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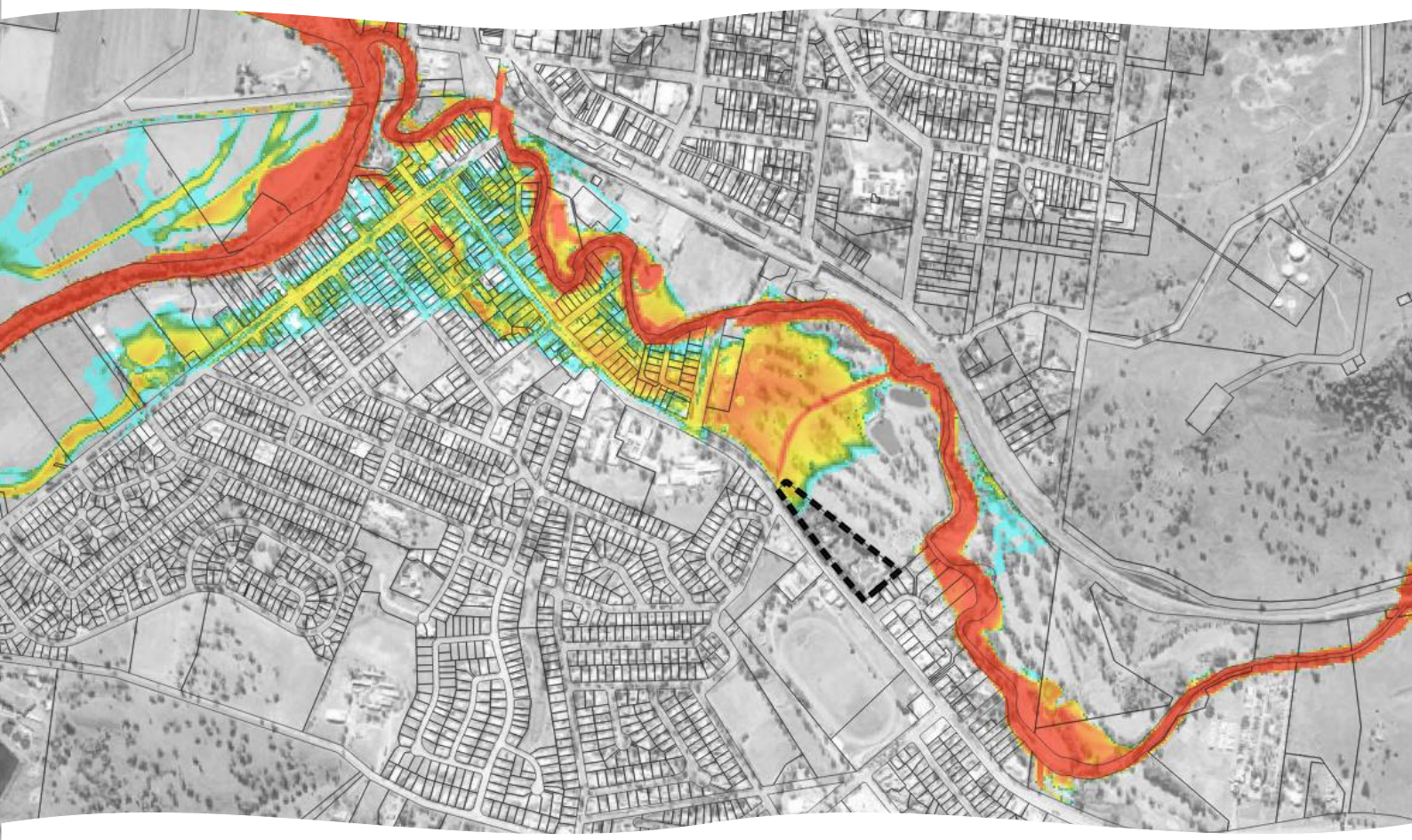
Pacific Brook Christian School

Flood Impact and Risk Assessment

R.T2583.002.02



August 2024

Final Report

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Prepared:	

Synopsis

Flood Impact and Risk Assessment for proposed Pacific Brook Christian School. The report details the flood behaviour at the Site, proposed development impact on existing design flood conditions.

Revision History

Revision	Description	Date
01	Draft	15/07/2024
02	Final	06/08/2024

Disclaimer

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1 Introduction

1.1 Project Overview

Torrent Consulting was engaged by Impact Group on behalf of Pacific Group of Christian Schools Ltd trading as Pacific Brook Christian School (PBCS) to prepare a Flood Impact Assessment (FIA) to assist in the approval process for the proposed development at the 72-74 Maitland Road, Muswellbrook, NSW (the Site). The proposed development is for the establishment of a new K-12 school (Pacific Brook Christian School) on the Site.

This Site is located within the Muscle Creek catchment and is subject to potential flood inundation during extreme rainfall events. Muscle Creek drains 92 km^2 of catchment upstream of Muswellbrook covering predominantly undeveloped land east of the Site as shown in Figure 1-1. The Muscle Creek channel alignment flows centrally through the township of Muswellbrook before joining the Hunter River.

The design flood conditions at the Site are established in the Muscle Creek Flood Study (RHDHV, 2017) and Muswellbrook Floodplain Risk Management Study and Plan (RHDHV, 2019). The existing flood study models include a XP-RAFTS hydrological model and TUFLOW 2-dimensional (2D) hydraulic model. The existing models were provided by Muswellbrook Shire Council (Council) for use in the assessment.

The models provide a platform to assess the implications of the existing flood risk for the Project within the context of Councils flood planning and stormwater management controls, and to identify potential impacts the development will have on local conditions.

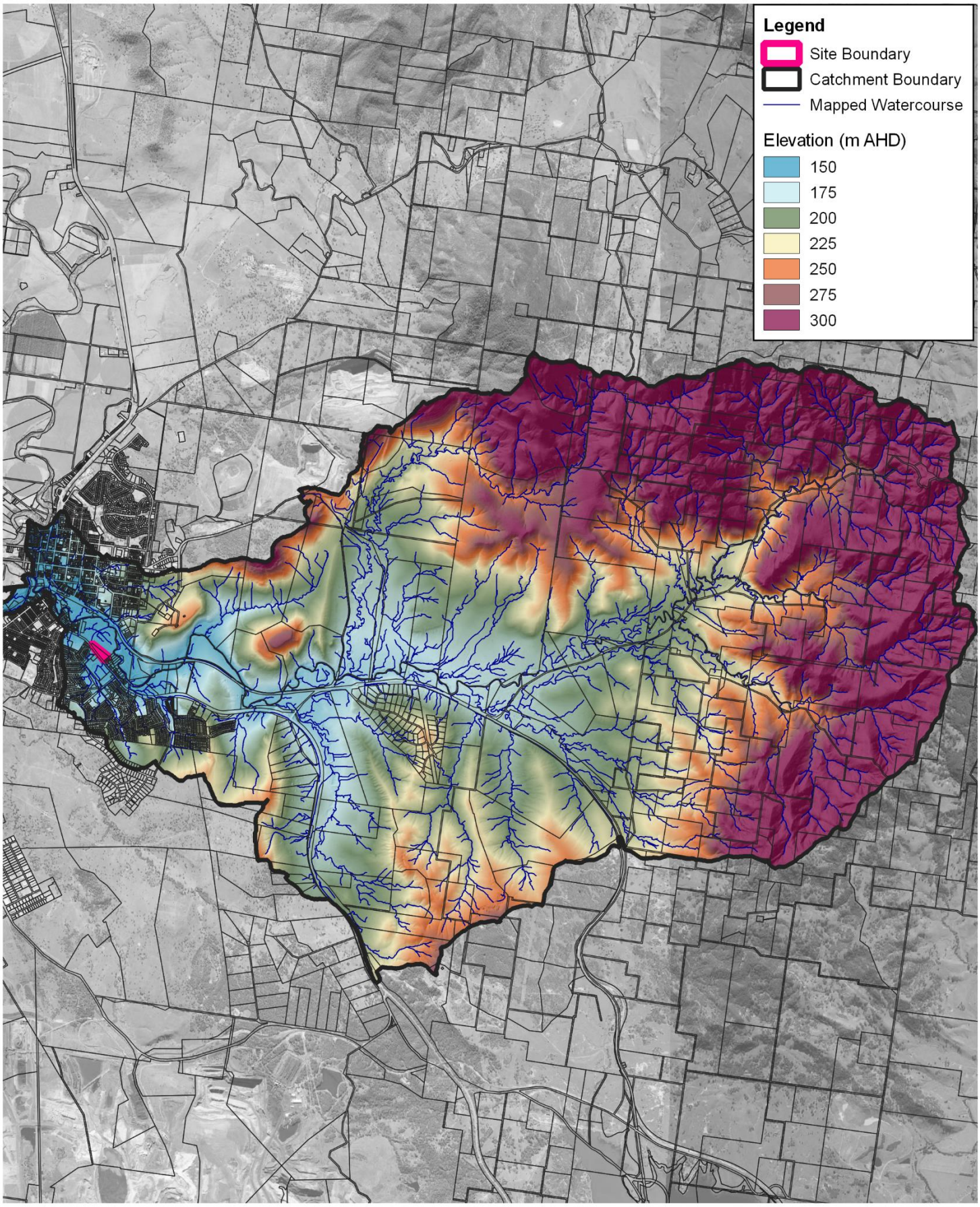
The proposed development comprises site preparation and remediation, tree removal, construction of new school buildings, covered outdoor learning area, covered walkways, car parking, landscaping and associated works. The proposed design and layout is provided in Appendix A.

1.2 Flood Planning Requirements

This Flood Impact and Risk Assessment and the accompanying Flood Emergency Response Plan is prepared to demonstrate the compatibility of the development proposal in accordance with the NSW Department of Planning and Environment's Flood Risk Management Manual 2023 and applicable flood risk planning provisions. A summary of relevant planning provisions with respect to flood risk management is provided hereunder.

1.2.1 Land Use Planning Directions

The NSW Department of Planning, Housing and Infrastructure Planning Circular PS 24-001 replaces Planning Circular PS07-003 and provides information on how to consider flooding in land use planning. This circular also discusses changes to local planning direction 4.1 on flooding, which affects planning proposals.



Title:

Muscle Creek Catchment Topography

0 2 4 km

approx. scale

Figure: 1-1

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Ministerial Direction 4.1 (the Direction) provides Direction on how to consider flooding implications when considering planning proposals on land identified within a flood planning area or below the probable maximum flood (extreme event).

The objectives of this Direction are as follows:

> a) ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and
>
> b) ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.

The *Considering Flooding in Land Use Planning Guideline* (2021) provides further guidance to councils on flood-related land use planning and the areas where flood-related development controls should apply. The guidelines outline a risk-based approach to development assessment taking into account the flood risk profile of each proposal which considers the flood characteristics for the location, the nature and type of development and any impacts on the existing community and surrounding properties. Matters to consider when determining the flood risk profile should include:

- whether the proposal is in a high-risk catchment
- the location of the proposal in relation to flood behaviour and constraints including:
  - floodway, flood storage area or flood fringe area
  - the hazard vulnerability classification of the land
  - frequency of inundation
- whether the proposal provides for safe occupation and efficient and effective evacuation in flood events and how it is to be achieved
- in high-risk catchments, whether the proposal is likely to result in a significant increase to the risk to life in other parts of the catchment in a PMF flood event
- any known evacuation constraints such as the flood emergency response classification for the area and available warning times (including rate of rise and when the evacuation route is cut off by floodwater)
- whether the proposal is for a sensitive or hazardous land use, or other higher risk uses and what mitigation strategies (if any) are proposed to reduce any identified risks
- whether there may be adverse flooding impacts on surrounding properties
- potential impacts of cut and fill and other building works on flood behaviour
- ability of proposed development to withstand flood impacts.

The prepared Flood Impact and Risk Assessment and the accompanying Flood Emergency Response Plan provides the relevant assessment of local flooding conditions, development impacts and emergency response requirements to enable appropriate assessment of the development proposal..

1.2.2 Muswellbrook Local Environmental Plan (2009)

The Muswellbrook LEP 2009 provides a framework for development of land and land use in the Muswellbrook LGA. Clause 5.21 relates to flood planning which states the following objectives:

a) to minimise the flood risk to life and property associated with the use of land;

b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change;

c) to avoid adverse or cumulative impacts on flood behaviour and the environment;

d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

In supporting these objectives, the LEP includes provision that development consent must not be granted unless the consent authority is satisfied that the development:

a) is compatible with the flood function and behaviour on the land; and

b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties; and

c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood; and

d) incorporates appropriate measures to manage risk to life in the event of a flood; and

e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

NSW Planning has prepared a *Special Flood Considerations Clause* as an optional clause to include in LEPs in order to better protect and manage new development in areas that could be at risk during floods. The special flood considerations clause would apply to:

- sensitive and hazardous development, such as caravan parks, hospitals and seniors housing, between the flood planning area and the probable maximum flood level
- development that is not sensitive or hazardous on land that the consent authority considers that, in a flood, may pose a particular risk to life and where people may need to evacuate, or where there are other safety concerns.

The Special Flood Considerations clause has been adopted in MLEP 2009. Accordingly, the flood impact and risk assessment for the development proposal has considered potential flood risk to future occupation of the floodplain for all events up to and including the PMF. This applies to the proposed development being considered a sensitive development type as an educational institution.

1.2.3 Muswellbrook Development Control Plan (2009)

Specific planning controls are outlined in the Muswellbrook DCP 2009 Section 13 – Floodplain Management. The following objectives are noted in the DCP:

- Establish guidelines for the development of flood prone land that are consistent with the NSW Flood Policy and NSW Floodplain Development Manual (2005) (*noting this is now Flood Risk Management Manual 2023*) and as updated by the associated Floodplain Risk Management Guides.
- Limit the intensification of residential uses and other inappropriate uses in flood affected areas.

- Promote flood compatible design and building that considers requirements for the development of flood prone land and does not adversely impact on adjoining properties or pose unnecessary risk or cost to the public or emergency services.
- Ensure measures are implemented to reduce private and public losses resulting from flooding and manage risks to property and life from flood events.
- Ensure that the development or use of floodplains waterways and riparian corridors does not adversely impact upon aesthetic, recreational and ecological values and takes into account potential changes resulting from climate change; and
- Provide guidance for assessing the LEP criteria for Development Consent, considering Council's responsibilities for floodplain management and flood related development standards as specified in other relevant legislation including the Local Government Act 1993 and Water Management Act 2000.

The DCP details the extent of flood related information required to be submitted with an application. The prepared Flood Impact and Risk Assessment and the accompanying Flood Emergency Response Plan addresses these requirements.

2 Design Flood Conditions

A high-level review of the existing Muscle Creek Flood Study models has found it fit-for-purpose in assessing the proposed development. Notwithstanding, additional modelling has been undertaken to confirm the general design flood inundation extents in the catchment and compatibility of the proposed development with the existing flood risk.

2.1 Model Configuration

The design hydrology for the Muscle Creek catchment (refer to Figure 1-1) was derived in the existing flood study through the development of an XP-RAFTS hydrological model. The release of the Australian Rainfall and Runoff 2019 (ARR2019) guidelines provides updated procedures for design flood estimation. This includes updated intensity-frequency-duration (IFD) rainfall estimates and application of a suite of revised temporal patterns for establishing critical design flood conditions. However, to provide consistency with Council's existing flood mapping, the current assessment maintains the same design flow hydrographs based on the Muscle Creek Flood Study.

A TUFLOW two-dimensional (2D) hydraulic model of the local reach of Muscle Creek defines the detailed design flood conditions in the local channel and floodplain environment, including the Site area. A summary of the key model configuration parameters is presented below.

2.1.1 Model Extent and Topography

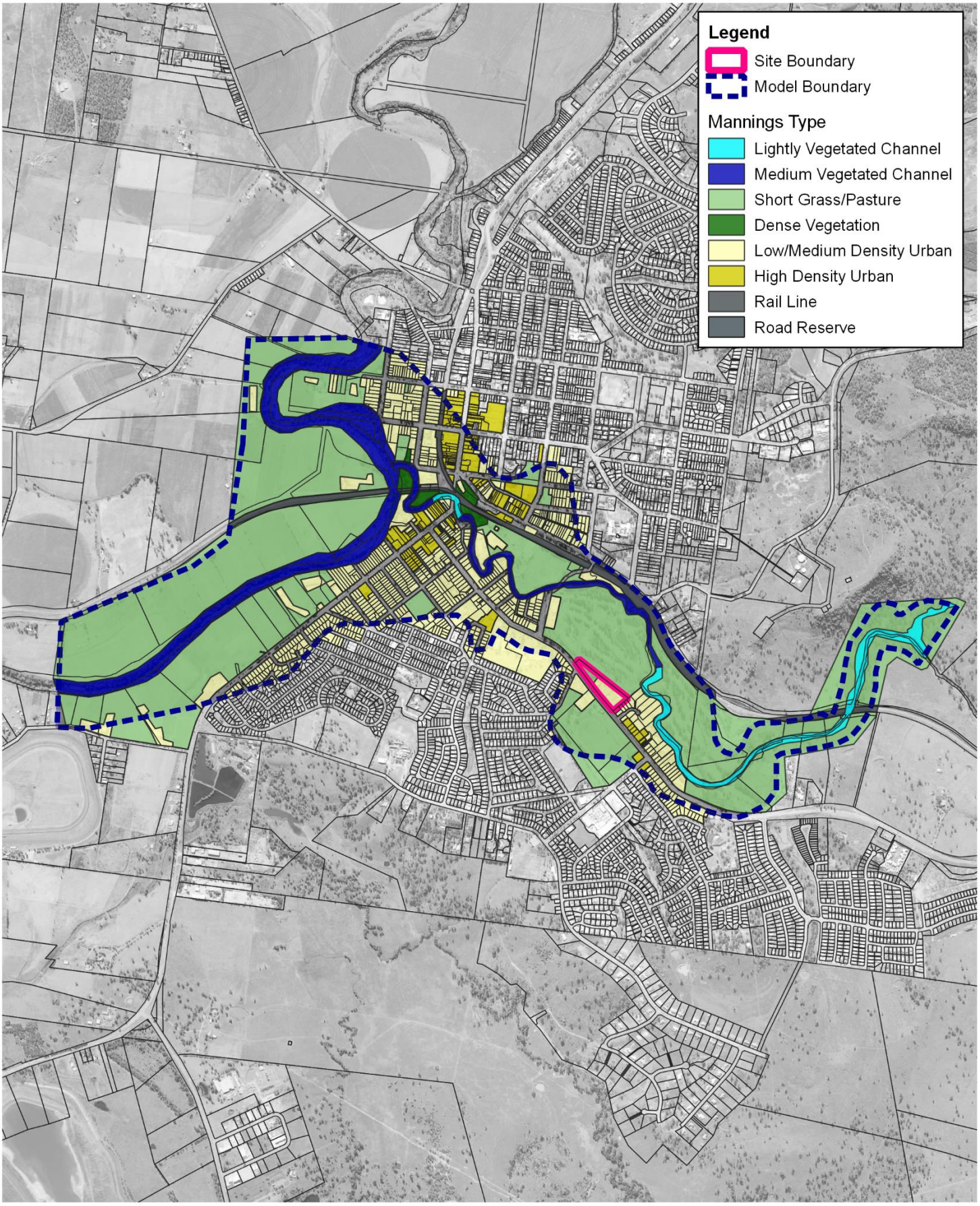
The TUFLOW model boundary is shown in Figure 2-1 covering the Muscle Creek floodplain from approximately 2.4km upstream of the Site to the confluence with the Hunter River. A short reach of the Hunter River upstream and downstream of the confluence is included in the model domain.

The adopted TUFLOW grid model resolution is 3m. The adopted resolution is sufficient to model the overland flow distribution through the Site and define the hydraulic flow characteristics including peak inundation extents. The model topography is based on LiDAR data provided by Council as per RHDHV (2017); however, the date of acquisition is not indicated. Notwithstanding, the model topography is expected to be representative of existing conditions and is similar to available NSW Spatial Services LiDAR data product, downloaded via the ELVIS Foundation Spatial Data portal.

2.1.2 Hydraulic Roughness

The development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are delineated from aerial photography and cadastral data identifying different land-uses (e.g., roads, urban areas, park lands, open space etc.) for modelling the variation in flow resistance.

Table 2-1 summarises the adopted Manning's 'n' coefficients for hydraulic roughness based on the land use distribution as shown in Figure 2-1. The adopted values are within typical industry adopted ranges.



Title:

TUFLOW Model Configuration

0 0.7 1.4 km

approx. scale

Figure: **2-1**

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Table 2-1 Hydraulic Model Surface Roughness Parameter

Land Use	Manning's 'n'
Lightly Vegetated Channel	0.035
Medium Vegetated Channel	0.045
Short Grass / Pasture	0.035
Dense Vegetation	0.040
Low/Medium Density Urban Lots	0.060
High Density Urban Lots	0.100
Rail Line	0.050
Road Corridor	0.020

2.1.3 Inflow Boundary Conditions

The TUFLOW model includes inflow boundaries at the upstream model extent on Muscle Creek providing for the flow from the upper catchment, a local inflow for the remainder of Muscle Creek catchment to the Hunter River applied downstream of the Site, and a minor inflow contribution to the Hunter River channel. The principal inflow condition influencing flooding conditions at the Site is the upstream Muscle Creek inflow.

The design model inflow hydrographs are derived from the XP-RAFTS model. The peak flows for the upstream Muscle Creek inflow boundary for the range of design flood magnitudes are summarised in Table 2-2.

Table 2-2 Design Flood Flows for Muscle Creek

Design Event	Peak Flow (m^3/s)
1 in 2 (50%) AEP	101
1 in 5 (20%) AEP	160
1 in 10 (10%) AEP	194
1 in 20 (5%) AEP	240
1 in 50 (2%) AEP	284
1 in 100 (1%) AEP	331
1 in 200 (0.5%) AEP	382
1 in 500 (0.2%) AEP	454
PMF	3000

2.2 Existing Peak Flood Conditions

The developed model has been simulated for the 1% AEP, 0.5% AEP, 0.2% AEP and PMF design condition. Note the Site is not impacted for flood events lower than the 1% AEP design flood magnitude. 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 2-2.

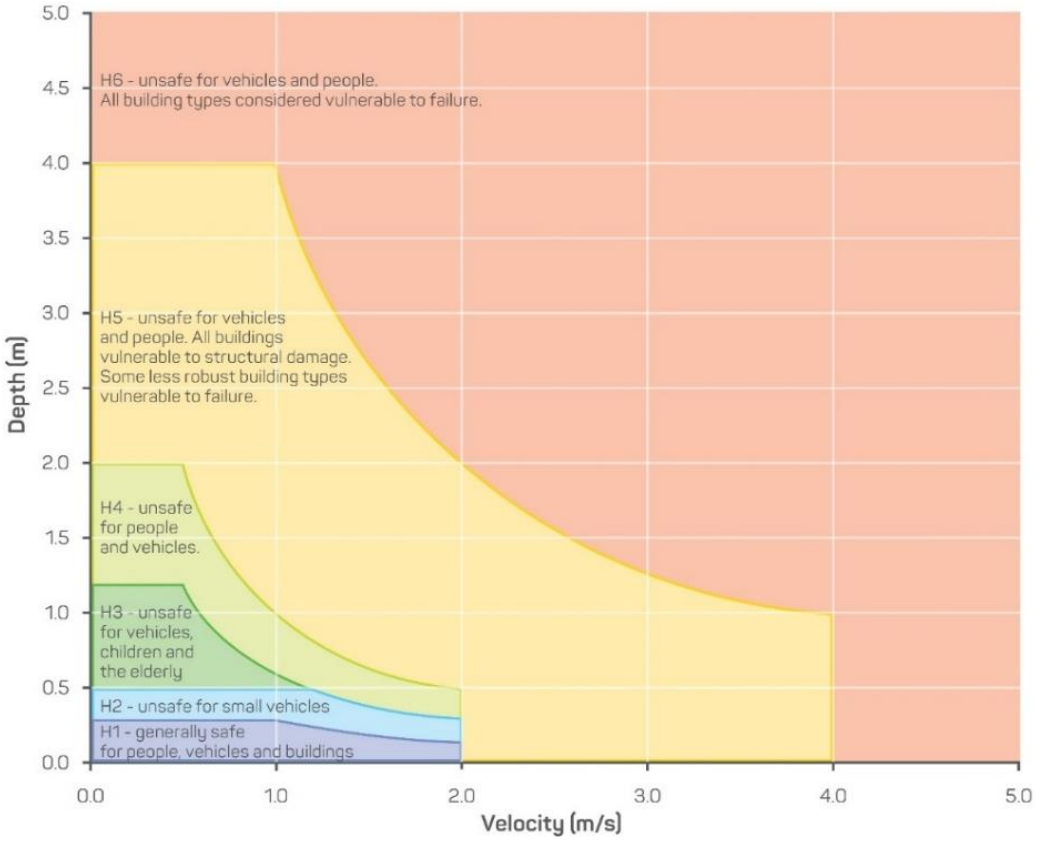
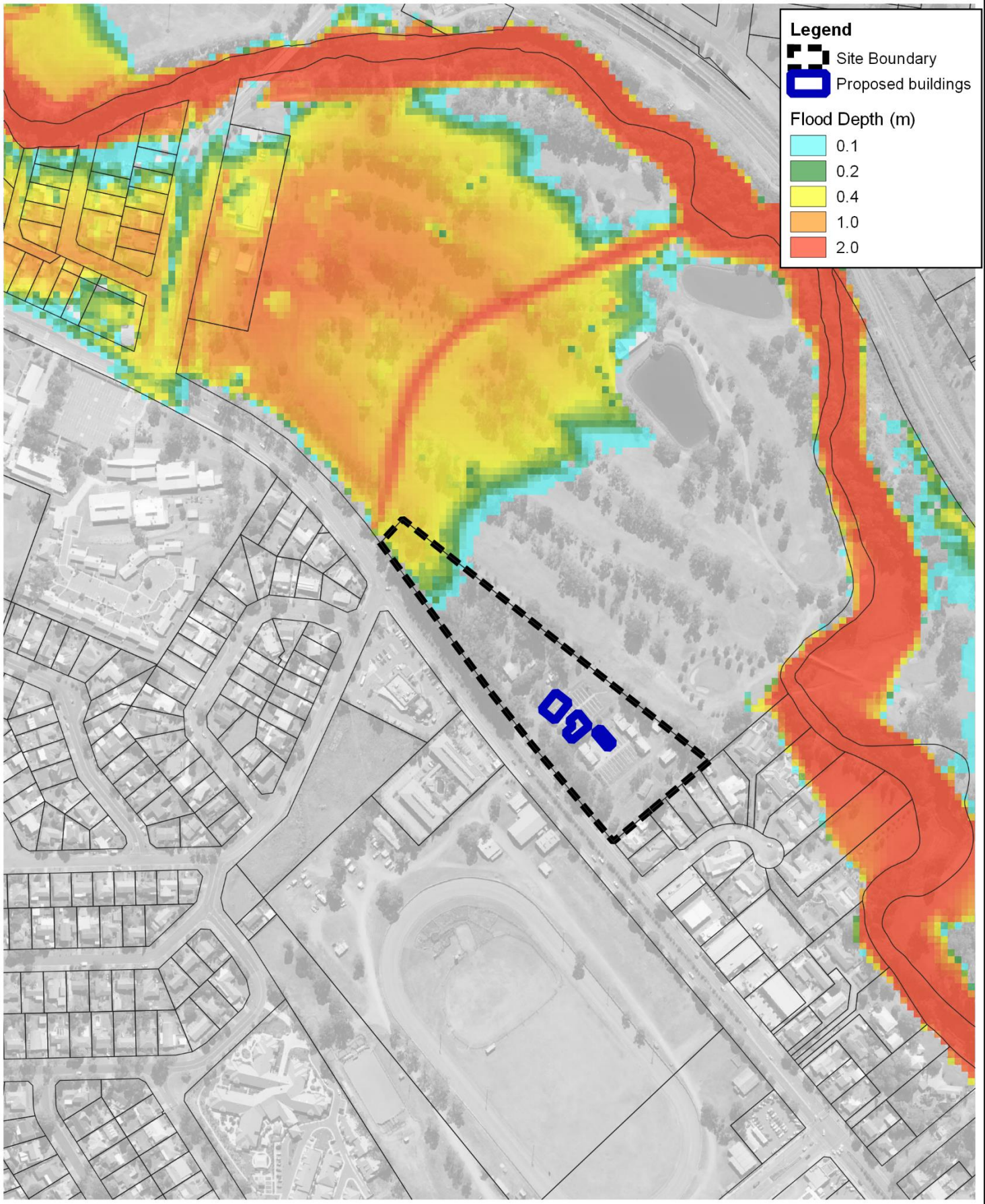


Figure 2-2 General Flood Hazard Vulnerability Curves (AIDR, 2017)

The simulated peak 1% AEP, 0.5% AEP, 0.2% AEP and PMF flood inundation extents and flood depth distribution for existing conditions are shown in Figure 2-3 to Figure 2-6. The locations of the proposed buildings are shown for reference to indicate the approximate location of the works relevant to the Site flood inundation extents.

At the 1% AEP flood event inundation affects only the lower end of Site, with localised backwater flooding from within the Golf Course. Similarly for the 0.5% AEP event, inundation is limited to the lower end of the Site albeit increasing in general extent across the Site. Flow through the Site, particularly in the location of the proposed building areas is firstly initiated at the 0.2% AEP flood magnitude. Overland flow paths are initiated from floodwater escaping the Muscle Creek channel upstream of the Site. At the 0.2% AEP flood magnitude, these overland flow paths through the Site are somewhat minor in terms of total convective flow, however, the flows increase considerably with increasing flood magnitude up to the PMF design event.



Title:

Peak Flood Depth - 1% AEP Event

0 100 200 m

approx. scale

Figure: **2-3**

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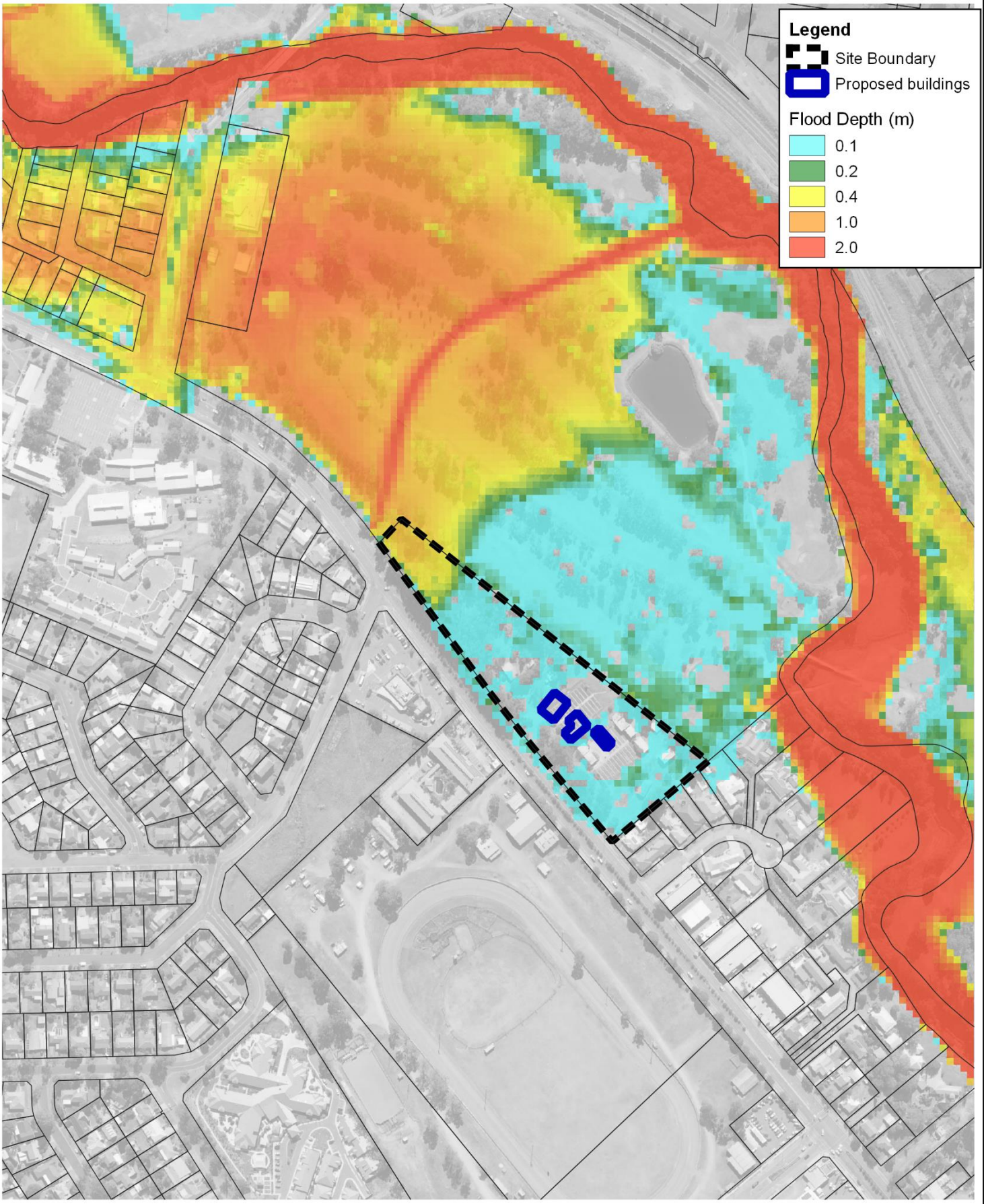

Title:

Peak Flood Depth - 0.5% AEP Event

0 100 200 m

approx. scale

Figure: **2-4**

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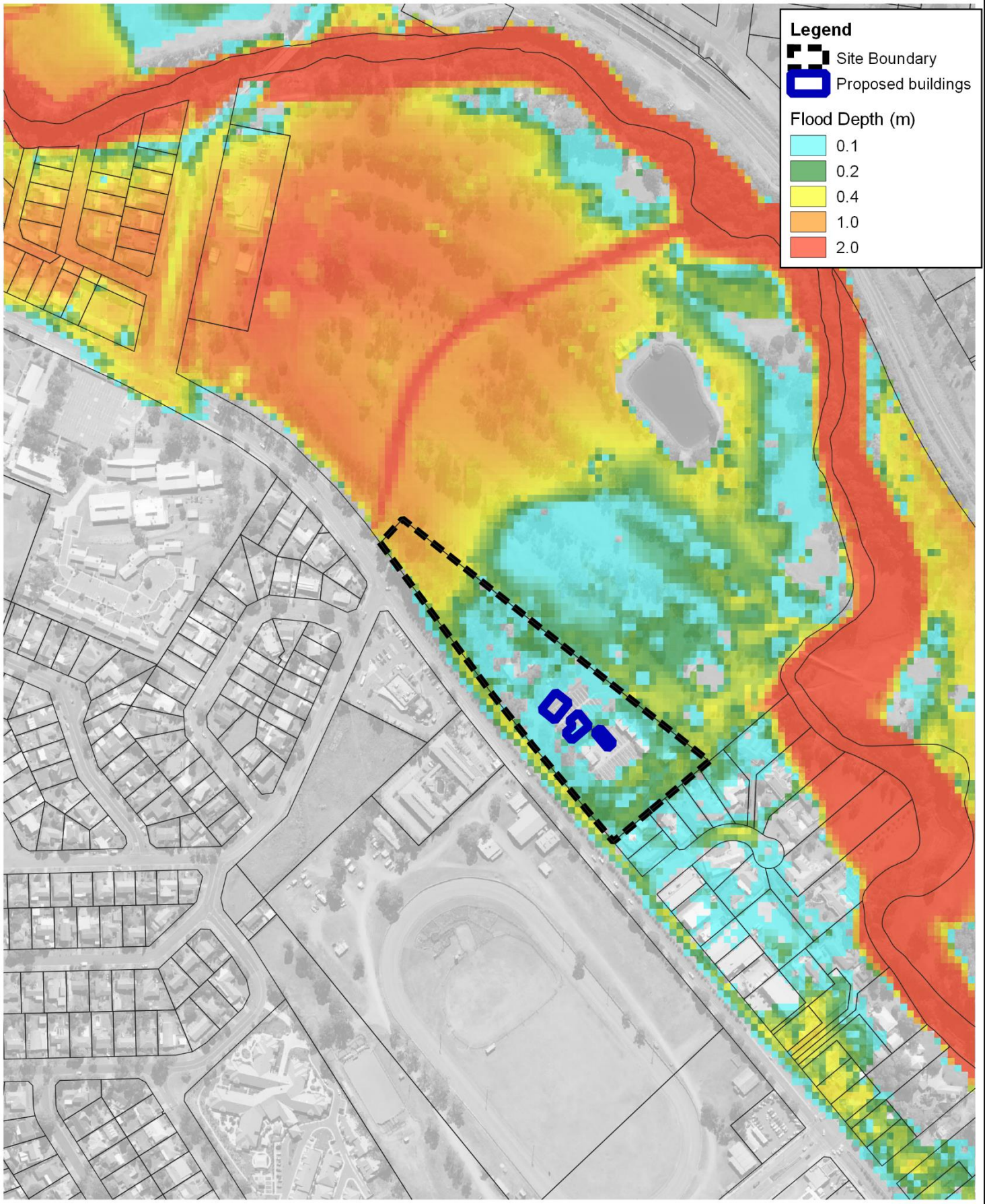

Title:

Peak Flood Depth - 0.2% AEP Event

0 100 200 m

approx. scale

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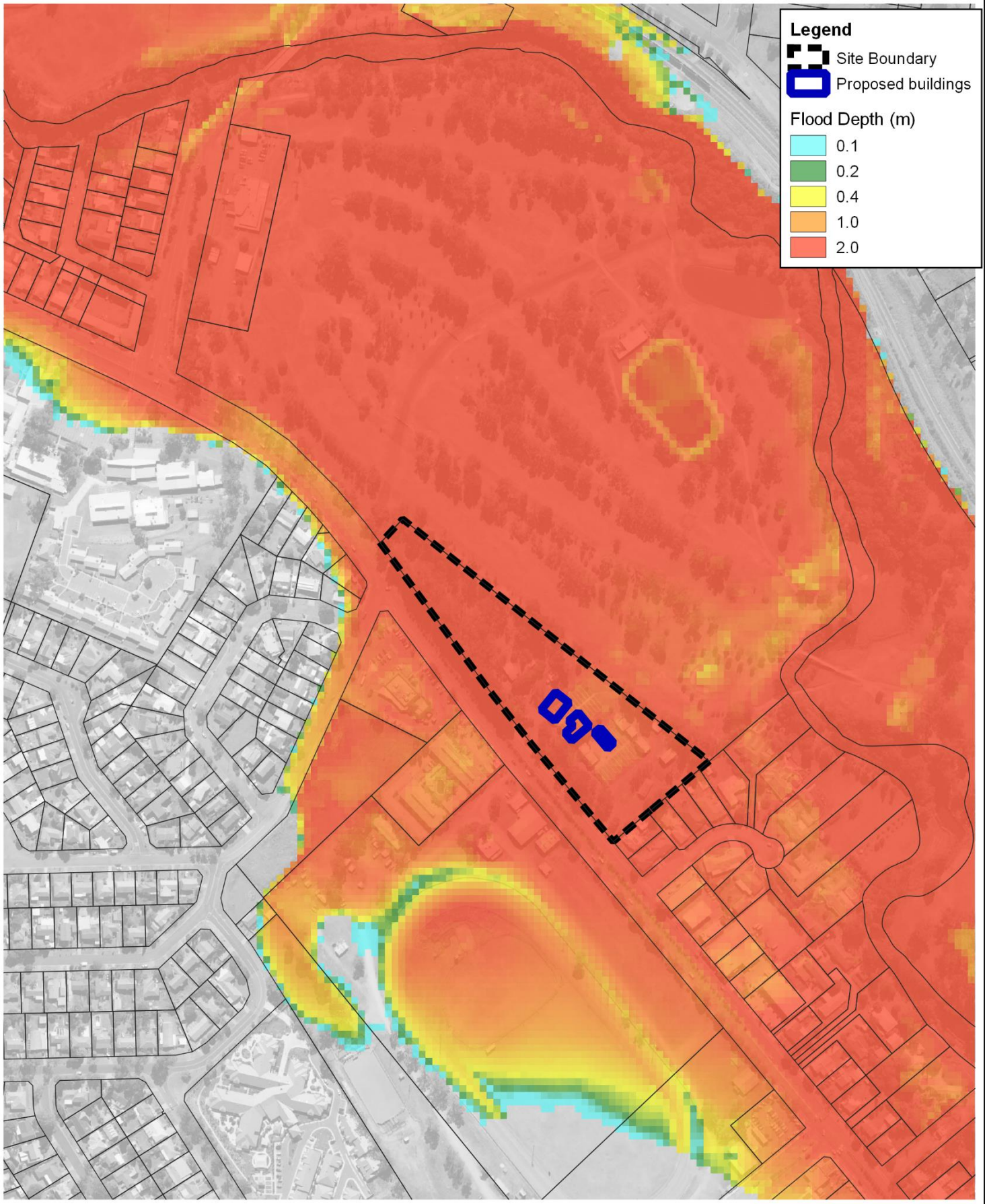

Title:

Peak Flood Depth - PMF Event

0 100 200 m

approx. scale

Figure: **2-6**

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3 Proposed Development

3.1 Design Layout and Model Representation

The proposed works layout is shown in Figure 3-1. Changes to the TUFLOW model to represent the post-development condition and assessment of potential flood impacts are summarised below.

- The proposed design surface has been incorporated into the TUFLOW model to overlay the base topography. The design surface modification incorporates:
  - Building platform for facilities encompassing the area of the General Learning Atea buildings, COLA, Science and Administration buildings and amenities building (variable height between 148.60m AHD and 149.15m AHD)
  - Raised ground levels within building footprint to represent design finished floor levels (149.625m AHD for General Learning and Administration buildings, 149.775m AHD for Amenities building)
- Surface roughness (Manning's 'n') values updated for proposed building footprint with adopted Manning's' 'n' value of 1.0. This high value allows for storage to be retained for above floor flooding conditions whilst limiting convective flow through the building footprint.

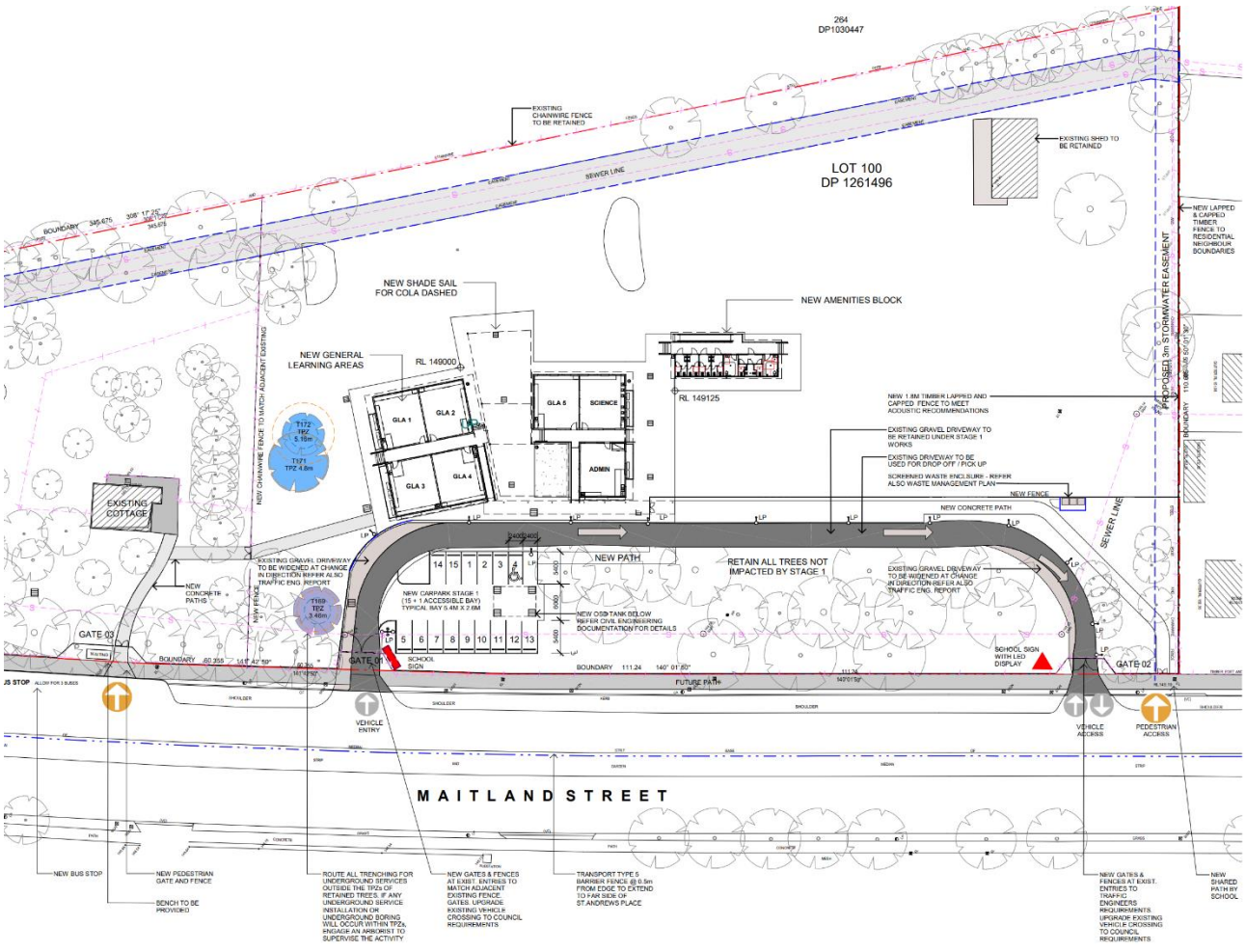

Figure 3-1 Proposed Layout

3.2 Post-Development Flooding Conditions

The models developed to establish existing flood conditions have been modified to represent post-development floodplain conditions as described above.

The relative impact of the proposed development has been considered in terms of potential changes to existing flood behaviour. The impact of the proposed development on existing design flood conditions can be better understood in a spatial context through comparison of the change in modelled peak flood levels and velocities.

Simulated changes in peak flood level for the 0.5% AEP, 0.2% AEP and PMF event are presented in Figure 3-2, Figure 3-3 and Figure 3-4 respectively. Note the works area is outside the 1% AEP flood extent such that no impact mapping is provided.

The impact mapping for the 0.5% AEP and 0.2% AEP events shown some very minor and localised changes in peak flood level within the development footprint immediately around the works area. These changes are largely driven by the small changes to the topography and the flow obstruction provided by the proposed buildings. Given the minor flood affectation to the Site for these magnitude events the resulting flood impacts are insignificant.

Figure 3-4 shows a greater impact of the proposed works on the PMF event. Given the increase in overland flows through the Site for this design flood magnitude, the building obstructions provide for increased flow impedance and redistribution of flow through the broader floodplain adjacent to the Site. These impacts are still noted as minor however, representing increased levels of only around 0.05cm offsite, typically where the flood depths are exceeding 2m under existing conditions. Accordingly, the small changes at the PMF level do not change the local flood risk profile or flood hazard classification from existing conditions.

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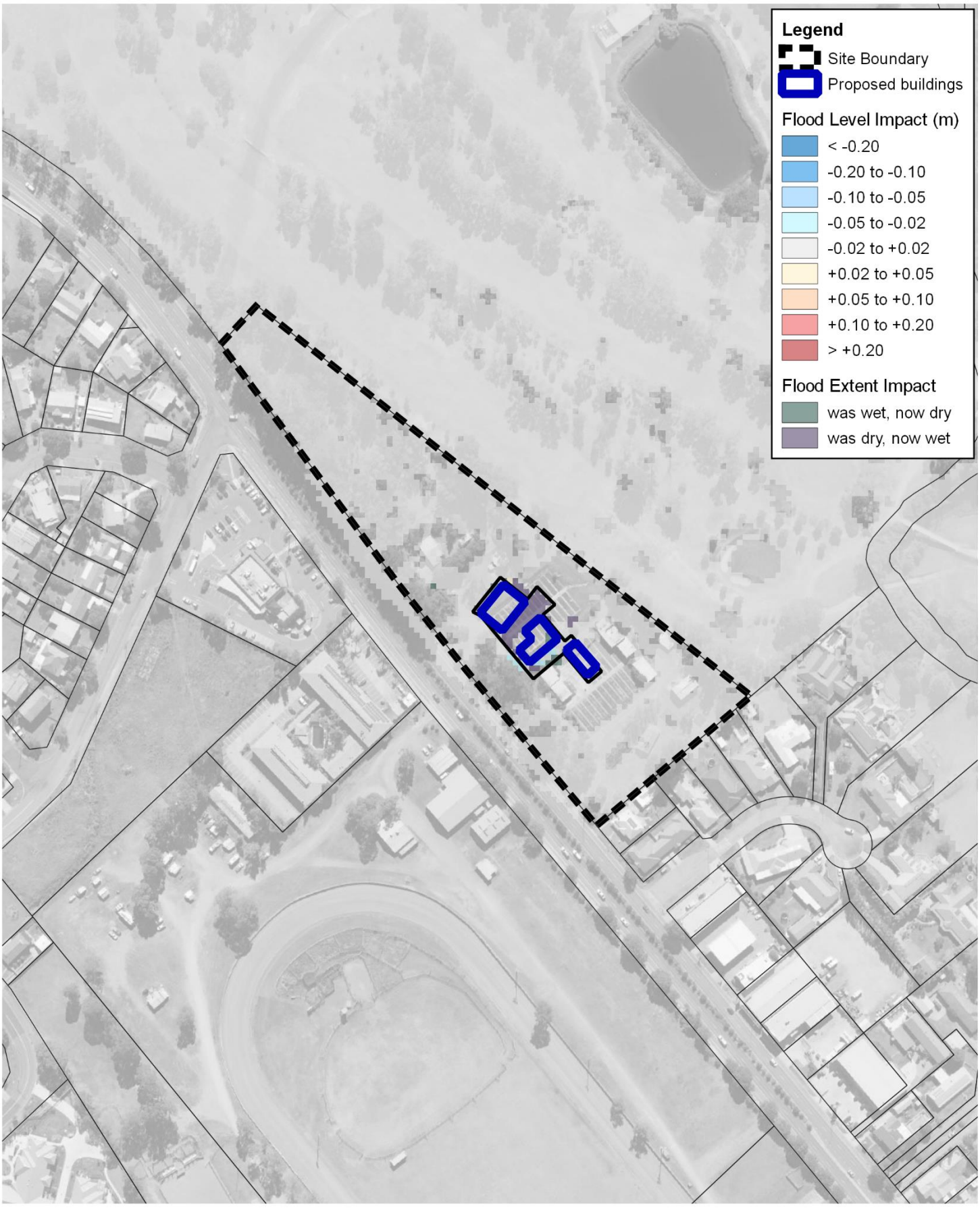

Title:

Post-Development Change in Peak Flood Level 0.5% AEP Event

0 70 140 m

approx. scale

Figure: **3-2**

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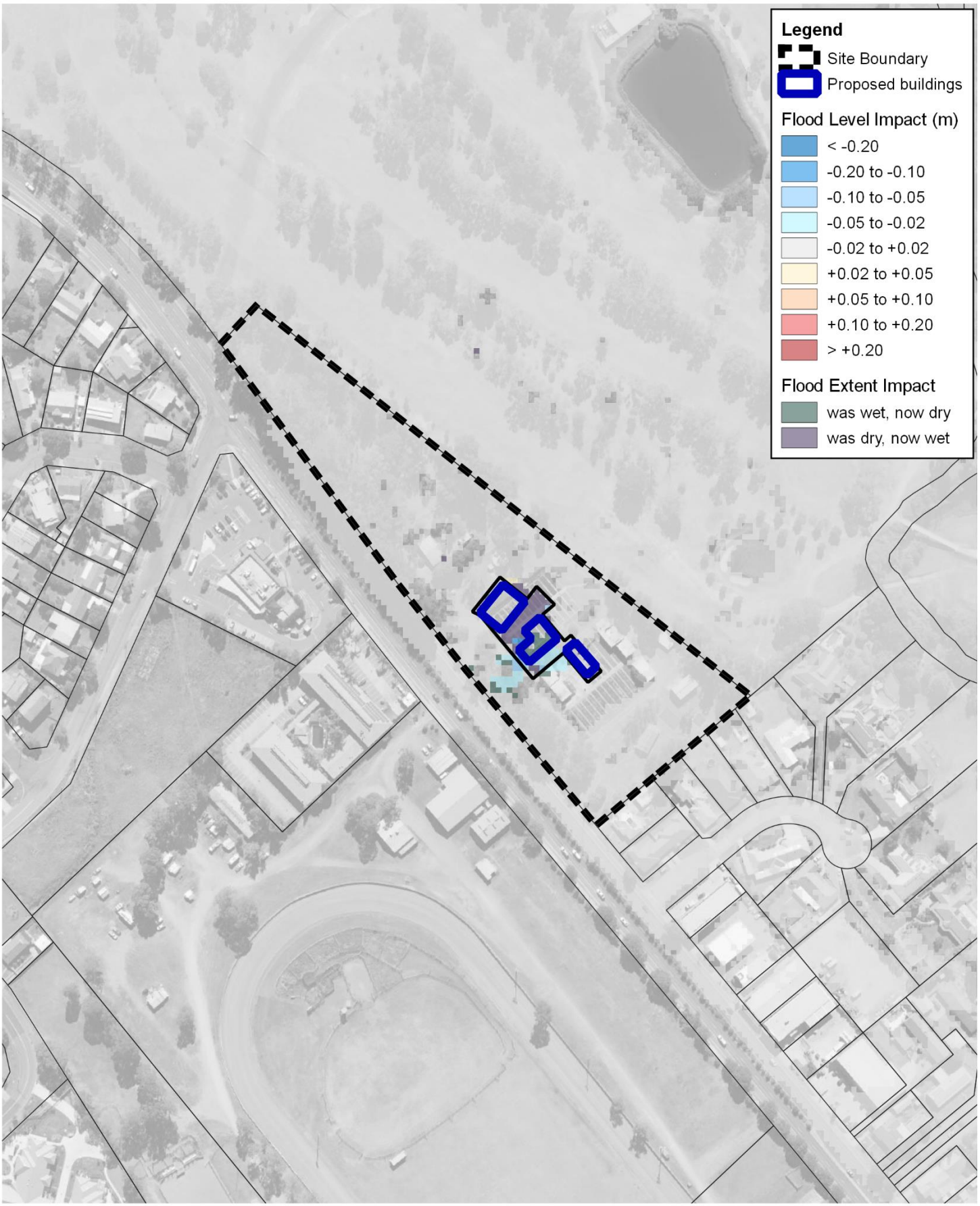

Title:

Post-Development Change in Peak Flood Level 0.2% AEP Event

0 70 140 m

approx. scale

Figure: **3-3**

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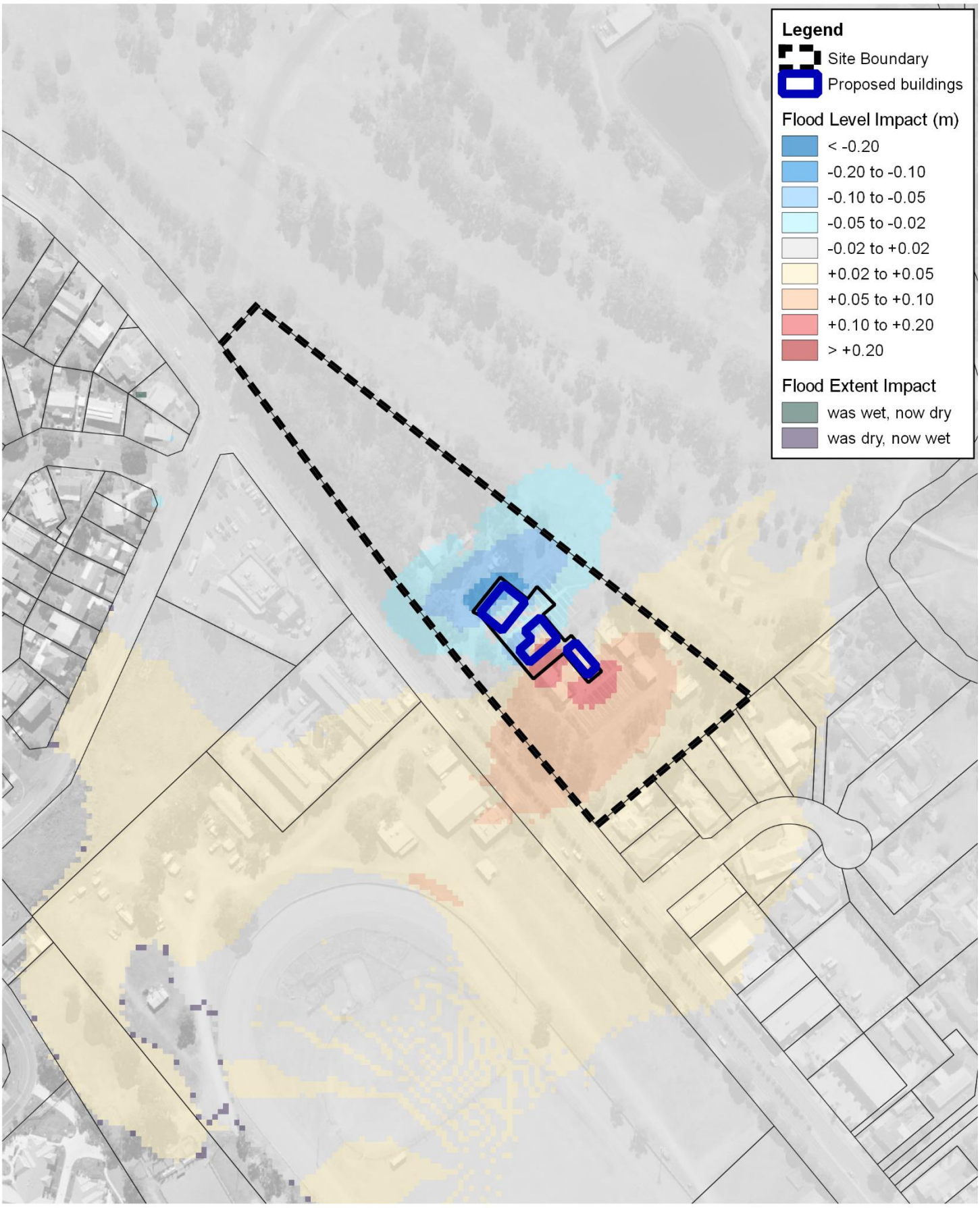

Title:

Post-Development Change in Peak Flood Level PMF Event

0 70 140 m

approx. scale

Figure: 3-4

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4 Conclusions

Torrent Consulting was engaged by Impact Group on behalf of Pacific Group of Christian Schools Ltd trading as Pacific Brook Christian School (PBCS) to prepare a Flood Impact Assessment (FIA) to assist in the approval process for the proposed development at the 72-74 Maitland Road, Muswellbrook NSW.

The design flood conditions at the Site are established in the Muscle Creek Flood Study (RHDHV, 2017) and Muswellbrook Floodplain Risk Management Study and Plan (RHDHV, 2019). The existing flood study models include a XP-RAFTS hydrological model and TUFLOW 2-dimensional (2D) hydraulic model. The existing models were provided by Muswellbrook Shire Council (Council) for use in the assessment.

The models were used to establish existing design flood conditions as a baseline condition for assessment of the relative impact of the proposed development. The 1% AEP design flood represents the principal flood planning event. Site flood inundation at the 1% AEP event is limited to the north-east section of the Site only and does not encroach into the proposed works area.

Changes to the TUFLOW model to represent the post-development condition and assessment of potential flood impacts for the higher order flood events including the 0.5% AEP, 0.2% AEP and PMF events. The modelling shows that the proposed development has an insignificant impact on the overall flood hazard profile at the Site or the adjacent floodplain environment. Whilst there are localised increases in the modelled peak flood depth and velocity, these do not translate to a significant impact to the combined flood hazard. Accordingly, the flood impact assessment confirms the compatibility of the proposed development with respect to the local flood conditions.

5 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*

BoM of Meteorology (2003) *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*

BoM of Meteorology (2016) *Intensity-Frequency-Duration (IFD) design rainfalls*

Muswellbrook Shire Council (2009) *Development Control Plan 2009*

Muswellbrook Shire Council (2009) *Muswellbrook Local Environmental Plan 2009*

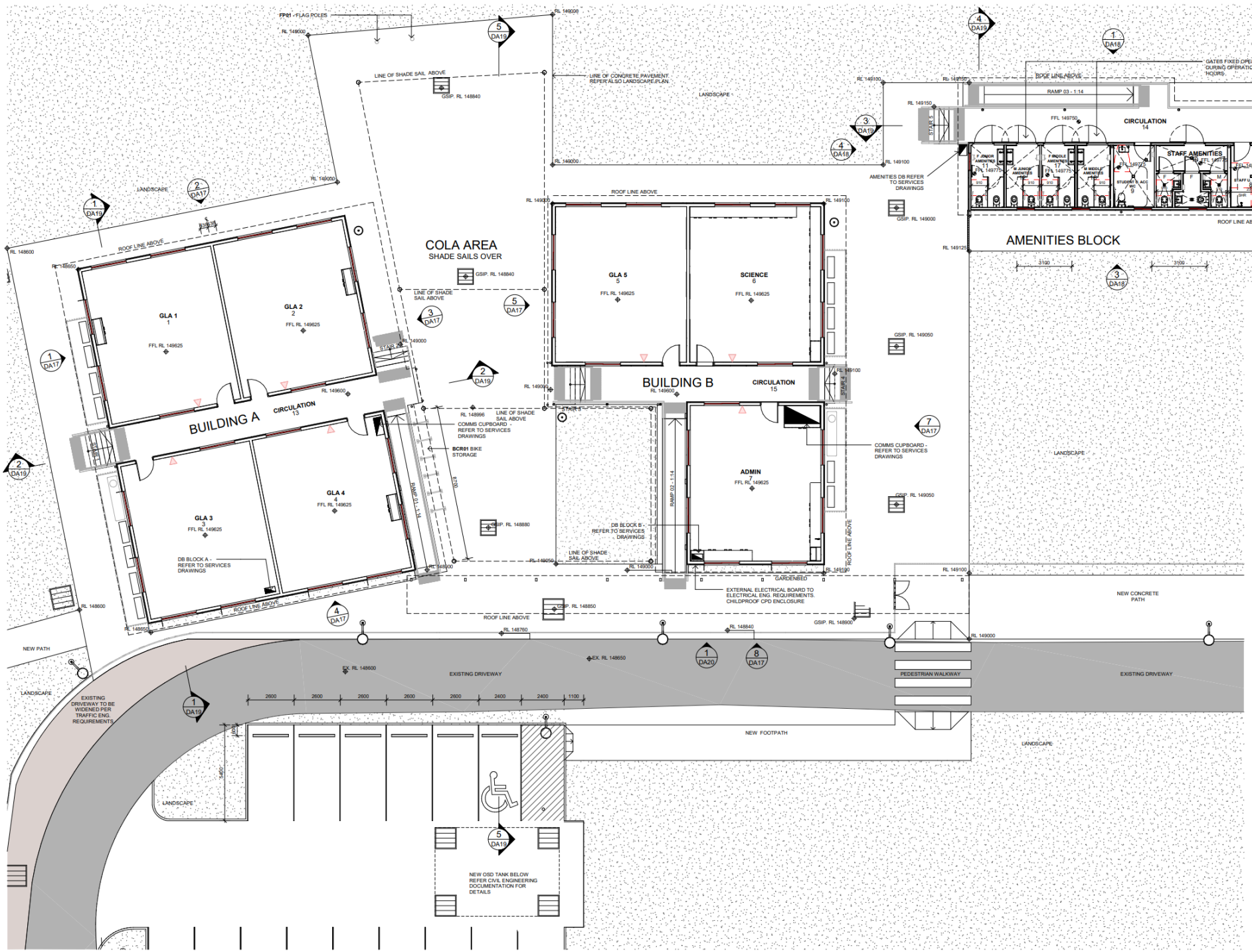
Geoscience Australia (2019) *Australian Rainfall and Runoff: A Guide to Flood Estimation*

Royal Haskoning DHV (2017) *Muscle Creek Flood Study*

Royal Haskoning DHV (2019) *Muswellbrook Floodplain Risk Management Study and Plan*

Appendix A Proposed Development

Appendix A



2 DA STAGE 1 - GF PLAN
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NBRS

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Issue

No.	Date	Description	Chkd
1	09.04.2024	ISSUE FOR CLIENT APPROVAL TO PROCEED	NBRS
2	18.04.2024	ISSUE FOR CONSULTANT COORDINATION	NBRS
3	04.06.2024	ISSUE FOR CLIENT APPROVAL	
4	14.06.2024	DEVELOPMENT APPLICATION	NBRS
5	21.06.2024	DEVELOPMENT APPLICATION ST 1	NBRS

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NBRS

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Nominated Architect:
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ABN 16 002 247 565

Project
Pacific Brook Christian School

at
Lot 100 DP1261496, 72-74 Maitland Street, Muswellbrook NSW
for
Pacific Brook Christian School Ltd

Drawing Title
STAGE 1 FLOOR PLANS

Date 21/06/2024 2:39:32 PM
Scale 1 : 100 @ A1

Drawing Reference 19055-NBRS-DR-A-DA16
Revision 5