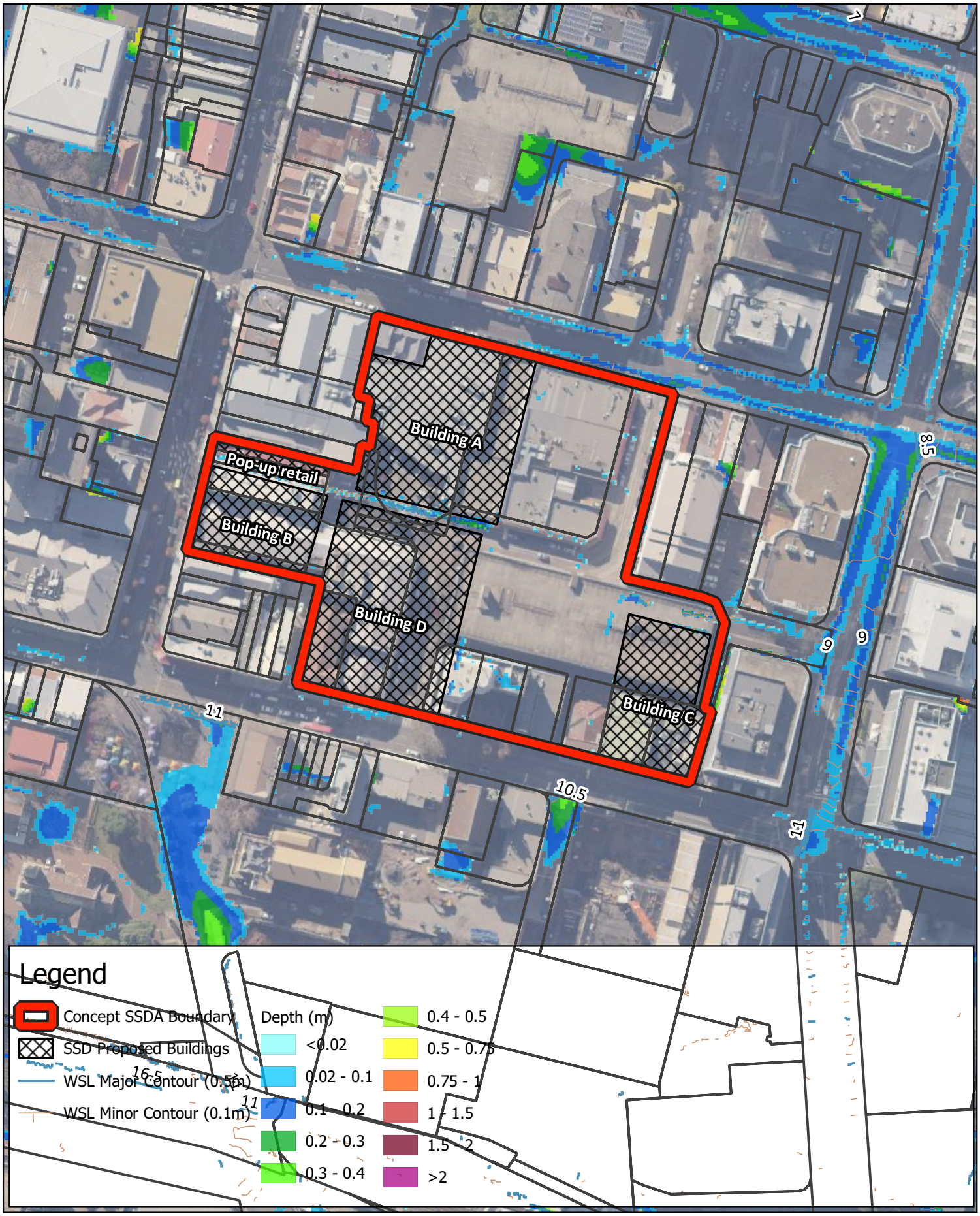
Appendix A Flood depth and hazard mapping



TITLE

Figure A-01
5% Climate Change Developed Flood Depth Map

PROJECT

EDS - SWM - Parramatta

0 50 100 m

NSW GOVERNMENT | sydney METRO

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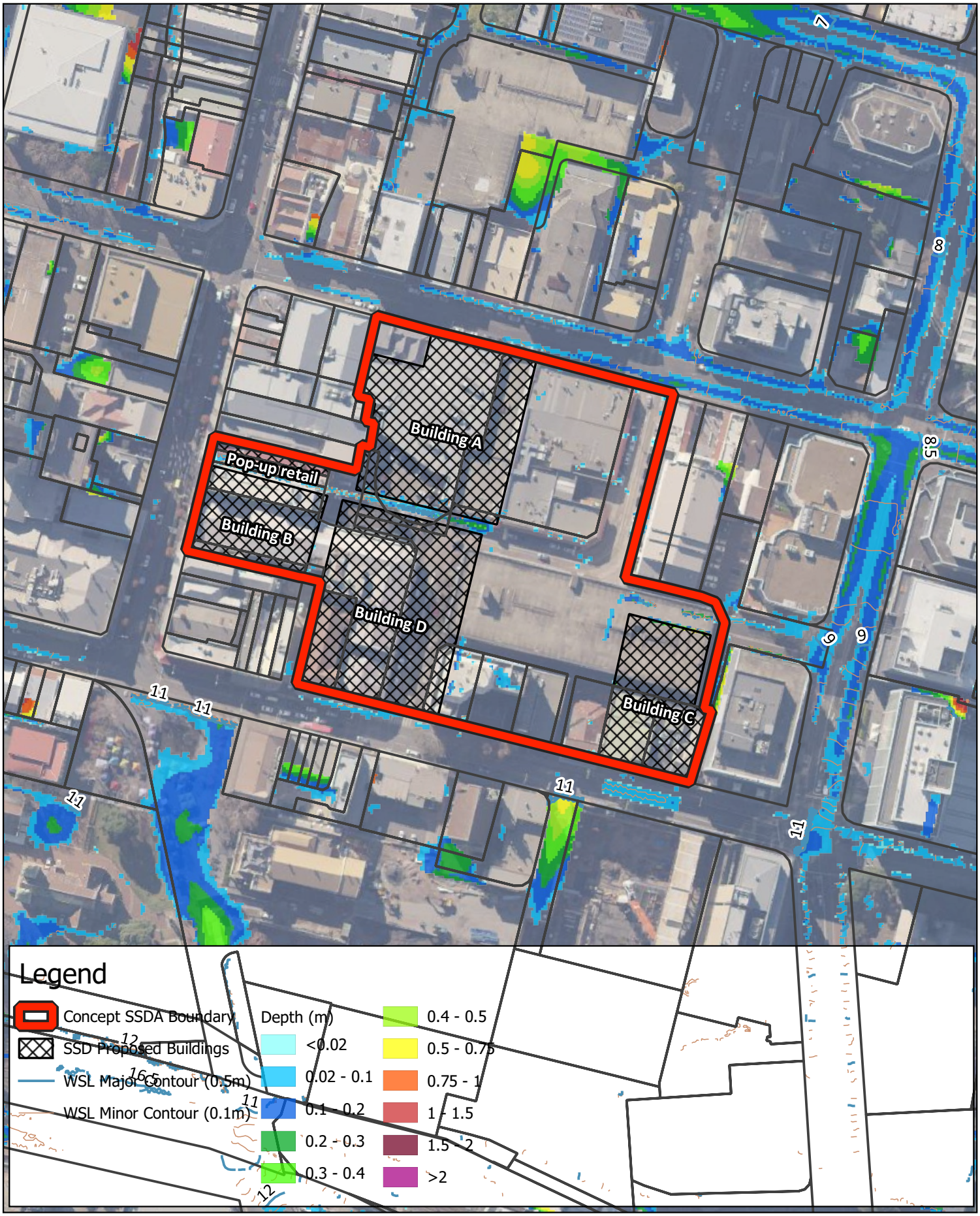

TITLE

Figure A-02
1% Climate Change Developed Flood Depth Map

PROJECT

EDS - SWM - Parramatta

0 50 100 m

NSW GOVERNMENT | sydney METRO

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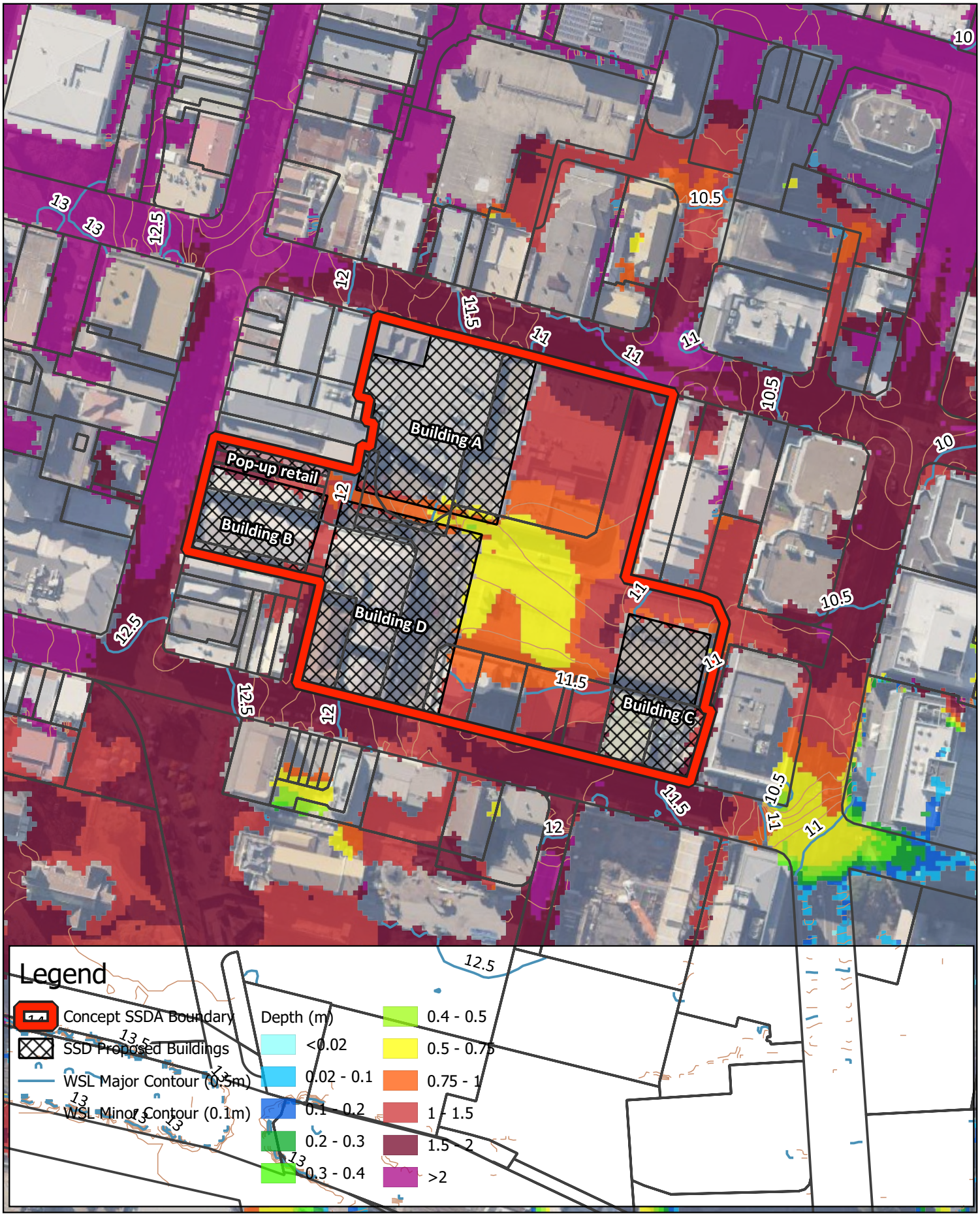

TITLE

Figure A-03
PMF Developed Flood Depth Map

PROJECT

EDS - SWM - Parramatta

0 50 100 m

NSW GOVERNMENT | sydney METRO

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