Flood Impact Assessment – Stage 1

High Street, Penrith

59918011

Prepared for
Toga Project Services Pty Ltd

6 October 2021

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Executive Summary

TOGA engaged Cardno for flooding advice in relation to a proposed development at High Street, Penrith, comprised of the eastern part of Lot 300 in DP124301.

This report has been prepared to support a development application for the Stage 1 development of this site to construct mixed use commerical/retail and residential buildings and associated road and public domain works.

The flooding context of the site has been considered with respect to mainstream flooding from the Nepean River, overland flow, drainage networks, flowpaths through the site and flood hazard.

The report presents the findings of an assessment of flooding at the site and the impacts of the proposed development on flooding, flood planning levels and compliance with Council development controls.

The site is partially within the flood planning area for the Nepean River flood extents and is impacted by overland flooding. The site is also significantly affected in the regional Probable Maximum Flood (PMF) event.

Overland flow flood modelling was undertaken for this study using the 2D TUFLOW model originally prepared by Cardno for the Penrith Detailed Overland Flow Flood Study (2015) for Penrith City Council. The following amendments were made specifically for this study:

> Grid size changed to a 2 m x 2 m grid;

> Addition of detailed ground survey for the site and surrounds;

> Update of the roughness of the site and surrounding areas; and

> Changes to terrain, roughness and building footprints for the proposed development scenario.

The 1% Annual Exceedance Probability (AEP) events and the Probable Maximum Flood (PMF) were modelled for the study. The results of the modelling demonstrate that the proposed development improves flooding conditions along High Street and Union Road near Mulgoa Road with flood level decreases of up to 5 cm which will be of benefit to the local community. There are localised minor increases in water levels of 2 cm to 5 cm as a result of the proposed development in the 1% AEP event. Impacts are constrained to the road reserve along High St and Union Lane and does not impact upon any property. Flood hazard at the site and in surrounding streets is low for the 1% AEP and the development does not alter the flood hazard in the area.

This report also includes a discussion of the flood-related development controls and how these apply to the development.

The development is compliant with Penrith City Council DCP (2014) and is suitable for development in relation to flood planning considerations.

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1 Background

1.1 Subject Site

The site is referred to as High Street and is located in the suburb of Penrith in the Penrith Government Area (LGA) and is comprised of the following lots the eastern part of Lot 300 in DP124301.

The site currently contains a single building, catering to auto retailing and car sales businesses. The site is bounded by High Street to the north, Mulgoa Road to the west and Union Road to the south and Union Lane ends at the eastern boundary of the site, as shown in **Figure 1-1**.

Figure 1-1 Locality Plan

1.2 Objective

The objective of the study is to undertake an assessment of flooding within and in the vicinity of the subject site and assess the compliance or otherwise of the proposed Stage 1 development with Council's Policies and development controls.

1.3 Proposed Development

The proposed development DA20/0148 seeks consent for a mixed-use development comprising two towers of 35 and 13 storeys located above a part 4 and part 2 storey podium providing 357 residential dwellings with ground level commercial tenancies, 3 levels of basement car parking, a new public road and associated site works on the land at 634-638 High Street and 87-93 Union Road, Penrith NSW.

The development application subject to the current proceedings is amended by way of changes detailed below:

- Podium - reduction in the scale of the podium from 5 storeys to 4 storeys in the middle section and 2 storeys at the northern and southern ends; decrease in the number of car parking spaces provided

within the podium; increased 'sleeving' of car parking provided in the podium with apartments; and enhanced articulation.

- Basement - increased basement car parking from 1 to 3 levels.
- Ground level - enhanced activation of the ground floor through relocation of the through site pedestrian link, redistributing and enlarging commercial floorspace, providing stepped sitting edges to the western colonnade facing John Tipping Grove, and increased landscaping.
- Levels 1 to 3 – increased activation and connection to ground level through additional apartments and enhanced design of communal open space area.
- Towers - reduction in the height of Tower 2 from 37 to 35 storeys, reduction in height of Tower 1 from 14 storeys to 13 storeys, and redesign to increase building articulation.

The development stages are shown in **Figure 1-2** and development plan for Stage 1 is shown in **Figure 1-3**.

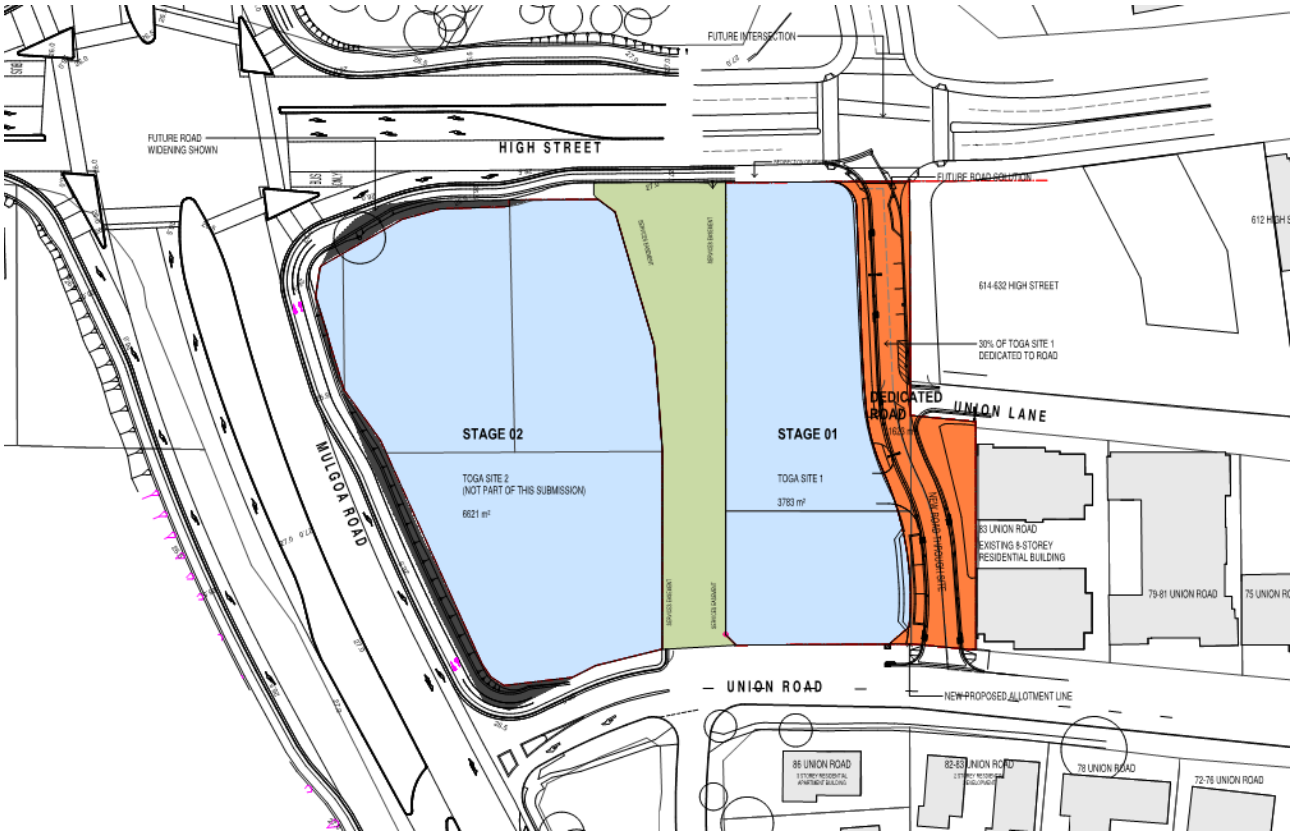

Figure 1-2 Proposed Development Staging

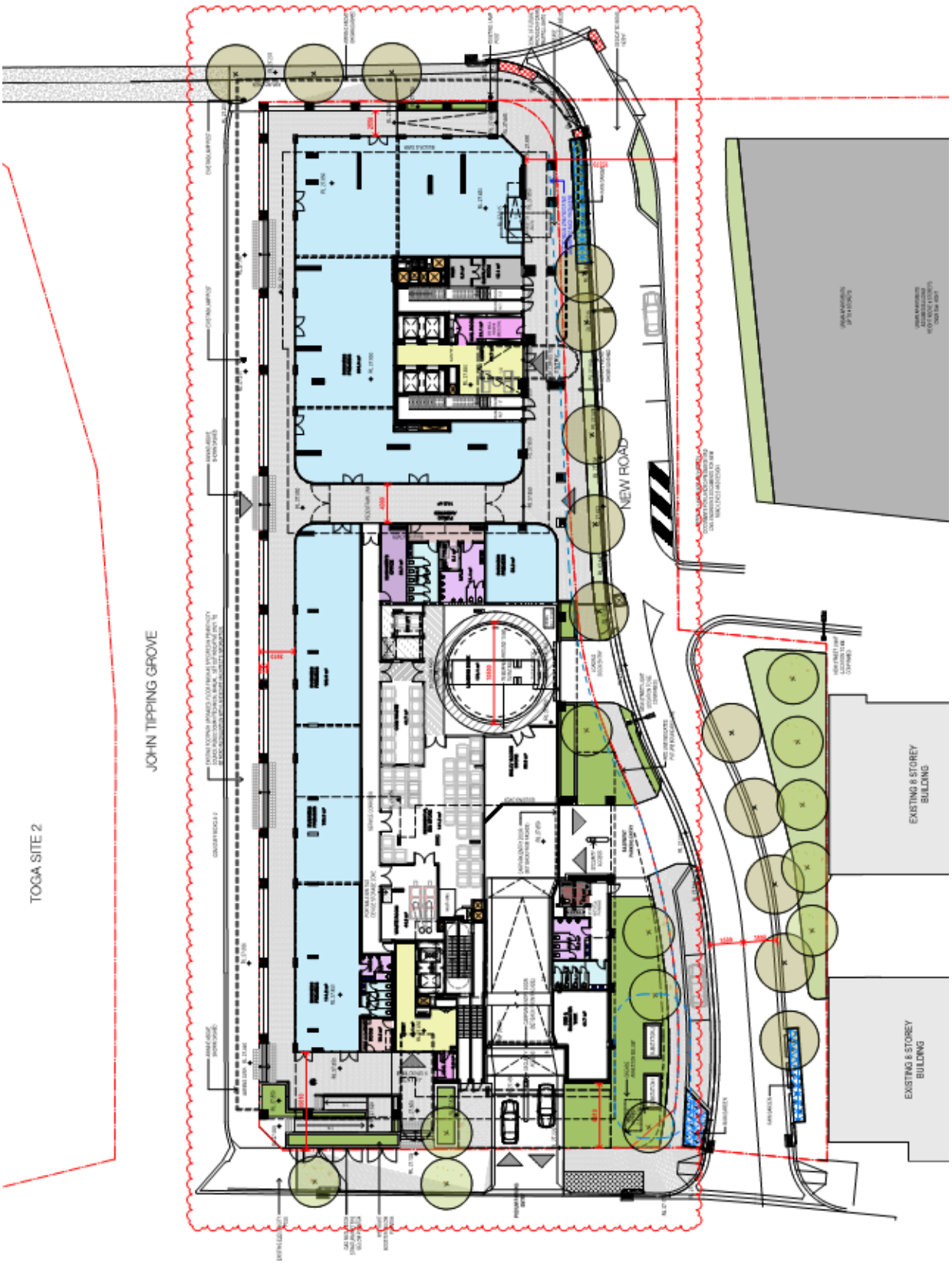

Figure 1-3 Proposed Stage 1 Development

1.4 Council Flood Impact Policy

Penrith City Council DCP 2014 Section C3 – Water Management provides the relevant controls for flood impact assessments.

The LEP contains provisions for development on land at or below the flood planning level, defined in the LEP as the level of a 1:100 Average Recurrence Interval (ARI) (1% AEP) flood event plus 0.5 m freeboard.

Regarding flood impact, the DCP (Section 3.5) requires that any development must not increase the flood hazard or risk to other properties. This includes the impact on any overland flow path. Development should not obstruct overland flow paths and must demonstrate that any overland flow is maintained for the 1% AEP event. However, Council will take a merit based approach when assessing development applications that affect the overland flow.

Filling of floodways or high hazard areas is not permitted and filling of other land at or below the flood planning level is generally not supported. However, Council will also adopt a merits based approach, including consideration of the following criteria:

- Flood levels are not increased by more than 0.1m by the proposed filling;
- Downstream velocities are not increased by more than 10% by the proposed filling;
- Proposed filling does not redistribute flows by more than 15%;
- The potential for cumulative effects of possible filling proposals in that area is minimal;
- There are alternative opportunities for flood storage;
- The development potential of surrounding properties is not adversely affected by the filling proposal;
- The flood liability of buildings on surrounding properties is not increased;
- No local drainage flow/runoff problems are created by the filling; and
- The filling does not occur within the drip line of existing trees.

The DCP has the following further requirements regarding Overland Flow Flooding (Section 2.4):

The following key principles shall also be considered in the overland flow flood study:

- All levels shown shall be to the Australian Height Datum (AHD)
- The development shall not adversely impact on surrounding properties through the diversion, concentration or ponding of overland flows (i.e. the extent, velocity and the depth of overland flow shall remain unchanged);
- The development shall not impede the passage of overland flow to cause a rise (afflux) in the water levels and / or increase velocities of flow on adjoining lands;
- The development shall accommodate the passage of overland flow over the site and, where applicable, shall be designed to withstand damage due to scour, debris and buoyancy forces;
- The development must not be sited where overland flows may result in a hazardous situation for future occupants in terms of depth and velocity of overland flows through the property (i.e. velocity-depth product greater than 0.4 is not acceptable);
- Overland flows shall be directed through common areas and not through private courtyards or on-site detention systems;
- No structures and / or filling are permitted within the overland flow path unless suitable flood mitigation measures approved by Council are to be implemented;
- Any fencing (including boundary fencing) over the extent of the overland flow path must be replaced with open style fencing or similar to allow the free passage of overland flows;
- Design elements such as concrete or paving shall be used to fix critical levels in overland flow paths to minimise interference by future occupiers; and
- Provision of adequate freeboard to finished floor levels.

2 Flooding and Stormwater Management Strategy

The following matters were considered in relation to flooding:

- Flood affectation of the site from:
    - mainstream flooding from the Nepean River
    - overland flow from the upstream catchments
- overland flowpaths
- flood hazard
- flood impacts of the development on surrounding areas and properties
- site access and emergency evacuation considerations.

2.1 Site topography and flowpaths

The terrain shows fall across the site starting from the eastern boundary of the site near Union Lane and continuing towards Mulgoa Road in a south westerly direction. There is a ridge through the eastern half of the site which grades away to the north and the southern half of the site generally grades in a south-westerly direction, towards Mulgoa Road. There is a continuous fall along the western boundary of the site from south to north and a low ridge exists at the stormwater drainage pit location at the Mulgoa Road boundary.

There are a number of drainage pits along the perimeter of the site that connect to stormwater drainage networks along High St, Union Rd and Mulgoa Rd.

The terrain, drainage networks and flowpaths for the subject site and its surrounds is shown in Error! R eference source not found.

2.2 Flood Context of the Site

2.2.1 Mainstream Flooding

The Nepean River flood levels were obtained from the Nepean River RMA-2 Model Draft Report v3 (WorleyParsons, July 2008, p 45 and p 76) and are shown in **Figure 2-1** and **Figure 2-2**. Flood levels during the 1% AEP event at the site are RL 26.3 m AHD which extends to Mulgoa Rd along the western edge of the site and the site is not affected by mainstream flooding during the 1% AEP event. Flood levels at the site are RL 31.6 m AHD in the PMF and the site would be inundated to depths of between 4.0m to 5.5m.

The Department of Planning & Environment (DPE) and Council have advised that revised flood levels from progressed modelling will be available in the near future and will need to be considered for the development when available. In particular in relation to the PMF and consideration of safe evacuation of the proposed development.

4.4 Flood Surfaces

A selection of peak flood hydraulic parameter surfaces (*water level, depth, velocity & V*d*) are presented in the following figures for Emu Plains/Penrith and Castlereagh.

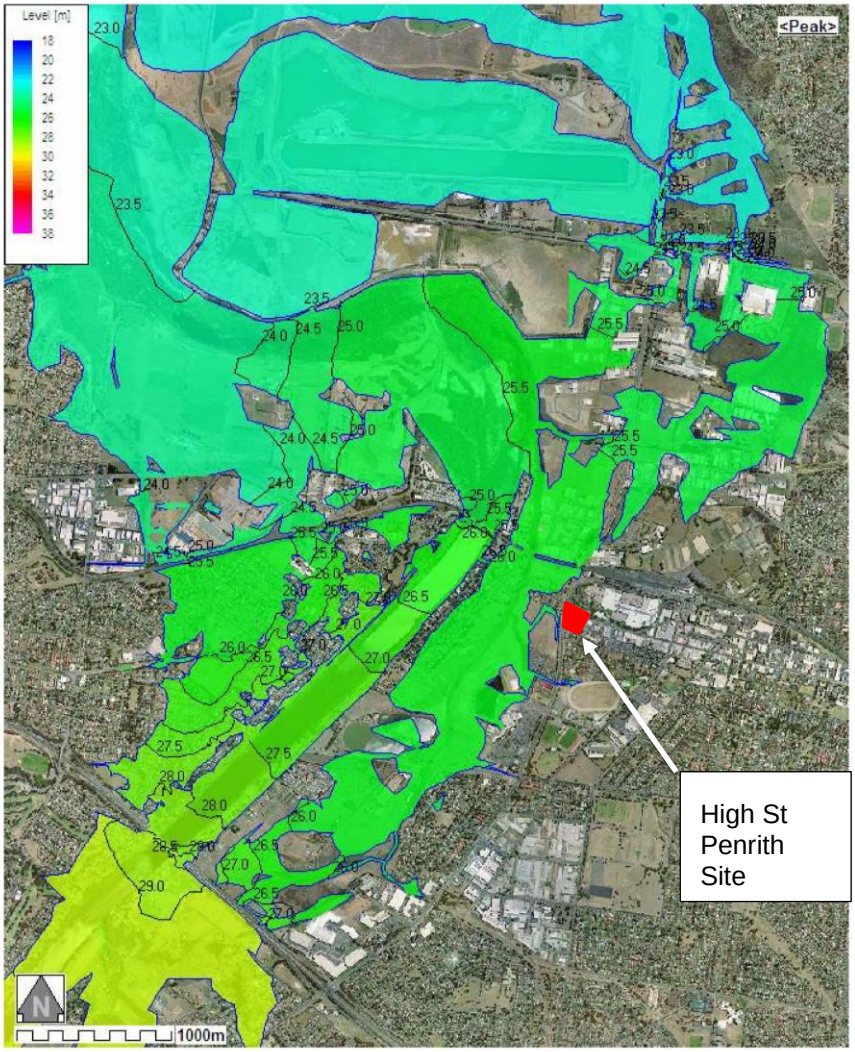

Figure 30 - 100yr ARI Peak Water Surface (Emu Plains & Penrith)

t:\5531 nepean\phase 2-2008\report\rp5531dmc080707-rpt.doc Page 45 5531 : Rev C : 08 July 2008

Figure 2-1 1% AEP Flood Extents from the 2008 Nepean River RMA-2 Model Draft Report v3

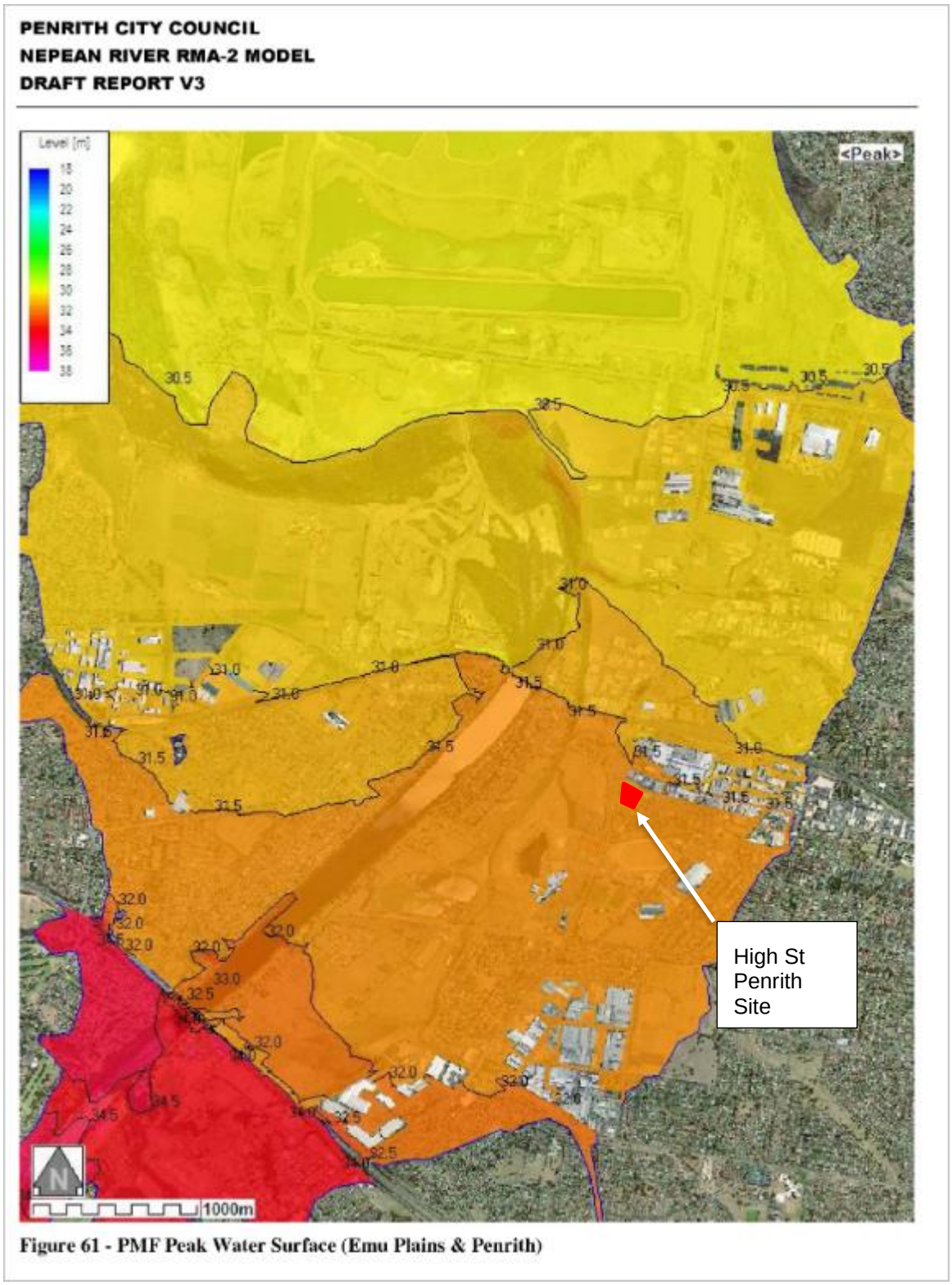

Figure 2-2 PMF Extents from the 2008 Nepean River RMA-2 Model Draft Report v3

2.2.2 Overland Flow

In 2015, Cardno undertook a flood study to define the overland flood behaviour for the entire Penrith CBD on behalf of Penrith City Council, referred to as the Penrith Detailed Overland Flow Flood Study.

The indicative 1% AEP flood depths for the site are shown in **Figure 2-3**, extracted from Figure 8.3 of the final report (Cardno, 2015). The results show that the subject site is partially affected, noting that the results used a 150mm depth filter to define flood extents.

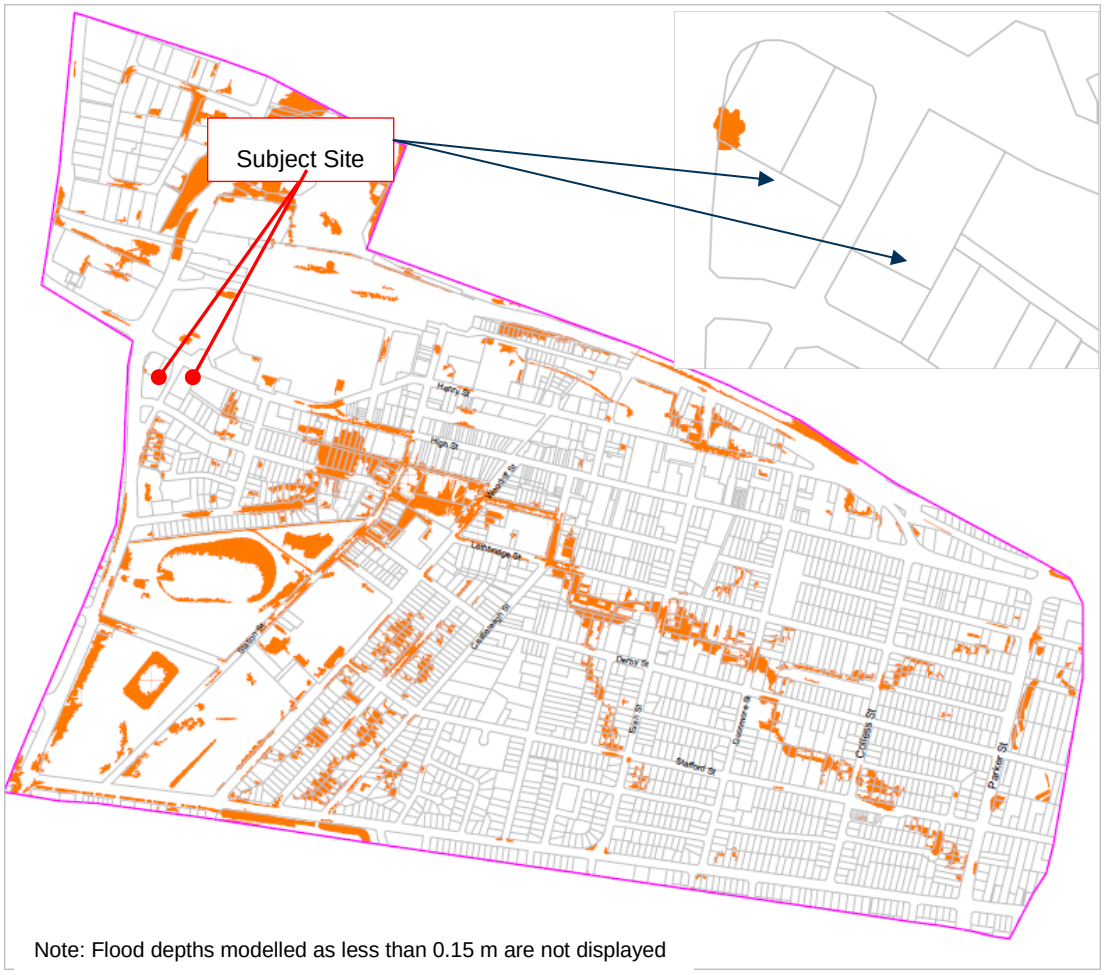

Figure 2-3 1% AEP Flood Extents from the 2015 Penrith Detailed Overland Flow Flood Study

As noted in Section 2.1 of this report, there is a shallow overland flowpath through the site from Union Lane towards Union Rd and Mulgoa Rd. As such, it is necessary to investigate the impacts of development on the site on this overland flowpath and surrounding areas including any mitigation measures to address impacts.

3 Hydrological and Hydraulic Modelling

3.1 Available Data

The following data was used to inform the modelling:

- Hydrology / hydraulic model inputs from the flood model (Cardno, 2015);
- Ground survey of the site prepared by RPS Australia East Pty Ltd dated 30/01/2017 (attached as **Appendix A**);
- Information from a site inspection undertaken on 20/07/2017;
- Architectural drawings for the site provided by TOGA received on 30/09/2021 and concept New Road tin provided by Robert Bird Group on 14/03/2018 (adopted per **Figure 1-2**); and
- Aerial photography of the site recorded by Nearmap in 2017.

3.2 Modelling Approach

In order to assess the flood behaviour of the site, the existing TUFLOW 1D/2D floodplain model was adopted and amended for the proposed development.

3.2.1 Model Topography

The model terrain grid was based on the Flood Study model, with the site and its surrounds informed by ground survey. The civil and surveying package 12d was used to generate a detailed 3D surface (digital terrain model) of the study area. A grid size of 2 m x 2 m was adopted for the study area.

The proposed Stage 1 development modelling was amended based on proposed building layout and the New Road design.

The existing terrain and flowpaths for the subject site and its surrounds is shown in **Figure 3-1** and the proposed terrain is shown in **Figure 3-2**, respectively.

3.2.2 Hydrology

A traditional hydrological XP-RAFTS model was developed for the entire catchment, including the areas upstream of the 2D domain. The primary purpose of this traditional hydrological model is to generate input hydrographs to the 1D/2D hydraulic model in the study area.

The ‘Direct Rainfall’ method (also known as ‘rainfall on the grid’) was used for areas within the 2D domain per the Flood Study (Cardno, 2015) model.

3.2.3 1D Hydraulics

The stormwater pit and pipe network was modelled as 1D elements in the TUFLOW model. Stormwater pit and pipe data for the catchment was adopted per the Flood Study (Cardno, 2015) model. **Figure 3-3 s**hows the 1d stormwater network and model boundary.

3.2.4 Boundary Conditions

The boundary conditions were adopted per the Flood Study (Cardno, 2015) model.

3.2.5 Design Flood Events

The 1% Annual Exceedance Probability (AEP) event and the Probable Maximum Flood (PMF) event were modelled for the purpose of the study.

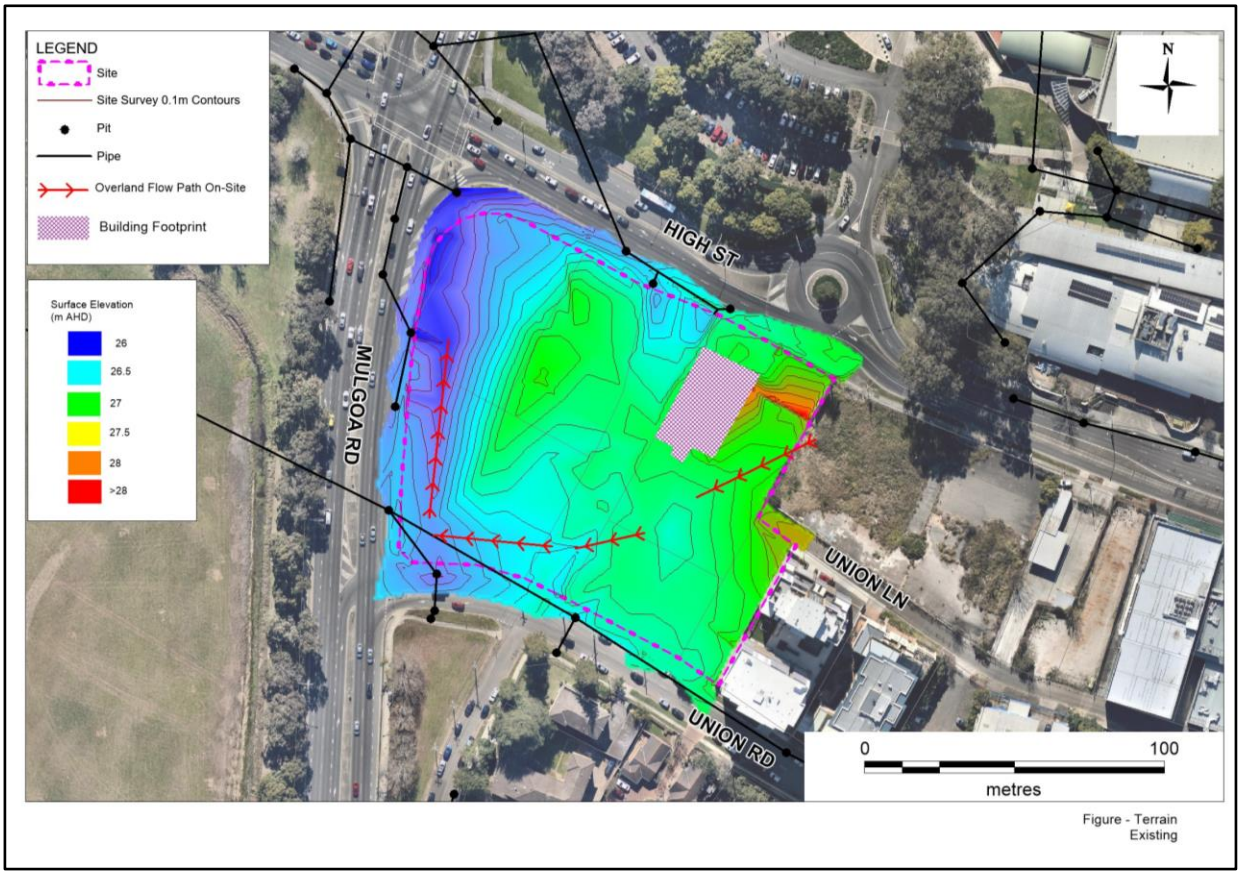

Figure 3-1 Existing Ground Levels

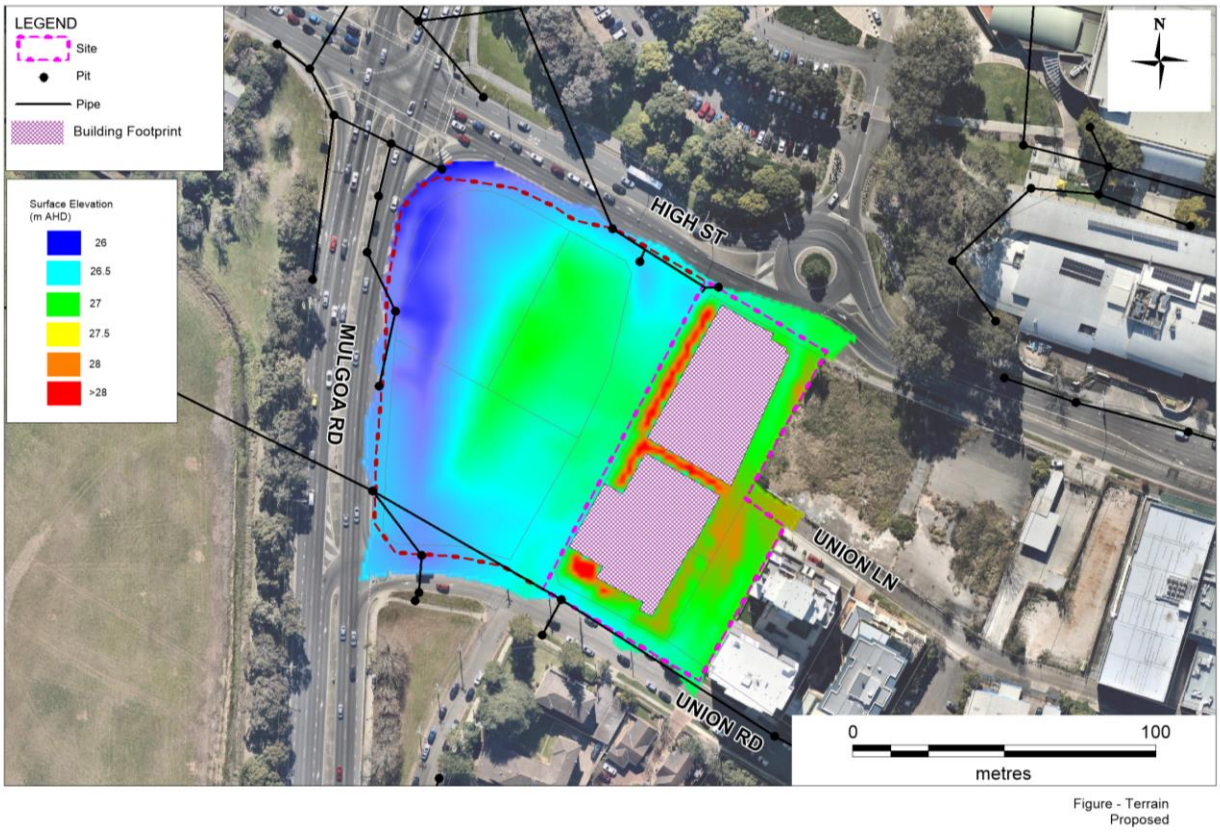

Figure 3-2 Proposed Ground Levels

Figure 3-3 TUFLOW Model 1d stormwater network and model boundary

3.3 Results

Cardno assessed flood behaviour for the noted design flood events under existing and proposed conditions.

3.3.1 Flood Behaviour under Existing Conditions

The site is partially affected by overland flow inundation during a 1% AEP event. Modelling indicates that in a 1% AEP event, runoff is conveyed overland in a south-west direction passing through the site from Union Lane towards the south west corner of the site near Union Road. The runoff continues in a northerly direction along western boundary to the low point of the site joining existing stormwater drainage at Mulgoa Road. The overland flow paths are as shown in **Figure 3-1**. The 1% AEP event and PMF peak water level, depth, velocity and hazard are mapped and shown in **Appendix B**.

The following comments are in relation to the 1% AEP event flood results in and adjacent to the site:

- The water levels along the site boundary range from RL 26.35 to 27.65 m AHD and is summarised in **Table 3-1**.
- The flood depth is less than 0.3 m.
- The flood velocity is below 0.5 m/s which is considered low.
- The provisional hazard is categorised under low hazard.

Table 3-1 – Peak Water Levels and Depths for Existing Scenario

Reference Label on Figure 3-4	1% AEP Peak Water Level (m AHD)	1% AEP Peak Depth (m)
A	27.00	0.15
B	27.05	0.15
C	27.40	0.09
D	27.65	0.07
E	27.40	0.11
F	27.10	0.20
G	26.75	0.15
H	26.50	0.16
I	26.45	0.16
J	26.35	0.21

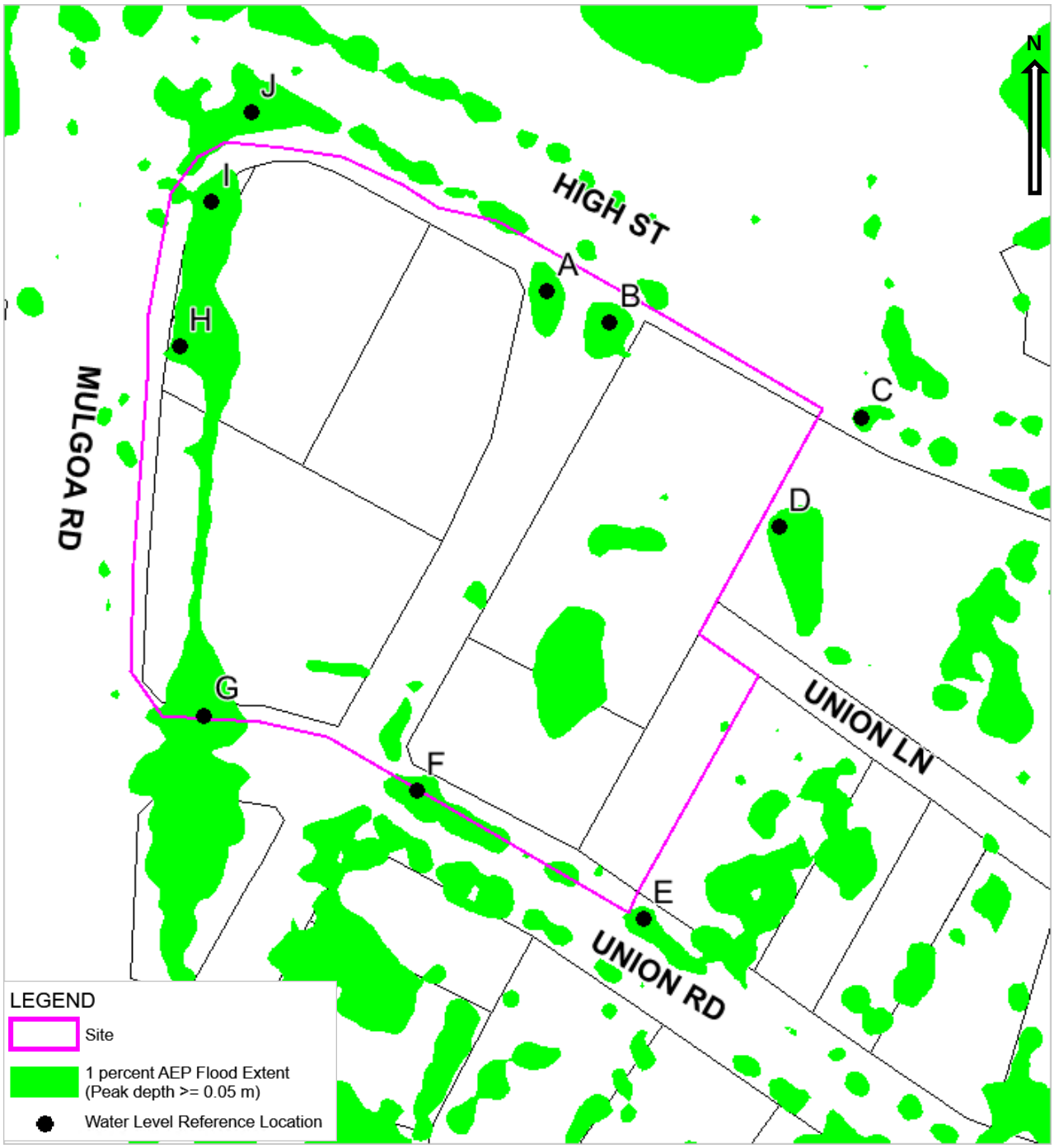

Figure 3-4 Results Extract from 1% AEP Event Existing Flood Model

Note: Flood extent is shown for depth greater or equal to 0.05 m in **Figure 3-4**. The Figures in **Appendix B** show flooding at depths of greater than 0.10 m. Council's adopted overland flow mapping shows depths greater than 0.15 m.

3.3.2 Flood Behaviour under Proposed Conditions

Modelled results of the proposed development have been mapped for the peak water level, depth, velocity and hazard for the 1% AEP and PMF event and are shown in **Appendix B**.

Modelling indicates that in a 1% AEP event, a shallow overland flow approaching the site towards the eastern boundary of the site, near Union Lane, is diverted down the New Road towards High Street. The 1% AEP event water level towards the north east corner of the site at High Street is 27.4 m AHD and along Union Road is 27.10 m AHD.

3.3.3 Impact Assessment

The impact of the development on flooding was assessed by comparing the peak water levels under Existing and Proposed Conditions. The assessed peak flood level differences under the 1% AEP event, is shown in **Appendix B**.

The model results show that the proposed development has reduced the flood level up to 5 cm towards the south west boundary of the site at Union Road. Due to the regrading of ground surface levels along the New Road, the small catchment flows from the eastern boundary of the site, near Union Lane are conveyed towards High Street and captured by the stormwater drainage network. This has resulted in decreases in water levels upstream of the site of up to 5 cm along High Street near Worth Street.

The model results shows that there are minor localised water levels increases of 2 cm to 5 cm at High Street and Union Lane in a 1% AEP event. However, there is no impact to neighbouring properties and flood hazard at the site and in surrounding streets is low for the 1% AEP and the development does not alter the flood hazard in the area.

4 Flood-related Development Controls

A review of Council's DCP in relation to flood impact assessments is presented in Section 1.4. The present section reviews the application of relevant flooding controls on the final form of the development, providing advice on how the development can achieve these.

4.1 DCP Requirements

A summary of the relevant Penrith City Council development controls for a number of development types is presented in **Table 4-1** below.

Table 4-1 Flooding Development Control Summary from Penrith DCP (2014)

Development Type	Floor Level	Materials and Services	Access	Comments for High Street Development
Residential - New Developments - Single Dwellings[1]	Floor levels of habitable rooms shall be at least 0.5 m above the 1% AEP (100 year ARI) flood; i.e. the flood planning level. The lowest floor level of habitable rooms shall be not more than 3.0 m above ground level. A certificate, prepared by a registered surveyor to verify the lowest floor level of a habitable room of a residential building to the required Australian Height Datum (AHD) level, shall be submitted to the Council upon completion of the building to that level. The building shall not be further constructed until approval is given by Council to proceed with construction works.	Any portion of buildings subject to inundation shall be built from flood compatible materials. All services associated with the development shall be adequately flood proofed.	Flood safe access and emergency egress shall be provided to all new developments and for dwelling replacements where practicable. Flood safe access means access that is generally considered satisfactory when the depth of flooding over vehicular driveways and roads is limited to approximately 0.25 m with low velocities.	For the Stage 1 development, there are no residential habitable rooms on the ground floor. All site access driveways and roads have less than 0.25m depth of flooding.
Industrial/ Commercial - New Development	Floor levels shall be at least 0.5m above the 1% AEP (100 year ARI) flood or the buildings shall be flood-proofed to a least 0.5m above the 1% AEP (100 year ARI) flood. If floor levels are below the 1% AEP (100 year ARI) flood level, the text in the below cell applies.		Flood safe access and emergency egress shall be provided to all new developments.	This is the relevant category for the Stage 1 development, which proposes commercial suites at ground level. Floor levels would be based on the adjacent flood levels and ground surfaces.
Industrial/ Commercial - Extensions and	Council may approve of the development with floor levels below the 1% AEP (100 year ARI) flood if it can be demonstrated by the applicant that all practical measures will	Any portion of buildings subject to inundation shall be built from flood		Considered if the site is "infill development". No floor levels proposed below the 1% AEP.

[1] The DCP does not provide commentary on medium or high density residential development.

Development Type	Floor Level	Materials and Services	Access	Comments for High Street Development
Infill Development	be taken to prevent or minimise the impact of flooding. Council will consider matters including: • The nature of the business to be carried out; • The frequency and depth of flooding; • The potential for personal and property loss; • The utility of the building for its proposed use; • Whether the filling of the site or raising of the floor levels would render the development of the property unworkable or uneconomical; • Whether the raising of the floor levels would be out of character with adjacent buildings; and • Any risk of pollution of water from storage or use of chemicals within the building.	compatible materials.		
Change of Use of Existing Buildings	Development consent for change of use of an existing building with floor levels below the 1% AEP (100 year ARI) flood will only be given where it can be demonstrated by the applicant that: There is no foreseeable risk of pollution associated with the proposed use of the building in the event that the 1% AEP (100 year ARI) flood occurs; All practical measures shall be taken to minimise the risk of flood damage to the property within the building by the 1% AEP (100 year ARI) flood. These measures could include: • Flood proofing the building to the level of the 1% AEP (100 year ARI) flood by either construction of a wall or levee bank or some other means of preventing water entry; • Raising the floor level of the building to the level of the 1% AEP (100 year ARI) flood; and/or			This clause is not relevant to the site as the use of existing buildings is not proposed. The development considers a mix of new commercial/retail and residential apartments.

Development Type	Floor Level	Materials and Services	Access	Comments for High Street Development
	• Storing all equipment, machinery and stock above the 1% AEP (100 year ARI) flood level.			
Residential Accommodation and Caravan Parks	Applications for residential accommodation, defined in the LEP, with the exception of dwelling houses, will be treated as per subdivisions. Applications for caravan parks will also be treated as per subdivisions. Other land uses which may attract large numbers of people. Council will generally not support an application for any land use which may attract large numbers of people (including schools, function centres, child care centres, hostels, etc.) on land below the flood planning level and on land that cannot be safely and effectively evacuated during a 1% AEP (100 year ARI) flood event.			The development land is on land that is below the flood planning level. However, safe evacuation during the 1% AEP can be demonstrated.
Subdivision	Generally, subdivision of land below the flood planning level will not be supported. Further provisions relating to the proposed subdivision of such land can be found in the Subdivision Section of this Plan.			Not applicable.
Storage of Potential Pollutants above 1% AEP (100 year ARI) Flood	All potential pollutants that are stored or detained on-site (such as on-site effluent treatment plants, pollutant stores or on-site water treatment facilities) should be stored above the 1% AEP (100 year ARI) flood. Details must be provided as part of any application to Council.			This clause may be relevant to possible future commercial uses at the site.
Access to Basement Parking	Access to basement parking shall have an entry threshold a minimum of 300 mm (0.3 m) above the top of the kerb. The threshold shall be increased within areas of flooding or local overland flows to a minimum of 300 mm (0.3 m) above the flood level. The design of the development shall ensure that floodwater cannot enter the car park in a 1% Annual Exceedance Probability (AEP) flood event.			The required basement parking driveway crest levels for the site would be 300 mm (0.3 m) above the relevant 1% AEP flood level. For Stage 1 development this is relevant for the basement entry via New Road.

4.2 Flood Planning Level Requirements

The Penrith Local Environment Plan (LEP) (2010) defines the Flood Planning Level as "*the level of a 1:100 ARI (average recurrence interval) flood event plus 0.5 metres freeboard.*" This level is frequently referred to in Council's Development Controls.

The proposed Stage 1 development consists of commercial/retail suites on the ground floor and residential apartments on upper floors with basement parking entry on Union Rd and podium parking entry on New Road adjacent to Union Lane.

The site is subject to both overland flooding and flooding that occurs from the Nepean River and these levels may govern flood planning.

4.2.1 Finished Floor Levels

The Nepean River flood levels at the site are RL 26.3 m AHD in the 1 % AEP flood and RL 31.6 m AHD in the PMF based on the Nepean River RMA-2 Model Draft Report v3 (WorleyParsons, July 2008, p 45 and p 76). The 1% AEP flood levels from the 2008 Nepean River RMA-2 Model Draft Report v3 are shown in **Figure 2-1**. 1% AEP Nepean River flooding is lower than the Stage 1 site and is not considered in setting flood planning levels.

It is noted that the nearest adjacent overland flow 1% AEP flood levels defined by Council flood maps is RL27.1m AHD which sets a minimum flood planning level for the site of 27.6m AHD. These flood extents filter out flow depths less than 150mm and hence do not show any flood levels adjacent to the site.

The local 1% AEP flood levels due to overland flow around the site are defined in this report and range from RL 26.3 m AHD at the northwest corner of the site (at the corner of High St and Mulgoa Rd) to RL 27.65 m AHD at the eastern boundary near Union Lane. However, flows around the site are generally of shallow depth and confined to the roads. There are locations along High St and Union Rd that have flow depths of 150mm or just less than 150mm. Whilst this is below Council's classification of overland flow it must be taken into account with the road levels and determining appropriate entry levels.

While the flow depths are shallow, there is a risk of blockage of the drainage system, diversion from other catchments and additional flows from rainfall against building walls of future adjacent developments, and wave action from cars driving through water on roads which could lead to higher flow depths. As such, it is prudent to ensure floor levels are set above the top of kerb level and grade back towards the street.

The current design has top of kerb levels adjacent to Union Lane of approximately RL 27.65m AHD. Allowing for grading up to the development entry locations, a Finished Floor Level of 27.85m AHD at ground floor level for the Commercial properties, lift wells and driveway entrances are appropriate at this location. This will prevent any rainfall on the public domain areas or overtopping flows from the street from entering the development.

The top of kerb level and flood levels at the corner of the New Road and High St are approximately 27.42m AHD. Flow depths under the proposed development scenario are 150mm at this corner and so a Finished Floor Level of RL 27.85m AHD provides for a 430mm freeboard above the top of kerb level and flood levels which comply with Council's LEP and DCP.

It is understood that the development needs to maintain a single finished floor level and the floor level is also constrained by the On Site Detention (OSD) levels and hence a single FFL of 27.85m AHD is to be adopted.

This proposed FFL of 27.85m AHD is appropriate as it is:

- above the minimum flood planning level derived from Council flood maps;
- provides 430mm freeboard from local flow depths along High St; and,
- provides a suitable freeboard above the ground surface and top of kerb levels for the New Road adjacent to Union Lane to prevent ingress of stormwater from the road.

4.2.2 Basement Parking

For the Stage 1 development, the basement entry via New Road requires the crest level at RL 27.50 m AHD (1% AEP flood level of 27.20 m AHD plus 0.3m). Basement entry reference location is shown in **Figure 4-1**.

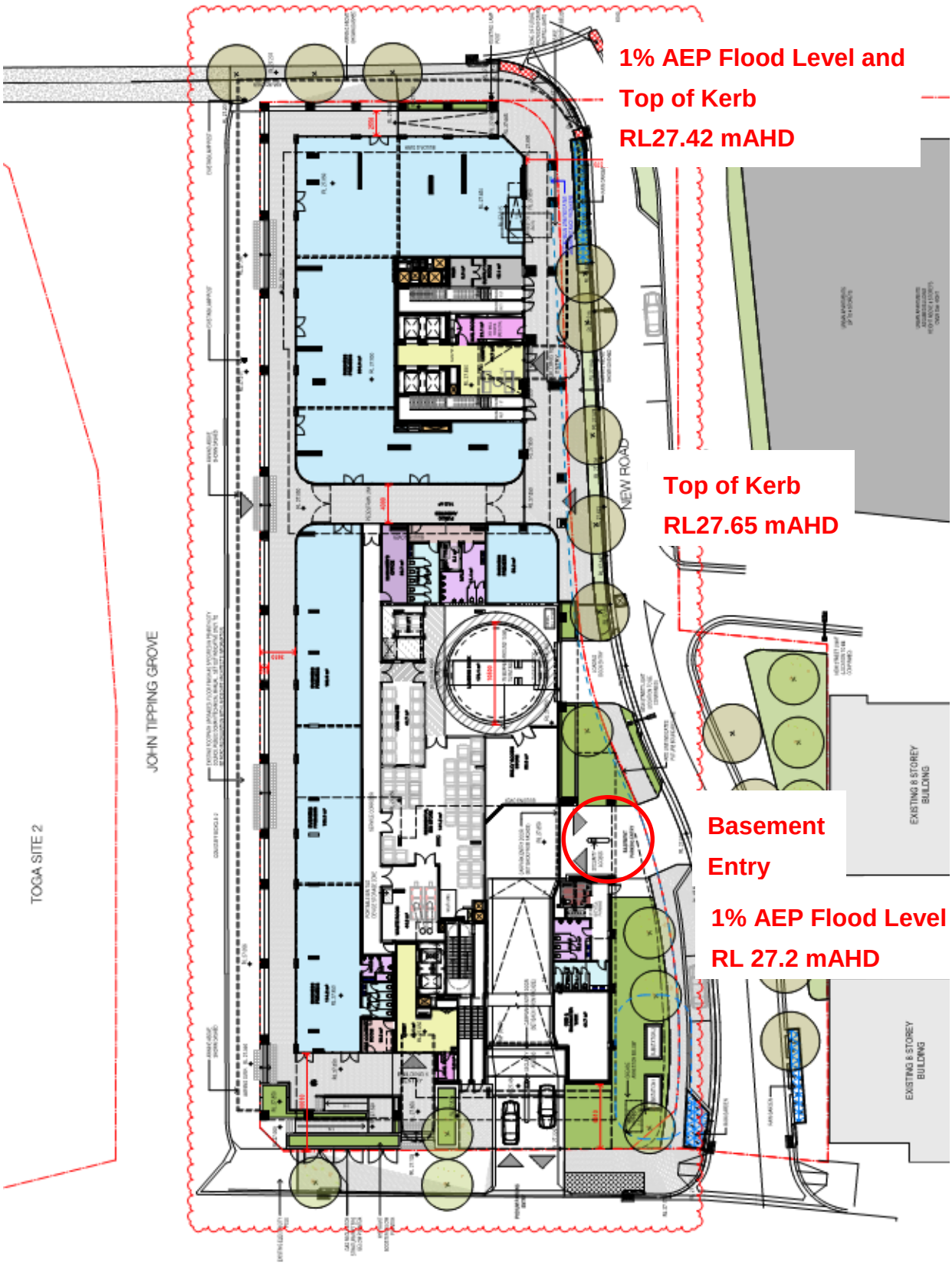

Figure 4-1 Flood Planning Level Reference Locations

4.3 Flood Planning Controls for PMF

Penrith City Council adopts a merits based approach to considering planning controls for the PMF. The Penrith DCP (2014) states:

"Developments that may have a significant impact on the extent of flooding experienced by nearby or downstream properties may be asked to consider floods larger than the 1% AEP (100 year ARI) flood event. Significant areas of Penrith are affected by the Probable Maximum Flood (PMF) and in some cases this will need to be considered in determining flood hazard."

Although not specified in the DCP, Cardno notes that the use of the proposed development may also be considered in determining floor level control for the PMF. Sensitive uses, where occupants may be less able to evacuate in an emergency may need to be elevated above the PMF.

4.4 Site access and evacuation

The site remains effectively flood free in a 1% AEP and no evacuation would be anticipated with respect to overland flooding. During mainstream flood events greater than the 1% AEP up to the PMF, the general strategy for evacuation would be evacuation via the road networks during the flood warning period and shelter in place as a backup for those not able to evacuate in time. The creation of multistorey buildings would allow residents to seek refuge within the development. People on the ground floor of the proposed buildings would evacuate vertically within each building and shelter in place at a level above the PMF until the flood subsided. For the Stage 1 development, the proposed second floor levels would be above the PMF level of 31.6m AHD (WorleyParsons, July 2008, p 76), allowing people to move above the flood during main stream flooding.

It is noted that the proposed Stage 1 development ground floor levels of 27.85m AHD and driveway crest level of 27.75 m AHD are above the overland flow PMF event levels. Hence, considering the short warning times for overland flooding, evacuation would not be possible and shelter in place would be suitable given the short time of inundation during such events.

A suitable flood warning system would be required, in association with a flood emergency response plan, to avoid reliance on the SES or other emergency services. Provision of suitable shelter space on site would minimise strain on emergency services and roads during flood events.

4.5 Mitigation Strategies

The proposed development has considered the flood affectation of the site along with overland flowpaths and design surface levels have been developed to ensure reduction in flood impacts. The New Road has been designed to direct any flows from the eastern boundary of the site, near Union Lane towards High Street. The proposed development plans do not have a significant impact of flooding and as such, additional mitigation strategies are not required or recommended. In some cases, where raising of the floor levels or crest levels of driveways would render the development of the property unworkable or uneconomical, other mitigation options such as levees or flood barriers can be considered.

These mitigation options are of a last resort and should only be adopted if achieving required levels is unfeasible.

Cardno recommends the proposed development adhere to the floor levels and crest levels stipulated in the DCP rather than adopting flood mitigation strategies.

5 Conclusion

Overland flow flood modelling was undertaken for the 1% Annual Exceedance Probability (AEP) and the Probable Maximum Flood (PMF) event.

An impact assessment determined that the proposed development represents an opportunity to improve flooding conditions along High Street and Union Road near Mulgoa Road which will be of benefit to the local community with no adverse flood impacts with the exception of localised minor impacts between 2 cm to 5 cm at Union lane and High Street, site frontage. Grading of the New Road would provide a continuous overland flow path and reduce flood levels.

The proposed development would improve the flood immunity of the site compared to existing conditions. Further, the development would provide on-site shelter to minimise the strain on emergency services and roads during flood events.

It is concluded that the proposed development complies with Council requirements as flood levels due to overland flow are not increased by more than 10 cm (0.1 m) by the proposed development, as outlined in **Section 1.4**.

The report has also outlined the requirements for building floor levels (typically above RL 27.85 m AHD) and Union Rd basement driveway crest level of 27.45m AHD for the Stage 1 development plan.

6 References

Cardno (2015). *Penrith Detailed Overland Flow Flood Study*

Penrith City Council (2014). *Penrith Development Control Plan 2014*

WorleyParsons (2008). *Nepean River RMA-2 Model Draft Report v3 2008*

7 Glossary

Average Recurrence Interval (ARI)	The long-term average period between occurrences equalling or exceeding a given value. For example a 20 year ARI flood would occur on average once every 20 years.
Annual Exceedance Probability (AEP)	The probability of an event occurring or being exceeded within a year. For example a 5% AEP flood would have a 5% chance of occurring in any year. An approximate conversion between ARI and AEP is provided.

AEP	ARI
63.2 %	1 year
39.3 %	2 year
18.1 %	5 year
10 %	10 year
5 %	20 year
2 %	50 year
1 %	100 year
0.5 %	200 year
0.2 %	500 year
0.0001-0.00001 %	PMF (10,000 -100,000 year)

Exceedances per Year (EY)	The number of times per year a threshold is exceeded.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Flood	The covering of normally dry land with water from a stream, river, estuary, lake, dam, major drainage and/or due to super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Freeboard	A height added to flood levels to provides reasonable certainty that the risk exposure accepted by deciding on a particular flood is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, driveway crest levels, etc.
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.
Frequent floods	More frequent than 14% AEP.
Intermediate floods	Between 3.2% and 14.4% AEP.
Rare floods	Rarer than 3.2% AEP.
Extreme floods	Less frequent than 1% AEP (up to and including the PMF).

High Street, Penrith

APPENDIX A

EXISTING SITE SURVEY

WESTERN SITE		EASTERN SITE	
LOT 12	DP717196	LOT 1	DP544302
LOT 13	DP717196	LOT 1	DP1202310
LOT 3	DP242506	LOT 2	DP1202310
LOT 36	DP731213		
AREA 7146m²		AREA 5406m²	

INDICATIVE AREA OF RMS ROAD WIDENING PROPOSAL

TITLE AFFECTATIONS

LOT 12 IN DP717196 IS AFFECTED BY A RESTRICTION ON THE USE OF LAND, LIMITING ACCESS TO PUBLIC ROAD.
LOT 13 IN DP717196 IS AFFECTED BY A COVENANT, LIMITING ACCESS TO PUBLIC ROAD.

SHORT LINE TABLE

NUMBER	BEARING	DISTANCE
1	209°16'30"	1.41
2	299°00'	0.285

REVISIONS					
No.	DATE	REVISION DETAILS	DRAWN	CHK	APP
A	01.02.2017	INITIAL VERSION	CPM	CPM	CPM

HORIZ. SCALE: 1:300 | VERT. SCALE: N/A @ A1
COORDINATES: MGA | DATUM: AHD
ORIGIN: PM12651 | ORIGIN: PM12651
6 3 0 6 12 18
SCALE IN METRES AT ORIGINAL REDUCTION RATIO

NOTES:
- ANY ELECTRONIC FILE IS PROVIDED WITHOUT WARRANTY AND SHOULD BE USED ONLY IN CONJUNCTION WITH THE SUPPLIED PDF/PAPER COPY OF THIS PLAN.
- NO BOUNDARY SURVEY HAS BEEN UNDERTAKEN.
- BEARINGS, DIMENSIONS AND AREA ARE FROM TITLE ONLY AND ARE SUBJECT TO CONFIRMATION BY BOUNDARY SURVEY.
- SERVICES SHOWN ARE INDICATIVE ONLY. POSITIONS ARE BASED ON SURFACE INDICATOR(S) LOCATED DURING FIELD SURVEY. CONFIRMATION OF THE EXACT POSITION SHOULD BE MADE TO THE RELEVANT AUTHORITIES PRIOR TO ANY EXCAVATION WORK. OTHER SERVICES MAY EXIST WHICH ARE NOT SHOWN.
- RIDGE, EAVE & GUTTER HEIGHTS HAVE BEEN OBTAINED BY AN INDIRECT METHOD AND ARE ACCURATE TO ± 0.05m.
- ADJOINING DWELLING, BUILDING HAVE BEEN PLOTTED FOR DIAGRAMMATIC PURPOSES ONLY.
- CONTOURS ARE AN INDICATION OF LANDFORM AND SHOULD NOT BE TAKEN IN PREFERENCE TO SPOT LEVELS SHOWN.
- CONTOUR INTERVAL 0.25m MINOR AND 1.0m MAJOR

CLIENT: TOGA

SURVEY:	AG	DATE OF SURVEY:	30.01.2017
DRAWN:	CPM	DATE OF PLAN:	01.02.2017
CHECKED:	CPM	DATE LAST SAVED:	01.02.2017
APPROVED:	CPM	DATE APPROVED:	01.02.2017

TITLE: TOPOGRAPHIC SURVEY OF 640-652, 634 – 638 HIGH STREET AND 87 – 91 UNION ROAD. BEING LOTS LOT 12 AND 13 IN DP717196, LOT 36 IN DP731213, LOT 3 DP242506 LOTS 1 AND 2 IN DP1202310 AND LOT 1 IN DP544302

DRAWING No: PR135128_DTL.dwg

JOB No: PR135128 | ISSUE: A

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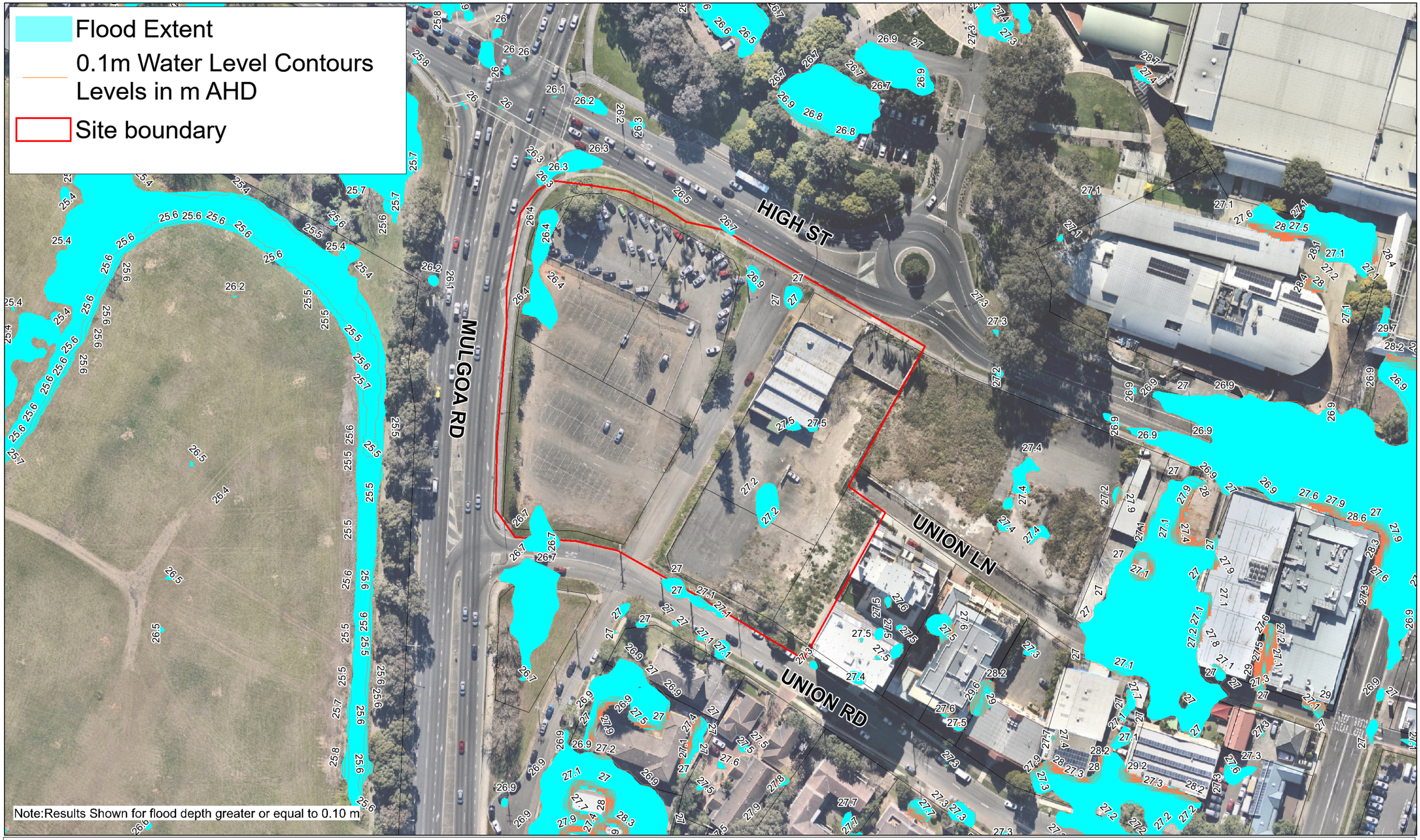
High Street, Penrith

APPENDIX B

FIGURES



Existing 1% AEP Flood Exent and Water Level Contours
Figure B1

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56

Flood Extent

0.1m Water Level Contours
Levels in m AHD

Site boundary

HIGH ST

MULGOA RD

UNION LN

UNION RD

Note:Results Shown for flood depth greater or equal to 0.10 m

N

W E

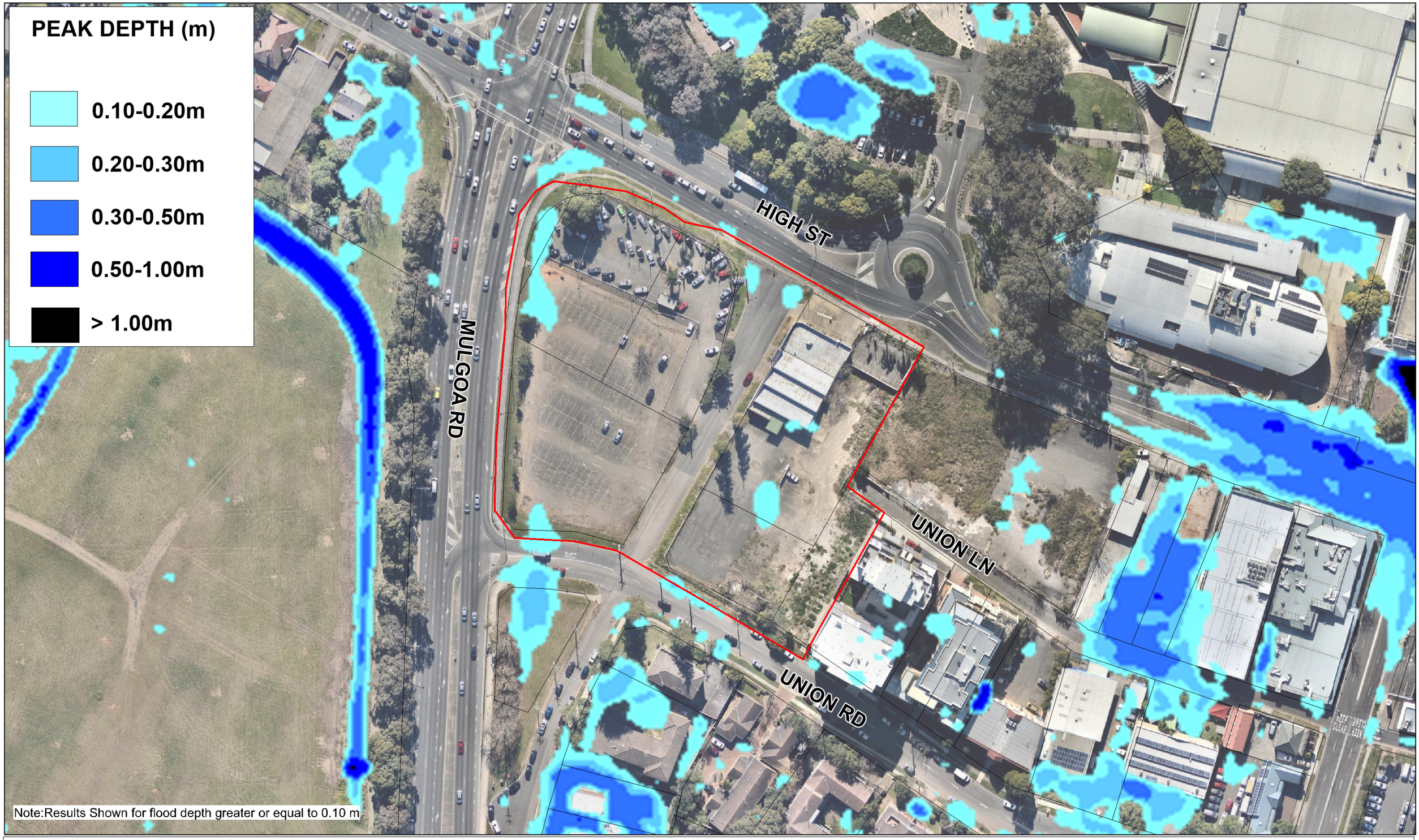
S

Existing PMF Exent and Water Level Contours
Figure B2

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56



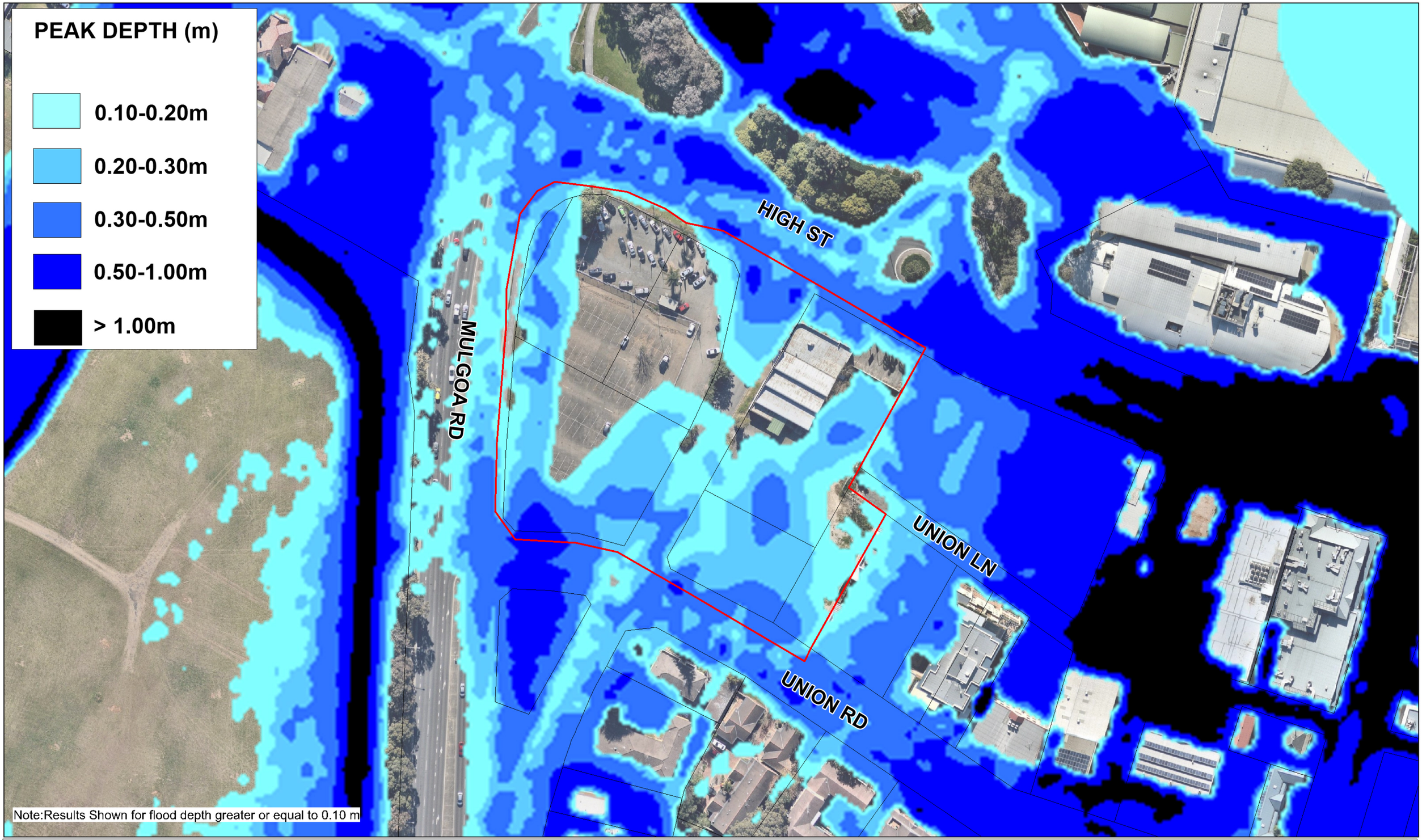
N
W E
S

Existing 1% AEP Flood Depth
Figure B3

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56



N
W E
S

Existing PMF Flood Depth
Figure B4

High Street Penrith Flood Impact Assessment

Cardno

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Project:59918011
Coordinate System: MGA Zone 56

Existing 1% AEP Flood Velocity
Figure B5

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
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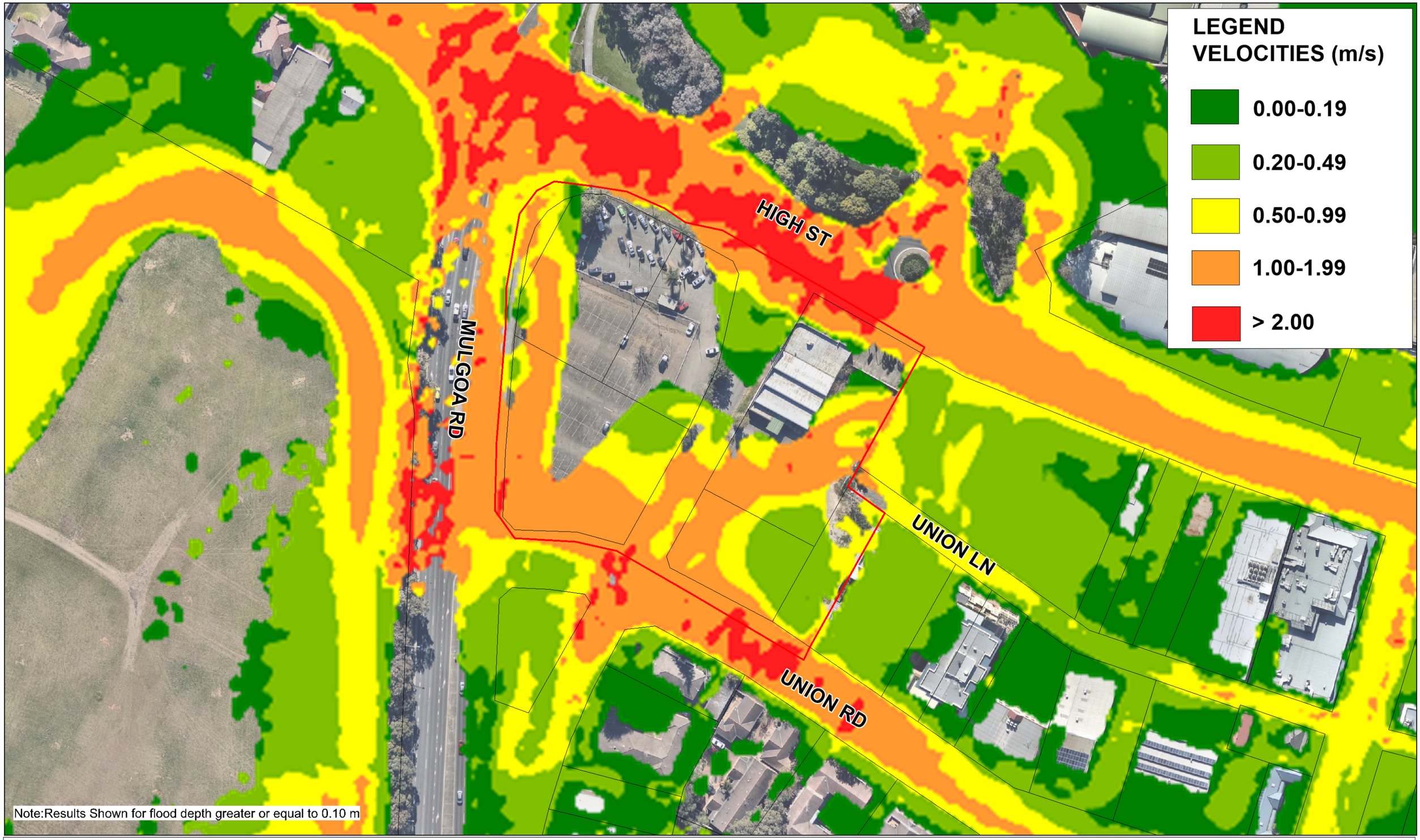
Project:59918011
Coordinate System: MGA Zone 56



Existing PMF Flood Velocity
Figure B6

High Street Penrith Flood Impact Assessment

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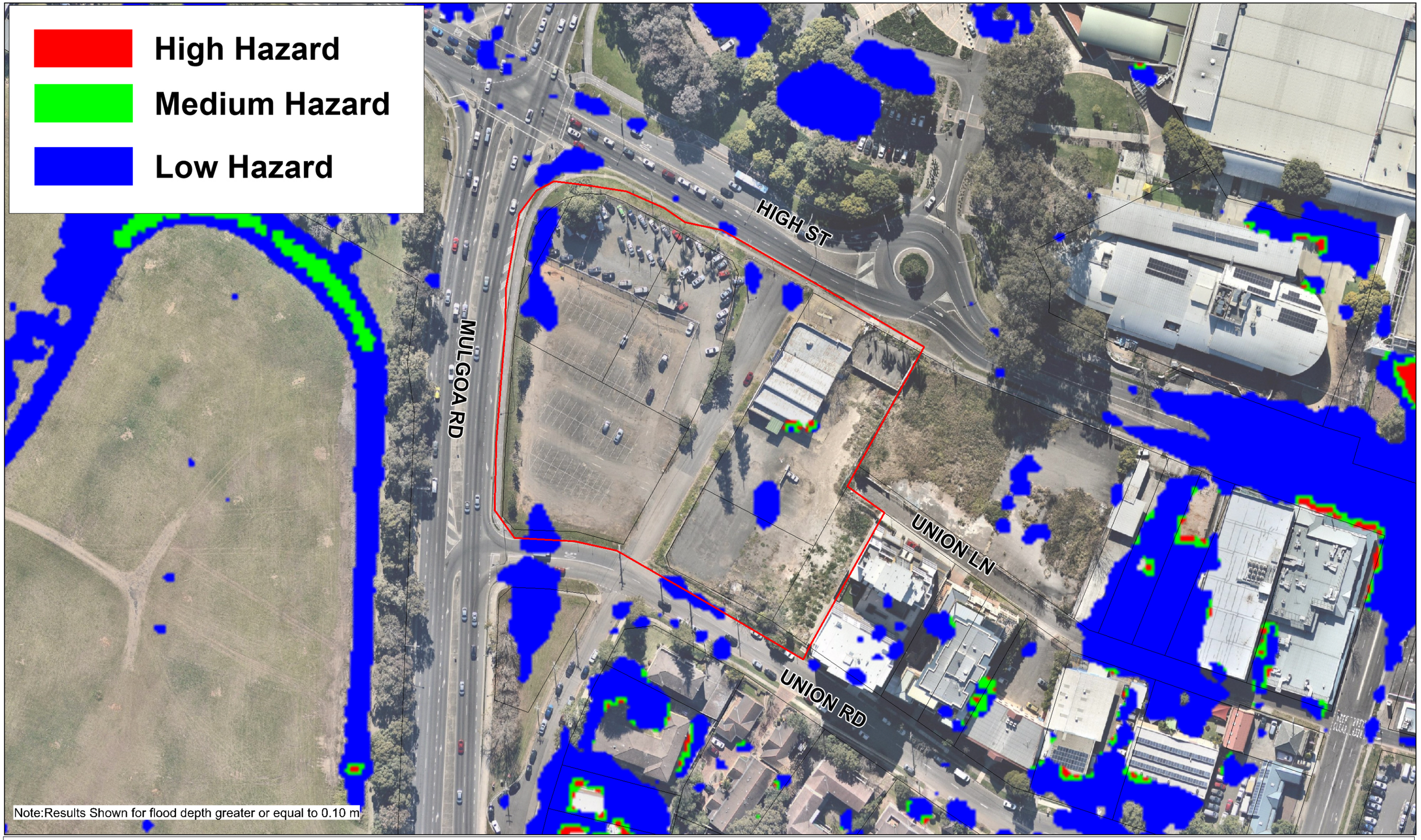
Coordinate System: MGA Zone 56

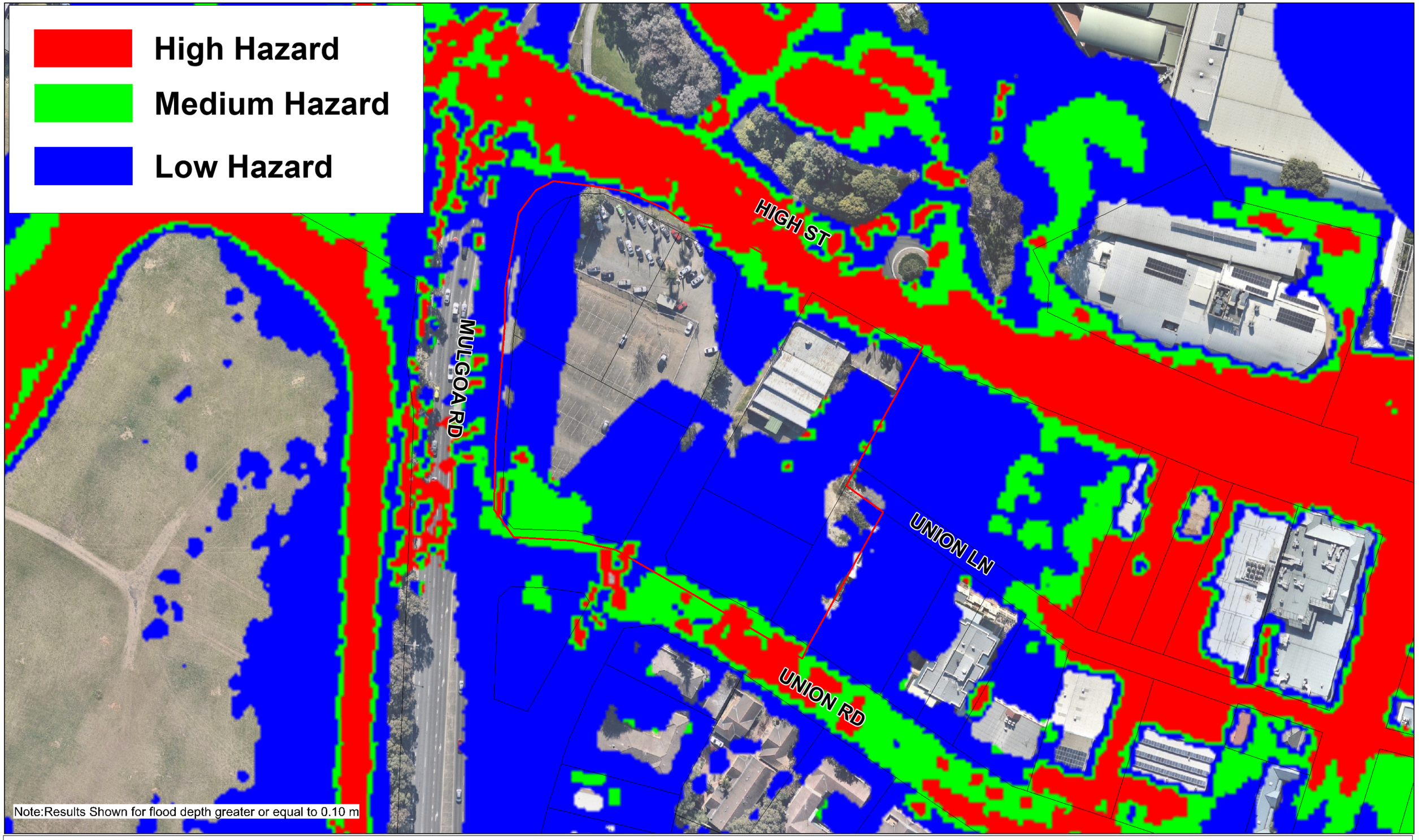


Existing 1% AEP Flood Hazard Map
Figure B7

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56



Existing PMF Hazard Map
Figure B8

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
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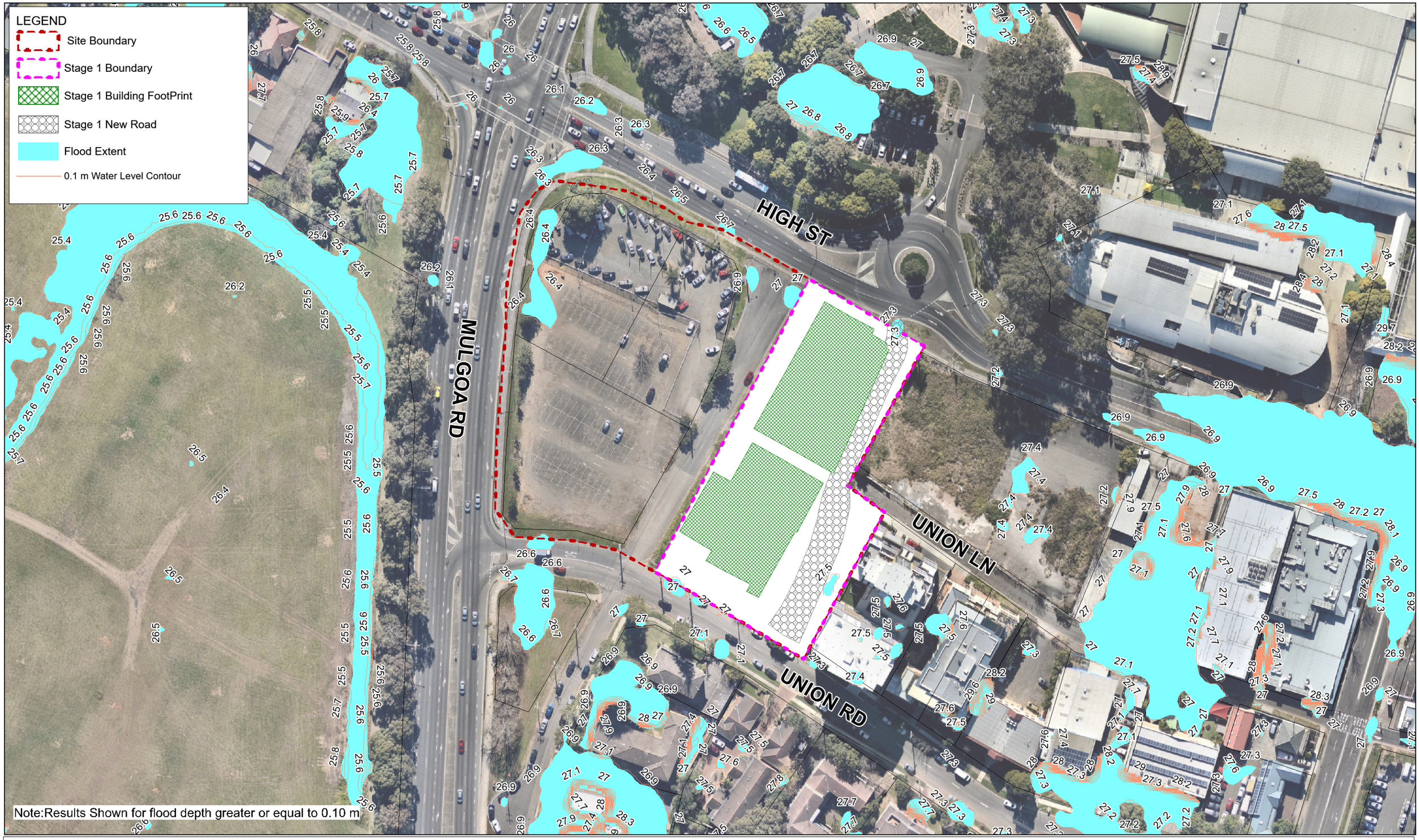
Coordinate System: MGA Zone 56



Proposed 1% AEP Flood Exent and Water Level Contours
Figure B9

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56

LEGEND

- Site Boundary
- Stage 1 Boundary
- Stage 1 Building FootPrint
- Stage 1 New Road
- Flood Extent
- 0.1 m Water Level Contour

HIGH ST

MULGOA RD

UNION LN

UNION RD

Note:Results Shown for flood depth greater or equal to 0.10 m

N

W E

S

Proposed PMF Flood Exent and Water Level Contours
Figure B10

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
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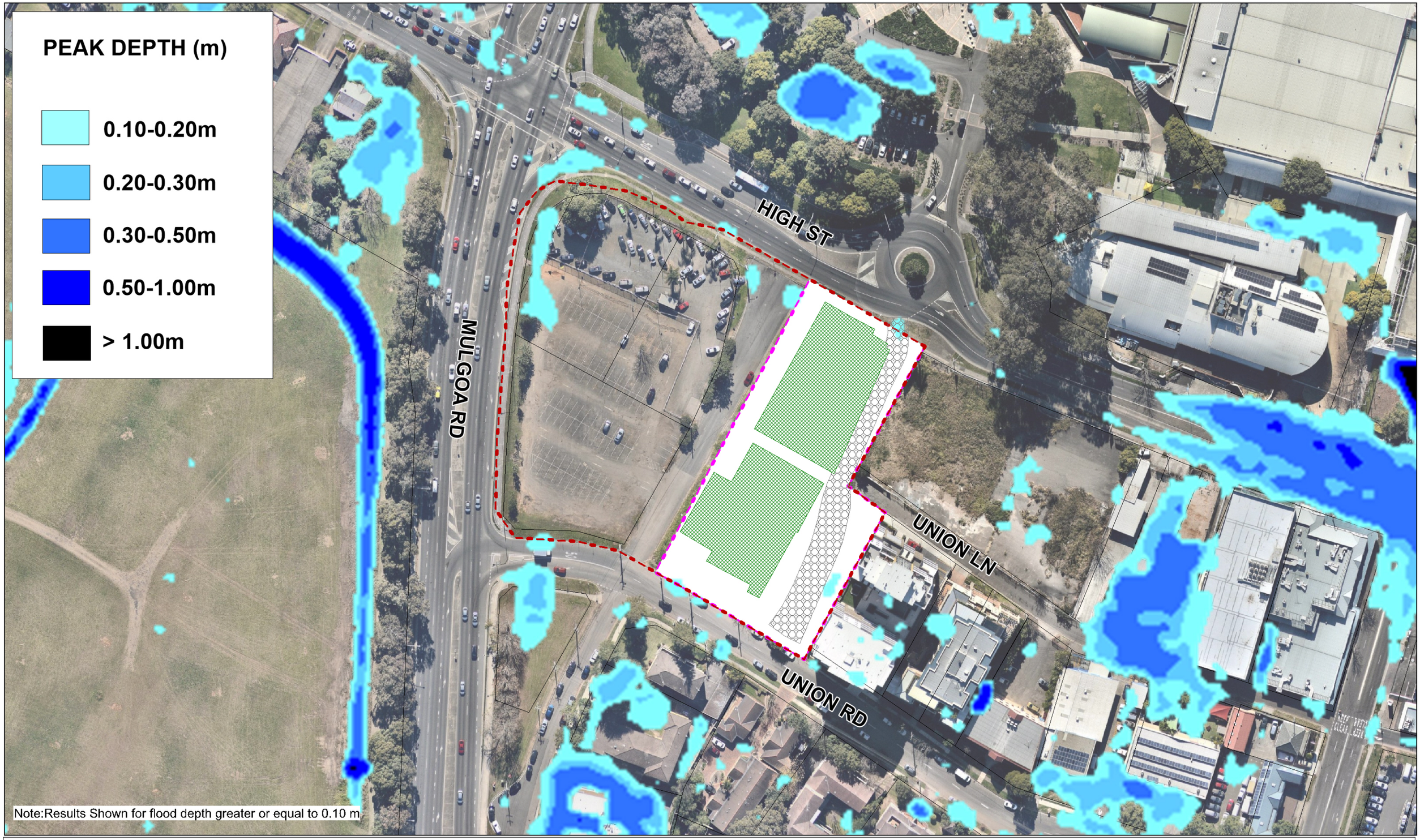
Project:59918011
Coordinate System: MGA Zone 56



Proposed 1% AEP Flood Depths
Figure B11

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
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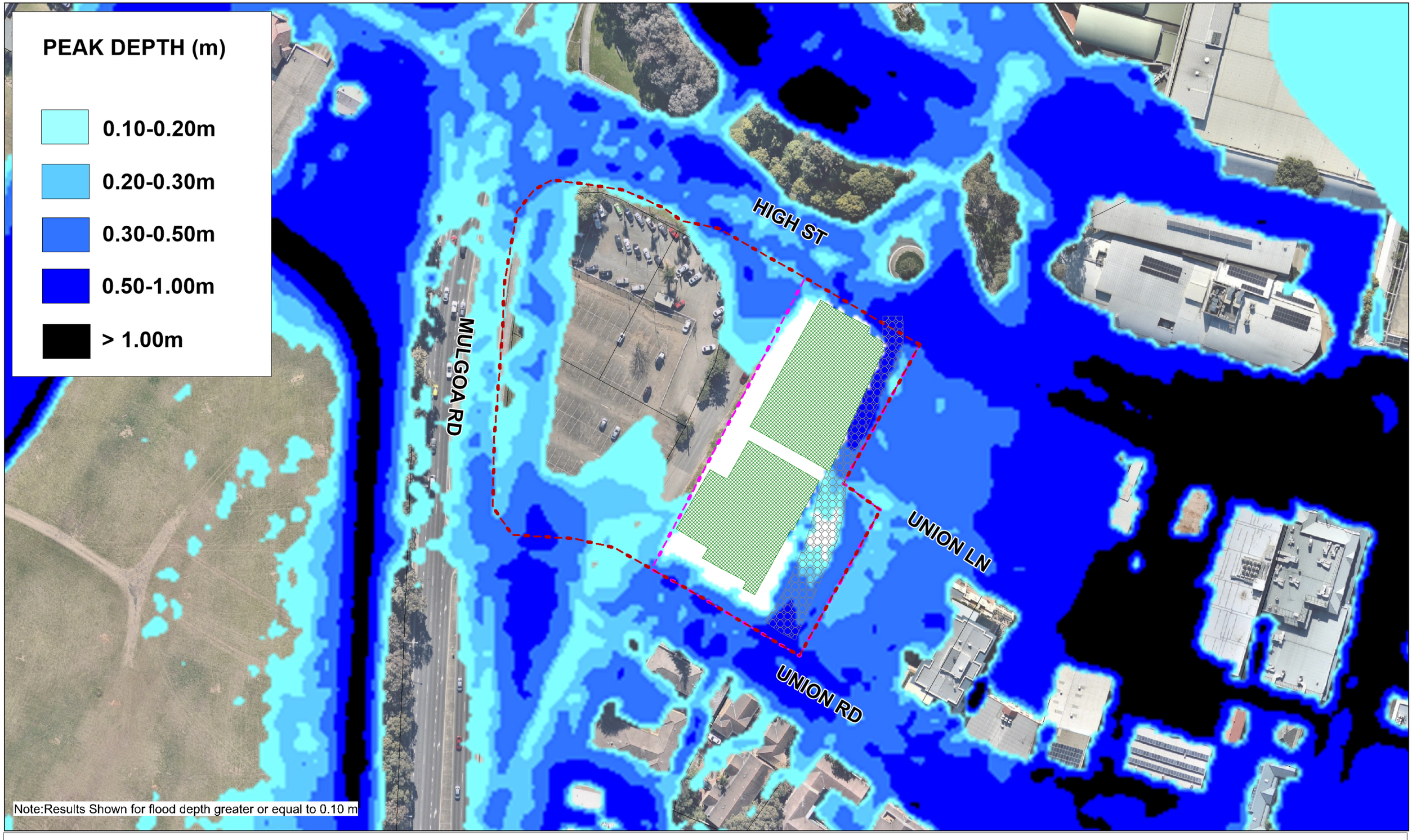
Project:59918011
Coordinate System: MGA Zone 56

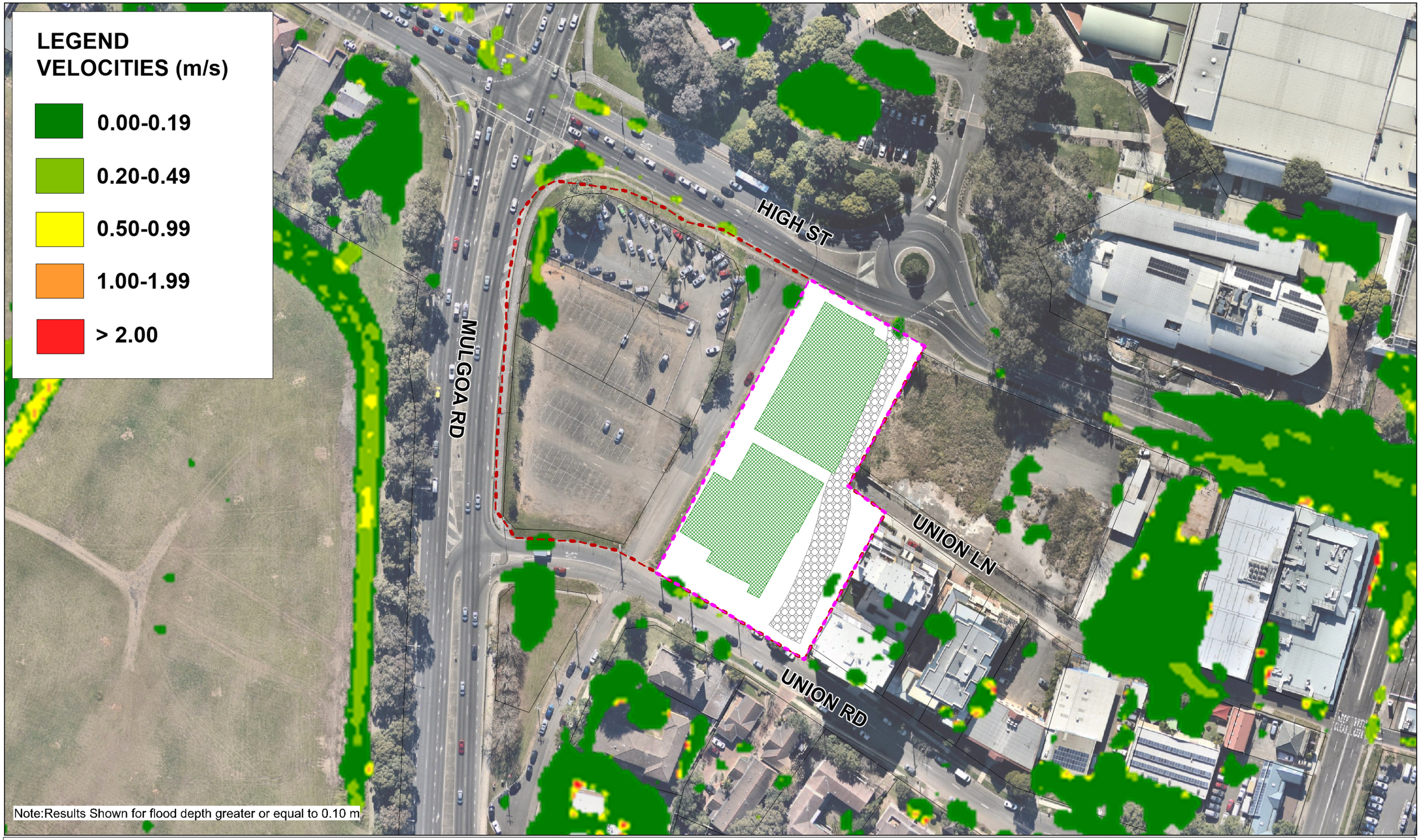


Proposed PMF Depths
Figure B12

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56

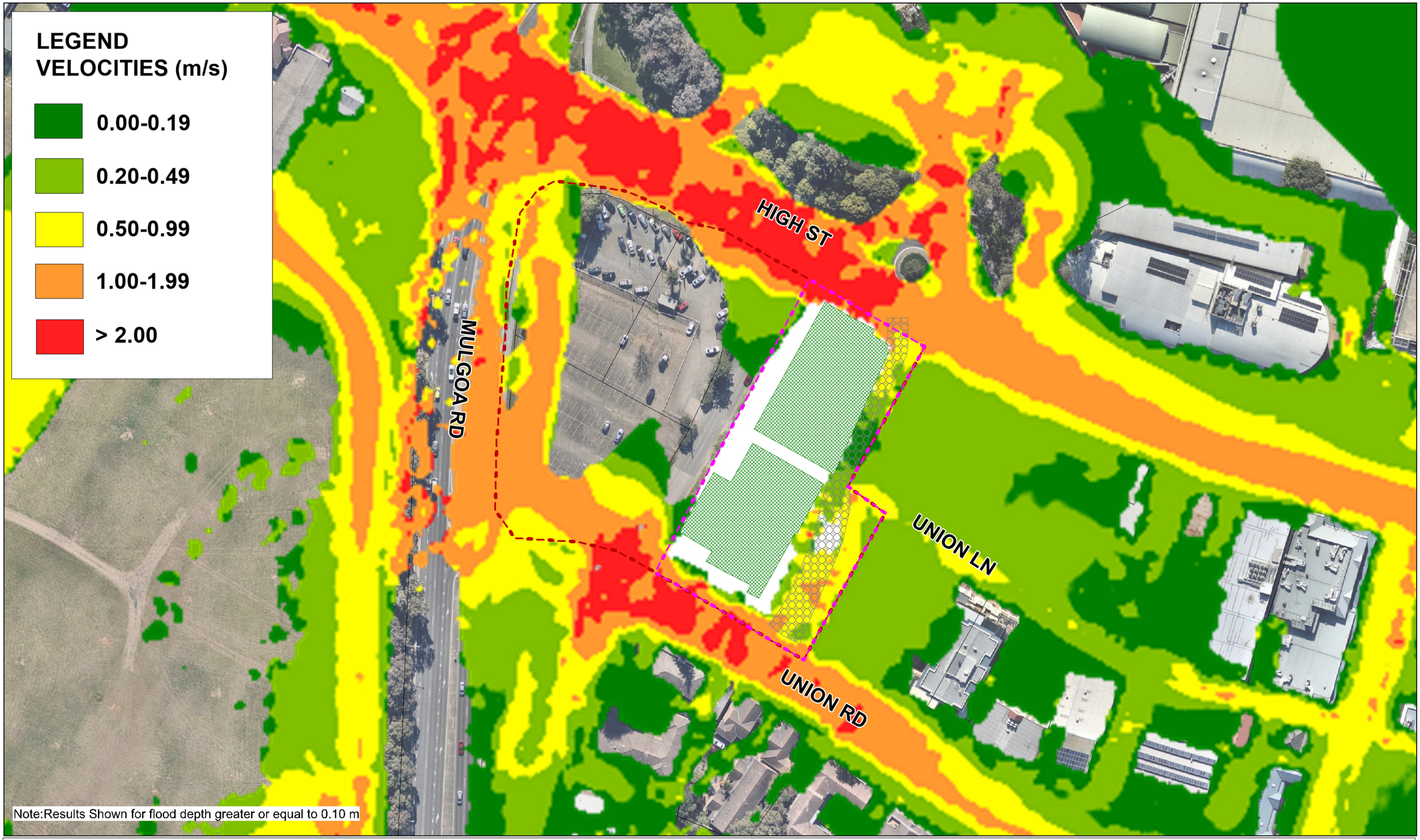


Proposed 1% AEP Flood Velocity
Figure B13

High Street Penrith Flood Impact Assessment

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56



Proposed PMF Velocity
Figure B14

High Street Penrith Flood Impact Assessment

Map Produced by Cardno NSW/ACT Pty Ltd
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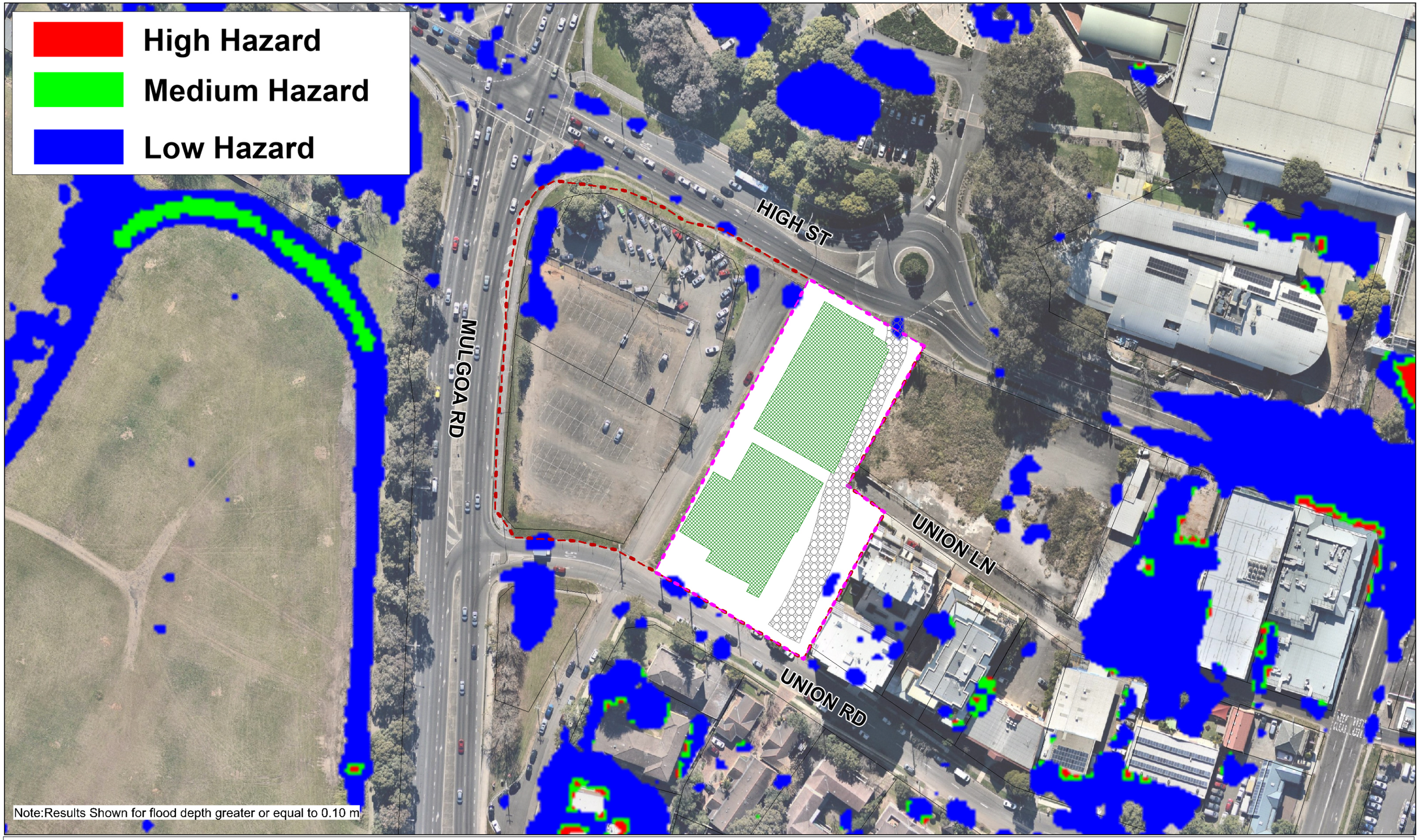
Project:59918011
Coordinate System: MGA Zone 56



Proposed 1% AEP Flood Hazard Map
Figure B15

High Street Penrith Flood Impact Assessment

Cardno

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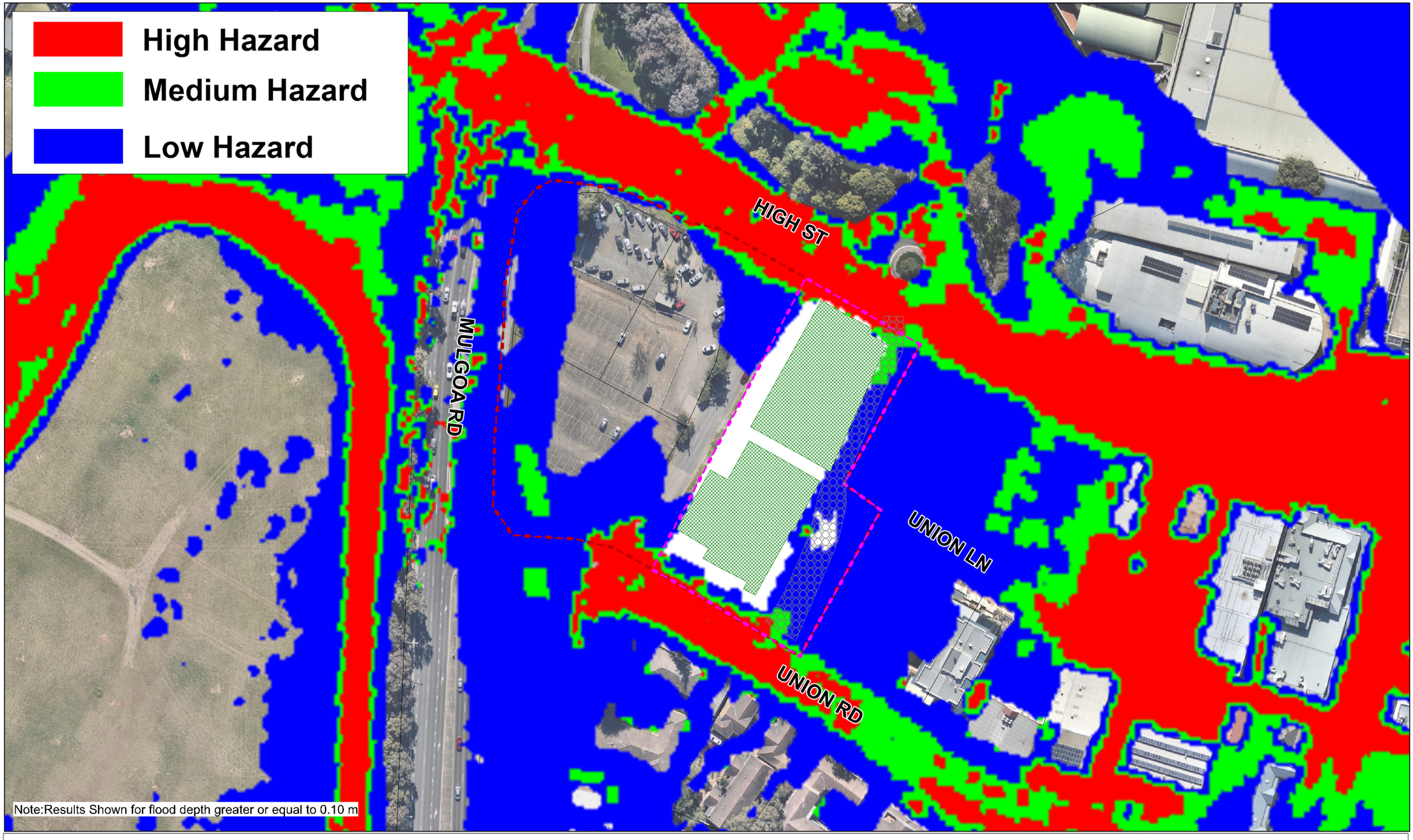
Date: 2018
Project:59918011
Coordinate System: MGA Zone 56



Proposed PMF Hazard Map
Figure B16

High Street Penrith Flood Impact Assessment

Map Produced by Cardno NSW/ACT Pty Ltd
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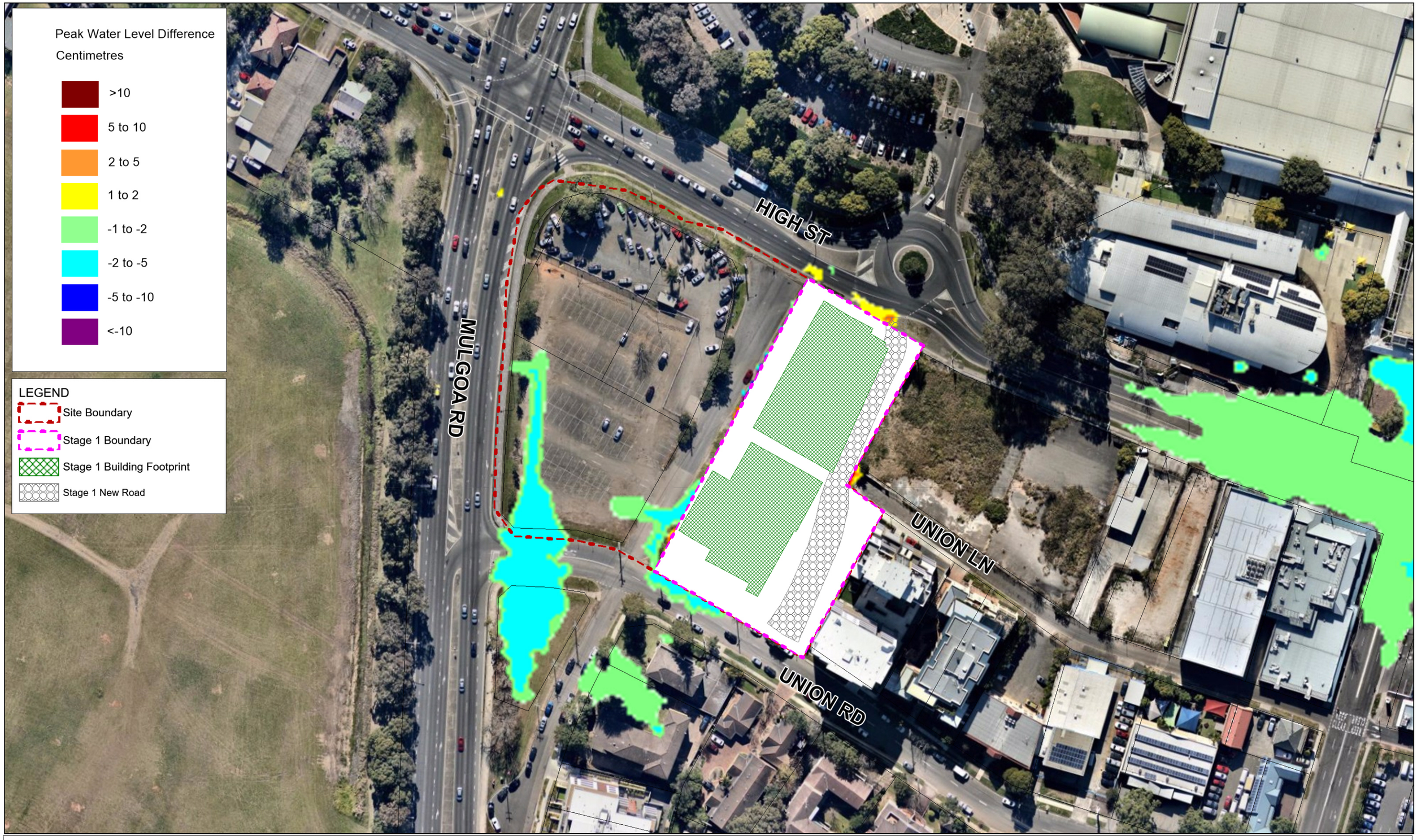
Project:59918011
Coordinate System: MGA Zone 56



1% AEP Water Level Difference Plot
Design Minus Existing
B17

High Street Penrith Flood Impact Assessment

Cardno

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Date: 2018
Project:59918011
Coordinate System: MGA Zone 56