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Date: 23 October 2018

Subject: **2 Bachell Avenue Flood Advice Memo (Rev 1c) - Final**

Dear Raymond,

Royal HaskoningDHV (RHDHV) has been commissioned to provide flood advice for the proposed development of a site at **2 Bachell Avenue Lidcombe, NSW**.

The main purpose of the project was to update a flood impact assessment (FIA) undertaken for a rezoning application for 2 Bachell Avenue. The initial development assessed in October 2015 was for a mixed residential development (refer Figure 2) while the current development is for a mixed commercial (employment generating) development (refer Figure 1).

This document provides some additional information supporting the updated Flood Impact Assessment Report. It also provides advice on a number of issues raised in Cumberland Council (2016), Assessment of Planning Proposal Application - Application for a planning proposal for land at 2 Bachell Avenue Lidcombe (PP-2/2016).

1 COMPARISON OF DEVELOPMENT FLOOD HYDRAULICS

As the purpose of the flood impact assessment was to support a rezoning application, full details of the final development were not provided and a less detailed flood model, which used increased roughness to represent the “total development” was used instead of a more detailed methodology. This is appropriate for a rezoning application, though a more detailed methodology (where building are included in the topography) is recommended to support the final development application (DA). Because the site is assumed to be raised above the 100yr design flood level, no overland flow across the site was assumed. This means that any changes in the site layout will not influence the events up to and including the 100yr ARI design event. It is assumed that the hydraulic capacity of the culvert is also unchanged and will not influence the results.

For the probable maximum flood (PMF) there is the potential for differences in hydraulic behaviour. However, due to the adopted modelling methodology, changes in site layout will not influence the results as individual buildings were not modelled.

The initial development assessed in October 2015 was for a mixed residential development (refer Figure 2) while the current development is for a mixed commercial (employment generating) development (refer Figure 1). A review of both designs show that both developments would allow overland flow from south to north so at a broad level, they would be hydraulically similar.

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***Figure 1**: Proposed Mixed Commercial Development (August 2018)*

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***Figure 2**: Proposed Mixed Residential Development (August 2015)*

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The developed conditions adopted in RHDHV (2015) include:

- The DEM was modified to simulate filling on-site and in the open channel immediately upstream of the site. A minimum level of 14m AHD was set just inside the southern boundary of the site. This then interfaces with existing levels at the northern and eastern boundaries of the site.
- a 2.4m x 2.1m Reinforced Concrete Box Culvert (RCBC) was modelled between the existing 2.47m x 1.85m RCBC under the rail line immediately upstream of the site and the 2.05m x 1.99m RCBC under Bachell Avenue on the downstream side of the site.

2 2016 HASLAMS CREEK FLOOD STUDY MODEL

It should be noted that the original FIA was undertaken prior to completion of the Haslams Creek Overland Flood Study (RHDHV 2016). A draft of the flood study report was issued to Council in May 2016. The study is yet to be adopted by Council, however, provides the most accurate and up to date flood information for the subject site. It is suggested that the modelling of the final design to be updated to use the model from the Overland Flood Study. The Overland Flood Study uses calibrated ILSAX hydrology which estimates slightly lower flows (and hence flood levels) than the FIA model.

It is recommended that it is requested that Council permits the setting of the FPL for the development to be based on the 2016 Flood Study instead of the older

3 CULVERT BLOCKAGE CONSIDERATIONS

It should be noted that the original FIA assumes that the new culvert through the site is unblocked. A sensitivity test (Test Case1) which adopted a 50% culvert blockage through the site was reported in the FIA and shows flooding of the site in this case for the 100yr ARI event. It should be noted that the adopted modelling methodology (applying a uniform level and “industrial” roughness across the site) makes the flooding appear worse. More detailed modelling is likely to be able show that the overland flow is confined to the defined overland flow path.

The updated Australian Rainfall and Runoff 2016 (ARR2016) provides the latest guidance on appropriate blockage assumptions for flood studies. Given that there are several upstream culverts, the adoption of a 50% blockage to the site culvert is unlikely to be warranted. A more detailed blockage assessment should be undertaken at the DA stage.

This could investigate whether a debris control structure (such as a trash rack) is required to reduce the potential impact of blockage on flooding at the site. Alternatively, if Council is unwilling to accept a lower site culvert blockage assumption the use of a larger design culvert may be a potential solution. The adoption of the 2016 Flood Study model which adopted lower design flows will reduce the impact of the blockage assumption.

4 CULVERT ENCASEMENT CONSIDERATIONS

Cumberland Council (2016), Assessment of Planning Proposal Application - Application for a planning proposal for land at 2 Bachell Avenue Lidcombe (PP-2/2016) also raised an issue with encasement of the culvert through the site.

The issue where *“the encasing of the channel through the whole site is not supported”* may also cause an issue with the current design that assumes a culvert through the site. If Council still does not

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support encasement, an alternate design would appear necessary. However, the Council assessment also states “It is noted that Sydney Water is the asset owner of the stormwater channel and therefore the proposed covering of this channel would be subject to Sydney Water approval.” so perhaps the issue is not for Council to decide though written approval from Sydney Water is required.

5 CULERT CLEARANCE REQUIREMENTS

The proposed development shows a 1st storey bridge, road access above the culvert running through the site. It is understood that Cumberland Council requires overhead access to all of Council managed culverts so that a crane can easily replace damaged culvert units. While it is understood that the culvert is currently a Sydney Water asset, it is possible that they may have a similar issue with access to the culvert. The provision of a gantry under the overhead structure could be considered if Council or Sydney Water raise this as an issue.

***Figure 3**: 3D Image of development showing reduced overhead culvert clearance*

6 MEETING MINUTES

A memo containing attendances and minutes of previous meeting with Sydney Water and Auburn Council is presented as an attachment to this report.

7 CONCLUSIONS

This memo provides updated flood advice for the proposed development located at 2 Bachell Avenue Lidcombe. It is a companion document to the updated Flood Impact Assessment (FIA) report.

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While the current FIA is suitable for a rezoning application, the assessment will require updating with the final design details prior to submission at the DA stage.

Should you have any queries regarding this memo, please do not hesitate to contact Rohan Hudson on 4926 9506.

Yours faithfully

HASKONING AUSTRALIA

Ben Patterson, Associate Director – Rivers and Water Management – Australia

REFERENCES

1) *Auburn City Council (2010),* ***Auburn Development Control Plan 2010 – Stormwater Drainage,*** *Accessed from Auburn City Council Website May 2016.*

2) *Bewsher Consulting, 2003,* ***Haslams Creek Floodplain Risk Management Study and Plan (Final Report)****, Prepared by Bewshers Consulting on behalf Auburn Council, January 2003.*

3) *Cumberland Council (2016),* ***Assessment of Planning Proposal Application - Application for a planning proposal for land at 2 Bachell Avenue Lidcombe (PP-2/2016),*** *December 2016.*

4) Institution of Engineers Australia (1987), '***Australian Rainfall and Runoff – A Guide to Flood Estimation'***

5) *Royal HaskoningDHV (2016),* ***Haslams Creek Overland Flood Study (Draft for review)****, Prepared by Royal HaskoningDHV on behalf Auburn City Council, 10th May 2016.*

6) *Royal HaskoningDHV (2018),* ***No.2 Bachell Avenue Lidcombe Flood Impact Assessment (Update)****, Prepared by Royal HaskoningDHV on behalf Raad Architects Pty Ltd, October 2018.*

7) *Royal HaskoningDHV (2015),* ***No.2 Bachell Avenue Lidcombe Flood Impact Assessment****, Prepared by Royal HaskoningDHV on behalf Raad Architects Pty Ltd, October 2015.*

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Memo

To	:	Nicole ElKouberci (Raad Architects)
From	:	Paul Hart / Rohan Hudson (RHDHV)
Date	:	1st October 2015
Copy	:	
Our reference	:	BachelAv_Meeting_Memo.docx

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MARITIME & WATERWAYS.

Subject : Meeting Note For Bachel Av Flood Impact Assessment

Two meetings regarding the Bachel Av flood impact assessment were held on Friday 25th September 2015.

Sydney Water Meeting

Attendees:
Michael Raad (RAA)
Paul Hart (RHDHV)
Ray Parcel (Sydney Water)

Ray's main comment was that he was happy to build over the existing culverted section as it was not a change from the existing conditions and prevented any H&S risks of daylighting / restoring the creek.

Auburn City Council Meeting

Attendees:
Michael Raad (RAA)
Paul Hart (RHDHV)
Bala Sudarsan
Siva Sivakumar

Council were generally happy with the development and modelling approach as long as their 50% blockage policy was adhered to and the modelling scenarios (listed in our FRA) were tested.

The advice provided in these meeting was used to inform the flood impact assessment.

Should you have any queries regarding this memo, please do not hesitate to contact Rohan Hudson on 4926 9506.

Yours faithfully
HASKONING AUSTRALIA

Rohan Hudson, Senior Engineer – Rivers and Water Management – Australia

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Royal HaskoningDHV
Enhancing Society Together

No.2 Bachell Avenue, Lidcombe
Flood Impact Assessment (Update)

For: Michael Raad Architects Pty Ltd

October 2018

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PROJECT INFORMATION

Project Name: No.2 Bachell Avenue, Lidcombe – Flood Impact Assessment (Update)

Project Number: PA1193 / PA1521-106

Report for: Michael Raad Architects Pty Ltd

PREPARATION, REVIEW AND AUTHORISATION

Revision #	Date	Prepared by	Reviewed by	Approved for Issue by
A – Draft for Client Review	12/10/2015	Alex Le Royer	Paul Hart	Ben Patterson
B - Draft for Client Review (with amended design)	5/10/2018	Alex Le Royer / Rohan Hudson	Ben Patterson	Ben Patterson
C - Final (with amended design)	23/10/2018	Alex Le Royer / Rohan Hudson	Ben Patterson	Ben Patterson

COMPANY DETAILS

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1 INTRODUCTION

Royal HaskoningDHV (RHDHV) were engaged by Raad Architects to undertake a Flood Impact Assessment (FIA) of a proposed development at No. 2 Bachell Avenue, Lidcombe. The proposed development site is currently an industrial printing press that straddles the Arthur Street Branch of Haslams Creek, in the Auburn City Council Local Government Area.

The following development is proposed:

- Acquisition and re-zoning of the site for employment generating development; and
- A mixed use development of public open space, food and drink shops, neighbourhood shops, indoor recreation facilities, industrial retail and wholesale outlets, hardware building suppliers, a high technology business precinct and a warehouse and distribution centre.

This document details a FIA for the project and is presented as follows:

- **Section 2** reviews applicable plans, policies and guidelines.
- **Section 3** provides a description of the existing catchment and floodplain characteristics.
- **Section 4** details the assessment methodology.
- **Section 5** discusses the assessment results, flood impacts and flood risk management measures proposed for the project.
- **Section 6** provides recommendations for potential future actions and analysis.
- **Section 7** acknowledges key references consulted in the preparation of this report.

It is noted that the developed conditions flood modelling undertaken for this report was based on a conceptual development layout only. Subsequent to the finalisation of the FIA for the proposed development, modifications to the development layout and design surface levels may occur as a result of changes to the civil design that has been prepared for the Development Application by others. These changes may locally influence the developed conditions flood model results that are documented in this report and may require remodelling. However, it is expected that the broad outcomes, in terms of flood impacts and risk management measures, of the modelling will be similar to the outcomes documented in this report.

This document provides a minor update to an initial FIA undertaken in October 2015. The update includes a description of the new plans for the development of the site as an employment generating development as opposed to predominately a residential development.

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2 RELEVANT PLANS STUDIES AND GUIDELINES

This section provides an overview of relevant studies, Council, Sydney Water, NSW Government and industry plans and guidelines that were considered when preparing this Flood Impact Assessment.

Haslams Creek Flood Study

A flood study was completed in 1999 for the Haslams Creek catchment upstream of the M4, including the proposed development site at No. 2 Bachell Avenue. The flood study was undertaken using 1D HEC-RAS modelling. The 1999 flood study estimated the following Annual Recurrence Interval (ARI) water levels on the proposed development site: 13.6m AHD (5 year ARI), 13.7m AHD (10 year ARI), 14.0m AHD (100 year ARI) and 15.9m AHD (Probable Maximum Flood). A typical ground level across the site is 13.5mAHD.

The flood study was revised by RHDHV using 2D TUFLOW modelling software covering the whole catchment in late-2015 to 2016. A draft of the flood study report was issued to Council in May 2016. The study is yet to be adopted by Council, however, it provides the most accurate and up to date flood information for the study site.

Auburn City Council DCP

The proposed development relates to Section 6.0 of the Stormwater Drainage Section of Councils 2010 Development Control Plan (DCP). The DCP states the following Performance Criteria to which any development should comply:

- **P1** The proposed development does not result in any increased risk to human life.
- **P2** The additional economic and social costs which may arise from damage to property from flooding is no greater than that which can reasonably be managed by the property owner and general community.
- **P3** The proposal should only be permitted where effective warning time and reliable access is available for the evacuation of an area potentially affected by floods. Evacuation should be consistent with any relevant disaster plans (DISPLAN) or flood plan where in existence.
- **P4** Development does not detrimentally increase the potential flood affectation on other development or properties.
- **P5** Development does not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (e.g. by unsympathetic house-raising) or by being incompatible with the streetscape or character of the locality.
- **P6** The proposal does not adversely impact upon the recreational, ecological, aesthetic or utilitarian use of the waterway corridors, and where possible, should provide for their enhancement, in accordance with ecologically sustainable development principles.

Sydney Water Corporation

Sydney Water's 'Building over or adjacent to Sydney Water stormwater assets' Policy is relevant and has been consulted.

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Based on this policy and guidelines, no buildings or permanent structures are to be proposed within 1m from the outside face of the stormwater channel wall. Permanent structures includes, but is not limited to, basement car parks, hanging balconies, roof eves, hanging stairs, stormwater pits, stormwater pipes and similar structures. This clearance requirement would apply for unlimited depth and height.

Australian Rainfall and Runoff

Australian Rainfall and Runoff (IEAust, 1987) is a document published by the Institution of Engineers, Australia. This document has been prepared to provide designers with the best available information on design flood estimation and is widely accepted as a design guideline for all flood and stormwater related investigation and design in Australia.

Australian Rainfall and Runoff is currently being revised as part of a Federal Government funded project. The revision was completed in 2016.

NSW Floodplain Development Manual

The *Floodplain Development Manual* is a document published in 2005 by the New South Wales State Government. The document details Flood Prone Land Policy which has the primary objective of reducing the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits from occupation and development of flood prone land.

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3 CATCHMENT DESCRIPTION AND PROPOSED DEVELOPMENT

3.1 Catchment Description

The site is located in an industrial/business district in Lidcombe's eastern suburbs. The total catchment to the downstream point of the proposed development site is 99.9ha. The upper catchment to the rail line is approximately 93.49ha, categorised by gentle slopes (typically less than 5%) and predominately consists of the Rockwood Cemetery. Between the cemetery and the site, flow must cross under a number of roads and rail lines before discharging into a vegetated open channel immediately upstream of the site. Flows are then conveyed through the site via a large Reinforced Concrete Box Culvert (RCBC) and concrete lined drain. Upon leaving the site, flows are conveyed via a concrete lined drain and associated culverts, until finally discharging into Haslams Creek, a tributary of the Parramatta River. **Plate 3-1** provides an aerial view of the catchment. **Plate 3-2** provides a close up aerial view of the proposed development under existing conditions.

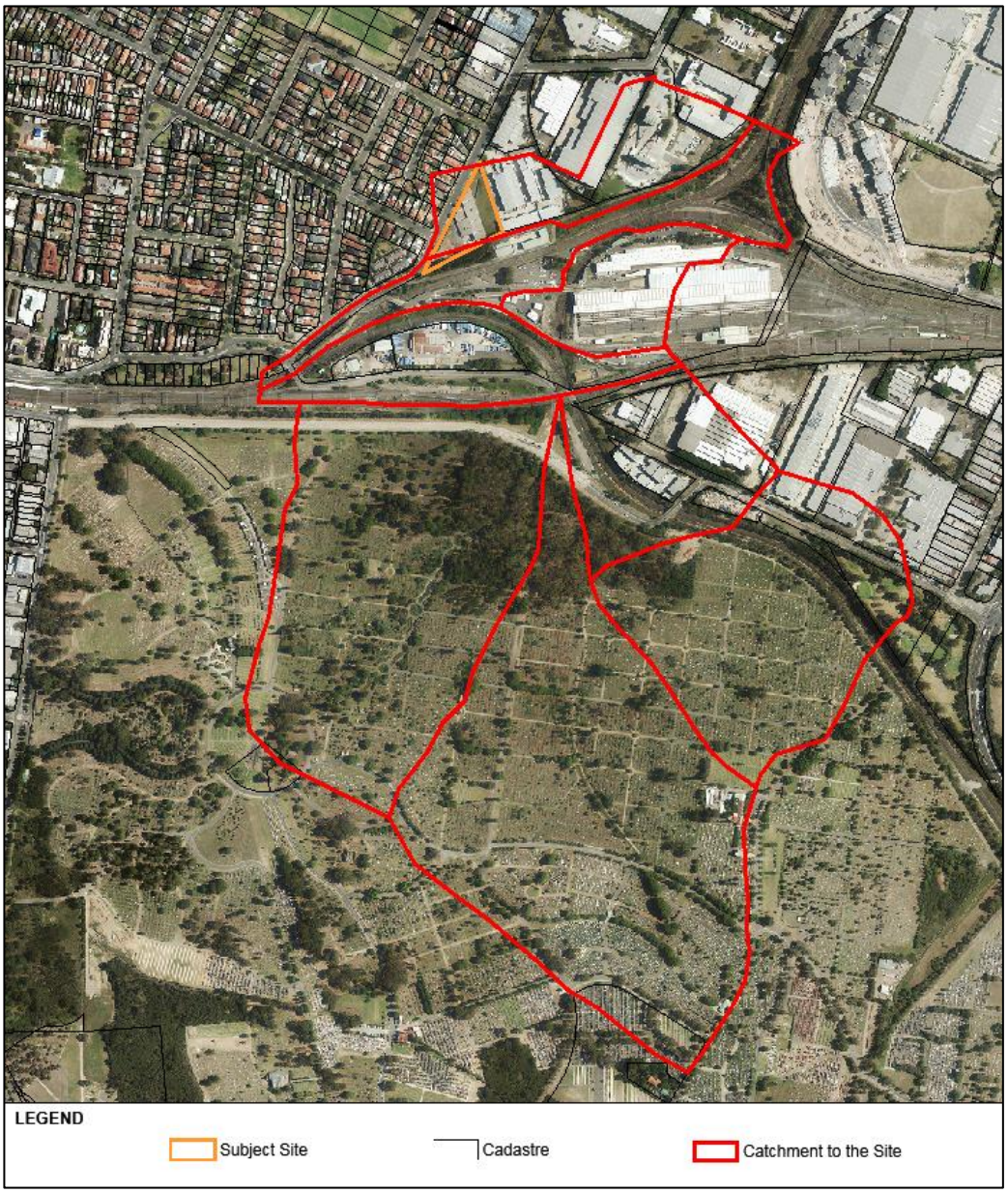

***Plate 3-1** – Catchment to the Study Site*

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Plate 3-2 – *Aerial View of the Study Site (source: Google Earth)*

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Plates 3-3 to 3-6 below are photos of the channel at key locations:

Plate 3-3 Upstream of the Railway Line

Plate 3-4 Between the Railway Line & the Site

Plate 3-5 Channel at Downstream end of Site

Plate 3-6 Channel Downstream of Bachell Ave

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3.2 Proposed Development

The proposed development would replace the existing printing press with a mixed use employment generating development including: public open space, food and drink shops, neighbourhood shops, indoor recreation facilities, industrial retail and wholesale outlets, hardware building suppliers, a high technology business precinct and a warehouse and distribution centre as shown by **Plate 3-7** below. To accommodate Sydney Water's policy of 'no buildings or permanent structures within 1m from the outside face of the stormwater channel wall' the watercourse in the northern half of the site is proposed to be realigned approximately 15m to the east of its current course (see red watercourse alignment). It is proposed to culvert the full length of the watercourse through the development site. The development immediately above the culverted watercourse would be a ground level car park, to act as a designated overland flow path to enable conveyance of overland flow in excess of the piped drainage system capacity, in accordance with the principles of AR&R (1987) and the NSW Floodplain Development Manual (2005). This development scenario was discussed with both Sydney Water and Council at separate meetings on 25 September 2015 and deemed, in principle, to be acceptable.

Plate 3-7 – *Proposed Development Concept*

Concept plans for the proposed development are also available in **Appendix A**.

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4 ASSESSMENT METHODOLOGY

4.1 Objectives

The FIA has the following key objectives:

- Produce a localised TUFLOW model using RHDHV's existing model for Haslams Creek.
- Simulate the 5% AEP, 1% AEP, PMF and 1% AEP under climate change conditions (increased rainfall intensity) for both the existing and proposed development scenarios.
- Size a culvert to contain the full 1% AEP flow through the site between the existing RCBC under the railway (immediate upstream of the site) and Bachell Avenue (immediately downstream of the site).
- Modify the Digital Elevation Model to simulate the proposed topographic changes for the proposed development at 2 Bachell Avenue.
- Assess the flood impacts of the proposed development and recommend any flood mitigation measures.

4.2 Available Data

The following data was available for use in the assessment:

- Conceptual sketches of the proposed development.
- A 1D/2D hydrologic / hydraulic model currently under development by RHDHV for the Haslams Creek Flood Study (2015). The model includes the following assumptions and features:
    - XP-RAFTS hydrology for input into TUFLOW was supplied based on a study undertaken by Bewsher Consulting for the Philips Park Detention Basin Study 2012.
    - A 3m x 3m grid resolution.
    - Large 1D elements representing culverts, bridges and open channels have been defined and are dynamically linked to the 2D domain.
    - Trunk drainage elements where information is available are dynamically linked to the 2D domain (refer to **Table 2** in **Section 4.3**).

4.3 Hydrologic / Hydraulic Modelling

The following section describes the model setup and modifications made to the above mentioned Haslams Creek model.

Existing Conditions Scenario

The Haslams Creek flood study model domain was truncated to allow for faster model run times. The revised downstream boundary of the model was set to immediately downstream of the Delhi Street culvert. The revised model domain and boundary assumptions are outlined in **Plate 4-1**.

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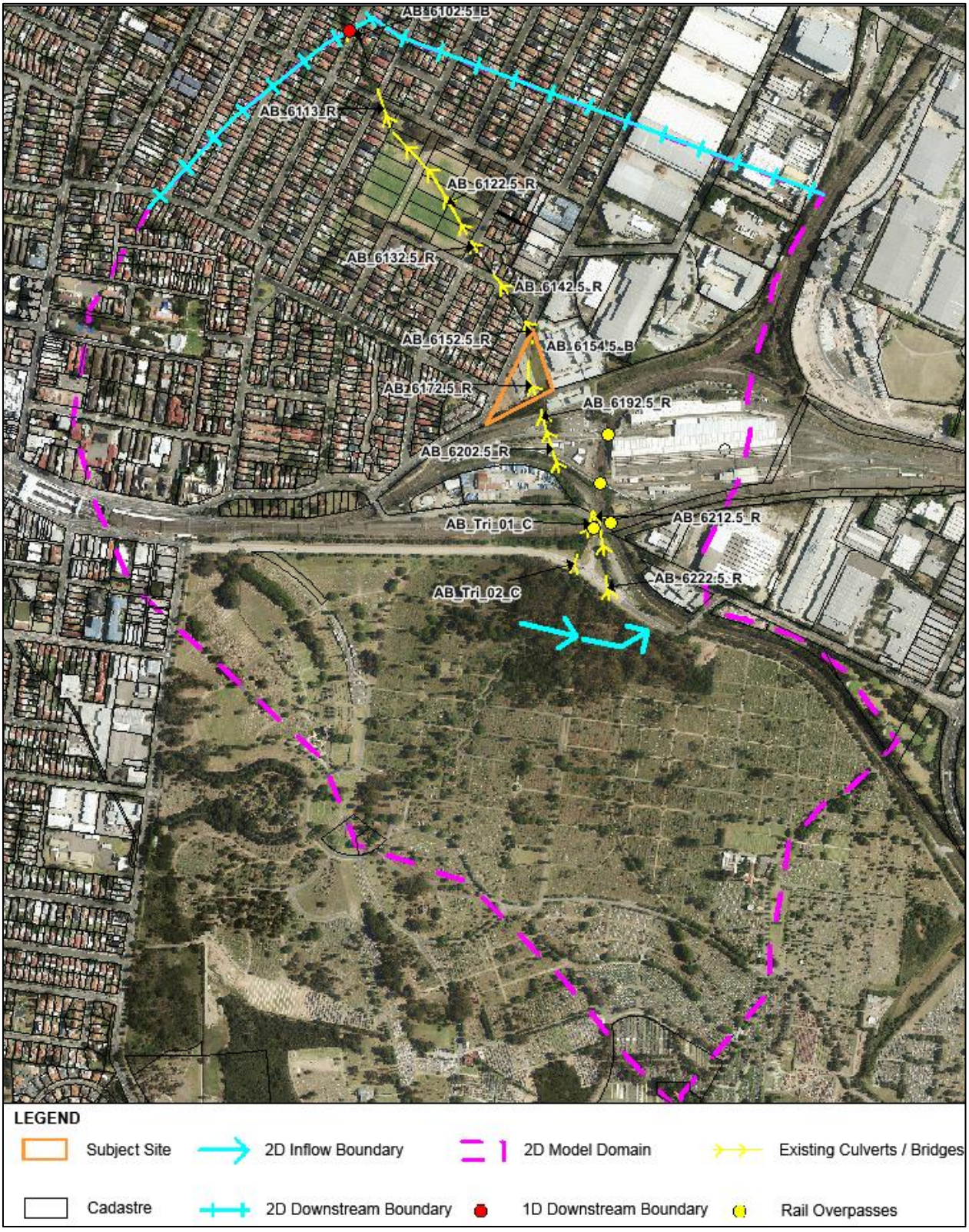

***Plate 4-1** – Model domain, boundary conditions and key structures*

The following revisions were made to the hydrologic / hydraulic models:

- A review of the existing hydrological model, including catchment delineation, catchment losses and parameterisation was undertaken. The model was deemed appropriate for use in

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this study with just some splitting of flows due to discreet flowpaths in the vicinity and upstream of the site. A critical duration of 2hrs for the 5% AEP and 1%AEP events was simulated while a 30min critical duration was simulated for the PMF.

- The model grid resolution was reduced to 2m x 2m.
- The tailwater level was set to 6m AHD (i.e. Delhi Street culvert running at near full capacity). The study site is at approximately 13.5m AHD, so the tailwater condition does not influence this assessment.
- Modification to the DEM was made to better represent the rail overpasses.
- Refinement was made to a number of the existing 1D channels within the model.
- Buildings in the vicinity of the site were blocked out to ensure flow depths through areas of overland flow were being more truly defined.
- The hydraulic roughness in and around the site was further refined (see **Table 1** below).
- 50% blockage was applied to all culverts in the model as directed by Council.
- Some minor trunk drainage elements were added in Bachell Avenue along the northern boundary of the site for completeness.

Table 1 – Surface Roughness

Surface	Manning's n
Road Reserve (Default)	0.020
Rail	0.035
Grassed Areas	0.035
Concrete Lined Channel	0.018
Medium Density Allotment	0.100
Industrial Areas	0.500
Densely Vegetated Areas	0.080
Open Water	0.020
Cemetery	0.060

As described in **Section 4.2**, existing structures have been defined in the model as 1D elements linked to the 2D domain. Information of the size and type of the key structures modelled is provided in **Table 2** below.

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Table 2 – Schedule of existing structures modelled

Structure Name	ID	Size & Type -span x height- (m)	Length (m)	Upstream Invert RL (mAHD)	Downstream Invert RL (mAHD)
Railway St RCBC*	AB_6222.5_R	2.3 x 1.5 RCBC*	48.5	15.29	15.06
Church St RCBC	AB_6212.5_R	1.02 x 0.9 RCBC	92.0	14.75	13.99
Railway St RCP	AB_Tri_02_C	1.05 diam Culvert	41.2	15.97	15.5
Church St RCP	AB_Tri_01_C	1.05 diam Culvert	51.7	15.47	14.17
Central Railway RCBC	AB_6202.5_R	1.87 x 1.85 RCBC	96.9	13.65	13.05
Northern Railway RCBC	AB_6192.5_R	2.47 x 1.85 RCBC	31.9	13.05	12.97
Site (existing) RCBC	AB_6172.5_R	2.65 x 1.96 RCBC	70.1	11.23	10.63
Site (existing) Bridge1	AB_6192.5_B	Bridge Span	5.5	-	-
Site (existing) Bridge2	AB_6153_B	Bridge Span	3.9	-	-
Bachell Ave RCBC	AB_6152.5_R	2.05 x 1.99 RCBC	24.8	9.95	9.67
Princess St RCBC	AB_6142.5_R	1.85 x 2.18 RCBC	49.5	9.04	8.54
Dalley St RCBC	AB_6132.5_R	1.63 x 2.03 RCBC	24.7	8.01	7.78
Phillips Park RCBC	AB_6122.5_R	1.77 x 2.47 RCBC	246.4	7.66	5.22
Platform St RCBC	AB_6113_R	2.6 x 1.51 RCBC	78.8	5.15	4.45
Delhi St Bridge	AB_6102.5_B	Bridge Span	19.3	-	-

** Reinforced Concrete Box Culvert*

Developed Conditions Scenario

The developed conditions scenario was simulated to determine the impacts of the proposed development on flood risk, while also providing an indication of required fill levels and culvert sizing for the development proposal. The modifications to the existing model included:

- The DEM was modified to simulate filling on-site and in the open channel immediately upstream of the site. A minimum level of 14m AHD was set just inside the southern boundary of the site. This then interfaces with existing levels at the northern and eastern boundaries of the site.
- A 2.4m x 2.1m Reinforced Concrete Box Culvert (RCBC) was modelled between the existing 2.47m x 1.85m RCBC under the rail line immediately upstream of the site and the 2.05m x 1.99m RCBC under Bachell Avenue on the downstream side of the site.
- A single 1.5m x 1.5m field inlet was placed just inside the southern boundary of the site to ensure flows currently draining the open channel immediately upstream of the site are captured and conveyed through the site as per existing conditions. Similarly a single 1.5m x 1.5m field inlet is located at the junction of the proposed RCBC and the existing RCBC under Bachell Avenue in the northern most corner of the site to act as an inlet / surcharge. A number of additional pits would be proposed along the box culvert for the final design, including at the culvert bends.
- The hydraulic roughness for the site was set to industrial (n=0.05).
- The blockage was removed from the culvert under Bachell Avenue as the system is effectively closed all the way to the existing railway culvert, which was still simulated with 50% blockage.

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Council further requested simulations to test the effects of blockages and upstream upgrades. These included:

TestCase1 - Removal of any blockage from the railway culvert, and instead applying the 50% blockage to the culvert within the site. This was applied to the culvert downstream of the aforementioned field inlet.

TestCase2 - Removal of any blockage from the railway culvert and proposed site culvert.

TestCase3 - Increased rail culvert dimension to ensure no upstream attenuation. The span of the two culverts under the rail lines immediately upstream of the site were nominally increased to 3m, with no blockage applied.

These additional scenarios were run for the 1% AEP event only.

No allowance has been made to account for increased flows due to development. Details of stormwater management controls are not included in this report but it is not thought that post development runoff rates will increase when compared to pre development runoff rates. This is to be investigated further after detailed design development of the proposed development.

The model setup reflecting the proposed development layout is presented in **Plate 4-2** below. Flood impacts of this design are discussed in **Section 5.3**.

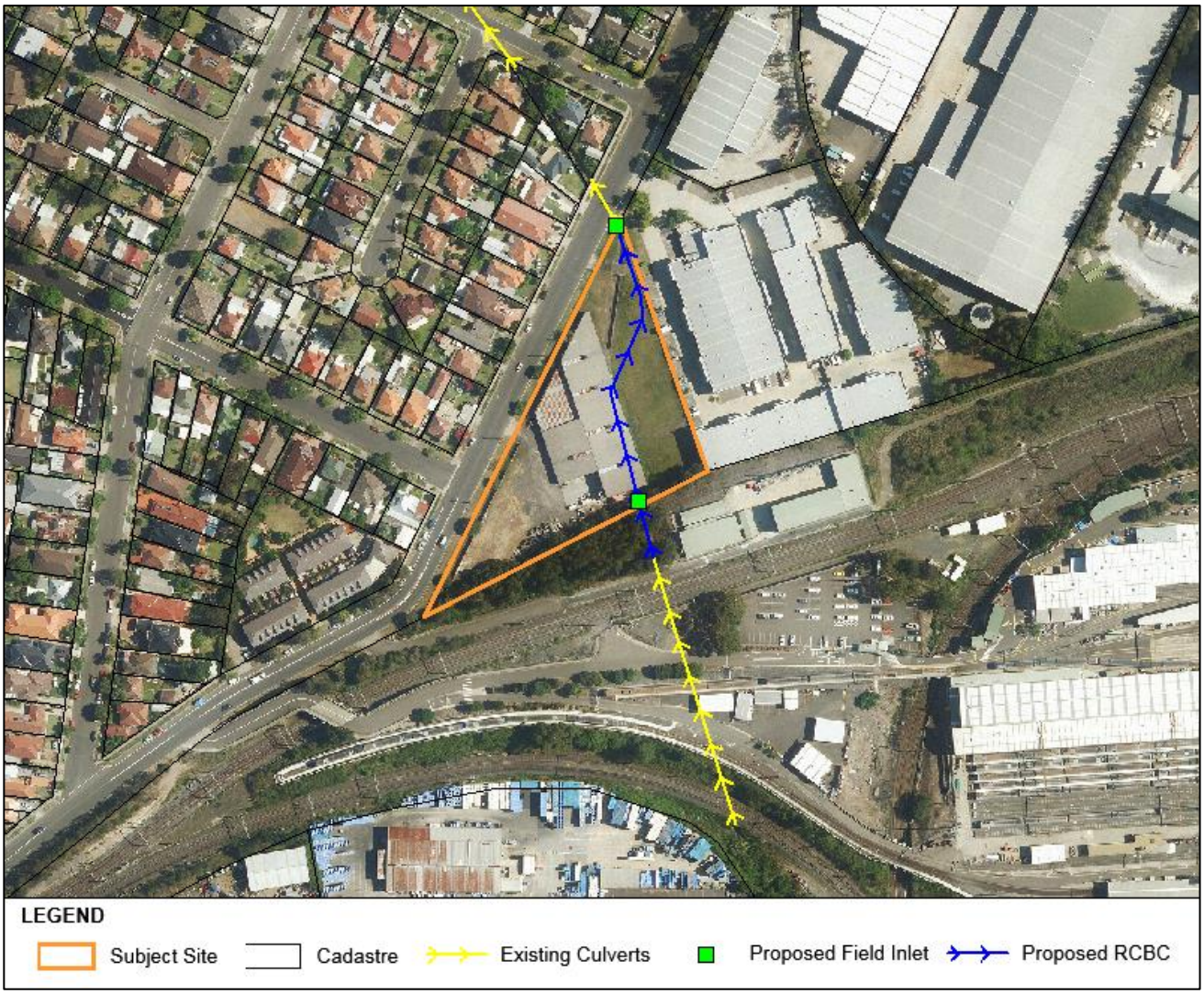

***Plate 4-2** –Model Setup Reflecting Proposed Development*

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5 RESULTS ANALYSIS AND FLOOD IMPACTS

5.1 Existing Conditions Results

Modelled flows (m^3/s), water levels (m AHD) and velocities (m/s) have been extracted at the key locations shown in **Plate 5-1** below. The modelled results are presented in **Tables 3 to 5**.

The 1% AEP flood map (extent and depth) is presented as **Plate 5-2**. Flood maps for other events are presented in **Appendix B**.

***Plate 5-1** – Reporting Locations*

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Table 3 – Existing Results – Peak Flowrate

ID	Location	Peak Flowrate (m^3/s)			
		5% AEP	1% AEP	1% AEP +CC	PMF
1	Open drain u/s of rail line	7.04	8.57	8.69	15.28
2	Open drain u/s of site	7.09	7.71	7.86	12.96
3	RCBC through site	7.83	8.27	8.37	9.64
4	Overland flow through site	0.07	0.53	0.68	5.98
5	Open drain d/s of building	7.69	7.98	8.00	13.54
6	Crest of Bachell Ave	3.78	5.32	5.82	28.09
7	Open drain d/s Bachell Ave	9.30	10.84	11.43	25.30

Table 4 – Existing Results – Peak Water Level

ID	Location	Water Level (mAHD)			
		5% AEP	1% AEP	1% AEP +CC	PMF
1	Open drain u/s of rail line	17.76	18.24	18.37	18.89
2	Open drain u/s of site	13.70	13.85	13.89	14.41
4	Overland flow through site	13.69	13.81	13.83	14.21
5	Open drain d/s of building	12.66	12.69	12.70	12.99
6	Crest of Bachell Ave	12.44	12.49	12.51	12.85
7	Open drain d/s Bachell Ave	12.01	12.07	12.09	12.47

Table 5 – Existing Results – Peak Flow Velocity

ID	Location	Velocity (m/s)			
		5% AEP	1% AEP	1% AEP +CC	PMF
1	Open drain u/s of rail line	0.8	0.9	1.0	1.9
2	Open drain u/s of site	1.7	1.7	1.7	1.4
3	RCBC through site	5.0	5.3	5.4	5.5
4	Overland flow through site	<0.1	<0.1	<0.1	0.12
5	Open drain d/s of building	2.1	2.1	2.1	2.0
6	Crest of Bachell Ave	<0.1	<0.1	<0.1	<0.1
7	Open drain d/s Bachell Ave	1.5	1.7	1.8	3.2

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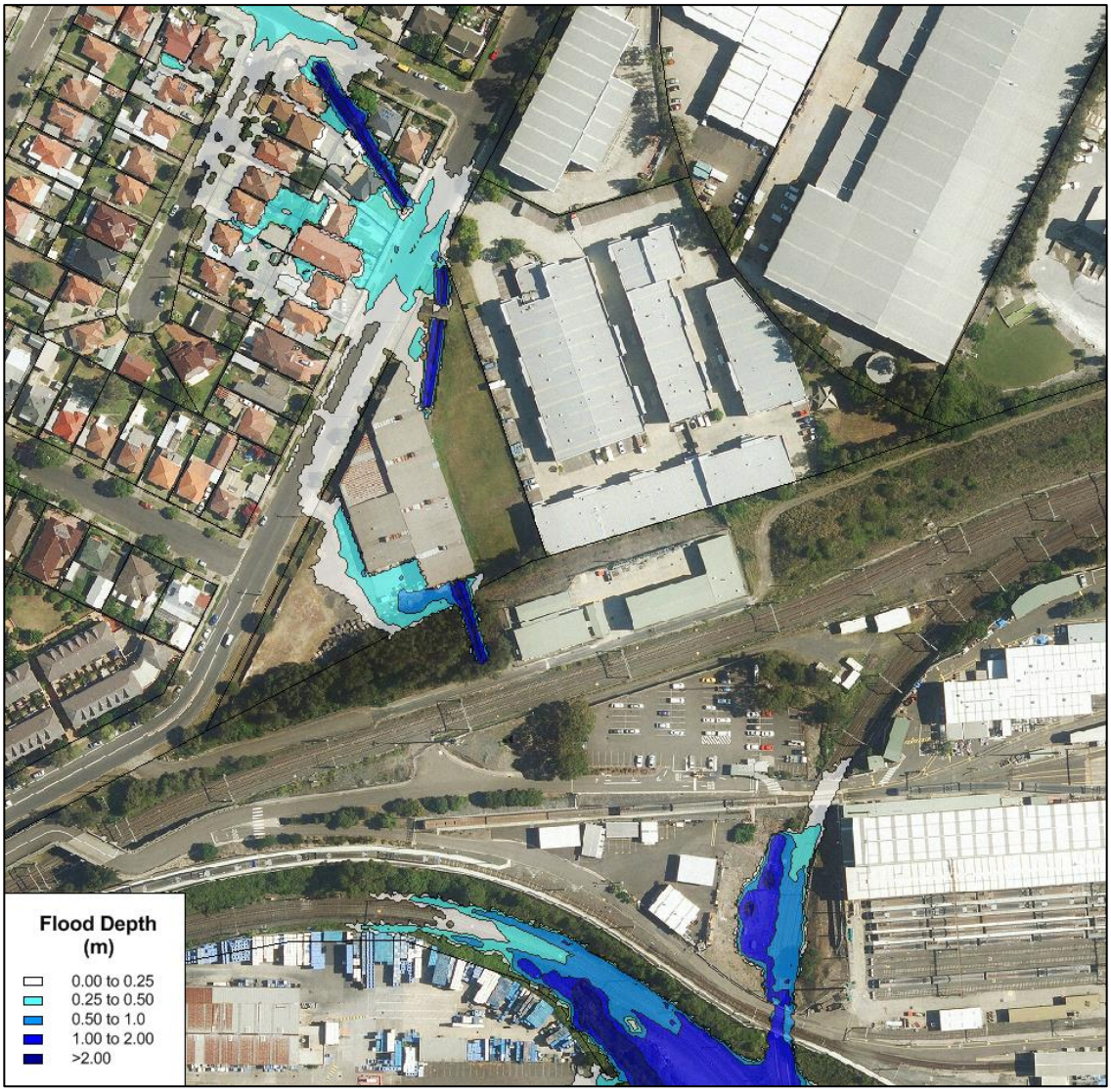

***Plate 5-2** – Existing Conditions Flood Map 1% AEP event*

Key findings for the existing condition 1% AEP event are as follows:

- The railway line culvert attenuates flow by 0.86m^3/s;
- The existing culvert under the printing press conveys 8.27 m^3/s, the vast majority of the 1% AEP flow rate from the whole catchment (8.57 m^3/s);
- Flow breaks out of the left hand bank at the upstream end of the site and flows as overland flow around the left hand side of the existing printing press building. The overland flowrate is low 0.53 m^3/s, with a velocity of <0.1m/s. The overland flow exits the site through the site entrance to Bachell Avenue and flows north down the road.
- The water level for the overland flow is 13.81 mAHD and 12.69 mAHD in the open channel downstream of the printing press. This compares to 14m AHD reported by Bewshers (1999).
- The modelled velocity in the existing culvert under the printing press is very high at 5.3 m/s, reducing to 2.1 m/s in the open channel downstream.

Figure B1, in **Appendix B** shows that some existing conditions flooding occurs even at the 5% AEP event, with the same flood mechanisms as described for the 1% AEP event. **Figure B4**, also in **Appendix B** shows the majority of the subject site is inundated during a PMF event.

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5.2 Design Conditions Results

Modelled flows, water levels and velocities for the proposed development scenario have been extracted at the same 7 locations for comparison. The modelled results are presented in **Tables 6 to 8** below. The 1% AEP flood map (extent and depth) is presented as **Plate 5-3**. The remaining events are presented in **Appendix C**.

Table 6 – Design Results – Peak Flowrate

ID	Location	Peak Flowrate (m^3/s)			
		5% AEP	1% AEP	1% AEP +CC	PMF
1	Open drain u/s of rail line	7.11	8.10	8.92	15.45
2	Open drain u/s of site	0.0	7.49	0.0	1.37
3	RCBC through site	6.95	8.63	7.63	14.65
6	Crest of Bachell Ave	0.0	0.0	0.10	10.67
7	Open drain d/s Bachell Ave	8.61	10.36	11.02	25.02

Table 7 – Design Results – Peak Water Level

ID	Location	Water Level (mAHD)			
		5% AEP	1% AEP	1% AEP +CC	PMF
1	Open drain u/s of rail line	17.78	18.25	18.38	19.87
2	Open drain u/s of site	0.0	0.0	0.0	14.69
3	Middle of site	0.0	0.0	0.0	14.23*
6	Crest of Bachell Ave	0.0	0.0	12.23	12.63
7	Open drain d/s Bachell Ave	12.00	12.07	12.09	12.45

** Note flood levels across the site in the design case need to consider that the fill levels have been approximated*

Table 8 – Design Results – Peak Flow Velocity

ID	Location	Velocity (m/s)			
		5% AEP	1% AEP	1% AEP +CC	PMF
1	Open drain u/s of rail line	0.8	0.9	1.0	1.9
2	Open drain u/s of site	0.0	0.0	0.0	<0.1
3	RCBC through site	3.2	3.4	3.3	3.6
6	Crest of Bachell Ave	0.0	0.0	<0.1	<0.1
7	Open drain d/s Bachell Ave	1.6	1.7	1.7	3.2

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***Plate 5-3** – Design conditions flood depth plot 1% AEP event*

Plate 5-3 shows that under the developed conditions scenario, the hydraulic modelling results indicate no flooding on the subject site. Furthermore flooding of approximately 10 residential properties immediately downstream of the site (between Bachell Avenue and Brenda Avenue) has been alleviated. This is due to flow through the site being contained in the proposed RCBC.

Figure C3, in Appendix C shows that the subject site remains flood free in the 1% AEP + climate change scenario. **Figure C4** however shows that during a PMF scenario the proposed RCBC is overwhelmed and the majority of the subject site is inundated. The highest PMF level on the site is 15.34 mAHD in the south east corner of the site, which then reduces across the site to 12.75 mAHD at the downstream point of the site.

5.3 Flood Impact

Tables 9 – 11 provide a comparison of modelled flowrates, water levels and flow velocities between the 1% AEP existing conditions and developed conditions scenarios. **Plate 5-4** shows the change

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on flood depth as a result proposed development for the 1% AEP event. The remaining events are presented in **Appendix D**.

Table 9 shows that at most locations the proposed development lowers flow rates slightly (by between 0.22 and 0.48m^3/s). The exception is at point 6 (the crest of Bachell Avenue at the downstream end of the site) where flow is removed completely as it is now contained within the proposed RCBC. Flow within the RCBC increases by 0.36m^3/s in the developed scenario.

Table 10 and **Plate 5-4** show that very minor increases in water level have been modelled immediately upstream of the railway line and downstream of Bachell Avenue. The modelled increase in flood depths in the 1% AEP event is 0.01m (10mm).

Table 11 shows that flow velocities do not change as a result of the proposed development except at point 3 due to the increased capacity of the proposed RCBC, and at point 6 where flow is removed completely as it would be contained within the RCBC.

Table 9 – Comparison of Peak Flowrates – 1% AEP

ID	Location Description	Existing m^3/s)	Design (m^3/s)	Difference (m^3/s)
1	Open Drain u/s of rail line	8.57	8.10	- 0.47
2	Open Drain u/s of site	7.71	7.49	- 0.22*
3	RCBC through site	8.27	8.63	+ 0.36
6	Crest of Bachell Ave	5.32	0.0	- 5.32
7	Open Drain d/s Bachell Ave	10.84	10.36	- 0.48

** Flow is contained in proposed RCBC.*

Table 10 – Comparison of Peak Water Levels – 1% AEP

ID	Location Description	Existing (m AHD)	Design (m AHD)	Difference (m)
1	Open Drain u/s of rail line	18.24	18.25	+ 0.01
2	Open Drain u/s of site	13.85	0.0	0.0
3	RCBC through site	-	-	-
6	Crest of Bachell Ave	12.49	0.0	0.0
7	Open Drain d/s Bachell Ave	12.07	12.07	0.0

Table 11 – Comparison of Peak Flow Velocity– 1% AEP

ID	Location Description	Existing m/s)	Design (m/s)	Difference (m/s)
1	Open Drain u/s of rail line	0.9	0.9	0.0
2	Open Drain u/s of site	1.7	0.0	0.0
3	RCBC through site	5.3	3.4	- 1.9
6	Crest of Bachell Ave	<0.1	0.0	0.0
7	Open Drain d/s Bachell Ave	1.7	1.7	0.0

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While a review of the 1D results indicates that the peak 1% AEP water level achieved in the proposed field inlet pit at the southern boundary is 12.77m AHD, the surface level of the pit is set at 13.2m AHD. Based on this it is proposed that minimum finished floor levels for any future buildings over the is site be set to RL13.7m AHD, to achieve the required 0.5m freeboard to the 1% AEP event.

***Plate 5-4** – Impact Plot: Change in 1% AEP Flood Depths*

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5.4 Council Test Cases

Table 12-14 presents a comparison of the 1% AEP results for the design case versus the three additional test cases requested by Council (described above in ***Section 4.3*** and repeated below).

TestCase1 - Removal of any blockage from the railway culvert, and instead applying the 50% blockage to culvert within the site. This was applied to the culvert downstream of the aforementioned field inlet.

TestCase2 - Removal of any blockage from the railway culvert and proposed site culvert.

TestCase3 - Increased rail culvert dimension to ensure no upstream attenuation. The span of the two culverts under the rail lines immediately upstream of the site were nominally increased to 3m, with no blockage applied. **Note:** both ARTC and Sydney trains have been consulted during the development of this FIA and neither have any plans to upgrade or increase the size of the railway culverts upstream of the site.

These additional scenarios were run for the 1% AEP event only. The 1% AEP flood depth plots for the test cases are provided in **Plate 5-5 to Plate 5-7**.

Table 12 – Comparison of Peak Flowrates for the various Test Cases – 1% AEP

ID	Location Description	Design	Design TestCase1	Design TestCase2	Design TestCase3
1	Open Drain u/s of rail line	8.10	15.12	15.42	20.18
3	RCBC through site	8.63	12.01	16.48	19.96
6	Crest of Bachell Ave	0.0	3.98	2.18	4.44
7	Open Drain d/s Bachell Ave	10.36	16.32	16.97	20.06

Table 13 – Comparison of Peak Water Levels for the various Test Cases – 1% AEP

ID	Location Description	Design	Design TestCase1	Design TestCase2	Design TestCase3
1	Open Drain u/s of rail line	18.25	17.58	17.52	16.91
3	RCBC through site	-	-	-	-
6	Crest of Bachell Ave	0.0	12.43	12.35	12.44
7	Open Drain d/s Bachell Ave	12.07	12.22	12.24	12.31

Table 14 – Comparison of Peak Flow Velocity for the various Test Cases – 1% AEP

ID	Location Description	Design	Design TestCase1	Design TestCase2	Design TestCase3
1	Open Drain u/s of rail line	0.9	1.1	1.1	1.4
3	RCBC through site	3.4	8.0	4.1	4.0
6	Crest of Bachell Ave	0.0	<0.1	<0.1	<0.1
7	Open Drain d/s Bachell Ave	1.7	2.4	2.4	2.8

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It is evident that for Test Case1, where the blockage has been applied to the proposed culvert within the site and the railway culverts are allowed to flow freely, that flows to the site are significantly increased such that the field inlet surcharges, filling the open channel and overtopping the southern boundary of the site. This is clearly visible in the **Plate 5-5**.

Plate 5-5 – Design conditions flood depth plot 1% AEP event – TestCase1

In Test Case2, where the blockage has been removed from both the proposed site culvert and the rail culverts (culvert under Bachell Avenue is also still assumed to have zero blockage) the additional flow allowed to reach the site results in surcharging of both proposed pits. While upstream of the site this is contained with the open channel, downstream of the site this results in additional flooding of Bachell Avenue and the adjacent residential properties over the base design case.

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Plate 5-6 *– Design conditions flood depth plot 1% AEP event – TestCase2*

For Test Case3, where the rail culverts are assumed to be upgraded, flooding has been significantly reduced upstream of these culverts. The increased flow to the site however results in a similar case to Test Case1, however with no blockage applied to the proposed site culvert, flooding of the site is less severe, while downstream of the site the impact are worse.

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***Plate 5-7** – Design conditions flood depth plot 1% AEP event – TestCase3*

5.5 Flood Evacuation

Given the nature of the proposed development it is important to consider safe flood evacuation from the site under extreme flood conditions such as the PMF, including for disabled and elderly people.

A detailed Flood Evacuation Plan has not been developed as part of this report. However it is considered that the final development proposals should include a Flood Evacuation Plan that considers options including:

- 'Shelter in Place' – Given the multi storey nature of the conceptual development design, provision of 'shelter in place' on the 2nd floor (or higher) above floor level;
- Provision of a walkway above the PMF level from the development to the South West corner of Bachell Avenue which is flood free would potentially allow safe egress from the site.

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6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions can be drawn from the above sections:

- Under existing conditions the railway line has a minor attenuation effect on flood risk to the study site.
- The existing site is at flood risk at the 1% AEP event (and 5% AEP see **Appendix B**). Flow breaks out of the left hand bank at the upstream end of the site and flows as overland flow around the left hand side of the existing printing press building. The overland flowrate is low 0.53 m^3/s, with a velocity of <0.1m/s. The overland flow exits the site through the site entrance to Bachell Avenue and flows north down the road. The water level for the overland flow is 13.81 mAHD and 12.69 mAHD in the open channel downstream of the printing press.
- Under the developed conditions scenario, with the proposed 2.4m x 2.1m culvert running the full length of the development site, the hydraulic modelling results indicate no flooding on the site in the 1% AEP event. Furthermore flooding of approximately 10 residential properties immediately downstream of the site is alleviated with flow though the site being contained within the proposed RCBC.
- The 1% AEP developed conditions flood risk is sensitive to different structure blockage assumptions. The site remains flood free in the 1% AEP event under design conditions if no structure blockage is applied. As the proposed site culvert is slightly smaller than the railway culvert that is immediately upstream, the potential for blockage is significantly reduced. It is recommended that during the DA Stage a blockage assessment using the new ARR2016 blockage guidance is undertaken.
- During a PMF flood, significant inundation of the site occurs in both the existing conditions (14.21m AHD) and developed scenarios (14.23m AHD).

6.2 Recommendations

The following recommendations can be made based on the outcomes of this study:

- The minimum Finished Floor Level for the site be set to RL13.7m AHD, to achieve the required 0.5m freeboard to the 1% AEP event.
- The updated development is considered hydraulically similar to the previous proposed development for the purposes of assessing a rezoning application. However, prior to submission of the final development application, the developed conditions modelling should be updated and rerun using the final design. This update should include adoption of the Flood Study (RHDHV, 2016) model setup (including ILSAX hydrology).
- A detailed Flood Evacuation Plan should be developed in consultation with Council, as part of the detailed design of the proposed development. The Flood Evacuation Plan should consider access to disabled or elderly flood refuges and could consider ‘Shelter in Place’ on the second storey above ground level, and / or an access way above the PMF level to the South West corner of Bachell Avenue.

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7 REFERENCES

1) TUFLOW User Manual (Build 2010-10-AB), *BMT WBM (2010).*

2) Australian Rainfall and Runoff – 'A Guide to Flood Estimation'. *Institution of Engineers Australia (1987),*

3) Building Over or Adjacent to Sydney Water Stormwater Assets. *Sydney water Corporation (2015).*

4) Development Control Plan. *Auburn City Council (2010)*

5) Haslams Creek Flood Study. *Bewshers (1999)*

6) Haslams Creek Overland Flood Study (Draft for review)*, Prepared by Royal HaskoningDHV on behalf Auburn City Council, 10th May 2016.*

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Appendix A – *Proposed Developed Layout*

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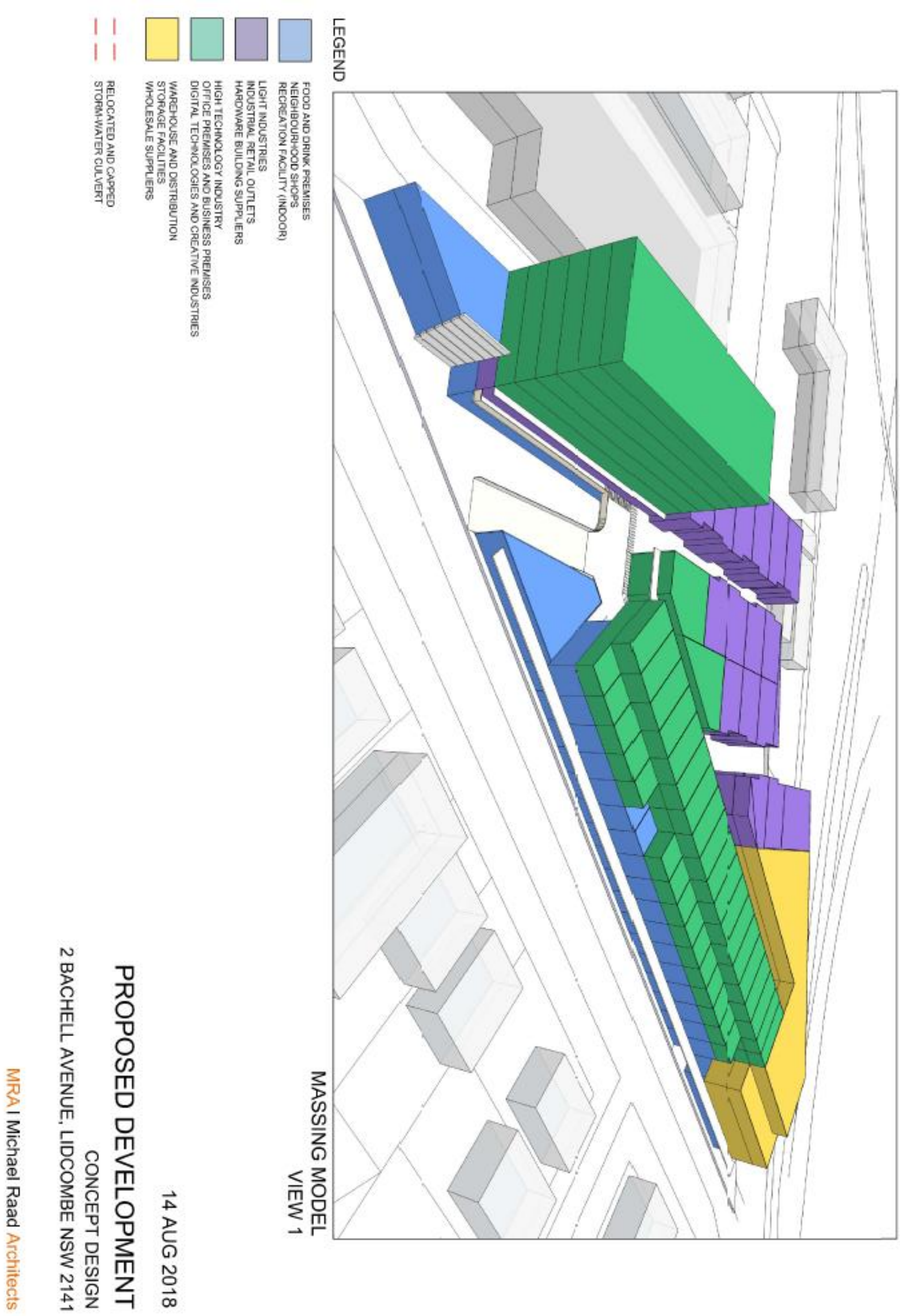

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Appendix B – *Existing Condition Flood Depth Plots*

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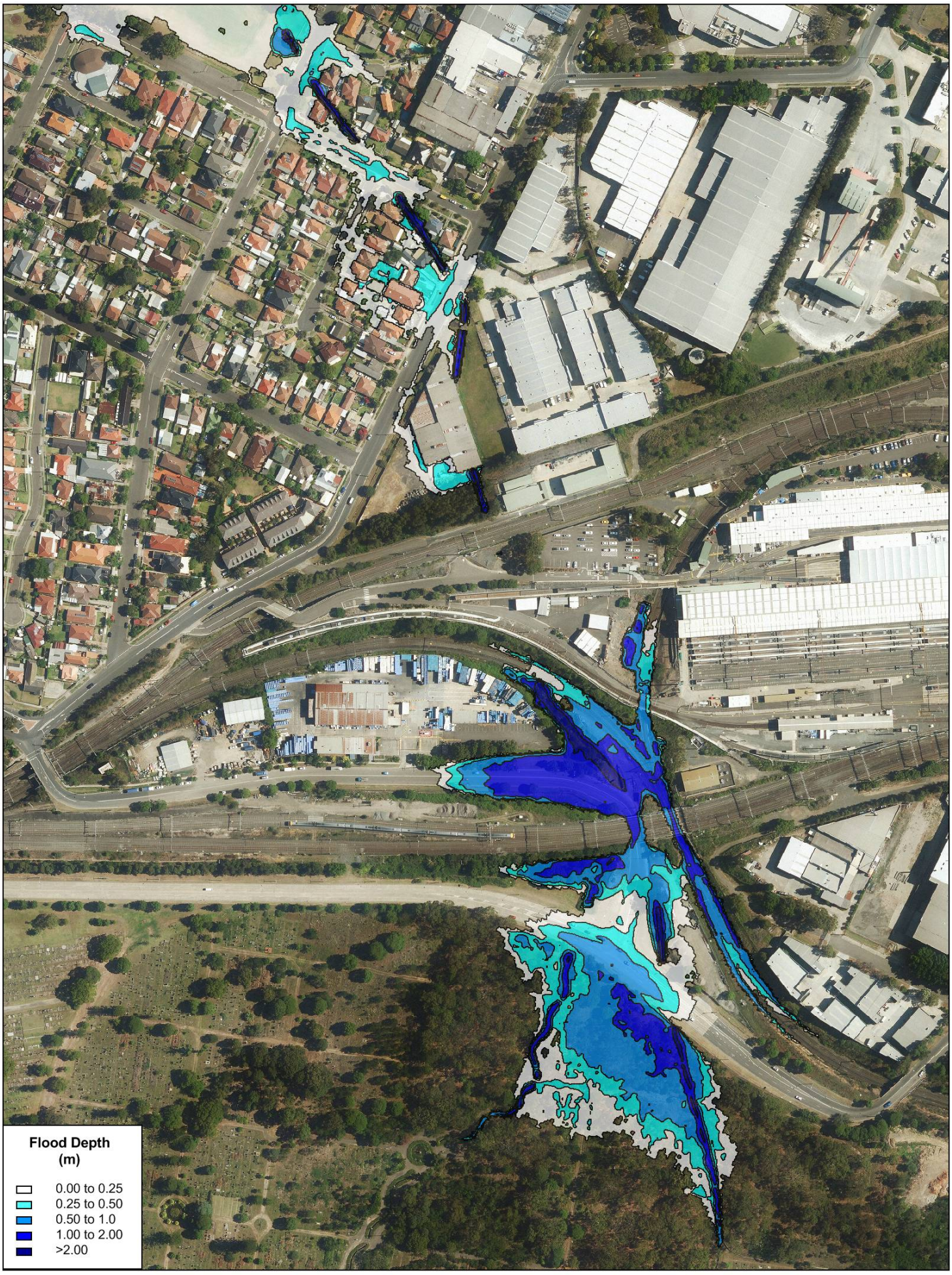

PROJECT NO: PA1193 PROJECT TITLE: 2 Bachell Avenue, Lidcombe - FIA

FIGURE B1 **Existing Scenario - 5% AEP Flood Depths**

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NORTH

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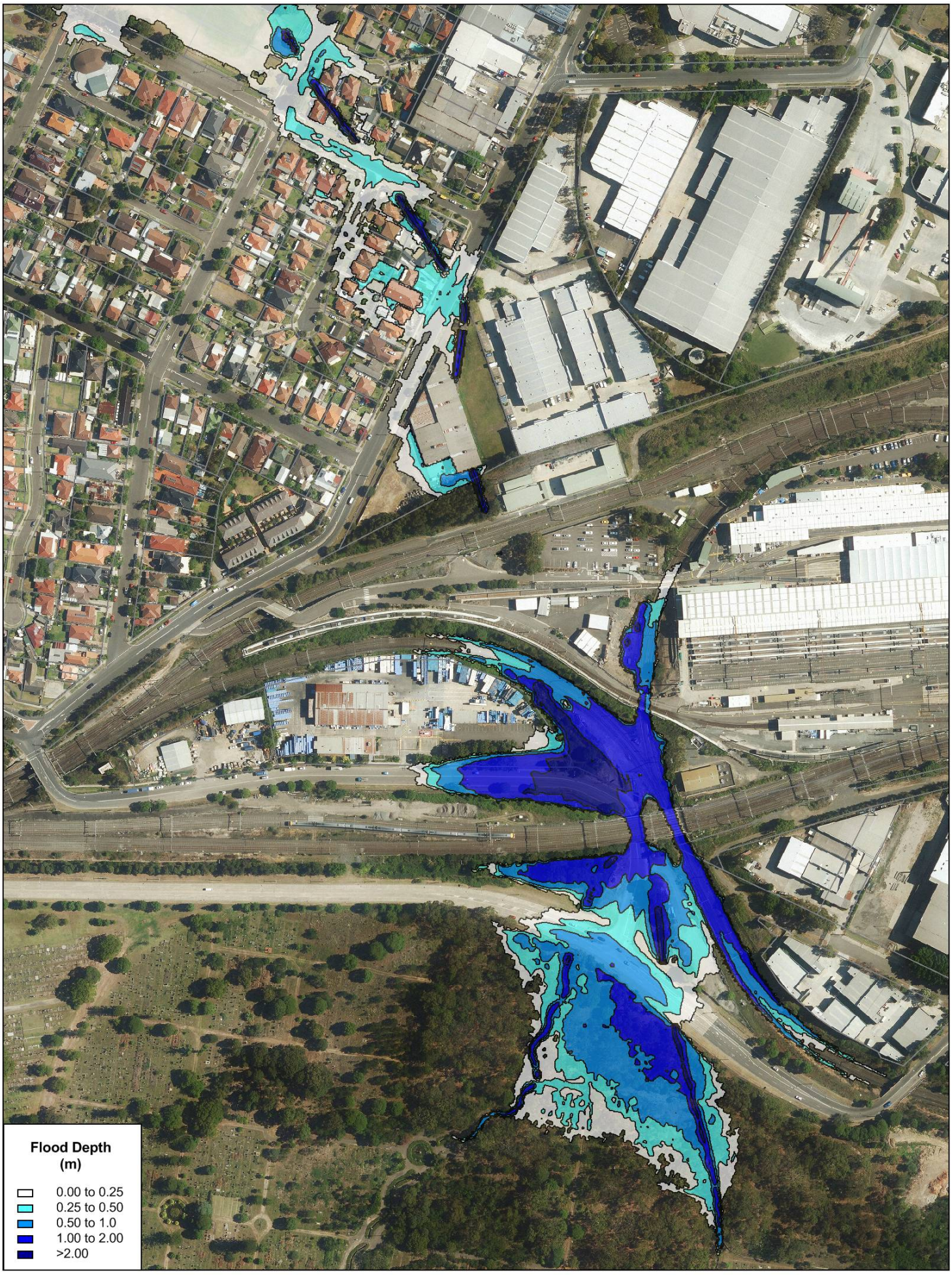

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FIGURE B2 **Existing Scenario - 1% AEP Flood Depths**

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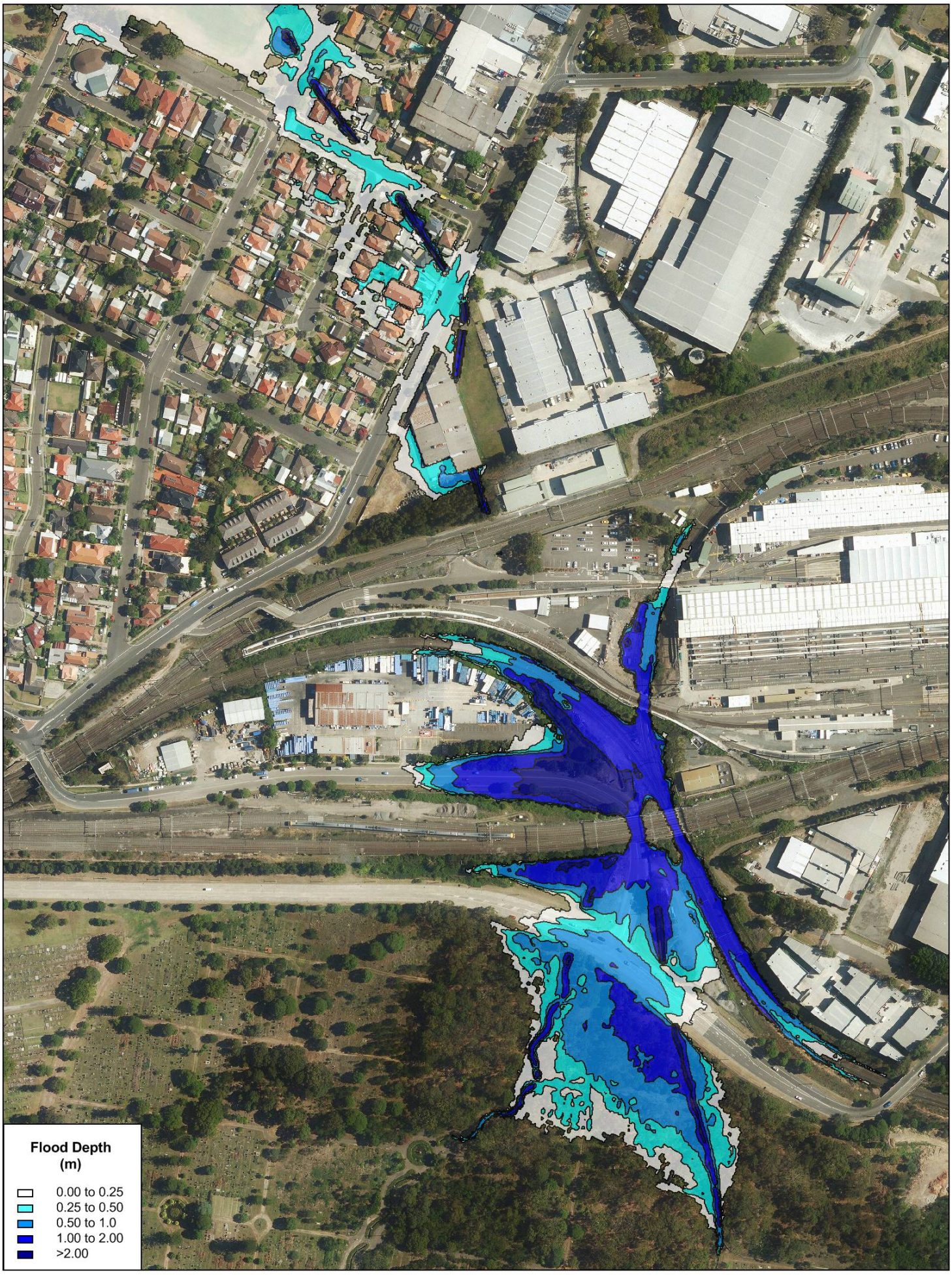

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FIGURE B3 **Existing Scenario - 1% AEP + Climate Change Flood Depths**

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FIGURE B4 **Existing Scenario - PMF Flood Depths**

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Appendix C – *Design Condition Flood Depth Plots*

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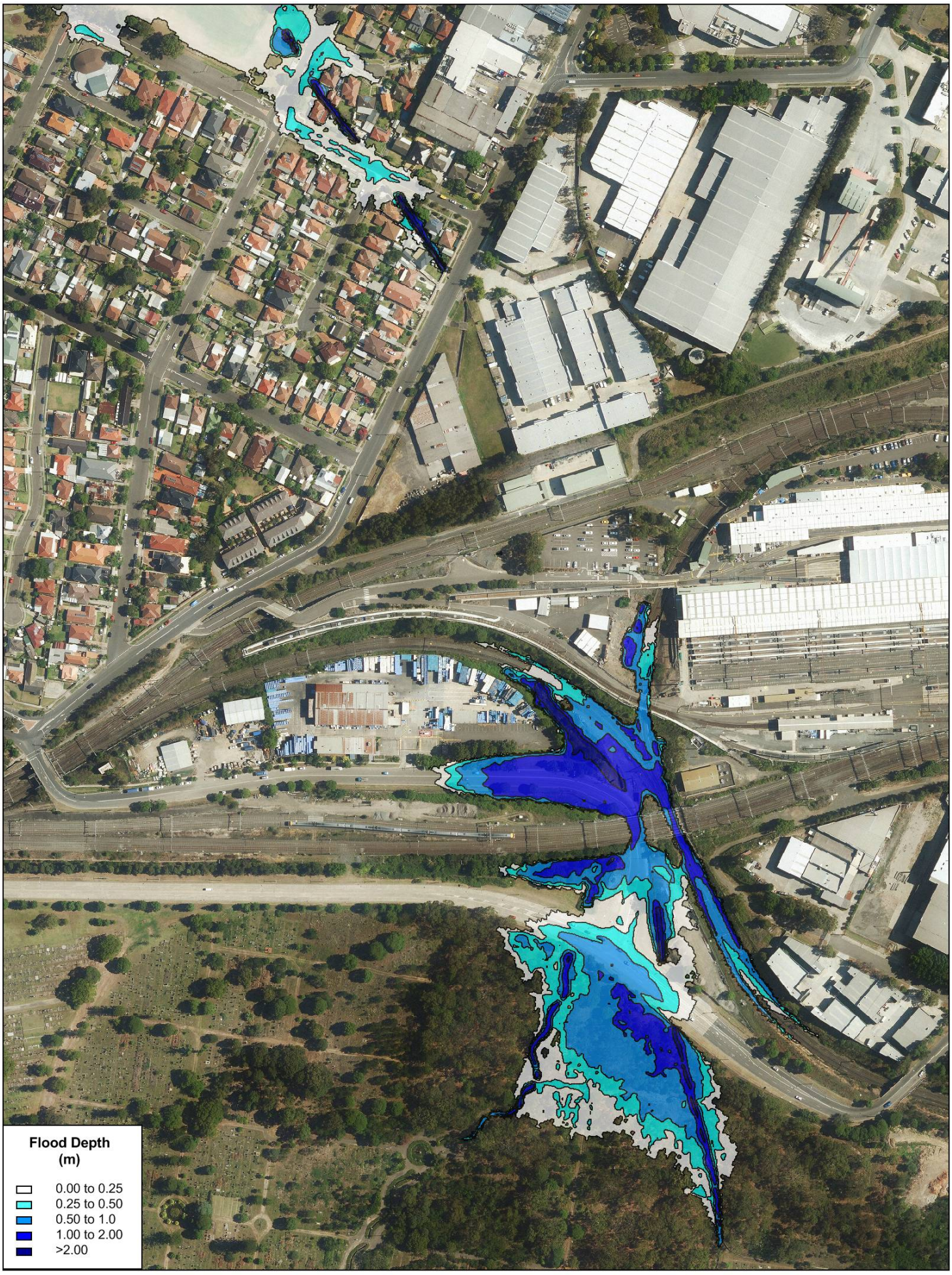

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FIGURE C1 **Design Scenario - 5% AEP Flood Depths**

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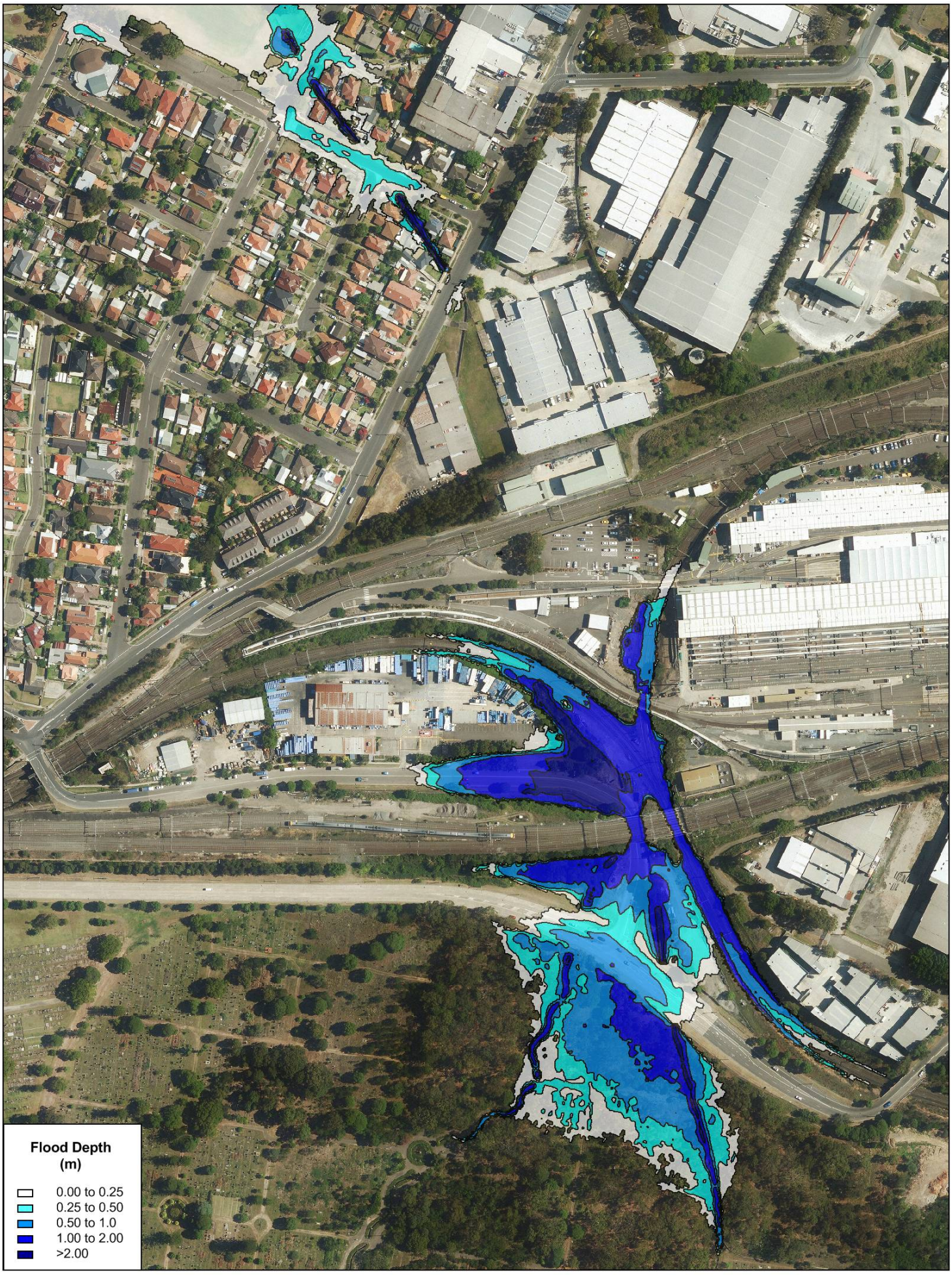

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FIGURE C2 **Design Scenario - 1% AEP Flood Depths**

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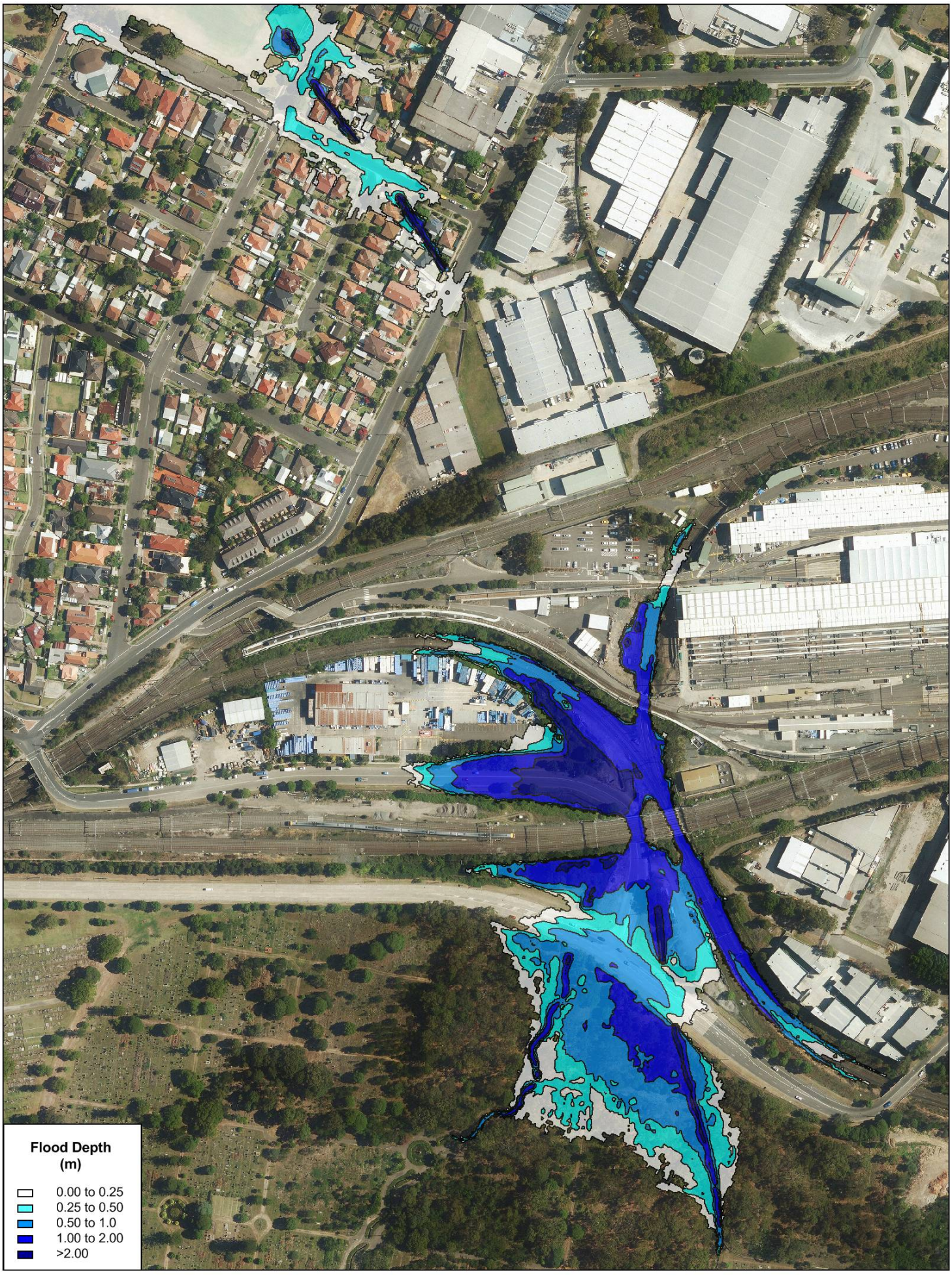

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FIGURE C3 **Design Scenario - 1% AEP + Climate Change Flood Depths**

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Approx. Scale

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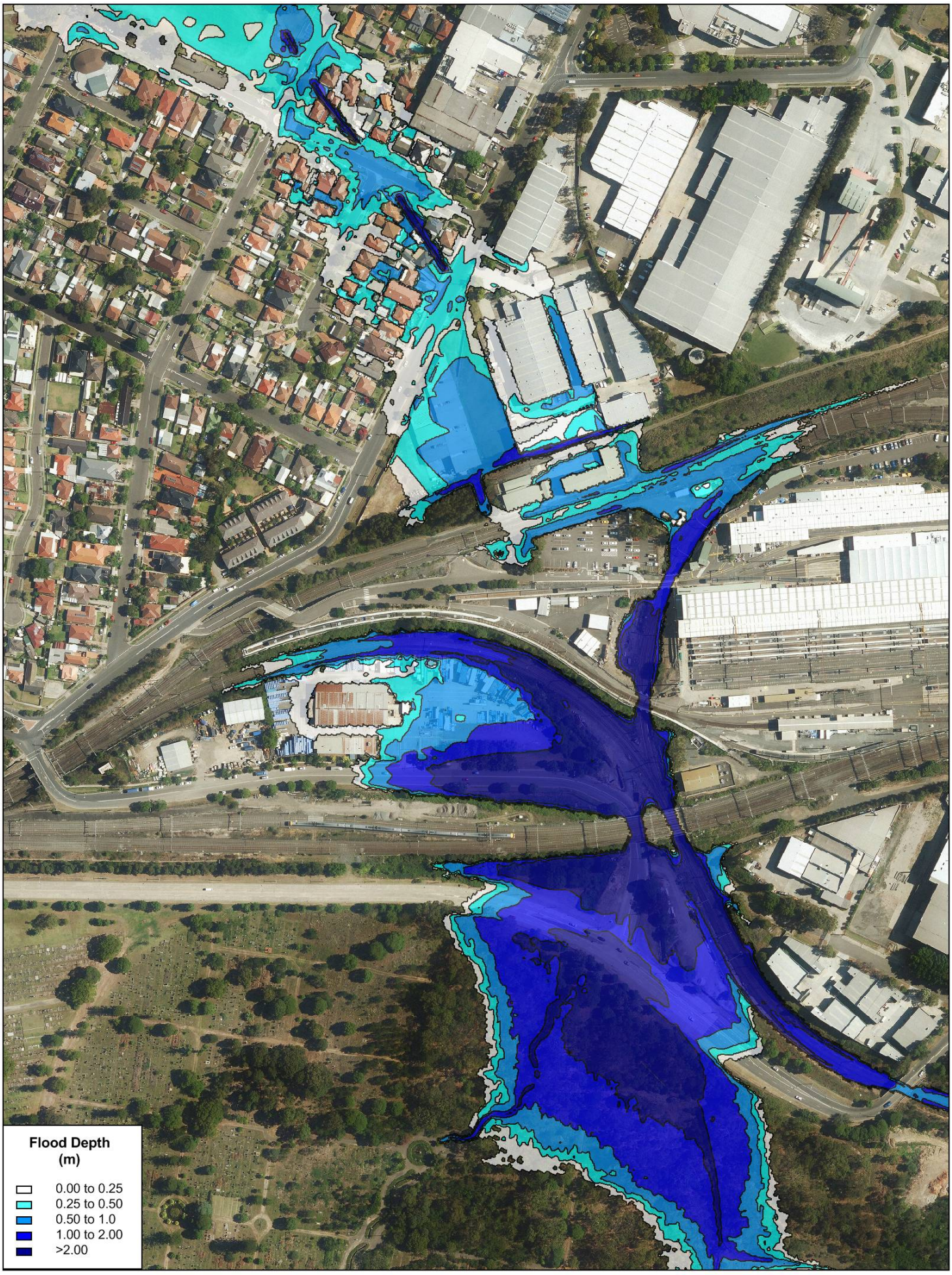

PROJECT NO: PA1193 PROJECT TITLE: 2 Bachell Avenue, Lidcombe - FIA

FIGURE C4 **Design Scenario - PMF Flood Depths**

REVISION A

DATE 01/10/2015

NORTH

0 25 50m
Approx. Scale

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Appendix D – *Flood Impact Plots*

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PROJECT NO: PA1193 PROJECT TITLE: 2 Bachell Avenue, Lidcombe - FIA

FIGURE D1 **Impact Plot - Change in 5% AEP Flood Depths**

REVISION A

DATE 01/10/2015

NORTH

0 25 50m
Approx. Scale

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FILEPATH \\HKAGC-SERVER\Share\01_Projects\PA1193_BachellAve_FIA\GIS\Workspaces\5%AEP_Impact.WOR

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FIGURE D2 **Impact Plot - Change in 1% AEP Flood Depths**

REVISION A

DATE 01/10/2015

NORTH

0 25 50m
Approx. Scale

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FIGURE D3 **Impact Plot - Change in 1% AEP + Climate Change Flood Depths**

REVISION A

DATE 01/10/2015

NORTH

0 25 50m
Approx. Scale

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PROJECT NO: PA1193 PROJECT TITLE: 2 Bachell Avenue, Lidcombe - FIA

FIGURE D4 **Impact Plot - Change in PMF Flood Depths**

REVISION A

DATE 01/10/2015

NORTH

0 25 50m
Approx. Scale

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