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Providing Specialist Services in the Fields of Hydrology and Hydraulics

Floodplain Risk Management Plan
Proposed Rezoning at
1-4 Old Bathurst Road, Emu Plains

for Urbanco Pty Ltd

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Report title:

Floodplain Risk Management Plan
Proposed Rezoning at 1-4 Old Bathurst Road, Emu Plains

Prepared for:

Urbanco Pty Ltd

Prepared by:

RIENCO CONSULTING

Water Engineering Specialists
PO Box 3094 Austinmer NSW 2515
Suite 203, 62 Moore Street Austinmer NSW 2515
ACN 000 960 850 ABN 14 000 960 850
Ph 0416 274447
Email secretary@rienco.com.au

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1. INTRODUCTION

1.1. BACKGROUND AND PROPOSED REZONING

The applicant seeks to rezone a portion of their land at Old Bathurst Road, Emu Plains. A Development Consent was issued in August 2020 to consolidate the land holding allotments, creating two lots (Lot 1 and Lot 2). Lot 1 was created as a future development parcel, comprising all of the IN2 zoned land along the Old Bathurst Road frontage and is approximately 20,000 m^2 in area. Whilst Lot 1 contains all of the land currently zoned IN2, not all of Lot 1 is zoned IN2.

Following Development Consent, Penrith Council completed and released more detailed flood modelling of the local Emu Plains catchment, via their *Emu Plains Overland Flow Flood Study (2020*). This indicated that the recently subdivided Lot 1 was not affected by overland flow in the 1% AEP design flood, but was still marginally affected in the same AEP flood from the regional Nepean River system. It is understood that a further review of more detailed up to date flood modelling of Nepean River Catchment (by Penrith Council) also identified that flood planning areas had been modified and refined over Lot 1 in the time that had elapsed. It was subsequently identified that the balance of Lot 1 (not presently zoned industrial) could be rezoned to Industrial land.

The purpose of the Planning Proposal is to rezone the remaining portion of Lot 1 to IN2 Light Industrial under the Penrith Local Environmental Plan (PLEP) 2010, addressing the land within Lot 1 which is currently a 'deferred matter'. The Planning Proposal notes that this will provide a consistent zoning across Lot 1 and the land fronting Old Bathurst Road. The Planning Proposal further notes that *no approval is sought for the site at this stage. A detailed Development Application will be prepared and lodged with Council following resolution of this Planning Proposal*.

During its ongoing assessment of the Planning Proposal, Penrith Council received correspondence from the Department of Planning, Industry and Environment (DPIE) (undated, DPIE ref IRF21/3043). This correspondence stated, inter alia:

> *The planning proposal seeks to rezone land from Deferred Matter Rural 'D' to IN2 Light Industrial. The proposal is inconsistent with Clause 5 of this direction as a planning proposal must not rezone land within the flood planning area from Rural to Industrial. Further assessment is required to address consistency with other parts of the Direction. It is understood that some cut and fill is also proposed. The preliminary cut and fill design plan submitted demonstrates minor filling of Lot 1, with the fill relocated from Lot 2 to ensure it is flood free at the 1 in 100 flood level. While cut and fill is not precluded, under clause 6 of the direction, any changes to the natural surface levels would need to demonstrate that the development will not result in significant flood impacts to other properties.*
>
> *Our initial review of the planning proposal against the new flood planning package is that there are no particular policies, or draft studies underway that would preclude this planning proposal being assessed on its merits, and any inconsistencies with Direction 4.3 could not be considered by the Minister where they could satisfactorily address Clause 9 of the Direction.*
>
> *Consistency with this Direction is an important threshold issue, and it is recommended that the applicant provide supporting documentation and the necessary flood studies to assess the planning proposal against Direction 4.3, and consistency with Clause 9 of the Direction, as part of the Gateway application. Council may need to provide the*

proponent with guidance on whether Clause 9(b) or 9(c) should be utilised to justify the inconsistency with this Direction.

Subsequently, Urbanco Pty Ltd (on behalf of the owners) has engaged Rienco Consulting to prepare a suitably detailed Floodplain Risk Management Plan that addresses the requirements of the Section 9.1 Direction Clause 4.3, as further described in **Section 1.2**.

1.2. PURPOSE OF THIS REPORT

The purpose of this report is to:

a) Review of existing flood information available for the site, as quantified in:
   i. Nepean River Flood Study (2018)
   ii. Emu Plains Overland Flow Flood Study (2020)
b) Prepare a detailed hydraulic model that replicates as best as practical the worst case 1% AEP design flood behaviour at the site under pre-development conditions.
c) Determine the potential impacts of the proposed development, and the associated flood hazard categorisation, by way of additional hydraulic modelling.
d) Review the proposed development, together with the hydraulic model results, and assess it against Clause 4.3 of the Section 9.1 Directions relating to flooding, and
e) Prepare a report summarising the above suitable for lodgement with Penrith City Council to accompany the PP.

1.3. LIMITATIONS AND ASSUMPTIONS

This report has been strictly prepared for the purposes stated in this report for exclusive use by the client. No other warranty, expressed or implied, is made as to the advice included in this report. This study specifically focuses on the quantification of flood behaviour at the subject site, given current conditions. This study does not address flood behaviour for other sites within the overall catchment except where explicitly noted in this report.

2. AVAILABLE DATA

2.1. SITE DESCRIPTION

The subject site is located in Emu Plains, NSW and is largely vacant land consisting of two adjoining parcels (Lot 1 and Lot 2). Lot 1 (the southern lot) is the focus of this investigation. Lot 1 is bounded to the north by Lot 2, to the east by Lapstone Creek and vacant land, to the south by Old Bathurst Road and to the west by Russell Street. **Figure 2.1-1** presents an aerial image of the site and surrounds.

Figure 2.1-1 Subject Site

Note: Image sourced from NearMap.

The highest topographic level at Lot 1 is located in the south-western corner adjacent to Old Bathurst Road, where existing ground levels are approximately RL +25.1m AHD. Lot 1 falls to the north and east, and falls to around RL +23.7m AHD along its northern and eastern boundaries.

2.2. SURVEY DATA

Topographic information was available in the form of Airborne Laser Scan (ALS) data. The NSW Government's Land & Property Information department (LPI) have supplied a 5m DEM from the underlying LiDAR 2011 dataset. Aerial imagery (2021) was also supplied for the subject site and surrounds via Nearmap.

2.3. SITE INSPECTION

A physical site inspection was not possible due to the current COVID-19 travel restrictions. Given the scope of works and nature of the report, the author does not consider that a site inspection would materially alter the recommendations of the report.

2.4. PREVIOUS STUDIES

2.4.1. Nepean River Flood Study (2018)

The Nepean River Flood Study was prepared by Advisian in 2018. As noted in the study, the Hawkesbury-Nepean River catchment is one of the largest coastal basins in NSW with an area of 21,400 square kilometres. The catchment at Penrith is approximately half of the total catchment area and of this portion, 80% is under the control of Warragamba Dam (PCC, 2021).

The Nepean River Flood Study quantified design flood flows, velocities, levels, extents, and hydraulic and hazard category mapping for a range of flood events under existing floodplain and catchment conditions. The Flood Study provides detailed mapping of various storm events over the Nepean River catchment within the Penrith LGA, inclusive of the 1 in 20 year storm through to the 1 in 2,000 year storm event and the Probable Maximum Flood (PCC, 2021).

Figure 2.4-1 below is an extract from the 2018 Study, summarising the peak flood extents across Lot 1 in the 1% AEP design flood in the Nepean River.

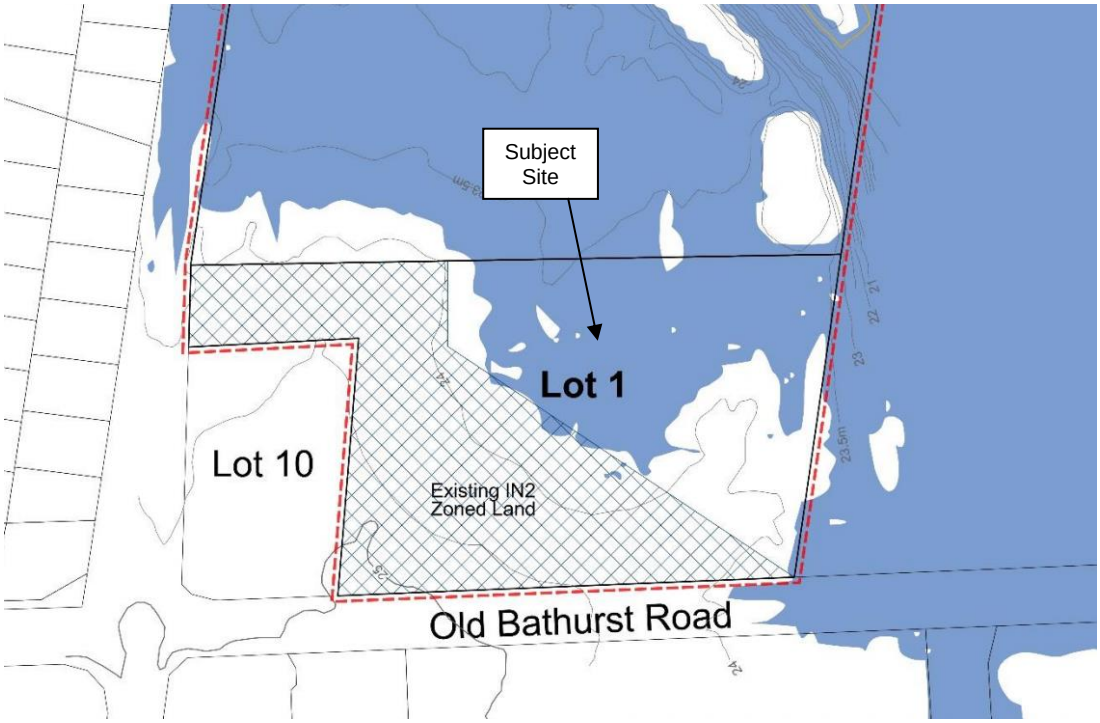

Figure 2.4-1 1% AEP Design Flood Extent under Nepean River Flood Behaviour

2.4.2. Emu Plains Overland Flow Flood Study (2020)

The Emu Plains Overland Flow Flood Study was prepared by BMT in 2020, on behalf of Penrith City Council. The study defined flood behaviour under historical, existing, and future conditions (incorporating potential impacts of climate change) for a full range of design flood events under localised flood behaviour from the Emu Plains catchment. The subject site is within this local catchment, being a subcatchment of the overall Nepean River.

The Study provides detailed mapping of various storm events over the Nepean River catchment within the Penrith LGA, inclusive of the 1 in 20 year storm through to the Probable Maximum Flood (PCC, 2021). In relation to Lot 1, the results from the Study confirm that Lot 1 is not flood affected by overland flow in the 1:100 year storm event, which is fully contained within the existing drainage canal (known as Lapstone Creek). **Figure 2.4-2** is an extract from the 2020 Study, summarising the peak flood extents across Lot 1 in the 1% AEP design flood derived from the local upstream catchment.

Figure 2.4-2 1% AEP Design Flood Extent under Local Catchment Flood Behaviour

3. HYDRAULIC MODELLING – PRE DEVELOPMENT

3.1. HYDRAULIC MODEL DEVELOPMENT

During its ongoing assessment of the Planning Proposal, Penrith Council received correspondence from the Department of Planning, Industry and Environment (DPIE) (undated, DPIE ref IRF21/3043). This correspondence stated, inter alia:

> *…..The preliminary cut and fill design plan submitted demonstrates minor filling of Lot 1, with the fill relocated from Lot 2 to ensure it is flood free at the 1 in 100 flood level. While cut and fill is not precluded, under clause 6 of the direction, any changes to the natural surface levels would need to demonstrate that the development will not result in significant flood impacts to other properties.*

As such, a hydraulic model was required to quantify the impacts of the proposed cut and fill in the standard design flood event – the 1% AEP design flood. Importantly, the cut and fill would have no impact on 1% AEP design flood from the local (Emu Plains) catchment, as the site is not inundated in that event from local catchment runoff (Emu Plains Overland Flow Flood Study, 2020). Therefore, the only hydraulic modelling necessary was modelling of the Nepean River system.

This has the potential to be no small task, given the large nature of PCC's 2018 model, and the relatively minor nature of the development. Further, PCC's 2018 modelling was undertaken in RMA-2, and whilst Rienco's staff have demonstrated experience with that model, using such an older model is never without its complexities. Run-times are also an important consideration in particular given the minor context of the cut and fill. These are all relevant and necessary considerations.

After due consideration, it was determined that a small sub-scale model of the Nepean River could be constructed to as best as practical replicate the results of PCC's 2018 modelling. This hydraulic model would then be fit for the purpose of carrying out additional modelling of the cut and fill, and quantifying the impacts (if any) of the cut and fill. TUFLOW was the model chosen to carry out this task. The model grid was established as a 5m grid across the entire model domain. The 2011 ALS data was used exclusively to extract elevation data to the TUFLOW grid, which is described in **Figure 3.1-1**.

In terms of boundary conditions, these were set to a fixed water surface level, derived from PCC's 2018 Study. The downstream boundary condition is sufficiently downstream of the subject site to allow flood behaviour (and any potential impacts) at the site to be satisfactorily determined. Model domain and boundary condition details are described in **Figure 3.1-1**.

Manning's surface roughness 'n' values were categorised and mapped, with each of the roughness zones then ascribed roughness characteristics. The values initially used for model establishment were derived from consideration of various industry recommendations (including Chow (1959), Hicks *et al* (1991) and Arcement *et al* (1984)), and are consistent with those in the calibrated and validated PCC model (Table 2, 2018).

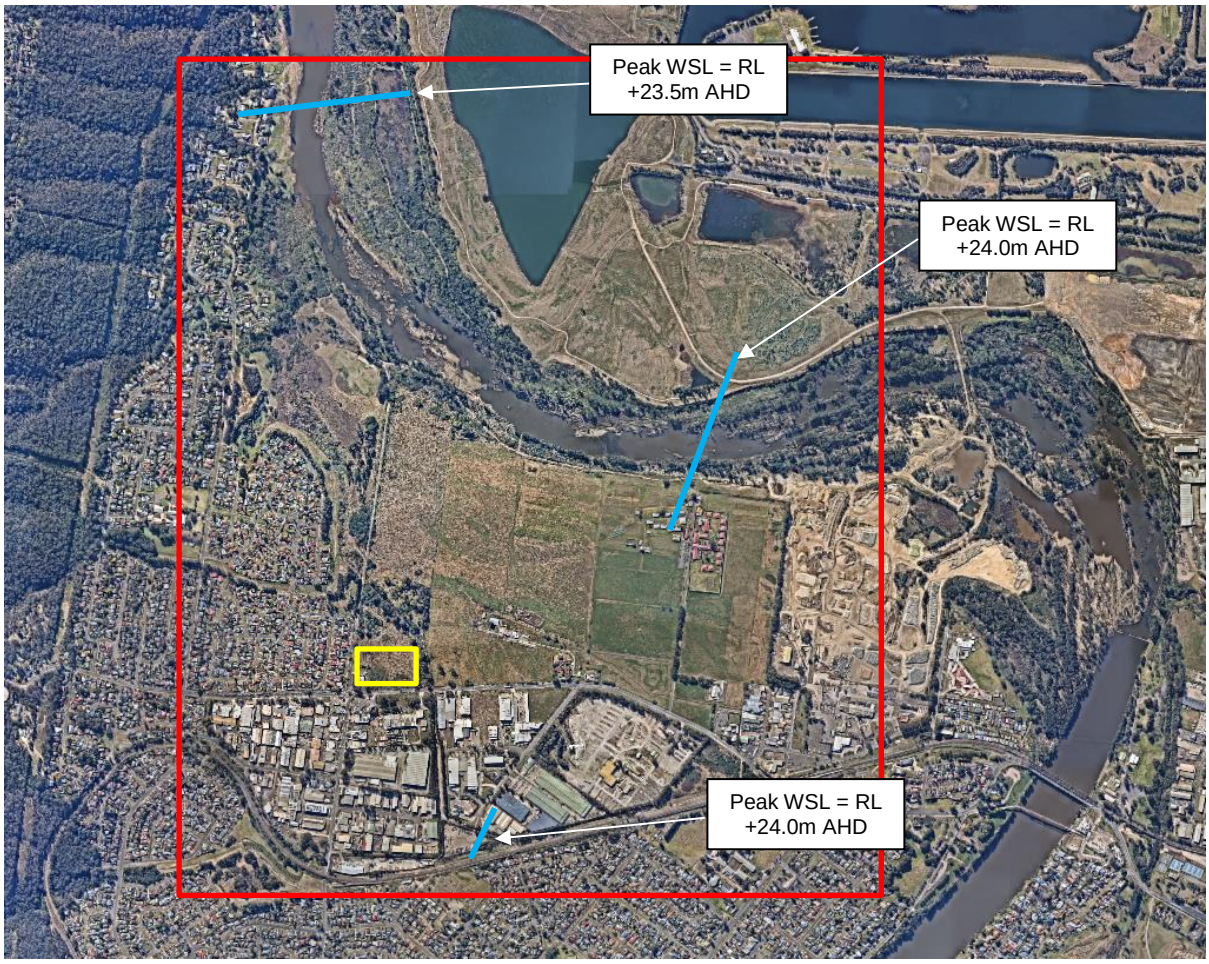

Figure 3.1-1 TUFLOW Grid and Boundary Condition Details

Note: TUFLOW 5m domain shown as red line. Subject site is shown indicatively in yellow. BC's shown indicatively as blue lines.

3.2. HYDRAULIC MODEL RESULTS

The model was run for the 1% AEP design event. A summary of the model results is described below in **Figure 3.2-1**. A full detailed set of model results is included as **Appendix B**. As can be seen in **Figure 3.2-1**, the peak 1% AEP flood depths vary across the site but are however relatively shallow across Lot 1, with peak flood depths reaching 250 mm along the northern boundary. Average peak flood depths across the lot in the 1% AEP design flood are less than 200 mm.

The entire area of Lot 1 is denoted as Low Provisional Hydraulic Hazard when assessed in accordance with Figure L-2 of the NSW Government's Floodplain Development Manual (2005).

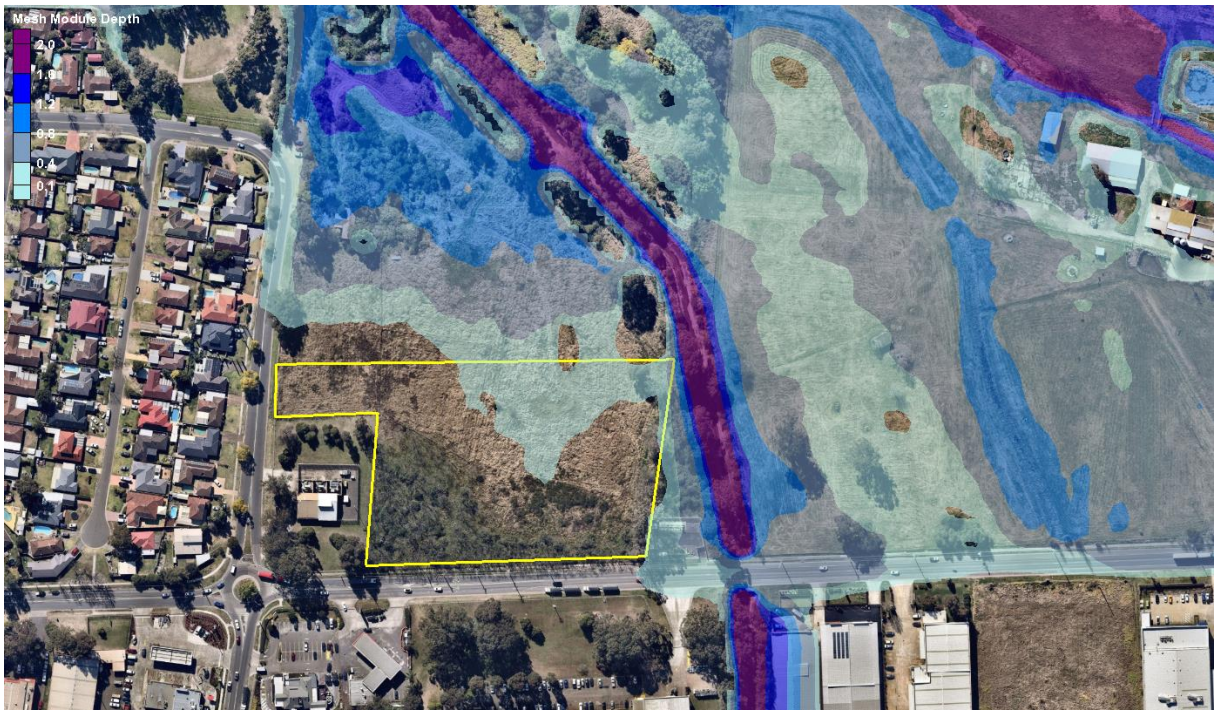

Figure 3.2-1 1% AEP Pre-Development Flood Extent and Depths

Note: Flood depths shaded 100 mm (light blue) to 2,000 mm (dark blue). All depths greater than 2,000 mm are all shaded dark blue.

4. HYDRAULIC MODELLING - POST DEVELOPMENT

4.1. HYDRAULIC MODEL DEVELOPMENT

The TUFLOW input files were modified to simulate the post-development scenario. The 3D TIN of the proposed cut and fill was provided to Rienco, and incorporated into the post-development modelling. No other changes were made to the model.

4.2. HYDRAULIC MODEL RESULTS

The model was re-run for the 1% AEP design event. A summary of the model results is described below in **Figure 4.2-1**. A full detailed set of model results is included as **Appendix B**. As can be interpreted from **Figure 4.2-1**, the proposed earthworks has facilitated a materially flood-free lot, and re-inundated the areas where the stockpiles were previously located.

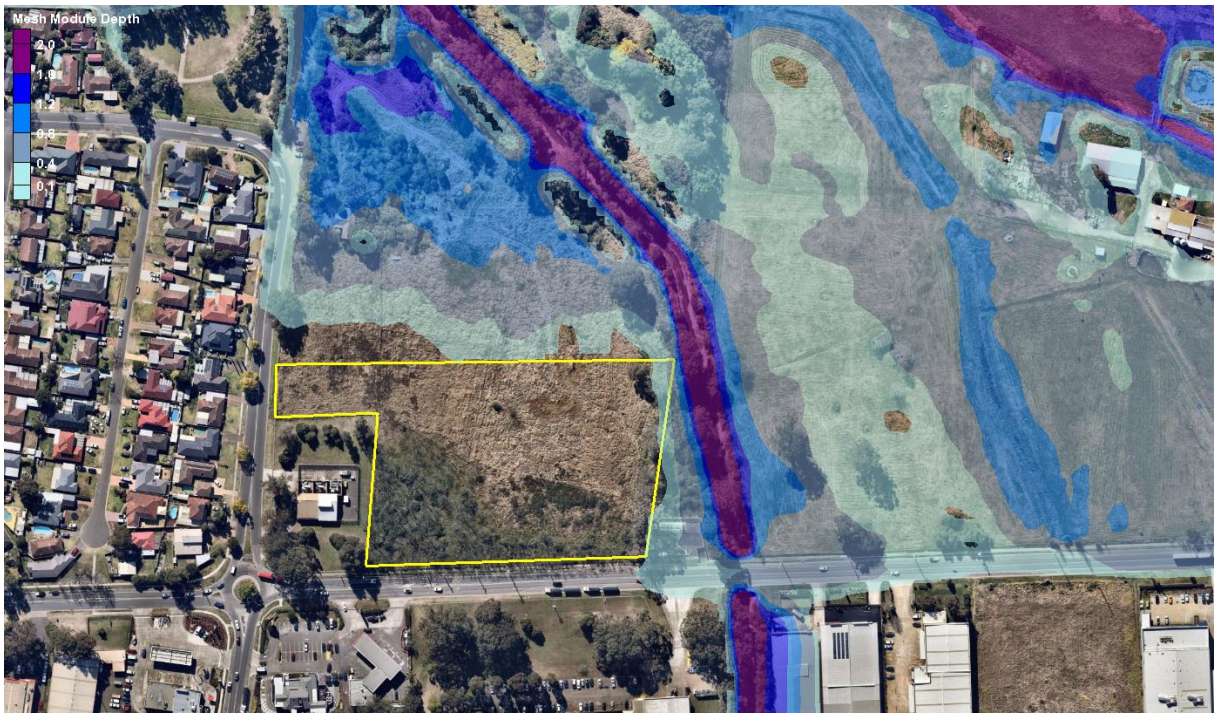

Figure 4.2-1 1% AEP Post-Development Flood Extent and Depths

Note: Flood depths shaded 100 mm (light blue) to 2,000 mm (dark blue). All depths greater than 2,000 mm are all shaded dark blue.

Whilst the modelling was only conducted for the 1% AEP design flood, this does not mean that consideration of a range of flood events was not possible. As noted in both the Nepean River Flood Study (2018) and the Emu Plains Overland Flow Flood Study (2020), the site is not flood affected by local or regional flooding in frequent events (i.e. 20yr ARI design flood). During this event, all runoff is confined to the western (Lapstone Creek) channel. Therefore, the proposed cut and fill could not influence more frequent flood behaviour. The above is also true in the 50yr ARI design flood.

In extreme flood events such as the Probable Maximum Flood (PMF), Lot 1 is inundated by several metres of runoff. In such an event, the minor cut and fill proposed would have an immaterial effect of flood behaviour. This is because not only does the proposed works balance flood storage, the depth-varying roughness effect applies and it is not plausible that the works could have any material influence on extreme flood behaviour.

5. PLANNING CONSIDERATIONS

5.1. REQUIREMENTS OF SECTION 9.1 DIRECTION

As the subject site is susceptible to flood events more frequent than the PMF event, it is defined under NSW legislation as 'Flood Prone Land'. This definition is consistent with the NSW Government's Floodplain Development Manual (2005). As the site is defined as Flood Prone Land, the Section 9.1 Direction (Section 4.3) applies to development on the subject site.

The Ministerial Section 9.1 Direction provides certain objectives and direction on what a relevant planning authority must do if this direction applies. **Table 5.1-1** describes each aspect of the Section 9.1 direction, and advice on how the proposed development complies.

Table 5.1-1 – Section 9.1 Direction Requirements

Section 9.1 Requirements	How the Proposal Addresses the Requirement
A planning proposal must include provisions that give effect to and are consistent with: (a) the NSW Flood Prone Land Policy, (b) the principles of the Floodplain Development Manual 2005, (c) the *Considering flooding in land use planning guideline 2021*, and (d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.	This report constitutes the provisions within the Planning Proposal that give effect to, and are consistent with, the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005.
A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones.	If it is considered that the planning proposal does seek to do this, this is permitted as long as 9 (a) or (b) of Clause 4.3 of the S9.1 Directions is met. See further discussion below.
(a) permit development in floodway areas, (b) permit development that will result in significant flood impacts to other properties, (c) permit development for the purposes of residential accommodation in high hazard areas, (d) permit a significant increase in the development and/or dwelling density of that land, (e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, (f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams,	The planning proposal does not propose: • Development that will result in significant flood impacts to other properties. • Development for the purposes of residential accommodation in high hazard areas • Development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate • Development to be carried out without development consent except for the purposes of exempt development or

drainage canals, levees, still require development consent, (g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or (h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.	agriculture. Dams, drainage canals, levees, still require development consent • A development which will result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services. • Development where hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event. The planning proposal could be considered to propose: • A significant increase in the development and/or dwelling density of that land The planning proposal can propose a significant increase in the development of the land, as long as 9 (a) or (b) of Clause 4.3 of the S9.1 Directions are met. See further discussion below.
A planning proposal must not contain provisions that apply to areas between the flood planning area and Probable Maximum Flood to which Special Flood Considerations apply which: (a) permit development in floodway areas, (b) permit development that will result in significant flood impacts to other properties, (c) permit a significant increase in the dwelling density of that land, (d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, (e) are likely to affect the safe occupation of and efficient evacuation of the lot, or (f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities	The proposed IN2 zone would eventually facilitate development (with consent) that was contained between the flood planning area and Probable Maximum Flood. At this time however, special considerations are not considered applicable as they correspond with the Special Considerations clause of the Standard LEP Template which has not been adopted by PCC. Nonetheless, the planning proposal does not contain provisions which are contrary to any of Items (a) to (f) in the 9.1 Direction.
For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.	The flood planning area acknowledged in this report is consistent with the principles of the Floodplain Development Manual 2005, and as determined in the Nepean River Flood Study, being the 1% AEP peak flood surface level plus 500 mm.
A planning proposal may be inconsistent with the terms of this direction only if the planning proposal authority can satisfy the Secretary of the	

Department of Planning, Industry and Environment (or their nominee) that:	
(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant Council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or	Penrith City Council has not adopted a Floodplain Risk Management Study or Plan for the Nepean River.
(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or	Penrith City Council has adopted a Floodplain Risk Management Study or Plan for the Nepean River.
(c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or	The Planning Proposal is supported by this report, which has been prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements.
(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.	The small portion of land being rezoned that could present *a significant increase in the development and/or dwelling density of that land* is considered of minor significance.

It can be seen from **Table 5.1-1** that the proposed development can readily meet the requirements of the Section 9.1 direction.

5.2. DEVELOPMENT RELATED IMPACTS ON FLOOD BEHAVIOUR

Figure 5.2-1 describes the impacts on peak flood surface levels in the 1% AEP event. A detailed map of these impacts is included in **Appendix B**.

Figure 5.2-1 1% AEP Peak Flood Surface Level Increases

There is no guidance provided in the Section 9.1 Directions regarding suitable flood impacts. DPIE's guidance on flood planning also offers no explicit guidance on how to assess the acceptability (or otherwise) of development related impacts on flood behaviour.

However Penrith City Council's DCP (2014) Part C3 does provide some guidance for acceptable impacts, noting that the cut and fill is not necessarily approved as part of the Planning Proposal and will (at some point) require further approvals. Clause 14 of the DCP (2014) is titled *Filling of Land At or Below the Flood Planning Level* provides guidance on the assessment of fill in the floodplain. It should be noted that the proposal is not strictly proposing 'fill' in the true context of floodplain filling, as it also provides for an overall earthworks balance and the net result of the proposal is no net fill.

Nonetheless, as an assessment of filling has been explicitly requested by DPIE, **Table 5.2-1** describes each aspect of the DCP's filling guidance, followed by commentary on how the proposal can comply with the DCP's guidance.

Table 5.2-1 – PCC DCP 2014 Guidance on Filling

Section 9.1 Requirements	How the Proposal Addresses the Requirement
Council will not grant consent to filling of floodways or high hazard areas	The site is not mapped as a floodway, or high hazard area in Council's Nepean River Flood Study (2018).
The filling of other land at or below the flood planning level will generally not be supported; however, Council will adopt a merits based approach	The earthworks is meritorious, as denoted within this report.
Flood levels are not increased by more than 0.1m by the proposed filling	Flood levels are not increased by more than 0.1m by the proposed earthworks, as quantified by the detailed modelling undertaken in this report.
Downstream velocities are not increased by more than 10% by the proposed filling	Downstream velocities are materially unaffected by the proposed earthworks, as quantified by the detailed modelling undertaken in this report.
Proposed filling does not redistribute flows by more than 15%	As flow is a function of depth and velocity, and given depth and velocity have not materially changed, the flow distribution in and around the cut and fill could not plausibly change.
The potential for cumulative effects of possible filling proposals in that area is minimal	The cumulative impacts of the proposal have merit, as there is no material flood impact and flood storage is balanced.
There are alternative opportunities for flood storage	There is no need for alternative opportunities to balance flood storage losses, as there are no losses from the proposal.
The development potential of surrounding properties is not adversely affected by the filling proposal	Development potential of surrounding properties is not adversely affected by the filling proposal, as quantified by the detailed modelling undertaken in this report. The filling is also offered with compensatory excavation.

The flood liability of buildings on surrounding properties is not increased	The flood liability of buildings on surrounding properties is not increased, as quantified by the detailed modelling undertaken in this report.
No local drainage flow/runoff problems are created by the filling	No local drainage flow/runoff problems are created by the filling, as quantified by the detailed modelling undertaken in this report.

To the extent that a DCP can reasonably be a relevant consideration for the Planning Proposal, it can be seen from **Table 5.2-1** that the proposed development can readily meet the DCP requirements for filling.

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the information contained within this report, it can be concluded that:

- The subject site is located in Emu Plains and is affected by mainstream regional flooding of the Nepean River in a 1% AEP design flood.
- Penrith City Council adopted catchment-wide flood studies quantifying pre-development design flood behaviour at the site, being:
    - Regional Flooding – Nepean River Flood Study (2018)
    - Local Catchment Flooding - Emu Plains Overland Flow Flood Study (2020)
- A detailed 2D TUFLOW model has been prepared for the subject site and surrounds. The model was run for the 1% AEP design flood event and replicates the design flood behaviour published in Council's Nepean River Flood Study (2018).
- The proposed development, specifically the cut and fill, was modelled as the 'post-development' scenario and the impact of the development was quantified by the hydraulic model.
- Flood behaviour for a range of design floods has been considered for the subject site and surrounds, from the 20 year ARI design flood up to and including the probable Maximum Flood.
- The proposal meets the requirements of the NSW Governments Section 9.1 Direction Clause 4.3. Where the proposal is considered inconsistent with this Direction, as per Clause 9 of the Section 9.1 Direction these inconsistencies are supported by this Floodplain Risk Management Plan.
- The requirements of the NSW Government's Floodplain Development Manual (2005) have been considered. There are no specific additional requirements stemming from the application of the Floodplain Development Manual, as the S9.1 Directions are consistent with the Floodplain Development Manual.

Based on the information contained within this report, it is recommended this report is included in the submission to PCC for the proposed development.

Prepared by:

Anthony Barthelmess
Dip. Eng, MEng. MIEAust CPEng RPEQ NER
Managing Director

7. REFERENCES AND BIBLIOGRAPHY

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Abbreviations

	Abbreviation Description
AEP	Annual Exceedance Probability; The probability of a rainfall or flood event of given magnitude being equalled or exceeded in any one year.
AHD	Australian Height Datum: National reference datum for level
ALS	Air-borne Laser Scanning; aerial survey technique used for definition of ground height
ARI	Average Recurrence Interval; The expected or average interval of time between exceedances of a rainfall or flood event of given magnitude.
AR&R	Australian Rainfall and Runoff; National Code of Practice for Drainage published by Institution of Engineers, Australia, 1987.
EDS	Embedded Design Storm; synthesised design storm involving embedment of an AR&R design burst within a second design burst of much longer duration
FPDM	Floodplain Development Manual; Guidelines for Development in Floodplains published by N.S.W. State Government, 2005.
FSL	Flood Surface Level;
GIS	Geographic Information Systems; A system of software and procedures designed to support management, manipulation, analysis and display of spatially referenced data.
IFD	Intensity-Frequency-Duration; parameters describing rainfall at a particular location.
ISG	Integrated Survey Grid; ISG: The rectangular co-ordinate system designed for integrated surveys in New South Wales. A Transverse Mercator projection with zones 2 degrees wide (Now largely replaced by the MGA).
LEP	Local Environment Plan; plan produced by Council defining areas where different development controls apply (e.g. residential vs industrial)
LGA	Local Government Area; political boundary area under management by a given local council. Council jurisdiction broadly involves provision of services such as planning, recreational facilities, maintenance of local road infrastructure and services such as waste disposal.
MGA	Mapping Grid of Australia; This is a standard 6° Universal Transverse Mercator (UTM) projection and is now used by all states and territories across Australia.
MHI	Maximum Height Indicator; measuring equipment used to record flood levels
PMF	Probable Maximum Flood; Flood calculated to be the maximum physically possible.
PMP	Probable Maximum Precipitation; Rainfall calculated to be the maximum physically possible.
RCP	Reinforced Concrete Pipe;
km	Kilometre; (Distance = 1,000m)
m	Metre; (Basic unit of length)
m^2	Square Metre; (Basic unit of area)
ha	Hectare; (Area =10,000 m2)
m^3	Cubic Metre; (Basic unit of volume)
m/s	Metres/Second; (Velocity)
m^3/s	Cubic Metre per Second; (Flowrate)
s	Second; (basic unit of time)
PCC	Penrith City Council; name of the council with jurisdiction over the Penrith LGA

Technical Terms

Term	Description
Alluvium	Material eroded, transported and deposited by streams.
Antecedent	Pre-existing (conditions e.g. wetness of soils).
Catchment	Area draining into a particular creek system, typically bounded by higher ground around its perimeter.
Critical Flow	Water flowing at a Froude No. of one.
Culvert	An enclosed conduit (typically pipe or box) that conveys stormwater below a road or embankment.
Discharge	The flowrate of water.
Escarpment	A cliff or steep slope, of some extent, generally separating two level or gently sloping areas.
Flood	A relatively high stream flow which overtops the stream banks.
Flood storages	Those parts of the floodplain important for the storage of floodwaters during the passage of a flood.
Floodways	Those areas where a significant volume of water flows during floods. They are often aligned with obvious naturally defined channels and are areas which, if partly blocked, would cause a significant redistribution of flow.
Flood Fringes	Those parts of the floodplain left after floodways and flood storages have been abstracted.
Froude No.	A measure of flow instability. Below a value of one, flow is tranquil and smooth, above one flow tends to be rough and undulating (as in rapids).
Geotechnical	Relating to Engineering and the materials of the earth's crust.
Gradient	Slope or rate of fall of land/pipe/stream.
Headwall	Wall constructed around inlet or outlet of a culvert.
Hydraulic	A term given to the study of water flow, as relates to the evaluation of flow depths, levels and velocities.
Hydrodynamic	The variation in water flow, depth, level and velocity with time
Hydrology	A term given to the study of the rainfall and runoff process.
Hydrograph	A graph of flood flow against time.
Hyetograph	A graph of rainfall intensity against time.
Isohyets	Lines joining points of equal rainfall on a plan.
Manning's n	A measure of channel or pipe roughness.
Orographic	Pertaining to changes in relief, mountains.
Orthophoto	Aerial photograph with contours, boundaries or grids added.
Pluviograph	An instrument which continuously records rain collected
Runoff	Water running off a catchment during a storm.
Scour	Rapid erosion of soil in the banks or bed of a creek, typically occurring in areas of high flow velocities and turbulence.
Siltation	The filling or raising up of the bed of a watercourse or channel by deposited silt.
Stratigraphy	The sequence of deposition of soils/rocks in layers.
Surcharge	Flow unable to enter a culvert or exiting from a pit as a result of inadequate capacity or overload.
Topography	The natural surface features of a region.
Urbanisation	The change in land usage from a natural to developed state.
Watercourse	A small stream or creek.

APPENDIX A – SITE SURVEY

Figure A1.1: ALS Survey Levels at Subject Site

APPENDIX B – DETAILED MODEL RESULTS

APPENDIX B1 – 1% AEP MODEL RESULTS – PRE-DEVELOPMENT

Figure B1.1: 1% AEP Flood Levels – Pre-Development

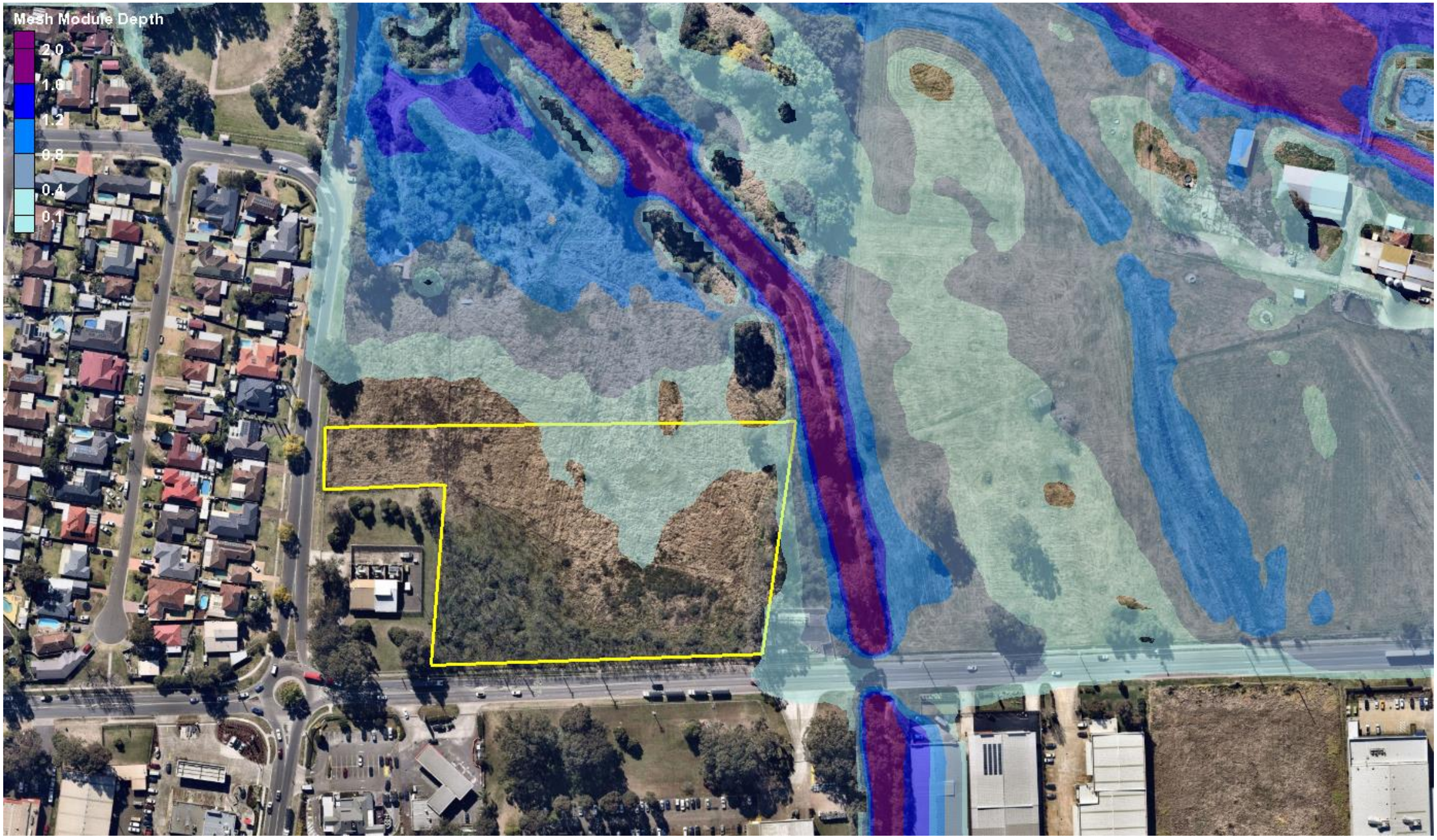

Figure B1.2: 1% AEP Flood Depths – Pre-Development

Note: Flood depths shaded from 0.1m (light blue) to 2.0m (dark blue). All depths over 2.0m shaded dark blue.

Figure B1.3: 1% AEP Flood Velocity – Pre-Development

Note: Flood velocity shaded from 0 m/s (yellow) to 1.0 m/s (orange). All velocity over 1.0 m/s shaded orange.

APPENDIX B2 – 1% AEP MODEL RESULTS – POST-DEVELOPMENT

Figure B2.1: 1% AEP Flood Levels – Post-Development

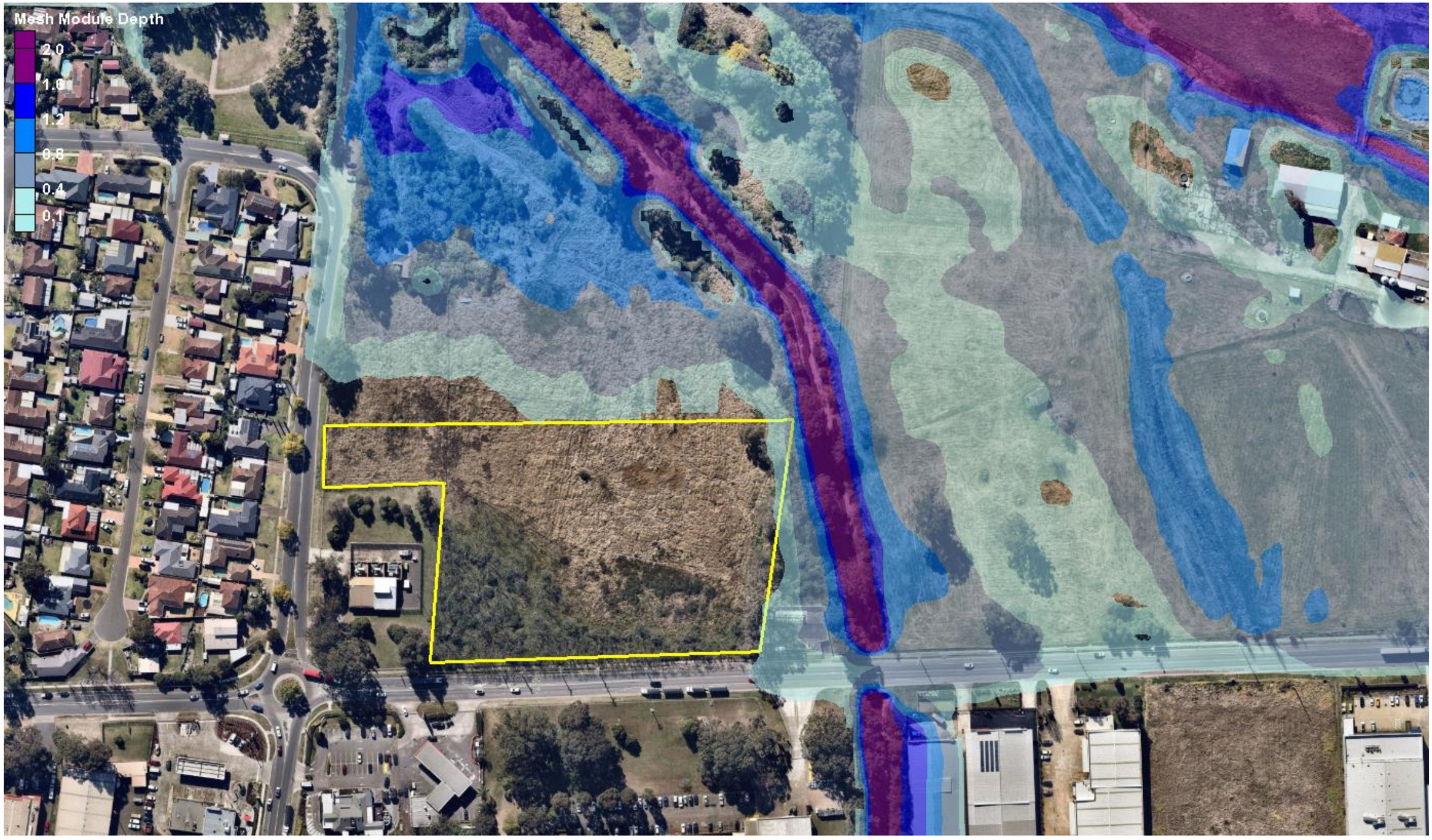

Figure B2.2: 1% AEP Flood Depths – Post-Development

Note: Flood depths shaded from 0.1m (light blue) to 2.0m (dark blue). All depths over 2.0m shaded dark blue.

Figure B2.3: 1% AEP Flood Velocity – Post-Development

Note: Flood velocity shaded from 0 m/s (yellow) to 1.0 m/s (orange). All velocity over 1.0 m/s shaded orange.

APPENDIX B3 – IMPACT MAP

Figure B3.1: 1% AEP Development Related Impacts to Peak Flood Surface Levels under Post-Development Conditions