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Providing Specialist Services in the Fields of Hydrology and Hydraulics

Floodplain Risk Management Plan Proposed Development at 105 Cooby Road, Tullimbar

for Tullimbar Heights Pty Ltd

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Report title:

Floodplain Risk Management Plan
Planning Proposal at 105 Cooby Road, Tullimbar

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1. INTRODUCTION

1.1. BACKGROUND AND PROPOSED DEVELOPMENT

The owners of the subject site seek to submit a Planning Proposal (PP) to Shellharbour City Council (SCC) to facilitate residential development on the land. The subject site is approximately 29 hectare and is currently used for grazing. Portions of the site are flood affected based on previous flood modelling and historic records. As such, Tullimbar Heights Pty Ltd has engaged Rienco Consulting to prepare a suitably detailed Floodplain Risk Management Plan that addresses the requirements of the S.117 Direction Clause 4.3, as further described in **Section 1.2**.

The proposed development consists of a residential subdivision, as summarised in **Figure 1.1-1** below. The proposal consists of a road network providing access to a series of lots of varying sizes. The proposal also involves the removal of an existing dam on the site, located 'online' in the existing Cooback Creek.

Figure 1.1-1 Proposed Development Plan

Note: Plans supplied by Indesco. North is at the top of the figure.

1.2. PURPOSE OF THIS REPORT

The purpose of this report is to:

a) Review of existing flood information available for the site.

b) Prepare a detailed hydrologic and hydraulic model that determines peak flood levels at the subject site for a range of events up to and including the Probable Maximum Flood (PMF).

c) Determine the potential impacts of the proposed development, and the associated flood hazard categorisation.

d) Review the proposed development, together with the hydraulic model results, and assess it against:

(a) S117 Directions relating to flooding, and

(b) Clause 6.3 of the SLEP (2013, as amended).

e) Prepare a report summarising the above suitable for lodgement with SCC with 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.

2. AVAILABLE DATA

2.1. SITE DESCRIPTION

The site is approximately 29 ha in area and is located in Tullimbar, NSW. It is bounded to the north, east and west by rural lands, and tributaries of Macquarie Rivulet, being Cooback Creek and Hazelton Creek. The site is bounded to the south by existing 'rural res' development. The site is currently used as grazing land. **Figure 2.1-1** presents an aerial image of the site and surrounds.

Figure 2.1-1 Subject Site

Note: Image sourced from Six Maps. Subject site is shown as red line work with yellow shading.

2.2. CATCHMENT DESCRIPTION

The catchment of Macquarie Rivulet lies within the Lake Illawarra sub-basin of the Wollongong Coastal Basin (#214). It drains 107 km^2 of mostly forested and rural lands and is located some 100 km to the south of Sydney on a thin band of coastal land between the Illawarra escarpment and the Tasman Sea. Macquarie Rivulet has its headwaters on the escarpment near Robertson, flowing east over the escarpment, to ultimately discharge into Lake Illawarra.

The drainage network of Macquarie Rivulet comprises three main arms:

- Macquarie Rivulet (the main arm draining the central portion of the catchment)
- Frazers Creek (a secondary arm draining the south-eastern sector)
- Marshall Mount Creek (a major arm draining the northern sector)

All three arms combine on the flood plain above the Princes Highway, to the immediate west of Albion Park airport. In large events, flows merge across the full width of the flood plain at this location to form a single near level pool of floodwater.

All three sub-catchments are predominantly rural with some existing urban development in the lower reaches of Frazers Creek and Macquarie Rivulet, around Albion Park. Areas to the west and south west of Albion Park are at present undergoing significant urban development.

Hazelton, Cooback and Yellow Rock Creeks are tributaries of Macquarie Rivulet, draining an area of mostly rural land to the south of the Illawarra Highway. The subject site has the potential to be affected by flooding from both Hazelton and Cooback Creeks. A catchment plan for areas upstream of the subject site is included as **Appendix B**.

2.3. SURVEY DATA

Topographic information was also available, in the form of Airborne Laser Scan (ALS) data. The NSW Government's Land & Property Information department (LPI) have supplied a 1m DEM from the 2015 ALS dataset. Aerial imagery (2015) was also supplied for the subject site and surrounds via LPI.

2.4. SITE INSPECTION

A detailed site inspection was undertaken by the author in November 2018. The site inspection confirmed the adequacy of the survey information used in this study.

2.5. PREVIOUS STUDIES

There are a multitude of previous studies available within the catchment of Macquarie Rivulet, but the three of most relevance to the proposed development are:

- Creek Realignment Design Report, Tullimbar Village (Forbes Rigby, 2004). Report prepared for Miltonbrook Pty Ltd for the Tullimbar Development, detailing design flood estimation for the Hazelton and Cooback Creek catchments.
- Macquarie Rivulet Flood Study (Rienco, 2011). Report prepared for Cardno Forbes Rigby for the Calderwood Development, detailing a calibrated and validated hydrology and hydraulic model, as well as design flood estimation.
- Shellharbour Council's Macquarie Rivulet Flood Study (WMA Water, 2017). Report prepared for Cardno Shellharbour Council as a catchment wide study prepared in accordance with the FPDM guidelines, detailing a calibrated and validated hydrology and hydraulic model, as well as design flood estimation.

These three studies have been used for reference throughout this report.

3. HYDROLOGIC MODELLING

3.1. HYDROLOGY MODEL DEVELOPMENT

A WBNM model has been created for this study, to determine peak flows at the subject site for all events up to and including the PMF. WBNM is an advanced storage-routing model that allows simulation of complex catchment behaviour. Further details of the models capabilities are available in the Research & Development section of www.rienco.com.au. This particular model was considered most appropriate to the task of modelling the study area, given its ability to simulate a wide range of catchment characteristics and its extensive use in the region. The model allowed flows to be established at various locations of interest throughout the model domain.

The model was established consistent with previous studies, principally:

- Macquarie Rivulet Flood Study (Rienco, 2011). Report prepared for Cardno Forbes Rigby for the Calderwood Development, detailing a calibrated and validated hydrology and hydraulic model, as well as design flood estimation.
- Creek Realignment Design Report, Tullimbar Village (Forbes Rigby, 2004). Report prepared for Miltonbrook Pty Ltd for the Tullimbar Development, detailing design flood estimation for the Hazelton and Cooback Creek catchments.

Model parameters were as per **Table 3.1-1**, and peak flow estimates were as per **Table 3.1-2**. Model parameters used in WBNM are consistent with locally derived parameters in calibrated and validated WBNM models, and are deemed appropriate for use in this study.

Table 3.1-1 – Summary of WBNM Model Parameters

Parameter	Adopted Value
Initial loss (pervious surface)	0 mm
Continuing loss (pervious surface)	2.5 mm/hr
C (Lag parameter)	1.3

A single design rainfall gauge were used from the AR&R isohyetal datasets (RAL29) and incorporated into the model. A detailed catchment plan is included as **Appendix B**.

3.2. HYDROLOGY MODEL CHECKS

Prior to using the model to establish design discharges, the model was checked in the following ways using a 2 hour, 1% AEP design rainfall burst.

- ***Overall volume conservation***. The total runoff volume (as calculated at the catchment outlet) was checked against total rainfall volume (i.e total amount of rain falling on the entire catchment surface). As expected from a correctly constructed model, these two values were the same once the volume of rainfall lost to groundwater and stored on the surface (and therefore not included in runoff at the outlet) were accounted for.

- ***Unit discharge – from local subareas.*** The unit discharge from each subarea was calculated by dividing the local runoff (sum of the pervious and impervious peak discharges) from each subarea by its area to give a discharge per hectare rate.

Unit discharge values should all lie within a typical range for a 1% AEP design storm of 2 hour burst duration in this area, of between 0.5 and 0.8 $m^3/s/ha$, with variation inside this range being due to spatial differences in rainfall and differences in area and impervious cover (larger sub-areas having lower unit discharges and more impervious sub-areas having higher unit discharges).

3.3. HYDROLOGY MODEL RESULTS

The WBNM model was then run for a full range of durations for the 1% AEP and PMF events. **Table 3.3-1** below describes the peak flow estimates from the WBNM modelling for each of the critical sub-areas. As can be seen, at the subject site, the critical duration design storm for the 1% AEP event is 60 minutes, and 45 minutes for the PMF.

Table 3.3-1 – Summary of Peak Flow Estimates at Various Locations

Location	1% AEP Peak Flows 60 min. Critical Duration	PMF Peak Flows 45 min. Critical Duration
Cooback Creek – Eastern Arm flowing into subject site *(WBNM Sub C1)*	10.2 m^3/s	23.4 m^3/s
Cooback Creek – Western Arm flowing into subject site *(WBNM Sub C9)*	3.0 m^3/s	5.8 m^3/s
Cooback Creek – Total Flow in Cooback Creek at Downstream Site Boundary *(WBNM Sub C4)*	19.1 m^3/s	45.6 m^3/s
Hazelton Creek – Total Flow in Hazelton Creek at Upstream Site Boundary *(WBNM Sub H5 plus H6)*	64.8 m^3/s	172.1 m^3/s

4. HYDRAULIC MODELLING – PRE DEVELOPMENT

4.1. HYDRAULIC MODEL DEVELOPMENT

The model grid was established as a 2m grid across the entire model domain. The 2015 ALS data was used exclusively to extract elevation data to the TUFLOW grid, which is described in **Figure 4.1-1**.

In terms of inflow boundary conditions, inflow hydrographs were directly input from the WBNM model results. The inflow hydrographs were taken from WBNM C1 to C5, C8, C9, H5 and H6. The downstream boundary condition was set to a Manning's equation with a slope of 3%, measured from the ALS data. The downstream boundary condition is sufficiently downstream (i.e. ~600m) of the subject site to allow flood behaviour at the site to be satisfactorily determined.

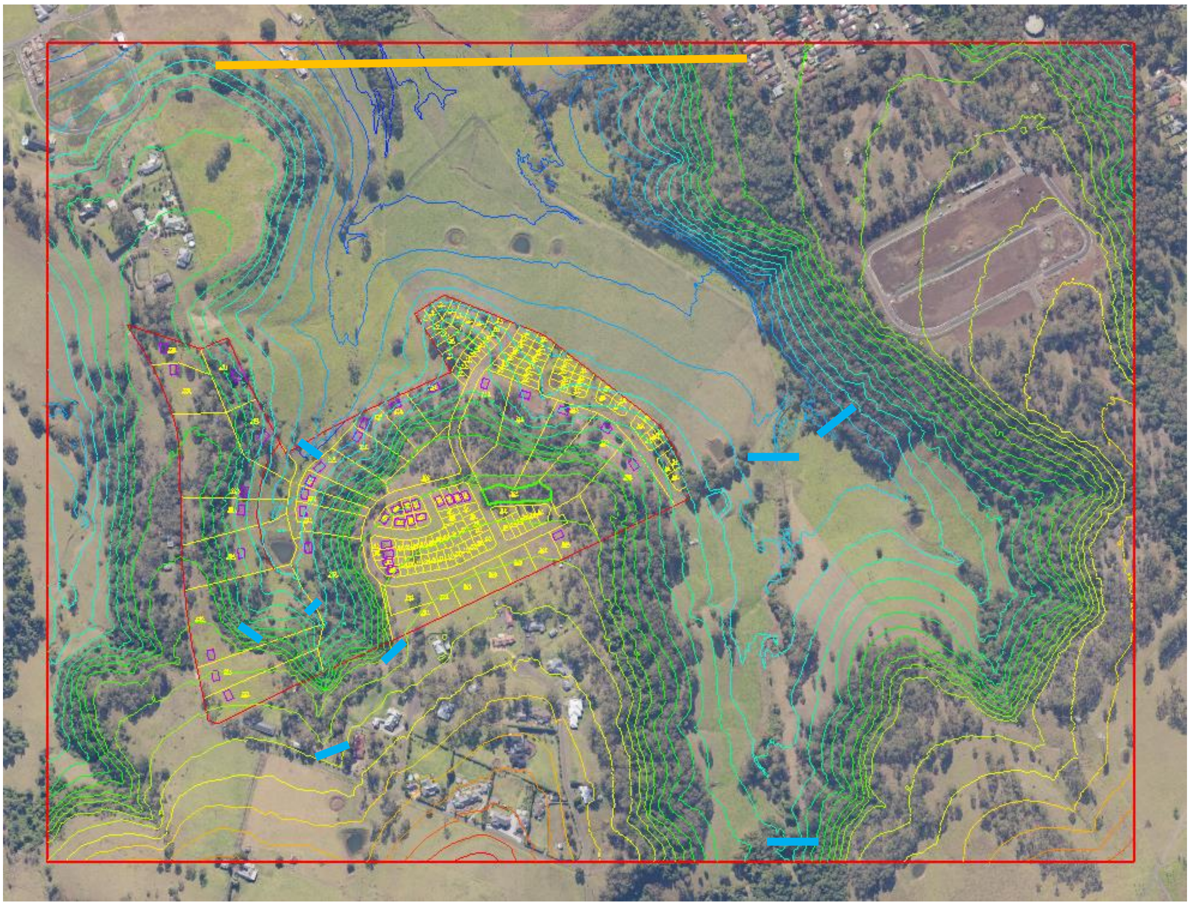

Figure 4.1-1 TUFLOW Grid and Boundary Condition Details

Note: TUFLOW 2m domain shown as red line. Inflow hydrograph BC's shown as blue lines, Manning's normal depth BC's shown as orange lines. Subject site is shown indicatively in yellow.

Manning's surface roughness 'n' values were taken from a detailed site inspection and the typical roughness values associated with those surfaces. **Table 4.1-1** describes the surface characteristics and the associated roughness values.

Table 4.1-1 – Manning's Surface Roughness Values

Surface Description	Assigned 'n' value in TUFLOW
Open Grass Paddocks	0.050
High Density Vegetation	0.150

Figure 4.1-2 describes the surface roughness mapping.

Figure 4.1-2 Pre-Development Manning's Surface Roughness Map

4.2. HYDRAULIC MODEL RESULTS

The model was run for the 1% AEP and PMF design events. 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 C**.

As can be seen in **Figure 4.2-1**, the peak 1% AEP flood depths vary across the site. Flooding is confined to the riparian and watercourse areas, which is expected given the incised nature of the watercourses through the subject site. The existing dam, online on Cooback Creek, overtops in the 1% AEP event which is, again, expected. Flooding in Hazelton Creek does not enter the subject site in the 1% AEP or PMF events.

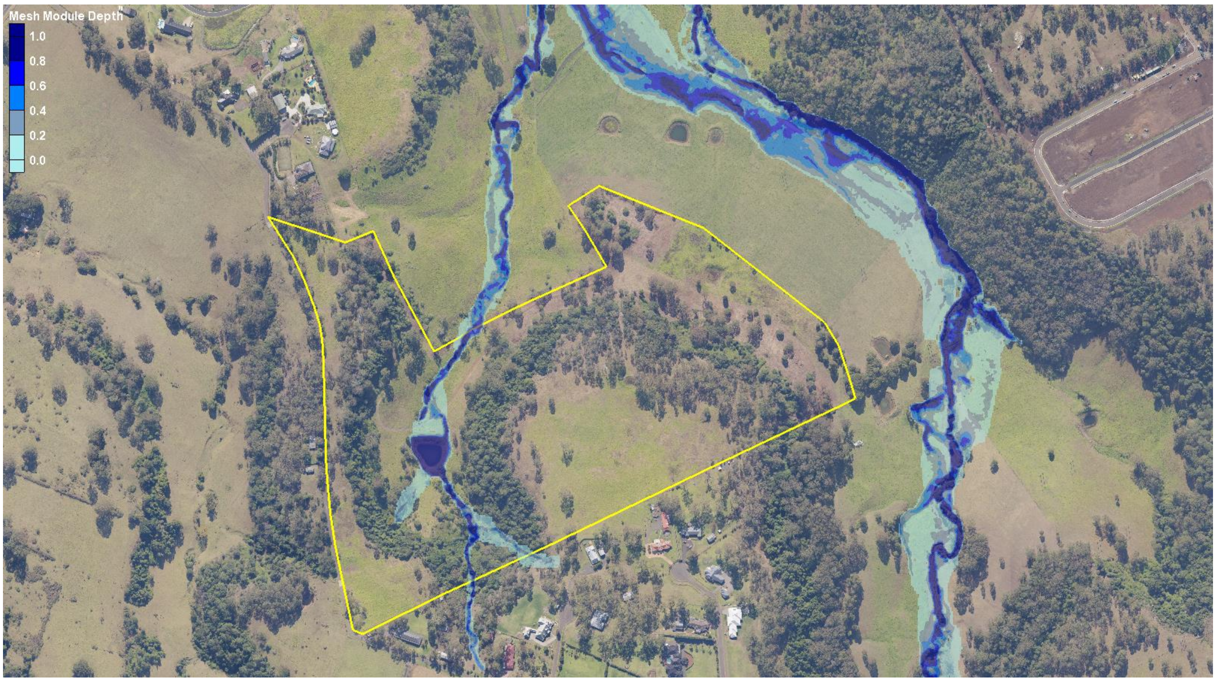

Figure 4.2-1 1% AEP Pre-Development Flood Extent and Depths

Note: Flood depths shaded 0mm (light blue) to 1,000mm (dark blue). All depths greater than 1,000mm are all shaded dark blue.

5. HYDRAULIC MODELLING - POST DEVELOPMENT

5.1. HYDRAULIC MODEL DEVELOPMENT

The TUFLOW input files were modified to simulate the post-development scenario. A nominal waterway crossing was added where one of the subdivision roads crosses Cooback Creek. The culvert size in the model is 2 x 3.6m (w) x 1.2m (h) culverts, however this will be confirmed during further detailed design. A small amount of fill was added to the model around the existing farm dam, which simulates the eventual design profile of the proposed access road.

Roughness values were not modified as part of the post-development modelling. The majority of the existing watercourse areas will remain as watercourse areas, and the pre-development roughness is considered consistent with the proposed objectives of the watercourses. Inflow hydrographs were also not altered, as any changes to peak flows caused by the development can be readily catered for via the provision of OSD on each lot.

5.2. HYDRAULIC MODEL RESULTS

The model was run for the 1% AEP and PMF design events. A summary of the model results is described below in **Figure 5.2-1**. A full detailed set of model results is included as **Appendix C**. As can be seen in **Figure 5.2-1**, the peak 1% AEP flood depths and extent are contained within the nominated riparian areas. The proposed open channel achieves its intended design purpose, by routing overland flow around the proposed development. The proposed watercourse crossing is not inundated in the 1% AEP event.

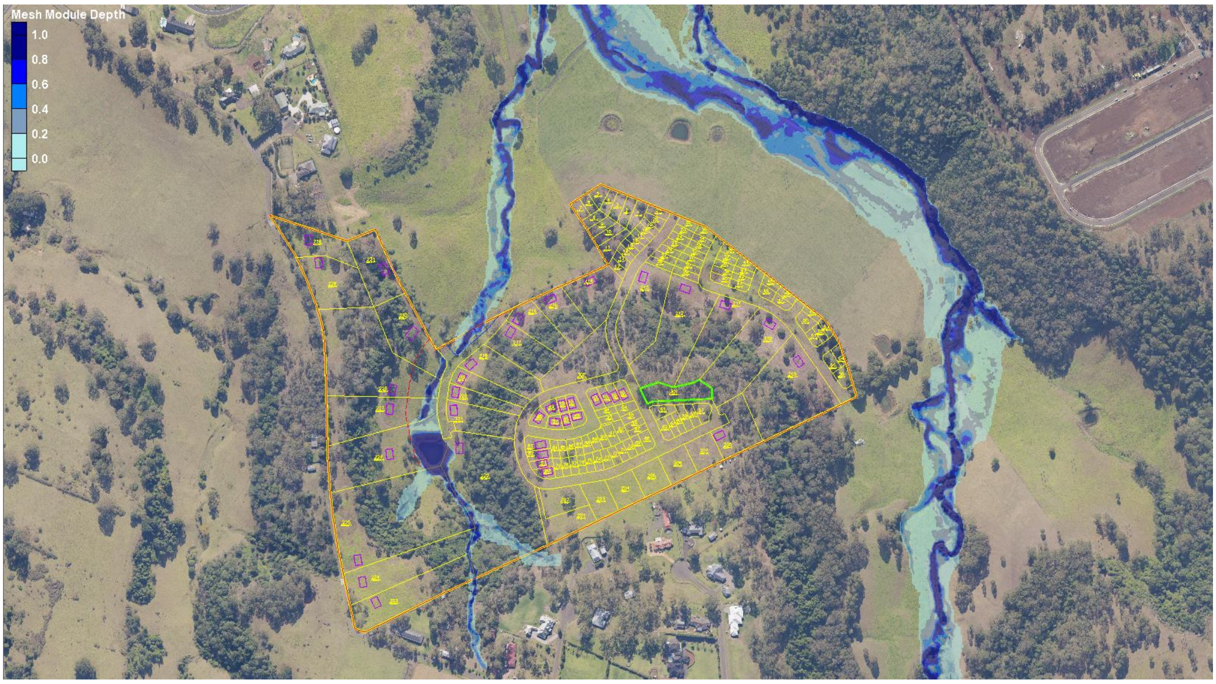

Figure 5.2-1 1% AEP Post-Development Flood Extent and Depths

Note: Flood depths shaded 0mm (light blue) to 1,000mm (dark blue). All depths greater than 1,000mm are all shaded dark blue.

None of the proposed building envelopes are affected by mainstream flooding from either Cooback or Hazelton Creeks in the 1% AEP or PMF events. This is an important conclusion from the model results, and underscores the suitability of the proposal with regard to flooding.

5.3. DEVELOPMENT RELATED IMPACTS ON FLOOD BEHAVIOUR

Figure 5.3-1 describes the impacts on peak flood surface levels in the 1% AEP event. A detailed map of these impacts is included in **Appendix C**. The impacts resulting from the proposed development are generally isolated to the subject site, within the existing watercourse.

Some impacts are noted on the downstream property, however these impacts are associated with the transition of the watercourse into the existing channel, and are temporary only. They can be readily reduced during detailed design of the watercourse and have no effect on land earmarked for residential development.

Figure 5.3-1 1% AEP Peak Flood Surface Level Increases

Note: Flood impacts shown from 50mm to 300mm.

Due to the improved channelization of the existing Cooback Creek watercourse, some increases in velocity are estimated. However, the potential scour or erosion that may come from these proposed velocities can be readily managed through detailed design, by the use our pools and riffle beds, and rock jams etc. This is consistent with the geomorphic treatments designed and constructed in Tullimbar below the site (Barthelmess, 2007).

5.4. PROVISIONAL HYDRAULIC HAZARD

The existing site is affected by the 1% AEP and is classified as a mix of Low and High Provisional Hydraulic Hazard (PHH) for the 1% AEP flood event, when assessed under the NSW Government's Floodplain Development Manual (Figure L-2). **Figure 5.4-1** below describes the pre-development PHH and **Figure 5.4-2** below describes the post-development PHH. As can be seen, all of the proposed residential lots are flood-free in the 1% AEP event and are therefore not subject to any hydraulic hazard.

In both the figures, dark blue shading denotes High Provisional Hydraulic Hazard, and light blue shading denotes Low Provisional Hydraulic Hazard, in accordance with the Floodplain Development Manual (Figure L-2).

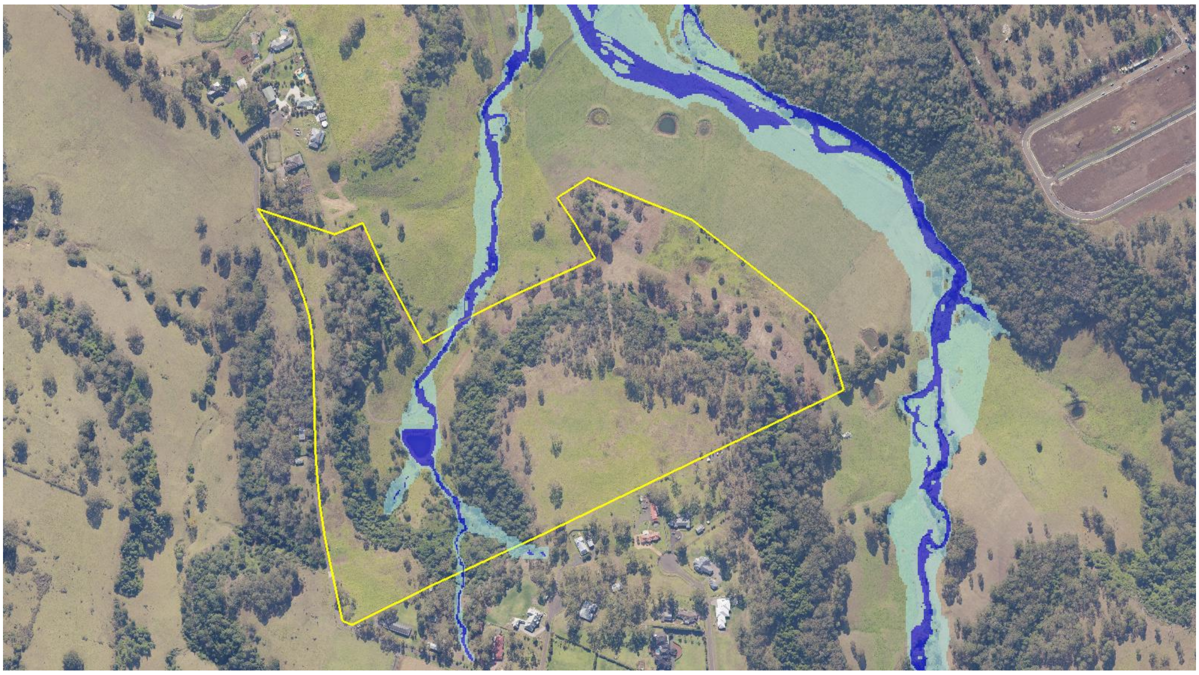

Figure 5.4-1 1% AEP Pre-Development Provisional Hydraulic Hazard

Note: Provisional Hydraulic Hazard designated by TUFLOW in accordance with NSW Government's Floodplain Development Manual Figure L-2 (2005).

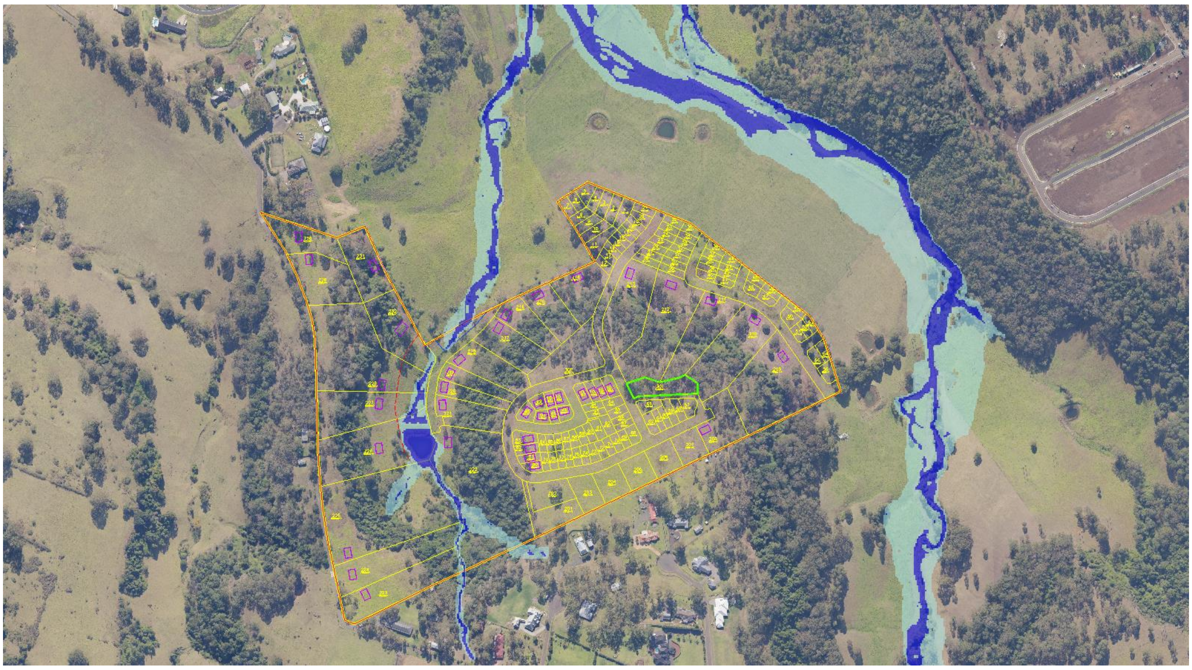

Figure 5.4-2 1% AEP Post-Development Provisional Hydraulic Hazard

Note: Provisional Hydraulic Hazard designated by TUFLOW in accordance with NSW Government's Floodplain Development Manual Figure L-2 (2005).

6. PLANNING REQUIREMENTS

6.1. REQUIREMENTS OF SECTION 117 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 117 Direction (Section 4.3) applies to development on the subject site.

The Ministerial Section 117 Direction (last amended 2nd March 2016) provides certain objectives and direction on what a relevant planning authority must do if this direction applies. **Table 6.1-1** describes each aspect of the S.117 direction, and advice on how the proposed development already complies, or what design aspects can be incorporated into the development to ensure compliance with the S.117 direction.

Table 6.1-1 – S.117 Direction Requirements

S.117 Requirements	How the Proposal Addresses the Requirement
A planning proposal must include provisions that give effect to, and are consistent with, the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).	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 areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.	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 S117 Directions is met. See further discussion below.
A planning proposal must not contain provisions that apply to the flood planning areas 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 development of that land, (d) are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or (e) permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodway's or high hazard areas), roads or exempt development.	The planning proposal does not propose: • Development in floodway areas. • Development that will result in significant flood impacts to other properties. • A development which will result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services. • Development to be carried out without development consent. The planning proposal does propose: • Significant increase in the development 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 S117 Directions are met. See further discussion below.
A planning proposal must not impose flood related development controls above the residential flood planning level for residential	The planning proposal does <u>not</u> impose flood related development controls above the residential flood planning level.

development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).	
A planning proposal may be inconsistent with this direction only if the relevant planning authority can satisfy the Director-General (or an officer of the Department nominated by the Director-General) that: (a) the planning proposal is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or (b) the provisions of the planning proposal that are inconsistent are of minor significance.	This report constitutes *a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual 2005,* and the planning proposal is in accordance with it.

It can be seen from **Table 6.1-1** that the proposed development can readily meet the requirements of the Section 117 direction.

6.2. ADDRESSING SHELLHARBOUR LEP CLAUSE 6.3

SCC's Local Environment Plan (LEP) 2013 sets forth its requirements for land for which the LEP applies (i.e. the subject site). **Table 6.2-1** describes each LEP clause and commentary on how the proposed development relates to the requirements of the LEP.

Table 6.2-1 – LEP Requirements Addressed for Proposed Development

LEP Requirement	How the Proposal Addresses the Requirement
The development… is compatible with the flood hazard of the land	The proposed development is entirely compatible with the flood hazard of the land. All lots proposed for residential development are flood free in all events up to and including the PMF.
The development… will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties,	The proposed development will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties. This is demonstrated by the detailed hydraulic modelling carried out in this report.
The development… incorporates appropriate measures to manage risk to life from flood	The proposed development does incorporate the optimum measure to manage risk to life from flooding, as all lots proposed for residential development are flood free in all events up to and including the PMF.
The development… will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses,	The model results show that the those aspects of the project that have the potential to *significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses* can be readily managed through detailed design.

The development… is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.	The proposed development will not result in unsustainable social and economic costs to the community as a consequence of flooding, as all lots proposed for residential development are flood free in all events up to and including the PMF.

It can be seen from **Table 6.2-1** that the proposed development meets or exceeds SCC's LEP requirements. In other words, if the land was suitably zoned for the proposed development to be permissible today, the proposed development already meets the requirements of the SLEP (2013).

7. CONCLUSIONS AND RECOMMENDATIONS

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

- SCC adopted its catchment-wide flood study in 2017, titled *Macquarie Rivulet Flood Study.* Its results are directly applicable to the subject site for quantifying flood behaviour in the pre-development scenario.
- A WBNM hydrologic model has been used to determine design flood estimates at the subject site and surrounds. This model uses data for its construction that is consistent with the *Macquarie Rivulet Flood Study (2017).*
- A detailed 2D TUFLOW model has been prepared for the subject site and surrounds. The model was run for the 1% AEP and Probable Maximum Floods (PMF).
- Flood behaviour for a range of design floods has been determined for the subject site and surrounds. This flood behaviour is consistent with the *Macquarie Rivulet Flood Study (2017)* model results and those within Rienco's previous work in the catchment.
- The Flood Planning Level for the site is difficult to specify as one level, given the flood gradient across the site. In any case, none of the proposed building envelopes are affected by mainstream flooding for all events up to and including the PMF.
- The proposal meets the requirement of the NSW Governments S.117 Direction Clause 4.3. Where the proposal is inconsistent with this Direction, as per Clause 9 of the S117 Direction these inconsistencies are supported by this Floodplain Risk Management Plan.
- The proposal meets the requirement of Shellharbour Council's LEP (2013) Clause 6.3.
- 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 S117 Directions and SCC's LEP (Clause 6.3) 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 SCC for the proposed development.

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Managing Director

8. 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)
SCC	Shellharbour City Council; name of the council with jurisdiction over the Shellharbour LGA

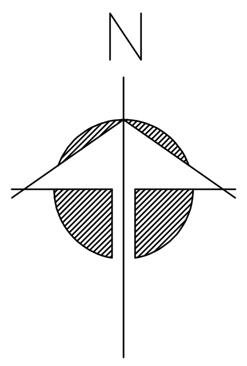
Technical Terms

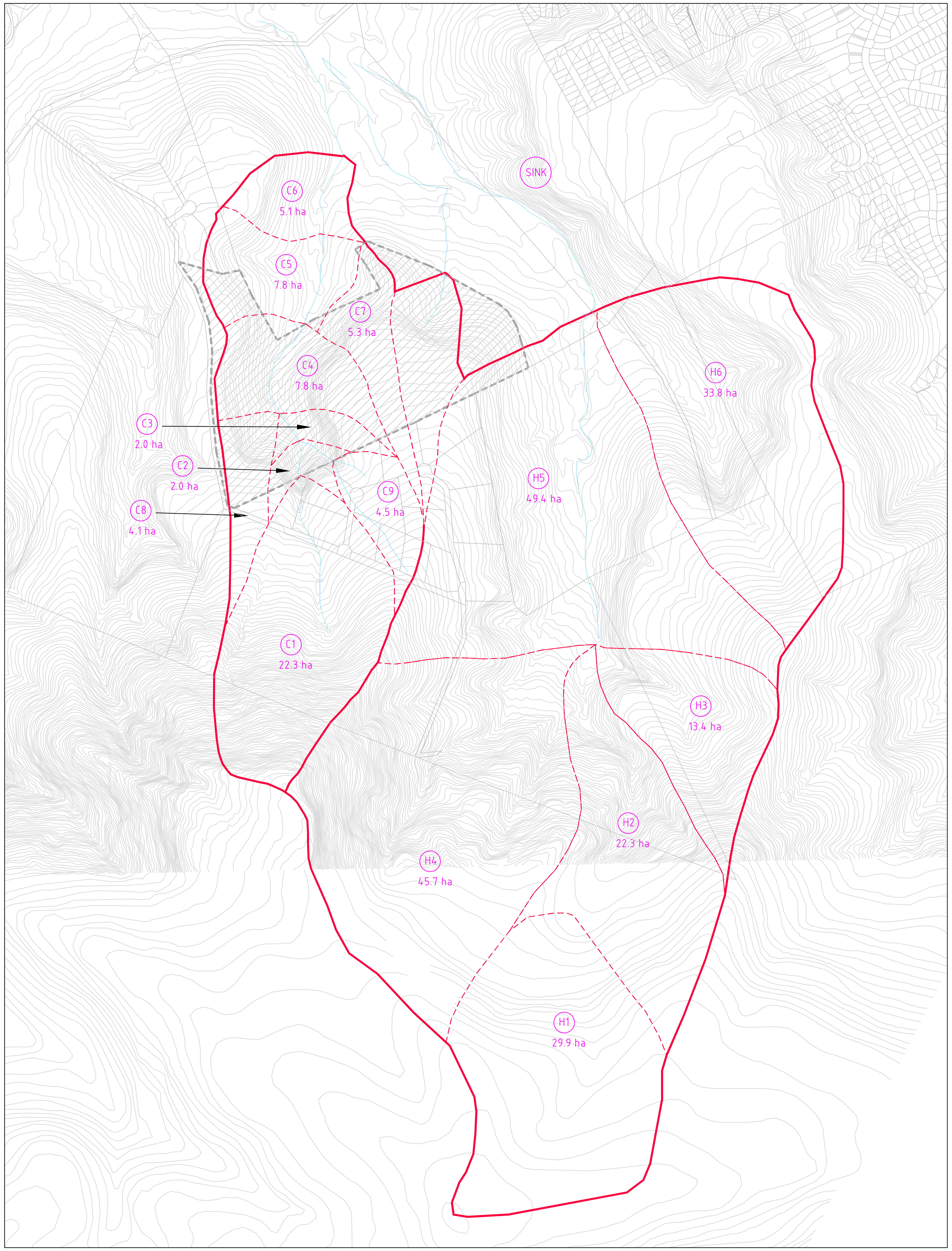
Term	Description
Alluvium	Material eroded, transported and deposited by streams.
Antecedent	Pre-existing (conditions e.g. wetness of soils).
Catchment	Area draining into a particular creek system, typically bounded by higher ground around its perimeter.
Critical Flow	Water flowing at a Froude No. of 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 – WBNM CATCHMENT PLAN





ISSUE:	DESCRIPTION:	DATE:	BY:
A	ISSUED FOR PLANNING PROPOSAL	15.12.18	AB

RIENCO CONSULTING

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TITLE: WBNM CATCHMENT PLAN

CLIENT: Indesco Wollongong

LOCATION: Cooby Road, Tullimbar

DRG No:	SCALE:	DRAWN BY:	REVISION:
1001	NTS	AB	A

APPENDIX C – DETAILED MODEL RESULTS

APPENDIX C1 – 1% AEP MODEL RESULTS – PRE-DEVELOPMENT

Figure C1.1: 1% AEP Flood Levels – Pre-Development

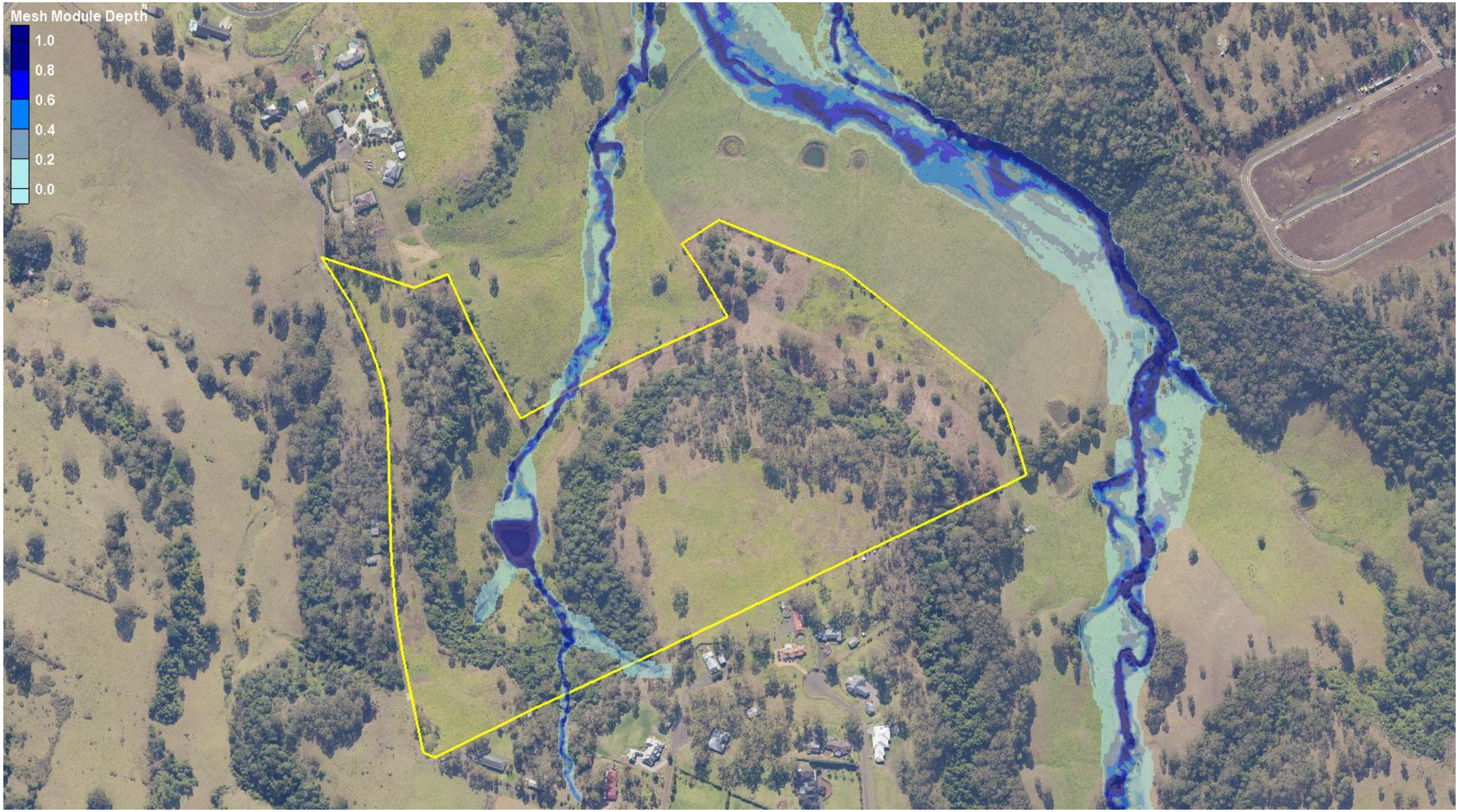

Figure C1.2: 1% AEP Flood Depths – Pre-Development

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue.

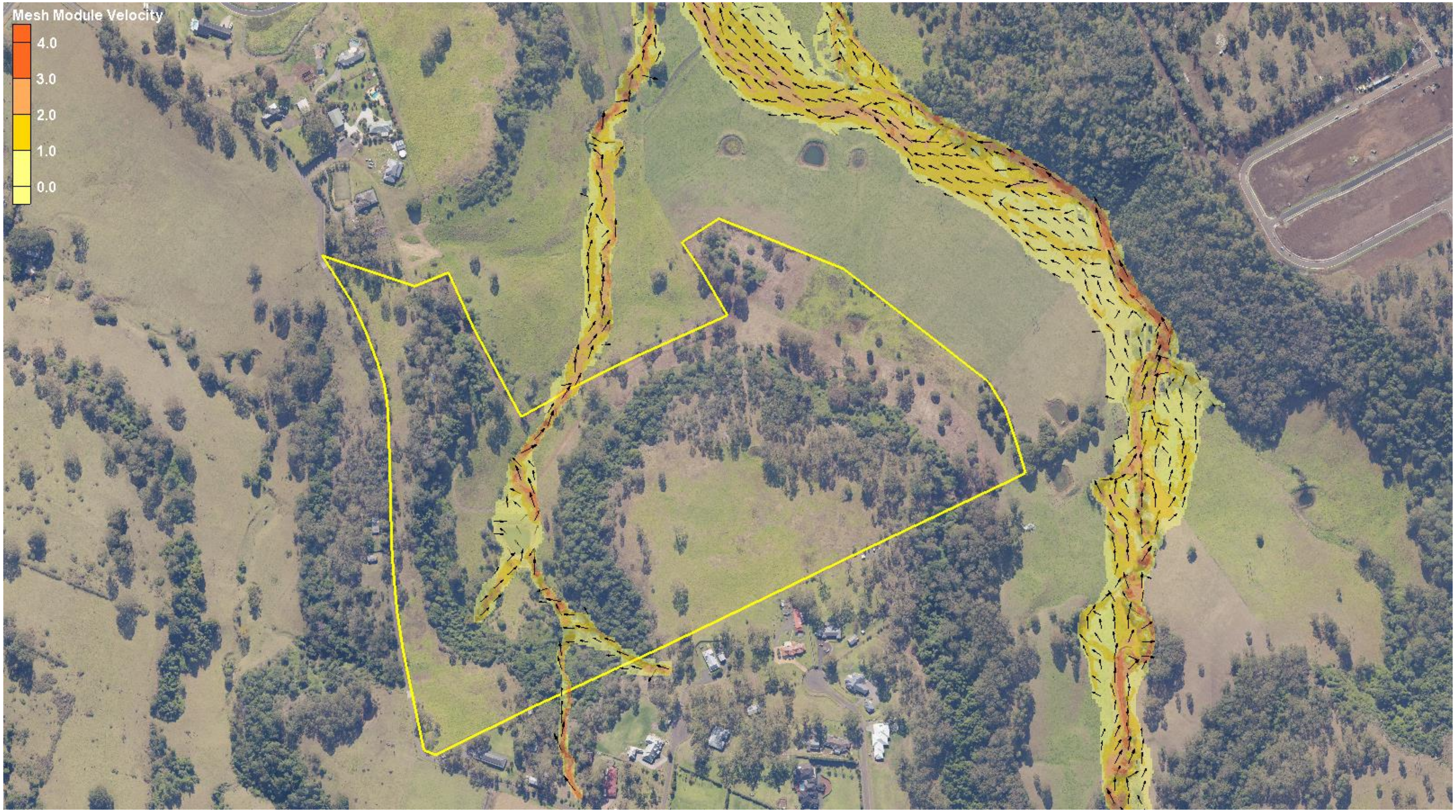

Figure C1.3: 1% AEP Flood Velocity – Pre-Development

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange.

APPENDIX C2 – 1% AEP MODEL RESULTS – POST-DEVELOPMENT

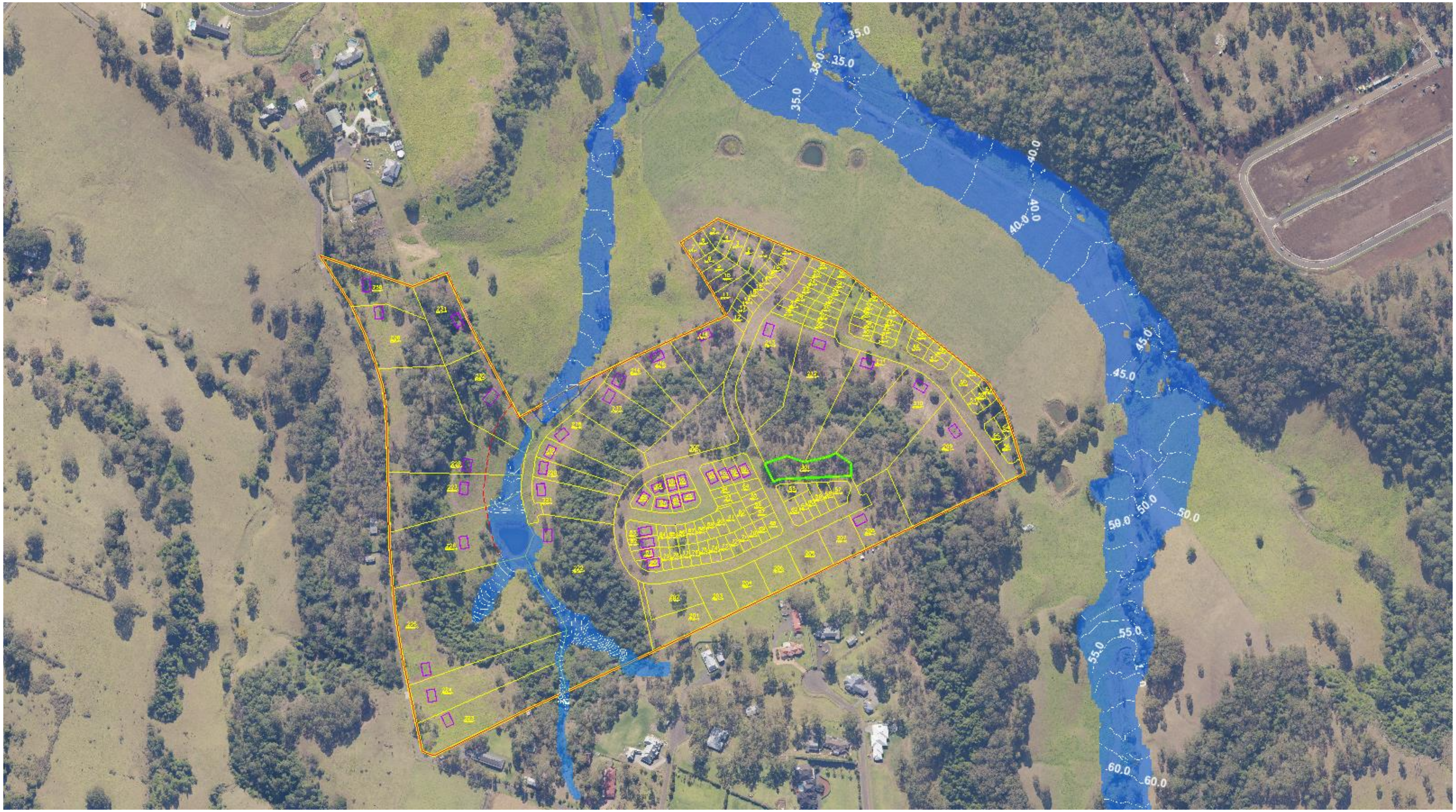

Figure C2.1: 1% AEP Flood Levels – Post-Development

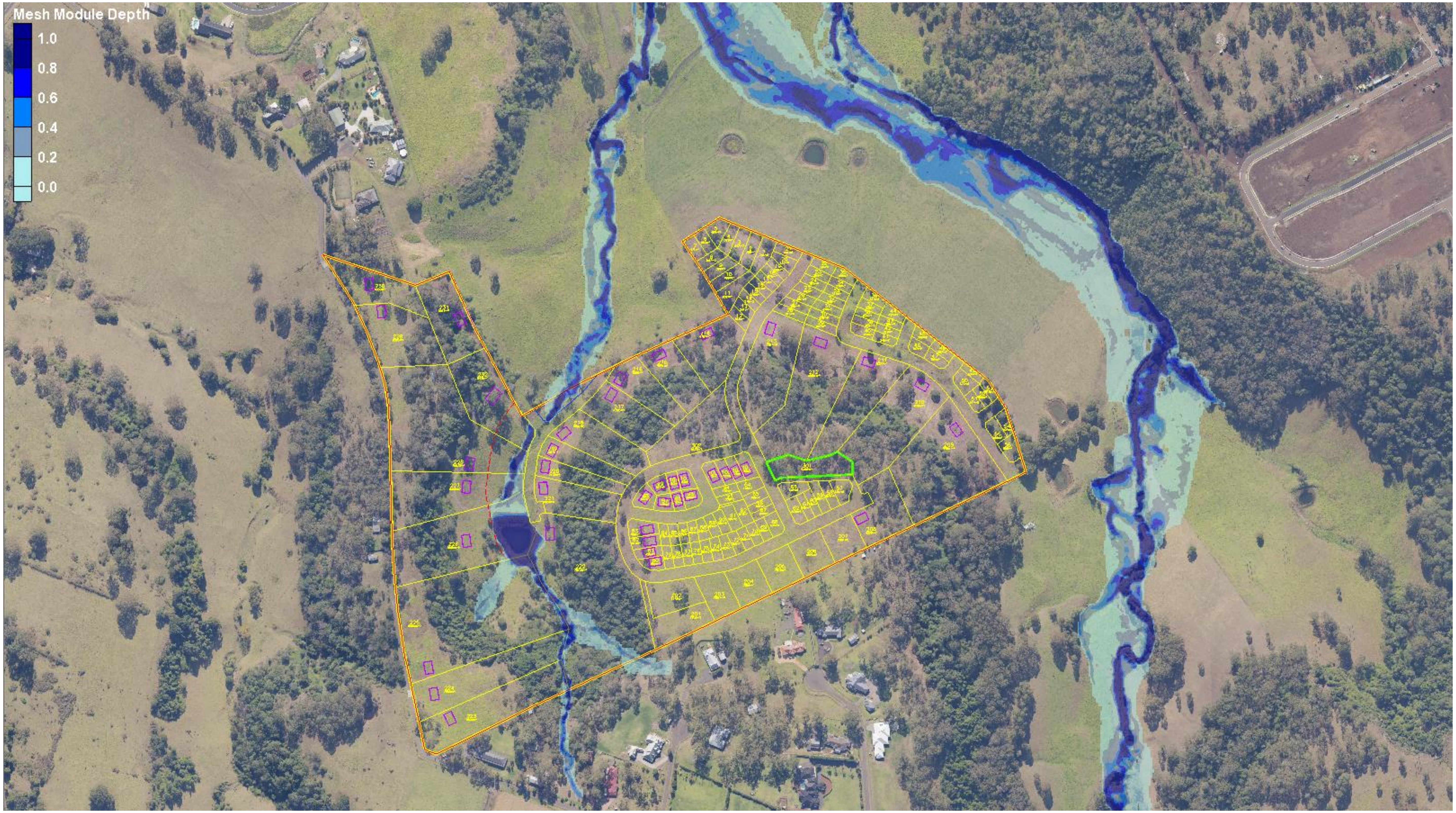

Figure C2.2: 1% AEP Flood Depths – Post-Development

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue.

Figure C2.3: 1% AEP Flood Velocity – Post-Development

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange.

APPENDIX C3 – PMF MODEL RESULTS – PRE-DEVELOPMENT

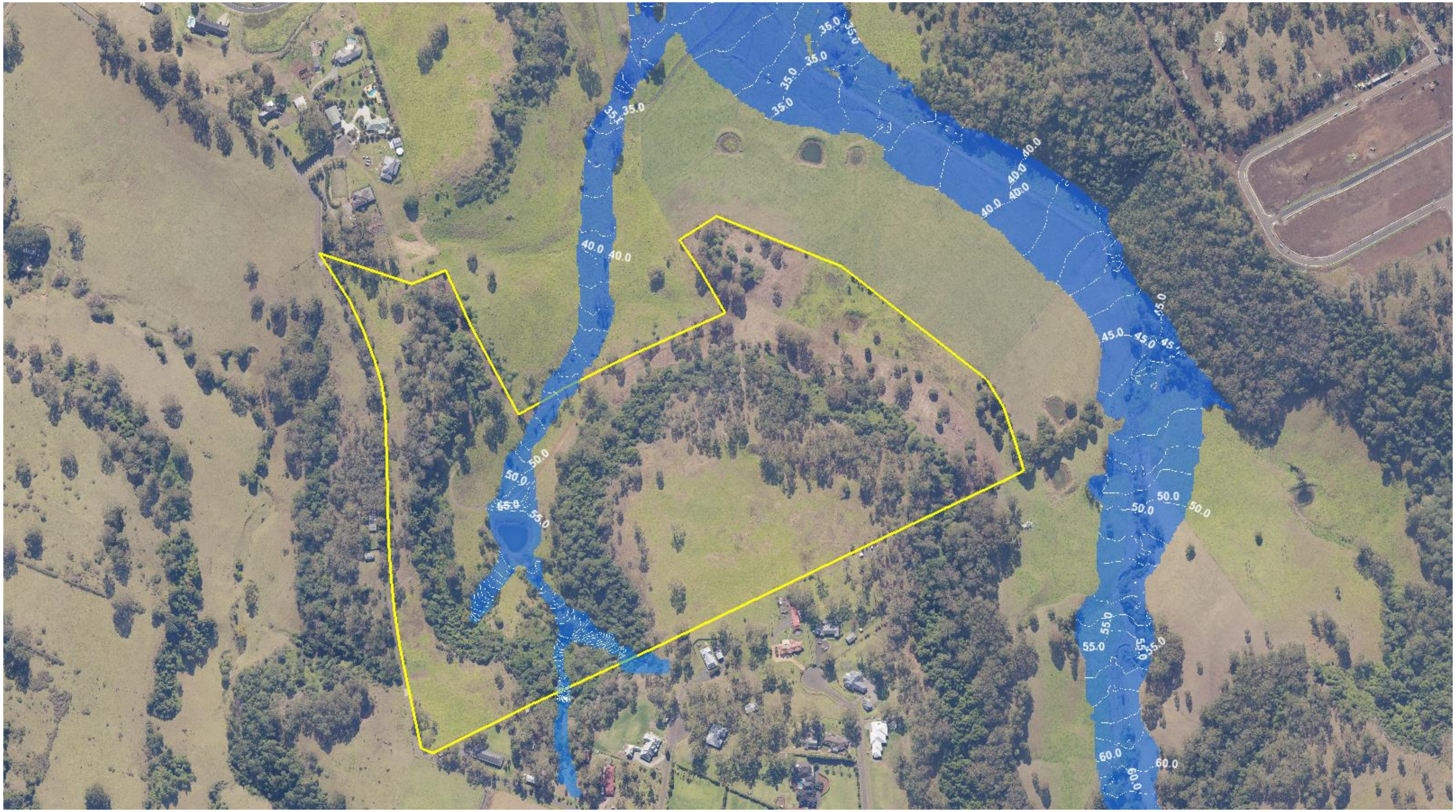

Figure C3.1: PMF Flood Levels – Pre-Development

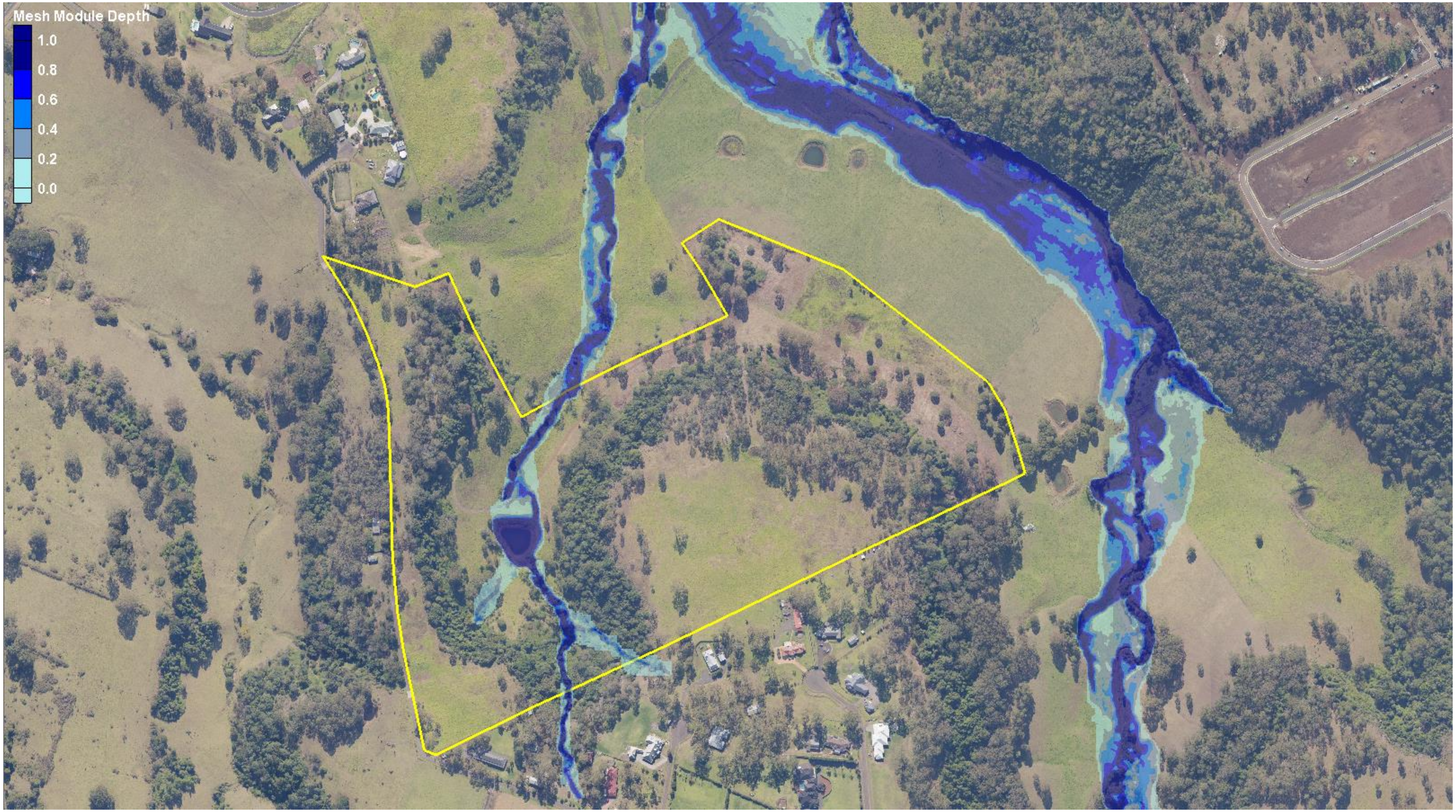

Figure C3.2: PMF Flood Depths - Pre-Development

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue

Figure C3.3: PMF Flood Velocity - Pre-Development

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange

APPENDIX C4 – PMF MODEL RESULTS – POST-DEVELOPMENT

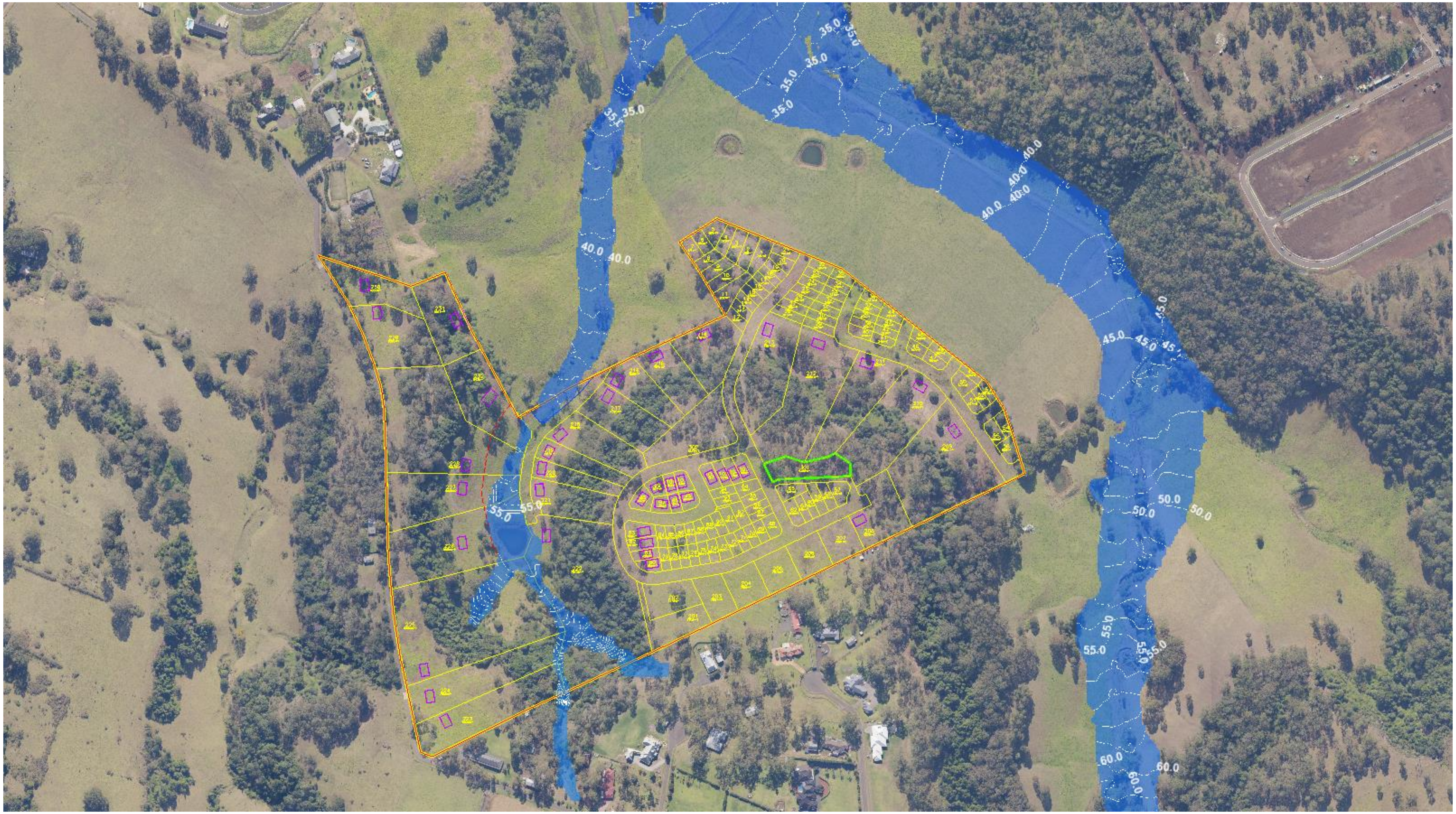

Figure C4.1: PMF Flood Levels - Post-Development

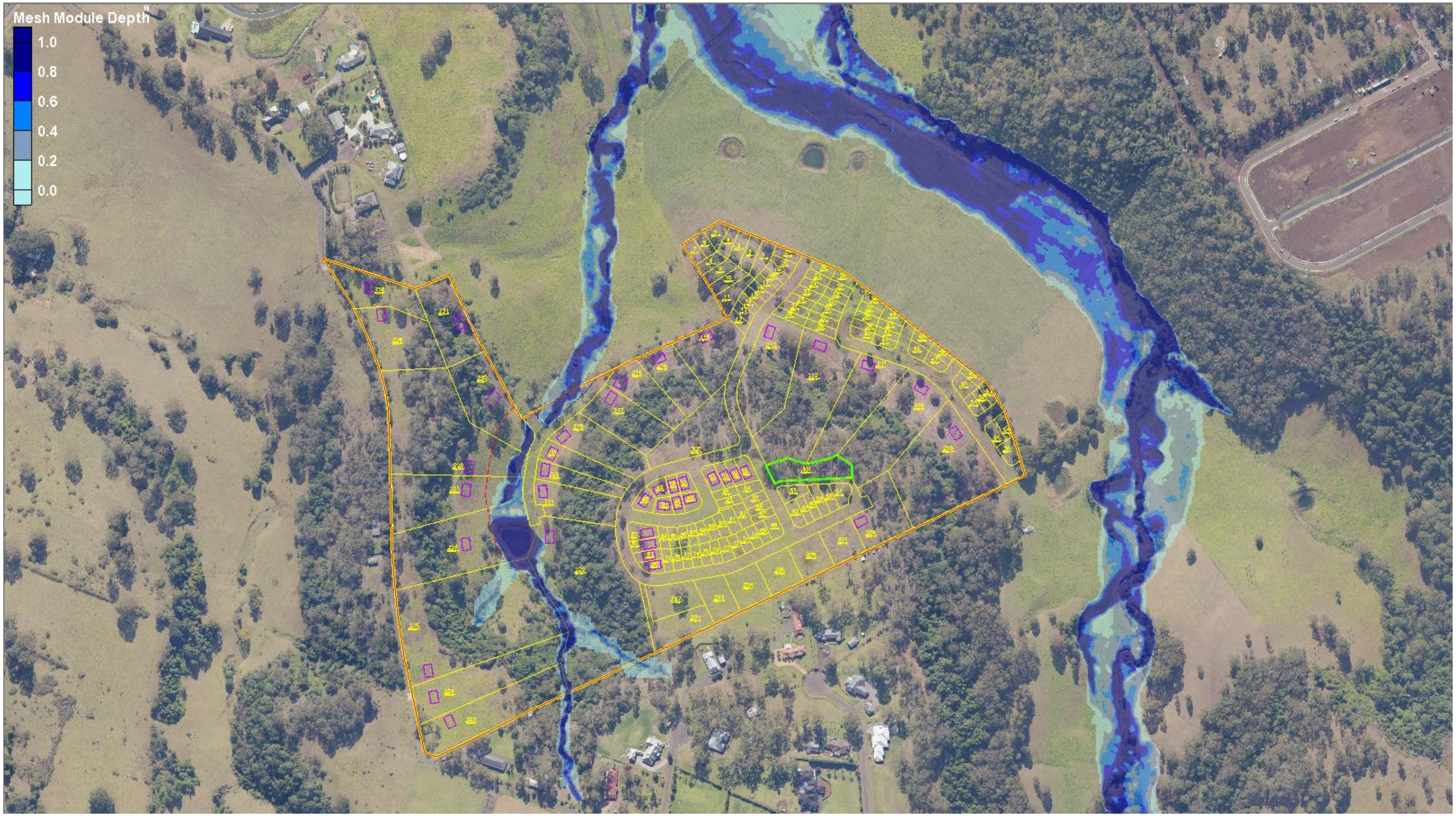

Figure C4.2: PMF Flood Depths - Post-Development

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue

Figure C4.3: PMF Flood Velocity - Post-Development

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange

APPENDIX 5 – IMPACT MAPS AND OTHER MODEL DATA

Figure C5.1: 1% AEP Development Related Increases to Peak Flood Surface Levels under Post-Development Conditions

Figure C5.2: 1% AEP Development Related Decreases to Peak Flood Surface Levels under Post-Development Conditions