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Our Ref: DJL: L.T2713.003.docx

04 June 2025

Brown Commercial Building
2 Elwell Close
Beresfield NSW 2322

Attention: Caitlin O'Brien

Dear Caitlin

RE: FLOOD IMPACT AND RISK ASSESSMENT FOR 27 STEAM STREET MAITLAND

Background

Torrent Consulting was engaged to undertake a Flood Impact and Risk Assessment (FIRA) to assist in the design and approval process for the proposed childcare facility at 27 Steam Street, Maitland (the Site). The Site is located within the broader Hunter River floodplain around 800 m south of Belmore Bridge, as presented in Figure 1. The figure shows the Site context within the local floodplain topography based on the NSW Spatial Services LiDAR data product downloaded via the ELVIS Foundation Spatial Data portal. The LiDAR survey was acquired in 2012, with a Digital Elevation Model (DEM) available at a 1 m resolution.

The Site is located on the edge of higher elevation topography adjoining a mix of residential and commercial property within the Maitland CBD. The western end of the Site grades to lower elevation at the edge of the Oakhampton floodway, an area of undeveloped open space which in major flood events conveys flood flows from the Hunter River connecting through to the Swamp Creek floodplain to the south of the Site.

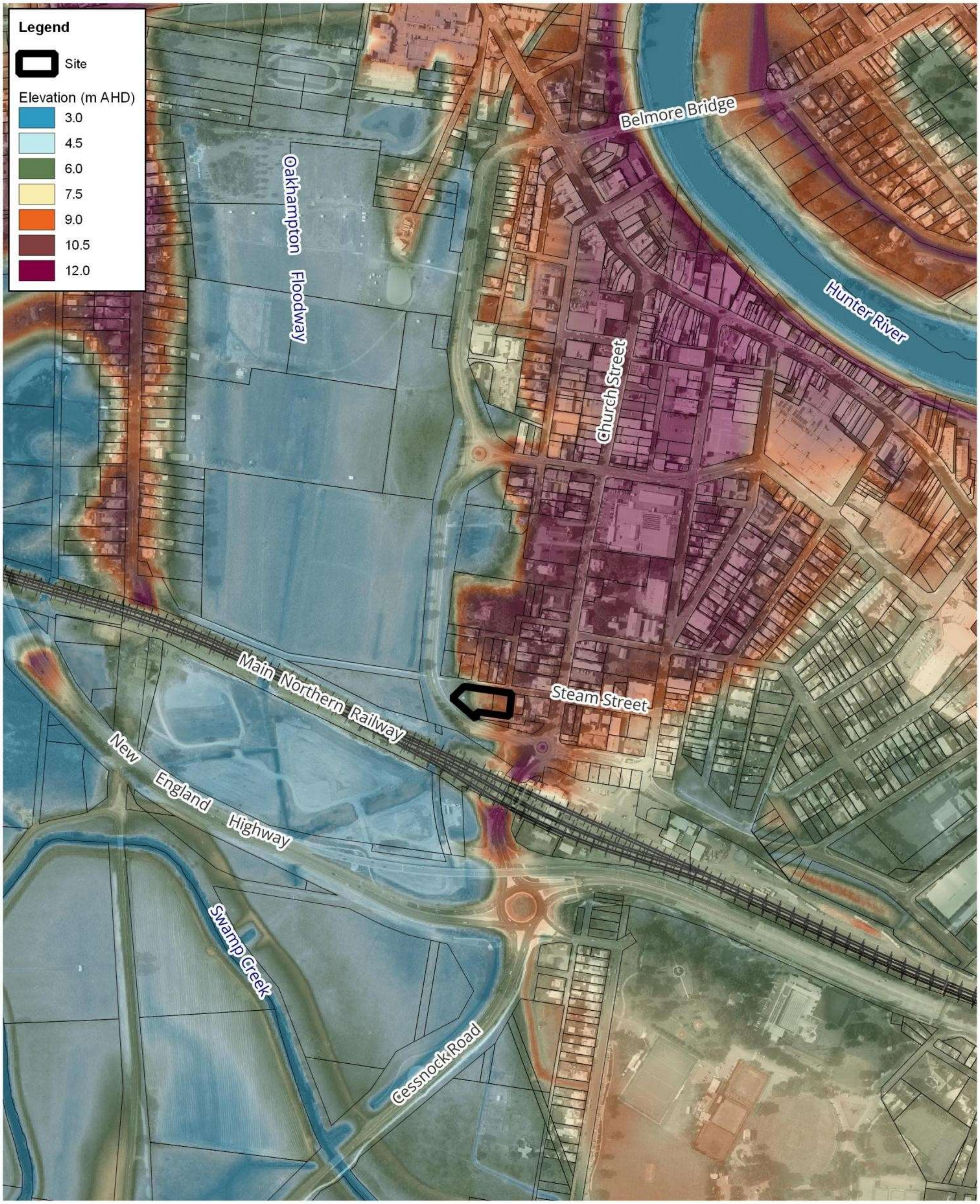
Existing Flood Information

in the Hunter River: Branxton to Green Rocks Flood Study (WMAWater 2010) completed for Maitland City Council (Council). A Flood Information Certificate issued by Council for the Site is included at Appendix A provided by Council includes the following design flood information.

- Peak 5% Annual Exceedance Probability (AEP) flood level - 7.55m AHD
- Peak 1% AEP flood level – 9.74m AHD
- Peak Probable Maximum Flood (PMF) level – 12.10m AHD

The local Site topography with the 5% AEP and 1% AEP flood depths and inundation extents (based on above flood levels) are shown in Figure 2. The indicative Site layout plan is included for reference. Note the WMAWater (2010) flood mapping shows the Site flood free at the 10% AEP flood magnitude.

The lowest elevation on the Site at the western boundary point is ~4.7m AHD with highest elevation at the eastern boundary of ~10.2m AHD. Accordingly, the entire Site is inundated at the PMF level. Flood depths vary across the Site with the typical rise in elevation from west to east.



Title:

Site Location and Floodplain Topography

0 200 400 m

approx. scale

Figure: 1

Revision: A

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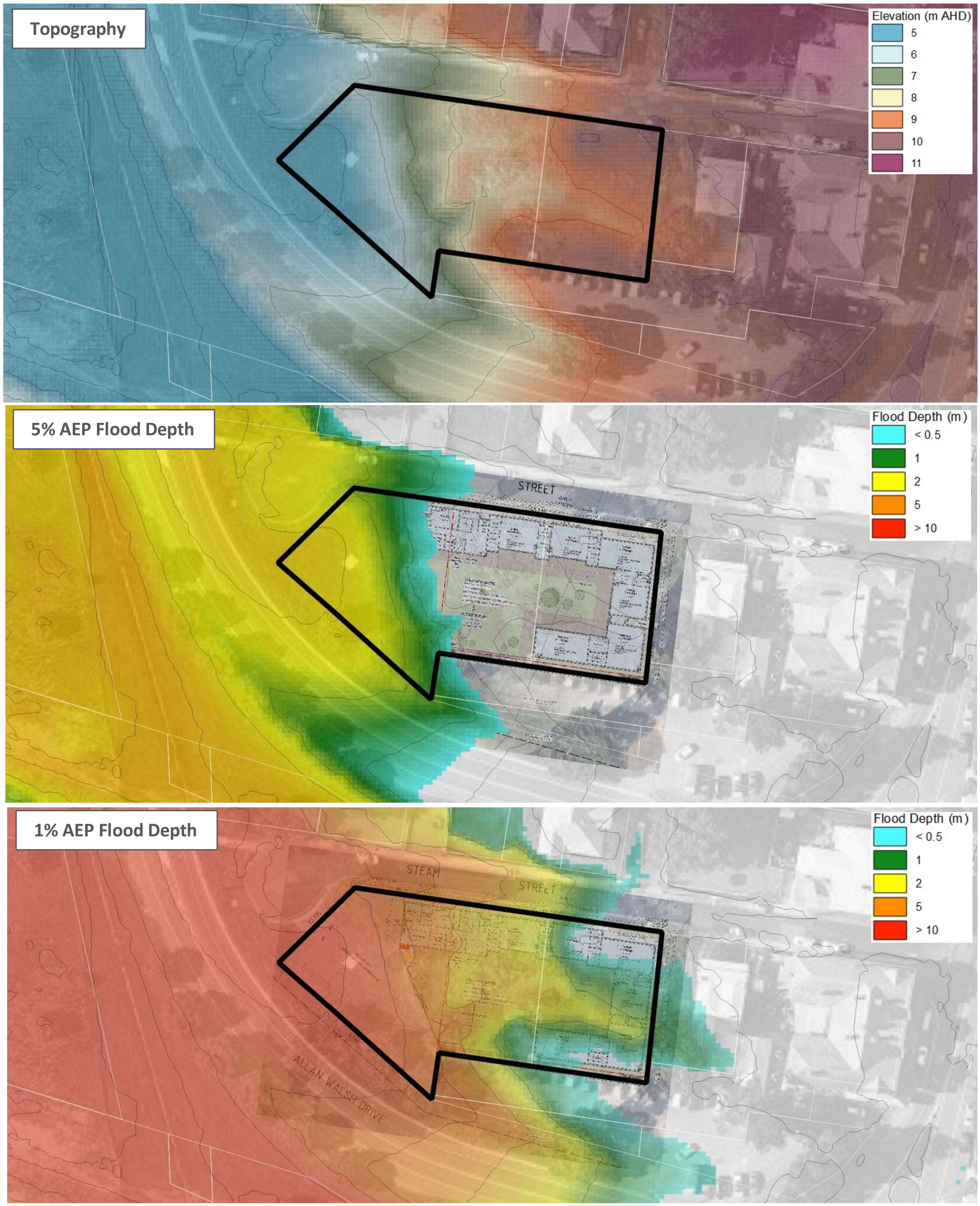

Title:

Detailed Site Topography and Flood Inundation Extents

0 20 40 m

approx. scale

Figure: **2**

Revision: **A**

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An extract of Councils 1% AEP flood function mapping is shown in Figure 3 with parts of the Site being classified as floodway. Floodways typically reflect highly convective areas of the floodplain conveying a significant discharge of floodwater. This is reflected in the floodway classification adopted in the Hunter River Floodplain Risk Management Study & Plan (WMAwater, 2015) from which the flood function mapping is derived:

- Floodway is defined as areas where:
  - the peak value of velocity multiplied by depth (V*D) > 1.0 m2/s AND peak velocity > 0.1 m/s, OR
  - peak velocity > 0.8 m/s.

The remainder of the floodplain is either Flood Storage or Flood Fringe:

- Flood Storage comprises areas outside the Floodway where peak depth > 1.5 m; and
- Flood Fringe comprises areas outside the Floodway where peak depth < 1.5 m.

The western portion of the Site is classified as Floodway corresponding to the higher depth and velocity conditions on the lower part of the Site. As the Site topography rises towards the edge of the floodplain in the eastern portion of the Site, the lower flood depth and velocity provide for mostly a Flood Fringe classicisation with a smaller area of flood storage.

It is noted that development within a floodway is typically preclude development under Councils planning controls. There are also some controls within the Flood Storage area limiting the volume of filling associated with potential development.

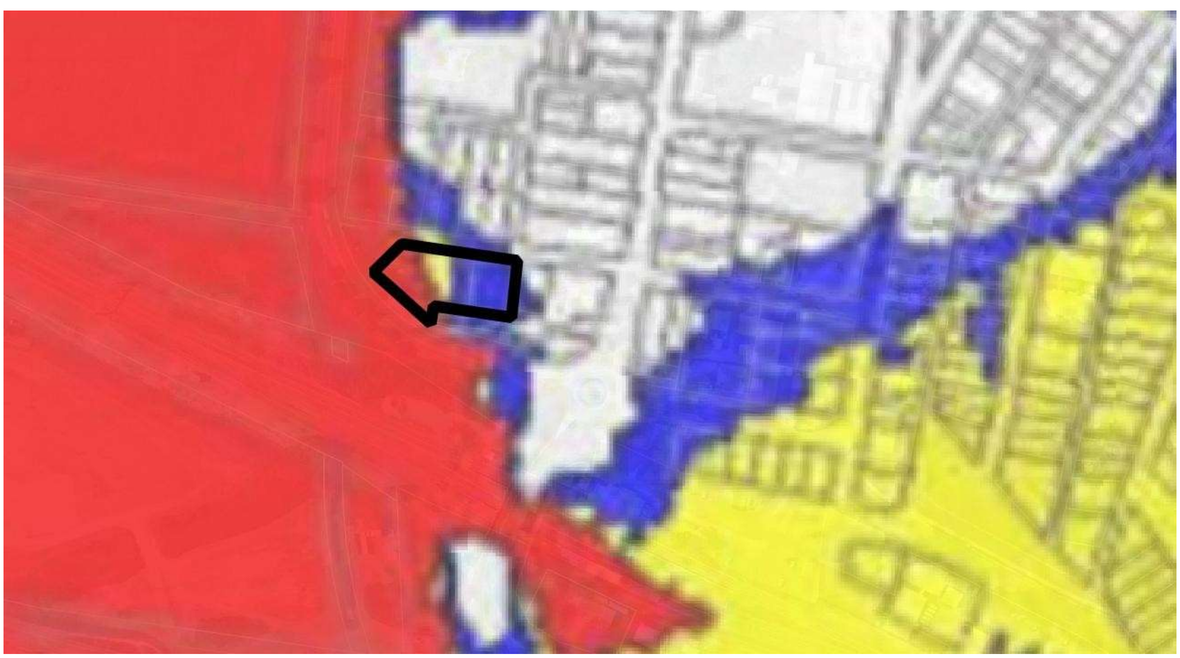


Figure 3 – 1% AEP Flood Function

Flood Impact Assessment

The proposed development incorporates an integrated multi-room ground floor single story building, outdoor play area and basement level car parking. Proposed development drawings are included in Appendix B, with an extract of the ground floor layout shown in Figure 4.

The building footprint occupies the eastern portion of the lot and has been configured to remain outside of the nominal floodway extent as shown in Figure 3.

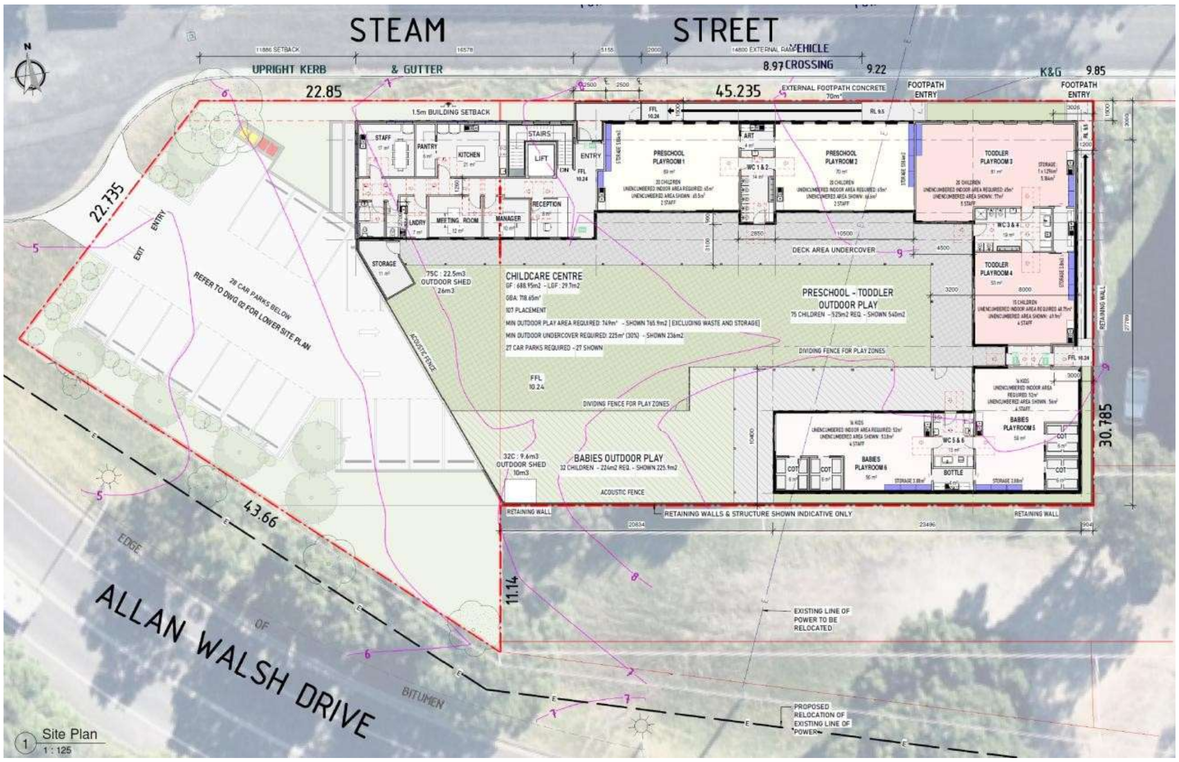


Figure 4 – Proposed Development Layout (Brown Commercial Building)

The proposed building footprint largely sits outside the 5% AEP design flood extent, however, the footprint provides for encroachment into the existing 1% AEP design flood inundation extents as shown in Figure 2. Accordingly, detailed modelling of post-development flood conditions was undertaken to assess potential flood impacts and requirement for mitigation measures.

The proposed development has the building and play area finished floor levels at the required FPL of 10.24m AHD (1% AEP flood level + 0.5m freeboard). This has been represented in the model by raising the ground level topography within the building and play area footprint to 10.24m AHD. Note that the basement car parking is not explicitly represented in the model. The basement level would essentially provide for additional surface flood storage, with storage calculations undertaken separate to the model simulations.

A TUFLOW model of the Hunter and Williams Rivers has been developed by Torrent Consulting. The model is calibrated using recorded data for the June 2007, April 2015 and July 2022 flood events and validated against the design flood conditions within the established flood models across the region. This validation includes the local flooding conditions in the Site locality, as established in the Hunter River Branxton to Green Rocks Flood Study (WMAWater, 2010). The setup and configuration of the TUFLOW model is outlined in Appendix C.

The developed model has been simulated for the 5% AEP, 1% AEP and PMF design condition. The model output includes the peak flood inundation extents and levels, peak flood depth, velocity, and flood hazard distributions.

The flood hazards have been determined in accordance with Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). This produces a six-tier hazard classification, based on modelled flood depths, velocities, and velocity-depth product. The hazard classes relate directly to the potential risk posed to people, vehicles, and buildings, as presented in Figure 5.

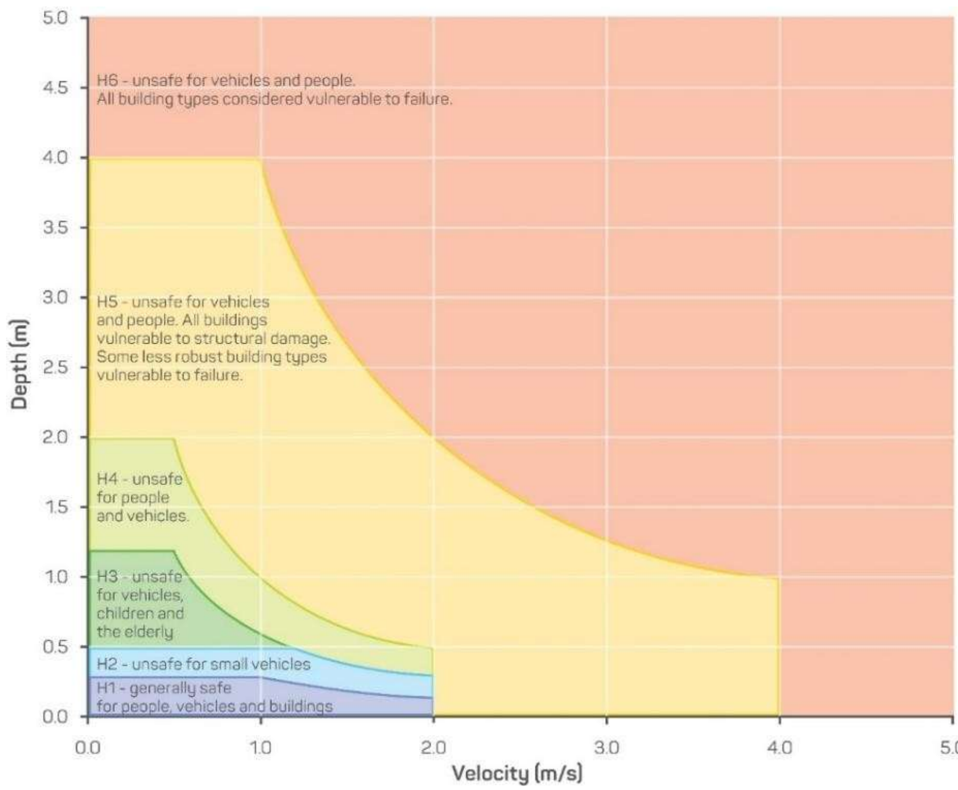
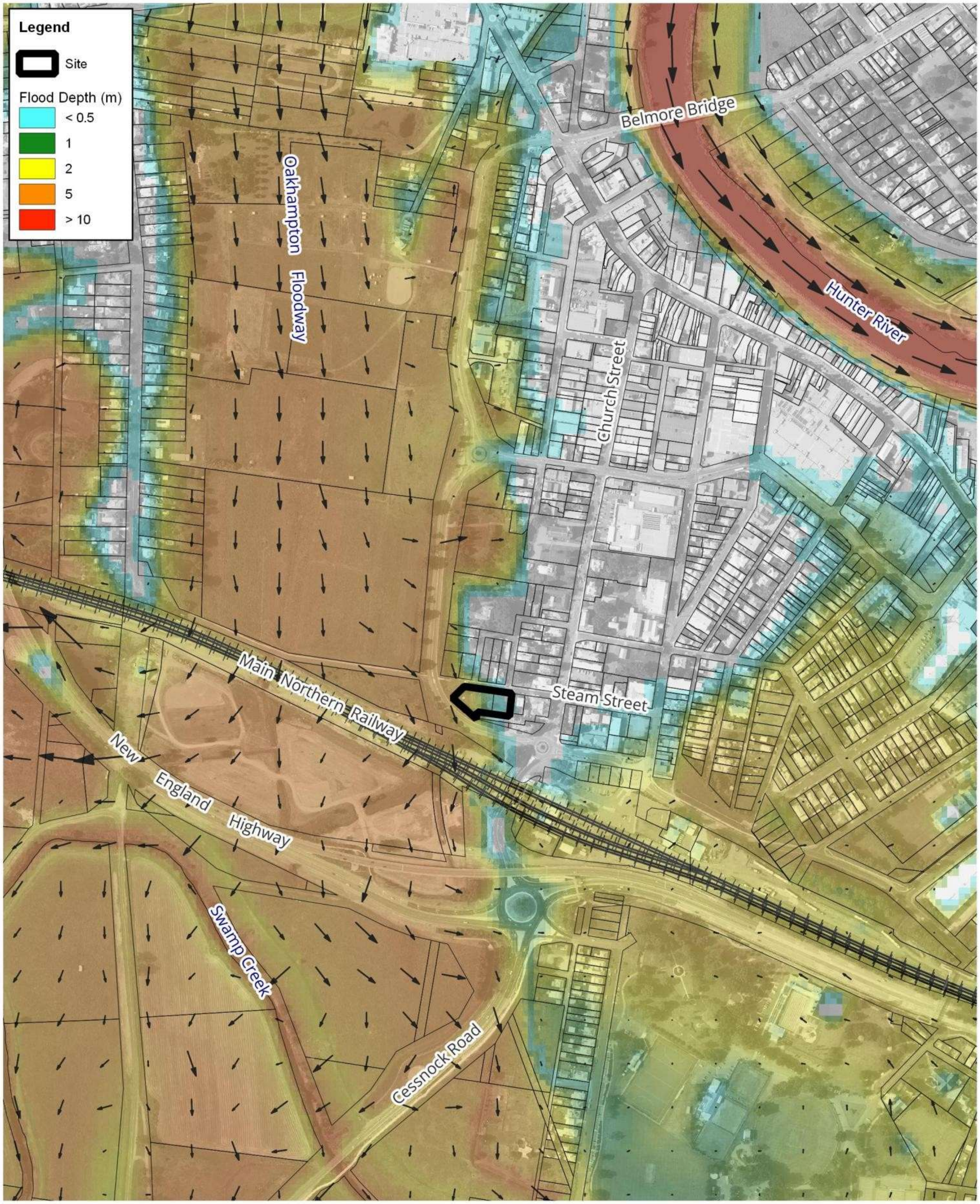


Figure 5 – General Flood Hazard Vulnerability Curves (AIDR, 2017)

The simulated existing 1% AEP design flood condition in the broader floodplain area around the Site is shown in Figure 6. Potential flooding of the Site is driven by significant flows conveyed through the Oakhampton Floodway as the Hunter River main channel capacity is exceeded and overbank flows are initiated via overtopping of the Oakhampton spillway on the right bank of the river to the north of the Site.

The activated floodway extends across some 500m of the floodplain adjacent to the Site at the 1% AEP event, with typical flood depths exceeding 5m. The Site is located at the outer edge of this in inundation extent, with variable depth across the Site corresponding to the ground elevation as shown in detail in Figure 2.



Title:

Peak 1% AEP Flood Depth and Inundation Extent Existing Conditions

Figure: 6

Revision: A

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A suite of flood mapping for the 5% AEP, 1% AEP and PMF events is provided in Appendix D including:

- Existing peak flood depth and inundation extent
- Existing peak flood velocity distribution
- Post-development peak flood level impacts
- Post-development peak flood velocity impacts
- Post-development peak flood hazard classification

A local Site detail of the existing conditions 1% AEP design flood inundation extent and depth distribution shown in Figure 7 forms the baseline condition for the development assessment. The mapping provides general consistency with Councils existing flood information in defining the peak 1% AEP flood level for the Site of 9.74m AHD, and providing for the FPL of 10.24m AHD setting the minimum finished floor levels for the proposed development. The eastern end of the Site is flood free with access to Steam Street, with the western end subject to higher levels of flood inundation (depths>4m) with extensive inundation across the Steam

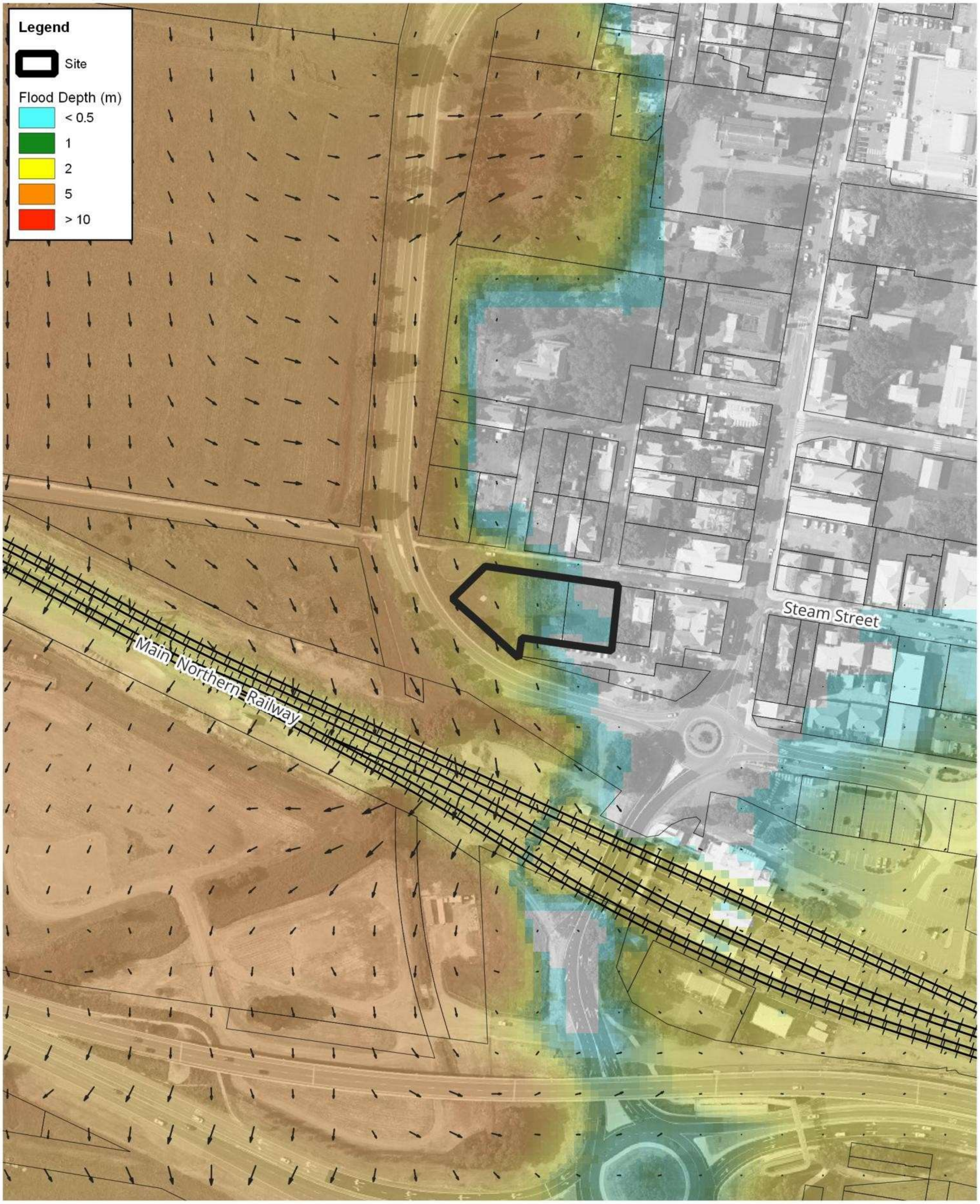
As noted, the simulated post-development conditions provides for total blockage within the proposed development footprint. Figure 8 shows no significant impacts on peak 1% AEP flood levels as a result of the proposed development. Whilst the development footprint encroaches into the existing 1% AEP flood extent, the resulting change in peak flood levels is limited noting:

- The development footprint does not extend into high flood conveyance zones indicative of Councils adopted floodway area. Accordingly there is no blockage of significant flow paths and limited redistribution of flow with respective to local flood conveyance through the Site
- The temporary flood storage on the Site taken up by the proposed development is extremely small in relation to the total volume of floodwater conveyed through the Oakhampton floodway and broader Hunter River floodplain in the Site locality.

The corresponding change in peak flood velocity as a result of the proposed development is shown in Figure 9. Similar to the peak flood levels, there is no significant change in peak velocities given the limited impact of the development on the existing floodplain flow distribution.

The flood impact mapping included in Appendix D for the 5% AEP and PMF events also show limited impact as a result of the development. There is no discernible impact for the 5% AEP event given the very limited encroachment of the development into the existing flood inundation extent. Minor impacts are shown for the PMF event given the more extensive existing flood inundation across the Site and the encroachment of the proposed buildings. However, both peak flood level impacts (<0.1m) and peak velocity impacts (<0.1m/s) are localised in extent and provide no material impact on adjacent properties noting the high existing level of flood affectation given peak flood depths and velocities are typically in excess of 3m and 2m/s respectively. This is reflected in the high flood hazard classification as shown in the hazard mapping in Appendix D.

Notwithstanding the limited flood impact shown, it is also noted that inundation of the basement parking area would provide for additional flood storage not represented in the post-development model configuration. This additional compensatory storage below existing ground levels would provide some offset from the encroachment of the building footprint into the existing flood inundation area.



Title:

Peak 1% AEP Flood Depth and Inundation Extent Existing Conditions - Site Detail

0 60 120 m

approx. scale

Figure: **7**

Revision: **A**

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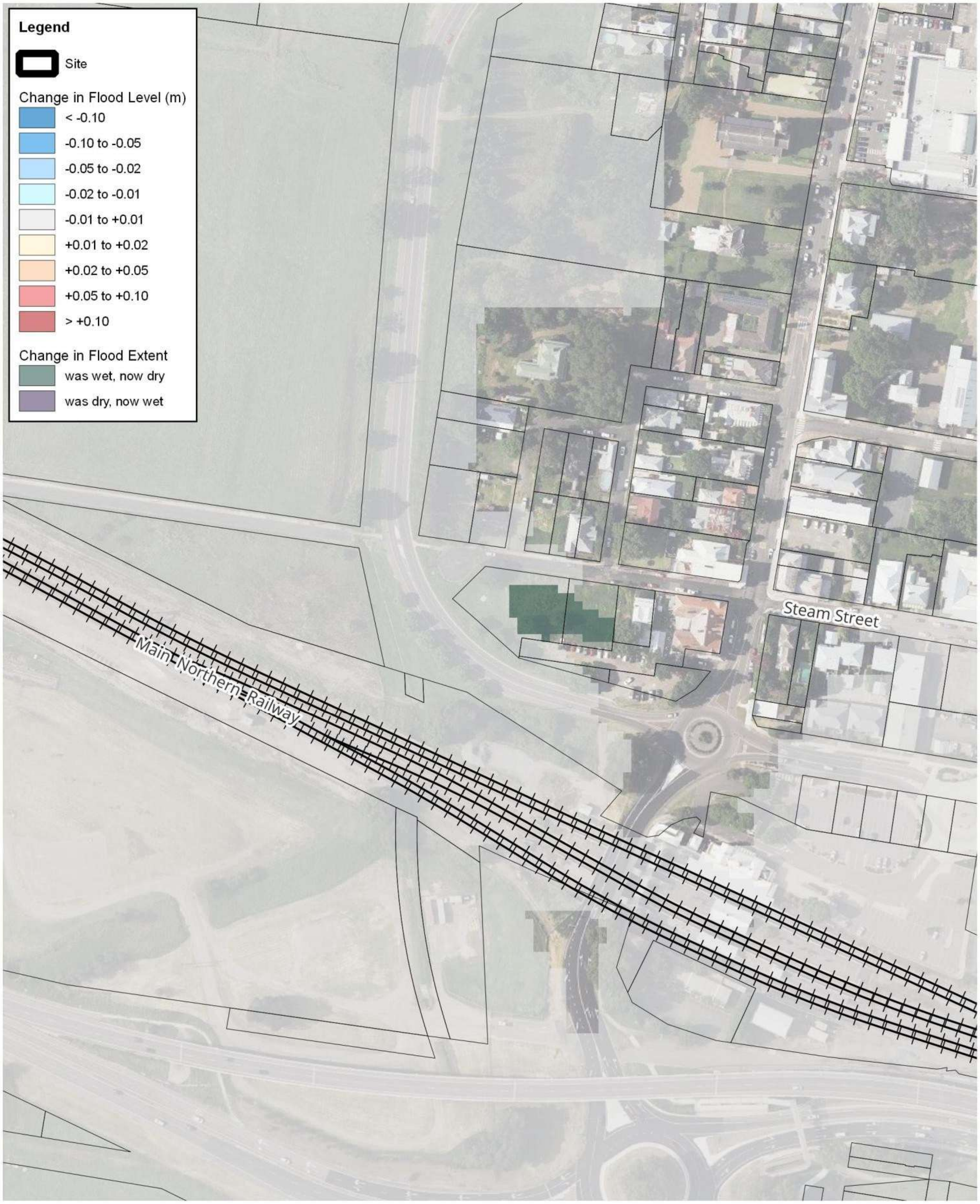

Title:

Change in Peak 1% AEP Flood Level Post-development

0 60 120 m

approx. scale

Figure: 8

Revision: A

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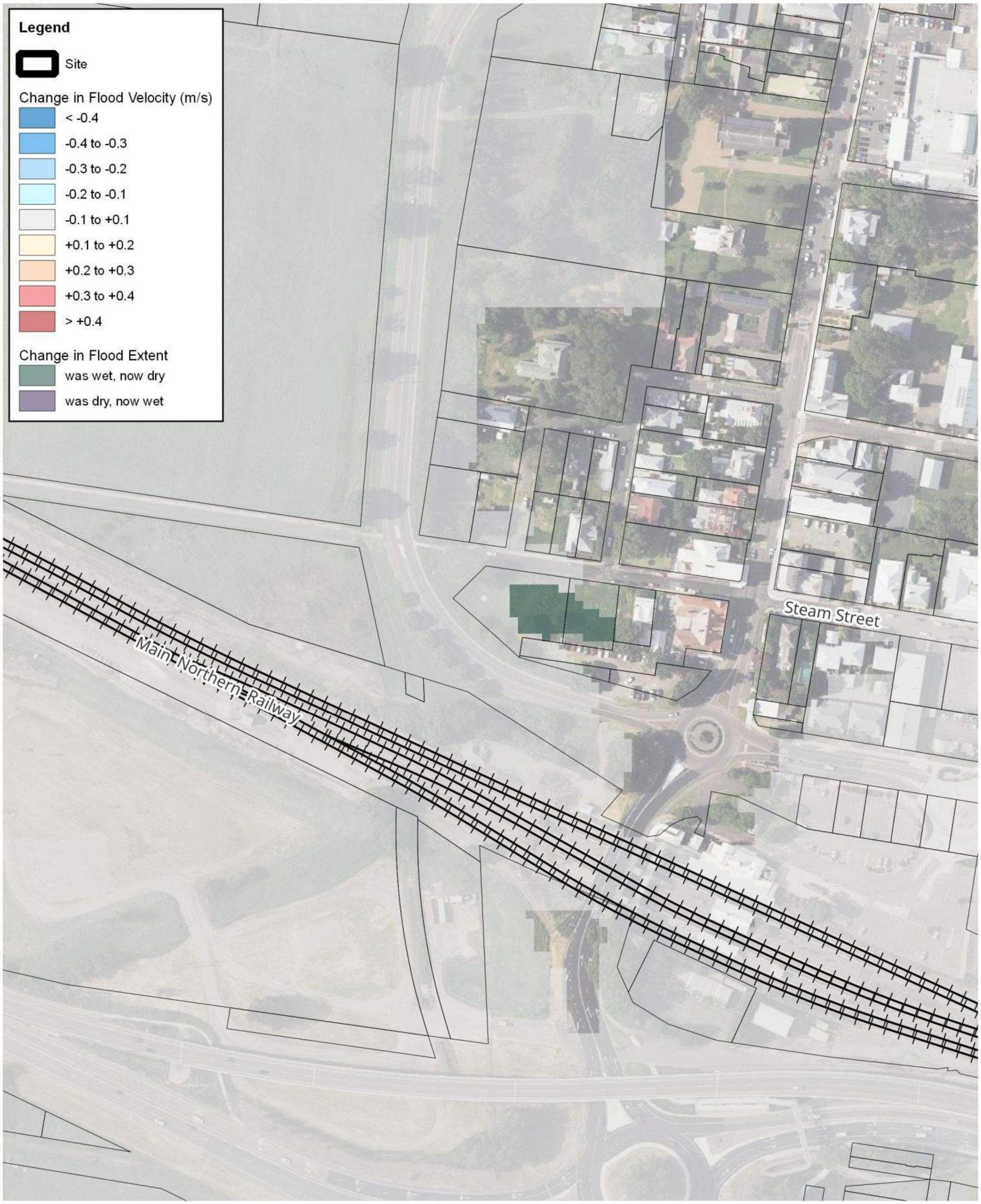

Title:

Change in Peak 1% AEP Flood Velocity Post-development

Figure: 9

Revision: A

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Flood Warning and Emergency Response

The PMF flood hazard classification for the post-development condition provides for high hazard (H5-H6) through the Site and on the surrounding road network. As noted, the entire Site would be subject to inundation at the PMF level (12.1m AHD) including the above floor inundation of the proposed buildings and play area. Whilst this may represent a significant risk to life for Site occupants, this risk is mitigated by the available flood warning opportunity and Site closure well before the onset of any flood affectation to the Site as discussed hereunder.

There are several gauges throughout the Hunter River system that the Bureau of Meteorology (BoM) incorporate into its operational flood warning network, including Maitland (Belmore Bridge) upstream of the Site.

Flood emergency response is initiated with relevant flood warnings issued by the BoM. Flood classifications in the form of locally defined flood levels are used in flood warnings to give an indication of the severity of flooding (minor, moderate or major) expected. These levels are used by the SES and BoM in flood bulletins and flood warnings. The flood classification levels are described by:

- Minor flooding: Causes inconvenience. Low-lying areas next to water courses are inundated. Minor roads may be closed and low-level bridges submerged. In urban areas inundation may affect some backyards and buildings below the floor level as well as bicycle and pedestrian paths. In rural areas removal of stock and equipment may be required.
- Moderate flooding: In addition to the above, the area of inundation is more substantial. Main traffic routes may be affected. Some buildings may be affected above the floor level. Evacuation of flood affected areas may be required. In rural areas removal of stock is required.
- Major flooding: In addition to the above, extensive rural areas and/or urban areas are inundated. Many buildings may be affected above the floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed. Evacuation of flood affected areas may be required. Utility services may be impacted.

The Maitland (Belmore Bridge) gauge is used for flood level classification and the issue of formal flood warnings on the Lower Hunter River. The Minor, Moderate and Major flood warning levels are summarised in Table 1.

Table 1 - Flood Classification Levels for Maitland (Belmore Bridge)

Flood Classifications (gauge reading m AHD)		
Minor	Moderate	Major
5.9	8.9	10.5

The BoM Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory (2024) provides a target flood warning time for quantitative flood level predictions at Maitland of:

- 12 hours prior to reaching 5.9m AHD trigger level (Minor flood event classification)

- 24 hours prior to reaching 7.1m AHD trigger level (between Minor and Moderate flood level classification).

The design peak flood levels (after WMAWater, 2010) at the gauge summarised in Table 2. Site inundation occurs for events above the Major flood level classification.

Table 2 - Design Peak Flood Levels at Maitland (Belmore Bridge)

Design Event	Flood Level (m AHD)
50% AEP	6.8
20% AEP	9.4
10% AEP	10.8
5% AEP	11.1
2% AEP	11.5
1% AEP	11.7

The 50%AEP and 20% AEP design flood levels at Maitland (Belmore Bridge) are 6.8m AHD and 9.4m AHD respectively. Therefore, the 7.1m AHD trigger level in the service level specification is expected to provide for a 24-hour lead warning for events in excess of the 20% AEP design flood magnitude.

Given the availability of at least 24-hours warning time prior to Site inundation, the proposed Child Care Facility would be closed in the days prior to flooding. This also provides ample warning time to prepare and secure the Site for flooding.

The available flood warning is further demonstrated in reviewing the Hunter River water level response for historical flood events. The water level hydrographs at Belmore Bridge for the February 1955, March 1971, June 2007 and July 2022 flood events are shown in Figure 10. The 2007 and 2022 data is from the available gauging station data, with the 1955 and 1971 profiles based on data presented in the Hunter River: Branxton to Green Rocks Flood Study (WMAwater, 2010). The event timing has been standardised to enable direct comparison of the rates of rise through the recorded stage range.

Figure 10 shows the 7.1m AHD threshold at Belmore Bridge corresponding to the BoM service level specification for minimum 24hour flood warning. Similarly, the 10.9m AHD threshold at Belmore Bridge is shown corresponding to the equivalent stage at which Site inundation is initiated (i.e. between 10% AEP and 5% AEP design flood magnitudes.

The events of June 2007 and July 2022 are the highest most recent events in this reach of the Hunter River and did not provide for inundation of the Site being nominally at around a 10% AEP flood magnitude. It is not known if Site inundation occurred in 1971, however, the peak water level at Belmore Bridge of ~11.1m AHD is representative of the 5% AEP flood magnitude which would typically provide for Site inundation as per Figure 2. The 1955 event is nominally a 0.5% AEP (1 in 200year) event at Maitland representing the highest flood event on record.

In addition to the 24hours warning time to the 7.1m AHD threshold in accordance with the BoM service level specification, the typical rate of rise for the major historical flood events (including 1955) provides for a further 24hours prior to Site inundation. Accordingly, it could be expected that flood warnings would be in place for two or more days in advance of Site inundation.

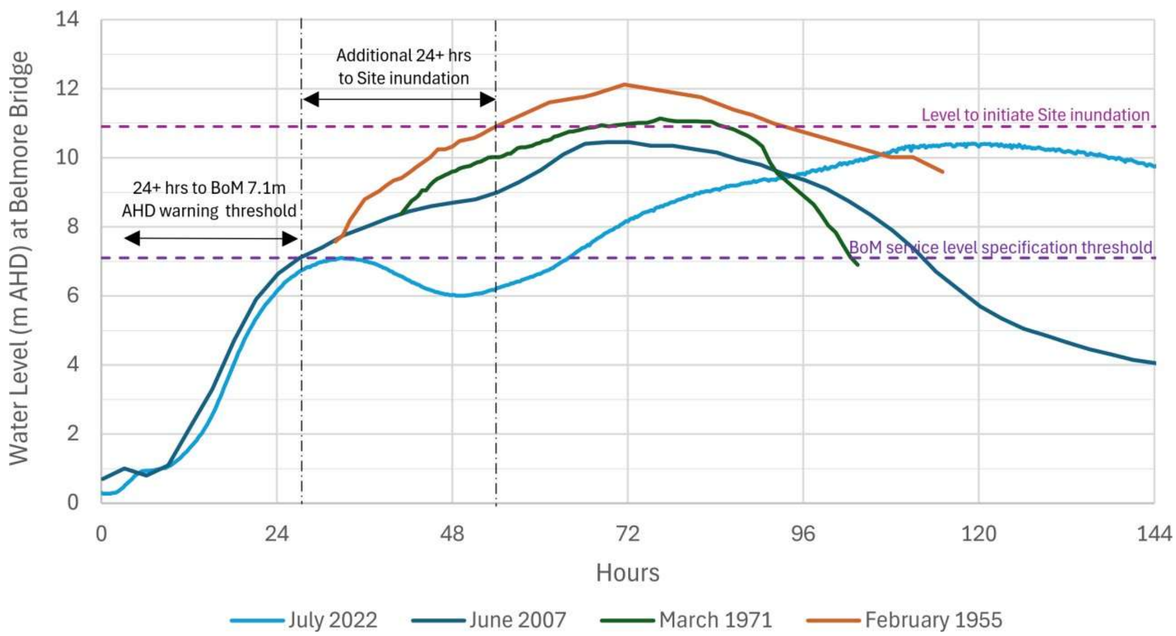


Figure 10 – Historical Event Flood Hydrographs

Given the availability of at least 24-hours (and likely 48hours) warning time prior to Site inundation, the proposed Child Care Facility would be closed in the days prior to flooding. This also provides ample warning time to prepare and secure the Site for flooding. Whilst the Child Care Facility would be classified as a sensitive land use, the available flood warning and early closure of the facility in the days prior to flood inundation effectively eliminates the flood risk.

Flood Planning Controls

Flood planning controls relevant to the Site are contained within Maitland DCP 2011 Section B.3 Hunter River Floodplain. A summary of the compliance of the proposed development to relevant flood planning controls is provided below:

Clause 2.1 Development below the Flood Planning Level (FPL)

The proposed development provides for construction within the existing FPA. The proposed development has the building and play area finished floor levels at the required FPL of 10.24m AHD (1% AEP flood level + 0.5m freeboard).

The flood impact assessment has demonstrated the proposed development will not increase the flood hazard or flood damage or adversely increase flood affectation on other properties.

Clause 2.2 Development in Floodways

The proposed development does not provide for any building or structure within the identified floodway extent, nor is there any proposed fill in this zone. Minor changes to the surface treatment (i.e. external car par areas as the western end of the Site) do not cause adverse flood impacts on existing flood flow distribution.

Clause 2.2 Development in Flood Storage and Fringe Areas

The DCP identifies limits on flood storage filling unless supported by detailed flood modelling. The FIRA modelling has confirmed no adverse impacts through loss of temporary flood storage on the Site. It is also noted that the modelling did not consider compensatory storage associated with basement carpark inundation which would further offset any loss in flood storage volume.

Clause 2.3 General Building Requirements

All habitable finished floors are at the FPL. Whilst the 1% AEP flood hazard at the western portion of the Site adjacent the proposed development is a H5 classification, this is a relatively low velocity/ low convective flow environment such that the hazard is driven by flood depth. The proposed construction is expected to withstand the corresponding hydrostatic forces, however, this will be confirmed by the structural engineers.

The eastern section of Steam Street provides for flood free access at the 5% AEP (1 in 20-year) magnitude, however, the carparking and basement carpark entry at the western end of the Site would be subject to inundation. Notwithstanding, the available flood warning time prior to loss of Site access (>24-hours) would provide for Site closure in advance of potential inundation and would underpin the Site flood emergency response.

Clause 2.5 Basement Car Parking

Given the design 1% AEP (1 in 100-year) flood condition, the proposed basement car parking entry level will be below the nominal entry level threshold requirement. However, noting the available warning time the general Site closure and all entry points will be able to be secured prior to inundation. The proposed design includes a stairwell provision from the basement carpark to the ground floor level above the FPL. Structural engineers to confirm the structural adequacy with respect to any hydrostatic pressure loading during basement inundation.

Conclusion

The Site at 27 Steam Street, Maitland, NSW requires a Flood Impact and Risk Assessment to assist in the approval process for the proposed child care facility which is located within the Hunter River floodplain.

The flood impact assessment has included use of a TUFLOW hydraulic model to simulate design flood conditions at the Site, whilst maintaining a reasonable consistency with the results of the previous studies. The flood impact assessment has determined that the proposed development does not result in adverse off-site flood impacts and has minimal impact on existing design flood conditions both local to the Site and in the broader floodplain.

Given the availability of at least 24-hours warning time prior to Site inundation, the proposed Child Care Facility would be closed in the days prior to flooding. This also provides ample warning time to prepare and secure the Site for flooding.

Whilst the Child Care Facility would be classified as a sensitive land use, the available flood warning and early closure of the facility in the days prior to flood inundation effectively eliminates the flood risk. This type of facility, including other commercial uses that can be closed, is a better use than residential development which is more likely to increase demand on emergency services and require relocation to evacuation centres or alternative accommodation in major events.

We trust that this report meets your requirements. For further information or clarification please contact the undersigned.

Yours faithfully

Torrent Consulting

Darren Lyons
Principal Water Resources Engineer
CPEng MIEAust RPEQ

References

AIDR (2017) *Guideline 7-3, Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*.

Bureau of Meteorology (2013) *Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory – Version 3.13*.

WMAWater (2010) *Hunter River: Branxton to Green Rocks Flood Study*. Maitland City Council.

WMAWater (2015) *Hunter River Floodplain Risk Management Study and Plan*. Maitland City Council.

APPENDIX A – Flood Certificate

Certificate No: 52948
Certificate Date: 05/11/2024
Fee Paid: $190.00
Receipt No: 2036024
Your Reference: 33 Steam St Maitland

FLOOD INFORMATION CERTIFICATE

APPLICANT:	Brown Commercial Building Caitlin O'Brien 2 Elwood Close Beresfield NSW 2322
PROPERTY DESCRIPTION:	33 Steam Street MAITLAND NSW 2320
PARCEL NUMBER:	52948
LEGAL DESCRIPTION:	LOT: 33 DP: DP1193849

IMPORTANT: Please read this Certificate carefully.

The information provided in this Certificate relates only to the land described above. If you need information about an adjoining property or nearby land, a separate certificate will be required. All information provided is correct as at the date of issue of this Certificate. However, it is possible for changes to occur at any time after the issue of this Certificate.

Flood Information

	Minimum value	Maximum Value
5% AEP (1 in 20yr) Level m AHD	7.54	7.55
1% AEP (1 in 100yr) Level m AHD	9.74	9.74
1% AEP Velocity	0.06	1.69
1% AEP Hazard	Low	High
PMF Level	12.06	12.10
PMF Velocity	0.30	2.42

Definitions

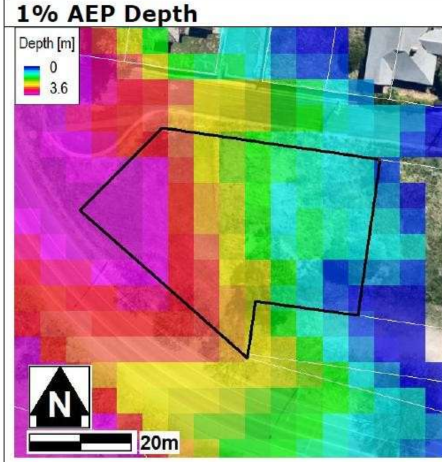
Annual exceedance probability (AEP) is the chance of a flood of a given or larger size occurring in anyone year, usually expressed as a percentage. For example, a 1% AEP flood has a 1% or 1 in 100 chance of being reached or exceeded in any given year.

Australian height datum (AHD) is a common national surface level datum often used as a referenced level for ground, flood and floor levels. 0.0m AHD corresponds approximately to mean sea level.

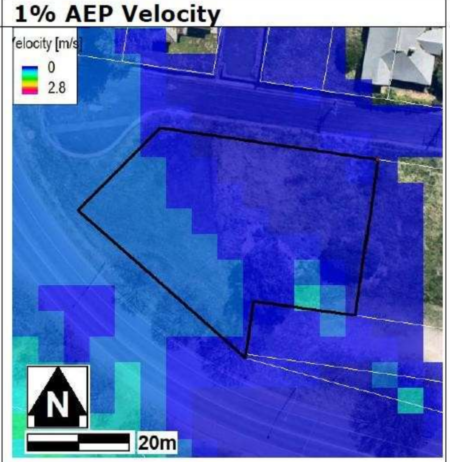
Probable maximum flood (PMF) is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

Maps of flood characteristics

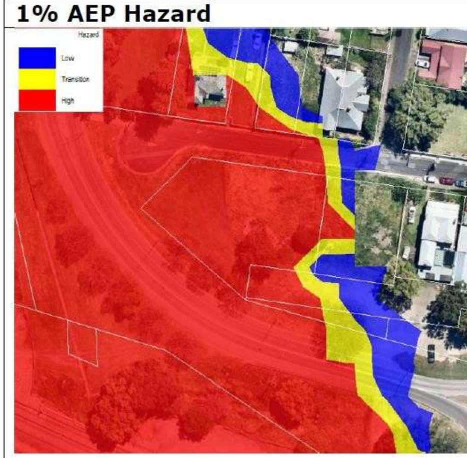
1% AEP Depth



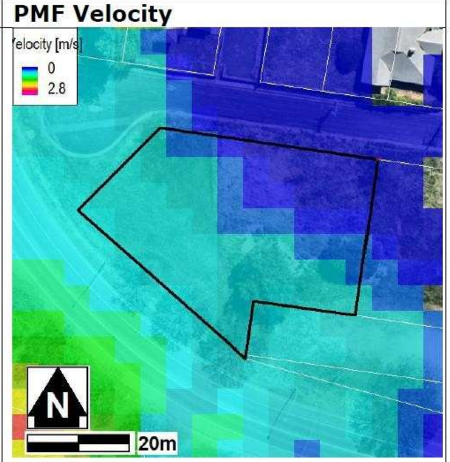
1% AEP Velocity



1% AEP Hazard



PMF Velocity



Disclaimer

The information contained in this certificate is based on flood modelling and any particular flood event (and the circumstances causing it) may be different to the scenarios modelled by the studies which provided the basis for this information. Due to the nature of this information and how it has been supplied to Council, Council does not promise that the information is free from error or omission. As a result, Council will not be responsible for any damage, however caused, by the provision of this information.

This flood information is subject to change as a result of updated flood modelling. This means Council cannot guarantee that the information is accurate after the day of issue.

Council does not know each recipients' reasons for seeking this information. Recipients are encouraged to obtain professional advice specific to their requirements regarding this information.

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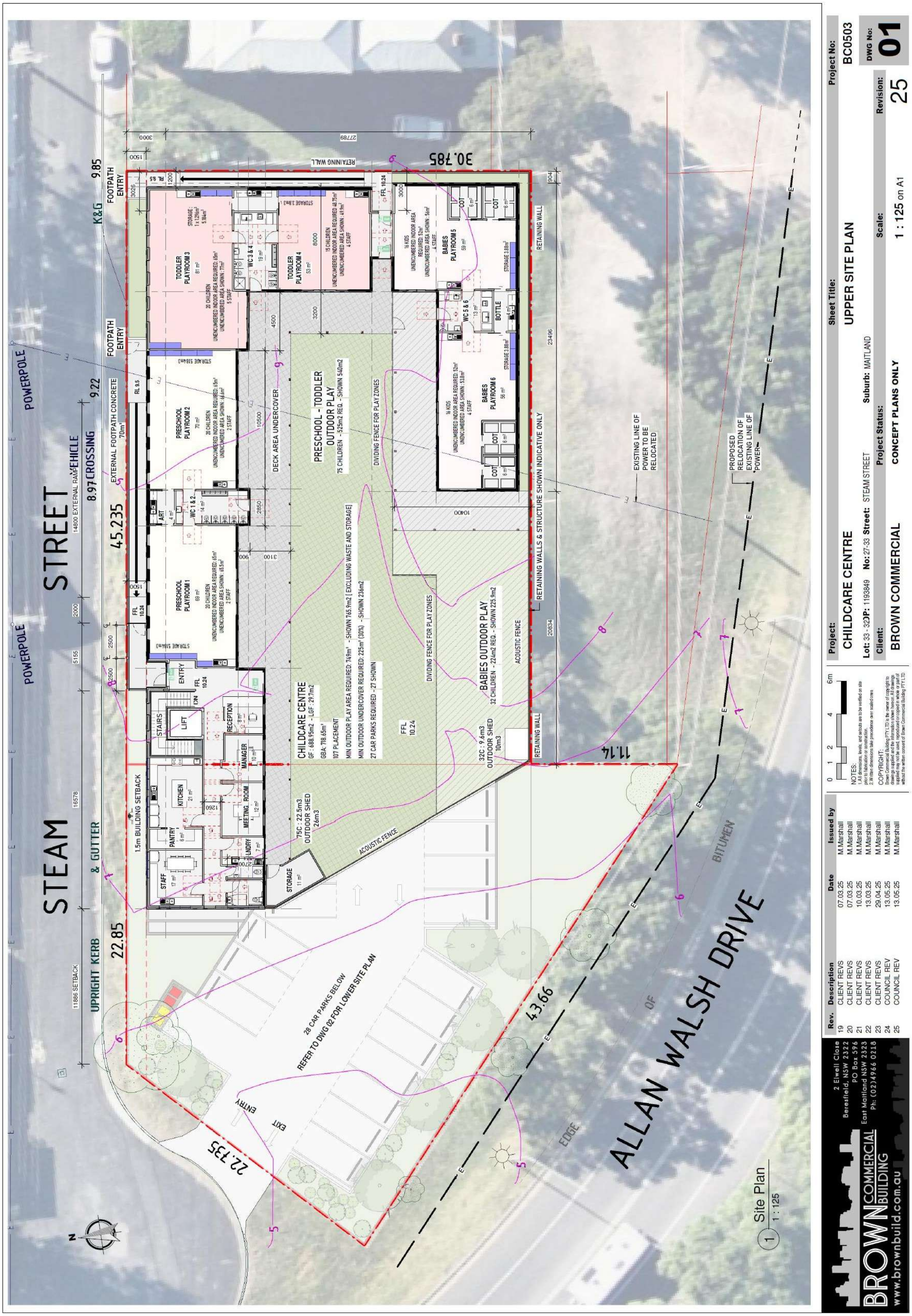
Maitland NSW 2320
t 02 4934 9700
f 02 4933 3209
info@maitland.nsw.gov.au
maitland.nsw.gov.au
All correspondence should be directed to: General Manager P.O. Box 220 Maitland NSW 2320

APPENDIX B – Proposed Development



STEAM STREET
ALLAN WALSH DRIVE
CHILDCARE CENTRE
PRESCHOOL - TODDLER OUTDOOR PLAY
BABIES OUTDOOR PLAY
28 CAR PARKS BELOW
REFER TO DWG 02 FOR LOWER SITE PLAN
Site Plan
1 : 125
Project: CHILDCARE CENTRE
Lot: 33 - 32DP: 1193849 No: 27-33 Street: STEAM STREET Suburb: MAITLAND
Client: BROWN COMMERCIAL
Sheet Title: UPPER SITE PLAN
Project Status: CONCEPT PLANS ONLY
Scale: 1 : 125 on A1
Project No: BC0503
DWG No: 01
Revision: 25
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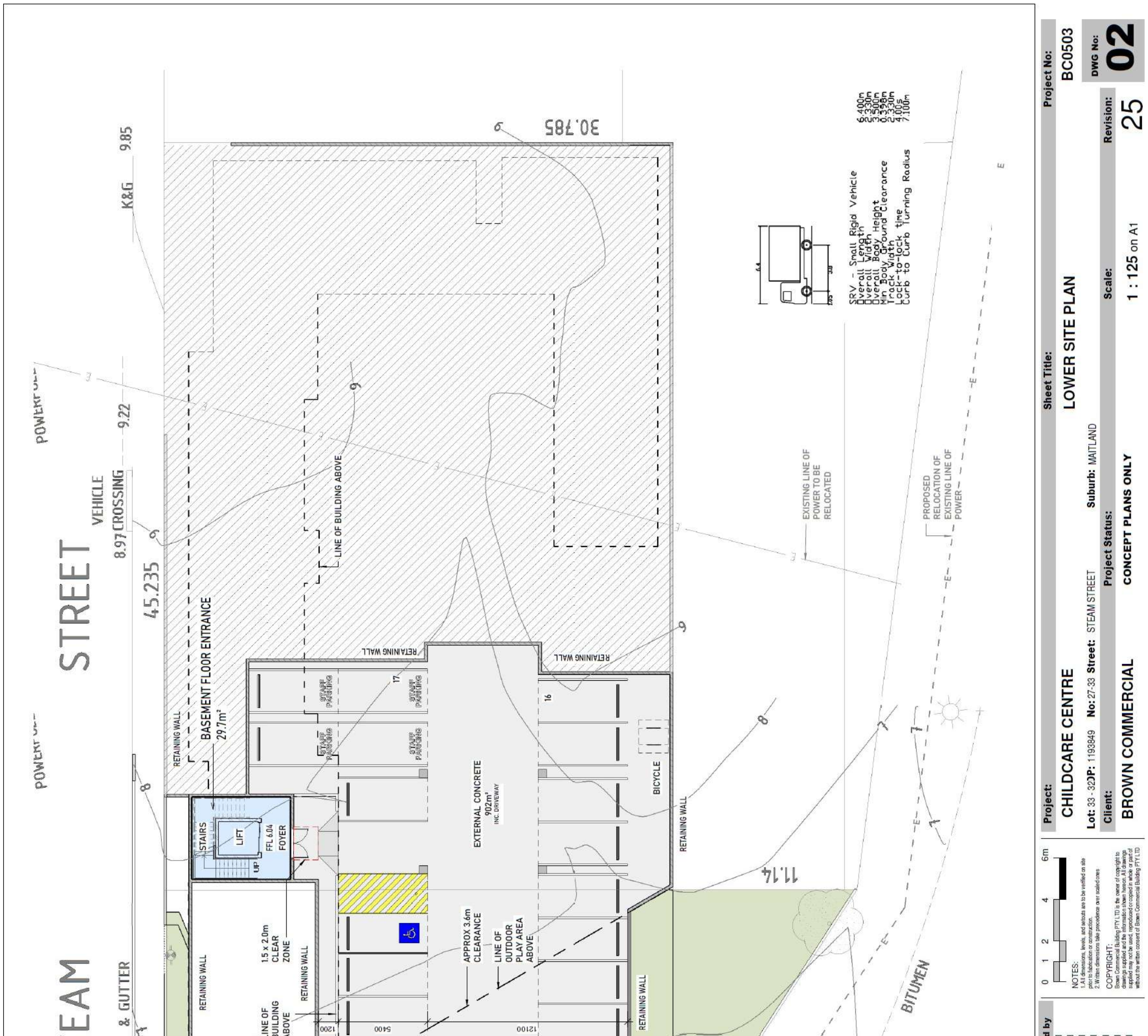
STEAM STREET
ALLAN WALSH DRIVE
BASEMENT FLOOR ENTRANCE 29.7m²
EXTERNAL CONCRETE 902m² INC. DRIVEWAY
SRV LOADING ZONE 6.5m x 3.5
WASTE ENCLOSURE
RETAINING WALL
LINE OF BUILDING ABOVE
BICYCLE
6.04 LWR CP
1 : 125
Project: CHILDCARE CENTRE
Lot: 33 - 32 DP: 1193849 No: 27-33 Street: STEAM STREET Suburb: MAITLAND
Client: BROWN COMMERCIAL
Project Status: CONCEPT PLANS ONLY
Sheet Title: LOWER SITE PLAN
Scale: 1 : 125 on A1
Project No: BC0503
DWG No: 02
Revision: 25
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1 NORTH Elevation
1 : 100

2 EAST Elevation
1 : 100

3 WEST Elevation
1 : 100

4 SOUTH Elevation
1 : 100

BROWN COMMERCIAL BUILDING
www.brownbuild.com.au
2 Elwell Close
Beresfield, NSW 2322
PO Box 596
East Maitland NSW 2323
Ph: (02)4966 0218

Rev.	Description	Date	Issued by
19	CLIENT REVS	07.03.25	M.Marshall
20	CLIENT REVS	07.03.25	M.Marshall
21	CLIENT REVS	10.03.25	M.Marshall
22	CLIENT REVS	13.03.25	M.Marshall
23	CLIENT REVS	29.04.25	M.Marshall
24	COUNCIL REV	13.05.25	M.Marshall
25	COUNCIL REV	13.05.25	M.Marshall

0 1 2 4 6m

NOTES:
1. All dimensions, levels, and setouts are to be verified on site prior to fabrication or construction.
2. Written dimensions take precedence over scaled ones

Project: CHILDCARE CENTRE
Lot: 33 - 32DP: 1193849 **No:** 27-33 **Street:** STEAM STREET **Suburb:** MAITLAND
Client: BROWN COMMERCIAL
Project Status: CONCEPT PLANS ONLY
Sheet Title: ELEVATIONS
Scale: 1 : 100 on A1
Project No: BC0503
DWG No: 03
Revision: 25

APPENDIX C – TUFLOW Model Development

Torrent Consulting has developed a TUFLOW hydraulic model covering the entire floodplain of the Lower Hunter River downstream to the river mouth at the Tasman Sea, including upstream to: Luskintyre on the Hunter River, Vacy on the Paterson River and Glen Martin on the Williams River, as presented in Figure A1

The catchment area of the Hunter River covers some 22 000 km^2, with the Paterson and Williams Rivers contributing around 1200 km^2 and 1300 km^2 respectively. The modelled area encompasses some 750 km^2.

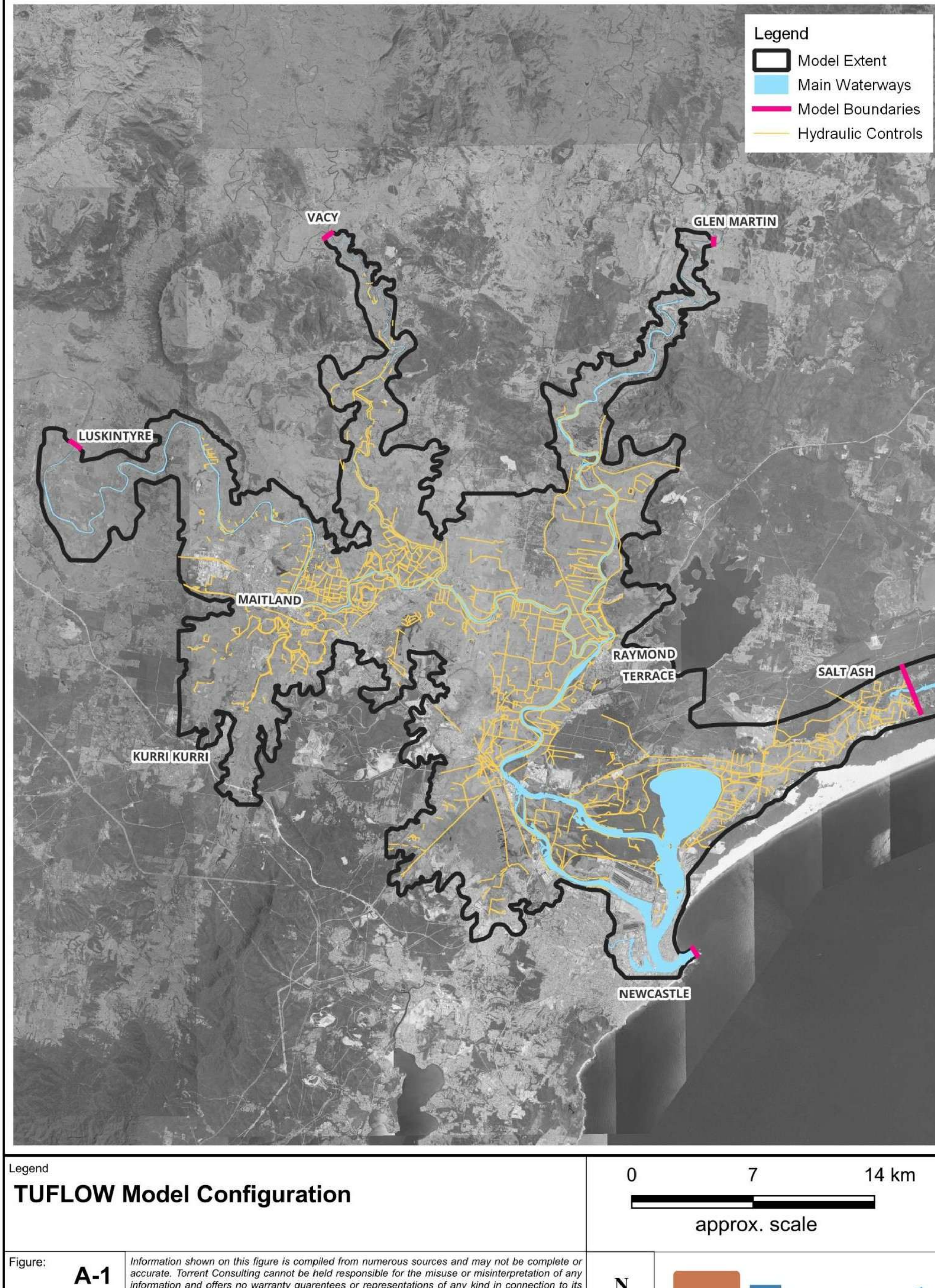
The model utilised the NSW Spatial Services LiDAR data product, downloaded via the ELVIS Foundation Spatial Data portal to define the floodplain topography. The model was constructed using a 20 m grid cell resolution, sampling elevations from the LiDAR data. The modelled floodplain contains numerous embankments that function as hydraulic controls and are of too small a scale to be adequately captured by the 20 m grid cell model resolution. Therefore, a network of breaklines was digitised along some 820 km of embankments and the underlying LiDAR data interrogated to populate the breaklines with the elevations of the embankment crests. These were then incorporated into the TUFLOW model using the Z Shape representation, which modifies model cell elevations to match those of the breaklines.

A total of 26 floodplain mound constructions were identified as having been constructed since the LiDAR data was captured in 2012-13, using available aerial imagery in Google Earth. The approximate extent of these mounds was identified from the imagery and incorporated into the TUFLOW model with assumed mound heights being adopted to raise them above the 1% AEP flood level.

The Hunter River Hydrographic Survey (May 2005) was used to provide representative channel cross-section information of the lower Hunter, Paterson and Williams Rivers. An appropriate channel topography was incorporated into the model, with a full 2D representation of both channel and floodplain. Aerial imagery was used to define separate surface materials for areas of cleared floodplain, river channel and remnant vegetation. Modelling of key hydraulic structures within the study area is also included for the Fullerton Cove and Salt Ash floodgates and culverts under Nelson Bay Road.

Many estuarine vegetation communities are not well penetrated, and are subsequently poorly filtered in, the LiDAR data product. These include areas of mangroves, saltmarsh, phragmites, rank grassland, wet heath, and other swampy habitats. The modelled floodplain elevations in these areas have therefore had an elevation correction adjustment applied to the LiDAR data. Site survey for this study identified the grasslands of the western study Lots to be around 0.2 m lower than the LiDAR representation. The swampier habitat of the eastern Lots is around 0.35 m lower than the LiDAR. Vegetation across the Hunter Estuary has been treated in this way in the TUFLOW model, with LiDAR elevations being lowered between 0.2 m and 0.6 m, depending on vegetation cover. The extent of the modified LiDAR elevations is presented in Figure A1.

The upstream model inflow boundaries on the Hunter, Paterson and Williams Rivers were developed using information contained in the Hunter River Branxton to Green Rocks Flood Study (WMA Water, 2010), the Paterson River Flood Study Vacy to Hinton (WMA Water, 2017) and the Williams River Flood Study (BMT WBM, 2009) respectively. Local hydrological inputs for the 750 km^2 of model area were also accounted for, although they are not overly important for the derivation of the design flood conditions. The downstream boundary of the model was configured as a tidal cycle with a peak water level of 1.1 m AHD, which is approximately an annual peak condition.



Legend

TUFLOW Model Configuration

Figure:	A-1	*Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.*
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The model was calibrated to provide consistency with the Hunter River Branxton to Green Rocks Flood Study and the Williamtown – Salt Ash Floodplain Risk Management Study through iterative adjustment of the Manning's 'n' roughness parameters for the digitised land use materials. The adopted Manning's 'n' values are provided in Table A1.

The TUFLOW model produced results at Maitland that closely match those of the Hunter River Branxton to Green Rocks Flood Study. Consistent results at Raymond Terrace were harder to achieve and were found to be significantly influenced by total inflow volumes more-so than peak flow rates alone.

Design flood levels at Oakhampton are driven principally by peak flows (with variations in volume effectively negligible). Flood Frequency Analysis (FFA) undertaken for the Hunter River Branxton to Green Rocks Flood Study and the Singleton Floodplain Risk Management Study (BMT, 2020) provide similar estimates of design flood flows for the Hunter River, which provides a good level of confidence in those estimates. The derivation of design flood flow estimates through FFA at Raymond Terrace is less certain, due to a shorter period of continuous record and a lack of a site rating curve. Using FLIKE to derive probabilistic estimates of design peak flows, the results for the rarer events were found to vary significantly depending on the assumptions made for data entry of historic flood thresholds. This is because there is less than 40 years of continuous record and the largest flood events all occurred before this period.

Table A1 – Adopted Manning's 'n' Values

Surface Material	Manning's 'n'
Cleared floodplain	0.040
Hunter River channel u/s Morpeth	0.030
Hunter River channel Morpeth to Raymond Terrace	0.025
Hunter River channel d/s Raymond Terrace	0.020
Paterson River channel	0.045
Williams River channel	0.025
Remnant vegetation	0.120
Mangroves	0.150

Rainfall-runoff modelling was undertaken for the entire Hunter River catchment using methods outlined in ARR 2019 to assist in establishing suitable design flow conditions at Raymond Terrace, specifically the relationship between modelled peak flow conditions at Oakhampton and Raymond Terrace. With flows on the Hunter River dominating volumes at Raymond Terrace, establishing a relationship between design flows at Oakhampton and expected design flows at Raymond Terrace provides a useful tool for validating design flood levels at Raymond Terrace. The Hunter River catchment rainfall-runoff modelling found the critical duration at Oakhampton to be 48 hours, whereas it was the 72-hour duration at Raymond Terrace – indicative of the additional reliance on overall flood volume to maintain peak flows and levels. Table A2 presents the design flows at Oakhampton and the estimated equivalent design flow condition at Raymond Terrace.

Table A2 – Hunter River Design Peak Flows (m^3/s)

Design Event	Oakhampton	Raymond Terrace
20% AEP	1700	1400
10% AEP	2600	2300
5% AEP	3800	3200
2% AEP	5800	4700
1% AEP	8000	6300
0.5% AEP	10 300	7900
0.2% AEP	13 500	10 200

Ultimately, design flow estimates were adopted from the FLIKE FFA for the 20% AEP and 10% AEP events and from the rainfall-runoff modelling analysis for the rarer flood events. Table 2 presents the design flows at Oakhampton and the estimated equivalent design flow condition at Raymond Terrace. A comparison of the adopted design flows at Raymond Terrace with the 90% confidence interval determined using FLIKE is presented in Chart A1.

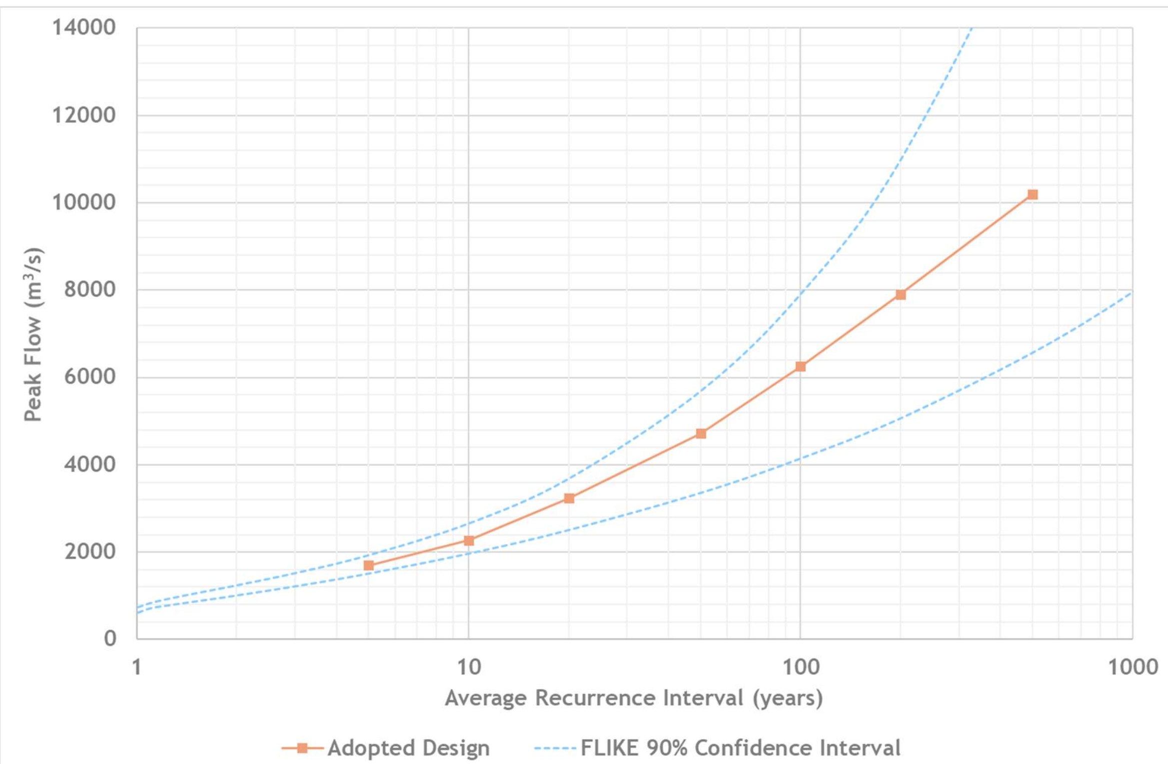


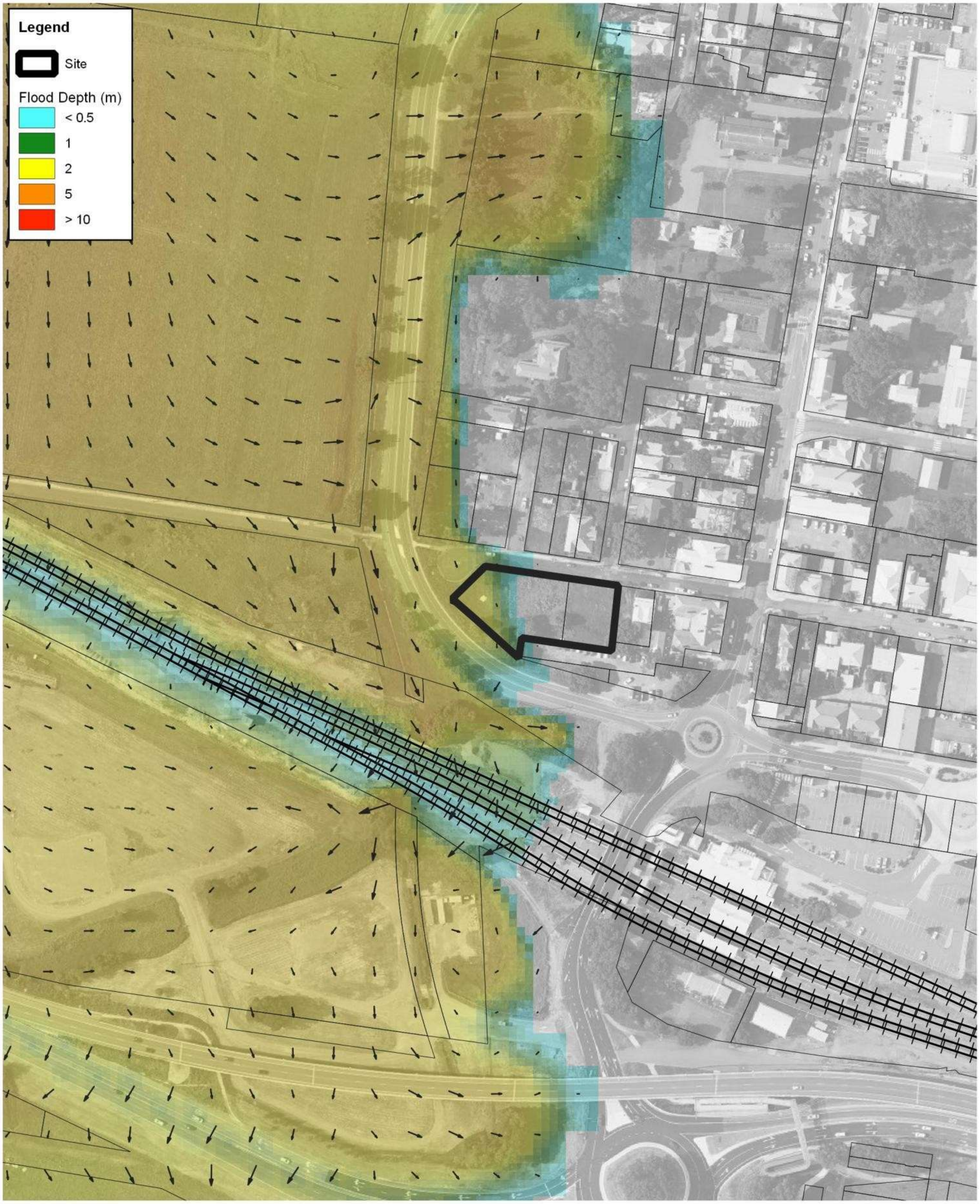
Chart A1 – Adopted Design Flood Flows at Raymond Terrace

Design flood flow hydrographs for the Hunter, Williams and Paterson Rivers were simulated in the TUFLOW model and the volumes of the flood recession were adjusted until the required peak flow conditions at Raymond Terrace were matched. The resultant peak flood levels at the Raymond Terrace gauge are presented in Table A3, together with those established for the Williamtown – Salt Ash Floodplain Risk Management Study. The overall consistency between the two is good and is well within the bounds of uncertainty of the FFA at Raymond Terrace.

Table A3 – Design Flood Levels at Raymond Terrace

Design Event	This Assessment	BMT WBM (2017)
20% AEP	2.6	2.2
10% AEP	2.9	3.0
5% AEP	3.3	3.3
2% AEP	4.0	4.1
1% AEP	4.7	4.8
0.5% AEP	5.3	5.2
0.2% AEP	6.1	N/A

APPENDIX D – Design Flood Mapping



Title:

Peak 5% AEP Flood Depth and Inundation Extent Existing Conditions - Site Detail

Figure: **D-1**

Revision: **A**

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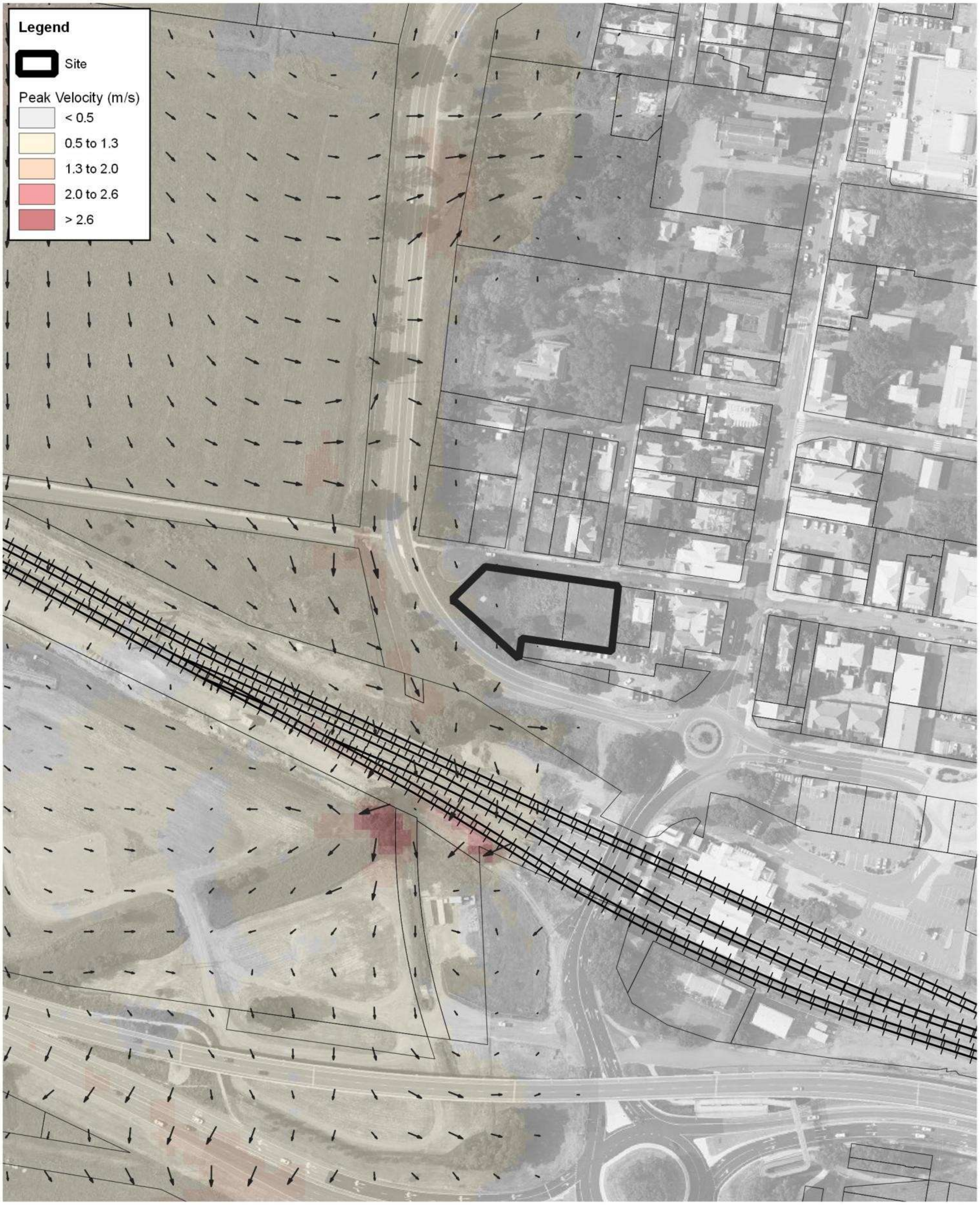

Title:

Peak 5%AEP Peak Flood Velocity Existing Conditions - Site Detail

Figure: **D-2**

Revision: **A**

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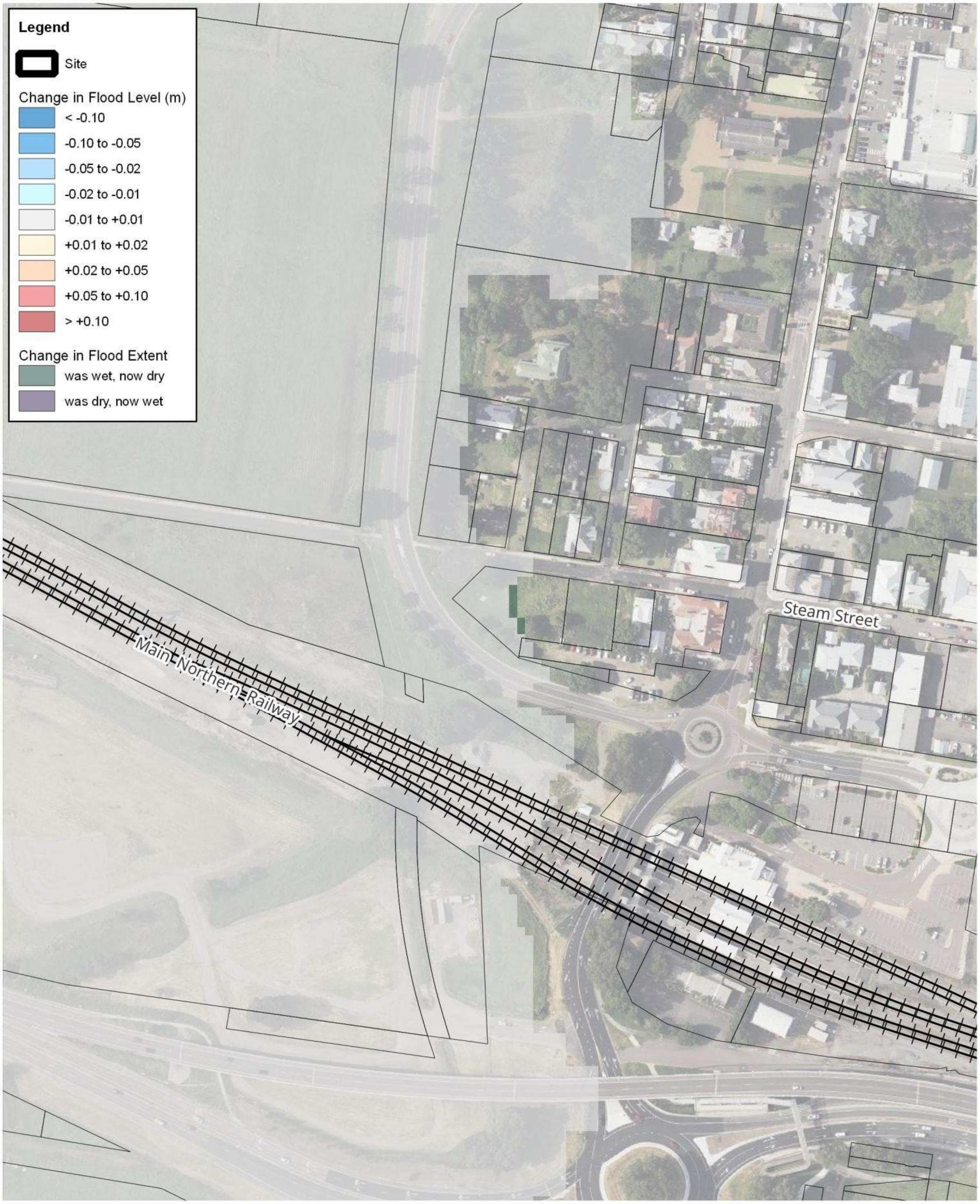

Title:

Change in Peak 5% AEP Flood Level Post-development

Figure: **D-3**

Revision: **A**

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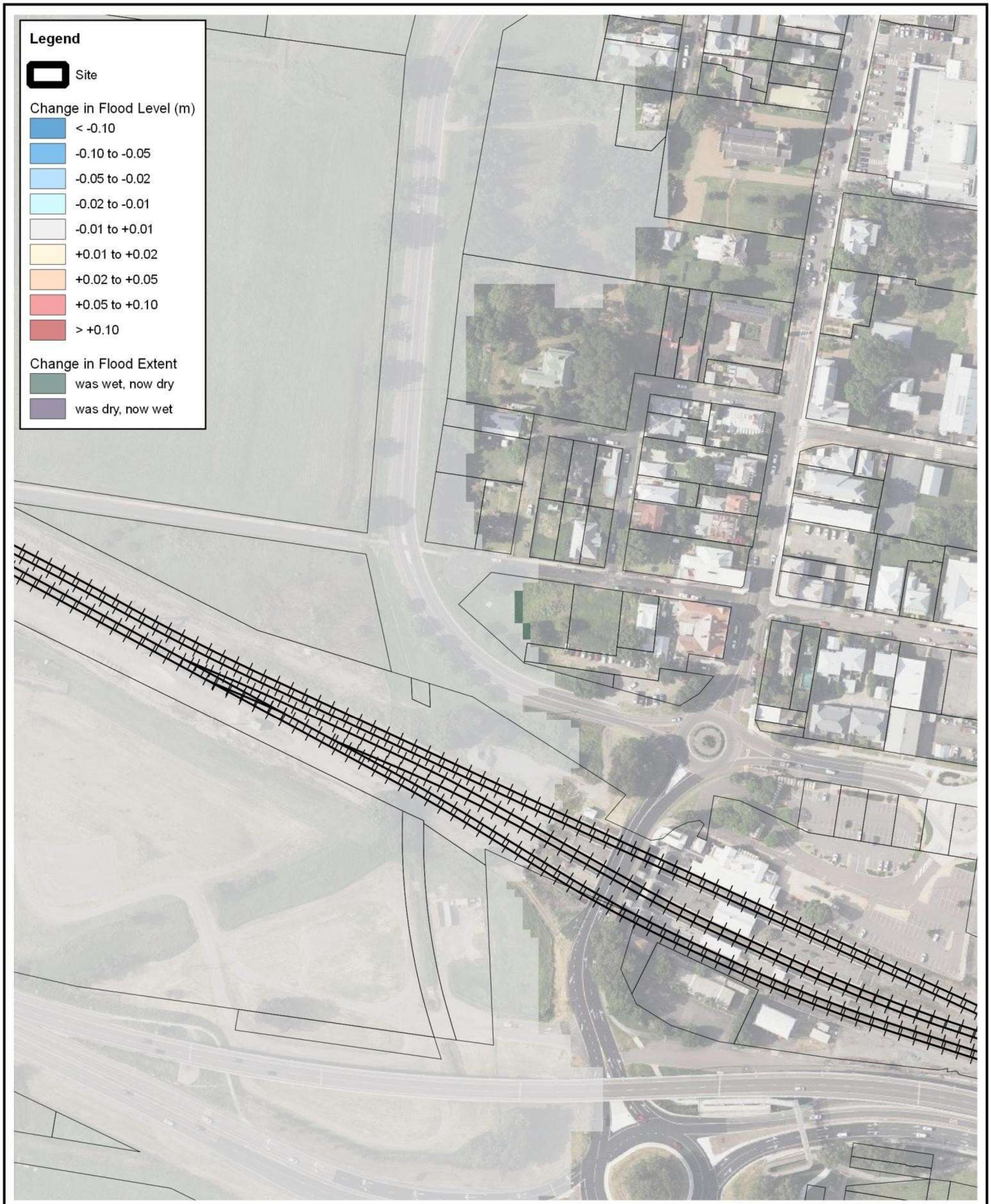

Title:

Change in Peak 1% AEP Flood Velocity Post-development

Figure: **D-4**

Revision: **A**

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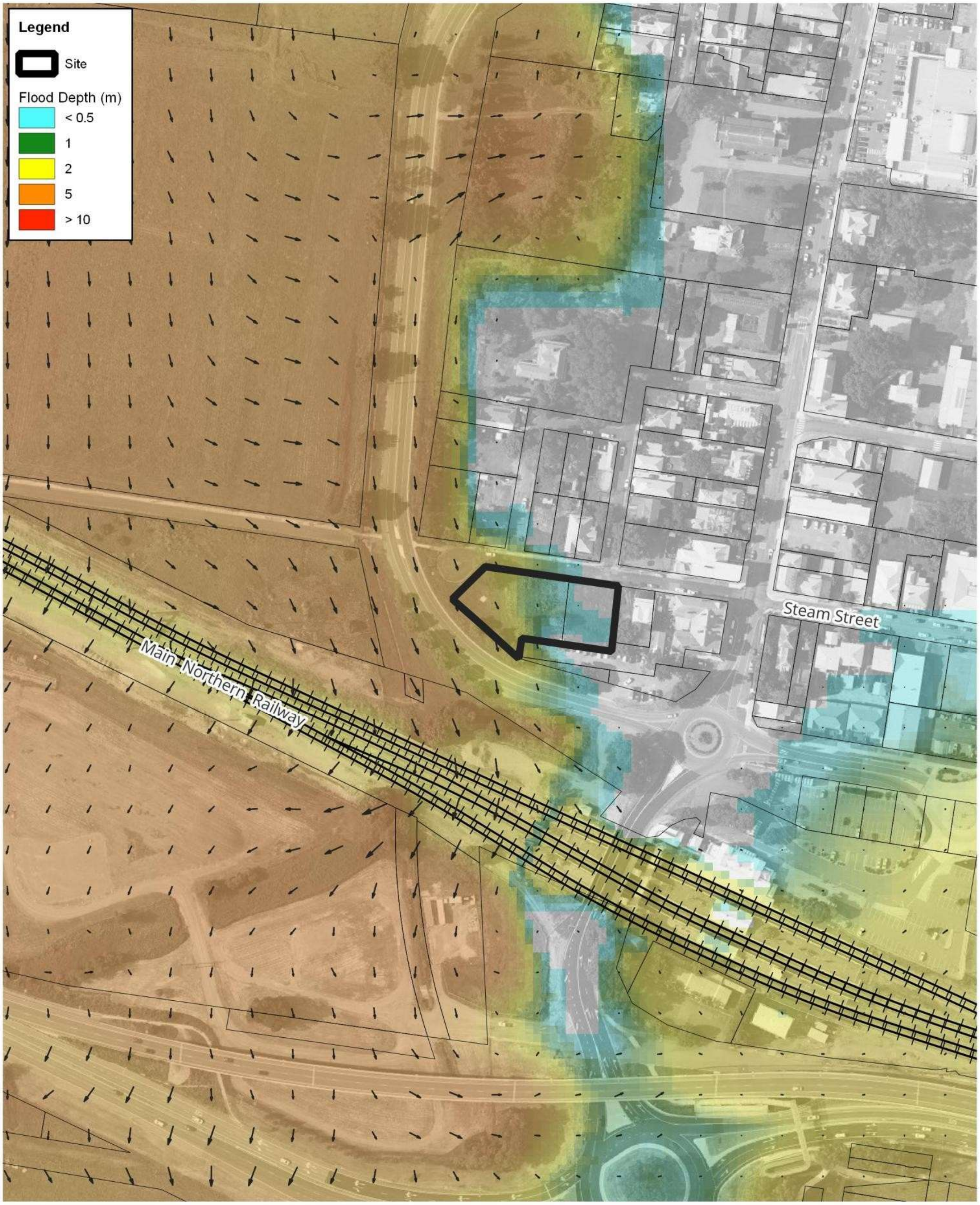

Title:

Peak 1% AEP Flood Depth and Inundation Extent Existing Conditions - Site Detail

0 60 120 m

approx. scale

Figure: **D-5**

Revision: **A**

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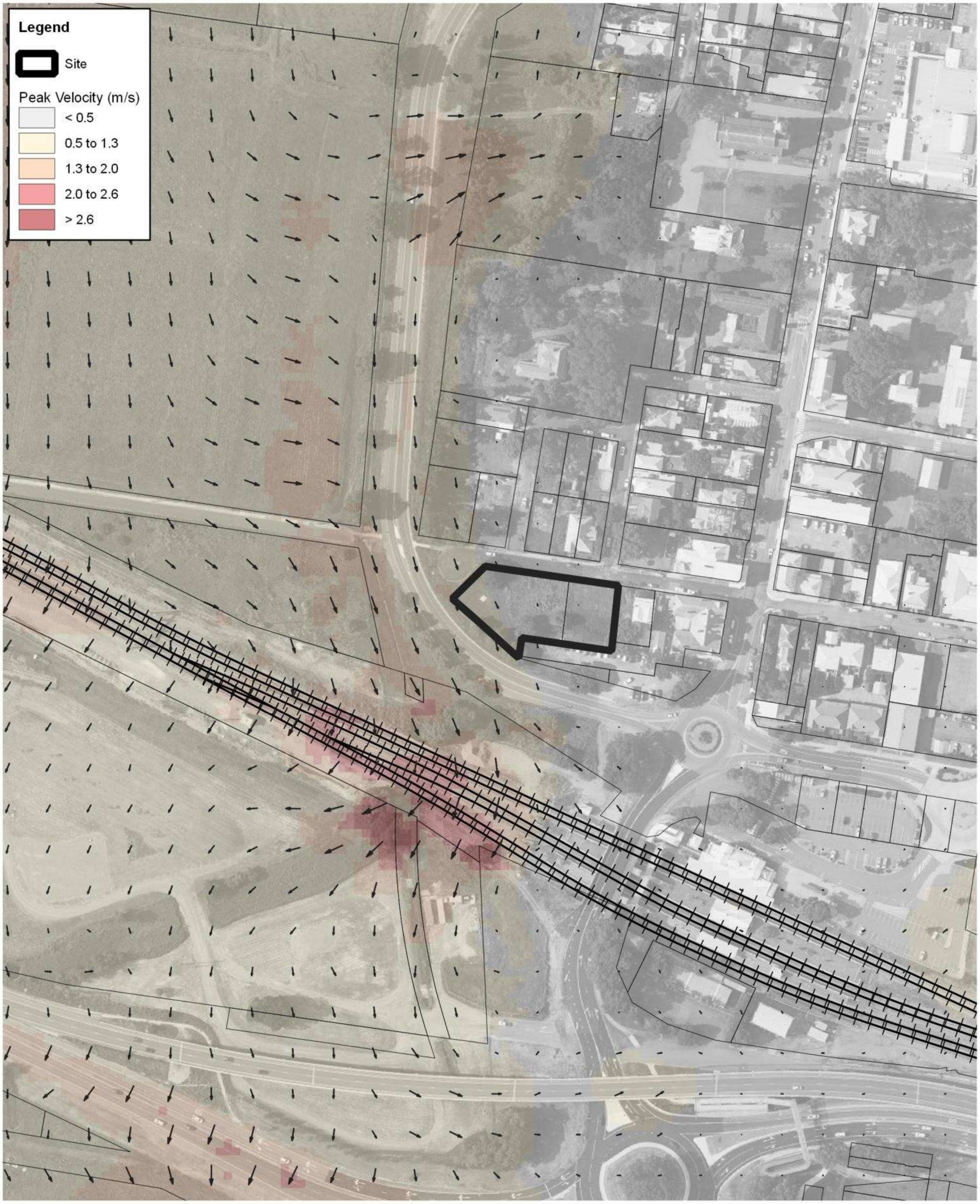

Title:

Peak 1%AEP Peak Flood Velocity Existing Conditions - Site Detail

0 60 120 m

approx. scale

Figure: **D-6**

Revision: **A**

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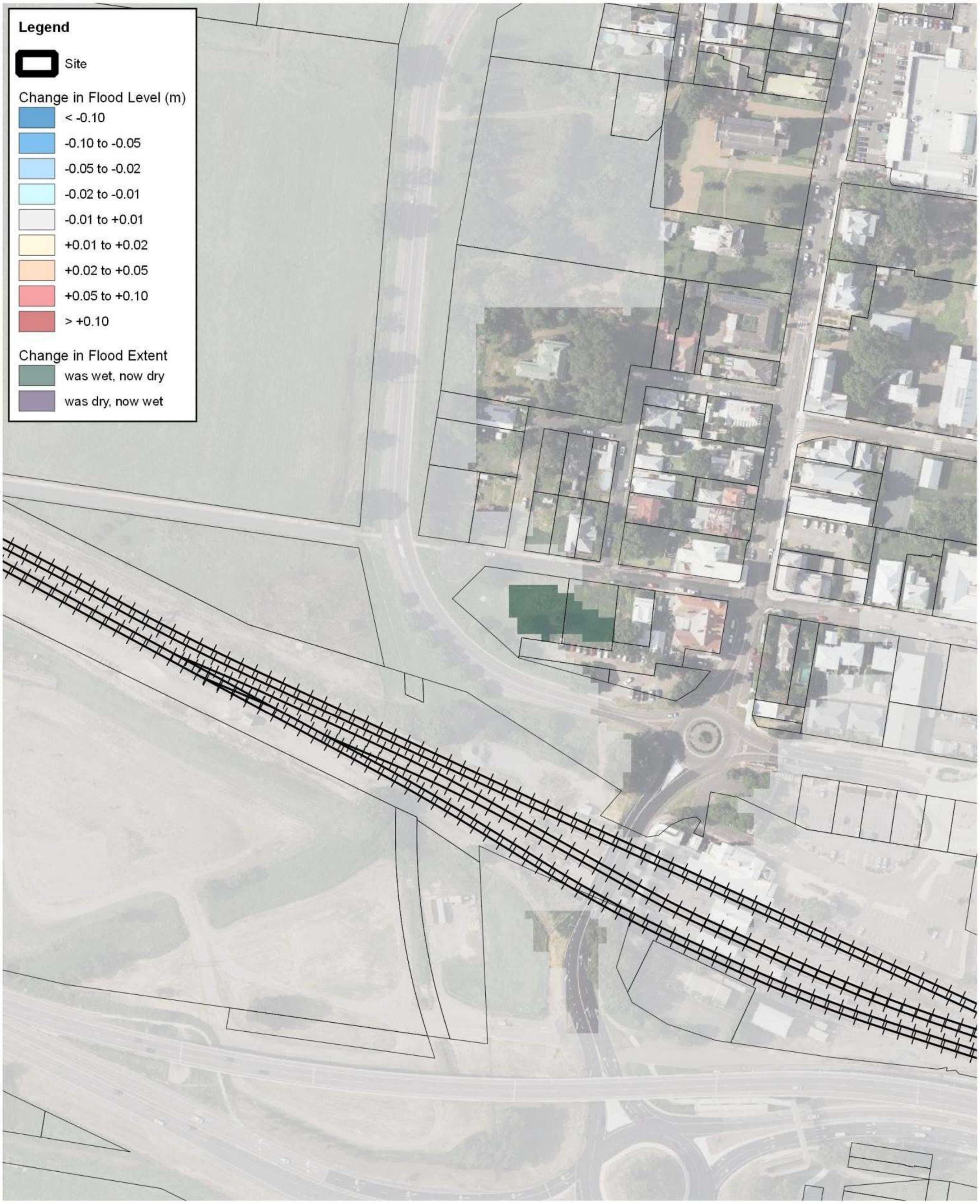

Title:

Change in Peak 1% AEP Flood Level Post-development

0 60 120 m

approx. scale

Figure:	D-7
Revision:	A

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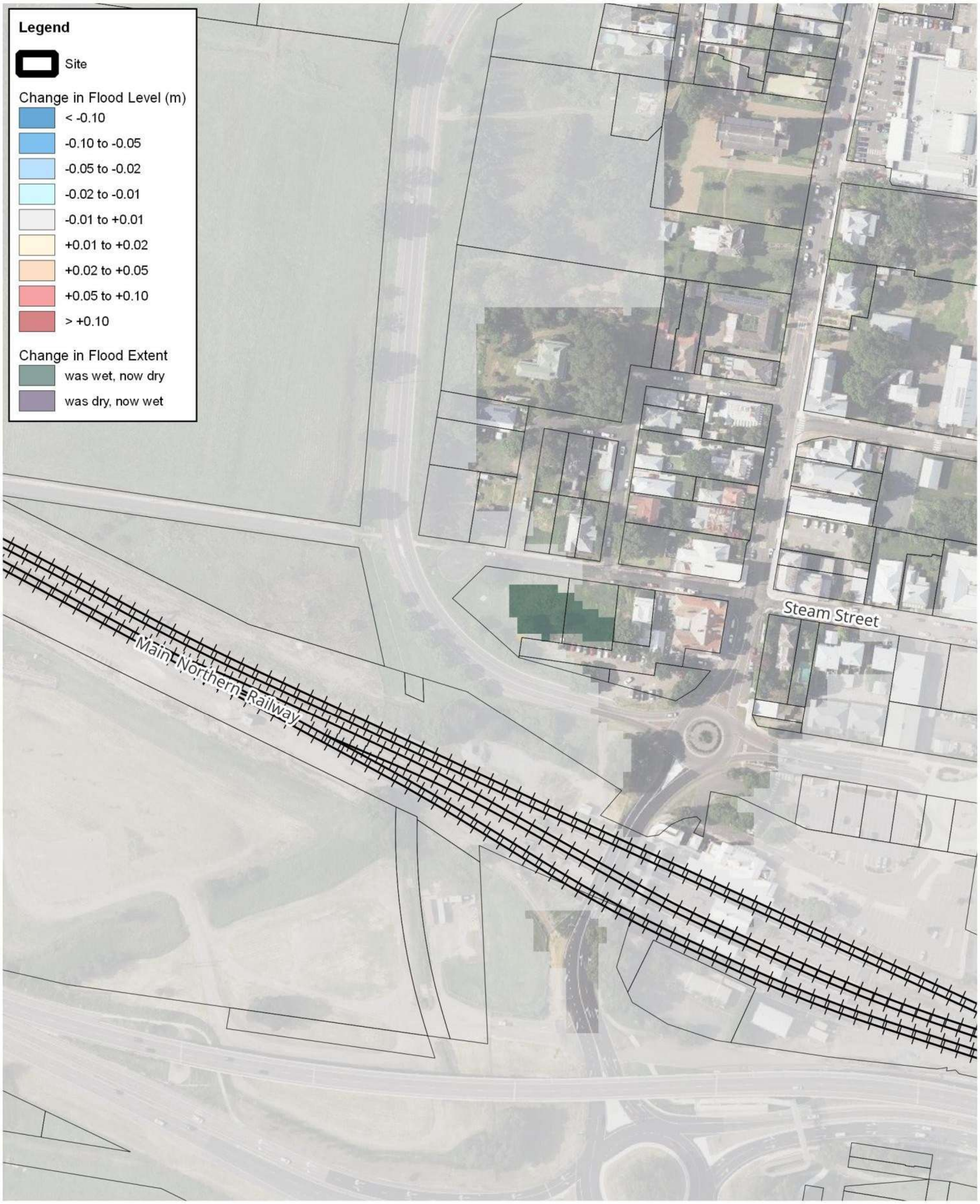

Title:

Change in Peak 1% AEP Flood Velocity Post-development

0 60 120 m

approx. scale

Figure: **D-8**

Revision: **A**

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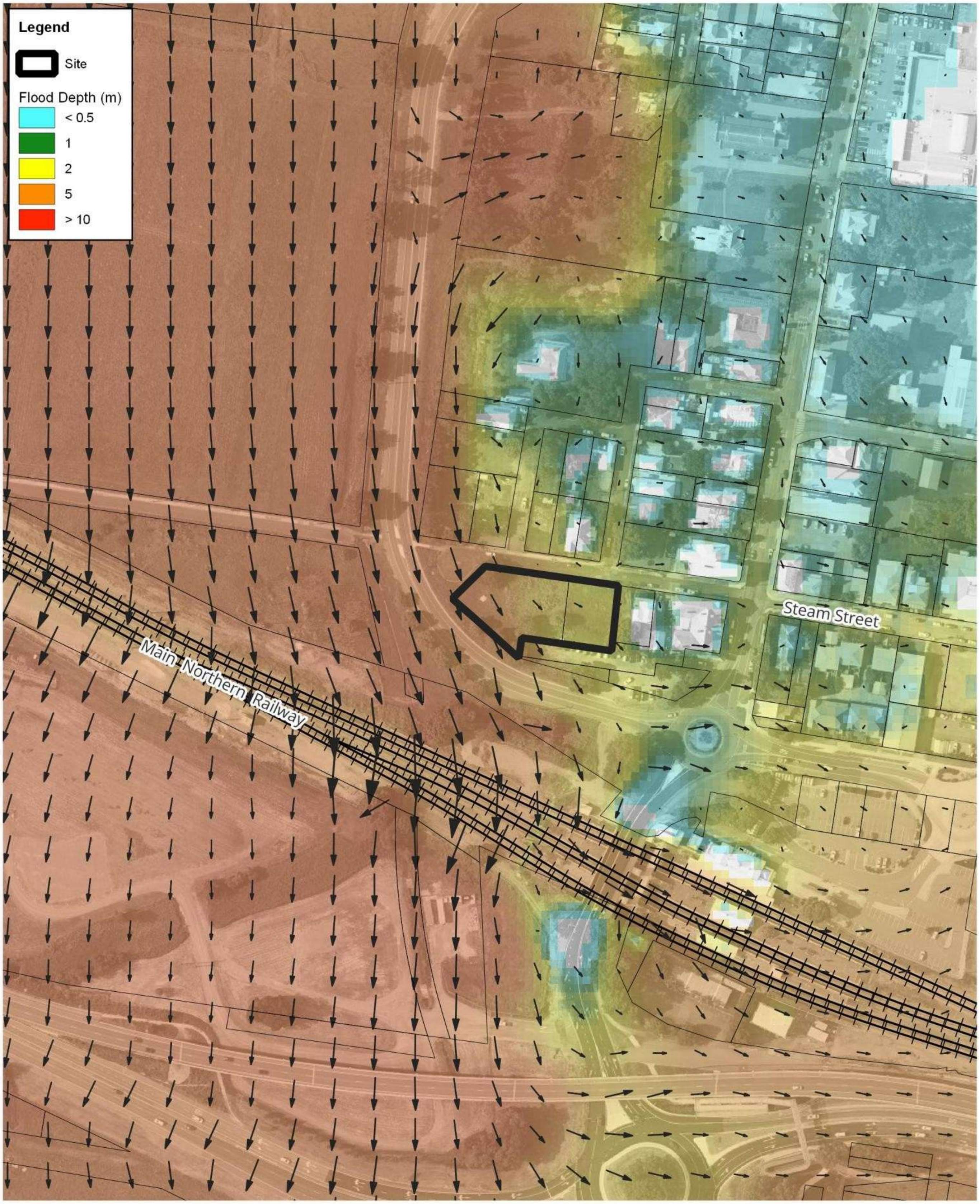

Title:

Peak PMF Flood Depth and Inundation Extent Existing Conditions - Site Detail

Figure: **D-9**

Revision: **A**

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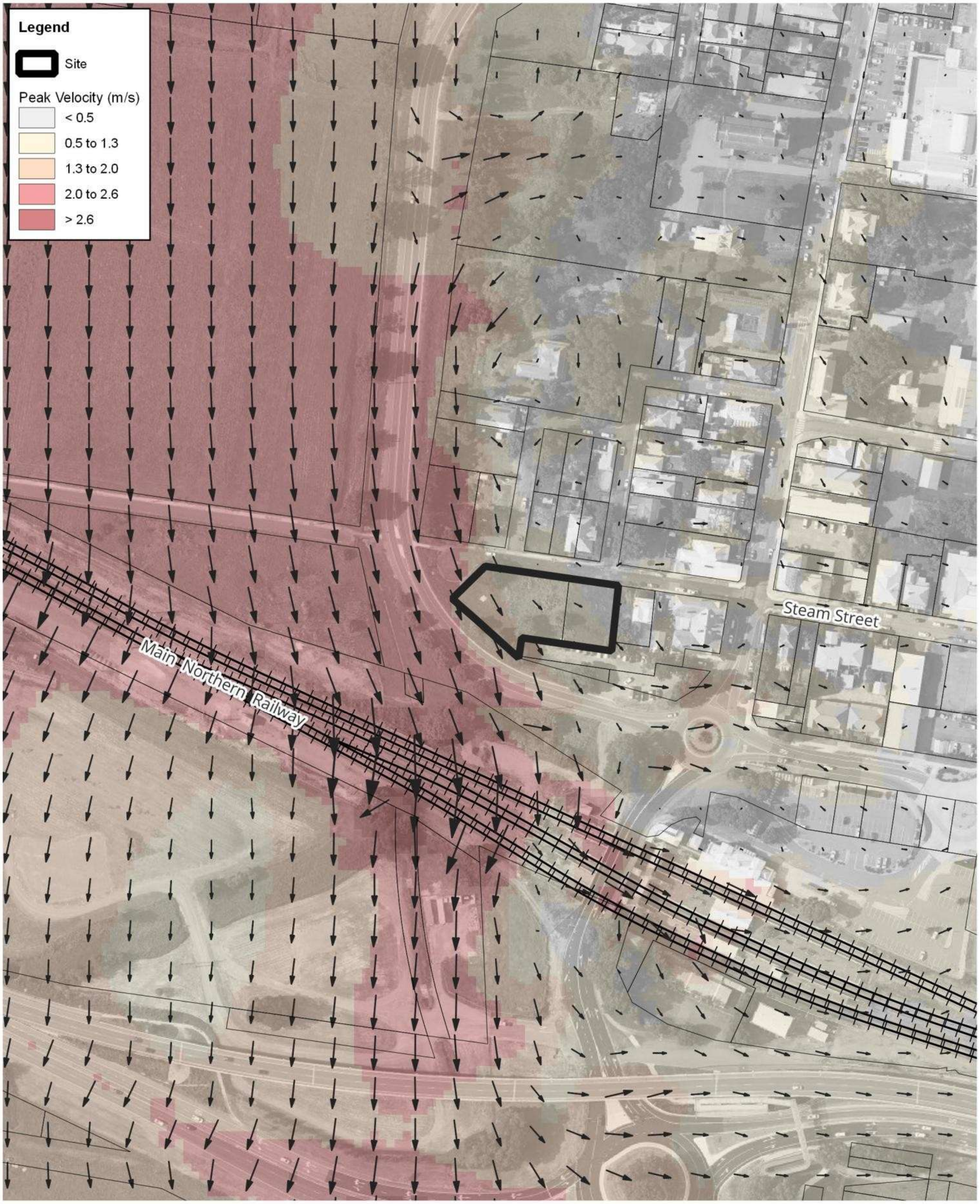

Title:

Peak PMF Peak Flood Velocity Existing Conditions - Site Detail

Figure: **D-10**

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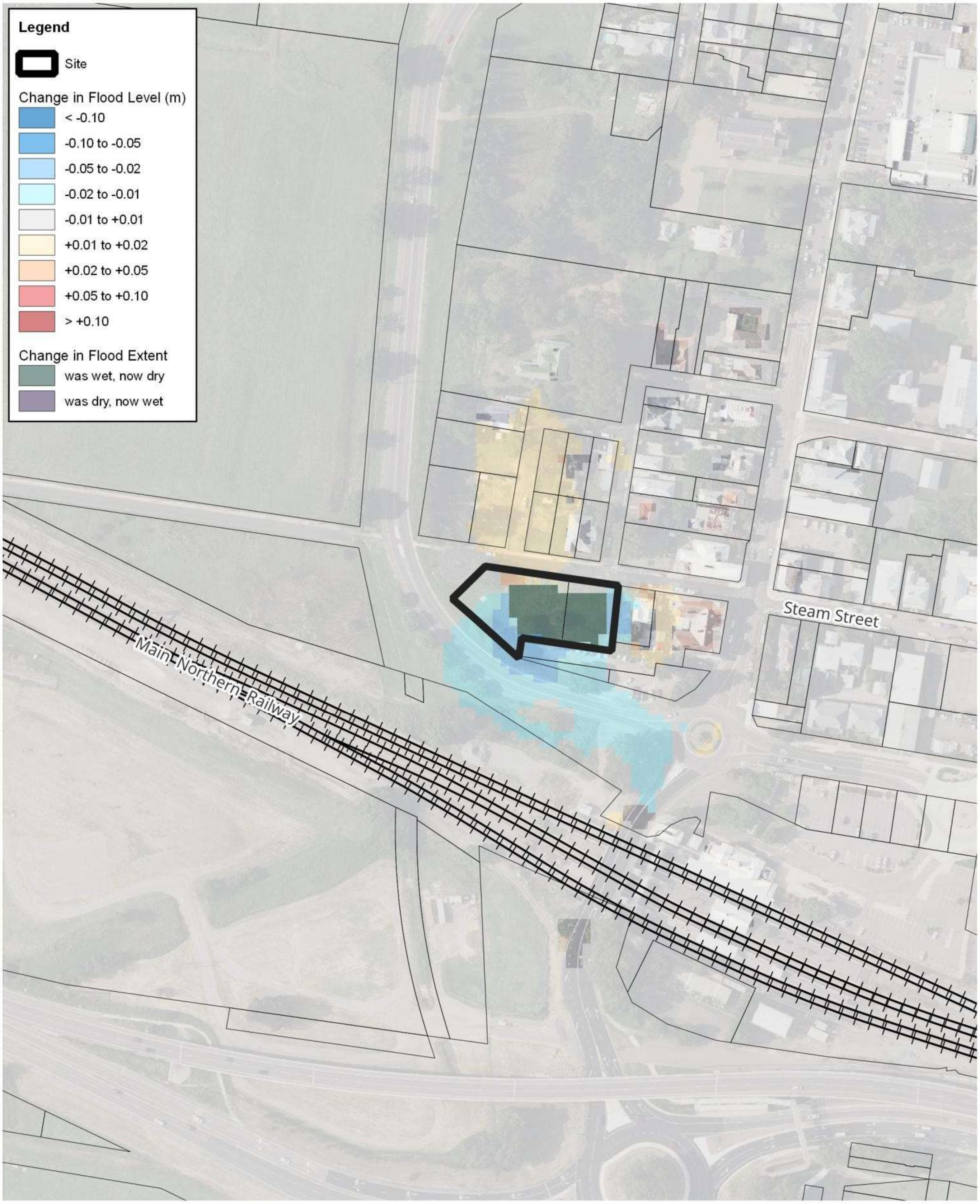

Title:

Change in Peak PMF Flood Level Post-development

0 60 120 m

approx. scale

Figure: **D-11**

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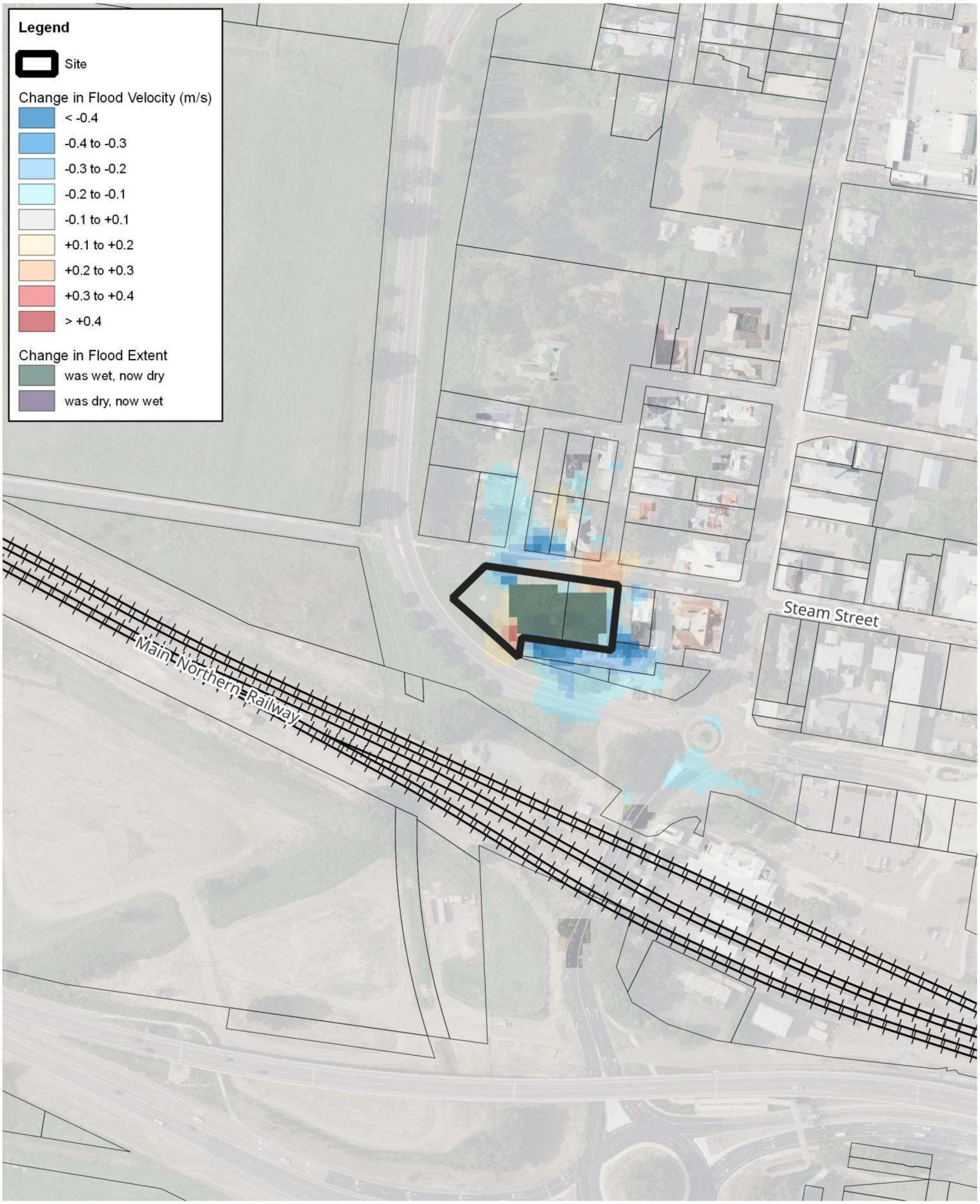

Title:

Change in Peak PMF AEP Flood Velocity Post-development

0 60 120 m

approx. scale

Figure: **D-12**

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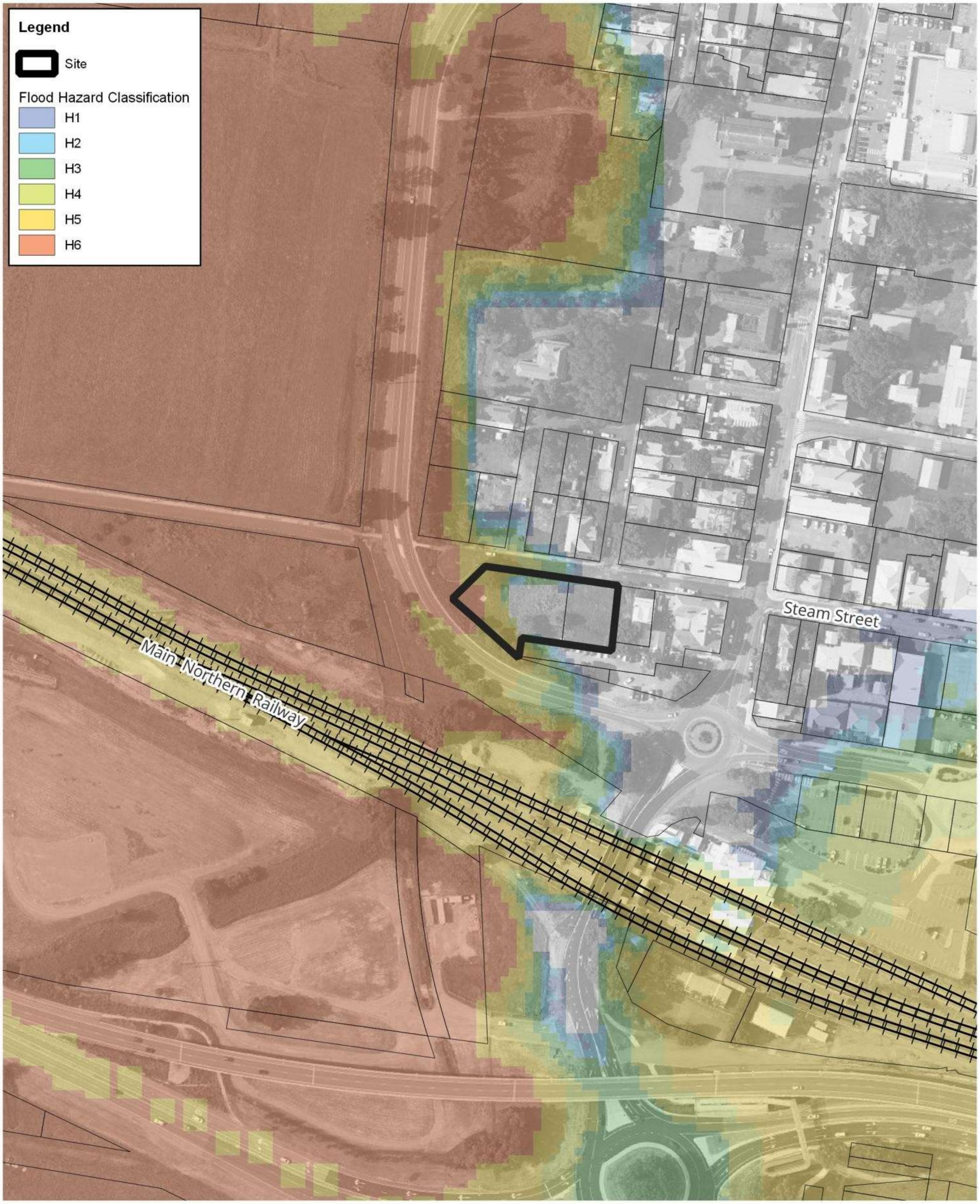

Title:

Peak 1% AEP Flood Hazard Classification Existing Conditions - Site Detail

Figure: **D-13**

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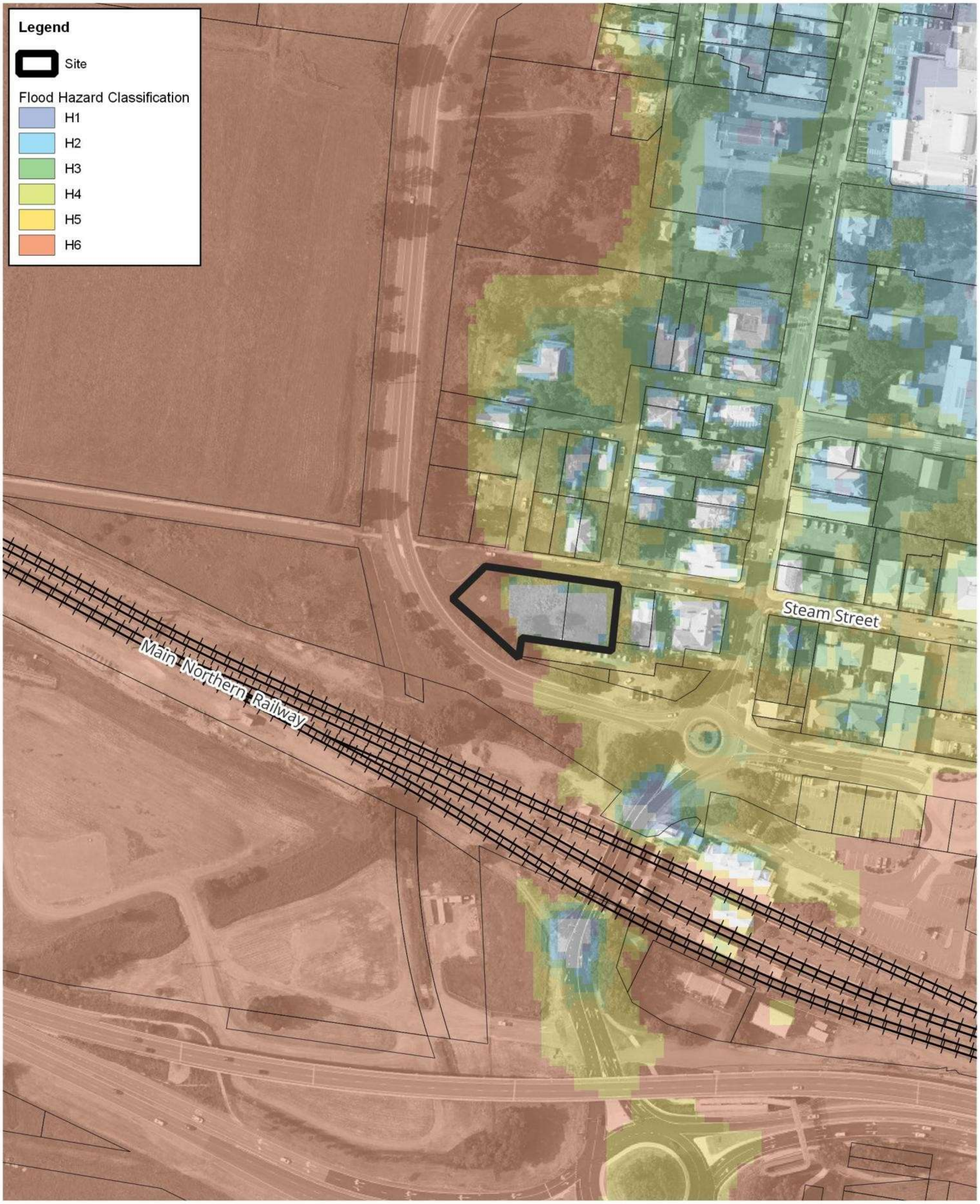

Title:

Peak PMF Flood Hazard Classification
Existing Conditions - Site Detail

0 60 120 m

approx. scale

Figure: **D-14**

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