WESTMEAD SOUTH – FLOODING, WATER QUALITY & STORMWATER STUDY

Contextual Analysis Report

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CONTACT

MARK COLEGATE
Associate Technical Director

T + 61 3 8623 4053
M + 61 477 003 499
E mark.colegate@arcadis.com

Arcadis
L18, Queen & Collins Tower
376-390 Collins Street, Melbourne
VIC 3000

CUMBERLAND CITY COUNCIL
WESTMEAD SOUTH

Flooding, Water Quality & Stormwater Study

Contextual Analysis Report

Author	Author Name	Newton Jon, Yuan Li
Checker	Checker Name	Mark Colegate
Approver	Approver Name	Mark Colegate

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1 INTRODUCTION

1.1 Project Background

In July 2020, Council endorsed the strategic planning work program for Cumberland City's key centres and strategic corridors, including Westmead South. The work program involves the preparation of a planning proposal for each of the key centres and strategic corridors identified in the work program, with the following activities to be undertaken prior to any additional reports being considered by Council:

- Completion of background analysis
- Early community consultation on the planning proposal
- Preparation of draft planning proposal
- Preparation of draft planning controls associated with the planning proposal
- Consideration of draft planning proposal by the Cumberland Local Planning Panel
- Councillor briefings prior to early community consultation and prior to consideration by the Cumberland Local Planning Panel

As part of the work program, this project is to prepare a Flooding, Water Quality and Stormwater Study for Westmead South Precinct to support the preparation of a planning proposal to amend the Cumberland Local Environmental Plan 2021 and the Cumberland Development Control Plan 2021. This report summarises the findings for Background and Contextual Analysis (Stage 1) of the Study.

1.2 Vision

1.2.1 Westmead Vision

Westmead, including Westmead South, is a place for connection, inspiration and collaboration. Celebrating the unique qualities and sensitive history of Dharug Country, Westmead seeks to become a place of truth-telling and healing. Westmead will attract specialists, researchers, health customers, students, entrepreneurs and residents to journey through Country under the cooling shade of trees, at the edge of restored waterways, and among the flora and fauna of a restored 'West Meadow'.

The overarching vision for the Westmead is that of a '**District in Nature**', as described in Westmead Public Domain Strategy (Greater Cities Commission, 2022). This vision is realised through an understanding of the historic natural context of Westmead and the natural systems that have shaped its development.

The 'District in Nature' is reflected through three contexts:

- River Setting – the defining natural system of Westmead
- Re-imagining the 'Western Meadow'
- A Managed Landscape

1.2.2 Vision for Water

Westmead is geographically divided into two north/ south ridgelines that were heavily forested prior to colonisation and overlooking valley areas with substantial waterways. The waterways in the Westmead PDS area are significant as this is where fresh water meets salt water, with an abundance of varied resources that were used and sustained by Dharug people and other visitors to the area. Waterways and the land around them have been places of significance for First Nations people for millennia. Depending on the location and available resources, waterways have been used as camping places for clans or smaller family groups, providing a source of water, food and other resources.

Natural waterway system conservation and design to support water systems is the key vision for water cycle management in Westmead, which is reflected in below aspects:

- consider holistic Catchment and sub catchment systems
- restore waterways and associated salt marsh Country
- revive/maintain habitat + ecosystems through caring for Country

- retro-fitting existing streets and spaces and creating new public infrastructure that embeds Country into the public domain
- prioritise a naturalised response to water on Country
- recommended 40% target canopy cover
- WSUD interventions – to promote water collection and re-use, to slow water movement, to hold, cleanse and allow infiltration, and to mitigate urban heat island effects.
- responsive, site specific interventions; for example streets parallel to low ground used for street-based swale systems, removing concrete channels, mini “wetlands” at base of sloping streets
- District permeability – slowing the movement of water, allowing it to infiltrate, re-establishing nature’s functions.

1.3 Objectives

1.3.1 Westmead South Master Planning Objectives

The overall objectives for the Westmead South Master Planning include the following aspects:

Urban Design

- To undertake a place-based response to precinct planning, that acknowledges the current and future desired character of the area including heritage conservation, the community fabric and natural environment.
- To maintain and enhance the cultural heritage of the precinct through retention.
- To design for growth and an increased diverse housing supply, including affordable housing, by integrating land use and transport infrastructure.
- To design and promote high quality, sustainably designed buildings with good amenity and accessibility.
- To create active and accessible public domains that encourages safe, social interactions. Hawkesbury Road, the Metro interchange and the Oakes Centre will be key transformational areas within the precinct.
- To enhance vehicle and active transport linkages within the sub-precinct, to the Westmead public transport interchange, and to the adjoining precincts of Westmead North, Wentworthville, and Parramatta CBD.
- To ensure that the future community’s needs and aspirations are considered through appropriate urban design and built form outcomes.

Environmental

- To promote sustainable design and built forms that reduce the ‘urban heat island’ impact, storm water runoff, and flooding impacts, and which allow for the regeneration of Westmead’s natural assets including the Parramatta River, Toongabbie, and Darling Mills Creeks.
- To provide adequate open space and recreational opportunities to meet the anticipated population growth for the whole Westmead Precinct.
- To design for natural environments that retain mature vegetation, protects and or enhances significant flora and fauna, where possible.
- To identify areas of contamination to ensure an appropriate land use response.

Social

- To ensure that adequate community infrastructure and support services are provided for the future population.
- To incorporate social and affordable housing needs through implementation of an affordable housing contribution scheme (where appropriate) and collaboration with the Land and Housing Corporation (LAHC).

Economic

- To ensure that any proposed development is financially viable and that the proposed mix of uses adequately reflects current and projected market requirements.
- To capitalise on infrastructure investment in the Parramatta light rail and future Sydney Metro.

- To protect existing industry within the precinct whilst also encouraging new emerging industries and technologies.

1.3.2 Flooding, Water Quality and Stormwater Study Objectives

The aim of the Flooding, Water Quality and Stormwater Study is to inform and support the development of the Westmead South Master Plan and subsequent Planning Proposal. The objectives of the Study include:

- Collaborate with the suite of consultants engaged by Council for the Master Plan.
- Understand the existing water quality, flooding, and stormwater management context in the study area.
- Test and assess the existing (base case) and proposed (development) scenarios proposed to advise on the potential impacts on flooding, water quality and stormwater management, with the consideration of the climate change and impacts within and external to the study area.
- Provide recommendations for the Westmead South Master Plan that will enable compliance with Local Planning Direction 4.1: Flooding (section 9.1 Ministerial Directions).
- Provide a flood risk assessment and implementation plan, including flood mitigation strategies, a stormwater management plan, a water quantity and quality assessment, and an integrated water cycle management strategy, that provides strategies and recommendations for each growth scenario.
- Prepare the required provisions, in collaboration with Council, which can be integrated into the Cumberland Local Environmental Plan 2021 and/or Cumberland Development Control Plan 2021.

The objectives for this Background and Contextual Analysis report (Stage 1 of the Study) can be summarised as follow:

- Review relevant literature, including existing studies on flooding and strategic planning in the study area and relevant guidelines.
- Update Council's adopted flood models to ARR 2019 and current conditions.
- Define the existing conditions flood behaviour of the study area for a range of events.
- Assess the flood risk of the proposed master plan.
- Assess the existing stormwater drainage infrastructure and the capacity.
- Identify IWCM and WSUD opportunities.

2 STUDY AREA

The Cumberland Local Government Area (LGA), proclaimed in May 2016, is situated 20 km west of Sydney and covers 72 km^2, with a population of 240,000 residents.

The study area (site) is the southern portion of Westmead Precinct, located at the central north part of the Cumberland LGA, as shown in Diagram 1. It plays an important role as a Gateway and residential community hub to the Westmead health and education facilities at the precinct's core.

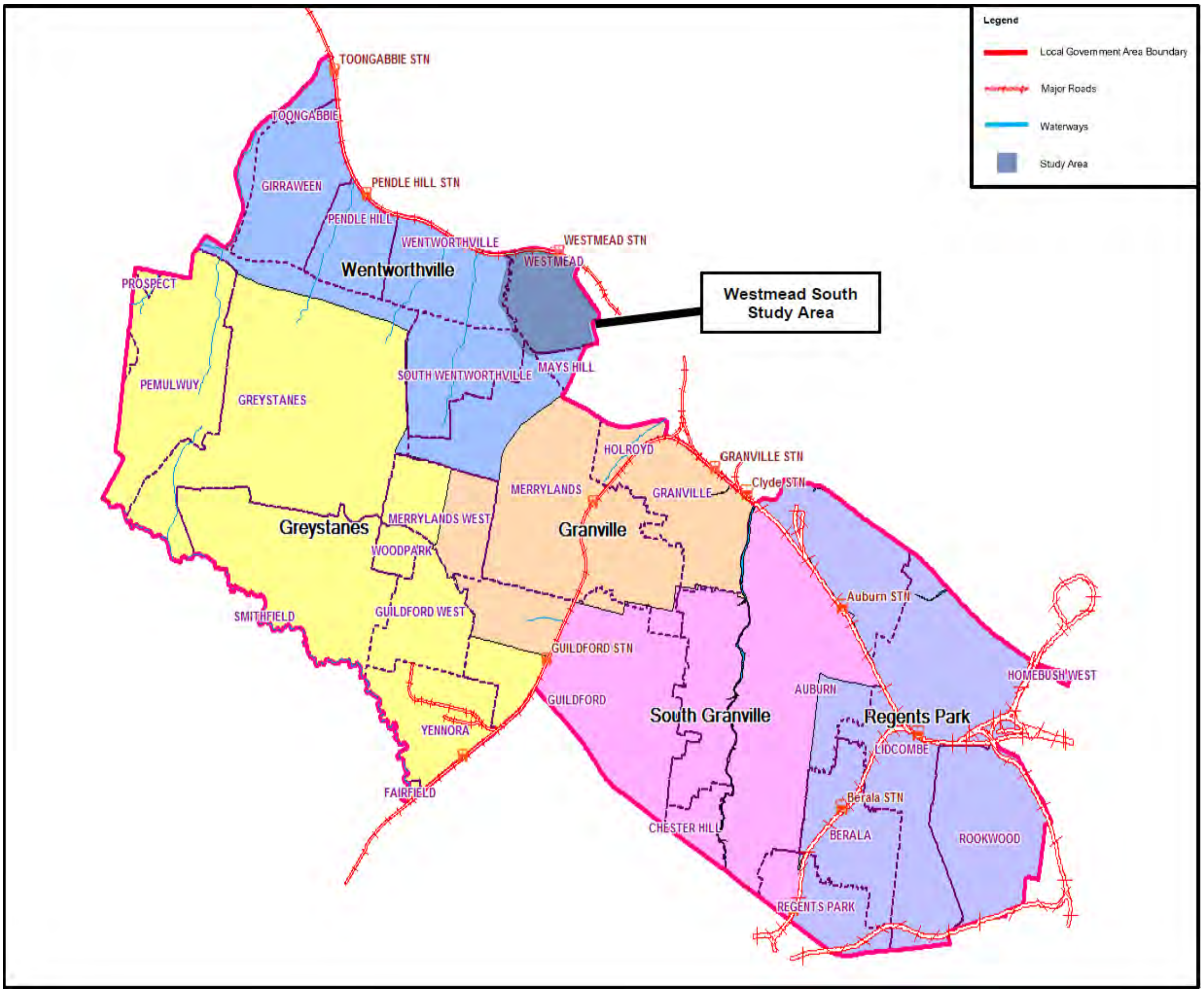


Diagram 1 - Site Location

2.1 Existing Site

The study area is bound by a railway line to the north, the Great Western Highway to the south, Mays Hill Precinct (Parramatta Park) to the east and Bridge Road to the west. It covers two local catchments, i.e., Domain Creek and Westmead Creek catchments, draining northwards towards the railway line. The area is fully urbanised with existing residential blocks, as illustrated in Diagram 2.

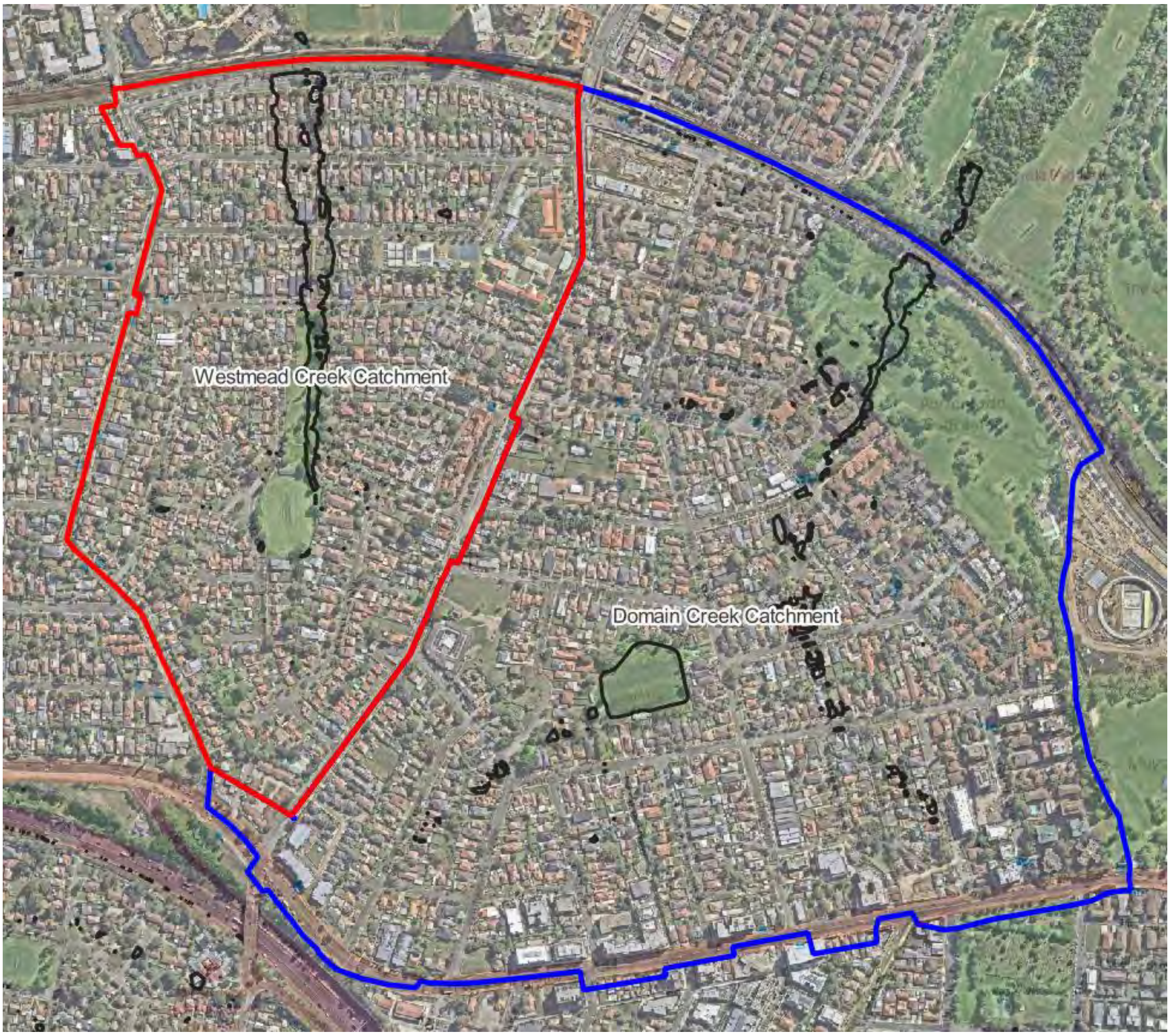
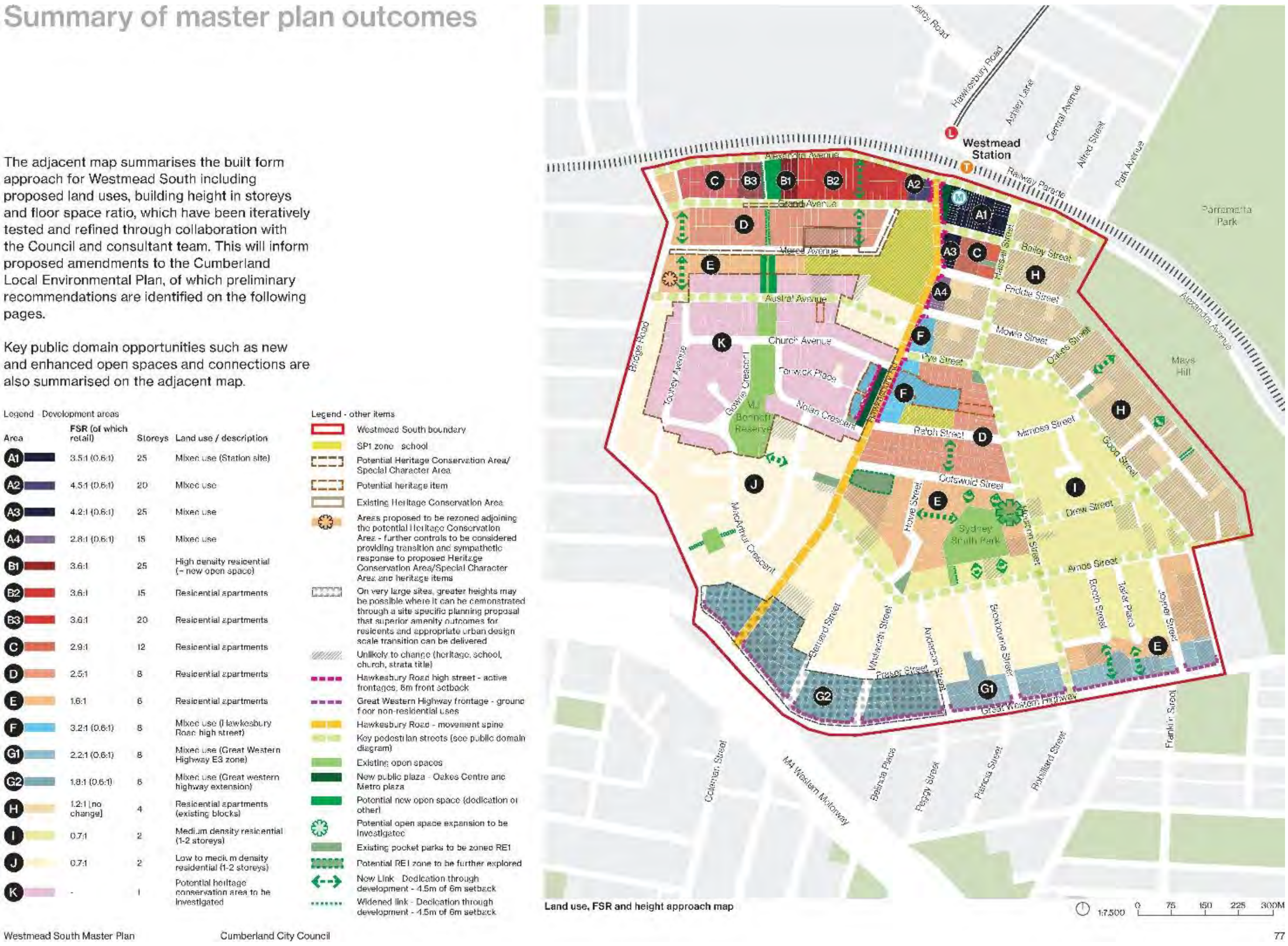


Diagram 2 - Study Catchments with Council Adopted 1% AEP Flow Path (Lyall & Associates, 2017)

2.2 Master Planning

Strategic planning work program has been taking place for Cumberland City's key centres and strategic corridors, including Westmead South, since 2020. As part of the program, Westmead South is being planned to provide diverse and affordable housing with associated specialised retail, commercial and community facilities to support existing and future residents who likely work in central Westmead and the Parramatta CBD.

The most recent urban design masterplan, as dated on 1 August 2023, is shown in Diagram 3. The master plan allows future Westmead South to accommodate over 30,000 residents, compared to approximately a population of 8,000 under existing conditions, by rezoning the general residential into high/median density residential apartments. The proposed masterplan will result in a significant increase of potable water demand and could also potentially impact the stormwater quality and quantity, as well as the flood risk within and external to the area, which are the issues this Study aiming to address.



Summary of master plan outcomes

The adjacent map summarises the built form approach for Westmead South including proposed land uses, building height in storeys and floor space ratio, which have been iteratively tested and refined through collaboration with the Council and consultant team. This will inform proposed amendments to the Cumberland Local Environmental Plan, of which preliminary recommendations are identified on the following pages.

Key public domain opportunities such as new and enhanced open spaces and connections are also summarised on the adjacent map.

Legend - Development areas

Area	FSR (of which retail)	Storeys	Land use / description
A1	3.5:1 (0.6:1)	25	Mixed use (Station site)
A2	4.5:1 (0.6:1)	20	Mixed use
A3	4.2:1 (0.6:1)	25	Mixed use
A4	2.8:1 (0.6:1)	15	Mixed use
B1	3.6:1	25	High density residential (+ new open space)
B2	3.6:1	15	Residential apartments
B3	3.6:1	20	Residential apartments
C	2.9:1	12	Residential apartments
D	2.5:1	8	Residential apartments
E	1.6:1	6	Residential apartments
F	3.2:1 (0.6:1)	8	Mixed use (Hawkesbury Road high street)
G1	2.2:1 (0.6:1)	8	Mixed use (Great Western Highway E3 zone)
G2	1.8:1 (0.6:1)	6	Mixed use (Great western highway extension)
H	1.2:1 (no change)	4	Residential apartments (existing blocks)
I	0.7:1	2	Medium density residential (1-2 storeys)
J	0.7:1	2	Low to medium density residential (1-2 storeys)
K	-	1	Potential heritage conservation area to be investigated

Legend - other items

- Westmead South boundary
- SP1 zone - school
- Potential Heritage Conservation Area/ Special Character Area
- Potential heritage item
- Existing Heritage Conservation Area
- Areas proposed to be rezoned adjoining the potential Heritage Conservation Area - further controls to be considered providing transition and sympathetic response to proposed Heritage Conservation Area/Special Character Area and heritage items
- On very large sites, greater heights may be possible where it can be demonstrated through a site specific planning proposal that superior amenity outcomes for residents and appropriate urban design scale transition can be delivered
- Unlikely to change (heritage, school, church, strata title)
- Hawkesbury Road high street - active frontages, 6m front setback
- Great Western Highway frontage - ground floor non-residential uses
- Hawkesbury Road - movement spine
- Key pedestrian streets (see public domain diagram)
- Existing open spaces
- New public plaza - Oakes Centre and Metro plaza
- Potential new open space (dedication or other)
- Potential open space expansion to be investigated
- Existing pocket parks to be zoned RE1
- Potential RE1 zone to be further explored
- New Link - Dedication through development - 4.5m of 6m setback
- Widened link - Dedication through development - 4.5m of 6m setback

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Diagram 3 – Study Area Proposed Conditions – Preferred Urban Design Masterplan as dated on 23 October 2023

3 PREVIOUS STUDIES

Relevant policies, strategies, and previous studies obtained for this Study are summarised in Table 1. Those studies were reviewed with a focus on flooding, stormwater, IWCM and WSUD.

Table 1 - Relevant policies, strategies, and studies

Title	Source
Greater Sydney Region Plan – "A Metropolis of Three Cities"	Greater Sydney Commission
Central City District Plan	Department of Planning and Environment
Future Transport Strategy 2056	Transport for NSW
Westmead 2036 Place Strategy	Department of Planning and Environment
Westmead Place-based Transport Strategy	Transport for NSW
Westmead Health and Innovation District Public Domain Strategy	Greater Cities Commission
Westmead South Land Use Capability Study, dated 13 September 2021	SGS Economics and Planning
Westmead South Centre Traffic and Transport Study, dated 8 February 2022	SCT Consulting
Westmead South Community Needs and Social Infrastructure Assessment Report dated 21 October 2022	GHD Pty Ltd
NSW BASIX	Department of Planning and Environment
Cumberland Community Strategic Plan 2017-2027	Cumberland City Council
Cumberland 2030: Our Local Strategic Planning Statement	Cumberland City Council
Cumberland Local Housing Strategy 2020	Cumberland City Council
Cumberland Cultural Plan 2019 – 2029	Cumberland City Council
Cumberland Local Infrastructure Contributions Plan 2020	Cumberland City Council
Cumberland Affordable Housing Strategy 2020	Cumberland City Council
Cumberland Open Space and Recreation Strategy 2019 – 2029	Cumberland City Council
Cumberland Urban Tree Strategy 2020	Cumberland City Council
Cumberland Community Facilities Strategy 2019 – 2029	Cumberland City Council
Cumberland Employment and Innovation Lands Strategy 2019	Cumberland City Council
Cumberland Local Environmental Plan 2021	Cumberland City Council
Cumberland Development Control Plan 2021	Cumberland City Council
Holroyd City LGA Overland Flood Study 2017	Lyall and Associates

3.1 Flood Study

An overland food study for the Holroyd City LGA, the majority of which has been merged into Cumberland City Council, was conducted by Lyall and Associates in 2017. The study covers Westmead and Domain Creek catchments, i.e., the Westmead South master planning area.

The DRAINS and TUFLOW models for Westmead and Domain Creek catchments from the 2017 study were provided by Council. The models were established in accordance with Australia Rainfall Runoff (ARR) 1987. The sub-catchment rainfall-runoff processes were modelled through DRAINS, producing inflow hydrographs for TUFLOW. No 1D hydraulic routing were modelled in DRAINS. The hydraulic models (TUFLOW) cover the main overland flow paths and the inflow generated by hydrologic models were implemented directly into pits through 1d_bc. The underground drainage, i.e., pits and pipes, and key culverts were represented through 1D elements.

The 2017 models were used as a base for this study and were updated to current best practice guideline, i.e., ARR 2019, and existing catchment conditions. The model updates are summarised in Section 4.

3.2 Stormwater and IWCM requirements

The stormwater and Integrated Water Cycle Management (IWCM) requirements for are mainly defined in:

- NSW BASIX;
- Cumberland Local Environmental Plan 2021; and
- Cumberland Development Control Plan 2021.

Relevant information has also been obtained from some background studies relevant to Westmead South master planning, including:

- Westmead 2036 Place Strategy;
- Westmead Health and Innovation District Public Domain Strategy;
- Westmead South Land Use Capability Study;
- Cumberland Open Space and Recreation Strategy 2019 – 2029; and
- Cumberland Urban Tree Strategy 2020.

Detailed analysis of stormwater and IWCM requirements and targets is discussed in Section 6.2.

4 FLOOD MODELLING

4.1 Overview

The following updates were performed:

- Updated rainfall data from ARR Datahub (including compliance to NSW specific advice):
    - Rainfall depths from 2016 Bureau of Meteorology data
    - 10 temporal patterns
    - Transformational pre-burst depths (accounting for varying probability neutral burst initial loss)
- Adopted ARR 2019 IL-CL method in the updated DRAINS model instead of the ILSAX method in the original model. The adopted loss parameters include:
    - Probability neutral burst initial loss (PNBIL), represented through transformational pre-burst
    - ARR Data hub continuing loss (CL) adjusted by 0.4 multiplier based on NSW specific advice.
- Updated impervious fractions, including further break down into ARR2019 surface types.
- Modelled ensemble of 10 storms and extracted envelope of maximum values according to ARR2019 methodology.

The sub-catchment layout was reviewed and considered to be reasonable. As such, no changes to the sub-catchment boundaries were performed. The sub-catchments are identified in Diagram 4.

Diagram 4 - Sub-catchment layout (Westmead Creek sub-catchments in red, Domain Creek sub-catchments in blue)

4.2 Hydrological Model Updating

Runoff hydrographs were generated in DRAINS. DRAINS is common software that is conventionally used as both a hydrologic and hydraulic model. However, for this project, it has only been used for the hydrologic component of the project.

4.2.1 Impervious Fractions

The impervious fractions of the sub-catchments were updated. This update involved two types of smaller updates:

1. Derivation of impervious fractions to match the latest aerial imagery and land use.
2. Further break down of the derived impervious fractions into ARR2019 surface types.

The ARR2019 approach involves breaking down urban catchments into three surface types. These are identified in Table 2.

Table 2 - ARR2019 urban catchment surface types

Surface Type	Description
Effective Impervious Area (EIA)	Impervious areas directly connected to drainage systems.
Indirectly Connected Area (ICA)	Impervious areas not directly connected to drainage systems. Pervious areas directly connected to drainage systems.
Pervious Area (PA)	Large pervious areas that do not interact with impervious areas or drainage systems.

However, DRAINS applies the ARR2019 approach differently. It has a slightly different definition of the surface types. These are described in Table 3.

Table 3 - DRAINS surface types for the ARR2019 approach

Surface Type	Description
Effective Impervious Area (EIA)	No change from ARR2019 definitions.
Remaining Impervious Area (RIA)	Impervious areas not directly connected to drainage systems. Impervious areas not directly connected to drainage systems.
Pervious Area (PA)	Any pervious areas, regardless of connectivity to impervious areas or drainage systems.

As such, the different surface type definitions correspond to different loss values. From a planning and flood-risk perspective, this change is not significant. However, any practitioner performing updates to the DRAINS model must take note of this subtle difference to avoid mixing the DRAINS ARR2019 methodology with the unmodified ARR2019 methodology.

The impervious fractions were updated according to the latest aerial imagery. The average total impervious area (TIA) fraction as well as the other surface types is shown in Table 4.

Table 4 – Average of Impervious Fractions used in 2017 and 2023 models

Model	Average TIA Fraction	Average Paved/EIA Fraction	Average Supplementary/RIA Fraction	Average Grassed/PA Fraction
2017 Model	0.37	0.37	-	0.63
2023 Model	0.56	0.35	0.21	0.44

As shown in Table 4, the TIA fraction has increase. A review of aerial imagery from 2017 to 2023 revealed that the increase in TIA is partially attributed to developments within the catchments. However, the majority of TIA increase is attributed to the low impervious fractions assigned to the sub-catchments in the 2017 model.

For example, an impervious fraction of 0.4 was assigned to the high-density areas towards the northeast of Domain catchment. These areas already existed when the 2017 model was built. In addition, these sub-catchments include the road, which should further increase the impervious fraction. Arcadis considers that the impervious fractions of the 2017 model were lower than expected range.

The increase in TIA resulted in an increase in runoff volumes. However, the net effect of the hydrological updates is discussed in Section 4.2.8. A table identifying the impervious fractions for each sub-catchment is included in Appendix A.

4.2.2 Loss Model and Routing Model

The 2017 model utilised the Horton/ILSAX hydrological model with parameters shown in Table 5. This was replaced with the ARR2019 Initial Loss-Continuing Loss (IL-CL) hydrological model with parameters shown in Table 6. This is due to the lack of calibration data to identify ILSAX parameters, noting that the 2017 report was for a much larger region (i.e., LGA) and the validation was carried out in other catchments. Therefore, according to NSW specific advice by ARR 2019, IL-CL method (i.e., PNBIL and CL adjusted by 0.4 factor) was adopted.

Table 5 - ILSAX hydrological model parameters

Parameter	Value
Paved (impervious) area depression storage	1 mm
Supplementary area depression storage	1 mm (not used)
Grassed (pervious) area depression storage	5 mm
Soil Type	3
Antecedent Moisture Condition	3
Initial Infiltration Rate	33.7 mm/h
Final Infiltration Rate	6 mm/h

Table 6 - ARR2019 IL-CL hydrological model parameters

Parameter	Value
Impervious Area Initial Loss	1 mm
Impervious Area Continuing Loss	0 mm/h
Pervious Area Initial Loss	28 mm
Pervious Area Continuing Loss	0.76 mm/hr

It should be noted that the ARR Datahub includes NSW-specific advice regarding the appropriate initial losses for pervious areas. These loss values are called the Probability Neutral Burst Initial Loss and vary depending on the duration and frequency of the storm. These are shown in Table 7.

Table 7 - Probability Neutral Burst Initial Loss in mm

Duration (min)	50%	20%	10%	5%	2%	1%
60	17.5	9	8.8	9.6	9.4	8.3
90	18.9	9.9	9.4	9.5	8.2	6.2
120	14.6	8.4	8.7	9	8.3	6.4
180	16.9	9.3	9	8.4	7.7	6

Since DRAINS is unable to nominate varying loss values, this step has been accounted for by modifying the pre-burst rainfall, discussed in Section 4.2.3.

4.2.3 Pre-burst Rainfall

The rainfall depths provided by the Bureau of Meteorology represent the burst depth. Pre-burst rainfall, however, is the rainfall that occurs before the burst of the storm. This rainfall has the effect of reducing the initial loss of the catchment. The pre-burst rainfall depths identified in Table 8 have been updated to account for the varying Probability Neutral Burst Initial Loss as described in Section 4.2.2.

Table 8 - Transformational Pre-Burst Rainfall in mm

Duration (min)	50%	20%	10%	5%	2%	1%
60	10.3	18.8	19	18.2	18.4	19.5
90	8.9	17.9	18.4	18.3	19.6	21.6
120	13.2	19.4	19.1	18.8	19.5	21.4
180	10.9	18.5	18.8	19.4	20.1	21.8

4.2.4 Rainfall Depths

Rainfall depths from the 2016 Bureau of Meteorology database were used as part of the update. The 2016 database is based on significantly more rainfall observations than the 1987 database. The difference between the two sources is shown in Table 9 and Table 10.

Table 9 - Difference in Rainfall Depths in mm (2016 Data minus 1987 Data)

	Frequency						
Duration (min)	1 / 63.2%	2 / 0.5EY	5 / 20%	10 / 10%	20 / 5%	50 / 2%	100 / 1%
5	0.45	0.12	-0.81	-0.56	-0.77	-0.93	-1.01
10	1.03	0.76	-0.2	0.43	0.34	0.23	0.17
15	1.23	0.91	-0.35	0.56	0.38	0.27	0.16
20	1.27	0.75	-0.83	0.06	-0.17	-0.49	-0.64
25	1.05	0.52	-1.46	-0.63	-1.02	-1.44	-1.74
30	0.98	0.11	-2.21	-1.39	-1.99	-2.55	-3.04
45	0.4	-0.94	-4.3	-3.74	-4.85	-5.94	-6.65
60	-0.12	-1.89	-6.14	-5.91	-7.35	-8.82	-9.85
90	-0.98	-3.37	-8.99	-9.08	-11.17	-13.31	-14.71
120	-1.54	-4.36	-10.93	-11.28	-13.79	-16.39	-18.03
180	-2.1	-5.58	-13.53	-13.98	-16.95	-20.09	-21.9

Table 10 - Difference in Rainfall Depths as a percentage of 1987 Data

Duration (min)	1 / 63.2%	2 / 0.5EY	5 / 20%	10 / 10%	20 / 5%	50 / 2%	100 / 1%
5	6%	1%	-7%	-4%	-5%	-6%	-5%
10	10%	6%	-1%	2%	2%	1%	1%
15	9%	5%	-2%	2%	1%	1%	0%
20	8%	4%	-3%	0%	-1%	-1%	-2%
25	6%	2%	-5%	-2%	-3%	-3%	-4%
30	5%	0%	-7%	-4%	-5%	-6%	-6%
45	2%	-3%	-12%	-9%	-10%	-11%	-11%
60	0%	-6%	-15%	-13%	-14%	-14%	-14%
90	-3%	-9%	-18%	-16%	-18%	-18%	-18%
120	-5%	-10%	-20%	-18%	-19%	-20%	-20%
180	-5%	-11%	-21%	-19%	-20%	-20%	-20%

As shown in the tables above, the 2016 rainfall depths are generally less than the 1987 rainfall depths for rarer events. The reduction in rainfall depths resulted in lower runoff volumes. However, the net effect of the hydrological updates is discussed in Section 4.2.8.

No changes to the rainfall depths were made for PMF events.

4.2.5 Rainfall Temporal Patterns and Storm Selection

Rainfall temporal patterns describe how rainfall is distributed across time. Storm selection is the process of selecting the storm that causes the highest peak flow and/or flood level at a specific location.

The ARR1987 approach includes one temporal pattern per duration and the duration yielding the highest peak flow and/or flood level is selected.

The ARR2019 approach involves modelling an ensemble of 10 temporal patterns per duration. For each duration, the temporal pattern corresponding to the median peak flow and/or flood level is selected. This is then followed by selecting the duration yielding the highest peak flow and/or flood level.

With that said, storm selection was performed fully in the hydraulic model and supersedes the hydrological model. Diagram 5 illustrates the difference in temporal patterns between the ARR1987 and ARR2019 approaches.

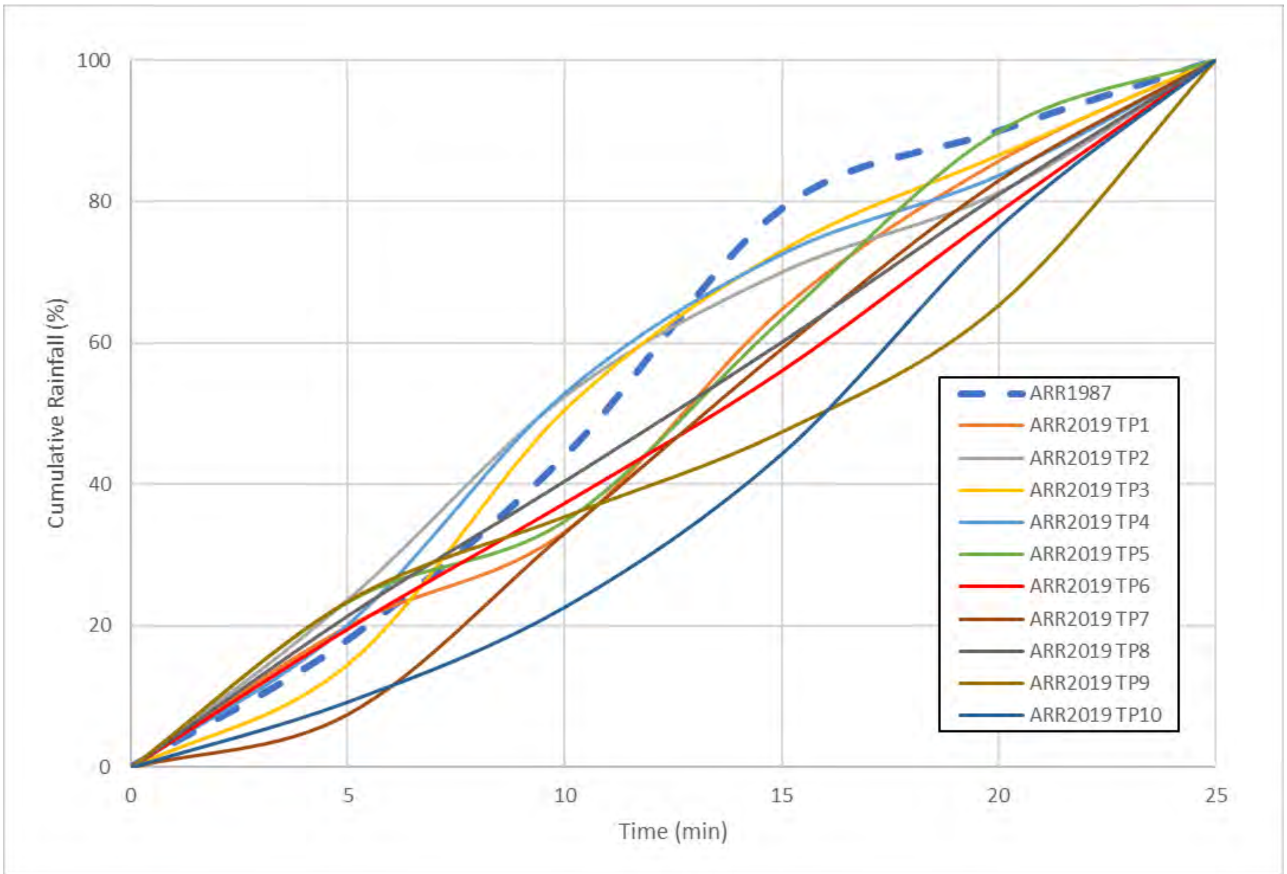


Diagram 5 - 1% AEP 25-minute storm temporal patterns (shown as cumulative % of rainfall)

As shown in Diagram 5, ARR2019 temporal patterns are generally more rear-loaded than ARR1987 for the 25-minute storm. Assessments of temporal patterns for other storm durations were not performed. This assessment was purely to identify the individual factors affecting the runoff hydrograph to ensure that the behaviour of the hydrograph is expected and reasonable.

No changes to the rainfall temporal patterns were made for PMF events.

4.2.6 Time of Concentration

The time of concentration is the time required for water to flow from the furthest point on a catchment to its outlet. This parameter greatly affects the runoff hydrograph from each sub-catchment due to its interaction with the storm durations and temporal patterns. Generally, a longer time of concentration yields a flatter hydrograph, corresponding to a lower peak and a longer base.

The Kinematic Wave Equation was used to determine the time of concentration of each sub-catchment. The parameters used are identified in Table 11.

Table 11 - Sub-catchment Parameters for Time of Concentration

Surface Type	Parameter	2017 model	2023 model
Paved / Effective Impervious Area	Additional time	5 minutes	Unchanged
	Flow path length	Calculated from DEM	Unchanged
	Flow path slope	Calculated from DEM	Unchanged
	Retardance coefficient n*	0.02	Unchanged
Supplementary / Remaining Impervious Area	Additional time	Not used	0
	Flow path length	Not used	0
	Flow path slope	Not used	Redundant due to 0 flow path length
	Retardance coefficient n*	Not used	Redundant due to 0 flow path length
Grassed / Pervious Area	Additional time	0	6
	Flow path length	30 m	Same as EIA
	Flow path slope	Same as Paved	Unchanged
	Retardance coefficient n*	0.04	0.02
	Lag time	Proportional to Paved flow path length	Removed – no longer available as a parameter

The hydrograph is especially sensitive to the time of concentration, of which, is sensitive to additional time and other flow path parameters. As such, particular care must be taken when selecting appropriate values for these parameters.

A review of the 2017 model found that the grassed area parameters were excessively conservative. The lag time parameter assumed a 2 m/s flow velocity, thus returning a time of concentration significantly shorter than the paved area. Arcadis believes the time of concentration for the grassed areas should not be shorter than the paved areas, and hence, the hydrographs from the 2017 model should be flatter.

As part of the ARR2019 update, additional times of Pervious Areas have been increased to 6 minutes and flow path parameters are now matching EIA. These steps result in a generally higher time of concentration and hence, a flatter hydrograph.

4.2.7 Climate Change Effects

There are two climate change effects that are relevant to flooding- sea level rise and increased rainfall. Sea level rise has been excluded from the assessment due to the location and elevation of the study area. With regards to increased rainfall, a rainfall multiplier has been applied for the 1% AEP storms. The ARR Datahub provides interim climate change factors up to the year 2090 and nominates a 19.7% increase in rainfall assuming a Representative Concentration Pathway (RCP) of 8.5 for the year 2090. The RCP is a projection of the carbon dioxide emissions, with 8.5 corresponding to the worst-case of the three RCPs provided.

4.2.8 Net Effect

The following image identifies 11 hydrographs from one of the sub-catchments. One hydrograph used the ARR1987 approach whereas the remaining ten used the ARR2019 approach.

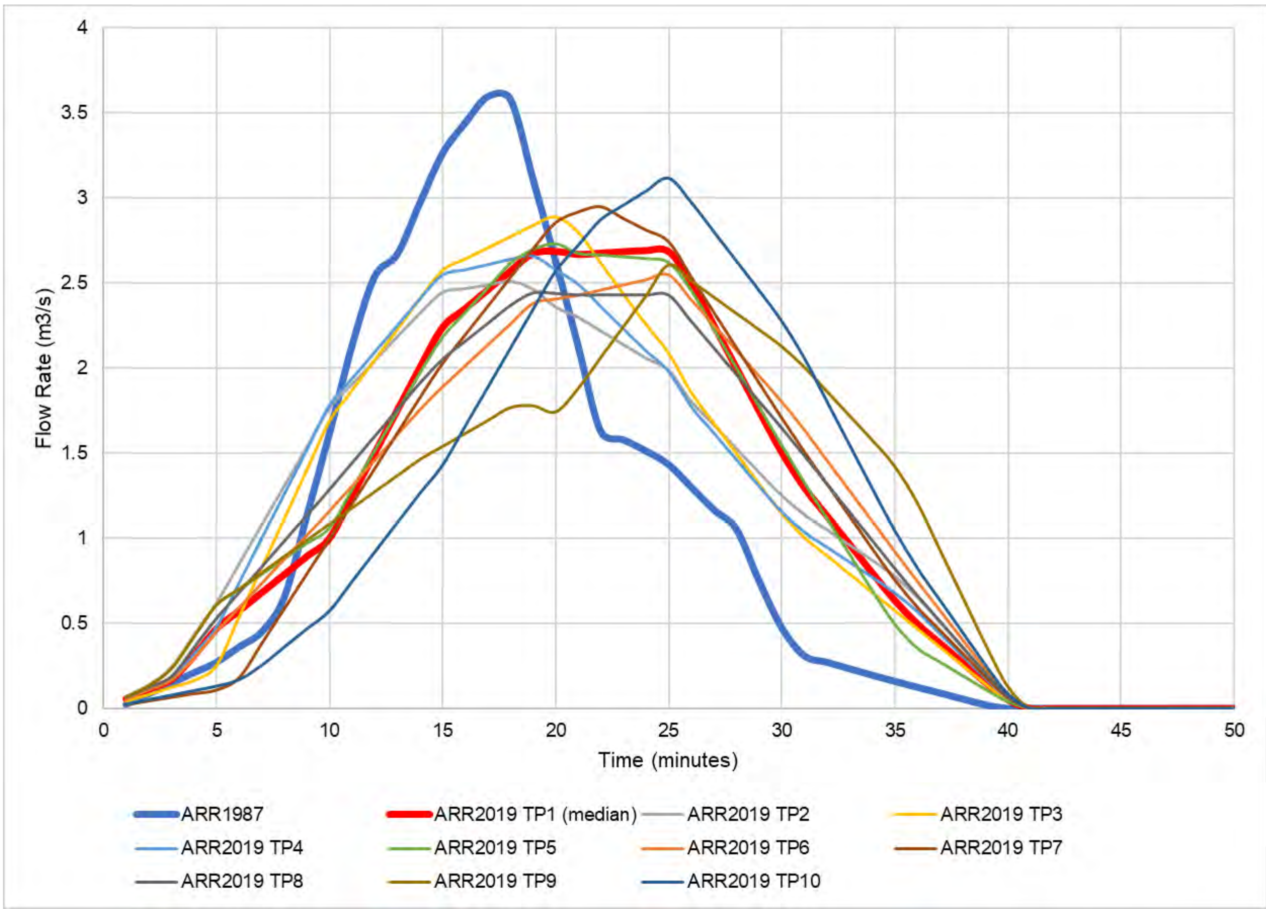


Diagram 6 - 1% AEP 25-minute storm Hydrographs for Wes_001 sub-catchment

As shown in Diagram 6, the ARR2019 approach produces a significantly lower peak flow, from 3.6 (using ARR1987 approach) to 2.7 m^3/s. This represents a reduction in peak flow of about 25%.

However, while the peak flow has reduced, there is also an increase in overall volume by about 10%. While Table 9 identifies a 4% reduction in rain, Appendix A identifies an increase in impervious fraction by 40%.

Arcadis believes that this behaviour is expected and is reasonable considering the different loss models, loss values, temporal patterns, rainfall data, and critical storm methodology.

4.3 Hydraulic Model Updating

4.3.1 DEM Comparison

The digital elevation model (DEM) used in the 2017 flood model was based off LiDAR captured in 2013. LiDAR captured in 2019 was also obtained. The metadata for the LiDAR sources is shown in Table 12.

Table 12 - LiDAR metadata

Source	2017 Model DEM	2019 ELVIS / Spatial Services NSW
Acquisition Date	April 2013	July 2019
Vertical Accuracy (mm)	150	300
Horizontal Accuracy (mm)	400	800
Confidence Interval	95%	95%
Flight Altitude (m)	1530	3500
DEM resolution (m)	1	1

The metadata shows that the LiDAR captured in 2013 has a higher accuracy. A comparison of the LiDAR sources against aerial imagery revealed that the 2013 LiDAR had a better horizontal alignment (and hence, accuracy) with the aerial image. This is shown in Diagram 7, where the 2013 LiDAR has a closer alignment to the road kerb compared to the 2019 LiDAR.

Diagram 7 – Ground Surface Elevation with cursor location corresponding to kerb & channel location (Black – 2013 LiDAR; Red – 2019 LiDAR)

There were no data sources available to compare the vertical accuracy of the LiDAR sources. However, when compared to each other, 2013 LiDAR was generally at a higher elevation than 2019 LiDAR. The differences are shown from Diagram 8 to Diagram 13.

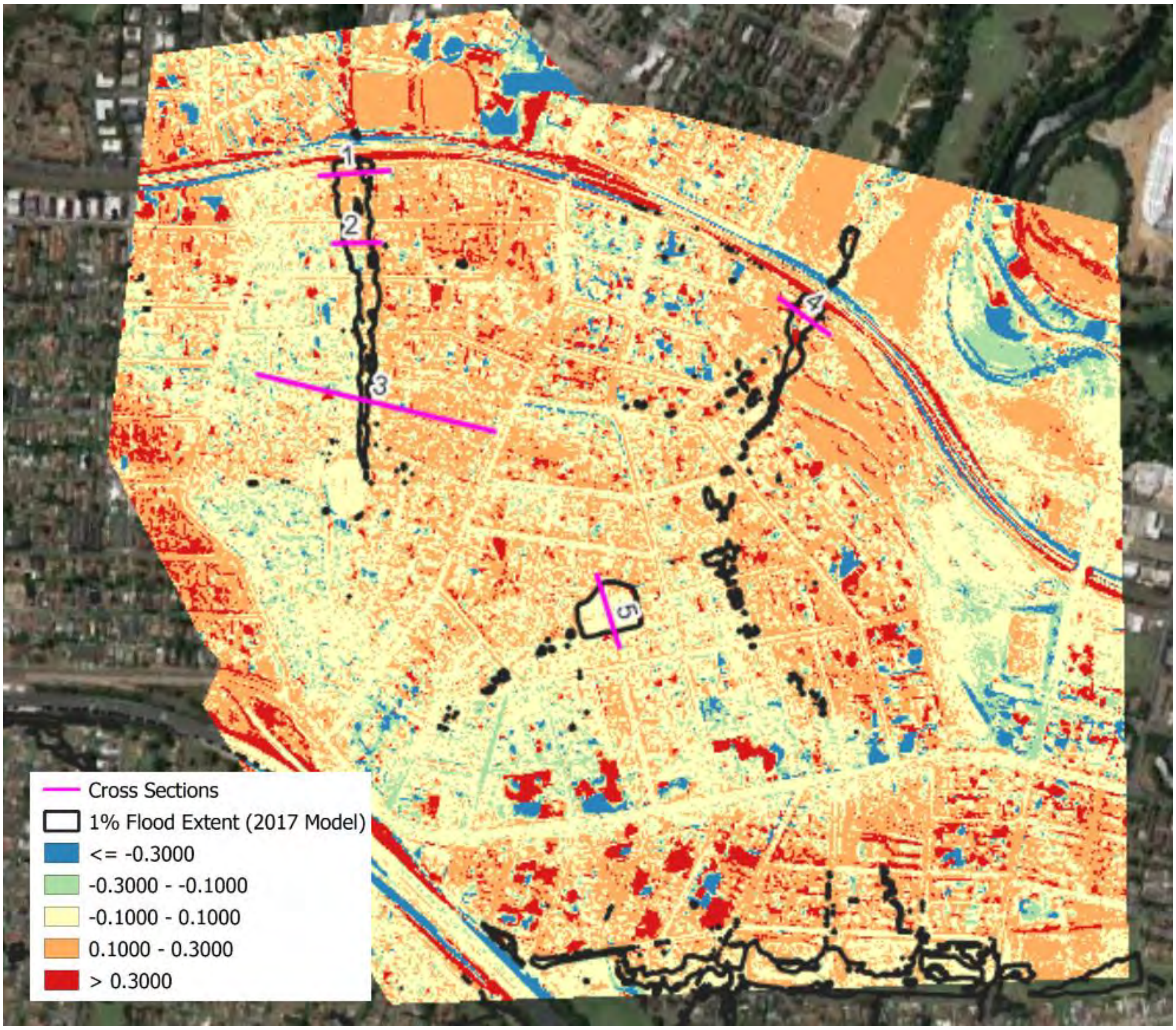


Diagram 8 - Difference between LiDAR elevation in metres (2013 LiDAR minus 2019 LiDAR)

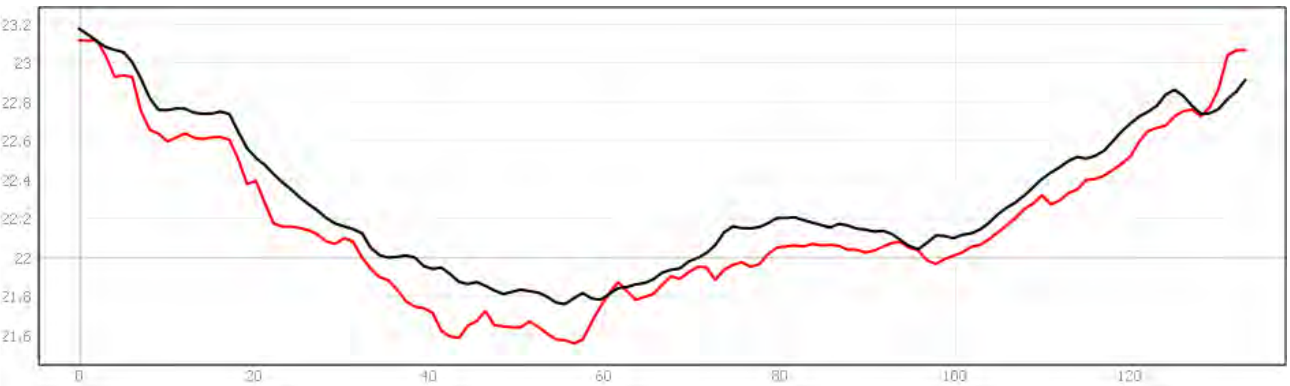


Diagram 9 – Ground Surface Elevation at Cross Section 1 (Black – 2013 LiDAR; Red – 2019 LiDAR)

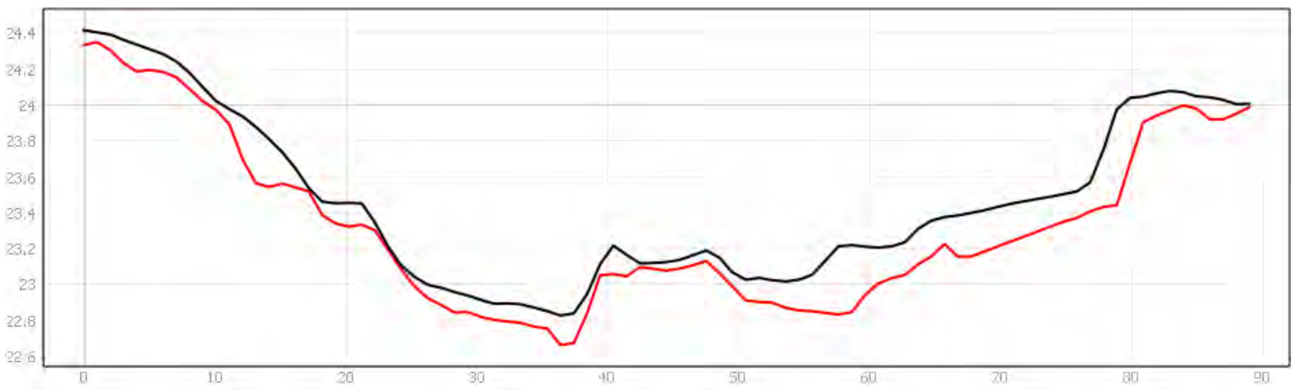


Diagram 10 – Ground Surface Elevation at Cross Section 2 (Black – 2013 LiDAR; Red – 2019 LiDAR)

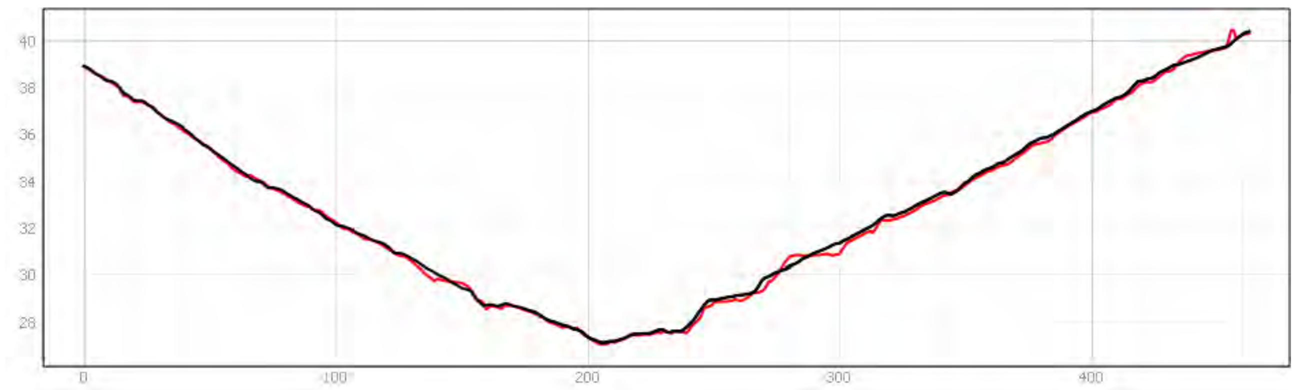


Diagram 11 – Ground Surface Elevation at Cross Section 3 (Black – 2013 LiDAR; Red – 2019 LiDAR)

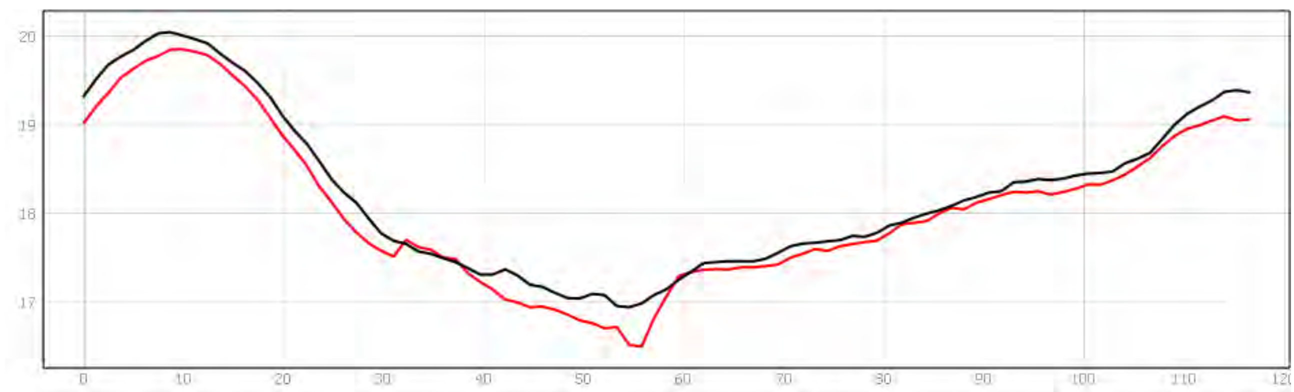


Diagram 12 – Ground Surface Elevation at Cross Section 4 (Black – 2013 LiDAR; Red – 2019 LiDAR)

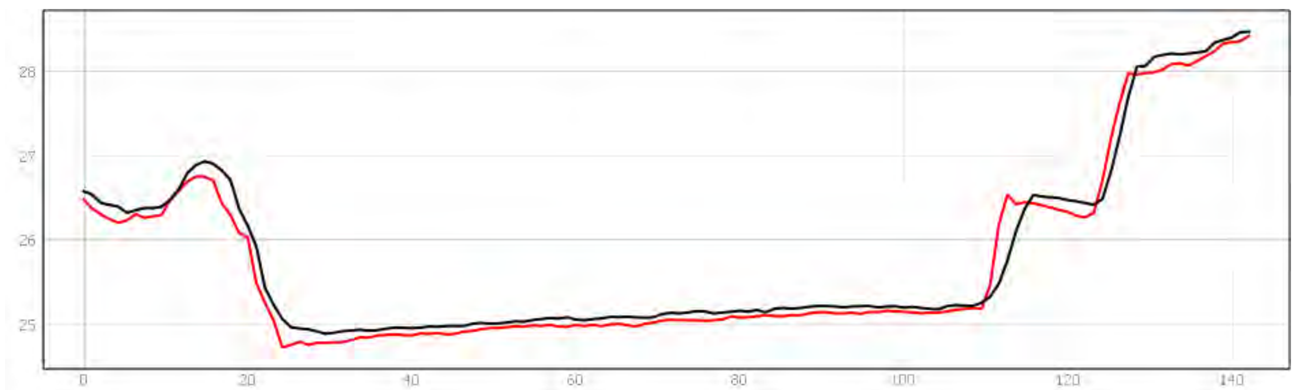


Diagram 13 – Ground Surface Elevation at Cross Section 5 (Black – 2013 LiDAR; Red – 2019 LiDAR)

Based on the cross-sections, there are no significant differences in levels between the 2013 and 2019 LiDAR within the predominant flow paths. In the absence of further information to verify the LiDAR levels (e.g., feature survey), the 2013 LiDAR was retained as it had better accuracy. To account for developments in the catchment, updated building polygons were used and checked against the latest aerial imagery.

It is worth noting that the 2013 LiDAR used by the 2017 Westmead Creek model does not match the 2013 LiDAR used by the 2017 Domain Creek model where both models overlap. While these differences are minor (+- 25 mm), these differences will contribute to small discrepancies if the models are merged or when the models are updated.

4.3.2 Building Footprints

The 2017 model accounted for building footprints by applying a high roughness value on these areas. This allowed water to flow across the footprints, thus assuming the buildings provided a level of flow conveyance as well as storage. Arcadis considers this approach to be inappropriate as it could underestimate the flood extent. Therefore, two updates were performed with respect to building footprints which were:

- Digitising building footprints that have been newly built.
- Removing buildings footprints from code 2D Domain.

4.3.3 Existing Stormwater Pipes

Council has provided a GIS layer identifying existing stormwater pipes, including information on the alignment and size. This was checked against the stormwater pipes modelled in the 2017 model.

It was found that the modelled stormwater pipes were generally consistent with the GIS layer provided by council. However, there were additional pipes modelled around the southern and northeast boundaries of the catchment, likely due to incomplete data or different asset ownership.

The drainage network was updated according to GIS information from council as well as photos taken from a site visit. These changes include:

- Changing the size of the pipe upstream of Church Avenue from 2x900DIA to 1x1050DIA
- Increasing the inflow pipe for the Sydney Smith Park basin from 1x2400Wx700H to 2x2400Wx700H

4.3.4 Other Model Features and Parameters

The TUFLOW solver was upgraded to the latest version, from 2013-12-AC to 2023-03-AB. The Classic solver with double precision was used. There is an opportunity to upgrade to the Heavily Parallelised Compute (HPC) solver with Sub-Grid Sampling (SGS) enabled. This would provide a higher definition of the terrain, potentially high grid resolutions, and smaller time steps. For complex urban assessments such as this, we recommend using the TUFLOW HPC with SGS. This could be explored in a future stage of the project.

Grid size and timesteps were maintained from the previous model. These are shown in Table 13.

Table 13 - Model grid size and timesteps

Parameter	Domain Creek Model	Westmead Creek Model
2D grid size (m)	2	2
2D timestep (seconds)	1	0.5
1D timestep (seconds)	1	0.5

Arcadis considers the grid size and timestep selected were a reasonable balance between model accuracy and simulation times. However, the hydrologic and hydraulic model updates caused instabilities in 5 of the 6 Domain Creek PMF runs. Upon interrogating the model, no clear source of the instability could be identified and therefore, no other changes to the model could be made. Hence, the 2D timestep for the Domain Creek model was reduced from 1 to 0.5 seconds for the PMF runs. This appeared to resolve the instability issues.

4.4 Model Validation

The 2017 model compared its peak flows with a MIKE 11 model by the Upper Parramatta River Catchment Trust (UPRCT). It was identified that the 2017 Westmead Creek model peak flows closely matched the UPRCT model peak flows. However, the 2017 Domain Creek model peak flows were significantly different from the UPRCT model peak flows. The reason for this is explained in Section 6.2.1 of the Holroyd City LGA Overland Flood Study report.

4.4.1 Comparison between Updated and Original Models

The net effect of all the changes to the hydrology and hydraulics is shown in Diagram 14.

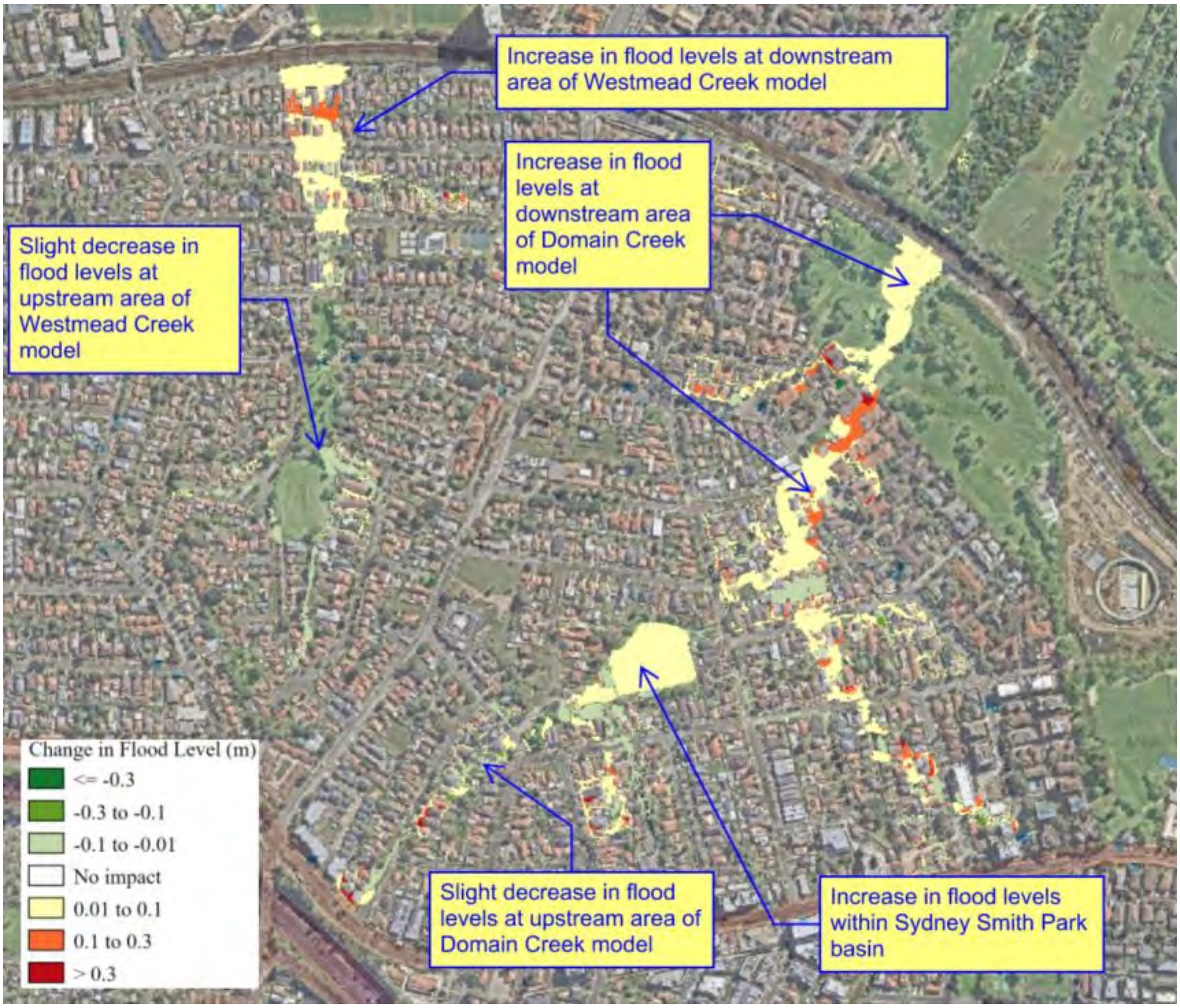


Diagram 14 – Change in 1% AEP flood level (2023 model minus 2017 model)

The increase in flood levels towards the downstream areas of the Domain Creek and Westmead Creek models is due to the reduction in flow area and storage caused by the "blocking out" of buildings from the model. This was not included in the previous model which assumed flow could be conveyed through and stored in buildings. Refer to Section 4.3.2

The increase in flood levels within the Sydney Smith Park basin is due to the increase in inlet pipe size, thus allowing more flow to enter the basin than previously modelled. Refer to Section 4.3.3.

The slight decrease in flood levels at the upstream areas of the Domain Creek and Westmead Creek models is due to the changes made to the hydrology. As discussed in Section 4.2.8, there is a general increase in runoff volume but a reduction in peak flows. A flood map identifying the change in flood level is included in Appendix C.

4.5 Existing Conditions Modelling

Hydrographs for the 10-minute to 3-hour storms for the 5%, 1%, 1% with Climate Change, 0.5% and the 0.2% AEP events were generated in the hydrological model and applied in the hydraulic model. Each storm duration had 10 temporal patterns. In addition, the PMF event was also modelled, consisting of 6 storm durations with 1 temporal pattern each. This totalled 506 storms modelled.

4.5.1 Flood Mapping

Flood envelopes to select the peak values of flood depth, flood level, velocity, flood hazard, and flood function were generated. The process of selecting peak values is discussed in Section 4.2.5. Diagram 16 shows the 1% AEP with Climate Change flood depths. Detailed flood maps are included in Appendix B.

4.5.1.1 Flood Hazard

The Australian Disaster Resilience Handbook Collection deals with floods in Handbook 7 (Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia). The supporting guideline 7-3 contains information relating to the categorisation of flood hazard. A summary of this categorisation is provided in Diagram 15.

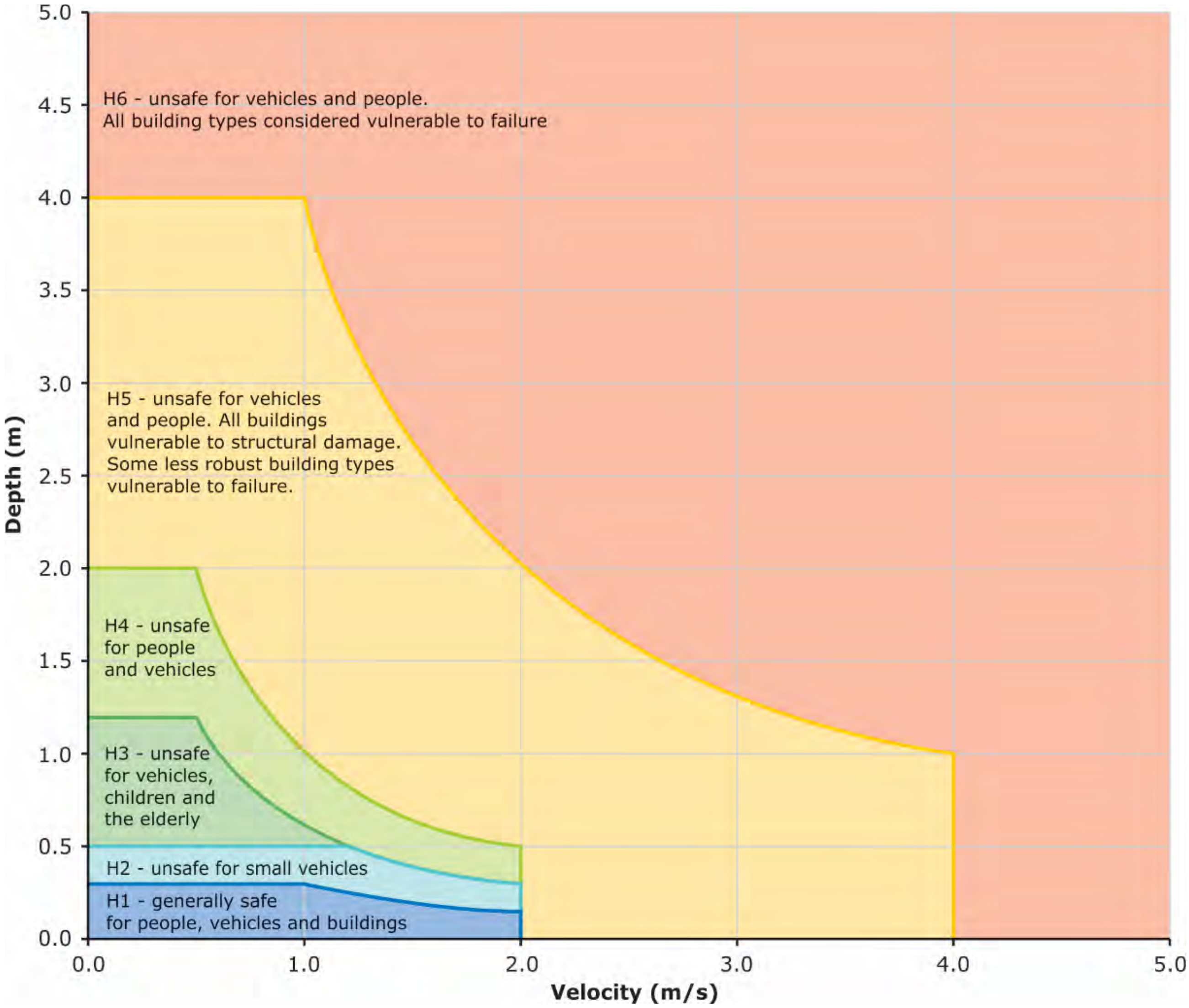


Diagram 15 – Flood Hazard Categorisation (ADR Handbook 7)

This classification provides a more detailed distinction and practical application of hazard categories, identifying the following 6 classes of hazard:

- H1 – No constraints, generally safe for vehicles, people and buildings;
- H2 – Unsafe for small vehicles;
- H3 – Unsafe for all vehicles, children and the elderly;
- H4 – Unsafe for all people and all vehicles;
- H5 – Unsafe for all people and all vehicles. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure. Buildings require special engineering design and construction; and
- H6 – Unsafe for all people and all vehicles. All building types considered vulnerable to failure.

4.5.1.2 Flood Function

With regards to flood function, additional steps were taken to classify the flood extent into the following categories:

- Floodway
- Flood storage
- Flood fringe

There is no quantitative definition of these three categories or accepted approach to differentiate between the various classifications. The delineation of these areas is somewhat subjective based on knowledge of an area and flood behaviour, hydraulic modelling and previous experience in categorising flood function. A number of approaches are available, such as the method defined by Howells et al (2003).

For this study, hydraulic categories were defined by the following criteria, based on the method by Howells et al (2003). Different thresholds were tested to understand the sensitivity of the classification to those parameters and below adopted values are considered to be a reasonable representation of the flood function of this catchment.

- Floodway is defined as areas where **either** of the conditions are met:
    - Peak value of Z0 (velocity x depth) > 0.25m^2/s **AND** peak velocity > 0.25m/s
    - Peak velocity > 1.0m/s **AND** peak depth > 0.1m

The remainder of the flood extent is either flood storage or flood fringe:

- Flood storage comprises of areas outside the floodway where peak depth > 0.2m
- Flood fringe comprises of areas outside the floodway where peak depth ≤ 0.2m

Diagram 16 - 1% AEP with Climate Change Flood Depths

4.5.2 Flood Risk Assessment

Scenario 2 proposed buildings were overlayed on the 1% AEP with climate change flood depths to assess flood risk. These are shown from Diagram 17 to Diagram 21.

It must be noted that at this stage, the flood model only considers existing conditions and the proposed buildings shown are for reference only. The inclusion of these buildings in the flood model will yield different flood levels. The flood depths and levels shown in the callouts are intended as a preliminary estimate of the required finished floor levels for the proposed buildings as well as an approximate guide of areas prone to flooding.

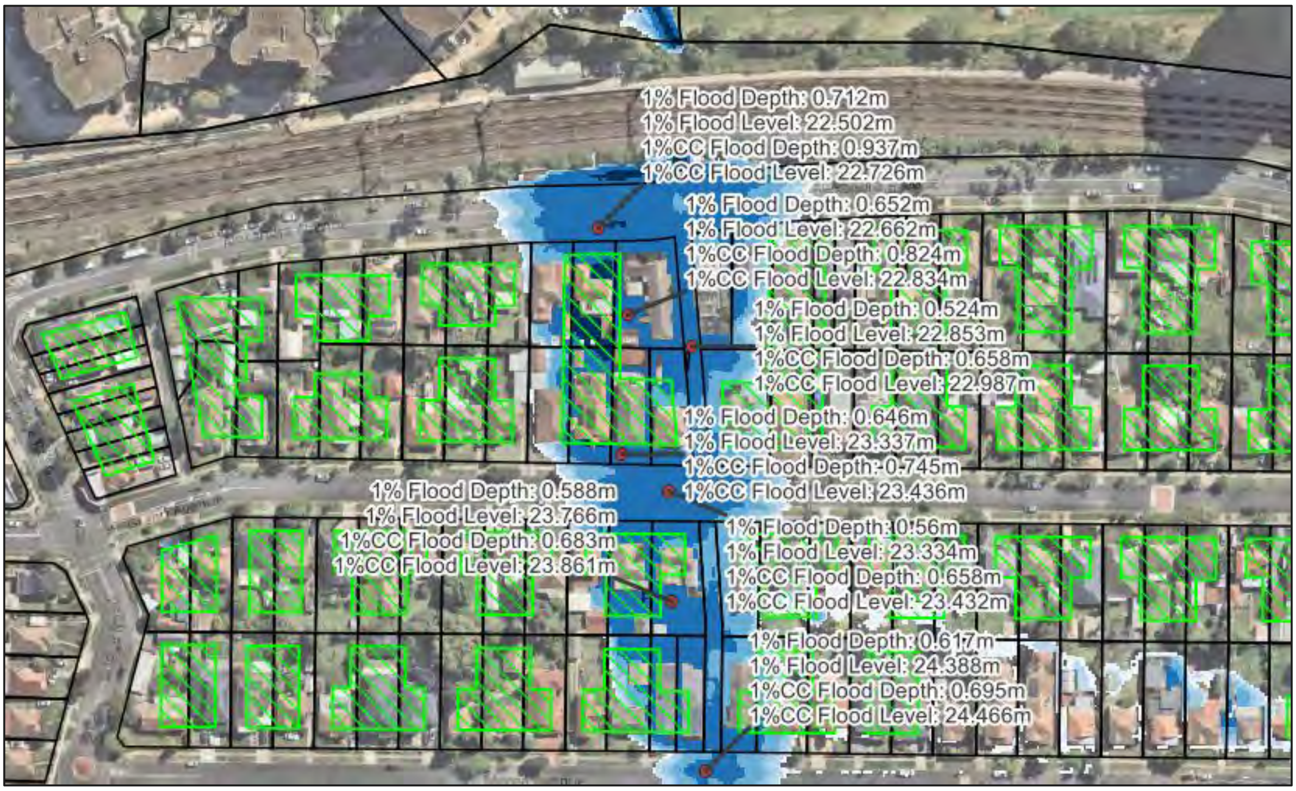


Diagram 17 – 1% AEP with Climate Change Flood Depths with Scenario 2 Buildings (Green) Overlayed at Grand Avenue, Westmead Creek

According to the recommendation from the NSW floodplain risk management manual, the finished floor levels of those residential buildings are to be set 0.5m (freeboard) above the 1% AEP with climate change flood level, as indicated in Diagram 17 and Diagram 18. Due to the topography, the proposed buildings are unlikely to change the general flood behaviour but will cause localised changes to flood levels.

The connection from Austral Avenue through to Alexandra Avenue is frequently inundated even in the 20% AEP event. Therefore, measures such as signage and warning systems must be included along the connection to ensure pedestrians and vehicles are safe and are well informed to take action during storm events.

The connection is also an ideal location for centralised WSUD assets because the catchment drains towards this area. However, further consideration in the placement and design of WSUD assets in this area is required to avoid damage of WSUD assets due to high flows. Inundation of WSUD assets is likely to scour the delicate plants and/or displace filter material or captured pollutants.

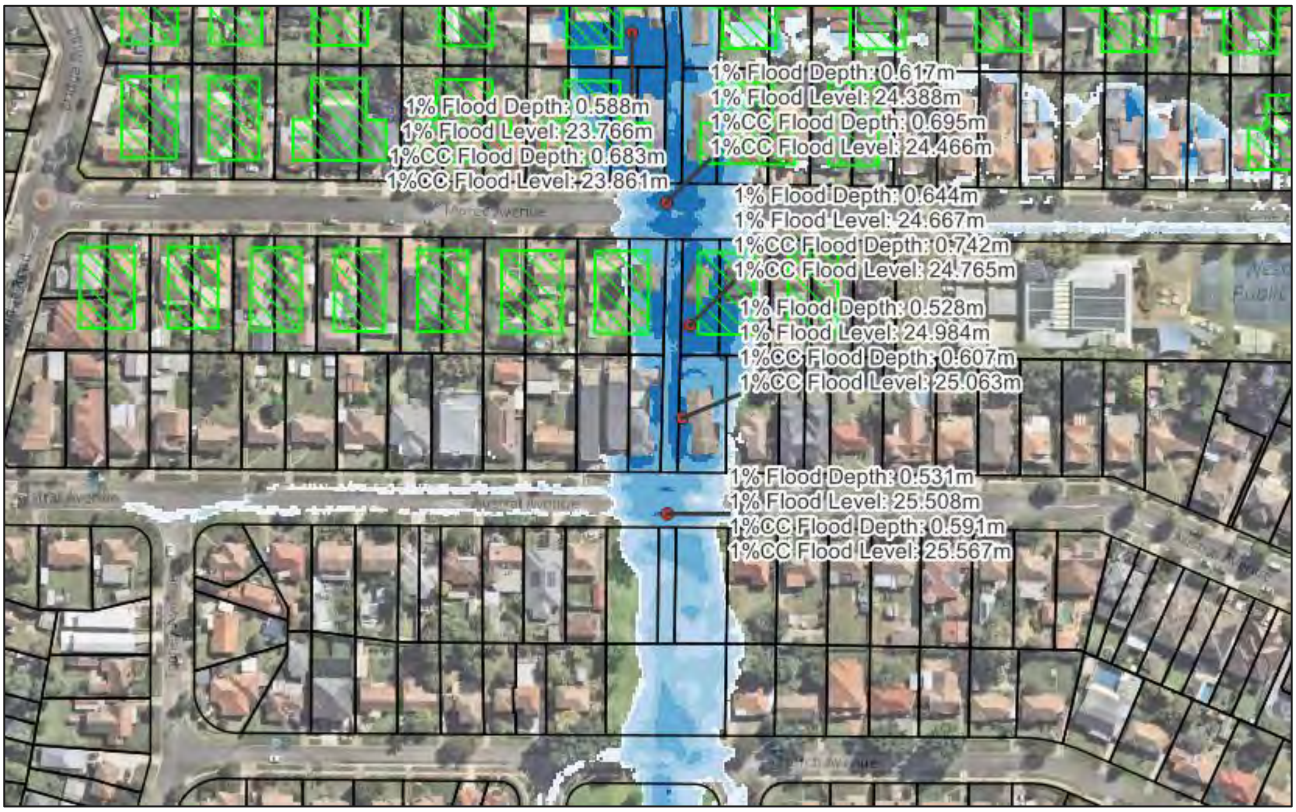


Diagram 18 – 1% AEP with Climate Change Flood Depths with Scenario 2 Buildings (Green) Overlayed at Austral Avenue, Westmead Creek

Diagram 19 shows the flood depths within Parramatta Park. The development is not likely to change the flood behaviour within Parramatta Park but will cause slight changes in flood levels.

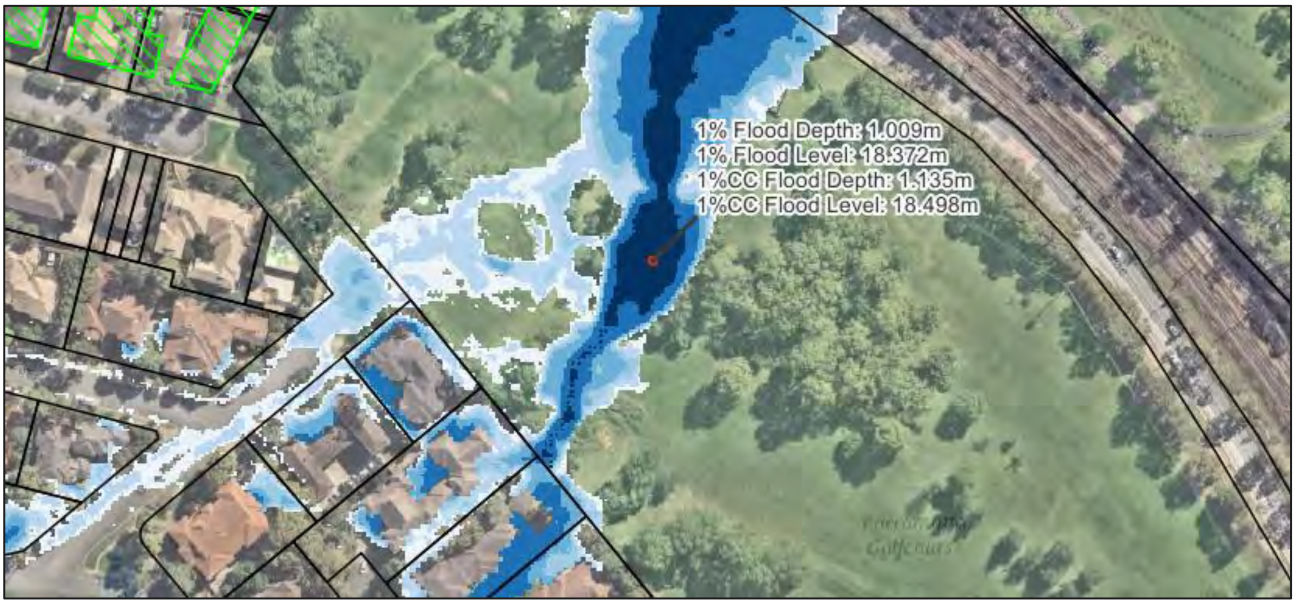


Diagram 19 - 1% AEP with Climate Change Flood Depths at Parramatta Park, Domain Creek

Diagram 20 - 1% AEP with Climate Change Flood Depths with Scenario 2 Buildings (Green) Overlayed at Thomas Clarke Street, Domain Creek

As mentioned above, the finished floor levels of those residential buildings are to be set 0.5m (freeboard) above the 1% AEP with climate change flood level, as indicated in Diagram 20. The flow behaviour in this area is generally more complex than other areas of the catchment. This is because the flow paths do not have an easement and pass directly through properties.

The changes due to the proposed buildings will likely result in significant change in the flow paths as the flow paths under existing conditions are not clearly defined or concentrated at any low point. This area will have a greater level of uncertainty with regards to the preliminary estimate of finished floor levels.

Diagram 21 - 1% AEP with Climate Change Flood Depths with Scenario 2 Buildings (Green) Overlayed at Sydney Smith Park, Domain Creek

Diagram 21 identifies the flood depths around Sydney Smith Park in the 1% AEP with climate change event. While flood depths are in excess of 1.5m within the park, this is an existing basin and therefore, is not an introduced flood risk. However, the basin was designed to contain the 1% AEP flows. Any changes to the flood behaviour that causes the basin to overflow in a more frequent event will constitute an increase in flood risk on the downstream (northeast) areas. Therefore, assessment of flow volumes and timing of the upstream areas is required to ensure flood risk is not increased in other areas of the catchment.

Similar to Diagram 20, the flow path from the southwest is not concentrated at any low point and flows through properties. Therefore, any changes due to the proposed building is likely to result in significant change to the flow paths and the preliminary estimate of finished floor levels has a greater level of uncertainty.

5 STORMWATER INFRASTRUCTURE ASSESSMENT

5.1.1 Underground Network

An assessment of the underground network indicates that most of them are full in the 20% AEP event as shown in Diagram 22. This means that the network is already at capacity and is unable to receive additional flows due to new impervious areas. Therefore, new developments need to maintain the existing impervious fraction or maintain the site discharge at existing flow rates.

Diagram 22 – Percentage full of existing stormwater pipes in the 20% AEP event

As expected, the pipes are also mostly full in the 1% AEP event Diagram 23. It should be noted that the presence of pipes that are 0 to 20% full in both the 20% AEP and 1% AEP events is due to the modelling methodology, which "injects" flow directly into some pipes.

This is a reasonable approach which assumes the capacity of the network is limited by the pipes rather than the pits. This approach also concentrates the flow path along the drainage network which is more realistic. However, the result is that some modelled pipes will not receive any flows and will seem as though additional capacity is available. It must be noted that these pipes are also likely to be at capacity and do not indicate that additional flow can be received by the network.

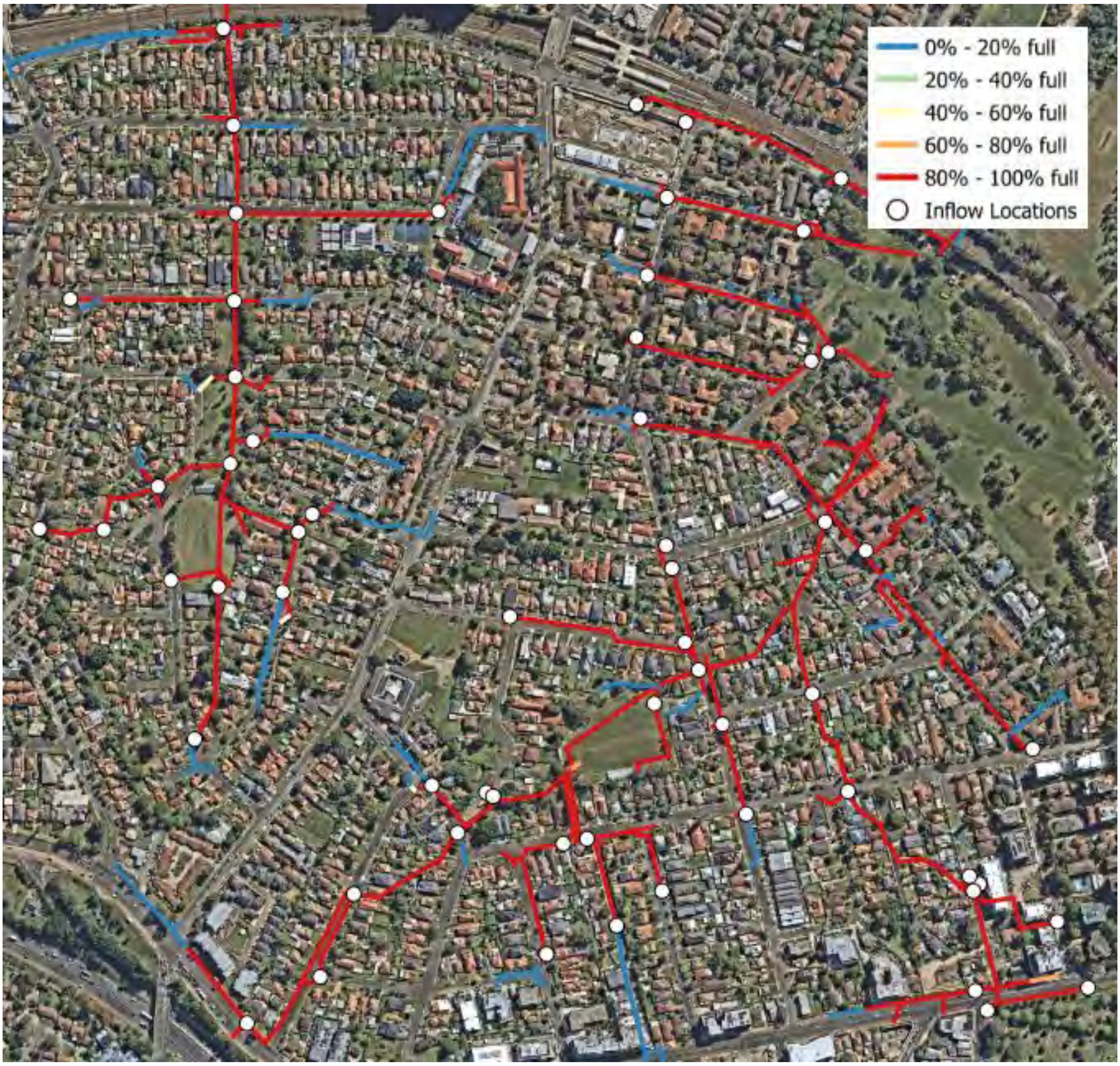


Diagram 23 - Percentage full of existing stormwater pipes in the 1% AEP event

5.1.2 Sydney Smith Park Basin

There is an existing basin within the Domain Creek catchment. The layout is shown in Diagram 24. It was designed to contain 1% AEP flows as well as capture flows during smaller events in an underground tank for irrigation purposes. For the purpose of flood assessments, the underground tank has been excluded and assumed to be full.

Diagram 24 - Layout of Sydney Smith Park Basin

Diagram 25 shows that most of the pipes are full in the 1% AEP event. The inlet pipe is activated when the downstream network is full. While the inlet pipe is not full and still has additional capacity to discharge flows into the basin, any additional flows discharged into the basin would cause higher flood levels and may engage the spillway in an event more frequent than 1% AEP. A detailed flood assessment must be undertaken to ensure the flows generated from the new developments do not introduce a new flood risk on downstream properties.

Diagram 25 - Percentage full of existing stormwater pipes in the 1% AEP event

6 INTEGRATED WATER CYCLE MANAGEMENT OPPORTUNITIES

Water is a key driver of economic and social development while it also has a basic function in maintaining the integrity of the natural environment. However, water is only one of a number of vital natural resources and it is imperative that water issues are not considered in isolation.

Managers have to make difficult decisions on water allocation. More and more they have to apportion diminishing supplies between ever-increasing demands. Drivers such as demographic and climatic changes further increase the stress on water resources. In addition, there is variability of supply through time as a result both of seasonal variation and inter-annual variation.

All too often the magnitude of variability and the timing and duration of periods of high and low supply are not predictable; this equates to unreliability of the resource which poses great challenges to water managers in particular and to societies as a whole. The natural variability can be overcome by supply-side infrastructure to assure reliable supply and reduce risks, albeit at high cost and often with negative impacts on the environment and sometimes on human health and livelihoods.

However, we are now finding that supply-side solutions alone are not adequate to address the ever-increasing demands from demographic, economic and climatic pressures. Waste-water treatment, water recycling and demand management measures are being introduced to counter the challenges of inadequate supply.

In addition to problems of water quantity there are also problems of water quality. Pollution of water sources is posing major problems for water users as well as for maintaining natural ecosystems.

In many regions the availability of water in both quantity and quality is being severely affected by climate variability and climate change, with more or less precipitation in different regions and more extreme weather events. In many regions, too, demand is increasing as a result of population growth and other demographic changes and agricultural and industrial expansion following changes in consumption and production patterns. As a result, some regions are now in a perpetual state of demand outstripping supply and in many more regions that is the case at critical times of the year or in years of low water availability.

The traditional fragmented approach is no longer viable and a more holistic approach to water management is essential. This is the rationale for the Integrated Water Cycle Management (IWCM) approach that has now been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands.

Westmead South is geographically divided into two catchments, i.e., Westmead Creek and Domain Creek catchments. The two catchments and waterways contribute to Parramatta River, which is a significant waterway affecting the Greater Sydney area. An IWCM promoting water sensitive urban design (WSUD) principles will have a great significance on local water cycle health and beneficial impact on downstream built environment and natural ecosystems.

This Section summarises the IWCM and WSUD targets based on the understanding of the precinct vision and review of existing policies and guidelines and identify potential opportunities for integration into Westmead South master plan.

6.1 Urban Water Cycle

The water cycle system in a natural catchment typically involves below processes:

- Rainfall and canopy inception
- Infiltration, evapotranspiration, and runoff generation
- Flow concentration and channel routing
- Sub-surface flow and groundwater propagation

In an urbanised area, such as Westmead South, water use and wastewater generation are integrated as additional process into the urban water cycle system. A conceptual comparison of natural and urban water cycle systems is shown in Diagram 26. Due to the increased impervious area and intensified human activities, the urbanisation alters the natural water cycle from different aspects, including:

- Reducing infiltration and evapotranspiration
- Increasing stormwater runoff volume
- Increasing peak flow and flood risks during storm events
- Deteriorating water quality

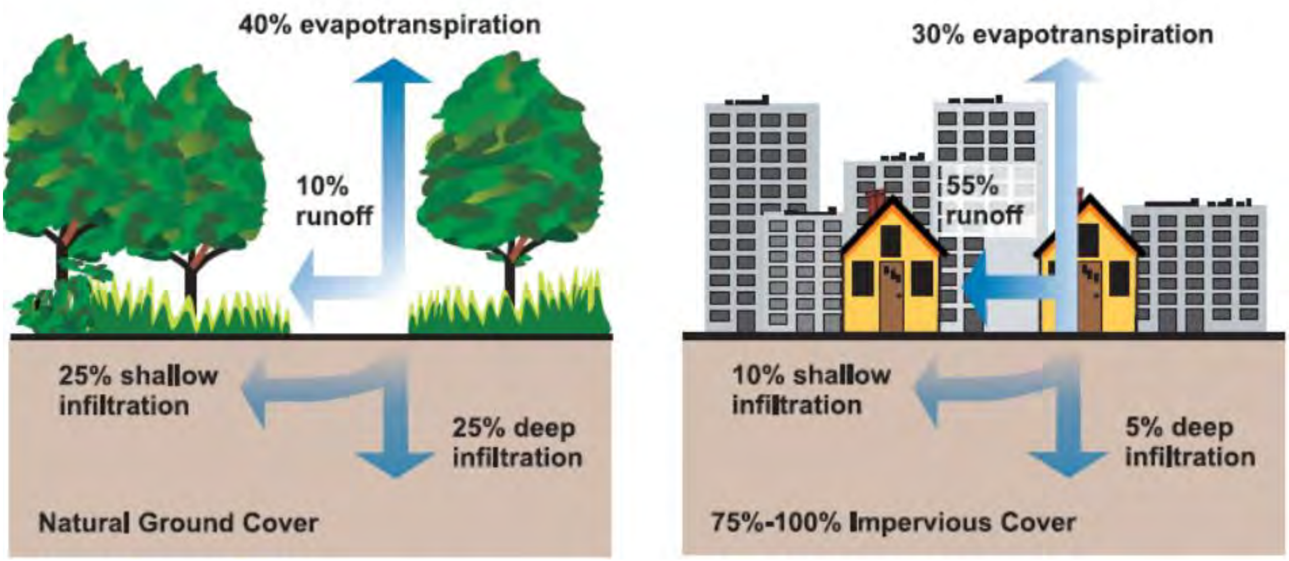


Diagram 26 - Natural and urban water cycle systems

To understand the water cycle and associated water quality and quantity budget of an urban environment, water balance analysis/modelling is typically required. A water balance analyses the input (source), output (demand) and storage changes of water within a designated system. A schematic of the type of data inputs for a water balance model is shown in Diagram 27.

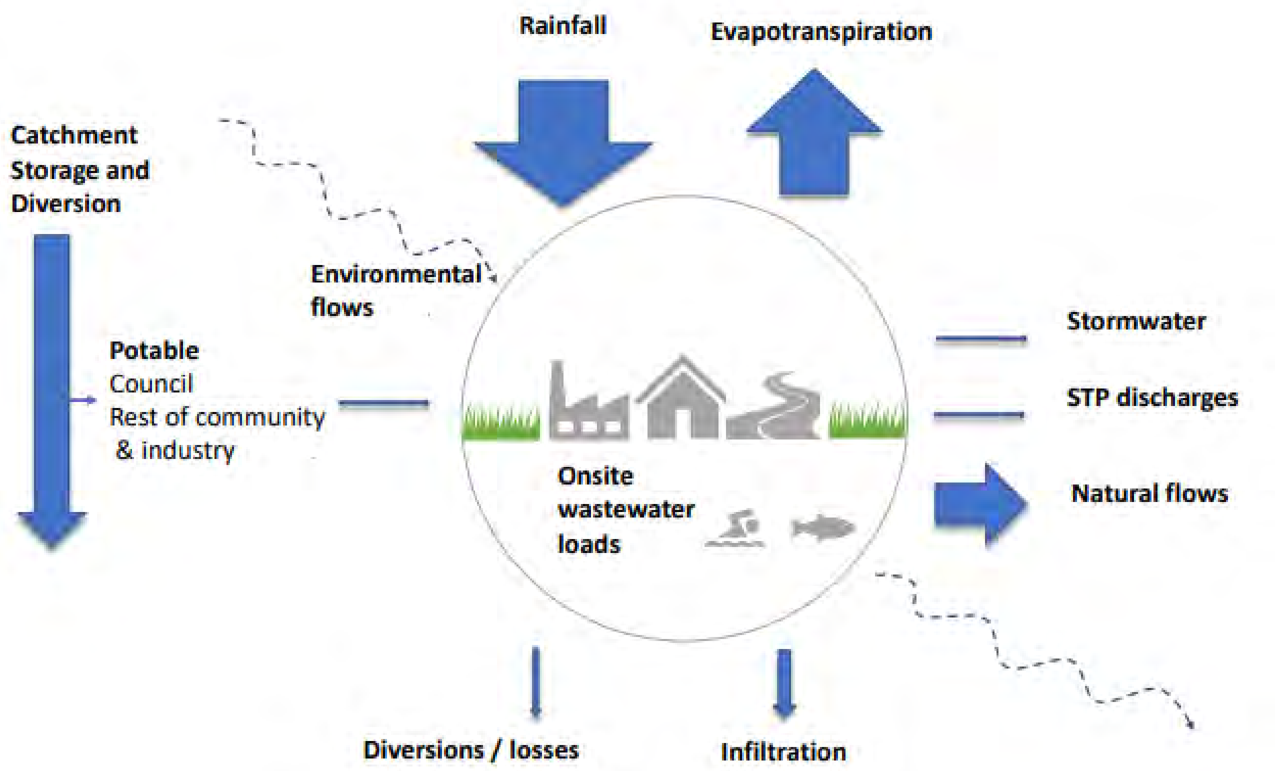


Diagram 27 – Schematics of a typical water balance analysis

6.2 WSUD Targets

Generally, WSUD aims create urban environments that allow the water cycle to function as it would naturally. As Westmead South is a fully urbanised area under existing conditions, the objective of the IWCM is defined to ensure the water cycle to perform similarly or better as it would be under pre-masterplan conditions.

Several quantitative targets need to be set up to enable that the main object is achieved. Traditionally, quantitative targets would be set for stormwater quality and stormwater peak discharge controls. With the advancement in IWCM and WSUD understanding and practices, the focus has been shifted to potable water usage/demand reduction and stormwater volume reduction.

As the findings of the IWCM strategy will be used to inform the preparation of a planning proposal to amend the Cumberland Local Environmental Plan (LEP) 2021 and the Cumberland Development Control Plan (DCP) 2021, it is critical to consider the stormwater and WSUD requirements in the current LEP and DCP. Based on the understanding of the precinct vision and review of existing policies and guidelines, including the current LEP and DCP, the preliminary WSUD targets are set out in Table 14 and Table 15. Those targets will be revisited after thorough modelling or analytical assessment, which will be the next stage of this Study, and could potentially be updated with the consideration of the site-specific conditions, which will be ultimately used to inform a precinct-specific amendment to the current LEP and DCP.

Table 14 – WSUD Targets

	Traditional	**WSUD (adopted for this Study)**
Stormwater quality	% reduction	% reduction
Stormwater peak	No-worsening	No-worsening
Stormwater volume	-	Reduction (to existing conditions)
Potable water consumption	-	% reduction, e.g., BASIX (40%) or higher

Stormwater Quality

The minimum targets for stormwater quality for Westmead South masterplan are defined in accordance with the requirements as in Cumberland DCP 2021, as summarised in Table 15. The actual treatment requirements are relevant to land use types, which will be assessed in the next stage.

Table 15 – Stormwater Quality Targets

Pollutant	Description	Reduction in Load
Litter e.g., cans, bottles, wrapping materials, food scraps	All anthropogenic materials with a minimum dimension >5mm	90%
Coarse sediment	Coarse sand and soil particles (<0.5mm diameter)	85%
Nutrients	Total phosphorous nitrogen	60%
Fine particles	Coarse sand and soil particles (<0.05mm diameter)	85%
Cooking oil and grease	Free floating oils that do not emulsify aqueous solutions	90%

Pollutant	Description	Reduction in Load
Hydrocarbons inc. motor fuels, oils and greases	Anthropogenic hydrocarbons that can be emulsified	90%

Stormwater Peak Discharge

The minimum targets for stormwater peak discharge for Westmead South masterplan are defined in accordance with the requirements as in Cumberland LEP 2021 and DCP 2021, as summarised as follows:

- On-site detention shall be required for all proposed development, re-development or new land subdivisions, except where:
  - The proposal is a one-off extension up to 150 m^2 impervious area for industrial or commercial development. Subsequent extensions require on-site detention facility.
  - Dwelling and secondary dwelling developments and any ancillary residential developments.
- The permissible site detention (PSD) and site storage requirements (SSR) shall comply with the Upper Parramatta River Catchment Trust requirements.
- Alternative values for the required storage volume can be considered for larger sites greater than 3,000 m^2 if the applicant demonstrates to Council's satisfaction using appropriate computer modelling that the relevant PSD shall be satisfied.
- Stormwater runoff from all new roof areas shall be routed through the OSD facility. Runoff entering the site from upstream and adjoining properties shall be directed bypassing the on-site detention system.

Stormwater Volume

There is no explicit quantitative target defined in Cumberland LEP 2021 and DCP 2021. However, the requirements of rainwater tanks, as promoted for water reuse target (see below section), will contribute to stormwater volume reduction.

In accordance with the Westmead Precinct strategic vision, i.e., 'District in Nature', and the vision for water, the preliminary target to stormwater volume is defined as:

- Stormwater volume to be maintained to existing/pre-masterplan conditions.

Potable Water Consumption

The minimum targets for potable water demand for Westmead South masterplan are defined in accordance with the requirements as in Cumberland DCP 2021 and BASIX, as summarised as follows:

- Promoting the use of water efficient appliances, e.g., 4 stars or above as rated through Water Efficiency Labelling and Standards (WELS) Scheme.
- For all developments (excluding single dwellings and dual occupancies), rainwater tanks or a water reuse device shall be incorporated into the stormwater drainage system with a minimum storage size of 5,000 L (for site area less than 1,500 m^2) and 10,000 L (for site area greater than 1500 m^2).
- For dwelling houses (includes alterations and additions) exceeding 65% impervious area, a minimum capacity of 4,000 litres shall be provided, or that amount required by BASIX.
  - The water section of BASIX aims to reduce the potable water consumption of all new residential developments. The benchmark is 90,340 L of water per person per year (or 247 L per person per day), which was the average potable water consumption of a pre-BASIX home.
  - The **40% reduction** target applies to 90% of new residential development and 98% of high-growth areas.

In the next stage of this Study, the rainwater tanks / reuse devices required in DCP 2021 will be assessed together with the effect of using water efficient appliances against the 40% potable water consumption reduction target. The final adopted targets for Westmead South will be updated (40% or higher) based on the modelling assessment.

6.3 WSUD Opportunities for Future Westmead South

There are a range of water management measures can be used to promote IWCM and WSUD principles. The range of water management options and scale of implementation can be summarised as in Table 16.Table 16 – Water Management Options

	SCALE			
MANAGEMENT TECHNIQUE	Regional	Precinct (PSP)	Development /Local	Domestic / Household
Aquifer Recharge and Rural Reuse				
Retarding Basins				
Purple pipe				
Potable Water				
Wetlands				
Sewerage Treatment & Recycled Water Plants				
Dams				
Rivers & Creeks				
Sewer Mining				
Stormwater capture and reuse				
Pricing				
Aquifer Recharge and Urban Reuse				
Land Use Layout & Green space				
Sediment traps				
Bio-retention systems				
Swales				
Local run off treatments				
Litter traps				
Infiltration trenches				
Porous Paving				
Rain Gardens				
Greywater Reuse				
Rainwater Capture (roofs) and re use				
Inspection and monitoring				
Rooftop greening				
Onsite domestic sewerage treatment and reuse				
Education				

A high-level screening of management options was undertaken against the draft Master Plan (Diagram 3). As the IWCM strategy to be developed as part of this Study will be used to inform the precinct planning and development control, i.e., amending DCP, the options suitable for precinct, development, and household scales were considered. With the consideration of existing waterways, masterplan, and local guidelines, the following measures have been preliminarily identified for assessment in next stage:

- Water efficient appliances
- Rainwater / Underground tanks
- Green roofs
- Porous pavement
- Tree pits
- Infiltration trenches or swales
- Raingardens

A preliminary high-level plan for the potential locations of the selected WSUD measures is shown in Diagram 28.

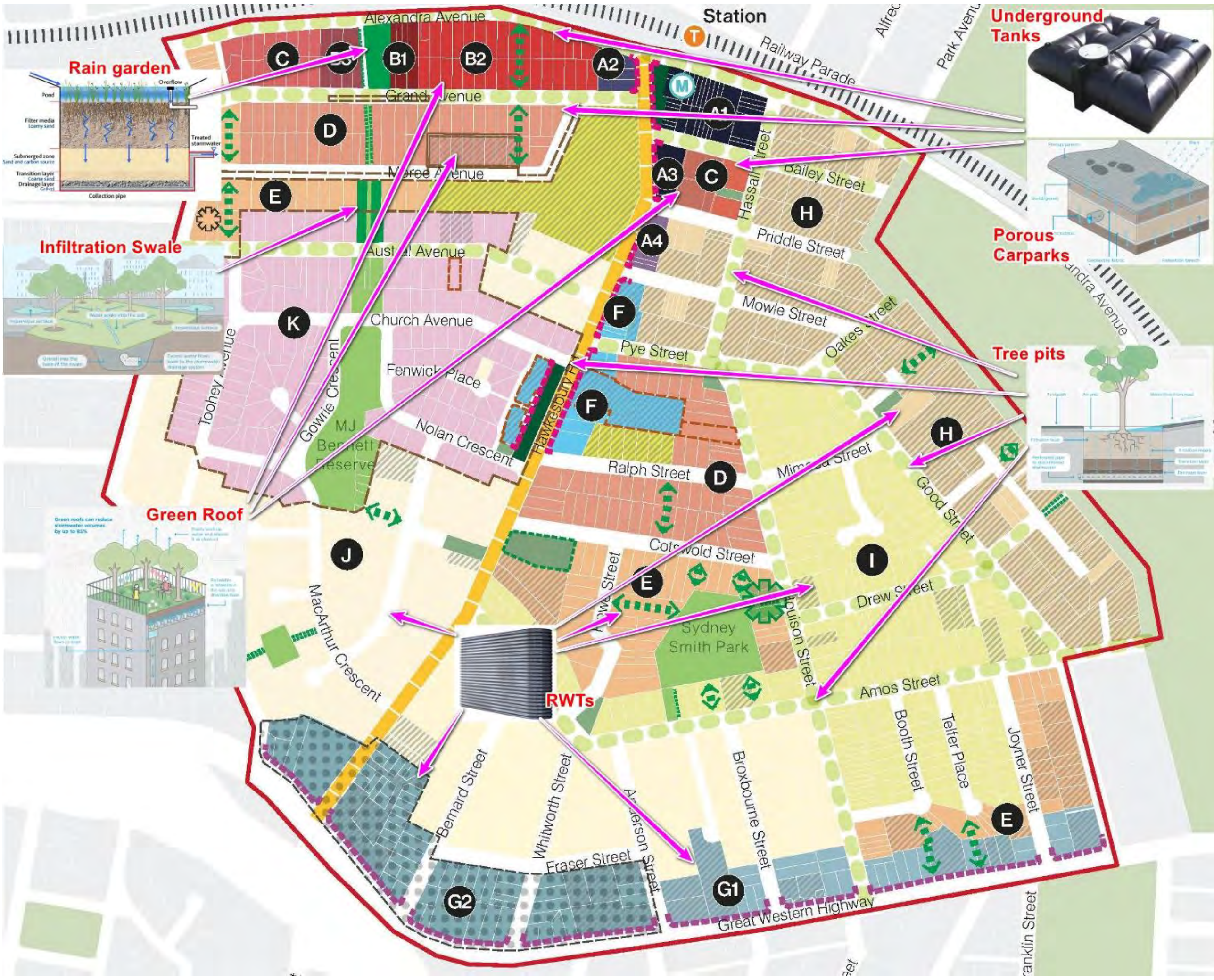


Diagram 28 – High-level plan for WSUD measures

6.3.1 Water Efficient Appliances

Water efficiency within new developments should be implemented in line with BASIX and green star rating requirements. Water efficient appliances and fixtures, e.g., hot water systems, shower heads, washing machines, and toilets, will save water, energy, and associated cost. Solar heated hot water systems are also encouraged. It is recommended to achieve 4 stars or above as rated through Water Efficiency Labelling and Standards (WELS) Scheme for new developments.

6.3.2 Rainwater / Underground Tanks

The use of rainwater tanks can reduce potable water demand, reduce stormwater runoff volumes, and improve stormwater quality. Rainwater tanks are recommended to be plumbed to all non-potable internal uses such as toilets, laundry and hot water units as well as used for garden/lawn irrigation. The reduction in stormwater volume will help to reduce the pressure on the precinct drainage system and the impact on receiving waterways.

Rainwater tanks are specifically required for new development as defined in Cumberland DCP 2021. This should be carried on for Westmead South master planning. Above ground rainwater tanks are considered to be suitable for single dwelling houses, town houses, or low-rise apartments, e.g., Zones E, F, J (Diagram 28). For the high-rise apartments, e.g., Zones A, B, C, D (Diagram 28), the potable water demand will be relatively high and there will be limited space to accommodate above-ground tanks, therefore, bigger size underground tanks are recommended for rainwater harvesting.

6.3.3 Green Roofs

A green roof enables a building rooftop to be partially or completely covered with vegetation and a growing medium. It can also include additional layers such as a root barrier and drainage and irrigation systems. Diagram 29 shows an example of typical green roof of a high-rise building.

A green roof can cool the roof, increase the 'permeability' of a building, absorb and retain rainwater, and thus reduce stormwater runoff in urban environments. It can be used together with or as an alternative to rainwater tanks. The potential and effectiveness of using green roofs will be further assessed in next stage for the high-rise apartments, e.g., Zones A, B, C, D (Diagram 28).

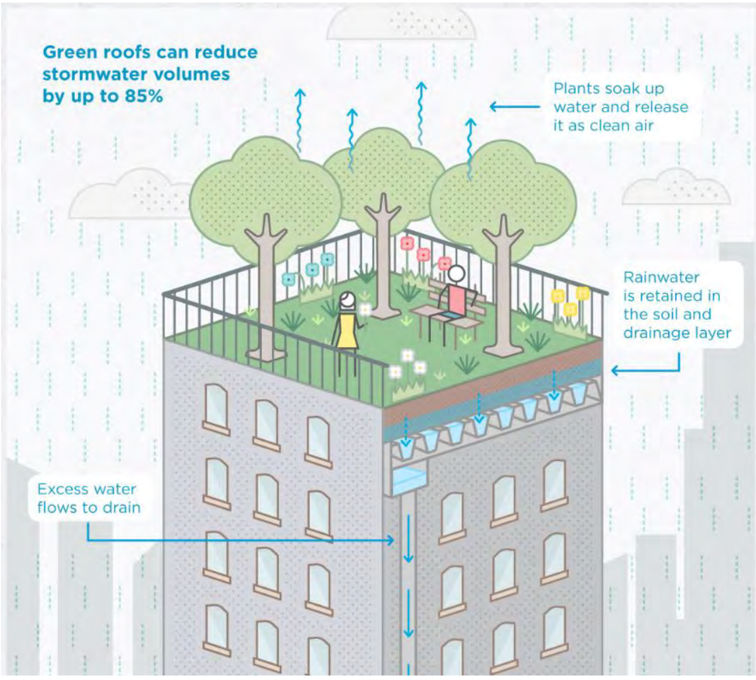


Diagram 29 – Schematics of green roof

6.3.4 Porous Pavement

Porous pavement (permeable pavement) enables rainfall to infiltrate through the permeable media (layer) into the soil below. The infiltrated water recharges soil moisture and ground water. By directing stormwater away from the drainage system, porous pavement reduces the discharge volume, delay the peak, and mitigate associated flood risk. Diagram 30 shows the schematic of a typical porous pavement and an example of a constructed permeable carpark.

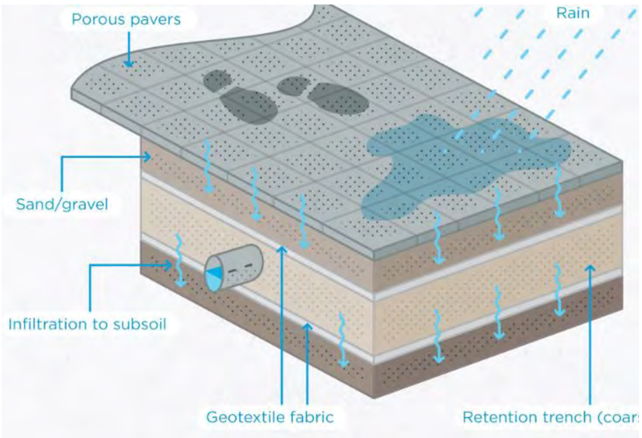


Diagram 30 – Schematics of porous pavement (left) and example of constructed permeable carpark (right)

The porous pavement, e.g., carparks, are recommended for the high-rise apartments, e.g., Zones A, B, C, D (Diagram 28) and will be further investigated through modelling exercise.

6.3.5 Tree Pits

Tree pits are suitable for water sensitive road design in urban areas. The street tree is lowered, typically below the invert of the kerb, to allow stormwater runoff from kerb and channel to enter the tree pit through inlet structure and filter through the vegetated media.

As noted in Cumberland Tree Strategy (Cumberland City Council, 2020), a raingarden tree pit system removes pollution from stormwater before entering waterways, reduces the amount of water required to support the tree in a compact small design suitable for urban areas. A raingarden tree pit has a temporary ponding, i.e., extended detention, above the filter media providing additional treatment within a small space. The specific tree inlet takes advantage of kerbside stormwater runoff. It captures stormwater through grate and/or permeable paving and use the water to passively irrigate the street trees.

Diagram 31 shows the schematic of a typical tree pit and an example of an inlet structure to capture water. Tree pits are recommended to be incorporated to all the new/upgraded road design in Westmead South.

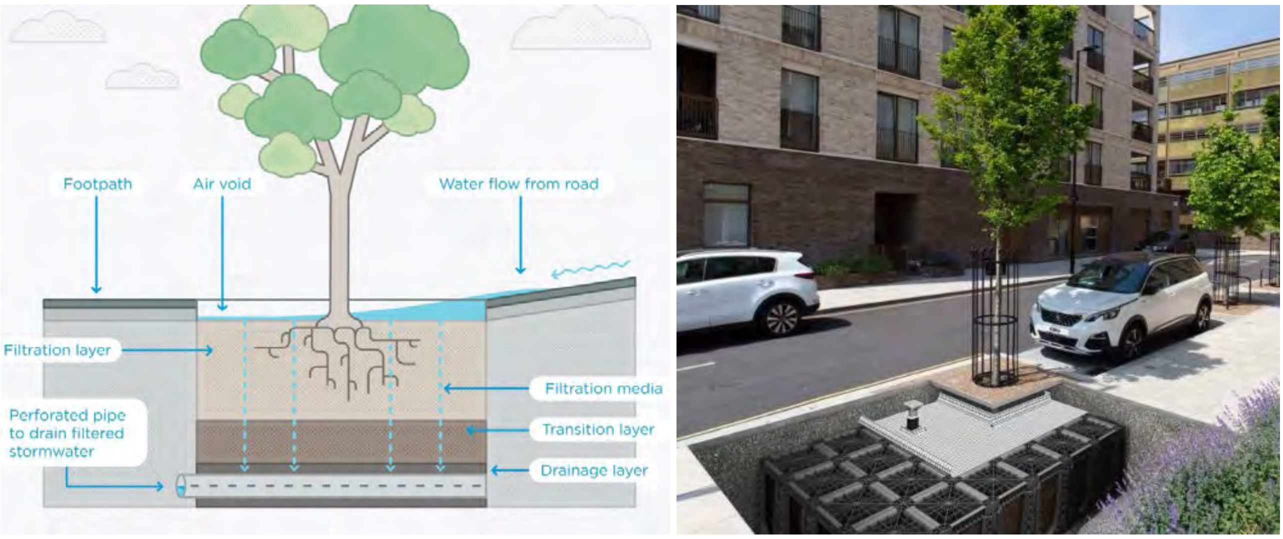


Diagram 31 – Schematics of tree pit (left) and example of the inlet structure (right)

6.3.6 Infiltration Trenches/Swales

An infiltration trench is an excavation filled with porous material, e.g., rock screenings. An infiltration swale is a swale with infiltration trench at the bottom of the swale, which allows longer extended detention than a normal trench to improve the infiltration and pollution removal.

Stormwater is directed into the infiltration trench/swale through a primary filter that retains sediment, litter and organic matter. The collected stormwater is utilised by vegetation grown in or around the trench and infiltrates into the surrounding soil. Similar to tree pits, Infiltration trenches/swales are suitable for passive irrigation of streetscape trees and vegetation. Diagram 32 shows a typical schematic of an infiltration swale. Infiltration trenches/swales are recommended along the green links along the main waterways, which will be further assessed through modelling exercise in the next stage.

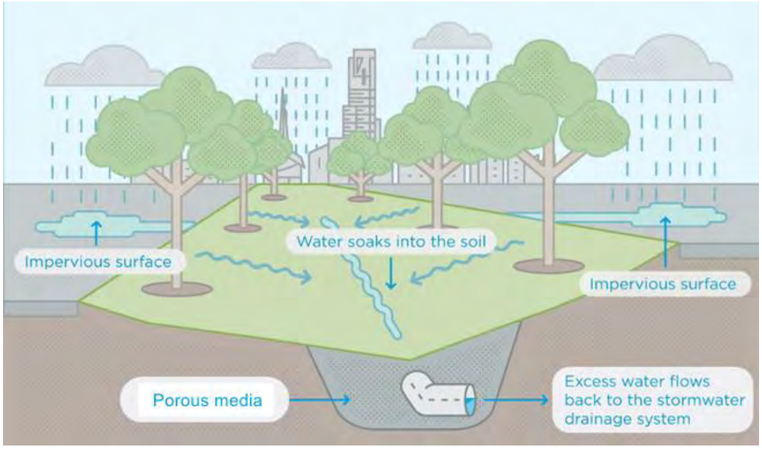


Diagram 32 – Schematics of an infiltration swale

6.3.7 Raingardens

A raingarden, or bioretention/biofiltration system, is a garden bed that uses plants and soils to capture, filter and clean stormwater. It is typically filled with vegetated sandy soil media, which improve the stormwater quality by allowing it to pond on the vegetated surface, then slowly infiltrate through the sandy soil media. Treated water is captured at the base of the system, which can be partially recharged into the soil and groundwater and partially discharged into underground drainage systems. Diagram 33 shows a typical schematic of a raingarden.

Raingardens are recommended to be fitted into the open spaces. For instance, there is limited space for a constructed wetland along the Westmead Creek upstream of the railway line, but a raingarden could be a good fit. This will be further investigated in the next stage.

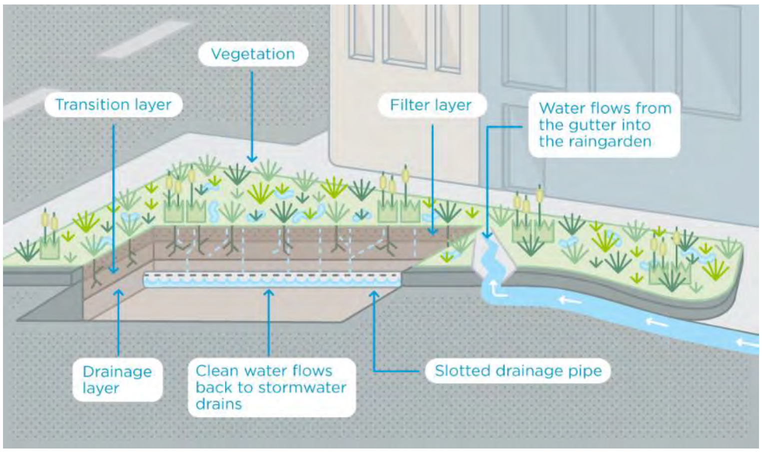


Diagram 33 – Schematics of a raingarden

6.4 Soil Permeability

The WSUD options with infiltration function, e.g., porous pavement, tree pits, infiltration systems, etc., can be designed with high hydraulic conductivity fillings, allowing water traveling through. However, the effectiveness and efficiency of those facilities are restricted by the permeability of the receiving soil. Therefore, it is critical to understand the soil type and permeability of the study area. The hydraulic conductivity of typical Australian soil types is detailed in Table 17**.**

Table 17 – Typical soil types and associated hydraulic conductivity

Soil Type	Saturated Hydraulic Conductivity (mm/hr)
Coarse Sand	> 360
Sand	180 to 360
Sandy Loam	36 to 180
Sandy Clay	3.6 to 36
Medium Clay	0.36 to 3.6
Heavy Clay	0.0036 to 0.36

The soil texture grids for the study area were obtained from Soil and Landscape Grid of Australia[1]. The average percentages of soil particles for the area are approximately:

- sand – 50%
- clay – 35%
- silt – 15%

Based on the soil texture data, the soil type of the area can be classified into Sandy Clay or Sandy Clay Loam, indicating the saturated hydraulic conductivity is 3.6 to 36 mm/hr. This will be used for modelling assessment in the next stage to ensure that the effectiveness of infiltration based WSUD opportunities is suitably represented.

[1] https://esoil.io/TERNLandscapes/Public/Pages/SLGA/

7 CONCLUSION

This report presents the background and contextual study (Stage 1) of Flooding, Water Quality & Stormwater Study for Westmead South Precinct Master Planning.

Council adopted hydrologic and hydraulic models (Lyall and Associates, 2017) were updated to ARR 2019 and current existing conditions. Flood level contours, depth, velocity, hazards, and function categories were mapped for 5%, 1%, 0.5%, 0.2%, 1% with climate change, and PMF for existing conditions. Flood risk assessment was conducted for the preferred master plan (Scenario 2).

The capacity of the existing underground drainage network was assessed for minor (20% AEP) and major (1% AEP) events, indicating most of the drainage pipes are full or nearly full during minor events.

The IWCM and WSUD objectives and potential opportunities were reviewed and nominated based on the geological characteristics, relevant background studies, existing policies, and the preferred master plan.

The developed conditions based on the master plan, pending on further refinement by the Urban Design team, will be assessed in the next stage. This includes:

- Flood impact and mitigation assessment
- Stormwater management plan and assessment
- IWCM plan and assessment

REFERENCES

Australian Institute for Disaster Resilience, *Australian Disaster Resilience Guideline 7-3 Flood Hazard – Supporting document for the implementation of Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*, 2017

Cumberland City Council, *Development Control Plan*, 2021

Cumberland City Council, *Cumberland Local Environmental Plan*, 2021

Cumberland City Council, *Cumberland Open Space and Recreation Strategy 2019–2029*, 2019

Cumberland City Council, *Cumberland Urban Tree Strategy*, 2020

Greater Cities Commission, *Westmead Health and Innovation District Public Domain Strategy*, 2022

Howells, L., McLuckie, D., Collings, G. and Lawson, N., *Defining the Floodway – Can One Size Fit All?* Floodplain Management Authorities of NSW 43rd Annual Conference, Forbes, 2003

Lyall & Associates, *Holroyd City LGA Overland Flood Study*, 2017

APPENDIX A IMPERVIOUS FRACTIONS FOR SUB-CATCHMENTS

Table A 1 - Fractions used in DRAINS (2017 Model)

Name	Paved	Supplementary	Grassed
Dom_01	0.4	0	0.6
Dom_02	0.4	0	0.6
Dom_03	0.8	0	0.2
Dom_04	0.4	0	0.6
Dom_05	0.4	0	0.6
Dom_06	0.4	0	0.6
Dom_07	0.4	0	0.6
Dom_08	0.4	0	0.6
Dom_09	0.4	0	0.6
Dom_10	0.4	0	0.6
Dom_11	0.4	0	0.6
Dom_12	0.4	0	0.6
Dom_13	0.4	0	0.6
Dom_14	0.4	0	0.6
Dom_15	0.4	0	0.6
Dom_16	0.35	0	0.65
Dom_17	0.4	0	0.6
Dom_18	0.4	0	0.6
Dom_19	0.2	0	0.8
Dom_20	0.4	0	0.6
Dom_21	0.4	0	0.6
Dom_22	0.4	0	0.6
Dom_23	0.7	0	0.3
Dom_24	0.8	0	0.2

Name	Paved	Supplementary	Grassed
Dom_25	0.6	0	0.4
Dom_26	0.4	0	0.6
Dom_27	0.3	0	0.7
Dom_28	0.4	0	0.6
Dom_29	0.3	0	0.7
Dom_30	0.4	0	0.6
Dom_31	0.4	0	0.6
Dom_32	0.4	0	0.6
Dom_33	0.3	0	0.7
Dom_34	0	0	1
Dom_35	0.75	0	0.25
Dom_36	0.25	0	0.75
Dom_37	0.4	0	0.6
Dom_38	0.4	0	0.6
Dom_39	0.4	0	0.6
Dom_40	0.4	0	0.6
Dom_41	0.4	0	0.6
Dom_42	0.4	0	0.6
Wes_001	0.4	0	0.6
Wes_0010	0.4	0	0.6
Wes_002	0.4	0	0.6
Wes_003	0.35	0	0.65
Wes_004	0.4	0	0.6
Wes_005	0.55	0	0.45
Wes_006	0.4	0	0.6
Wes_007	0.2	0	0.8
Wes_008	0.4	0	0.6

Name	Paved	Supplementary	Grassed
Wes_009	0.4	0	0.6
Wes_011	0.4	0	0.6
Wes_012	0.4	0	0.6
Wes_013	0.65	0	0.35
Wes_014	0.4	0	0.6
Wes_015	0.4	0	0.6
Wes_016	0.4	0	0.6
Wes_017	0.4	0	0.6
Wes_018	0.4	0	0.6

Table A 2 - Fractions of ARR2019 Surface Types

Name	TIA	EIA	ICA	PA
Dom_01	0.732	0.437	0.541	0.022
Dom_02	0.529	0.317	0.683	0
Dom_03	0.724	0.434	0.566	0
Dom_04	0.542	0.325	0.675	0
Dom_05	0.466	0.280	0.720	0
Dom_06	0.664	0.431	0.569	0
Dom_07	0.844	0.619	0.381	0
Dom_08	0.785	0.471	0.529	0
Dom_09	0.820	0.528	0.472	0
Dom_10	0.800	0.480	0.520	0
Dom_11	0.800	0.480	0.520	0
Dom_12	0.799	0.480	0.520	0
Dom_13	0.820	0.529	0.471	0
Dom_14	0.800	0.480	0.520	0
Dom_15	0.651	0.390	0.610	0

Name	TIA	EIA	ICA	PA
Dom_16	0.608	0.377	0.586	0.037
Dom_17	0.669	0.402	0.598	0
Dom_18	0.673	0.404	0.596	0
Dom_19	0.628	0.377	0.623	0
Dom_20	0.822	0.534	0.466	0
Dom_21	0.479	0.288	0.712	0
Dom_22	0.493	0.296	0.704	0
Dom_23	0.538	0.323	0.677	0
Dom_24	0.829	0.549	0.451	0
Dom_25	0.622	0.373	0.618	0.009
Dom_26	0.800	0.480	0.520	0
Dom_27	0.587	0.351	0.362	0.287
Dom_28	0.767	0.460	0.533	0.007
Dom_29	0.701	0.481	0.354	0.165
Dom_30	0.635	0.406	0.594	0
Dom_31	0.800	0.480	0.520	0
Dom_32	0.843	0.583	0.417	0
Dom_33	0.730	0.553	0.278	0.169
Dom_34	0.177	0.106	0.125	0.769
Dom_35	0.800	0.480	0.520	0
Dom_36	0.309	0.161	0.472	0.367
Dom_37	0.642	0.422	0.578	0
Dom_38	0.406	0.240	0.707	0.053
Dom_39	0.548	0.329	0.671	0
Dom_40	0.738	0.527	0.473	0
Dom_41	0.485	0.291	0.709	0
Dom_42	0.628	0.424	0.576	0

Name	TIA	EIA	ICA	PA
Wes_001	0.560	0.341	0.659	0
Wes_0010	0.501	0.297	0.645	0.058
Wes_002	0.489	0.293	0.698	0.009
Wes_003	0.448	0.259	0.595	0.146
Wes_004	0.575	0.360	0.640	0
Wes_005	0.674	0.420	0.555	0.025
Wes_006	0.472	0.282	0.663	0.055
Wes_007	0.296	0.150	0.431	0.419
Wes_008	0.379	0.224	0.714	0.062
Wes_009	0.518	0.311	0.689	0
Wes_011	0.492	0.295	0.705	0
Wes_012	0.489	0.293	0.698	0.009
Wes_013	0.717	0.430	0.570	0
Wes_014	0.492	0.295	0.705	0
Wes_015	0.481	0.288	0.712	0
Wes_016	0.489	0.294	0.706	0
Wes_017	0.538	0.323	0.677	0
Wes_018	0.477	0.286	0.714	0

Table A 3 - Fractions used in DRAINS (2023 Model)

Name	EIA	RIA	PA
Dom_01	0.437	0.294	0.269
Dom_02	0.317	0.211	0.472
Dom_03	0.434	0.289	0.277
Dom_04	0.325	0.217	0.458
Dom_05	0.280	0.186	0.534
Dom_06	0.431	0.233	0.336

Name	EIA	RIA	PA
Dom_07	0.619	0.224	0.157
Dom_08	0.471	0.314	0.215
Dom_09	0.528	0.292	0.180
Dom_10	0.480	0.320	0.200
Dom_11	0.480	0.320	0.200
Dom_12	0.480	0.320	0.200
Dom_13	0.529	0.291	0.180
Dom_14	0.480	0.320	0.200
Dom_15	0.390	0.260	0.350
Dom_16	0.377	0.231	0.392
Dom_17	0.402	0.268	0.330
Dom_18	0.404	0.269	0.327
Dom_19	0.377	0.251	0.372
Dom_20	0.534	0.288	0.178
Dom_21	0.288	0.192	0.520
Dom_22	0.296	0.197	0.507
Dom_23	0.323	0.215	0.462
Dom_24	0.549	0.280	0.171
Dom_25	0.373	0.249	0.378
Dom_26	0.480	0.320	0.200
Dom_27	0.351	0.236	0.413
Dom_28	0.460	0.307	0.233
Dom_29	0.481	0.220	0.299
Dom_30	0.406	0.229	0.365
Dom_31	0.480	0.320	0.200
Dom_32	0.583	0.260	0.157
Dom_33	0.553	0.176	0.271

Name	EIA	RIA	PA
Dom_34	0.106	0.071	0.823
Dom_35	0.480	0.320	0.200
Dom_36	0.161	0.148	0.691
Dom_37	0.422	0.220	0.358
Dom_38	0.240	0.166	0.594
Dom_39	0.329	0.219	0.452
Dom_40	0.527	0.211	0.262
Dom_41	0.291	0.194	0.515
Dom_42	0.424	0.204	0.372
Wes_001	0.341	0.219	0.440
Wes_0010	0.297	0.204	0.499
Wes_002	0.293	0.196	0.511
Wes_003	0.259	0.189	0.552
Wes_004	0.360	0.216	0.424
Wes_005	0.420	0.254	0.326
Wes_006	0.282	0.190	0.528
Wes_007	0.150	0.147	0.703
Wes_008	0.224	0.156	0.620
Wes_009	0.311	0.207	0.482
Wes_011	0.295	0.197	0.508
Wes_012	0.293	0.196	0.511
Wes_013	0.430	0.287	0.283
Wes_014	0.295	0.197	0.508
Wes_015	0.288	0.192	0.520
Wes_016	0.294	0.196	0.510
Wes_017	0.323	0.215	0.462
Wes_018	0.286	0.191	0.523

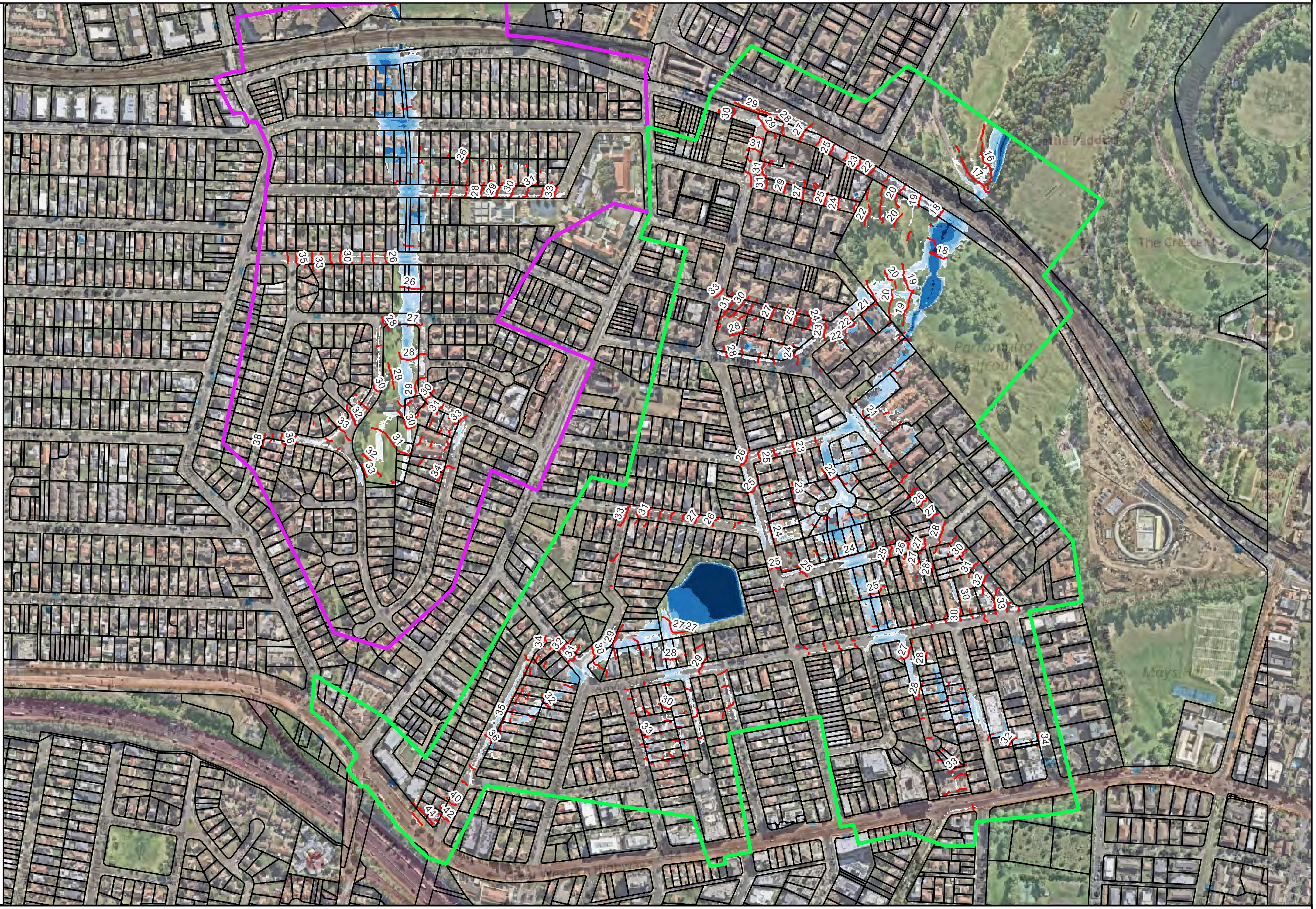
APPENDIX B EXISTING CONDITIONS FLOOD MAPS

Figure B-1 - 5% AEP Flood Depths with Flood Level Contours
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary
- Flood Level Contours (mAHD)

Flood Depths (m)
- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00



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0 200 400 600 800 m

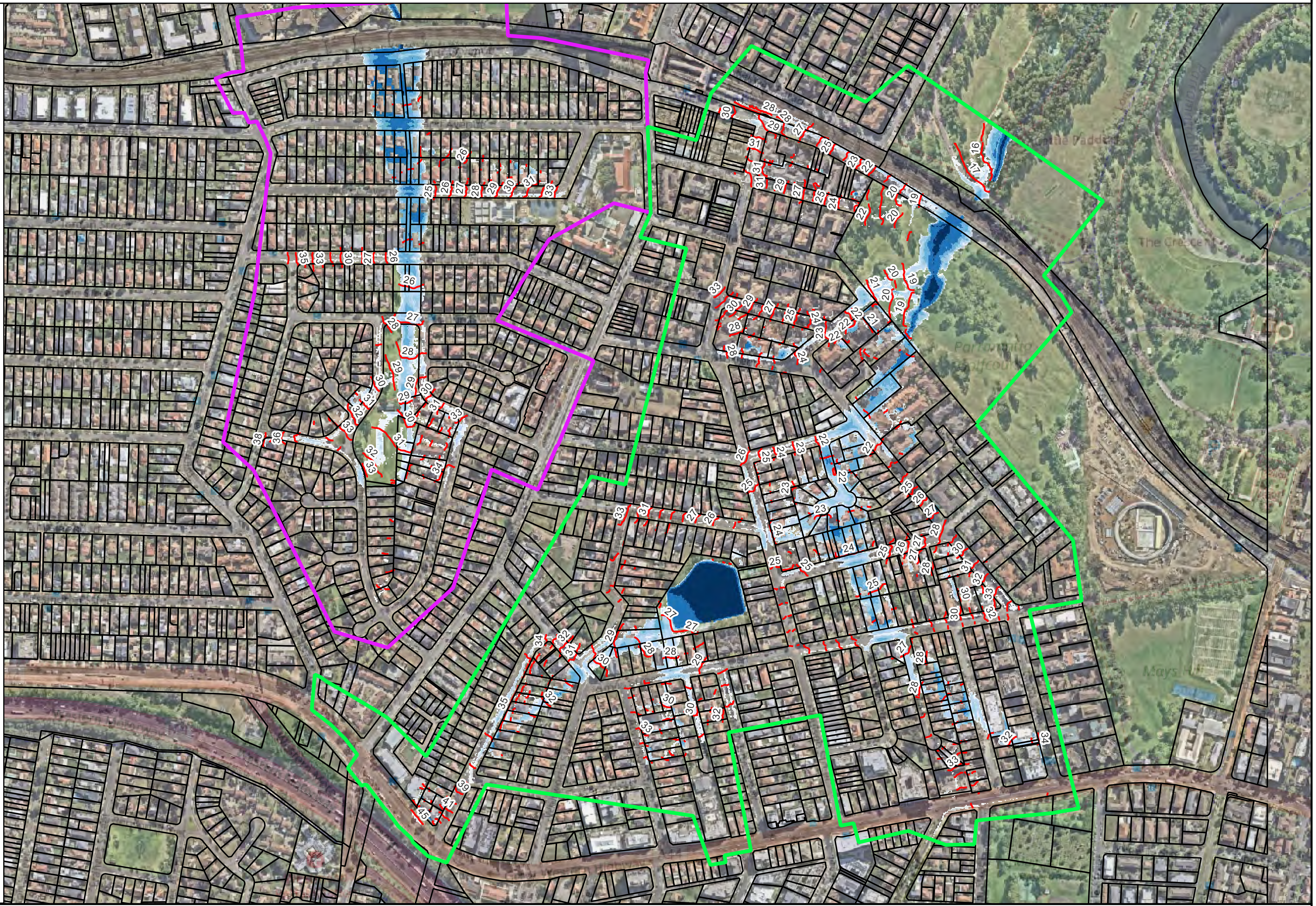
ARCADIS

Figure B-2 - 1% AEP Flood Depths with Flood Level Contours
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary
- Flood Level Contours (mAHD)

Flood Depths (m)
- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00



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Arcadis endeavours to ensure that the information provided in this map is correct at the time of publication. Arcadis does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

0 200 400 600 800 m

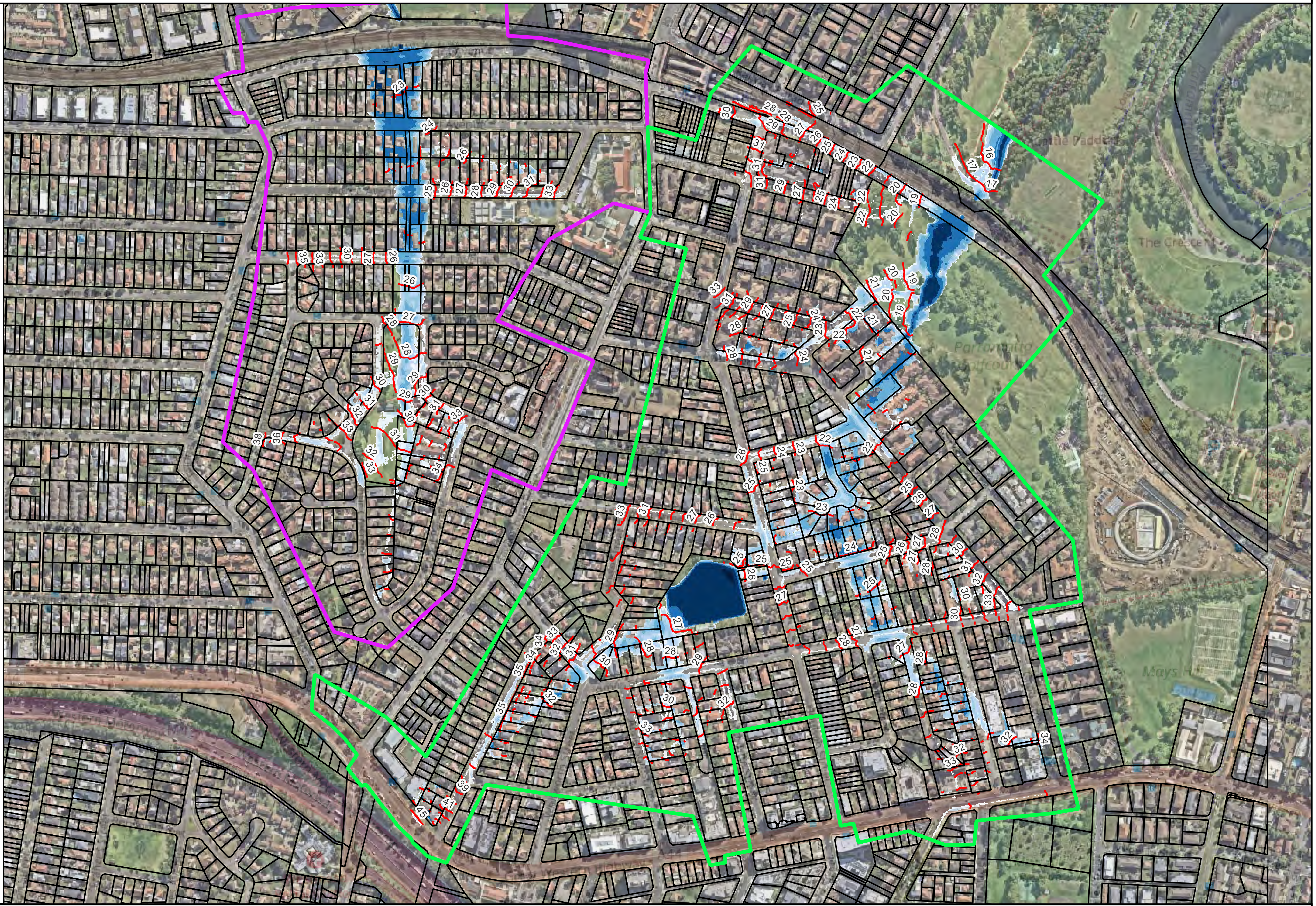
ARCADIS

Figure B-3 - 1% AEP with CC Flood Depths with Flood Level Contours
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary
- Flood Level Contours (mAHD)

Flood Depths (m)
- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00



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0 200 400 600 800 m

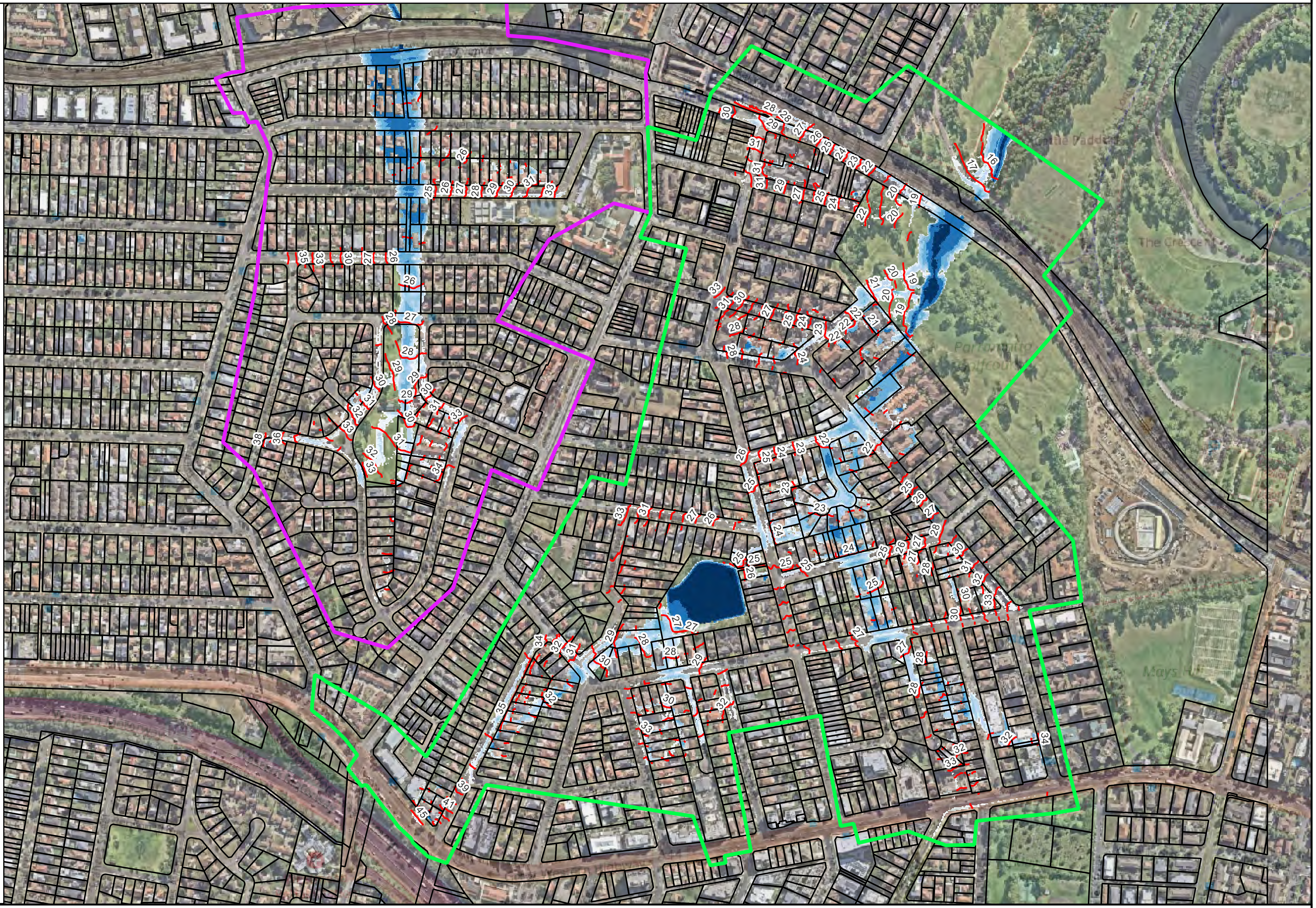
ARCADIS

Figure B-4 - 0.5% AEP Flood Depths with Flood Level Contours
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary
- Flood Level Contours (mAHD)

Flood Depths (m)
- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00



N

0 200 400 600 800 m

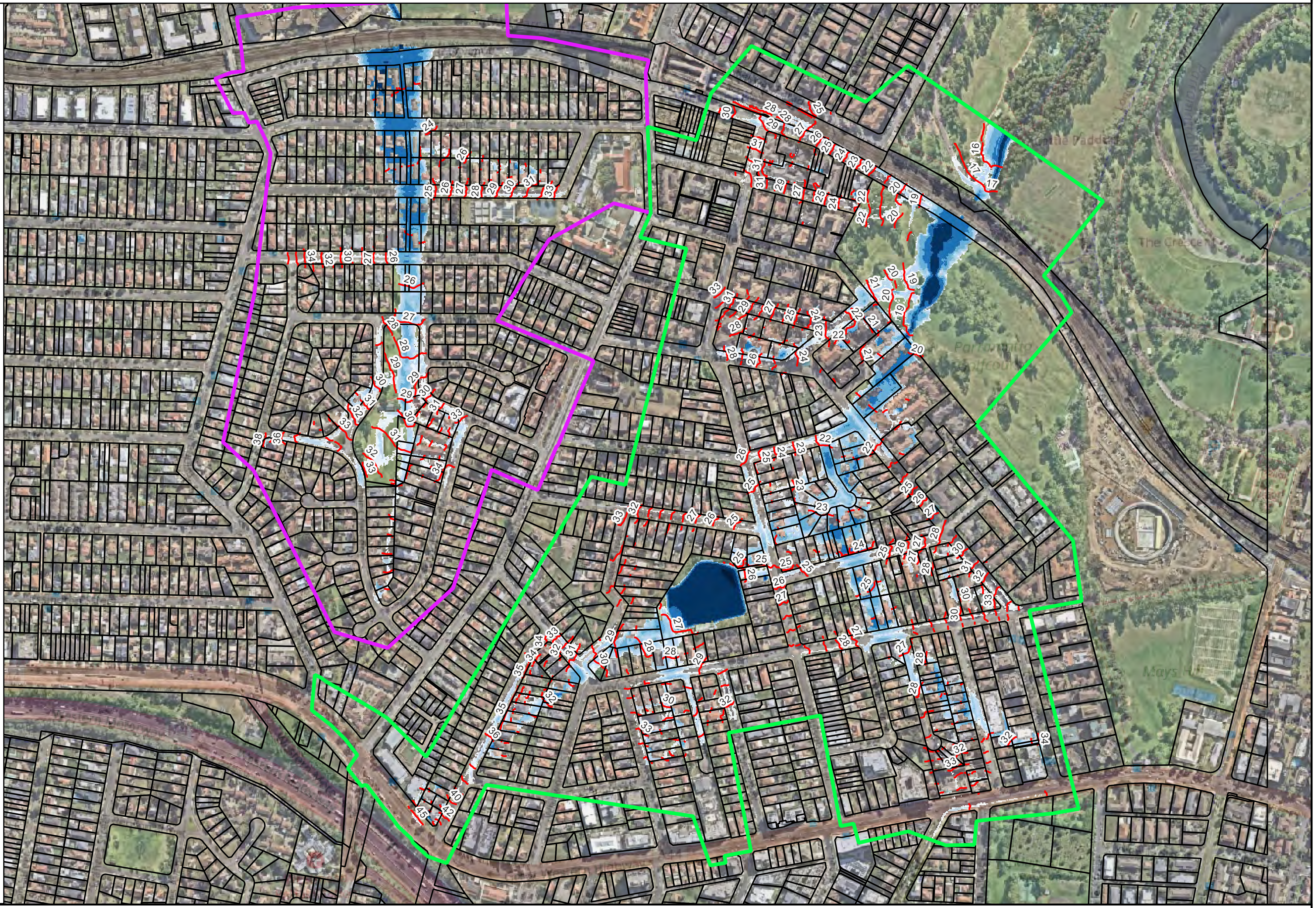
ARCADIS

Figure B-5 - 0.2% AEP Flood Depths with Flood Level Contours
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary
- Flood Level Contours (mAHD)

Flood Depths (m)
- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00



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0 200 400 600 800 m

Figure B-6 - PMF Flood Depths with Flood Level Contours
Existing Conditions

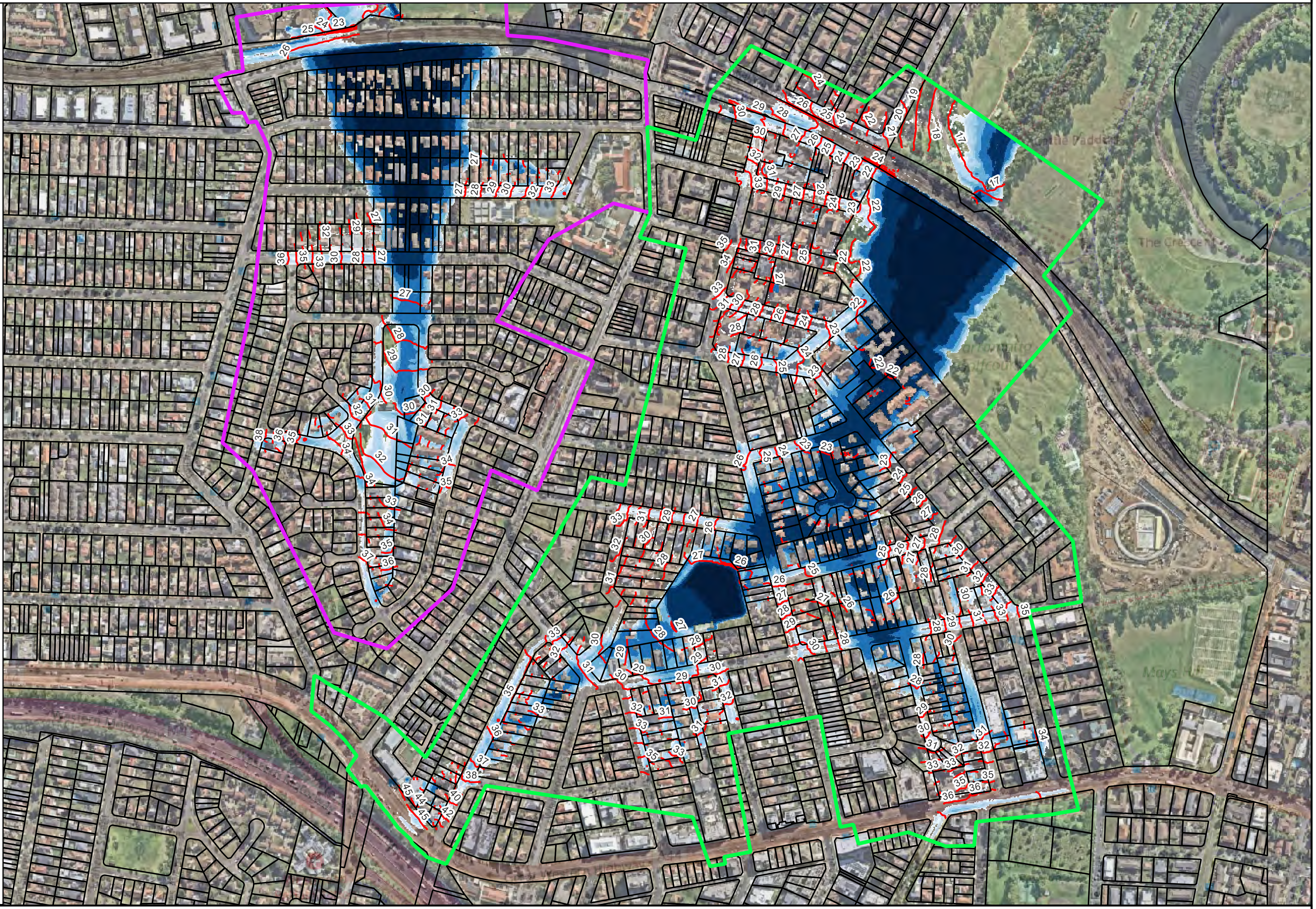
Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)

- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary
- Flood Level Contours (mAHD)

Flood Depths (m)

- <= 0.05 (not shown)
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- > 2.00



N

0 200 400 600 800 m

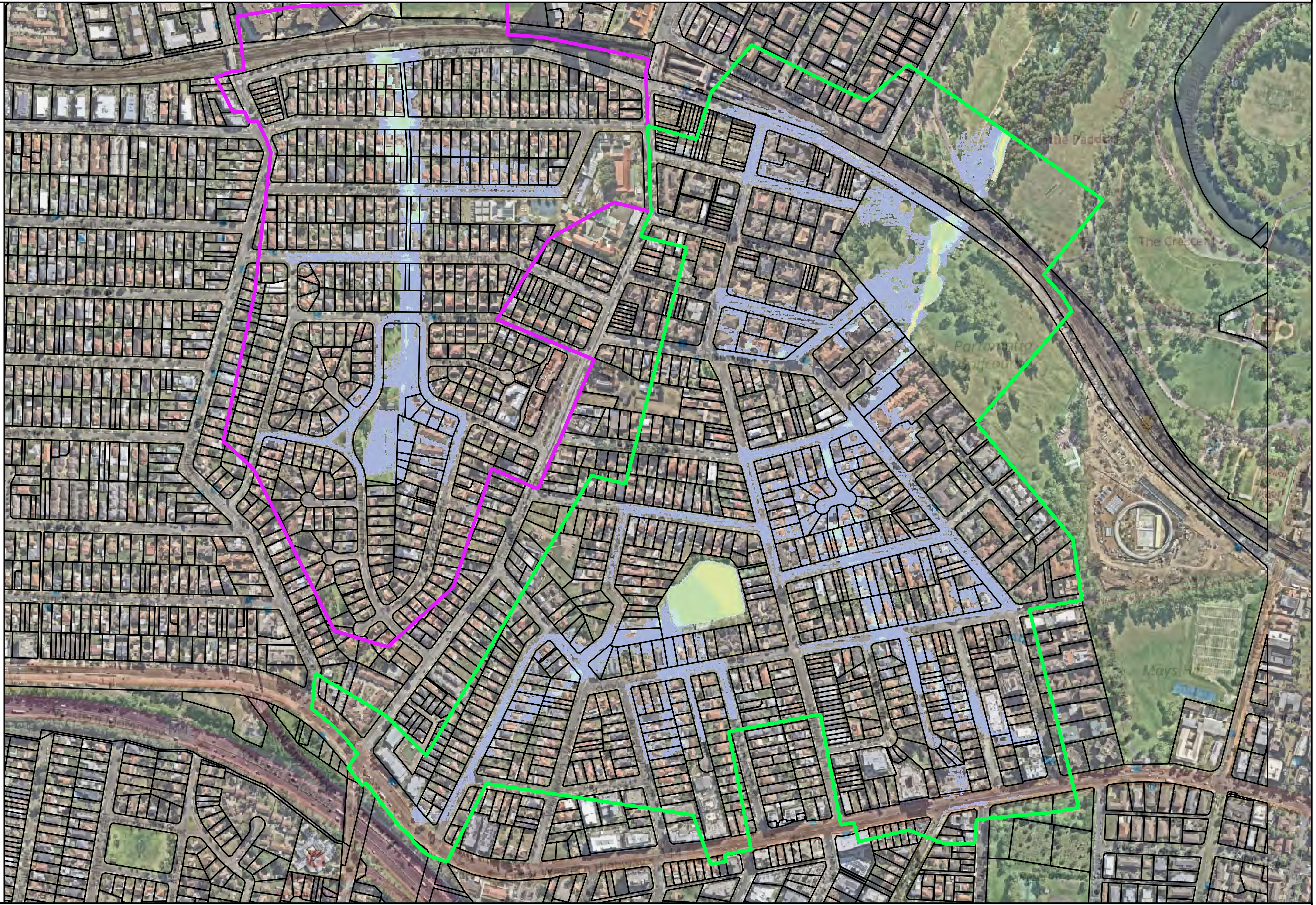
ARCADIS

Figure B-7 - 5% AEP Flood Hazard Categories
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

ZAEM1 Flood Hazard
- 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.



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0 200 400 600 800 m

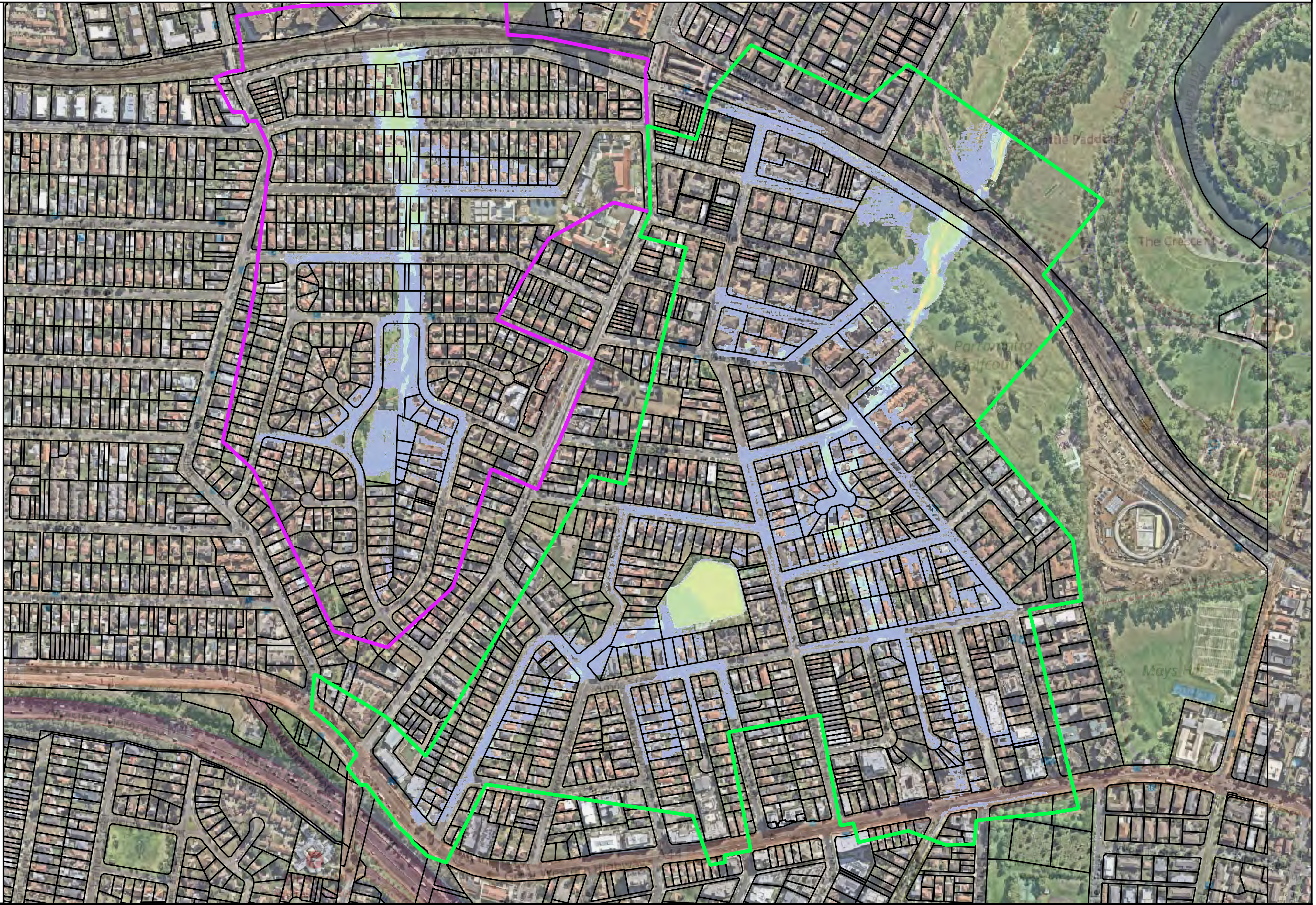
ARCADIS

Figure B-8 - 1% AEP Flood Hazard Categories
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

ZAEM1 Flood Hazard
- 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.



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0 200 400 600 800 m

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Figure B-9 - 1% AEP with CC Flood Hazard Categories
Existing Conditions

Westmead South
30181752
Cumberland City Council

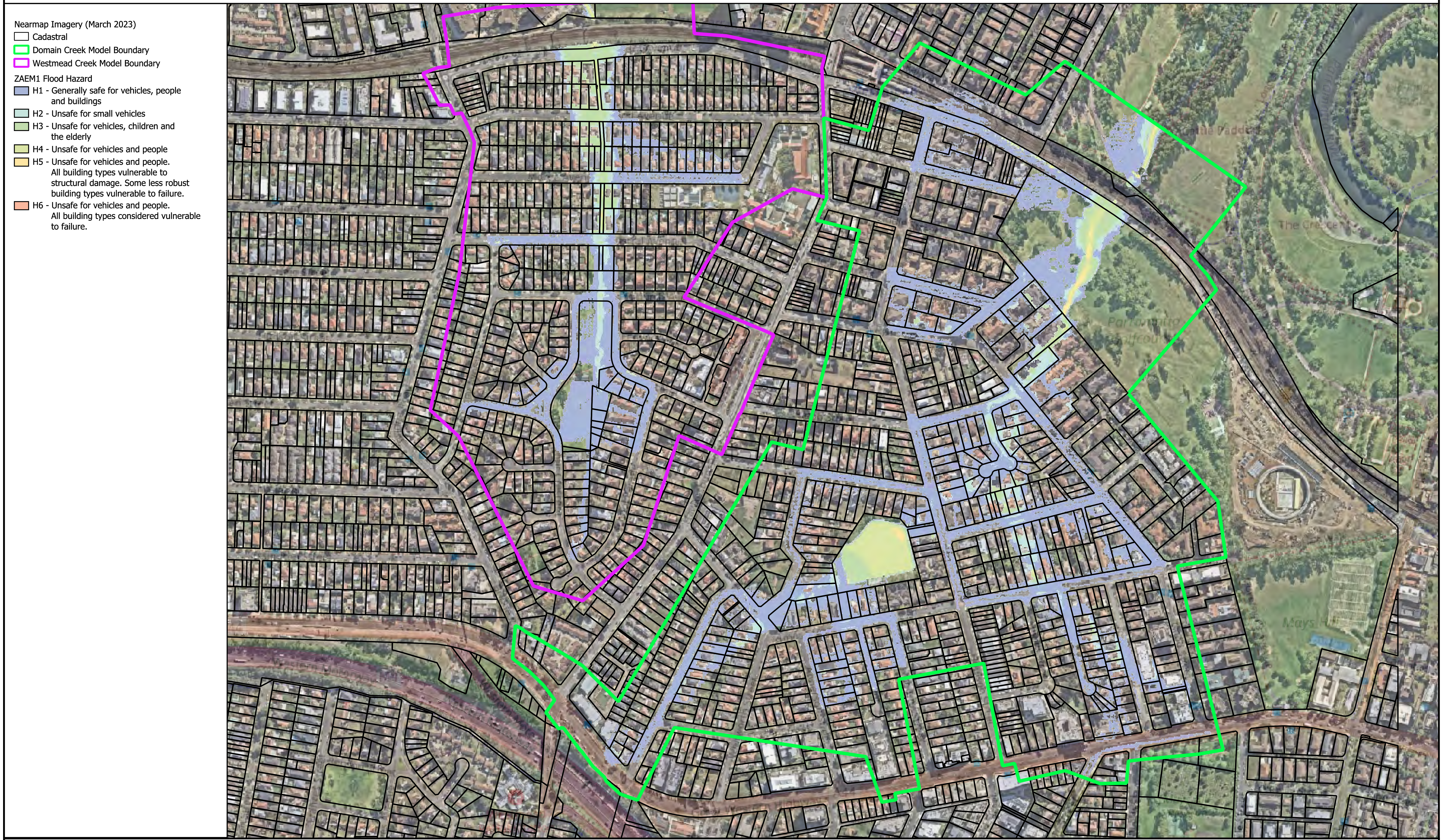

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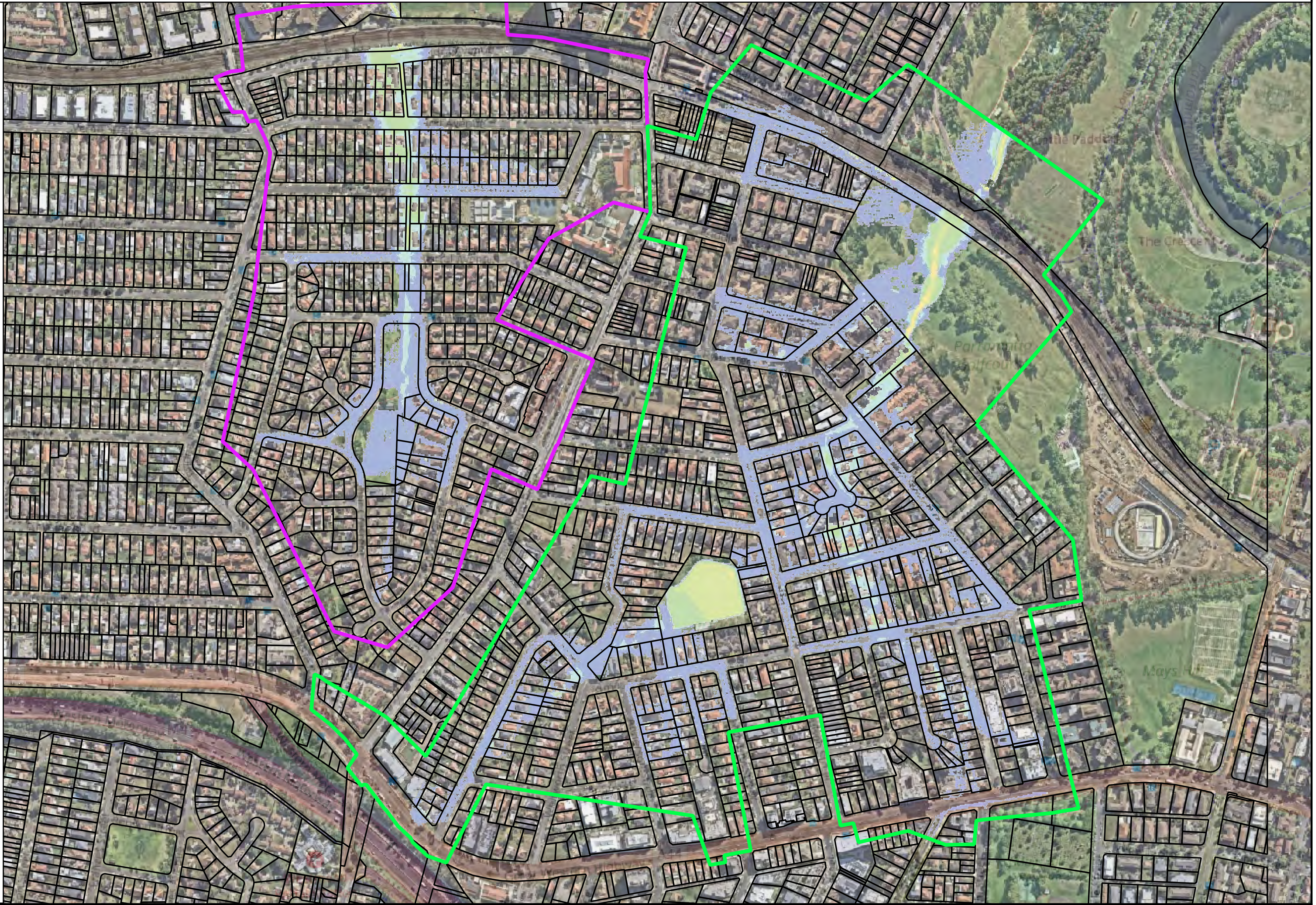
Figure B-10 - 0.5% AEP Flood Hazard Categories
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

ZAEM1 Flood Hazard
- 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.



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0 200 400 600 800 m

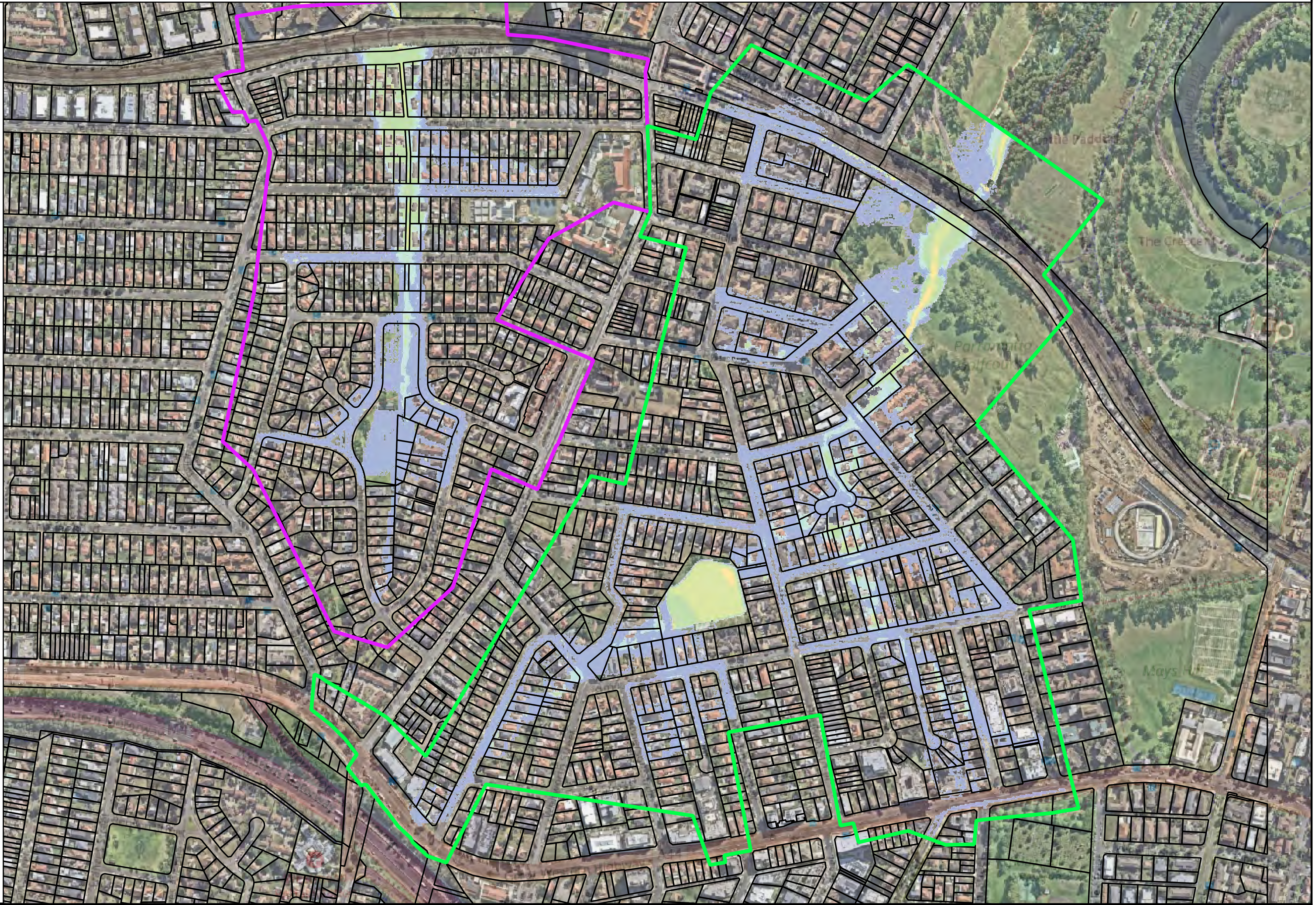
ARCADIS

Figure B-11 - 0.2% AEP Flood Hazard Categories
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

ZAEM1 Flood Hazard
- 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.



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0 200 400 600 800 m

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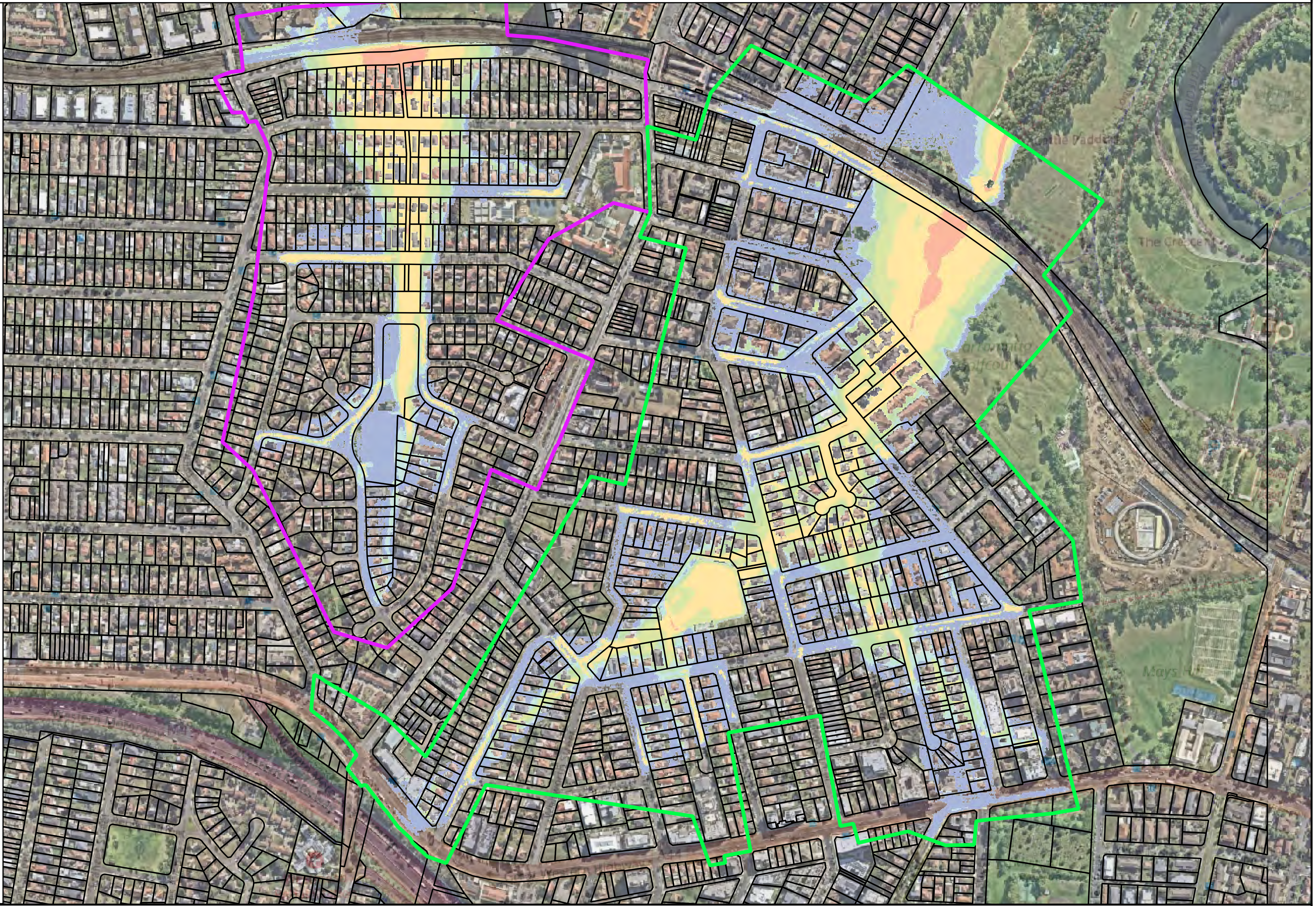
Figure B-12 - PMF Flood Hazard Categories
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

ZAEM1 Flood Hazard
- 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.



N

0 200 400 600 800 m

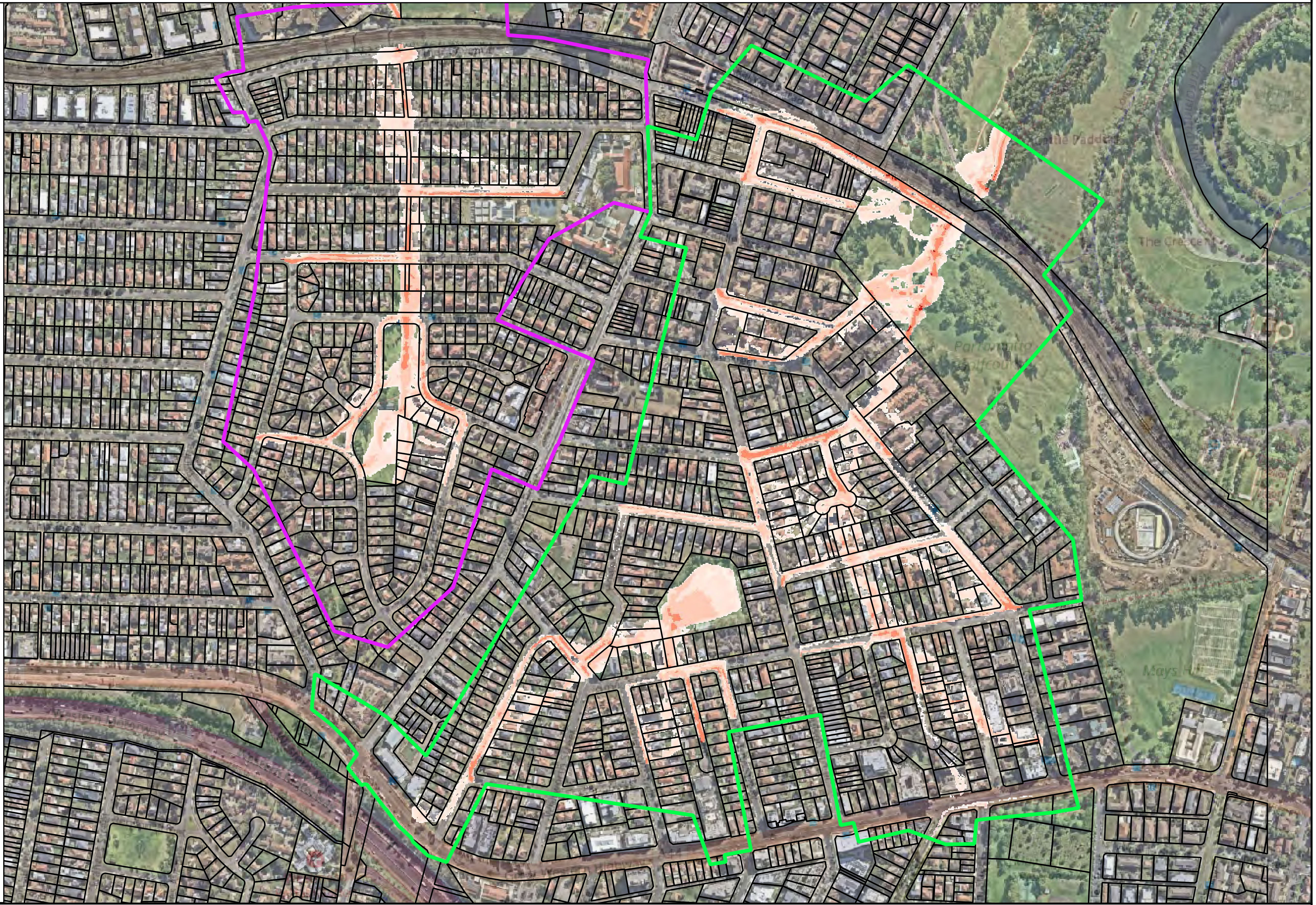
ARCADIS

Figure B-13 - 5% AEP Flow Velocities
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Velocity (m/s)
- <= 0.1(not shown)
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 4.0
- > 4.0



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0 200 400 600 800 m

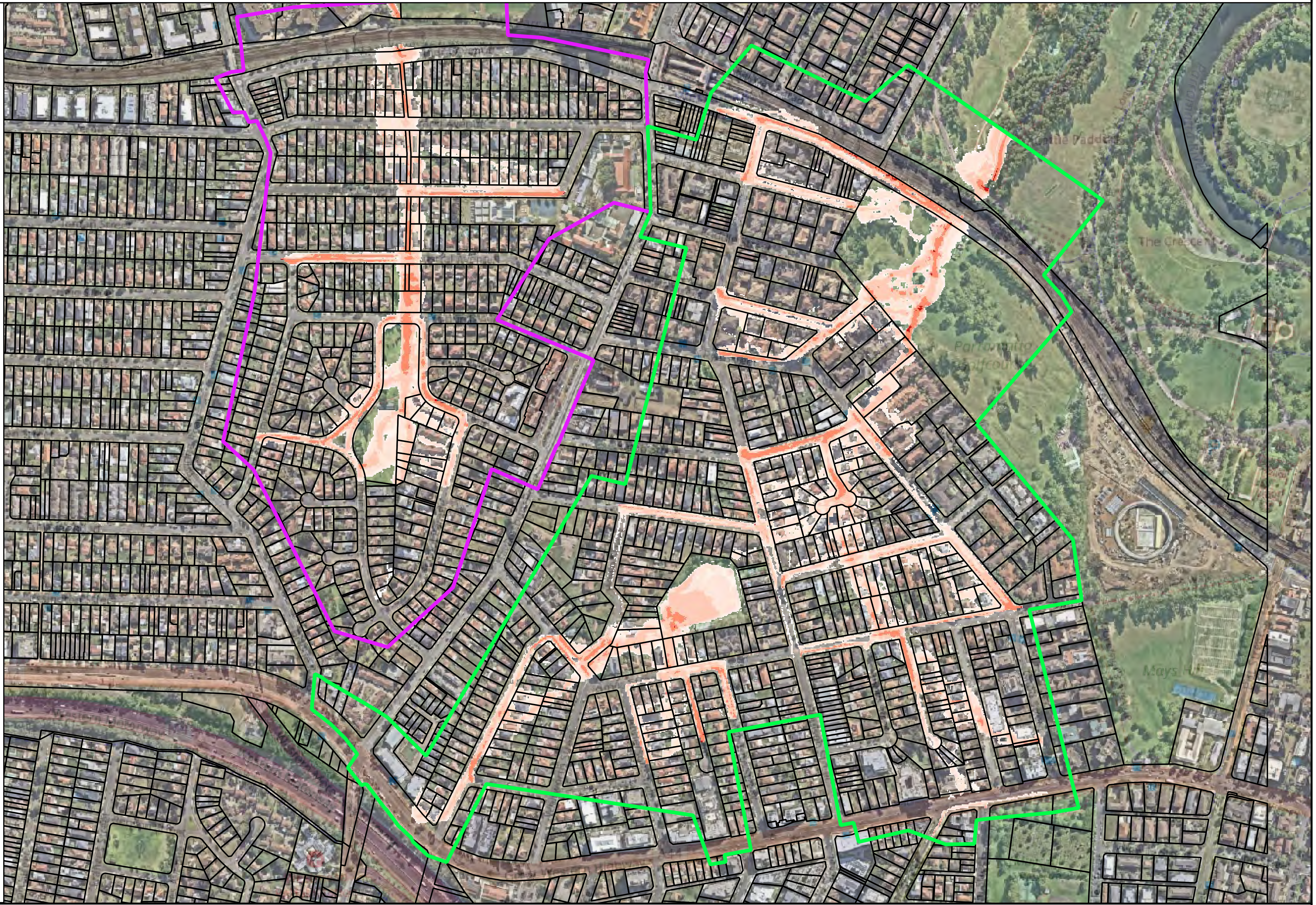
ARCADIS

Figure B-14 - 1% AEP Flow Velocities
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Velocity (m/s)
- <= 0.1(not shown)
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 4.0
- > 4.0



N

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0 200 400 600 800 m

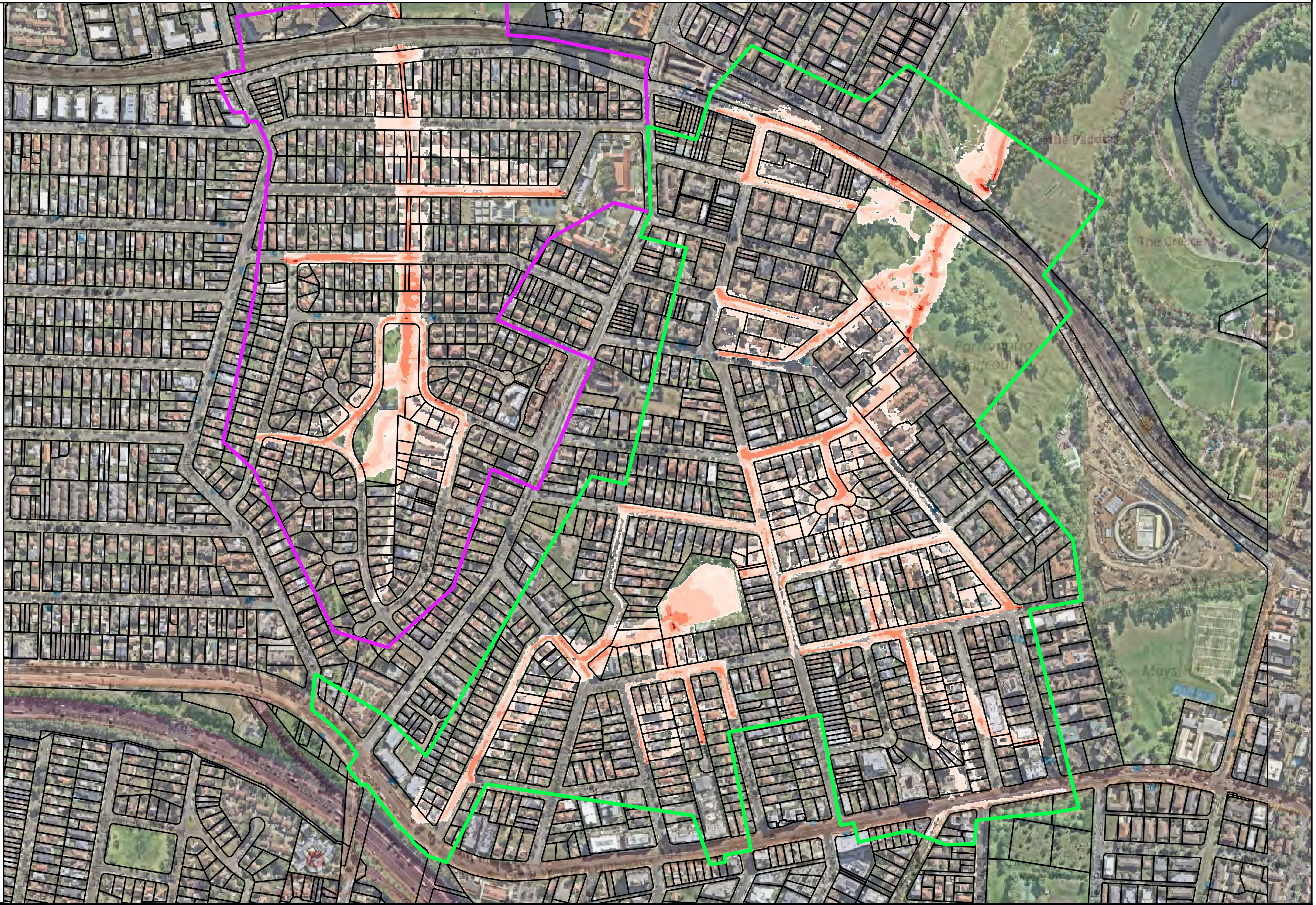
ARCADIS

Figure B-15 - 1% AEP with CC Flow Velocities
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Velocity (m/s)
- <= 0.1(not shown)
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 4.0
- > 4.0



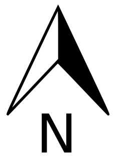


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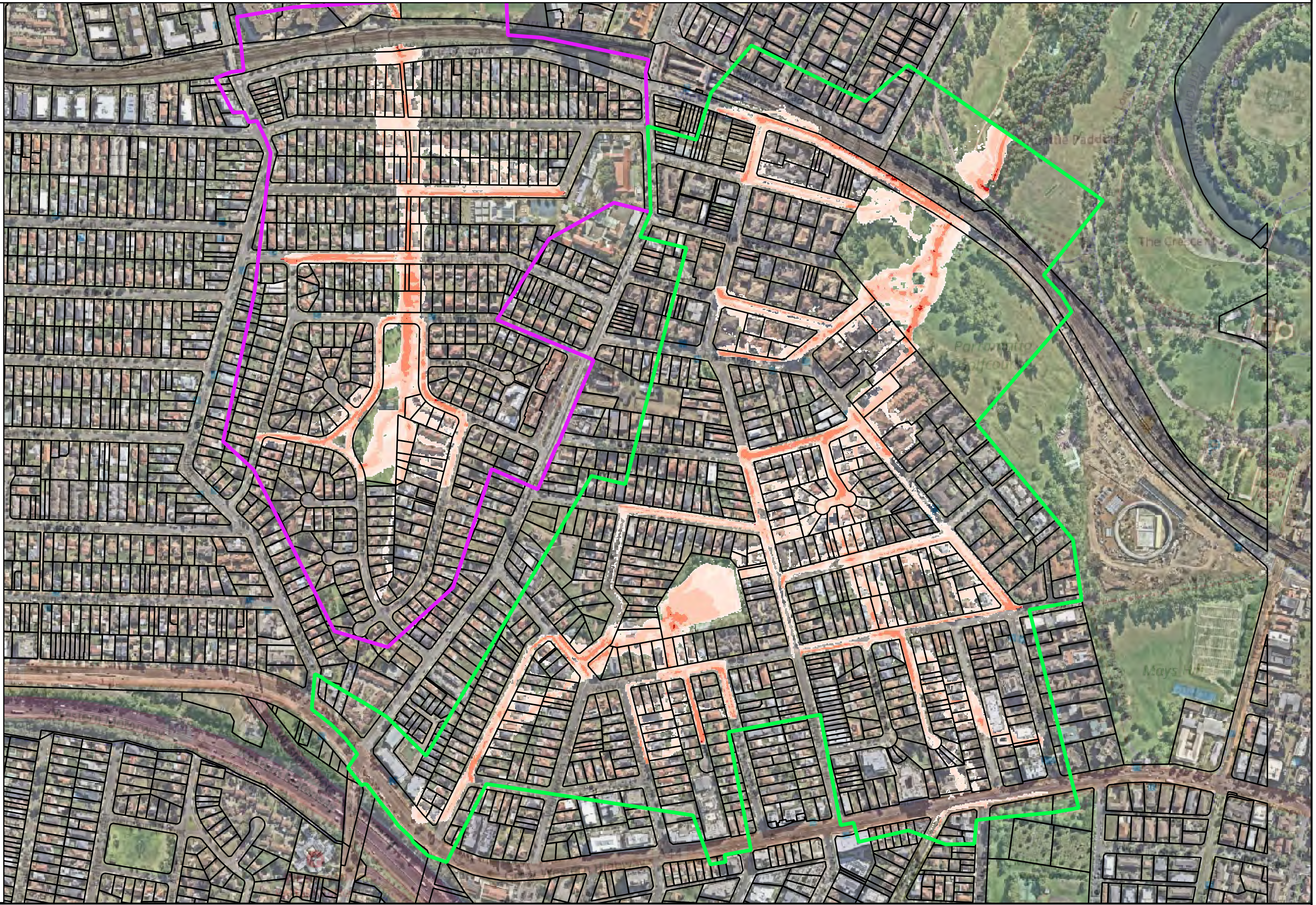
Figure B-16 - 0.5% AEP Flow Velocities
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Velocity (m/s)
- <= 0.1(not shown)
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 4.0
- > 4.0



N

0 200 400 600 800 m

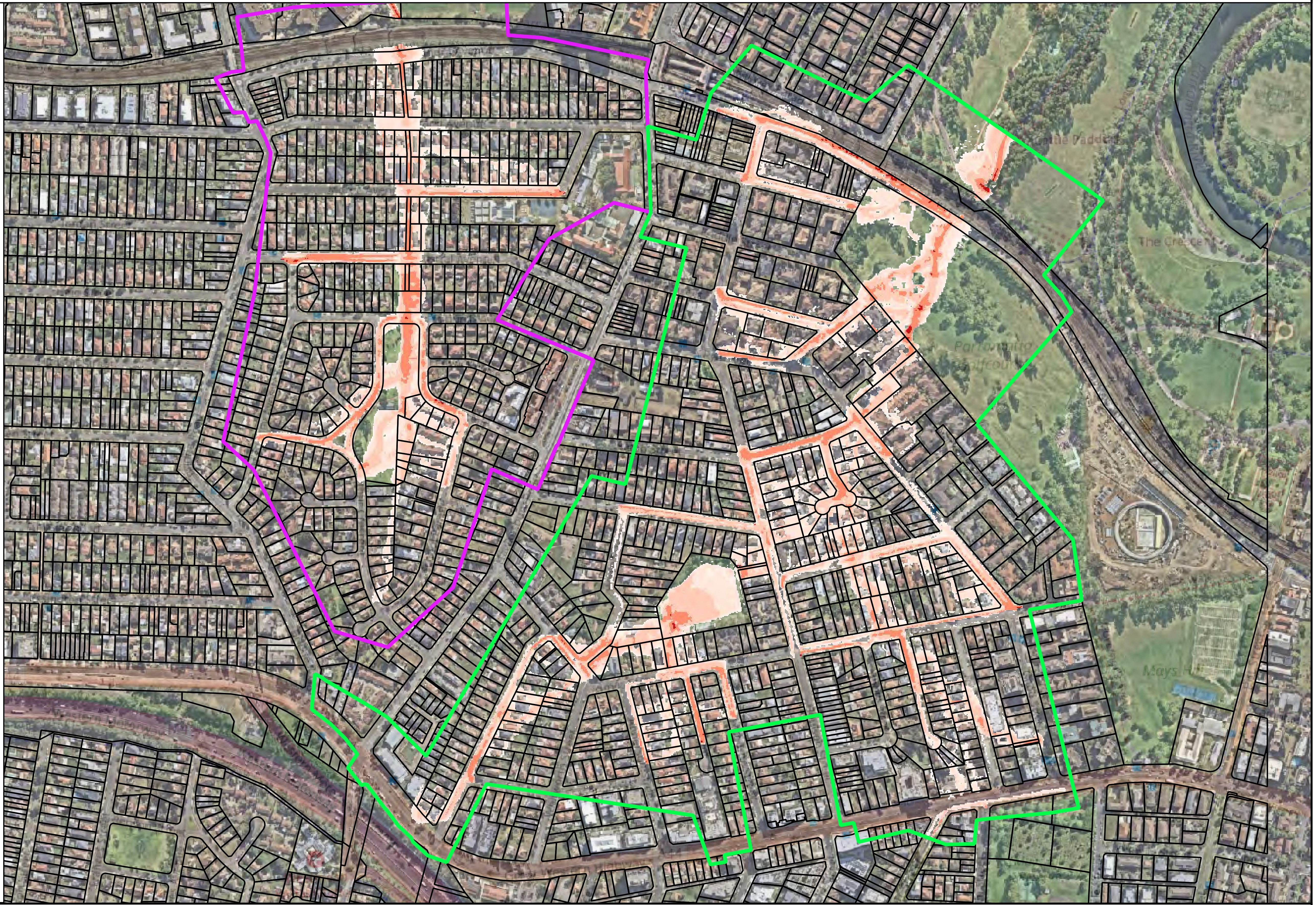
ARCADIS

Figure B-17 - 0.2% AEP Flow Velocities
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Velocity (m/s)
- <= 0.1(not shown)
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 4.0
- > 4.0



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0 200 400 600 800 m

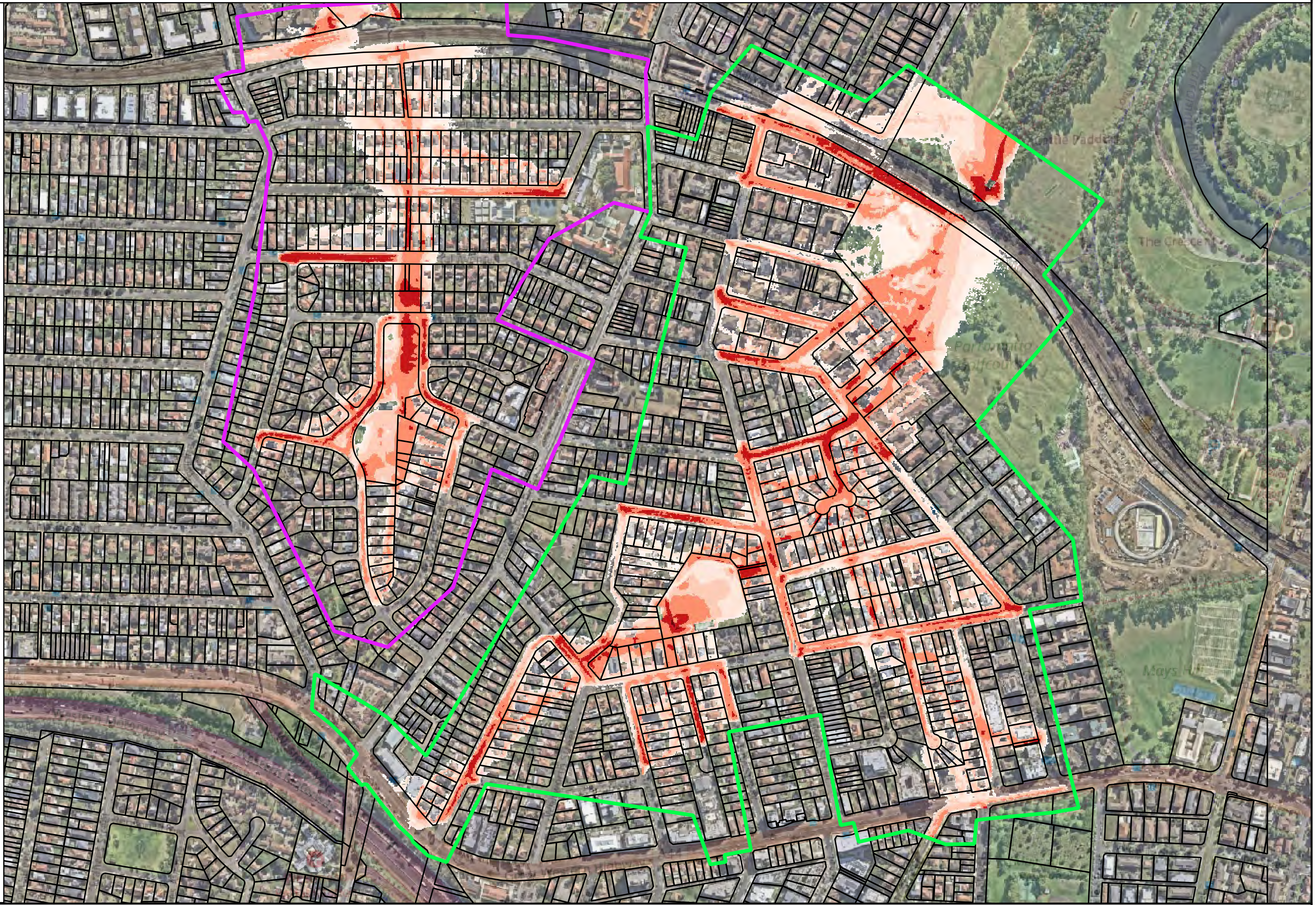
ARCADIS

Figure B-18 - PMF Flow Velocities
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Velocity (m/s)
- <= 0.1(not shown)
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 4.0
- > 4.0



N

0 200 400 600 800 m

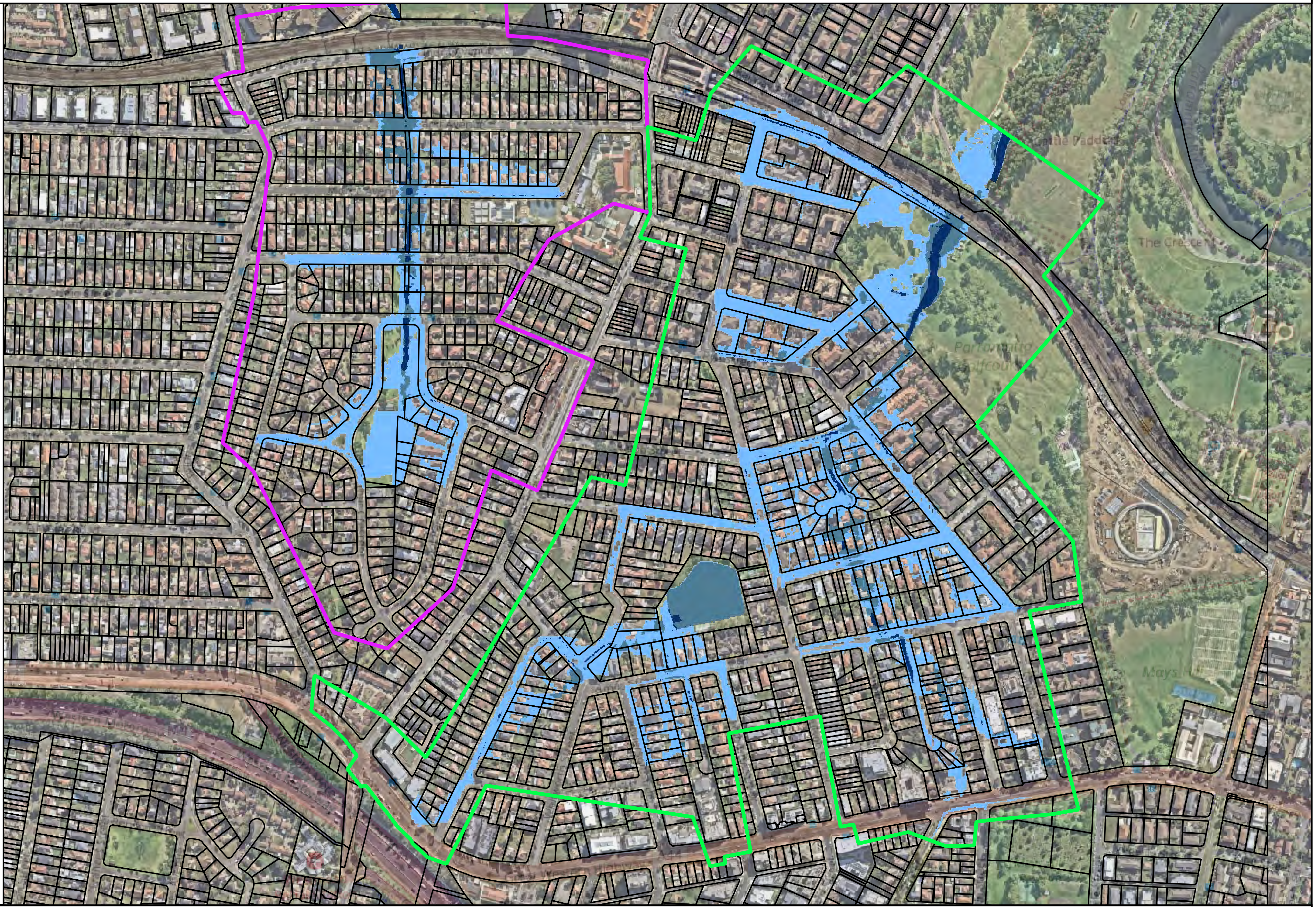
ARCADIS

Figure B-19 - 5% AEP Flood Function
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Hydraulic Categorisation
- Floodway
- Flood Storage
- Flood Fringe



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0 200 400 600 800 m

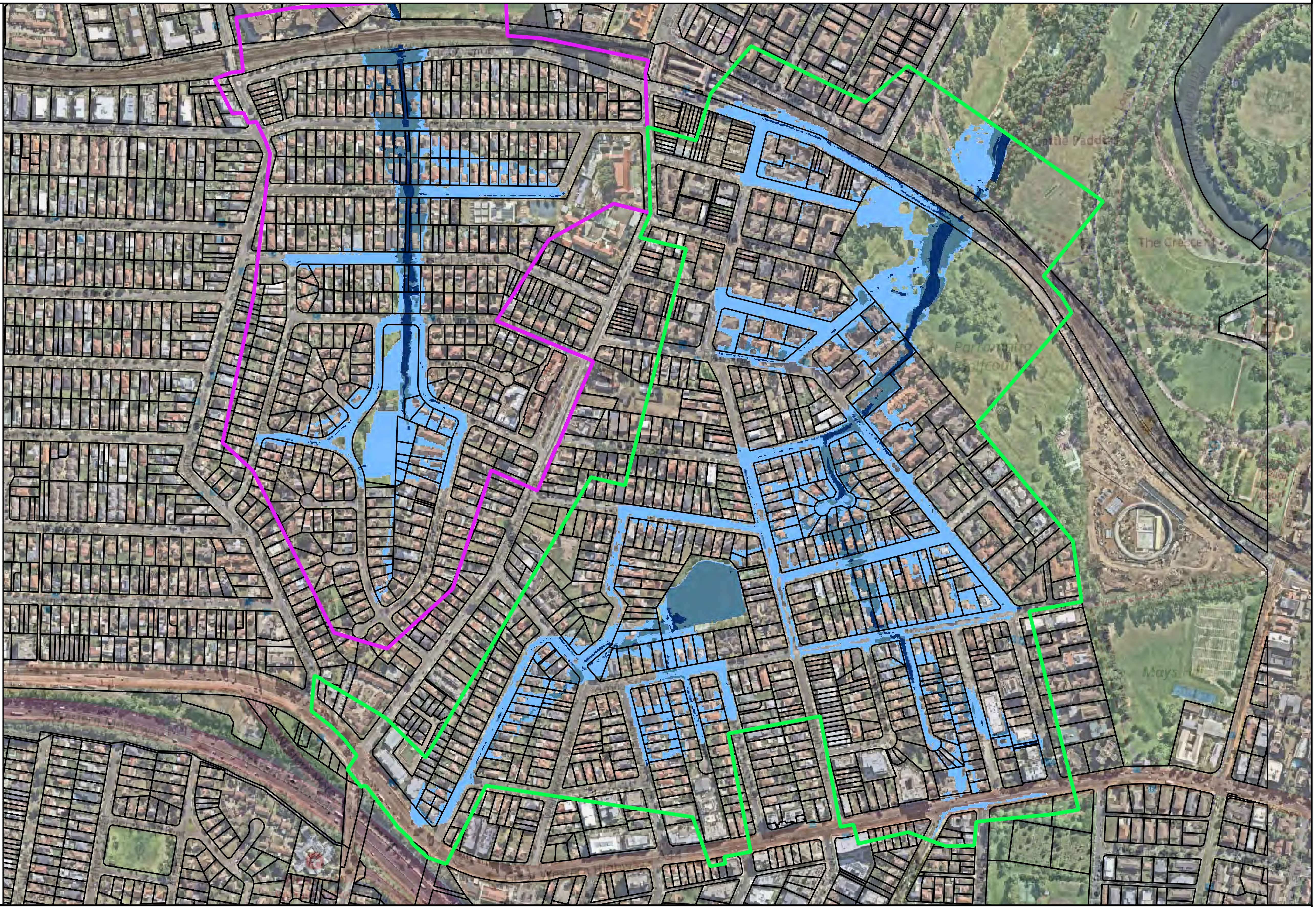
ARCADIS

Figure B-20 - 1% AEP Flood Function
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Hydraulic Categorisation
- Floodway
- Flood Storage
- Flood Fringe



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0 200 400 600 800 m

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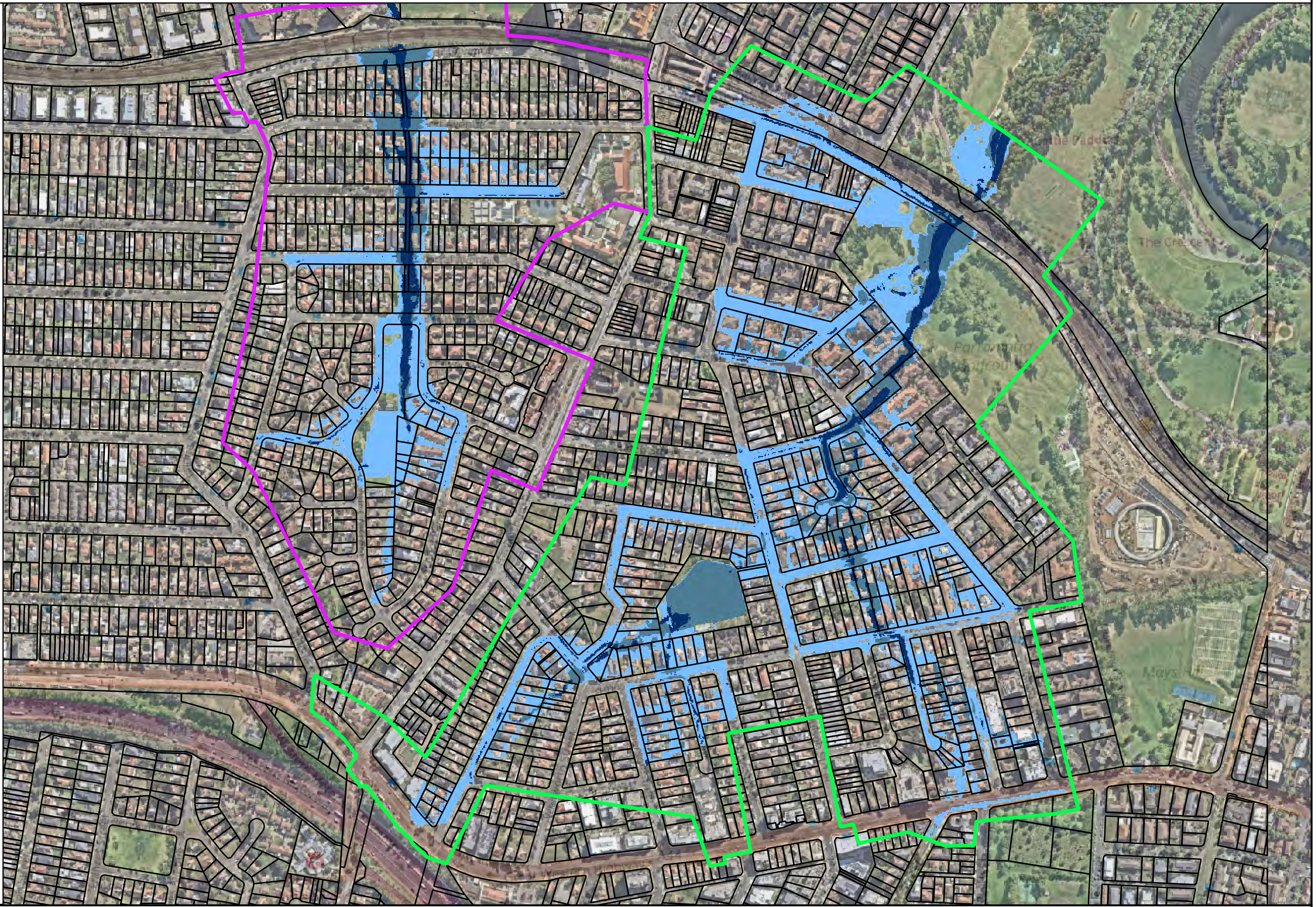
Figure B-21 - 1% AEP with CC Flood Function
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Hydraulic Categorisation
- Floodway
- Flood Storage
- Flood Fringe



N

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0 200 400 600 800 m

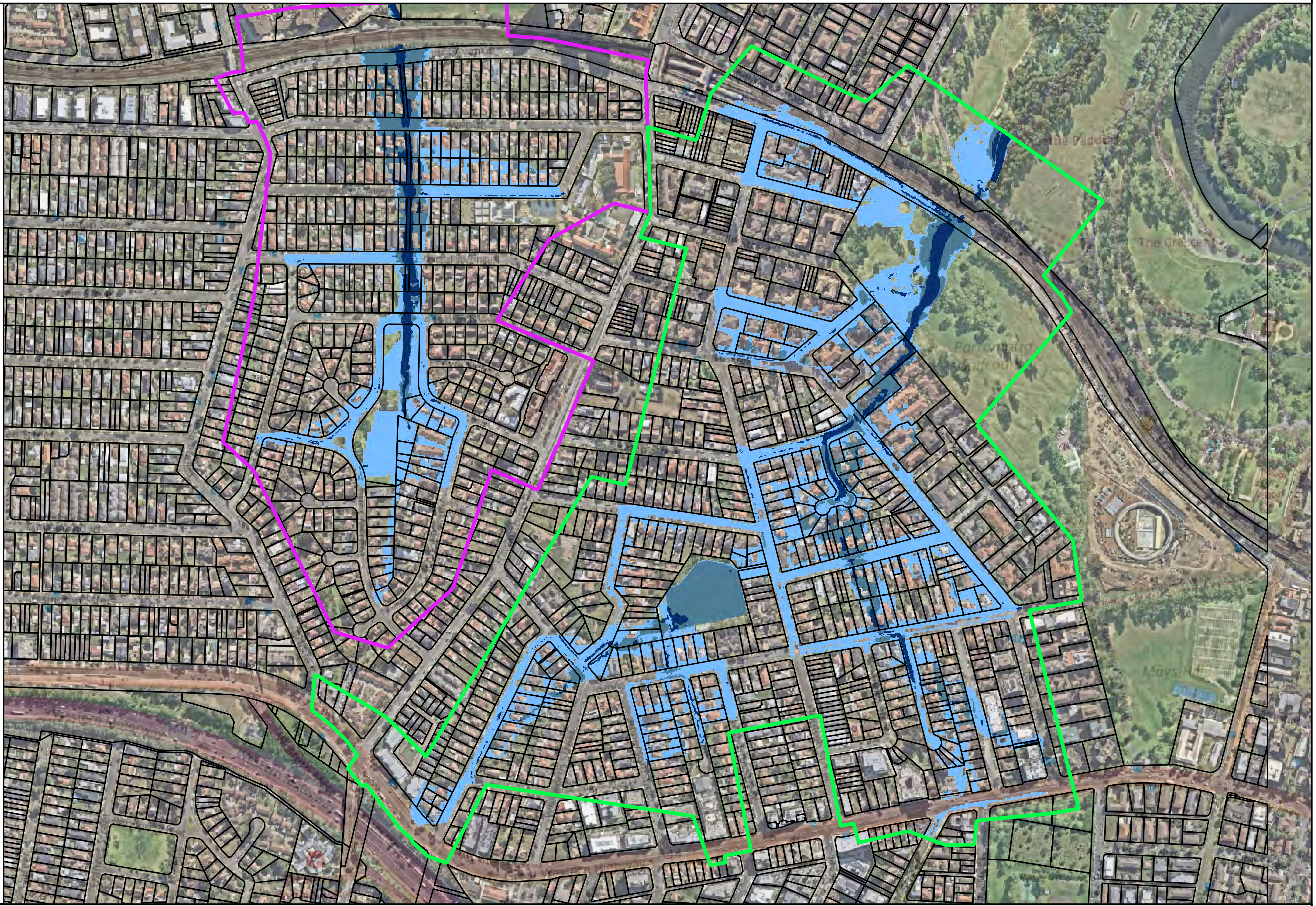
ARCADIS

Figure B-22 - 0.5% AEP Flood Function
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Hydraulic Categorisation
- Floodway
- Flood Storage
- Flood Fringe



N

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0 200 400 600 800 m

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Figure B-23 - 0.2% AEP Flood Function
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Hydraulic Categorisation
- Floodway
- Flood Storage
- Flood Fringe

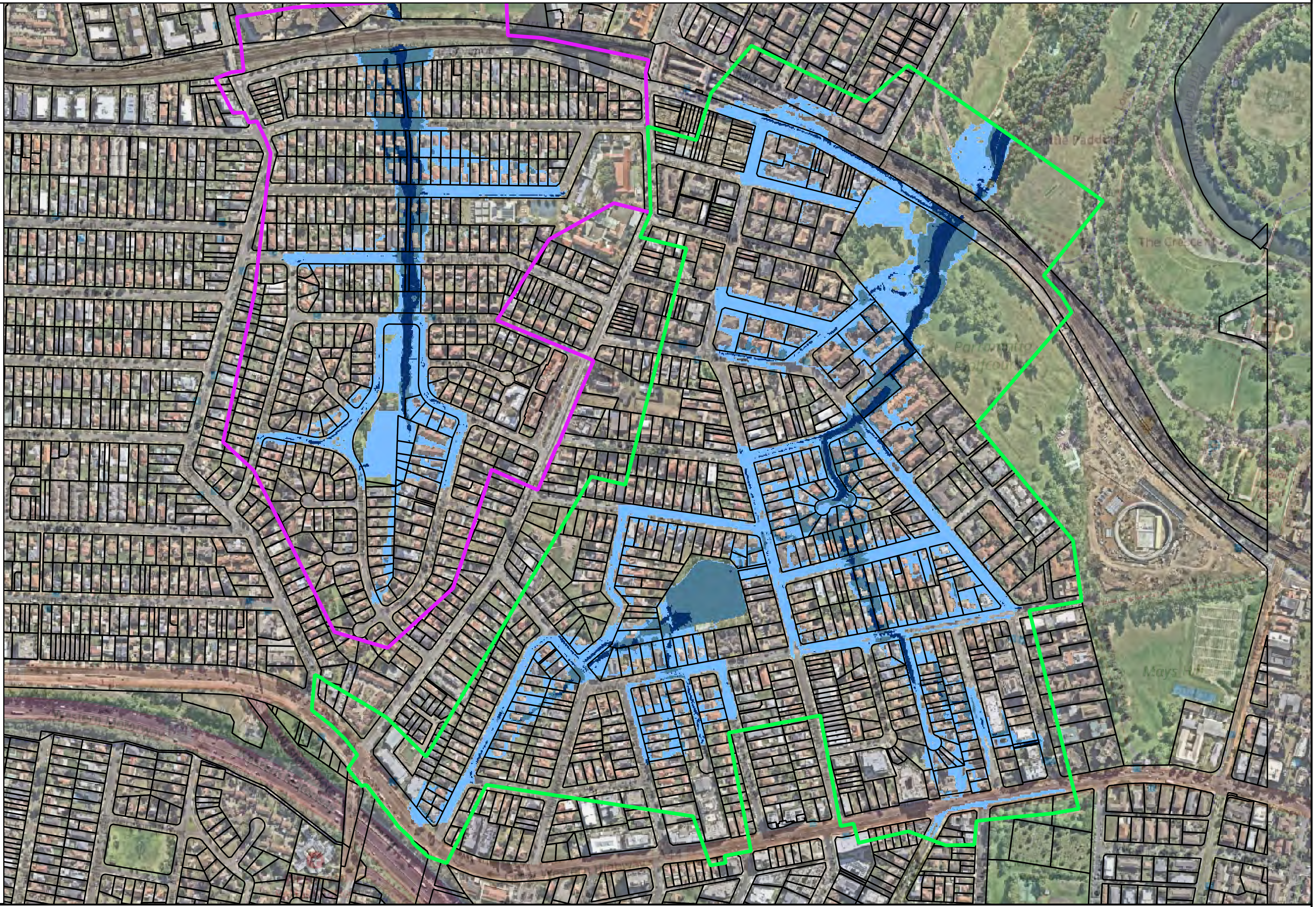

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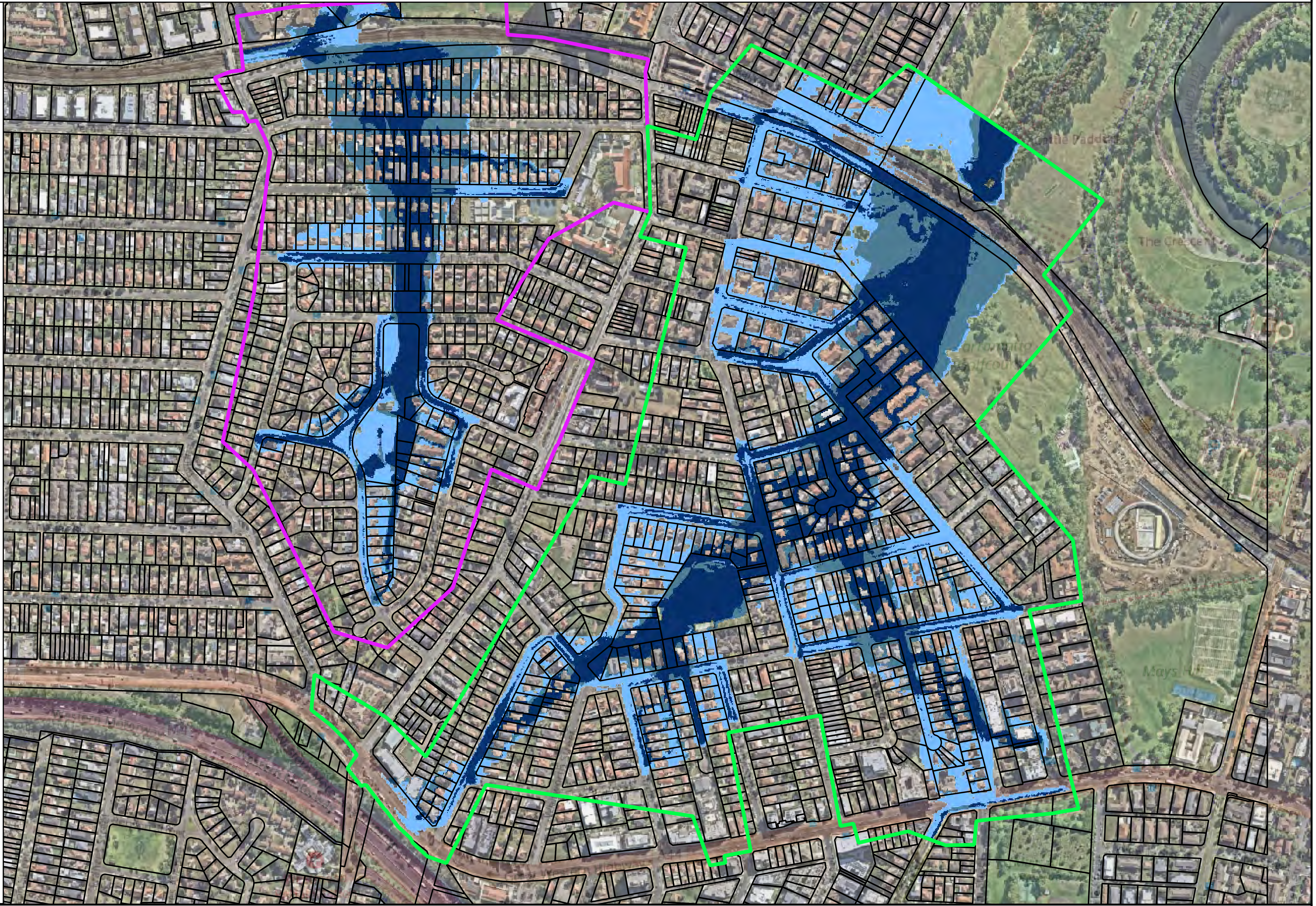
Figure B-24 - PMF Flood Function
Existing Conditions

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
- Cadastral
- Domain Creek Model Boundary
- Westmead Creek Model Boundary

Hydraulic Categorisation
- Floodway
- Flood Storage
- Flood Fringe



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0 200 400 600 800 m

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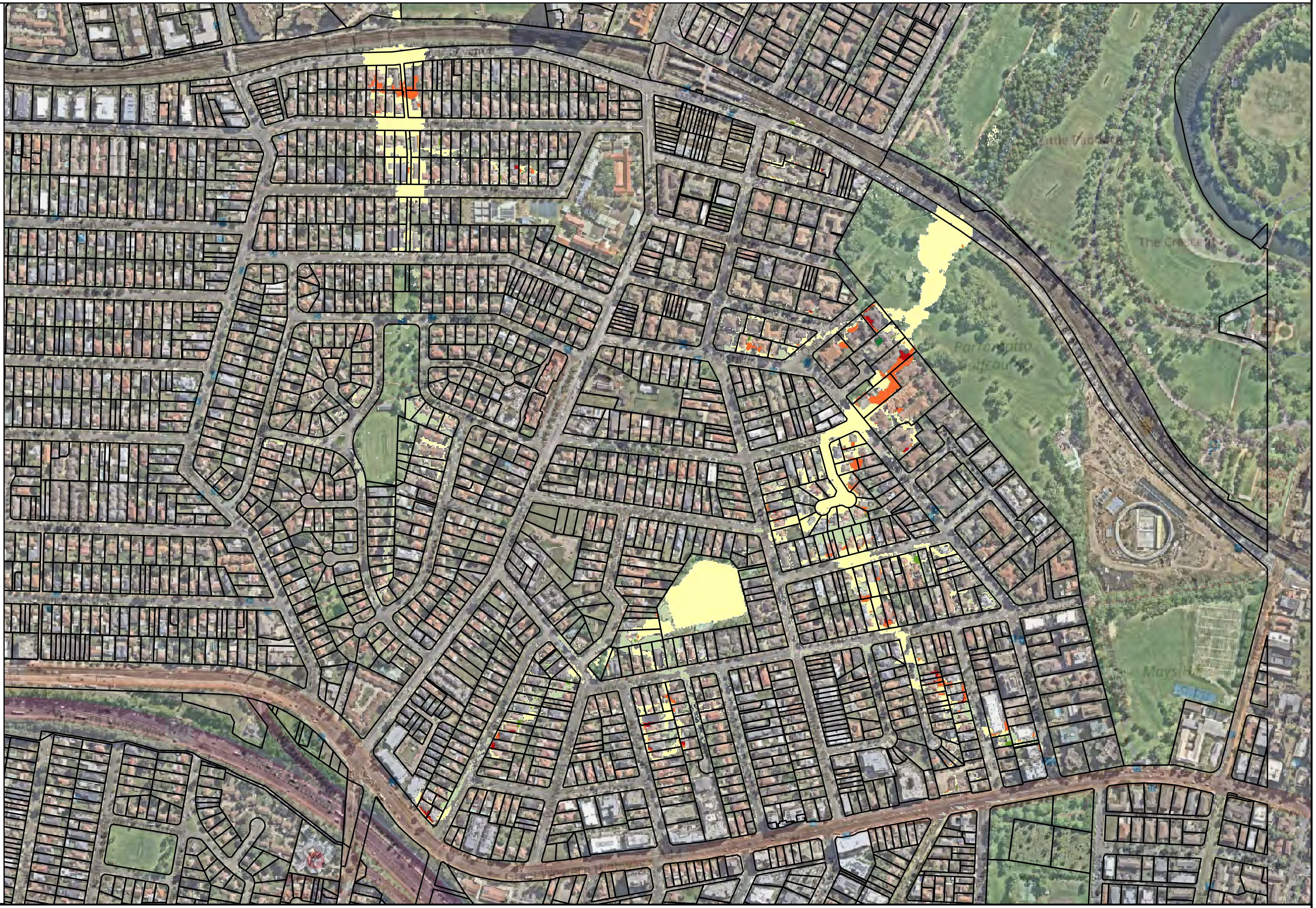
APPENDIX C COMPARISON TO PREVIOUS MODEL

Figure C-1 - 1% AEP Change in Flood Level
Existing Condition (Current model) - Existing Condition (Previous model)

Westmead South
30181752
Cumberland City Council

Nearmap Imagery (March 2023)
Cadastral
Domain Creek Model Boundary
Westmead Creek Model Boundary
Change in Flood Level (m)
<= -0.3
-0.3 to -0.1
-0.1 to -0.01
No impact
0.01 to 0.1
0.1 to 0.3
> 0.3



N

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0 200 400 600 800 m

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built assets