

Our ref: L.A11940.003.002_RFI_Response.docx

17 December 2024

Transport for NSW
Level 37 680 George Street
Sydney NSW 2000

Attention: Pat Patel

Dear Pat

RE: Responses to Lake Macquarie City Council's RFI comments

This document forms an addendum to BMT's Concept development application and first stage of development (65 Glendale Road, Glendale) Flood Impact Assessment Report (R.A11940.001.04_GlendaleFIA). A request for information (RFI) was received from Lake Macquarie City Council in response to the development application and this document seeks to respond to the flooding related RFIs.

Comment 2.1

The flood model that informs the FIA is an updated model from a 'Glendale Development Flood Risk Assessment' (FRA) completed by BMT in 2015 and updated to include current elevations and landforms within the study area. Council Staff were not aware of the 2015 FRA and as such are not certain if the report is supportable or accurate for the site.

Response

BMT 2015 model (ref: R.N205391.001) was a local model based on the WMA 2013 model with refined grid size and other features, and results validated against the 2013 flood study report. BMT 2015 report is attached in Annex A, to ensure appropriate ability to review model details.

Comment 2.2

No qualitative or quantitative assessment against the WMA water Winding Creek and Lower Cockle Creek has been provided.

Response

Review of 2017 Flood Study mapping against results from the Glendale FRA was undertaken and confirmed overall consistency in results for this reach of Winding Creek as discussed in BMT's 2015 report (Annex A).

Comment 2.3

In adopting the 2015 flood model, the FIA uses 1987 ARR rainfall data to develop the hydrology model. The more current 2019 ARR rainfall data shall be used to ensure accuracy.

Response

Council's adopted flood study uses ARR1987, the approach used in this study is consistent. Evidence has been provided to support BMT's position that an update to ARR2019 methodology was not needed, which has been agreed and accepted by Council (refer to email correspondences attached in Annex B).

A detailed analysis of ARR1987 and ARR2019 methodologies conducted by BMT is outlined below.

Comparison of ARR1987 and ARR2019 methodologies

An analysis of design rainfall data was conducted for the site (black curve in Figure 1.1) and for 10 scattered locations across the Winding Creek catchment (grey curves in Figure 1.1). The findings are as follows:

- The ARR2019 IFD curves demonstrate negligible spatial variability across the catchment. This is expected due to the relatively small extension of the catchment (~25 km²).
- ARR2019 rainfall depths are approximately 15% higher than those used in the original flood study (red curve in Figure 1.1) developed with ARR1987 methodologies.

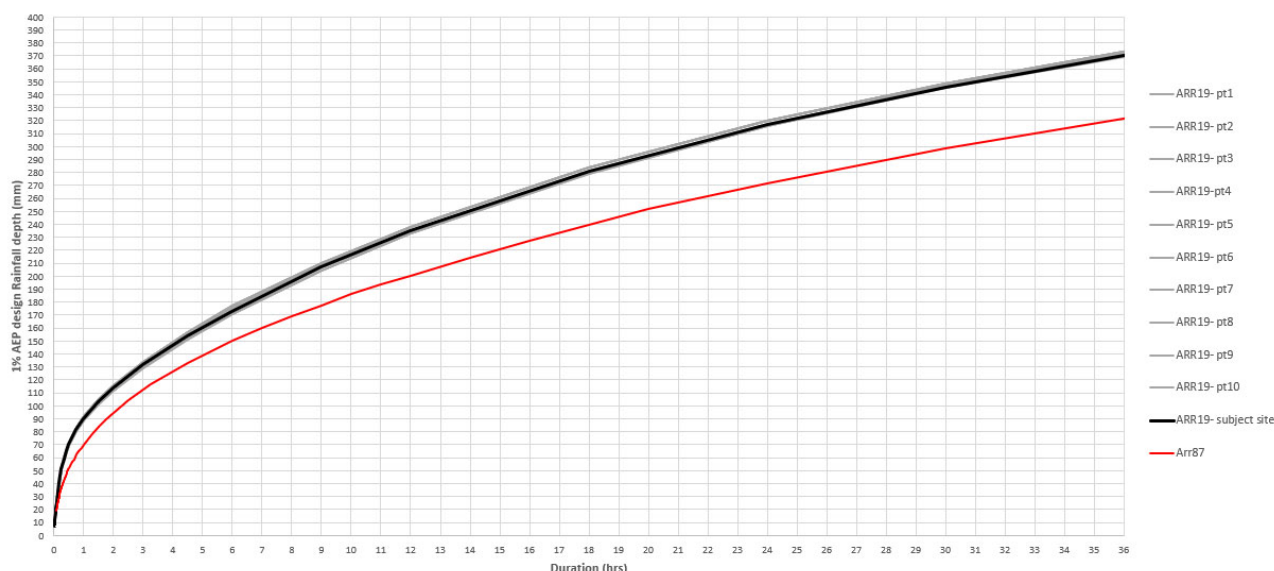


Figure 1.1 Comparison of ARR1987 and ARR2019 Design Rainfall Data

ARR2019 WBNM Model

The WBNM model was re-run with ARR2019 procedures, while maintaining the same calibrated values for hydrological losses and lag parameters as in the original ARR1987 based model. The results indicate:

- A peak flow of approximately 200 m³/s at the downstream end of the catchment, located about 1 km downstream of the site (Figure 1.2).
- Despite higher rainfall depths with ARR2019, the 9-hour flow calculated with ARR1987 exceeds all peak flows calculated using ARR2019 for other durations (Figure 1.3). This outcome is attributed to differences in:
 - Temporal patterns between ARR1987 and ARR2019.
 - Critical design storm selection in ARR2019, which prioritizes temporal patterns associated with median flows rather than maximum flows.

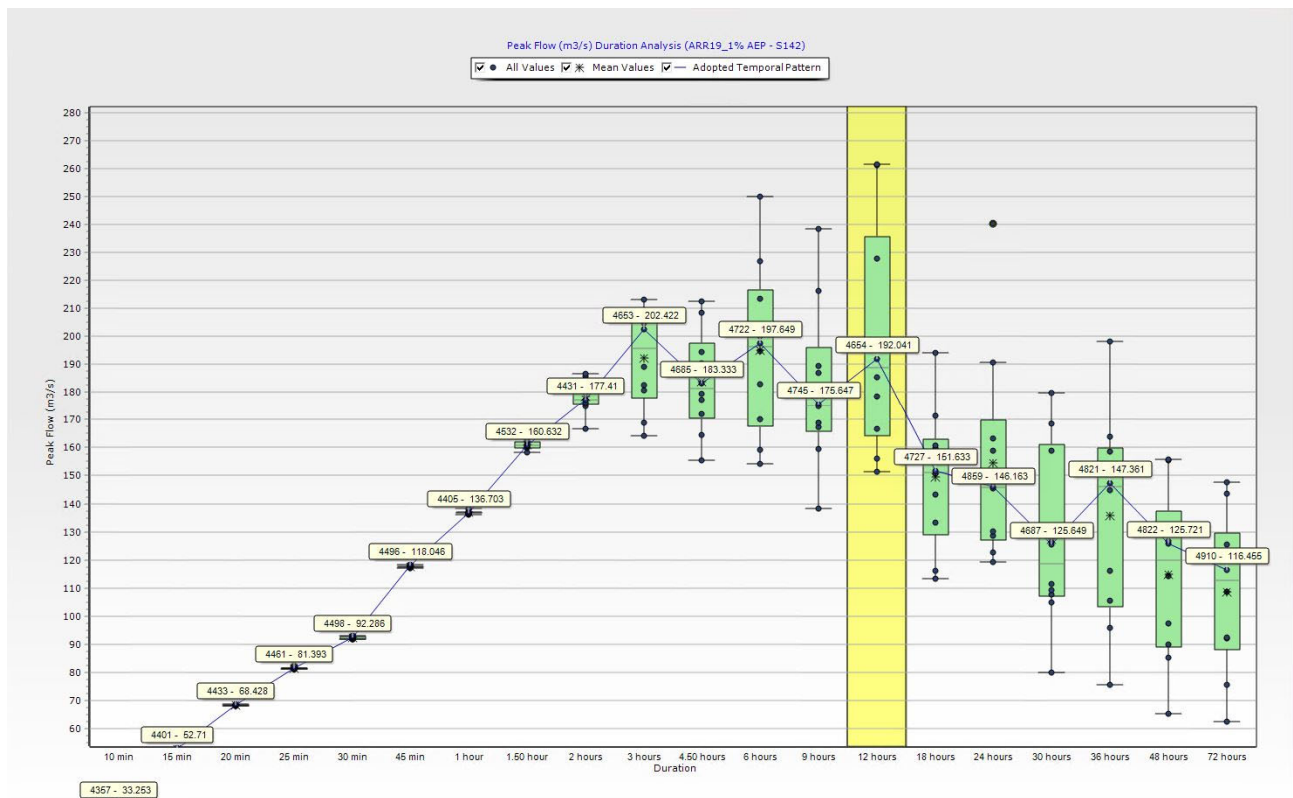


Figure 1.2 WBNM ARR2019 Results

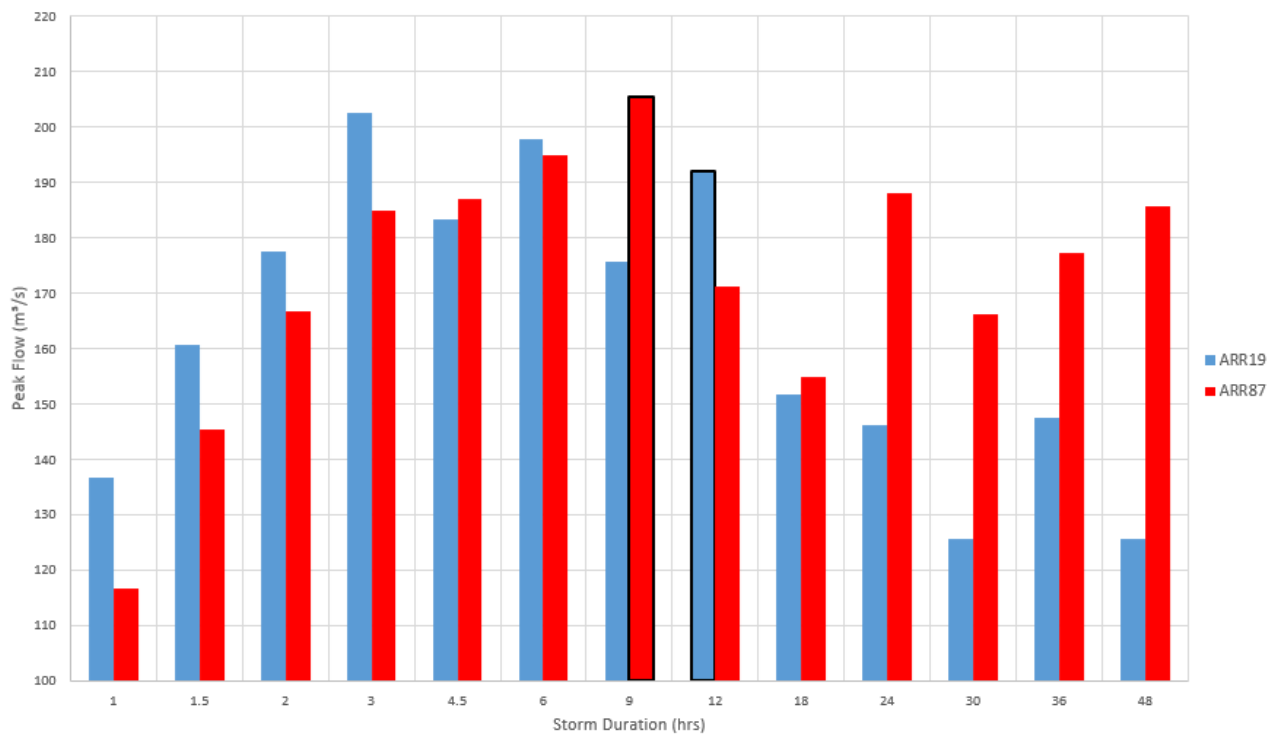


Figure 1.3 Peak flow comparison for different storm durations

Unit Flow Rate and Regional Consistency

The 1% AEP peak flow for the catchment using ARR1987 is 205 m³/s. When divided by the catchment size (2541 ha), this yields a unit flow rate of approximately 0.08 m³/s per hectare. This value aligns well with unit flow rates observed for other catchments across NSW (Figure 1.4).

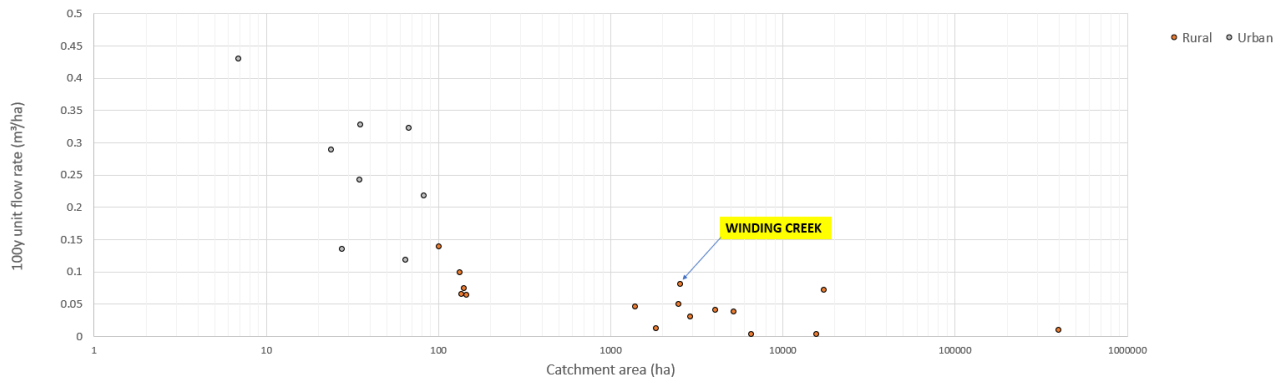


Figure 1.4 Comparison of unit flow rates

The comparison of maximum flow values calculated using ARR1987 and ARR2019 methodologies indicates minimal differences, suggesting that updating the model to ARR2019 methodologies is unnecessary.

Observations from similar updates in other catchments support this conclusion. Specific case studies further illustrate this point:

- In the Throsby, Styx, and Cottage Creek catchments for a site in Broadsmeadow, peak flood levels calculated using ARR1987 and ARR2019 methodologies were found to be substantially the same.
- For a private development in Kotara, a similar flow was observed when comparing the results of ARR1987 and ARR2019 methodologies.

These findings align with the results of WMAwater's ARR2019 study for the Inner West Council, which states: *"The update to the ARR19 methodologies generally reduces the flood levels and flows compared to previous ARR87 hydrology, due primarily to the updated information about design rainfall intensities and temporal patterns."*

Based on this analysis, utilising ARR1987 procedures is expected to produce results that are comparable to or slightly more conservative than those obtained using ARR2019. An update to ARR2019 methodologies is therefore not considered necessary.

Comment 2.4

The report proposes to elevate the developable proportion of lot 2 on a slab constructed on piers. This structure will have the residential property(s) at the flood planning level (FPL = 1% AEP plus 500mm) and the ground level below the suspended slab will be a car park set at the 5% AEP level. The report proposes to include a wall along the eastern side of the suspended structure to provide "flood immunity during the 5% AEP event". This statement raises a number of questions as the level of the carpark should already be set at the 5% AEP level, and therefore should not require additional flood protection for this event.

It is not clear whether the proposed wall has been included in the post-development model as an obstruction, which may cause afflux to flow resulting in flood impacts on adjacent property. Furthermore, it is not clear whether the piers for the suspended structure have been included as obstructions within the model which may also cause afflux, particularly if they are constructed close together and could become blocked by debris and floating vehicles during a flood event greater than the 5% AEP.

Clarity of what consideration have been made shall be provided, noting Council is unlikely to be supportive of the additional blockages within the 5% AEP.

Response

The structure has been modelled as a layered flow constriction with obvert at 11mAHD, 10% blockage and a form loss coefficient of 0.1. Piers would be sufficiently spaced to avoid risk of blockage. The natural surface has been maintained underneath the structure to maintain flood storage in events greater than the 5% AEP event.

The concept DA identifies a strategic flood management response for adoption and verification through a design specific assessment that is best undertaken as part of the detailed development application for the proposed development of Lot 2.

Comment 2.5

The FIA appears to have disregarded overland flow in the post development scenario when setting the FPL for lot 1. It proposes that inter-allotment drainage will be incorporated into the development to manage overland flows through this area.

Response

Overland flows were included, no local drainage was included. Modelling has been updated to include major swales designed to convey flows from north to south across Lot 1. Pits and pipes (minor drainage) are assumed to be blocked during a major event. Please see response to comment 2.8 for details about modelling updates.

Modelling shows that the flows can be accommodated and safely conveyed. The detailed development application(s) for Lot 1 will provide flood modelling to demonstrate that the detailed design of Lot 1 will incorporate the effective management of these flows.

Comment 2.6

Pits and pipes become blocked during flood events and cannot be relied upon to manage flood flows (drainage pipes typically only account for the 10% AEP).

DCP controls for the FPL should still be applied to overland flooding and under the current arrangement floor levels will be lower than the required level.

Response

Modelling has been updated and design changes are incorporated to manage overland flooding. Please refer to comment 2.8 for details.

Comment 2.7

The FIA and attached mapping indicate flood impacts downstream of up to 40 mm over a broad area. In my experience flood impacts of less than 10 mm can be considered within the accuracy of modelling processes and anything greater than 10 mm unacceptable flood impacts. While the area subject to

increased flood levels appears to be public land it is not overly good practice to accept this as potential future development or works on the land could be impacted.

Increases to flood level are most critical to adjacent privately owned land as the increases in levels, even minor, can have a flow on effect to increasing potential flood damages, flood insurance costs and costs associated with constructing new flood compliant developments.

Response

The purpose of the flood impact criteria is to prevent 'adverse' impacts, being impacts that cause damage, disruption or inconvenience. Generally, no damage, disruption or inconvenience is caused by minor flood impacts on open space. Austroads suggests up to 400mm of impact on open space/forest is acceptable for major transport infrastructure (AGRD05-23_Guide_to_Road_Design_Part-5_Drainage_General_and_Hydrology_Considerations, section 6.10) Another consideration is cumulative impacts of future development. In this case, the upstream catchment is highly developed and so this is not considered a major concern.

Comment 2.8

There will be a direct impact to flooding of Main Road which is a Transport for NSW (TfNSW) asset. TfNSW requirements for increased impact on their assets are low and shall be confirmed with the TfNSW if they are willing to accept any increased flood in this instance.

Response

Flood modelling has been updated to minimise the overland flooding within Lot 1. Impacts predicted on Main Road are discussed in relation to revised model results. Details of the model updates and results are included below.

Model updates:

- Included proposed stormwater bypass swales and proposed major stormwater pipes to convey flows from north to south across Lot 1 (Figure 1.5).
- Local stormwater network was assumed to be completely blocked during major storm events and was not included in the model
- Water entry into Lot 1 was prevented in the flood model by implementing thin walls (TUFLOW 2d zsh layer) along the northern site boundary and internal lot boundaries. This approach ensures the overland flow goes where intended and can inform updates to the proposed design during subsequent project stages based on flood modelling results (such as by incorporating increased fill level, localised bunds, swales, or similar).

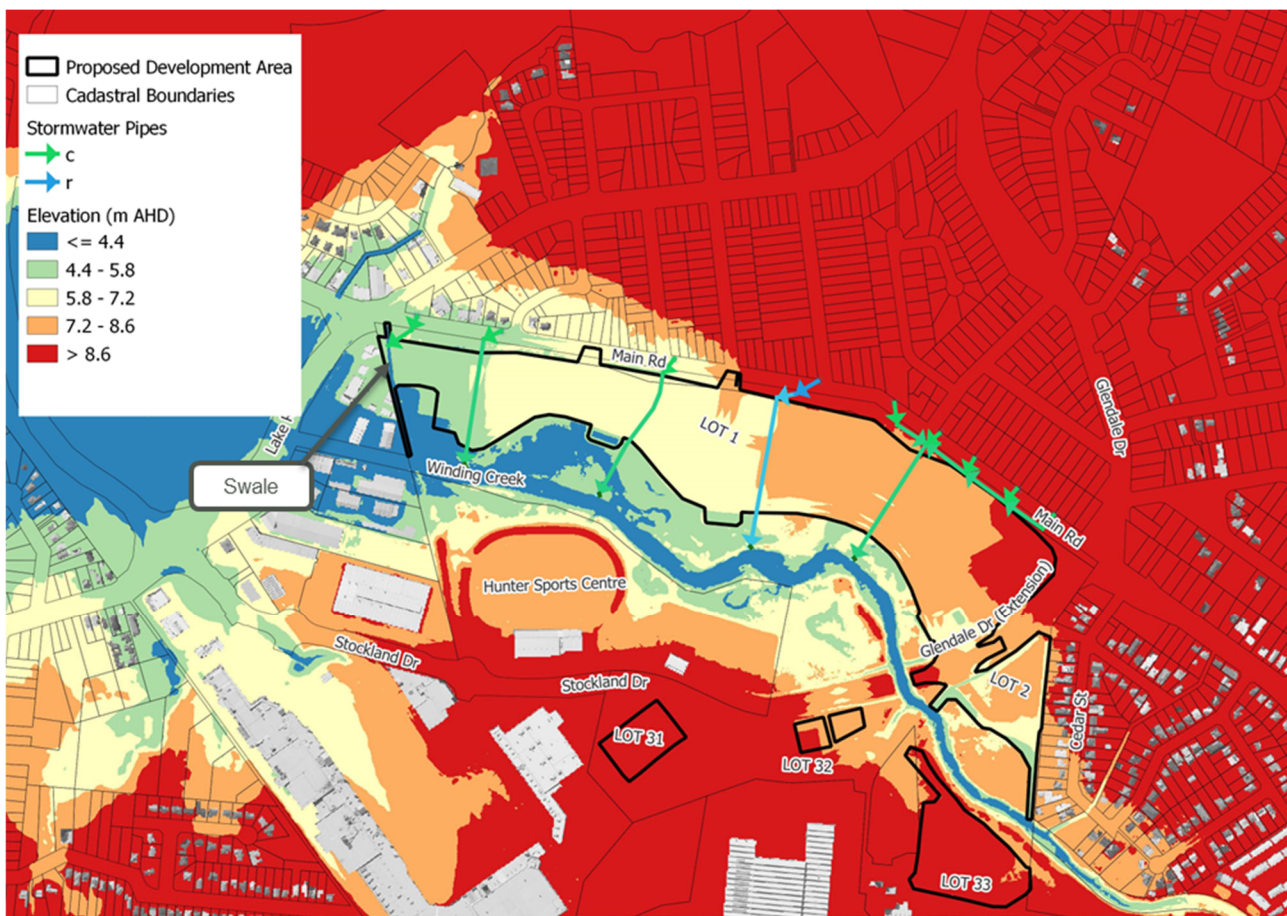


Figure 1.5 Stormwater pipes and swale at the Site on Lot 1 for Developed scenario

Flood impacts - 5% AEP event

During the 5% AEP flood, flood levels are reduced along the upstream portion of Winding Creek and within upstream properties near the junction of Cedar Street and Norfolk Street. This reduction results from the proposed grading of land south of the planned Lot 2 parking area and drainage channels which locally improve flow conveyance.

Downstream of Lake Road the predicted afflux is minor, approximately 35mm, and does not impact existing dwellings. Although the flood level within Winding Creek increases by up to 110mm the development is not expected to cause a significant rise in creek velocity. Velocity increases are generally less than 0.15m/s with reductions in areas where the existing velocity is high such as locations with velocities reaching up to 2m/s.

Flood levels within the industrial properties south of the Main Road and Lake Road junction are also predicted to decrease. Flood level increase along Main Road is discussed separately below.

The proposed development effectively manages flood impacts for the 5% AEP event, minimizing changes to flood levels and velocities while improving flow conditions in key areas.

Flood impacts - 1% AEP event

During the 1% Annual Exceedance Probability (AEP) flood, a significant reduction in peak flood levels is predicted for properties upstream of Lot 2. This reduction extends to properties along Cedar Street, Norfolk Street, Boston Close, and Palm Street.

Downstream of Lake Road, the afflux is less than 40mm and is predicted to have limited or no impact on existing dwellings. Along the Winding Creek corridor, peak flood levels are expected to increase by up to 300mm. These increases occur within the riparian and C2 Zone areas, which are not part of developable or adjoining land uses.

Similar to the 5% AEP flood, the development works are not expected to cause a significant increase in velocity within Winding Creek, except for a few isolated areas where velocity increases range from 0.3 to 0.5m/s. The maximum post-development velocity in areas where an increase is observed is 2.2m/s. This occurs just downstream of the western boundary of the site, north-west of the Hunter Sports Centre. Flood level increase along Main Road is discussed below.

The floodwater depth at the Glendale Drive East sag point remains largely unchanged due to the raised level of the sag point, which effectively mitigates the afflux generated by the Lot 1 infill. This adjustment ensures that the provisional flood hazard at the sag point remains negligible despite the development. Some afflux is observed on the Glendale Drive extension at the western sag point, with an increase in peak flood level of approximately 45mm. This afflux is attributed to the blockage of Lot 32, which restricts the distribution of backwater from the creek. However, the hazard level on Glendale Drive remains consistent with the existing scenario.

The proposed development results in flood behaviour changes that are generally localized and within acceptable limits. The mitigation measures ensure that impacts on surrounding properties and infrastructure are minimal, maintaining existing flood hazard levels in key areas.

Flood impacts - 1% AEP + CC Event

During the 1% AEP + CC flood, peak flood levels for properties upstream of Glendale Drive are significantly reduced. However, a localized afflux is observed on the Glendale Drive extension at the western sag point where the peak flood level increases by approximately 70mm. This afflux results from the blockage at Lot 32, which restricts the distribution of backwater from the creek. Despite this, the hazard level on Glendale Drive remains consistent with the Existing Scenario.

Along Winding Creek, peak flood level increases are typically up to 300mm, with a few areas experiencing an afflux of approximately 500mm. In addition, some areas along the creek show localized velocity increases of up to 0.7m/s, though these increases are confined to specific locations rather than being widespread.

In summary, while localized increases in flood levels and velocities are identified, these impacts are limited to specific areas and do not indicate a significant change in overall hazard levels for the affected regions.

Flood impacts on Main Road

Minor impacts have been identified on Main Road outside the project boundary. These impacts can be addressed during the detailed design phase of the proposed drainage network and proposed upgrade to Main Road. No upgrade to Main Road is currently included in the flood modelling.

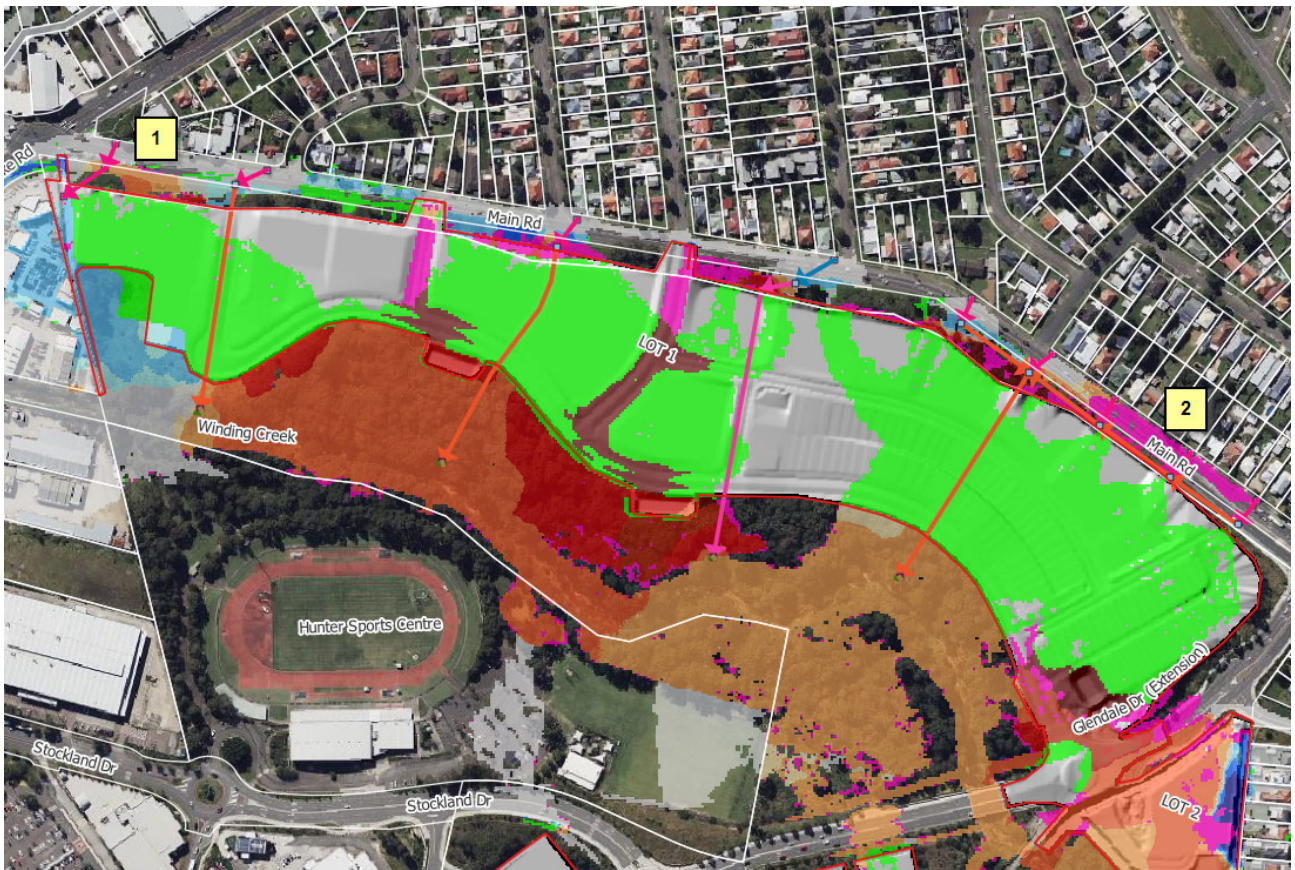


Figure 1.6 Change in flood level during 1%AEP event

Table 1.1 Change in flood level (m)

Location	5% AEP	1% AEP	1% AEP + CC
1	0.079	0.092	0.119
2	Newly flooded	0.150	0.161

Location 1 – Within the road corridor near Main Road and Lake Road intersection

The flood level within the road corridor increased by up to 92mm during the 1% AEP event due to water ponding against the designed surface. To address this issue, additional flow can be redirected to the stormwater bypass swale located east of the affected area. This measure is expected to effectively mitigate the observed increase in flood levels.

Location 2 – Within road corridor near Main Road and Glendale Drive intersection

The flood level within the road corridor increased by up to 150mm during the 1% AEP event. The majority of the impacts are caused by sheet flows. The residual impacts will be resolved during later design phases of the proposed drainage network and can be achieved by increasing inlet capacity, upsizing major pipes, or incorporating flood storage options to manage residual impacts effectively. Additionally, an upgrade to Main Road is proposed, which will offer further opportunity to improve drainage and reduce sheet flow.

Overland flow in Lot 1

Water entry into Lot 1 was prevented in the flood model by incorporating thin walls in the flood model layer along the northern site boundary and internal lot boundaries. This approach and the modelled results will inform the design during the next project stages through measures such as:

- Modifications to the proposed design surface
- Modifications to major drainage design
- Adjustments to the road design within Lot 1
- Inclusion of flood storage options

Flood maps for existing and developed scenarios are presented in Annex C.

Comment 2.9

Table 3.1 of the FIA seeks to address compliance of the development against all flood related development controls in the DCP. However, a number of the controls the table notes the development as being compliant, such as floor level controls, are not relevant to the concept subdivision stage of the development application process. This table should be updated to reflect the stages at which all controls will be completely resolved, and compliance achieved.

Response

Updated tables are listed below.

Table 1.2 Response to LMDCP 2014 Requirements

Development Control Requirement	Response	Compliance with DCP Requirements
1. Development must be consistent with the current version of the NSW Floodplain Development Manual, and any relevant local flood study, floodplain management study or plan applying to the land that has been endorsed by Council.	The development is consistent with the 'Floodplain Risk Management Manual' (2023), as well as the 'Winding Creek and Lower Cockle Creek Flood Risk Management Study and Plan' (WMA Water, 2017) which is Council's adopted study for this catchment. In line with the requirements of the 'Floodplain Risk Management Manual' (2023), an appropriately detailed study has been undertaken to assess the flood risk at the Site and determine the impact of the proposed development relative to existing flood conditions. The TUFLOW model that formed the basis of this FIA was verified against the results of Council's 2017 study.	Compliant
2. Buildings must not be located in an identified floodway.	Figure B-15 in Annex C shows the extent of floodways in the 1% AEP flood under existing conditions. Whilst majority of the proposed works lie outside the Winding Creek floodway extent, some proposed infill is proposed located within designated floodway areas. During the meeting held on 3 March	Compliant

	2023, Lake Macquarie City Council's representative, Alexander Bennett, clarified that performance criteria are applied, and if the infill of floodways does not result in significant off-Site afflux, then filling can be considered from a flooding perspective.	
3. Buildings and other structures, including fences, must be designed so as not to impede the flow of floodwaters or entrap debris.	The design of buildings and other structures ensures that they do not obstruct the flow of floodwaters or create obstacles for debris. An example of this is the suspended structure within Lot 2. No fences are proposed as part of this application. However, if any fences are proposed on-Site as part of future detailed design, appropriate open style fencing should be incorporated to allow for the unimpeded movement of floodwaters in flow conveyance areas. It is also noted that there is predicted to be no substantial redistribution of flow or impedance of existing flow conveyance (refer impact maps provided in Annex C).	Compliant
4. Fill is not permitted within core riparian zones, within the Lakefront Development Area or the Foreshore Development Area, or within the extent of the 100-year probable ARI (1% AEP) flood event.	The proposed development does not include filling in the Winding Creek riparian zone. However, the placement of fill is proposed within the 1% AEP flood extent. Therefore, reference is made to DCP requirement no. 8 (refer below) of the LMDCP 2014, which allows for lesser provisions where the applicant can demonstrate that the type of development or proposed use does not pose a significant risk to life or property due to flooding. It is also noted that there are no significant adverse impacts predicted for existing development outside the Site boundary or nearby infrastructure for events up to the 1% AEP flood as a result of the proposal development (refer impact maps in Annex C).	Compliant
5. Any use of fill associated with development must not substantially impede the flow of floodwater and must not contribute to flooding or ponding of water on any other property.	The flood impact assessment demonstrated that the off-site flood impacts due to the proposed development is predicted to be minimal during events up to and including the 1% AEP flood, and do not adversely impact adjacent development or infrastructure.	Compliant subject to detailed design
6. Additions or alterations to existing development will be assessed on the merits of the situation, having regard to	No alteration to any existing development is proposed as part of this application.	Compliant

meeting an acceptable level of risk of flood damage.		
7. Development on lots adjoining areas affected by a 100-year probable ARI event will be subject to floor height requirements, even when the Site may not be subject to flooding from the 100-year probable ARI event. This requirement is not applicable for land higher than 500 mm above the 100-year probable ARI, as calculated for the relevant site.	Compliance with LMDCP 2014 and specifically with “ <i>Table 2 - Flood Planning Levels and floor height requirements for areas affected by catchment flooding</i> ” that are covered by a Floodplain Management Study and Plan has been checked. It has been confirmed that all minimum floor level requirements have been met and the project complies with necessary regulations.	Compliant
8. Development where 100-year probable ARI levels are not available, and which could be flood liable, should be designed to meet an acceptable level of risk from flood damage. This may require the preparation of a Local Flood Study that considers cumulative impact issues and demonstrates negligible impacts on other lands.	Specific TUFLOW modelling for the Site and proposed development was completed using a TUFLOW model originally developed for the 2015 Glendale FRA and verified against the results of the 'Winding Creek and Lower Cockle Creek Flood Risk Management Study and Plan' (WMA Water, 2017). The results of this modelling enabled a relative assessment of the impact of Post-development Scenario flood conditions on Existing Scenario flood conditions, and indicated that there will be no significant adverse impacts on other lands during the 1% AEP flood.	Compliant

Table 1.3 Response to LMDCP 2014 Requirements – Stage XX

Development Control Requirement	Response	Compliance with DCP Requirements
1. The proposed development must consider and respond to flooding hazards. It must also mitigate risks to life and/or property through design and positioning of development.	The proposed development design will incorporate a comprehensive approach to mitigate the potential risks and hazards associated with flooding, in order to protect the safety of the residents and occupants of the proposed development and prevent damage to property. This includes the siting of proposed works within areas of the Site with lower flood risk and the placement of habitable floor levels within the development above the FPL (i.e. 1% AEP peak flood level plus 0.5 m freeboard). Additionally, upper floors of the buildings will be situated above the PMF level.	Compliant

Development Control Requirement	Response	Compliance with DCP Requirements
	It is important to note that the NSW State Emergency Service (SES) does not endorse development plans that involve sheltering or isolation in buildings surrounded by floodwater. This strategy does not offer the same level of risk management as evacuation. Therefore, in case of severe weather conditions, the preferred emergency strategy is site evacuation. To ensure the safety of the evacuation process, provisional flood hazard maps for post-development conditions are provided in Annex CAnnex C. These demonstrate that Main Road, which serves as the primary evacuation route for the proposed development, will remain flood-free for all events up to and including the PMF. A detailed Flood Emergency Response Plan (FERP) will be developed for the Site as part of future project stages. This plan will outline emergency response considerations and appropriate measures to management risk to life in the event of a flood.	
2. Habitable rooms and commercial development must have a finished floor height at least 500 mm above the 100-year ARI (1% AEP) event, or is to have equivalent measures in place to mitigate flood damage (e.g. flood barrier system with evacuation plan). Where probability flood levels are not available, habitable rooms must have a finished floor height at least 500 mm above the highest observed flood level for the development site.	The proposed development will be situated above the FPL (i.e. 1% AEP peak flood level plus 0.5 m freeboard). It is worth noting that there are no plans to introduce any sensitive use developments that would require consideration of a higher FPL.	Compliant
3. Non-habitable rooms must have a finished floor height at or above the 20 year probable ARI (5% AEP) event. Where probability flood levels are not available, non-habitable rooms must have a finished floor height at or above the highest observed flood level for the Site,	It is proposed to construct Lot 2 on a pier supported slab structure to elevate the buildings above the FPL. The underside of the building will be used for car parking, which will be set at the 5% AEP level of 7.7 mAHD.	Compliant

Development Control Requirement	Response	Compliance with DCP Requirements
except where this would result in a floor level more than 500 mm above the existing ground level. In this case, a floor level of at least 500 mm above existing ground level must be achieved.		
4. Lesser provisions may be acceptable where the applicant can demonstrate that the type of development or the proposed use poses no significant risk to life or property by flooding.	Risks and hazards associated with flooding will be minimised by elevating the Site above the 1% AEP flood level and FPL. Evacuation strategies will be detailed during following design stages.	Compliant
5. Development on designated flood prone land should incorporate the floodplain risk management measures, as recommended by a local flood study, floodplain management study or plan, which identifies and addresses appropriate actions in the event of flooding.	A flood emergency response plan (FERP) will be prepared to outline the proposed strategy for flood emergency management on-Site when the detailed design of the development is undertaken in future stages of work. The FERP should address post-development flood risk up to the PMF and consider the expected number of people on-Site. It should information on time to onset, rate of rise and duration of flooding, flood warning opportunities, and potential evacuation strategies and procedures in terms of alignment with local SES flood plans, consideration of evacuation routes and flood refuges, flood preparedness, and potential for Shelter-in-Place as a backup strategy if evacuation cannot be achieved.	Compliant
6. Development on land subject to flooding must use flood compatible materials that will minimise damage by flooding.	Buildings within the PMF extent should be constructed using flood compatible materials. It is proposed that this is considered as part of the detailed design process.	Compliant

Comment 2.10

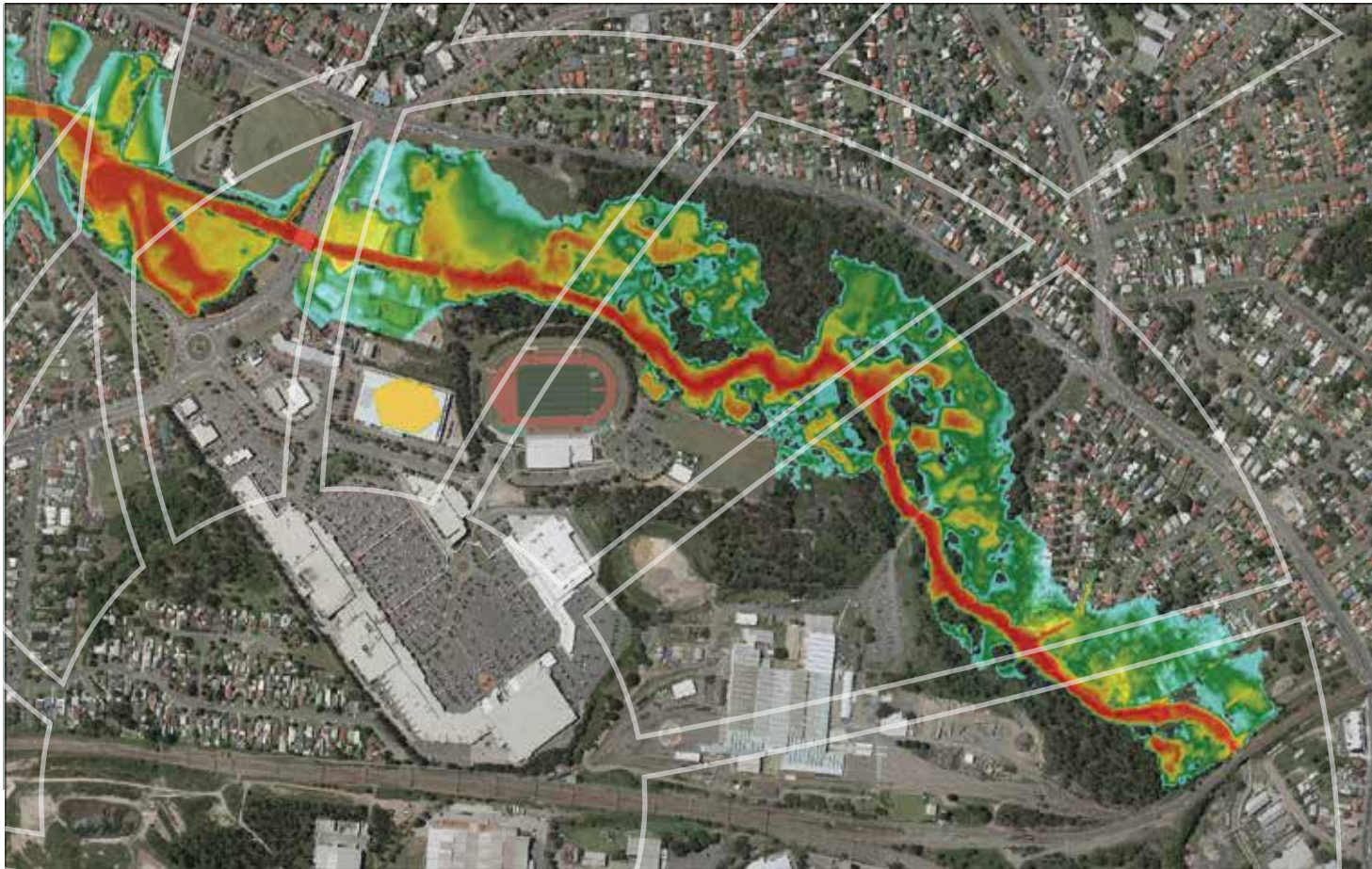
It is noted Council does not have software available to review TUFLOW models. The information above shall be reviewed and expanded to clarify modelling assumptions and internal review confirms that there is sufficient detail then third-party review may be avoided.

Response

Noted, previous reporting (2015) attached in Annex A and comparison between ARR 1987 and 2019 approaches is outlined in response to comment 2.3.

Annex A Glendale Development Flood Risk Assessment Report (BMT, 2015)

“Where will our knowledge take you?”



Glendale Development Flood Risk Assessment

Final Report

December 2015

Glendale Development Flood Assessment

Prepared for: Hunter Development Corporation

Prepared by: BMT WBM Pty Ltd (Member of the BMT group of companies)

Offices

*Brisbane
Denver
London
Mackay
Melbourne
Newcastle
Perth
Sydney
Vancouver*

Document Control Sheet

BMT WBM Pty Ltd 126 Belford Street Broadmeadow NSW 2292 Australia PO Box 266 Broadmeadow NSW 2292 Tel: +61 2 4940 8882 Fax: +61 2 4940 8887 ABN 54 010 830 421 www.bmtwbm.com.au	Document:	R.N20539.001.00.docx
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	Project Manager:	Darren Lyons
	Author:	Darren Lyons
	Client:	Hunter Development Corporation
	Client Contact:	Pavla Board
	Client Reference:	
Synopsis: Summary of Flood Impact Assessment for proposed land development at Glendale		

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Contents

1	Introduction	1
1.1	Site Location	1
1.2	Previous Investigations	4
2	Model Development	5
2.1	Hydraulic Model	5
2.1.1	Extent and Layout	5
2.1.2	Topography	5
2.1.3	Structures	7
2.1.4	Hydraulic Roughness	9
2.1.5	Design Inflows	9
2.1.6	Downstream Boundary	10
3	Existing Flood Behaviour	11
3.1	Design Flood Conditions	11
3.2	Hydraulic Categories	14
4	Flood Impact Assessment	16
4.1	Proposed Development	16
4.2	Flood Impacts	18
4.3	Conclusion	20
5	References	23

List of Figures

Figure 1-1	Site Locality Plan	2
Figure 1-2	Winding Creek Catchment Topography	3
Figure 2-1	Model Area Topography	6
Figure 2-2	Lake Road Bridge over Winding Creek, Glendale	7
Figure 2-3	Glendale Drive Extension	8
Figure 2-4	Design 1% AEP Inflow Hydrograph	10
Figure 3-1	1% AEP Existing Design Flood Conditions	12
Figure 3-2	PMF Existing Design Flood Conditions	13
Figure 3-3	Hydraulic Category Mapping (1% AEP Event)	15
Figure 4-1	Land Use Zoning	17
Figure 4-2	Change in Peak Flood Level (1% AEP Event) Development Scenario 1	19

Figure 4-3	Change in Peak Flood Level (1% AEP Event) Development Scenario 2	21
Figure 4-4	Change in Peak Flood Velocity (1% AEP Event) Development Scenario 2	22

List of Tables

Table 2-1	Adopted Hydraulic Roughness Coefficients	9
Table 2-2	Adopted Design Inflows	10

1 Introduction

This report has been commissioned by Hunter Development Corporation (HDC) for the purpose of identifying potential constraints with respect to flooding for proposed residential/commercial development at Main Road, Glendale. The report considers the impact of local catchment flooding of Winding Creek on the development potential of the project area lands.

1.1 Site Location

The project area lands are located adjacent to Winding Creek principally along Main Road at Glendale as shown in Figure 1-1. Nominal project areas labelled 1A, 1B, 3A and 3B are shown for reference. All project areas occupy existing undeveloped land within or adjacent to the Winding Creek riparian corridor in the reach downstream of the Northern Railway to approximately Lake Road, Glendale.

The Winding Creek catchment encompasses an area of approximately 25km² extending from Charlestown to Argenton as shown in Figure 1-2. The catchment includes all or parts of the suburbs of Charlestown, Kotara South, Garden Suburb, Cardiff Heights, Cardiff South, Macquarie Hills, Cardiff, Glendale and Argenton.

The catchment is characterised by relatively steep tributary catchments which feed Winding Creek along its entire reach from Charlestown through to the confluence with Cockle Creek at Argenton. Most of the known flooding issues occur on the main channel along the generally low-lying floodplain as flow contribution from the tributary channels accumulates. This is particularly the case in Cardiff, where development has encroached on the natural floodplain, with Winding Creek channelised through the main urban areas. Once the channel capacity is exceeded, overland flow paths through the developed floodplain become problematic, as experienced in the recent June 2007 event.

Winding Creek itself is a tributary of Cockle Creek, which eventually flows into the northern part of Lake Macquarie some 6km downstream of the Glendale project area. Whilst the lower reaches of the Winding Creek/Cockle Creek system and the broader Lake Macquarie are tidally influenced, the Glendale project area lands are located beyond the tidal limit. Accordingly, the flooding conditions at the Glendale project area lands are only influenced by the local catchment runoff within the Winding Creek catchment itself.



Title:
Locality Plan

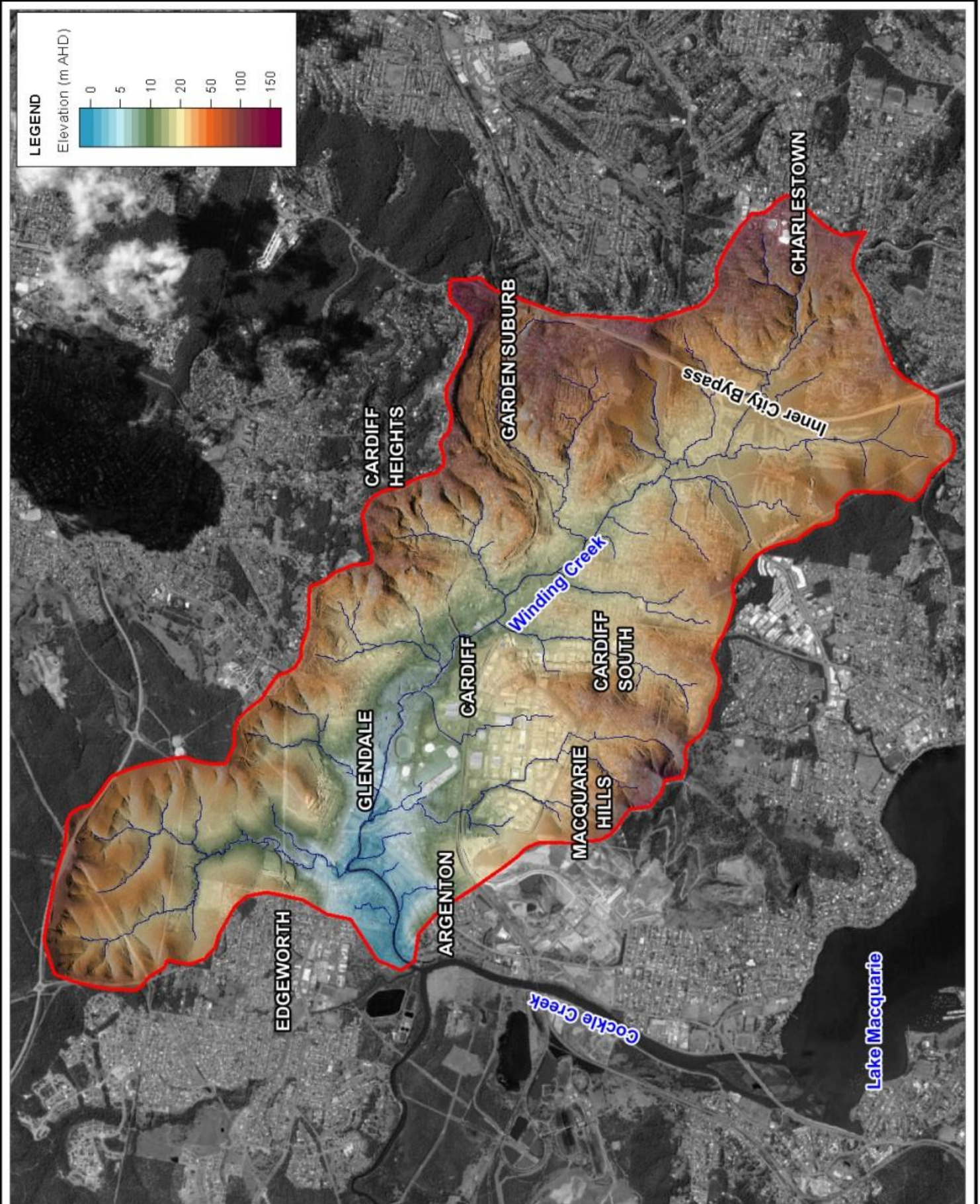
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Title:
Winding Creek Catchment Topography

Figure:
1-2

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Introduction

1.2 Previous Investigations

The Draft Winding Creek and Lower Cockle Creek Flood Study (WMA Water, August 2013) was undertaken on behalf of Lake Macquarie City Council (Council) to establish existing design flood conditions throughout the catchment. The study incorporated the development of detailed hydrologic and hydraulic models to simulate catchment flood behaviour. The developed models were calibrated using historical flood data for events including June 2007 and February 1990.

It is understood that Council are currently undertaking the Floodplain Risk Management Study and Plan for this catchment, and accordingly final model configurations/data are not available for use in the current investigation. Nevertheless, the design flood conditions for Glendale project area lands were established and documented in the previous flood study.

The WMA Water (2013) report therefore forms the basis for the model establishment in the current investigation of the Glendale project area lands. As documented in subsequent sections of the report, a general consistency in model configurations and simulated design flood behaviour has been established between the Council study and the current investigation.

2 Model Development

The primary objective of the flood assessment is to define the existing flood behaviour within the study area through the establishment of appropriate numerical models. The models are then utilised to examine the relative impact on existing flood behaviour of potential development within the nominal project areas.

The development of the hydraulic model including model configuration, data and assumptions is summarised below. As noted in Section 1.2, the model development has aimed for relative consistency with Council's existing flood study model where appropriate.

2.1 Hydraulic Model

2.1.1 Extent and Layout

A TUFLOW two-dimensional hydraulic model has been developed for a local reach of Winding Creek in the vicinity of the project area lands. The adopted extent of the hydraulic model is shown in Figure 2-1 and covers a reach length of some 2.8km extending from the railway bridge upstream of the development site, to downstream of Frederick Street in the Golf Course area. The project areas adjacent to Winding Creek are shown for reference.

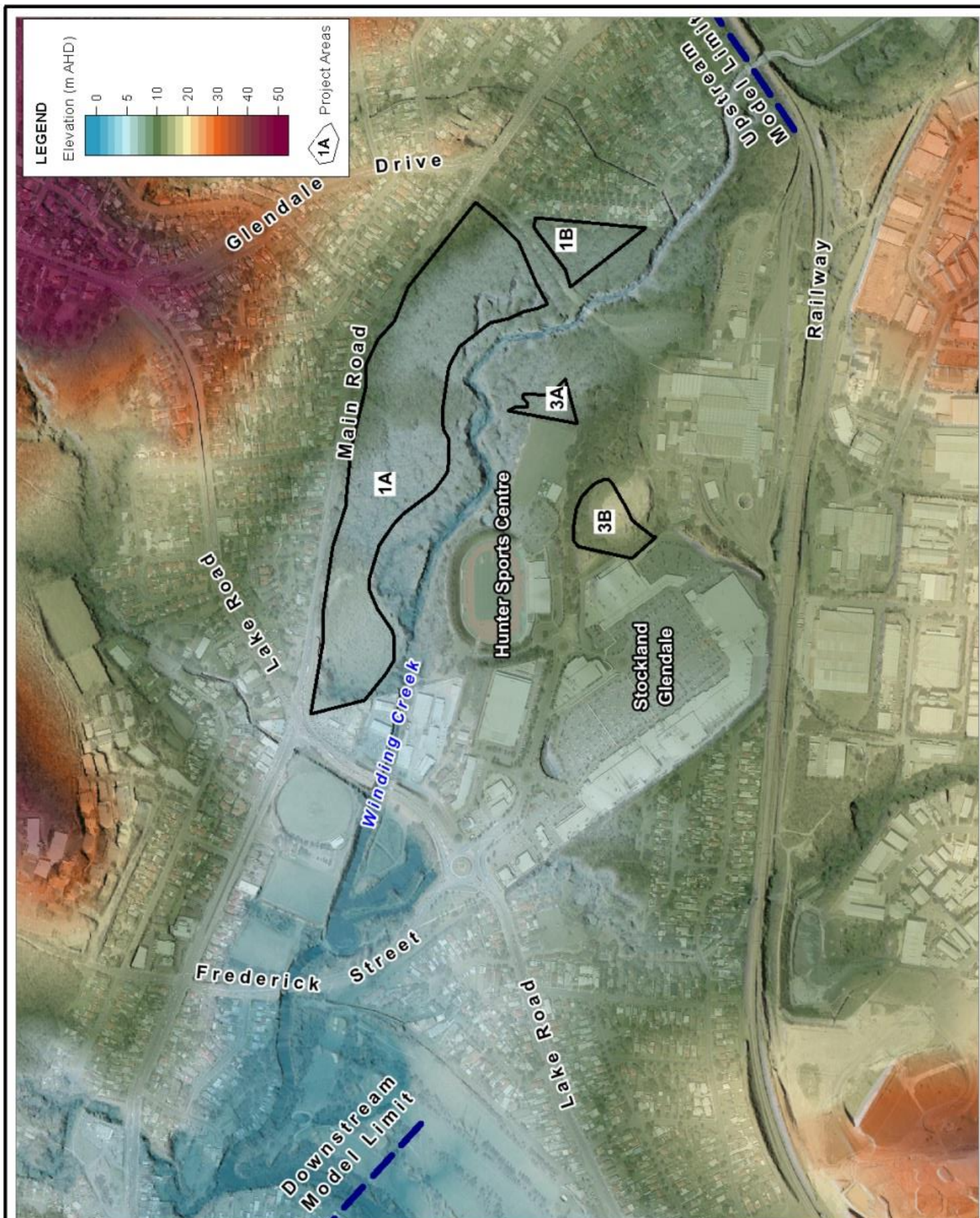
The upstream boundary provides for the design inflow location for the local reach from Winding Creek catchment flows. The adopted inflows are discussed further in Section 2.1.5. The downstream boundary has been extended so as not to influence simulated flood behaviour in the project area lands.

2.1.2 Topography

The availability of LiDAR data allowed for a high resolution Digital Elevation Model (DEM) to be derived, as presented in Figure 2-1. The LiDAR data set used was acquired in 2007 by the NSW Dept. of Planning. The ground surface elevation for the TUFLOW model grid points are sampled directly from the DEM. It is a representation of the ground surface and does not include features such as building or vegetation.

A TUFLOW 2D domain resolution of 2m was adopted for the study area. It should be noted that TUFLOW samples elevation points at cell centres, mid-sides and corners, so a 2m cell size results in elevations being sampled from the underlying DEM every 1m. This resolution was selected to provide the necessary detail required for accurate representation of the catchment. It is noted that the TUFLOW models in Council's Winding Creek Flood Study utilised a minimum grid resolution of 3m.

As evidenced in the topography, the nominal project areas are typically located in the lower-lying floodplain areas adjacent to the alignment of the Winding Creek main channel. The typical floodplain elevations range from around 6-7m AHD around Glendale Drive to around 5m AHD towards Lake Road.



Title:
Model Area Topography

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2-1

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2.1.3 Structures

There are a number of structures present within the model domain that will influence the flooding behaviour within the study area. There are existing bridge crossings over the Winding Creek channel at Glendale Drive, Lake Road and Frederick Street. The approach embankments for these structures provide for a significant restriction to floodplain flows and accordingly represent major hydraulic controls within the modelled reach. The adopted 2m TUFLOW grid resolution coupled with the waterway opening and approach embankment geometry defined by the LiDAR DEM allows for appropriate representation of these controls within the model. Figure 2-2 shows an example of the constricted waterway opening on Winding Creek at the Lake Road bridge structure.



Figure 2-2 Lake Road Bridge over Winding Creek, Glendale

As part of the Lake Macquarie Transport Interchange (LMTI) project, a major roadwork extension to Glendale Drive crossing the Winding Creek floodplain is proposed. The works is described in the Review of Environmental Factors (SMEC, 2014) and incorporates a hydraulic and flooding impacts assessment. This assessment concluded:

- The proposed Winding Creek Bridge soffit level is positioned above the 1% AEP flood level, with approximately 660 mm freeboard;
- The proposed road level is flood free for flood events up to and including the 5% AEP event and there is no overtopping at the crest of the low point in the road for the 1% AEP event;
- There are no flooding impacts downstream of the proposed bridge for the 1% AEP event; and
- There are no significant flooding impacts at the proposed bridge and upstream of the proposed bridge for events up to and including the 1% AEP event (i.e. model results suggest no afflux immediately upstream of the proposed bridge).

For the current assessment, it is considered appropriate to include the road proposal in the model configuration to define baseline flooding conditions. The proposed Glendale Drive extension over Winding Creek is shown in Figure 2-3.



Title:
Glendale Drive Extension

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2-3

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Figure 2-3 shows the alignment and finished design surface of the proposed road embankment and bridge crossing of Winding Creek (note: the bridge deck has been removed from the coloured DEM to show the waterway opening between bridge abutments). The design elevations were provided to BMT WBM by HDC for inclusion in the TUFLOW model. The inclusion of the Glendale Drive extension represents the only change in model topography between the current study and Council's existing Winding Creek model in the corresponding study reach.

2.1.4 Hydraulic Roughness

The development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are delineated from aerial photography and cadastral data identifying different land-uses (e.g. forest, cleared land, roads, urban areas, etc.) for modelling the variation in flow resistance. The hydraulic roughness is one of the principal calibration parameters within the hydraulic model and has a major influence on flow routing and flood levels.

The roughness values adopted in the hydraulic model for various land surface types are summarised in Table 2-1. These values are consistent with the values adopted in Council's flood study (WMAWater, 2013).

Table 2-1 Adopted Hydraulic Roughness Coefficients

Land Use / Surface Type	Manning's 'n' Value
Grass	0.05
Heavy Vegetation	0.12
Roads	0.02
Lots	0.06
Concrete Channel	0.02
Natural Creek	0.05

2.1.5 Design Inflows

The design inflows to the model have been based on the documented peak flows in the Draft Winding Creek and Cockle Creek Flood Study (WMAWater, 2013). The flood study incorporated development of a WBNM (Watershed Bounded Network Model) hydrological model to derive sub-catchment flows throughout the entire Winding Creek catchment. These hydrological inputs were incorporated in the Winding Creek TUFLOW model with the routed peak flows reported at various locations throughout the study area.

The reported peak flow values corresponding to the location on Winding Creek downstream of the Norfolk Street tributary represent the design peak flows for the reach in consideration in the current study. The peak design flows for a range of events are summarised in Table 2-2.

Table 2-2 Adopted Design Inflows

Design Event	Peak Design Flow (m ³ /s)
5% AEP (20yr ARI)	96.0
1% AEP (100yr ARI)	123.1
Probable Maximum Flood	622.3

The Council flood study identified the 9-hour storm duration as the critical duration for this reach of the Winding Creek catchment. BMT WBM developed a catchment wide hydrological model of Winding Creek to derive an appropriate hydrograph shape based on the identified critical storm duration. This hydrograph shape was scaled to the corresponding design peak inflows summarised in Table 2-2 to establish model inflow conditions. The adopted 1% AEP event inflow hydrograph is shown in Figure 2-4.

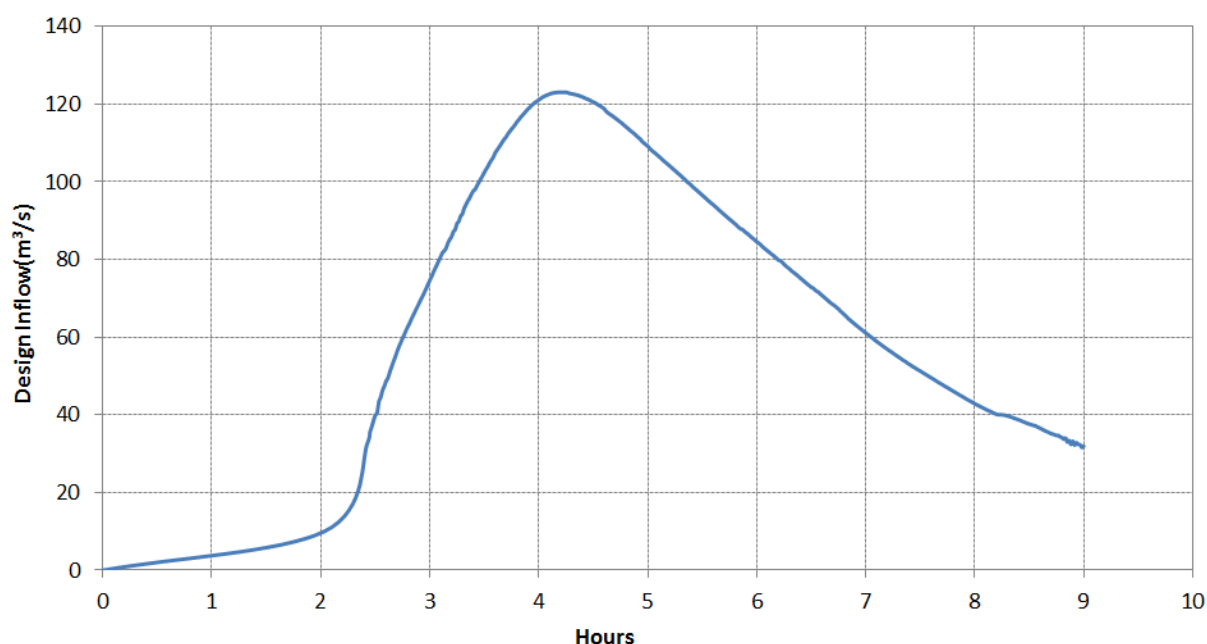


Figure 2-4 Design 1% AEP Inflow Hydrograph

2.1.6 Downstream Boundary

The downstream model boundary is located in the reach of Winding Creek through the Waratah Golf Course downstream of Frederick Street. This location is far enough downstream of the project area so as not to influence design flood conditions. A nominal stage-discharge boundary condition was adopted at this location.

3 Existing Flood Behaviour

3.1 Design Flood Conditions

Design floods are hypothetical floods used for planning and floodplain risk management investigations. The 1% AEP flood conditions are typically used to manage flood damages (e.g. setting flood immunity requirements and design levels) whilst the PMF flood conditions are ordinarily used from a flood management perspective when considering risks to life. The design results presented in the report from this point focus on the 1% AEP and PMF events as the typically used flood planning events.

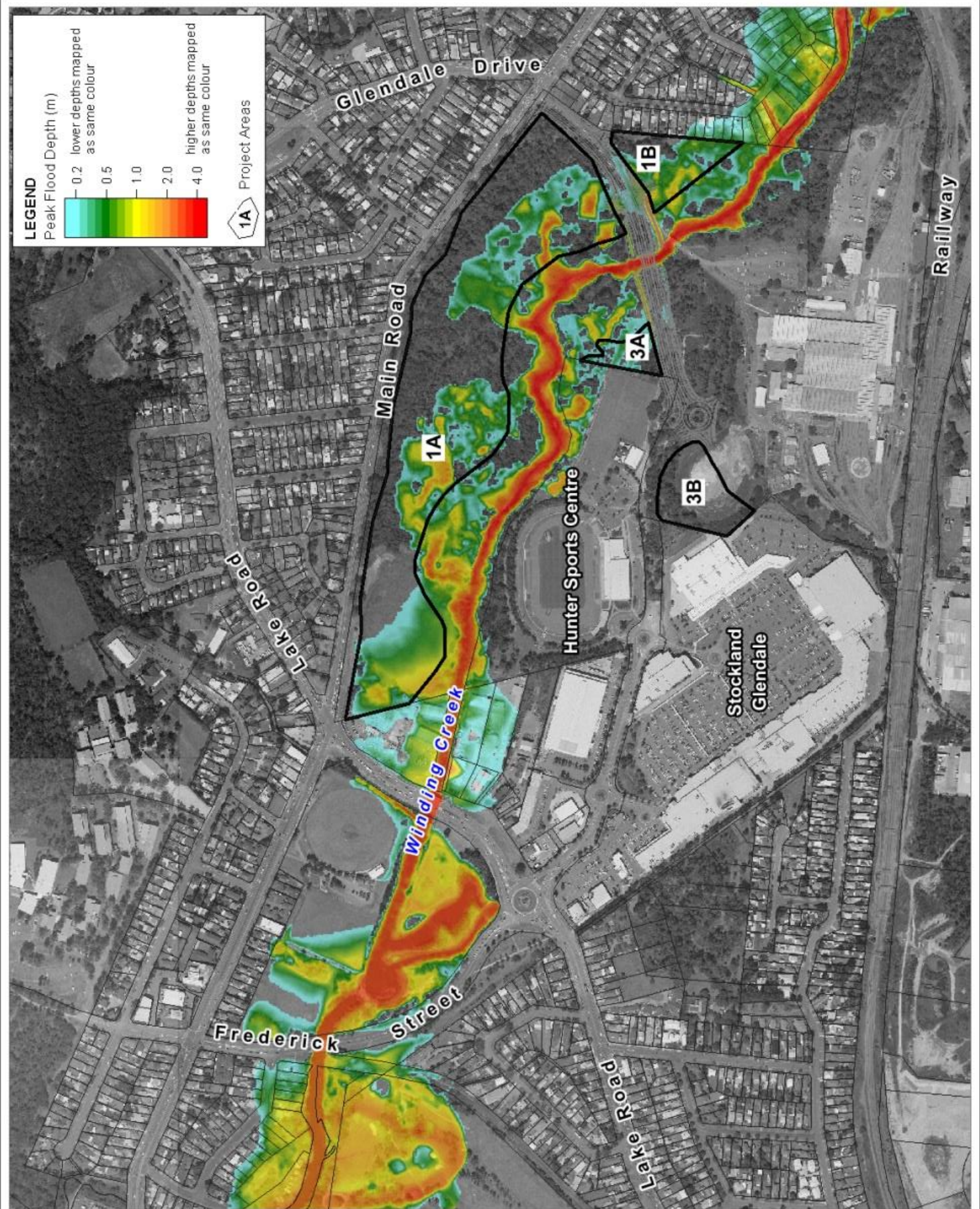
The model developed as described in Section 2 was simulated for the 1% AEP and PMF design events for existing conditions (including the Glendale Drive extension). The simulated peak inundation extent and flood depth distribution is shown in Figure 3-1 and Figure 3-2 for the 1% AEP and PMF events respectively. Review of Council's flood study mapping has confirmed the overall consistency in the simulated flood conditions along this reach of Winding Creek. Accordingly, the developed models are considered appropriate for further assessment of the potential development areas.

Parts of the nominal project areas are inundated at the peak 1% AEP flood level. The depth of inundation varies in accordance with the local topography. As indicated by the depth distribution, the majority of floodwater is typically conveyed within the main channel of Winding Creek. The nature of the local topography is such that most of the out-of-bank inundation is limited to the right floodplain. There is relatively limited floodplain inundation on the left bank, which includes the Hunter Sports Centre area. Some areas of existing development adjacent to the project areas are subject to minor inundation at the 1% AEP flood level including residential property in Cedar Street (upstream of Glendale Drive) and industrial/commercial property upstream of Main Road.

The peak 1% AEP flood levels vary across the project areas from approximately 8m AHD at parcel 1B to approximately 5m AHD at the downstream end of parcel 1A towards Lake Road. The most significant flood affectation is to Parcel 1A with some depths of inundation within the parcel footprint areas exceeding 1.5m. These areas appear to coincide with relic channels or tributaries of the main channel, however are typically disconnected from the major flow paths.

There is no significant inundation to the major access roads in the locality for the 1% AEP event. This includes the proposed Glendale Drive extension, Lake Road and Frederick Street crossings of Winding Creek and Main Road adjacent to the floodplain area.

Under PMF conditions, there is extensive inundation across the project areas and the broader Winding Creek floodplain with typical depths of inundation excess of 3m. The peak PMF flood levels vary across the project areas from approximately 10m AHD at parcel 1B to approximately 6.5m AHD at the downstream end of parcel 1A towards Lake Road. This level of inundation also provides for the major transport routes including Glendale Drive, Main Road, Lake Street and Frederick Street.



Title:
Existing Peak 1% AEP Design Flood Conditions

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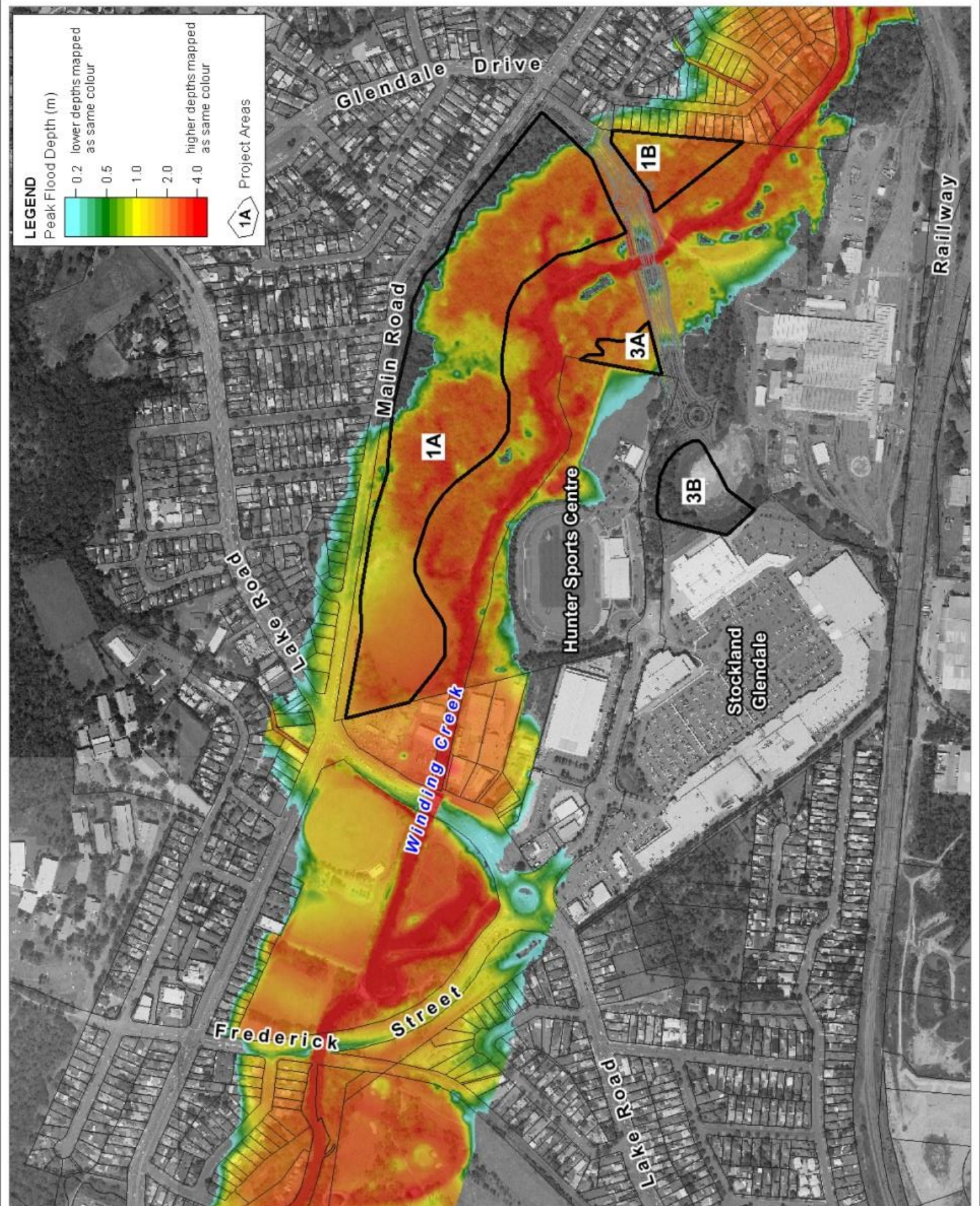


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Title:
Existing Peak PMF Design Flood Conditions

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3.2 Hydraulic Categories

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringes. Descriptions of these terms within the Floodplain Development Manual (NSW Government, 2005) are essentially qualitative in nature and emphasises is placed on the need for site specific consideration when determining appropriate methods for hydraulic category classification. The hydraulic categories as defined in the Floodplain Development Manual and the advised general guidelines to assist in the delineation of flooding and flood storage areas are:

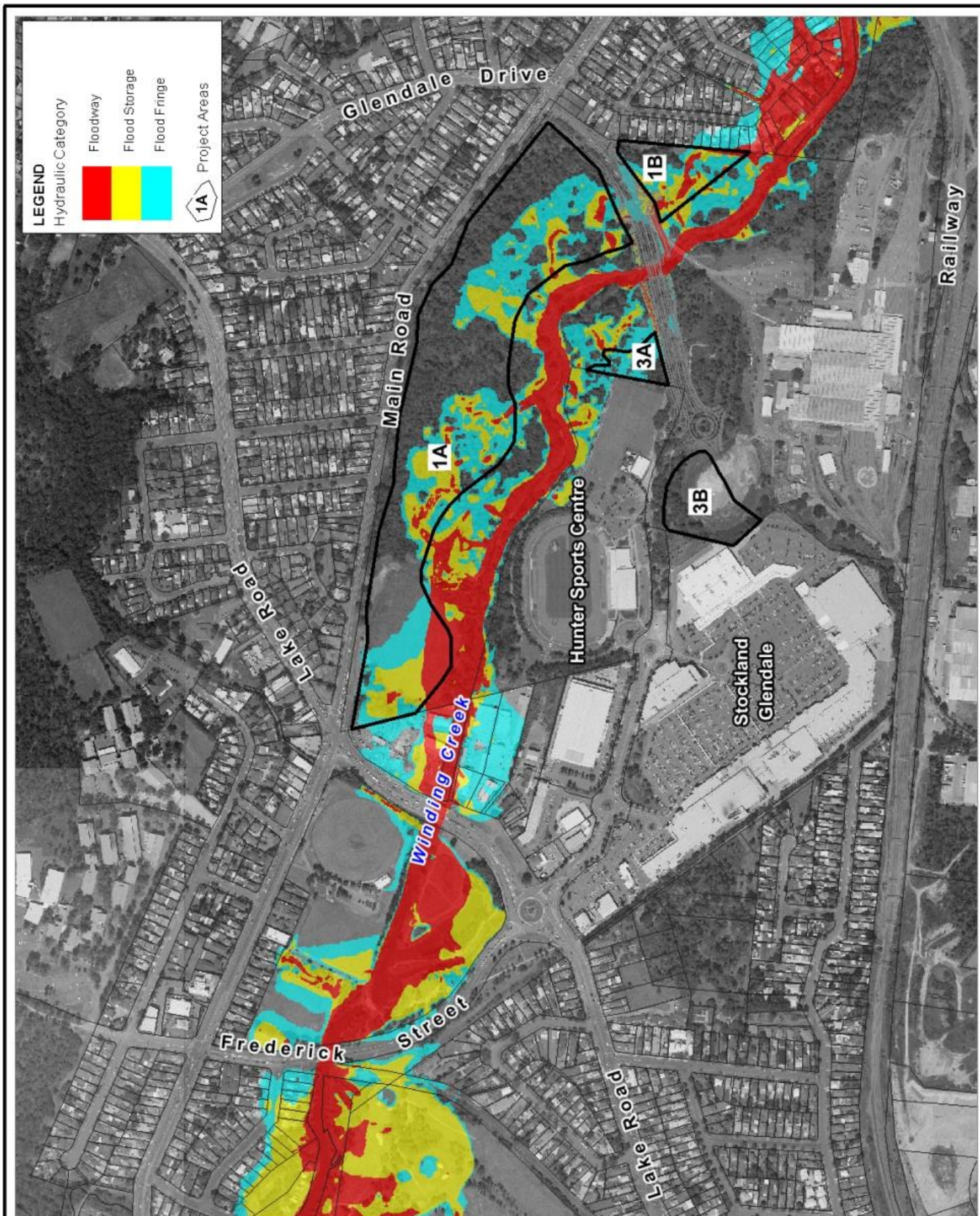
- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- **Flood Storage** - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.
- **Flood Fringe** - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not significantly affect the flood pattern or flood levels.

Council's flood study adopted the following categorisation:

*Floodway = Velocity * Depth > 0.25m²/s AND Velocity > 0.25m/s OR Velocity > 1m/s*

The remainder of the floodplain outside the Floodway becomes either Flood Storage or Flood Fringe. In this study Flood Storage was defined as the land outside the Floodway if the depth is greater than 0.5m and Flood Fringe if the depth is less than 0.5m.

The hydraulic categories based on the above classifications are shown in Figure 3-3. The mapping identifies the floodways typically limited to the main channel of Winding Creek. However, there are some areas of floodway located within the project area parcels. For floodway areas development is generally not permitted. Further discussion on flood related development controls applicable to the proposed development site are presented in Section 4.1.



Title:
Hydraulic Category Mapping (1% AEP Event)

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3-3

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4 Flood Impact Assessment

4.1 Proposed Development

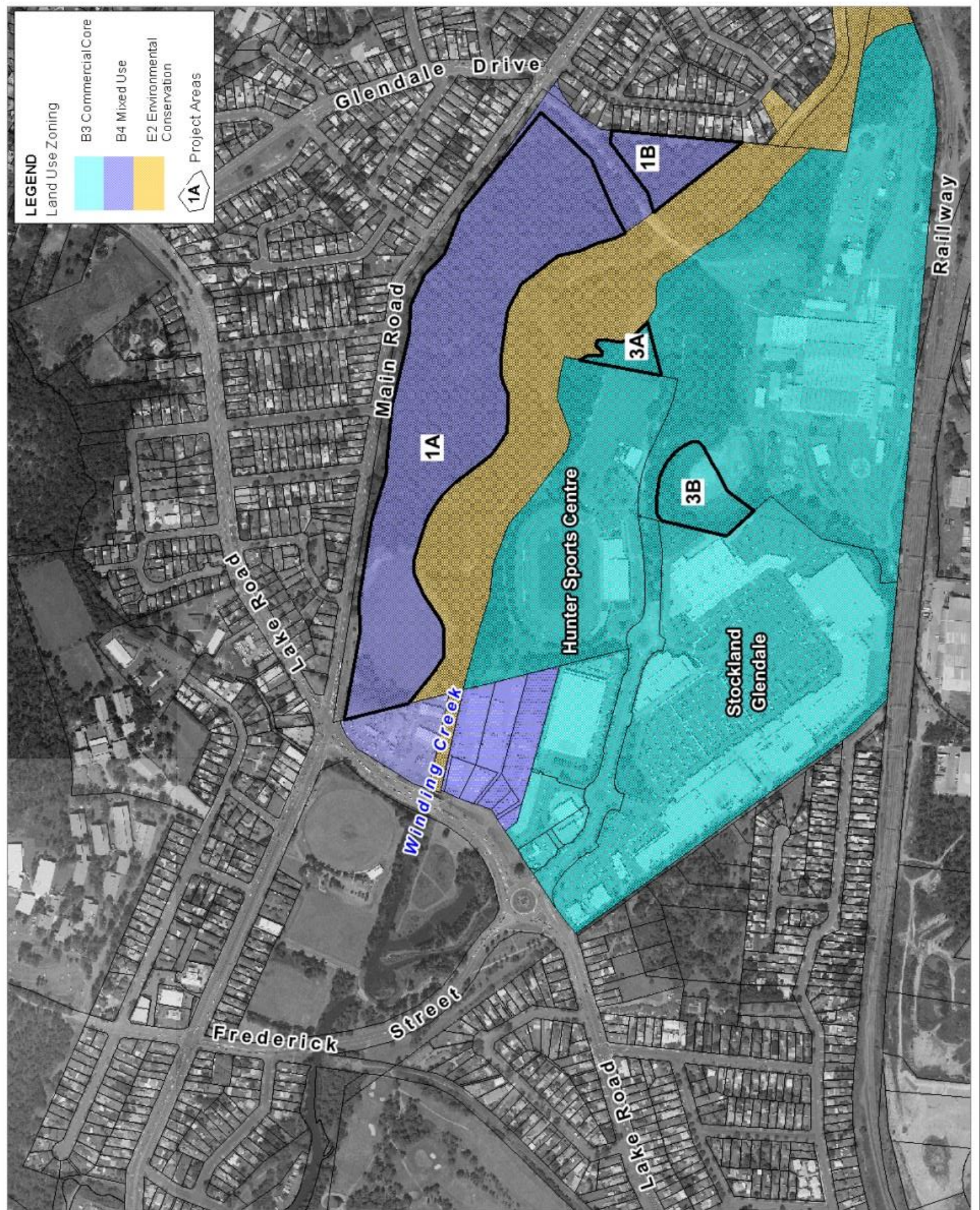
The preliminary flood impact assessment is undertaken to identify the opportunities and constraints for potential development in the project areas. The previous report sections have established the existing design flood conditions to use as the baseline conditions for the development assessment. Further consideration is given hereunder to the flood related development controls in accordance with Council's existing policies and the established design flood conditions.

The current Land Use Zoning in the Lake Macquarie Local Environmental Plan 2014 (LMLEP 2014) is shown in Figure 4-1. The cadastral parcels associated with the project areas comprise:

- E2 Environmental Conservation – this is largely the riparian corridor of Winding Creek
- B4 Mixed Use – comprising predominantly the 1A and 1B project areas on the right floodplain of Winding Creek outside the E2 zoning boundary; and
- B3 Commercial Core - comprising part of the 3A and all of the 3B project areas on the left floodplain of Winding Creek outside the E2 zoning boundary

The proposed development areas therefore largely comprise B3/B4 Business Zones. Reference is made to the Lake Macquarie Development Control Plan 2014: Part 4 – Development in Business Zones for the flood related development controls applicable to the site. The key controls with respect to development of these parcels considering the existing design flood conditions of Winding Creek are summarised below.

- Buildings must not be located in an identified floodway;
- Buildings and other structures, including fences, must be designed so as not to impede the flow of floodwaters or entrap debris;
- Habitable rooms and commercial development must have a finished floor height at least 500mm above the 100 year ARI (1% AEP) event, or is to have equivalent measures in place to mitigate flood damage (e.g. flood barrier system with evacuation plan). Where probability flood levels are not available, habitable rooms must have a finished floor height at least 500mm above the highest observed flood level for the development site.
- Fill is not permitted within core riparian zones, within the Lakefront Development Area or the Foreshore Development Area, or within the extent of the 100 year probable ARI (1% AEP) flood event.
- Lesser provisions may be acceptable where the applicant can demonstrate that the type of development or the proposed use poses no significant risk to life or property by flooding.
- Any use of fill associated with development must not substantially impede the flow of floodwater, and must not contribute to flooding or ponding of water on any other property.



Title:
Land Use Zoning

Figure:
4-1

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In order to achieve the required flood immunity standard for the development, some level of ground modification and/or elevated floor levels would be required. Filling of the site has the potential to redistribute floodwaters and exacerbate flooding conditions on neighbouring properties.

The site filling patterns would be dependent on the development layouts considering the building footprints, internal road networks, car park areas and open space requirements. In order to assess the potential for filling at this stage, it has been assumed that the whole site has an elevation in excess of the 1% AEP flood level (i.e. the whole development area has been excluded from interacting with the floodplain for storage and flow conveyance). This is a conservative assumption, as there may be some scope for having lower levels across portions of the lot (e.g. landscaping areas). However, final details of the internal layout of the development would be determined at detailed design and has not been tested at this stage of the flood impact assessment.

It is noted that the nominal project areas extend into the existing 1% AEP flood inundation extents and also incorporate some areas identified as floodway. Proposed development would change the flooding conditions throughout the site and within the local reach of Winding Creek. The existing Council policy provides for this development opportunity provided conditions related to adverse impacts on neighbouring property are demonstrated to be acceptable.

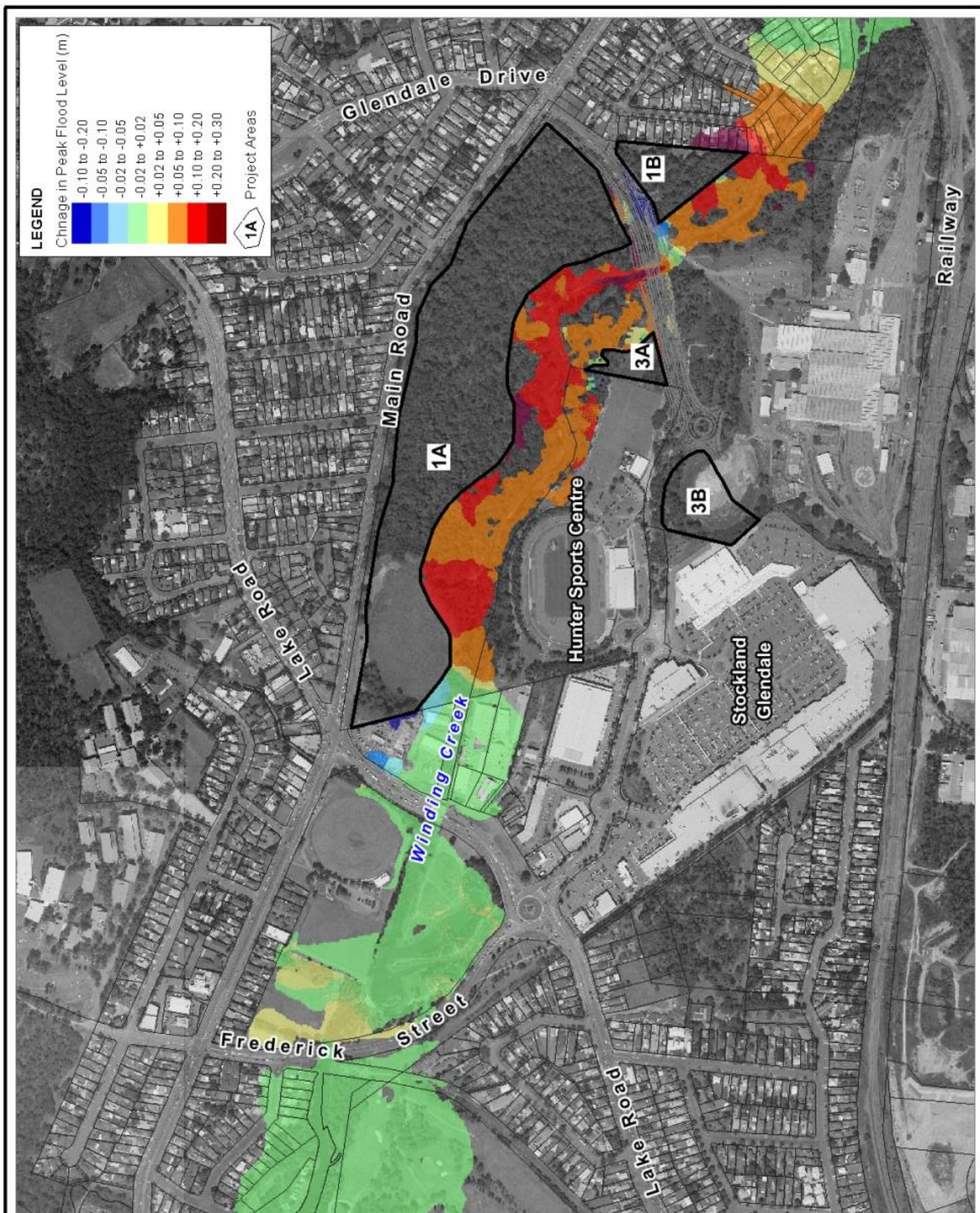
4.2 Flood Impacts

The relative impact of the proposed development has been considered in terms of potential adverse impacts on existing flood behaviour. Whilst the development may be anticipated to largely remain outside of identified floodway areas, some changes to the existing flooding regimes can be expected. In determining relative impacts of the proposed development there is potential for:

- Redistribution of flow arising from works on the floodplain;
- Concentration discharges and subsequent impact on downstream areas; and
- Increase in flood levels through impedance of overland flow paths and loss of temporary flood storage.

The models developed to establish existing flood conditions have been modified to represent post-development development floodplain conditions and assess relative impacts. As noted, without design surfaces at this stage of the assessment, ground elevations within the proposed development footprints have been raised above the existing design flood levels to assess relative impacts.

Figure 4-2 shows the change in peak 1% AEP flood level for complete filling of the project area boundaries as shown. The most significant impacts in terms of magnitude of the increase in peak flood levels are adjacent to the 1A project area. Increases in peak flood level through the broader reach of Winding Creek are typically less than 0.1m for the proposed development footprints, with smaller areas of more localised increase in excess of 0.2m. Significantly however, the area of impact adjacent to the 1A project area is limited to within the existing riparian corridor. As noted previously, the area on the left bank of Winding Creek, including the Hunter Sports Centre, is located on typically higher ground on the floodplain, above the 1% AEP design flood levels. Accordingly, the increases in peak flood level within the riparian corridor have no adverse impact on existing neighbouring development.



Title:
**Change in Peak Design Flood Level (1% AEP Event)
Development Scenario 1**

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There are increases in peak flood levels in the vicinity of existing residential development upstream of the 1B project area. Some properties in Cedar/Norfolk Streets were identified as subject to inundation under existing conditions for the 1% AEP event. With filling of the floodplain associated with project area 1B, local increases of up to 0.4m are simulated for the 1% AEP peak flood level.

In contrast to the impacts associated with project area 1A being limited to the existing riparian corridor, the impacts of project area 1B extending to existing residential property would typically not be acceptable in standard floodplain risk management practice.

A second development scenario has been simulated with removal of the 1B project area to demonstrate a reduced impact on the existing Cedar/Norfolk Street properties. The simulated impacts therefore represent those associated with filling of project areas 1A, 3A and 3B only as shown in Figure 4-3. With removal of the 1B project area, the impact on Cedar/Norfolk Street properties is removed with the extent of impacts of the remaining development area being limited to the riparian corridor downstream of the existing residential development in Cedar/Norfolk Streets.

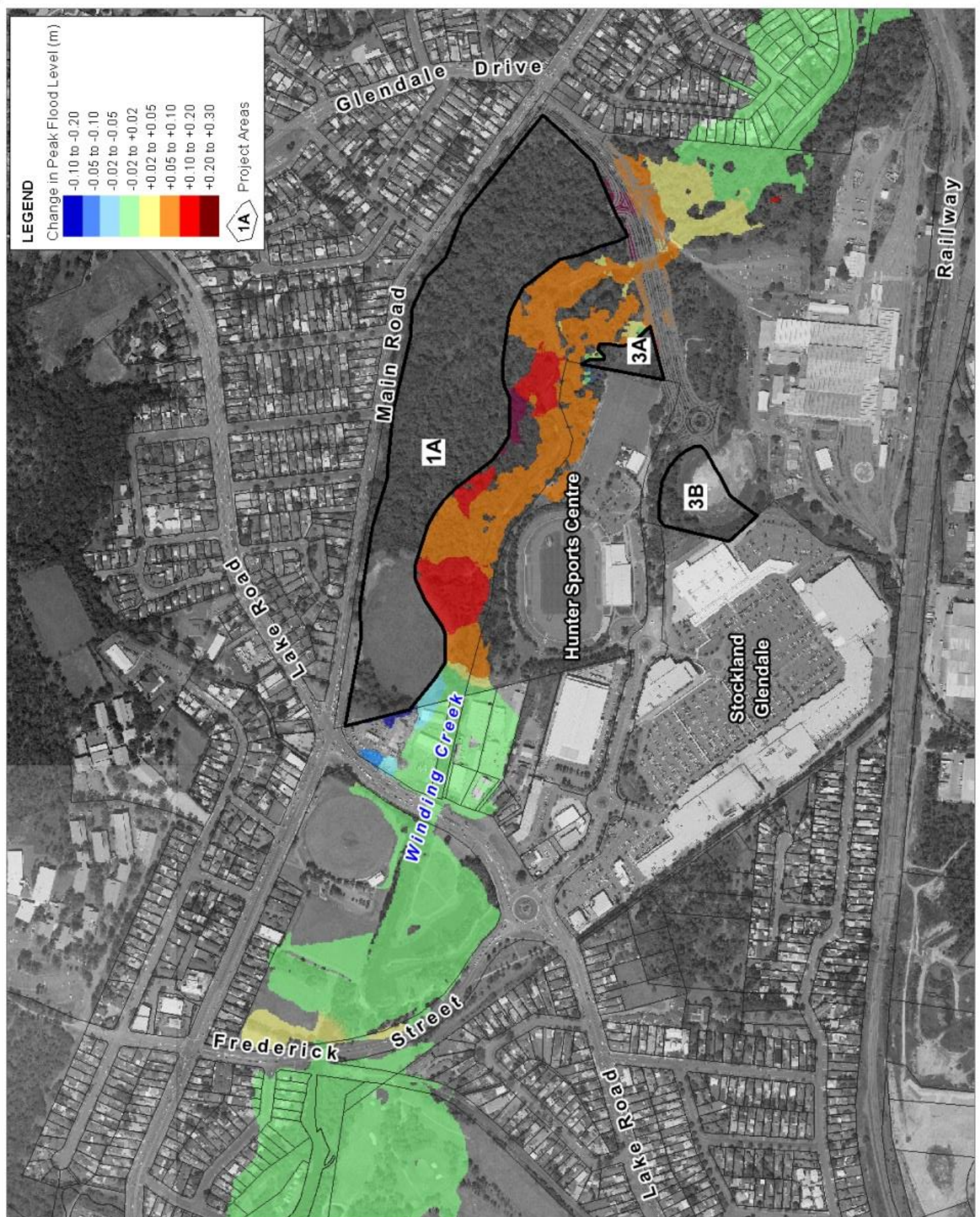
The encroachment of the development footprints into existing flood inundation extents also changes the flow distribution across the floodplain. Figure 4-4 shows the change in peak flood velocity for the second development scenario (project area 1B removed) from the existing condition velocity distribution. Typically there is an increase in peak flow velocity associated with the constriction of the floodplain adjacent to filled development 1A and 3A areas. The magnitude of velocity increase however is relatively minor ($<0.2\text{m/s}$), particularly with existing mainstream channel velocities of the order of 1.5m/s .

4.3 Conclusion

On the basis of the above results, it is considered that development areas 1A, 3A and 3B do not provide any significant adverse impacts on neighbouring property. Whilst there are impacts in terms of peak flood level increases and minor increases in peak flood velocity, the extent of the impacts are limited to within the existing riparian corridor of Winding Creek. No existing development is affected by the impacts and there is no increase in overall flood inundation extents.

The development area 1B provides for impacts to existing properties in the Cedar/Norfolk Street locality which is considered unacceptable. It should be noted that a reduced development footprint for area 1B would reduce impacts to existing properties, thereby providing some viability for development within this parcel. For example, limiting the development footprint to outside the existing 1% AEP flood inundation extent would eliminate impacts at the 1% AEP level.

Potential development within the existing E2 Environmental Conservation zoned land (refer to Figure 4-1) has not been considered in detail in this report. Some of these areas are noted as outside the existing flood extents and therefore may be suitable for development from a flood impact perspective. Further, it is likely that some minor encroachment of additional footprint area into the E2 zones (e.g. for permitter roads) would not provide for additional unacceptable flood impact (subject to model confirmation).



Title:
**Change in Peak Design Flood Level (1% AEP Event)
Development Scenario 2**

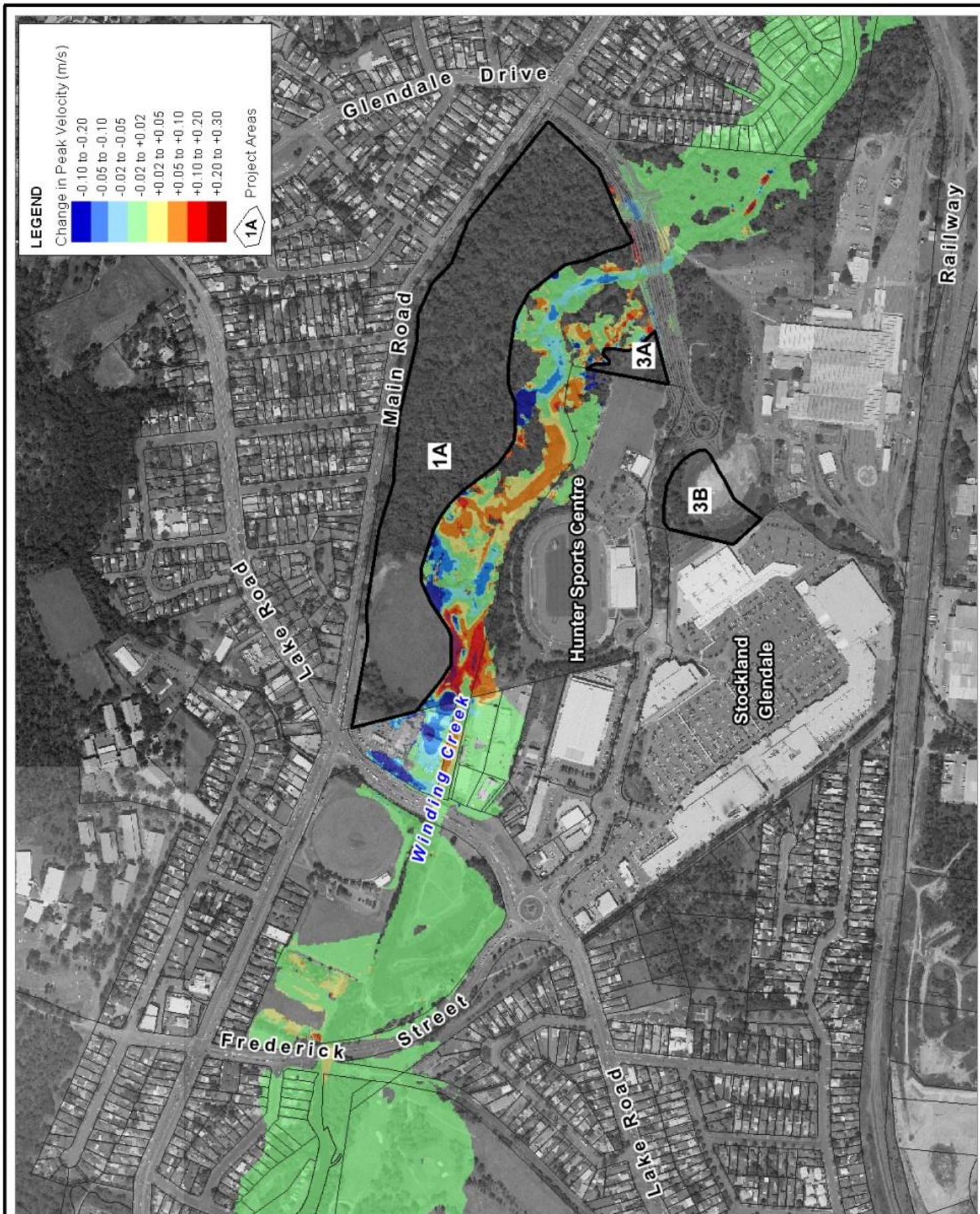
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Title:
**Change in Peak Flood Velocity(1% AEP Event)
Development Scenario 2**

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5 References

Lake Macquarie City Council (2015) *Lake Macquarie Development Control Plan 2014: Part 4 – Development in Business Zones*

NSW Government (2005) *Floodplain Development Manual*

SMEC (2014) *Lake Macquarie Transport Interchange Stage 1 - Review of Environmental Factors*

WMAWater (2013) *Draft Winding Creek and Lower Cockle Creek Flood Study*

Annex B Acceptance of ARR1987 Methodologies

Hi Pat

Please see Council responses below:

Flood

While ARR19 would be Council's preferred method in this instance ARR87 will be accepted in accordance with previous discussion undertaken prior to lodgement

On further review Jack has questioned why the unit flow rate for the site falls within the range for rural catchments. It would be expected that the results should fall within the range for an urban catchment given the amount of development that's occurred upstream of the site.

Jack has also undertaken a brief review of the Flood Risk Assessment and didn't raise any specific concerns. However, still recommend that all previous studies used as supporting evidence/data for the development be summarised and comments provided in the current flood report.

Traffic & Transport and Engineering

- *Council to confirm access approach to Lot 31 is supportable and feasible through review of issued concept plan.*

No objection to access approach for lot 31 as discussed.

- *Council to confirm position and provide clarification on impacts to shared paths and the proposed pathway network. Council to provide mark-up to confirm location.*
- *Council to confirm inclusion of foot bridge across Winding Creek.*

Update to be provided shortly

Biodiversity

- *Council to confirm proposed locations for requested Glider Poles and Rope Bridges for VMP update.*

Update to be provided shortly

Landscape

Tentative time sent through for Thursday at 215pm.

If you have any immediate question please reach out.

Regards

Glen Mathews

Principal Development Planner



T [+61 2 4921 0399](tel:+61249210399) M [+61 439 647 504](tel:+61439647504)

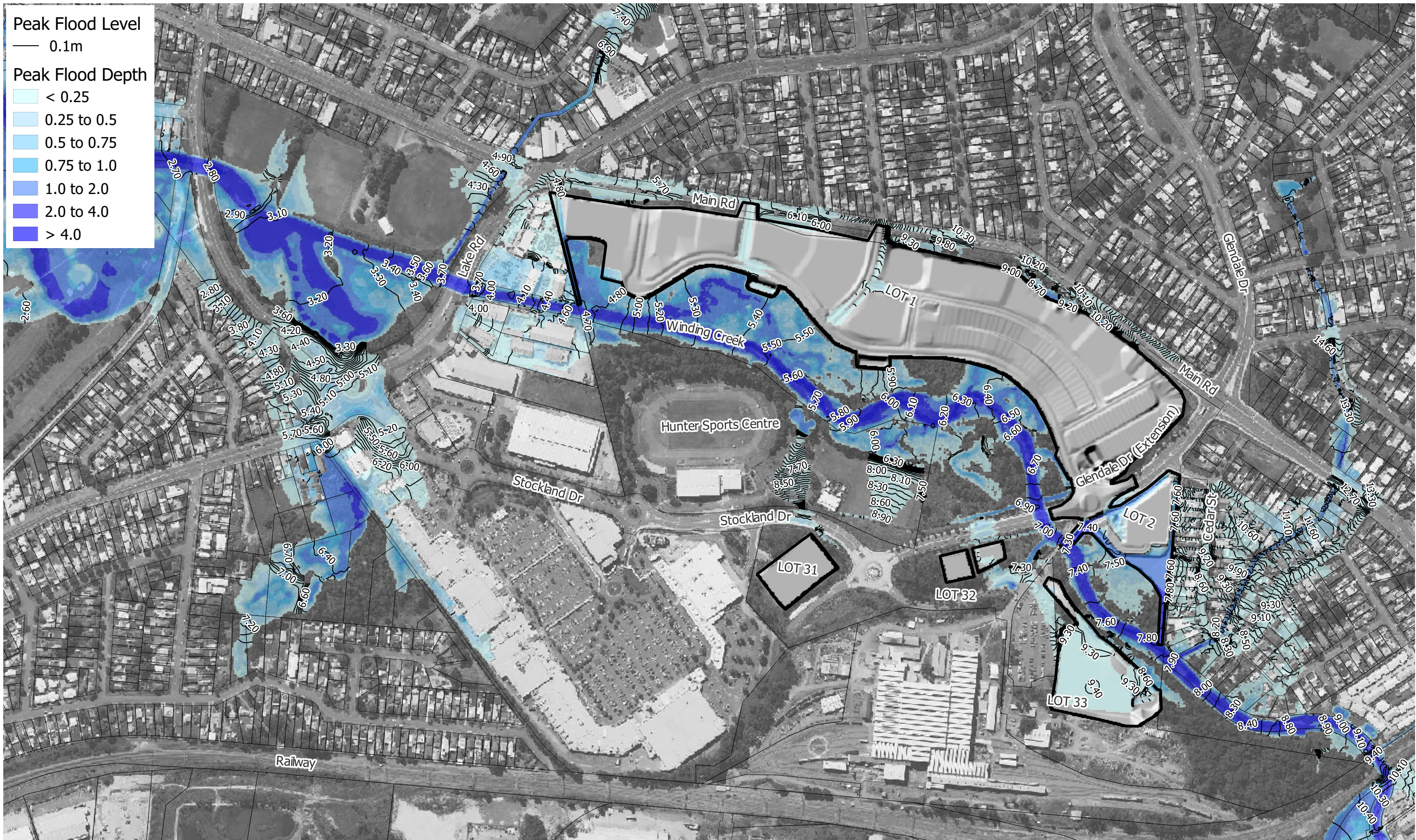
E gmathews@lakemac.nsw.gov.au

lakemac.com.au



Dhumaan ngayin Awabakurlangu kirraanan barayidin
We acknowledge and respect the Awabakal people who have cared for and nurtured this country.

Annex C Flood Maps



Legend

-  Proposed Development Area
-  Cadastral Boundaries

Title:

**Peak Flood Level and Depth - Post-development Scenario -
5% AEP Flood**

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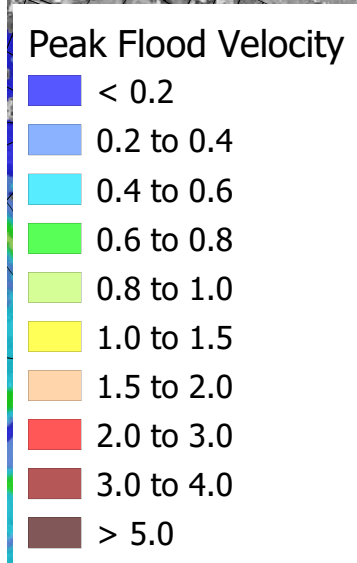
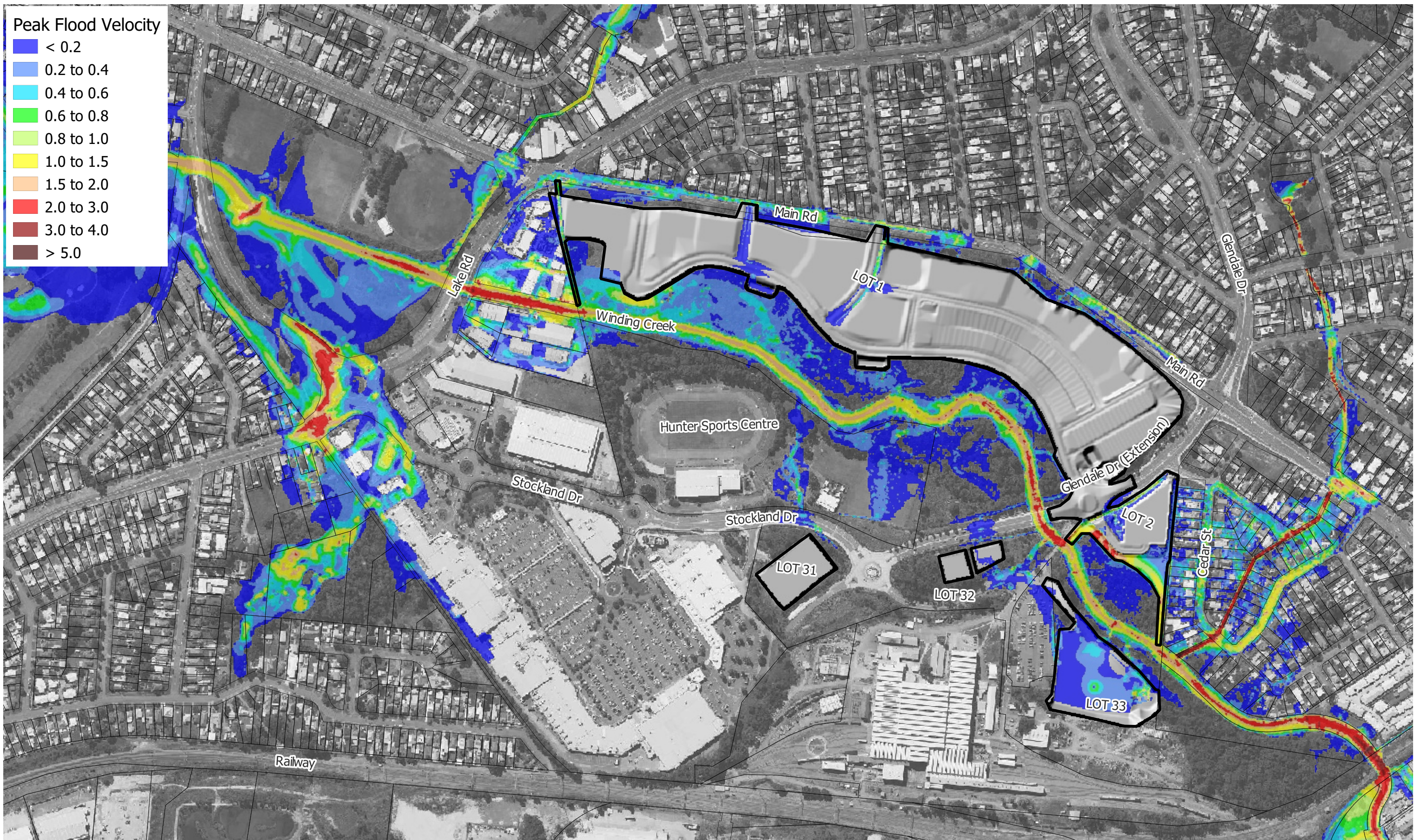
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Legend Proposed Development Area Cadastral Boundaries	Title: Peak Flood Velocity - Post-development Scenario - 5% AEP Flood	Drawing: B-02	Rev: A
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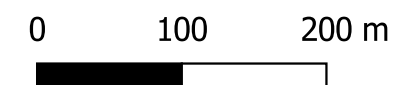


Legend

- Proposed Development Area
- Cadastral Boundaries

Title:
**Provisional Flood Hazard - Post-Development Scenario - 5%
AEP Flood**

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Drawing:
B-03

Rev:
A



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Change in Peak Flood Level - 5% AEP Flood

Drawing:

B-04

Rev:

A

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0 100 200 m



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title: Change in Peak Flood Velocity - 5% AEP Flood

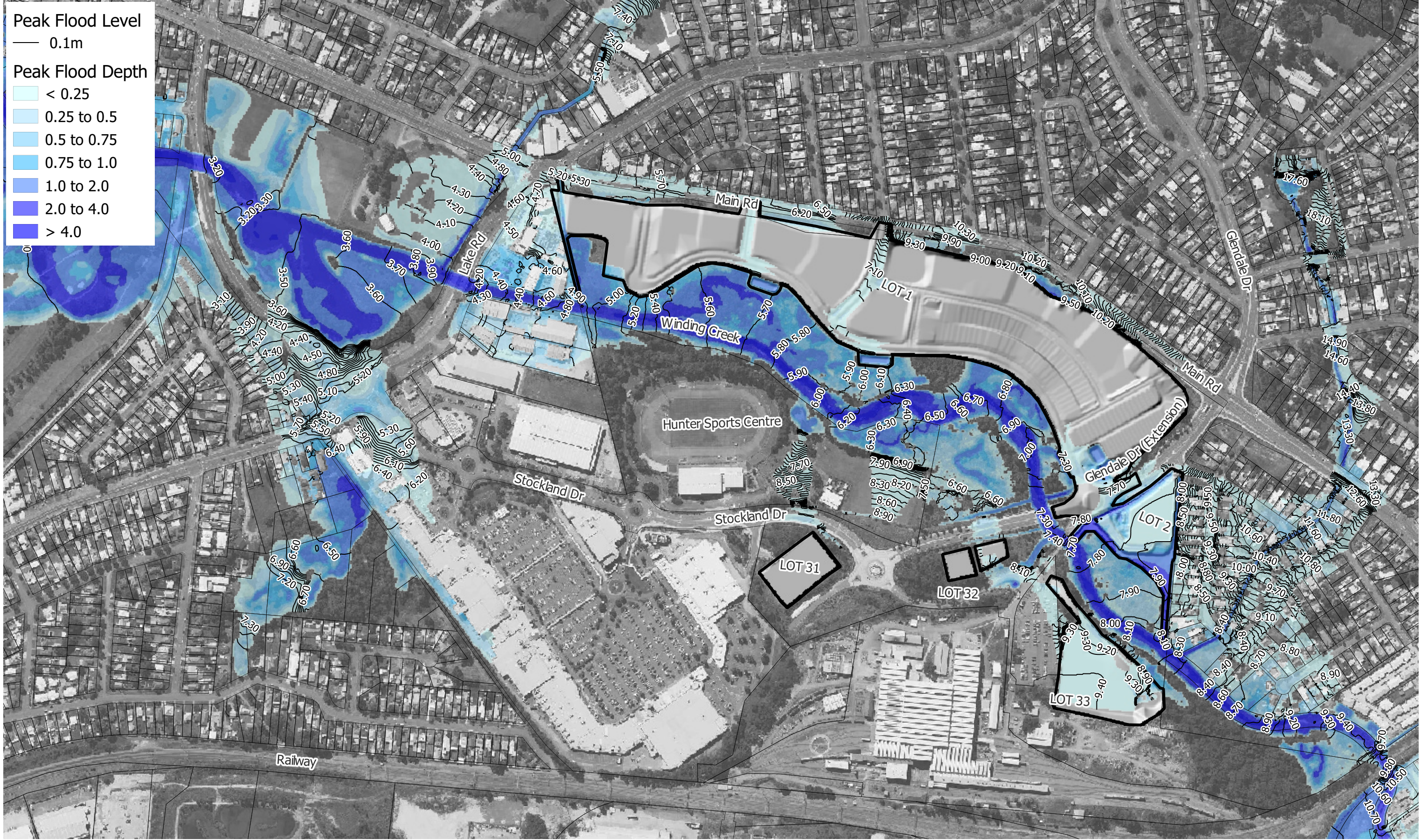
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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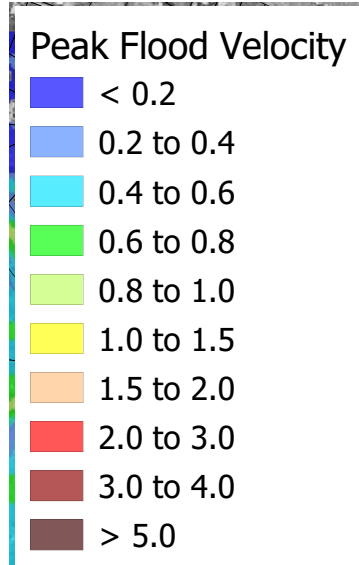
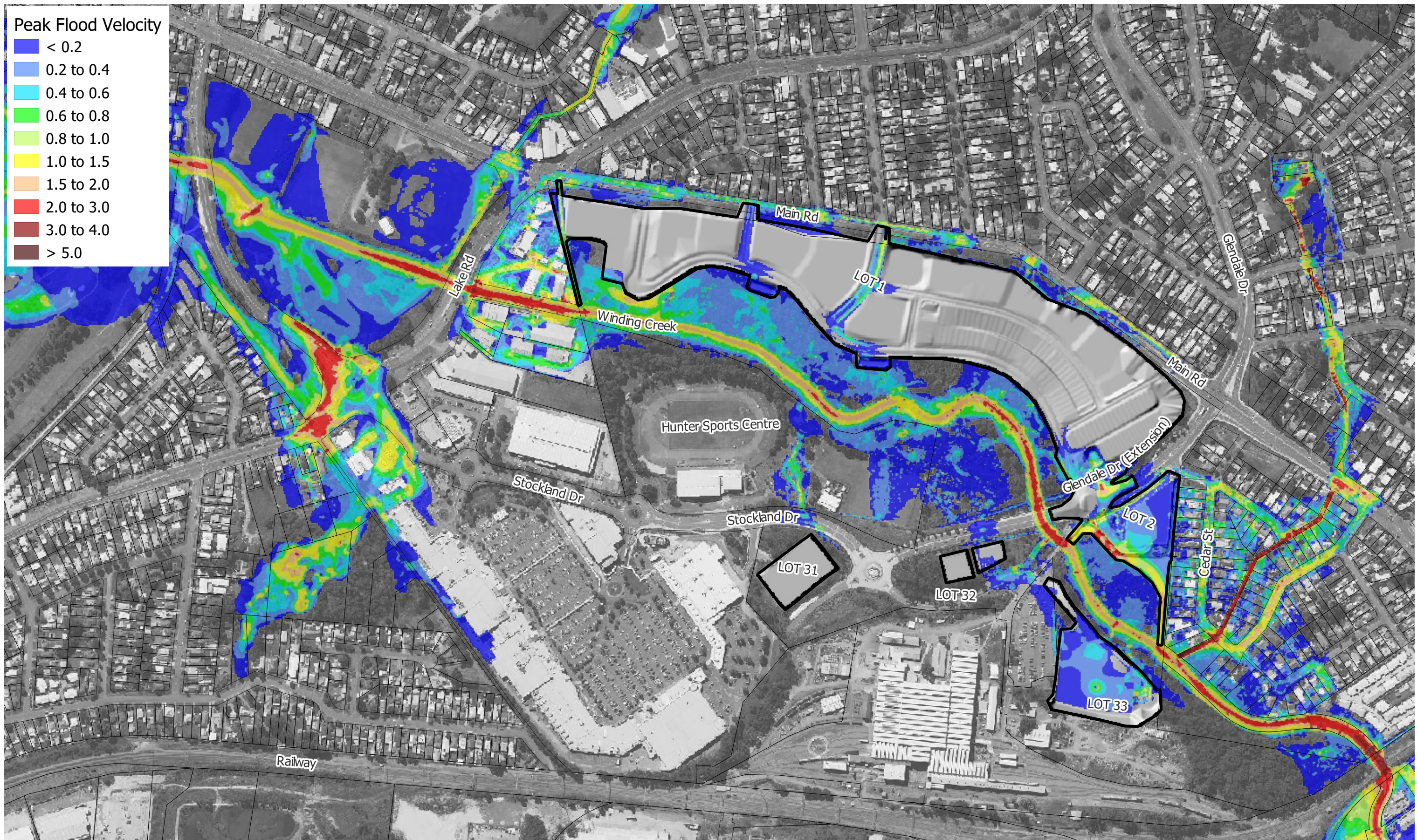
Drawing: B 05 Rev: A



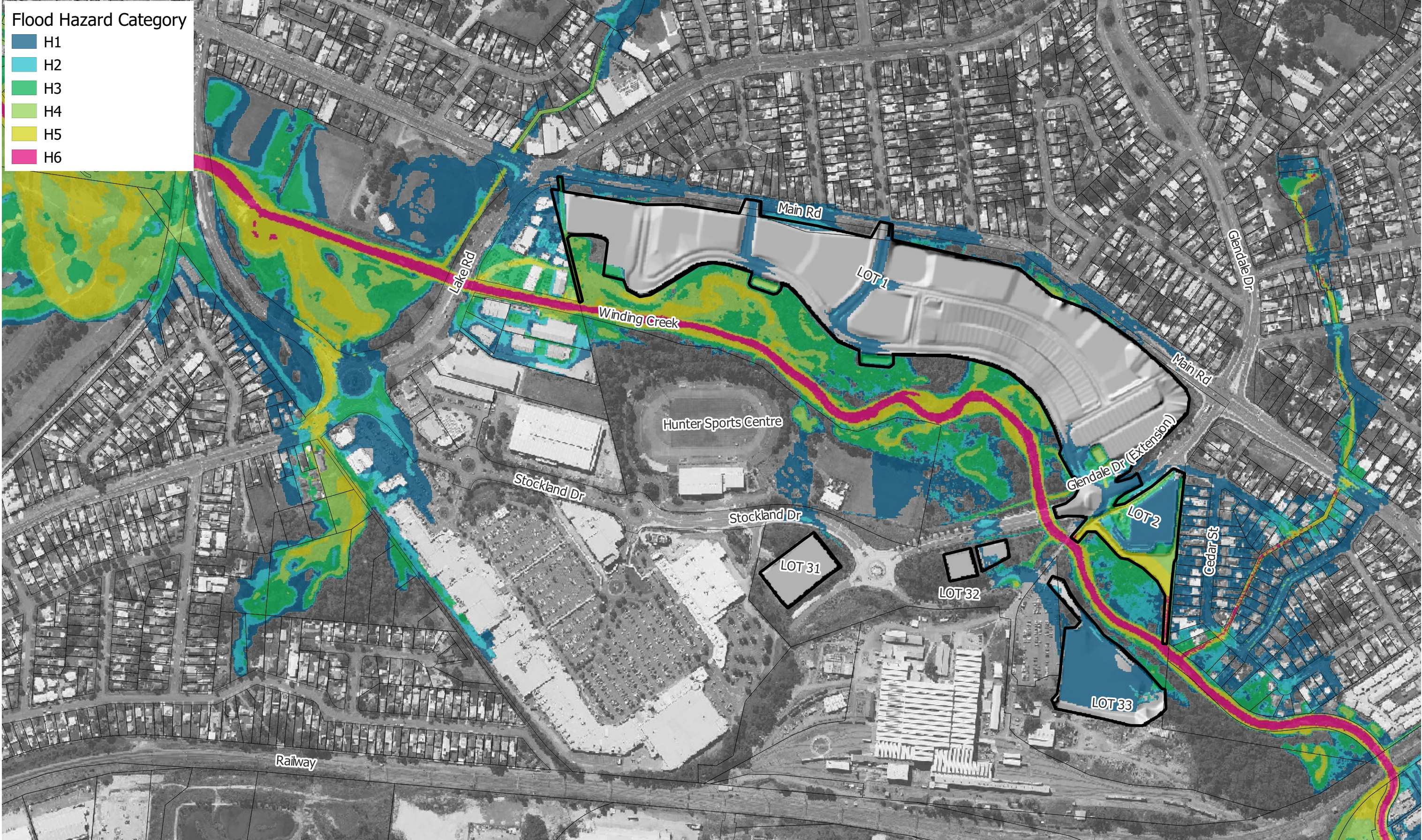
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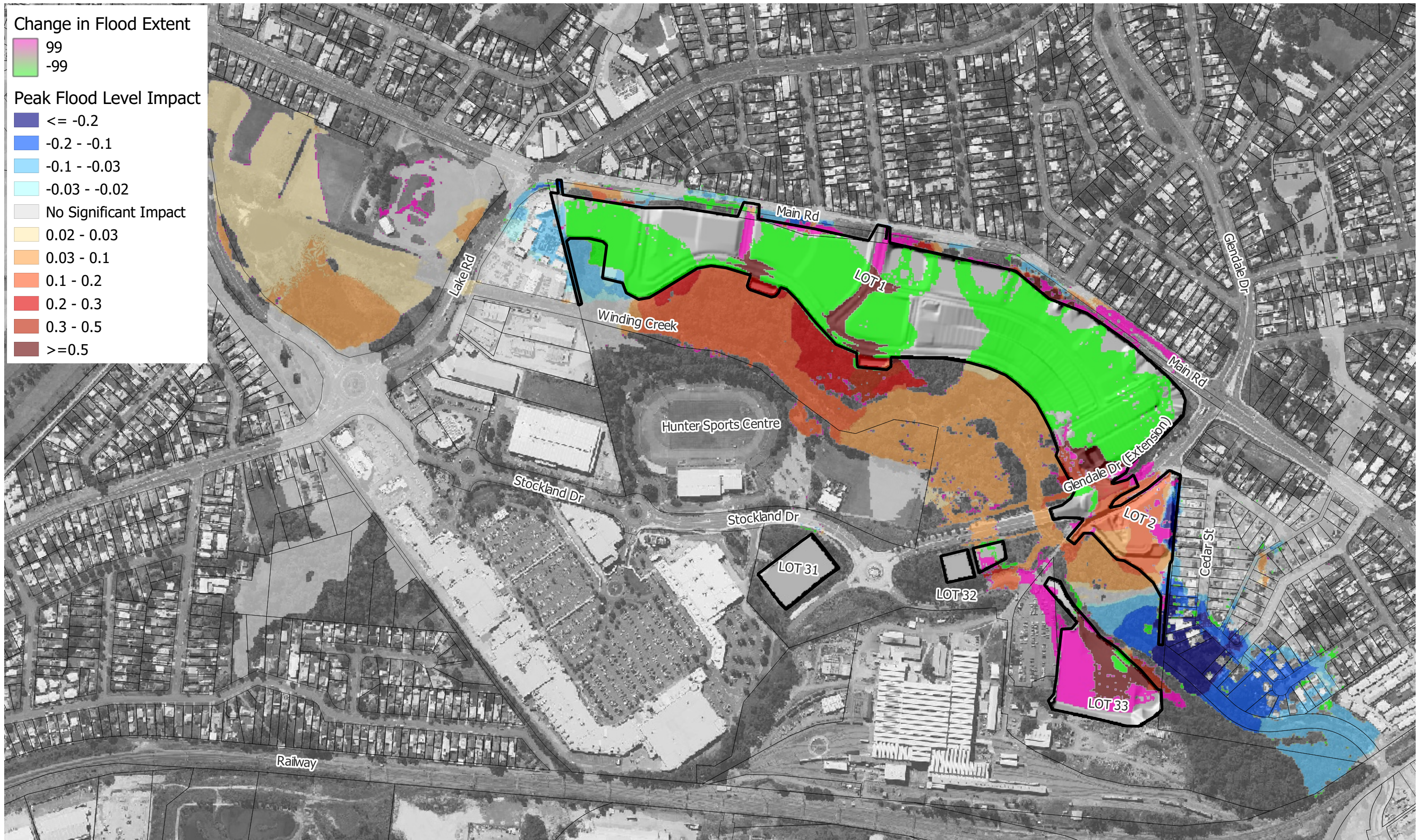
Legend Proposed Development Area Cadastral Boundaries	Title: Peak Flood Level and Depth - Post-development Scenario - 1% AEP Flood	Drawing: B-06	Rev: A
	BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	0 100 200 m	 www.bmt.org
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Legend Proposed Development Area Cadastral Boundaries	Title: Peak Flood Velocity - Post-development Scenario - 1% AEP Flood	Drawing: B-07	Rev: A
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Legend Proposed Development Area Cadastral Boundaries	Title: Provisional Flood Hazard - Post-development Scenario - 1% AEP Flood	Drawing: B-08	Rev: A
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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Change in Peak Flood Level - 1% AEP Flood

Drawing:

B-09

Rev:

A

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0 100 200 m



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Change in Peak Flood Velocity - 1% AEP Flood

Drawing:

B-10

Rev:

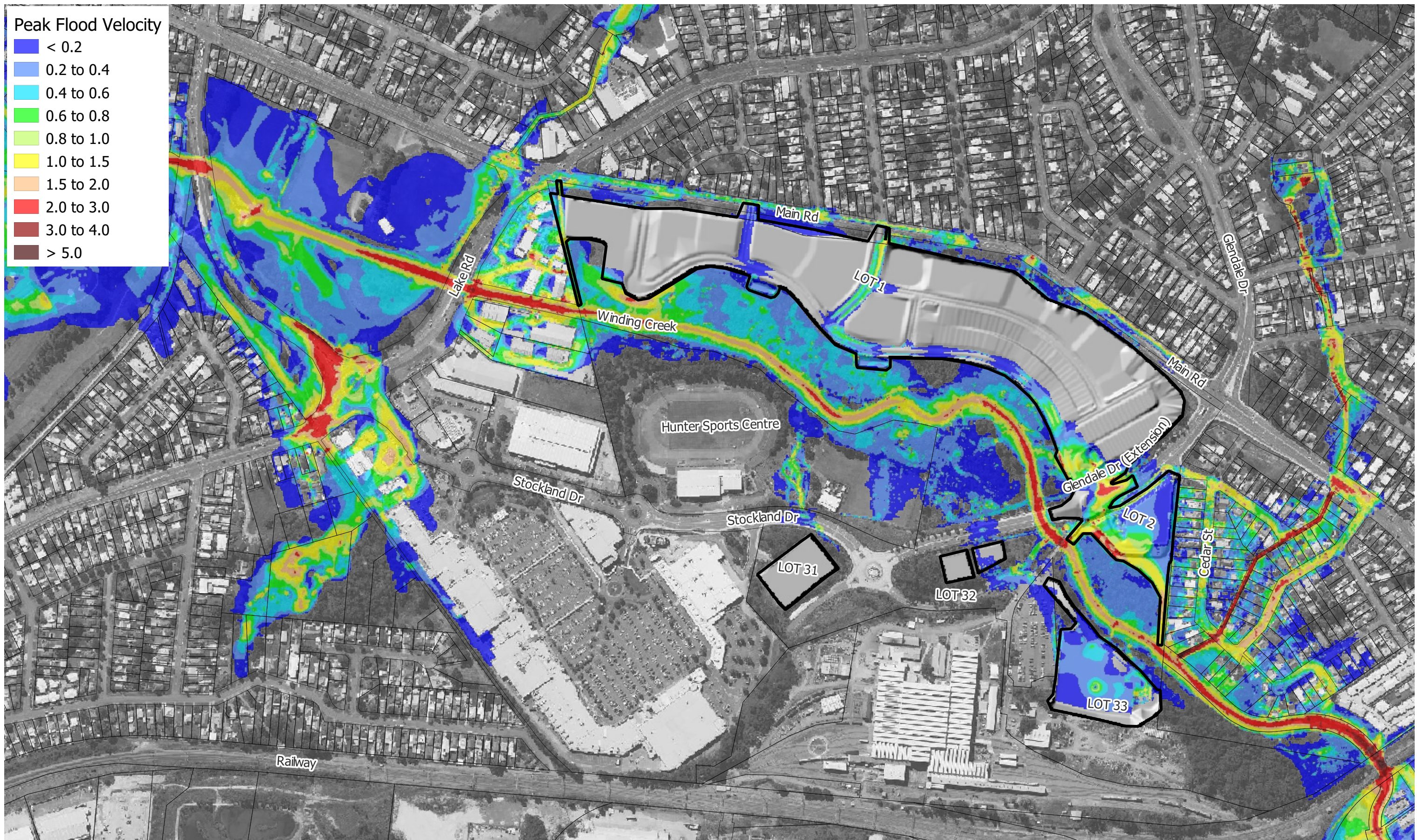
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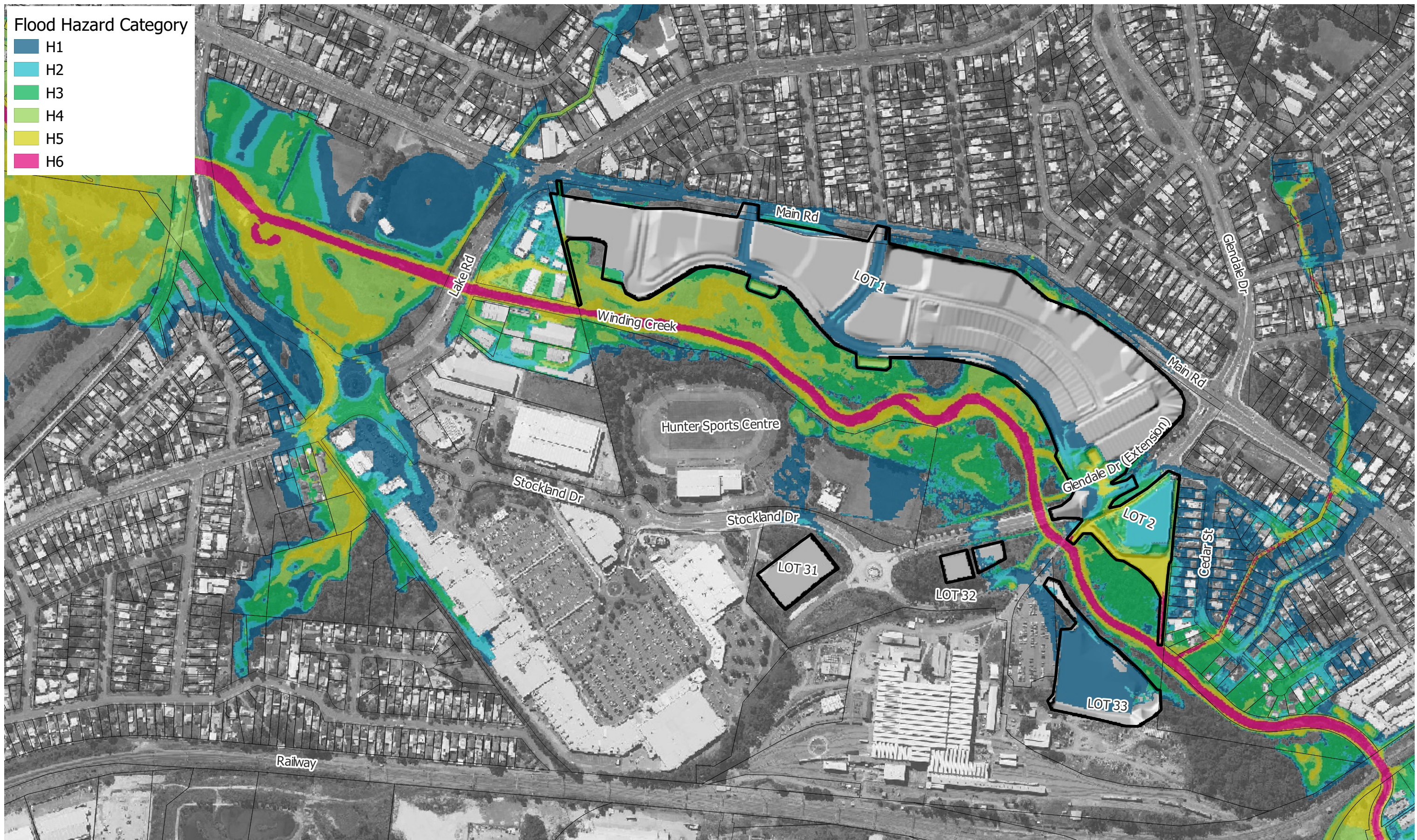
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Legend Proposed Development Area Cadastral Boundaries	Title: Peak Flood Velocity - Post-development Scenario - 1% +CC AEP Flood	Drawing: B-12	Rev: A
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Legend Proposed Development Area Cadastral Boundaries	Title: Provisional Flood Hazard - Post-development Scenario- 1% +CC AEP Flood	Drawing: B-13	Rev: A
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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Change in Peak Flood Level - 1%+CC AEP Flood

Drawing:

B-14

Rev:

A

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0 100 200 m



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Change in Peak Flood Velocity - 1%+CC AEP Flood

Drawing:

B-15

Rev:

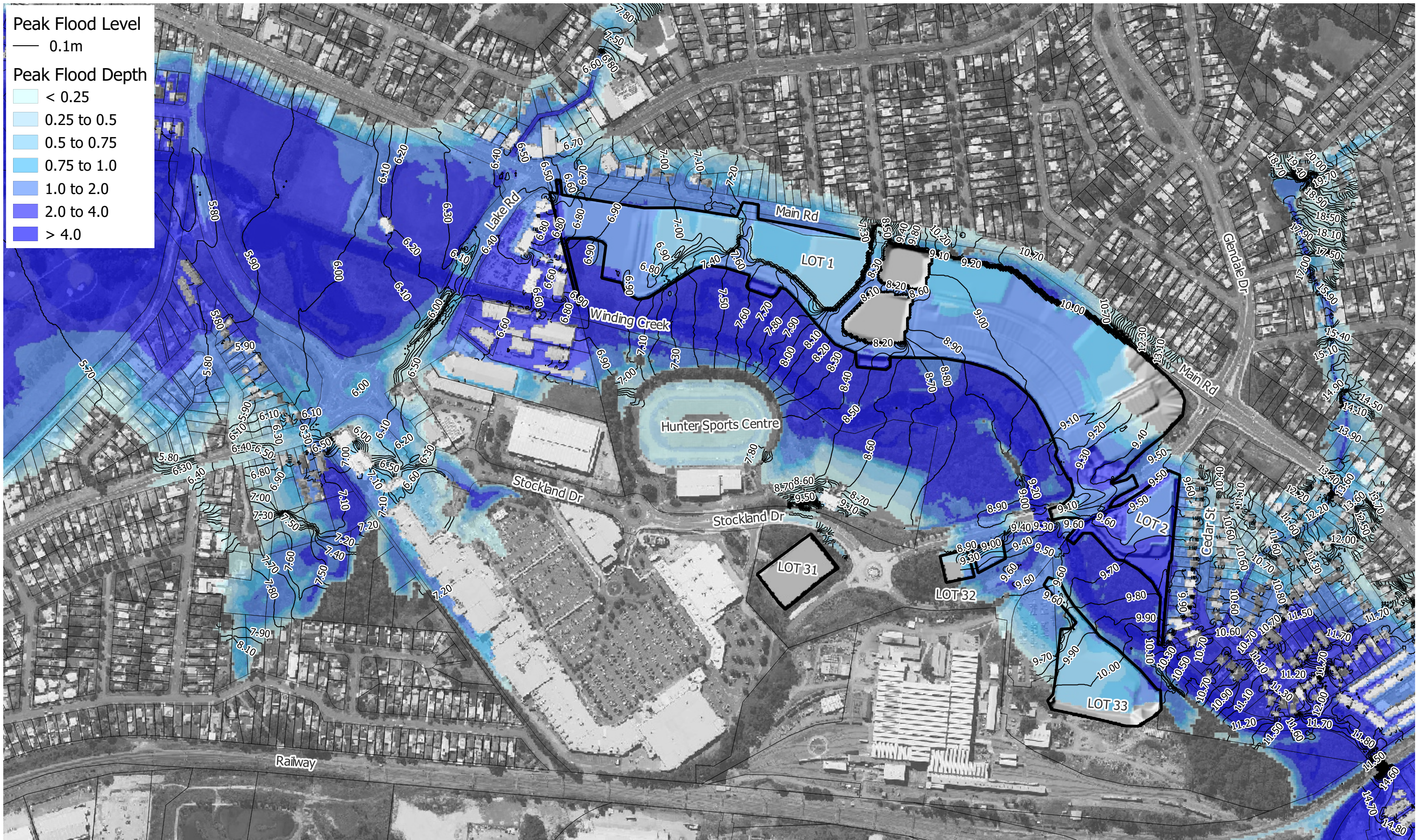
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0 100 200 m



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Legend

-  Proposed Development Area
-  Cadastral Boundaries

Title:

Peak Flood Level and Depth - Post-development Scenario - PMF

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0 100 200 m



Drawing:

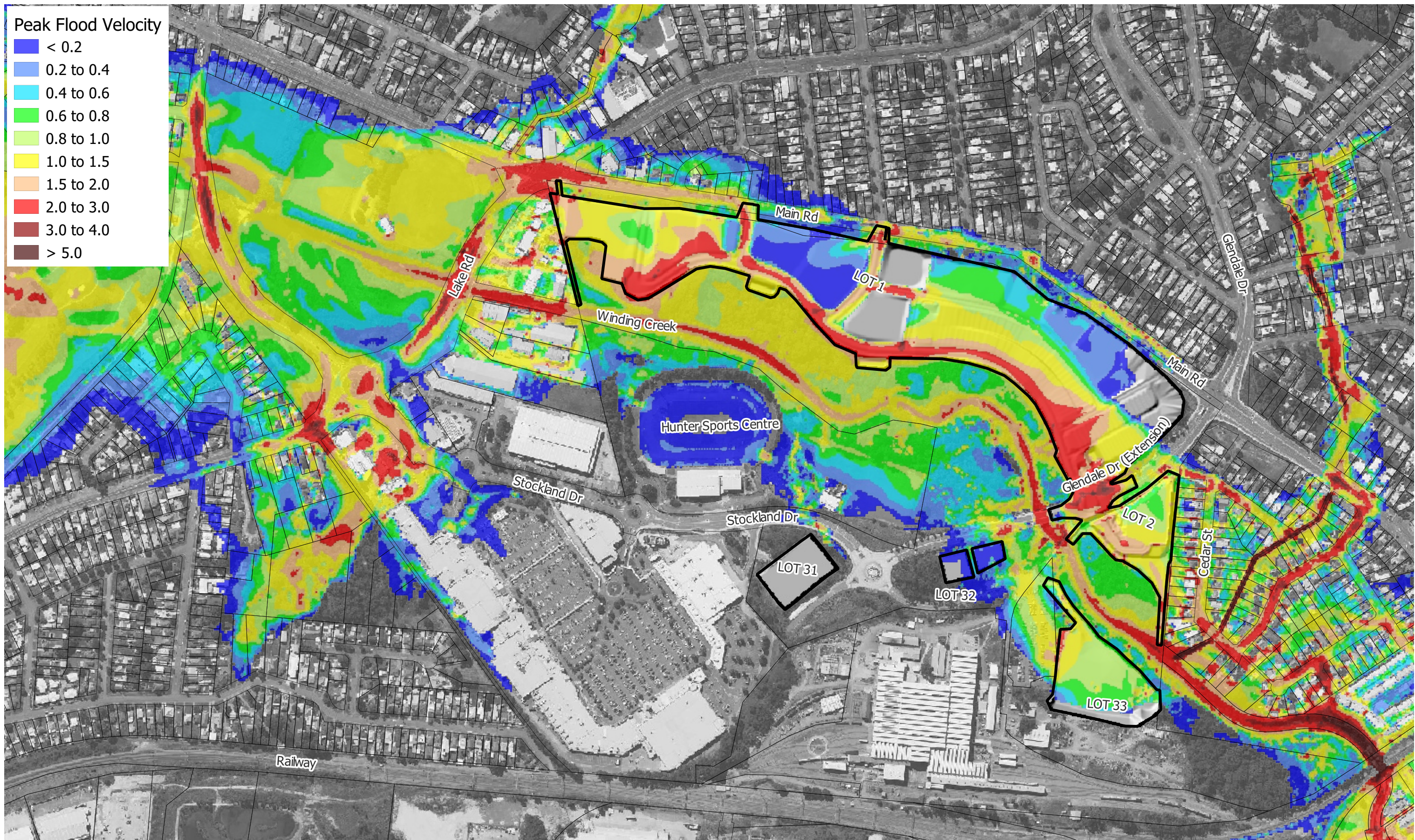
B-16

Rev:

A



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:
Peak Flood Velocity - Post-development Scenario - PMF

Drawing:
B-17

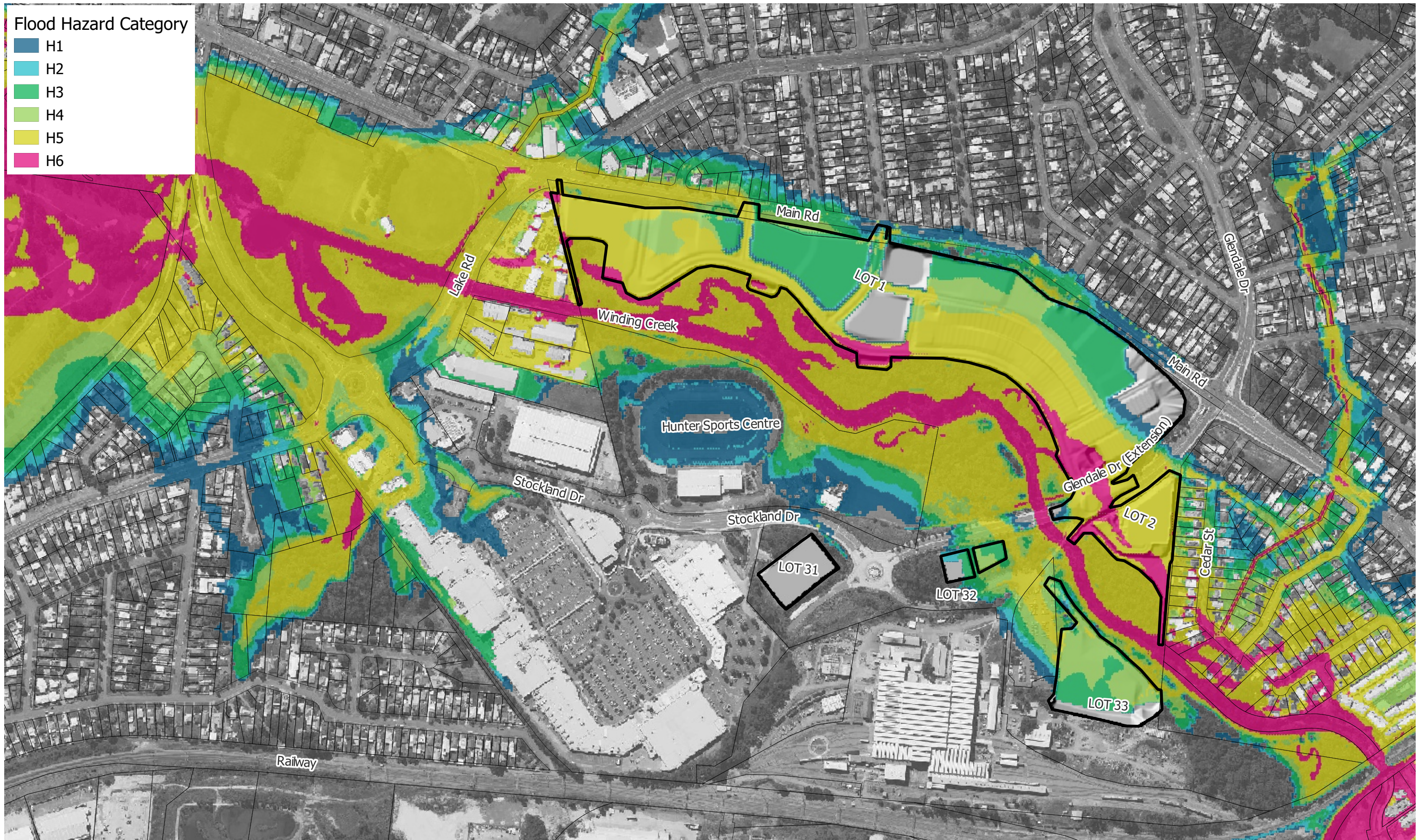
Rev:
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0 100 200 m



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Provisional Flood Hazard - Post-development Scenario - PMF

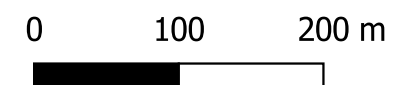
Drawing:

B-18

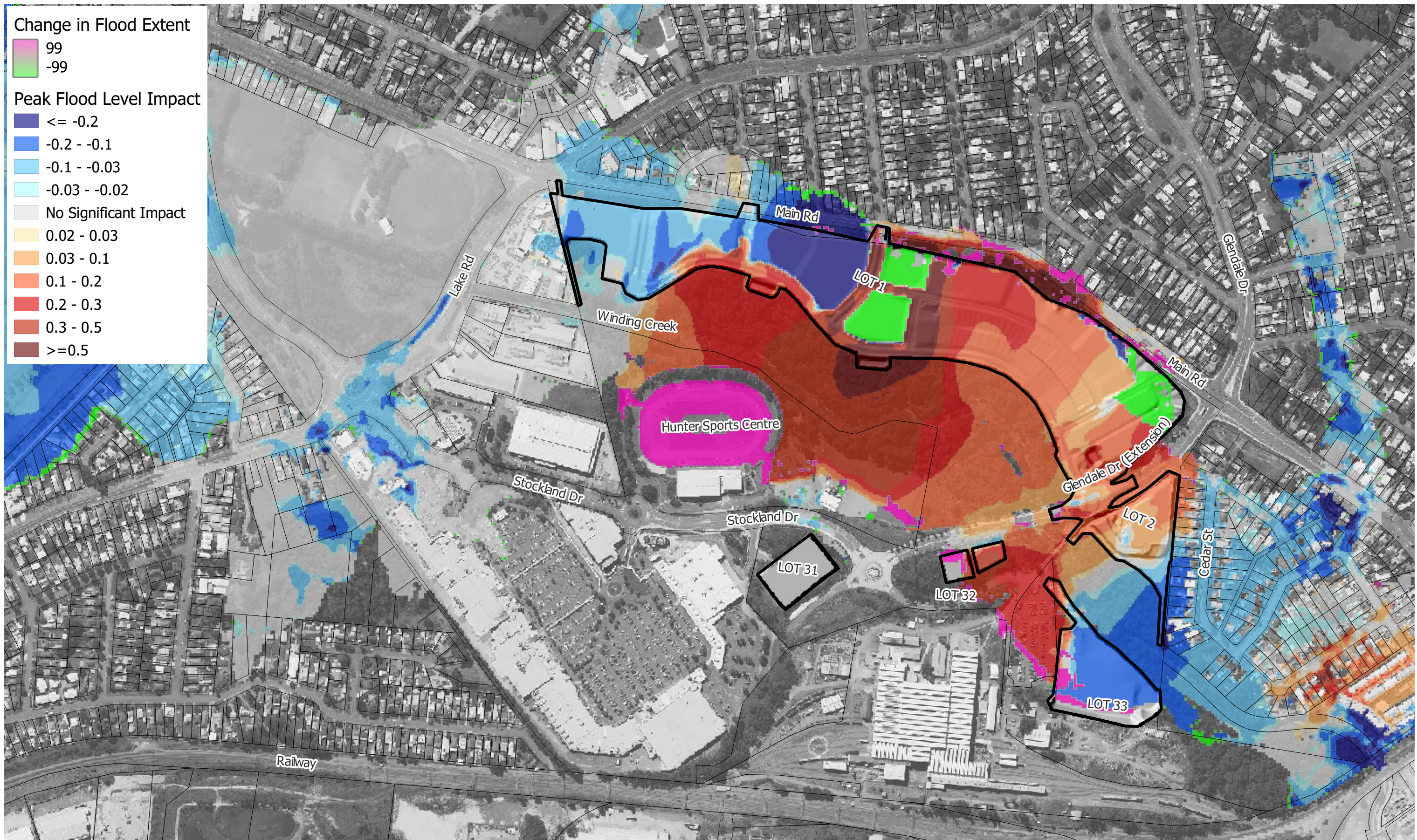
Rev:

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Change in Flood Extent

99

-99

Peak Flood Level Impact

<= -0.2

-0.2 - -0.1

-0.1 - -0.03

-0.03 - -0.02

No Significant Impact

0.02 - 0.03

0.03 - 0.1

0.1 - 0.2

0.2 - 0.3

0.3 - 0.5

>=0.5

Legend

Proposed Development Area

Cadastral Boundaries

Title:
Change in Peak Flood Level - PMF

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0100200 m

Drawing:
B-19

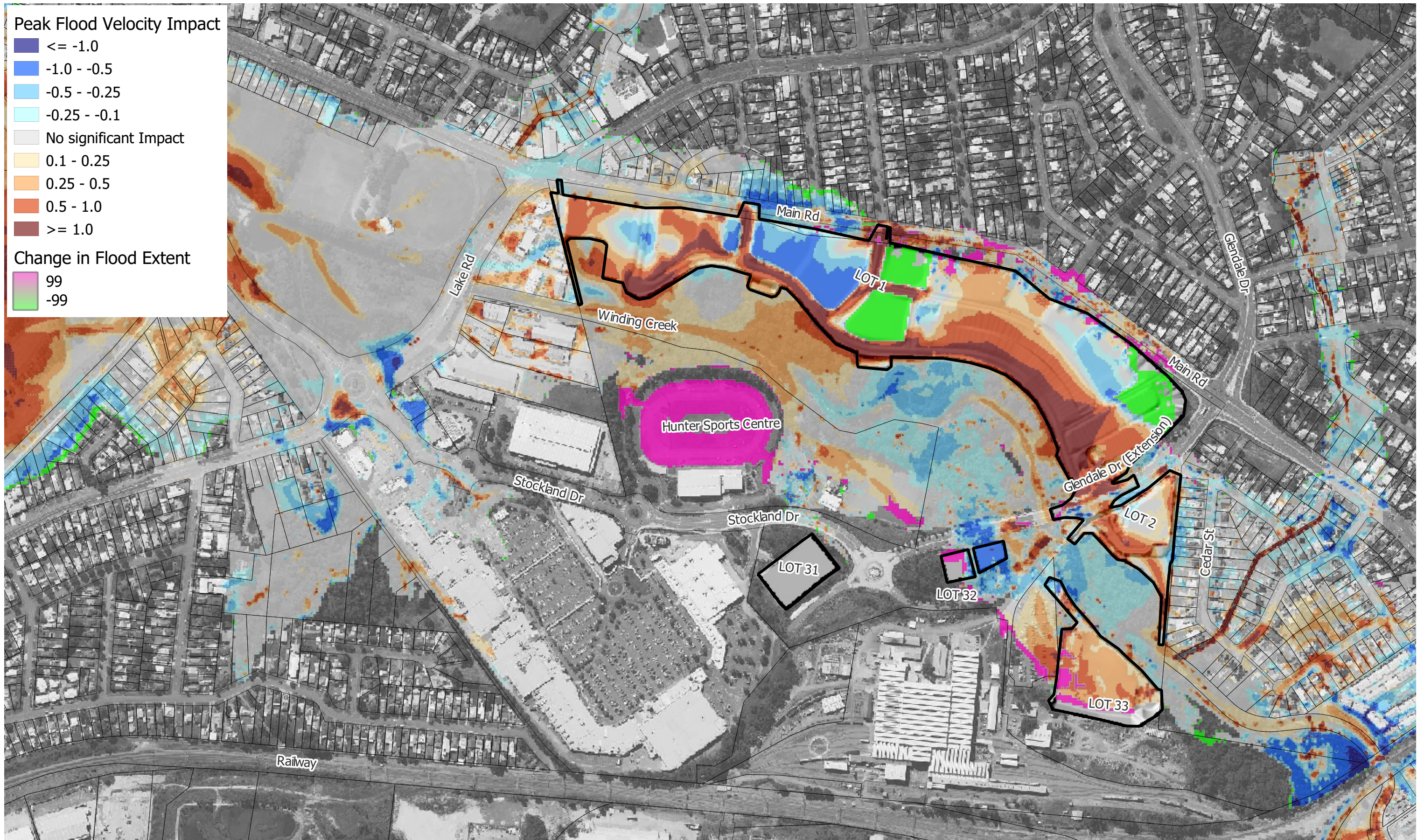
Rev:
A



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Legend

- Proposed Development Area
- Cadastral Boundaries

Title:

Change in Peak Flood Velocity - PMF

Drawing:

B-20

Rev:

A

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0 100 200 m



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