Mullumbimby Hospital Planning Proposal
Flooding and Stormwater

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The Amendment Record below records the history and issue status of this document.

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Executive Summary

Assessments of flooding and stormwater have been completed to support the Planning Proposal. These assessments have been completed using development details commensurate with the level of site master planning and supporting data available. Key aims of the assessment has been to provide further knowledge of potential site constraints, as well as confirm the likely compliance of future Site development with Council's development controls.

Overall, there were few limitations identified, as detailed below:

- The Site is elevated above the Probable Maximum Flood (PMF) in that there is only a very small portion of the far eastern site impacted by this extreme flood event. This indicates that there are no applicable flood planning levels to be achieved by future development. There will be no requirement for a flood impact assessment study or similar as the Site is effectively not flood prone.

- The Site will be isolated from the Mullumbimby township during rare and extreme flood events. The duration of the isolation may extent from around 12 to 20 hours. This is unlikely to be a major concern to healthy able-bodied residents who reside in their homes for the duration of the event. However, there may still be a need for some residents to evacuate prior to the onset of flooding to assist others, or to access personal supports as this time of isolation may be of concern. There are multiple rainfall and water level gauges in the region and in the vicinity of the Site, that may assist in the provision of data to assist in this activity.

- The Site contains no watercourses, and no part of the Site may be considered as waterfront land owing to its distance from Mullumbimby Creek.

- The Site will likely require the provision of overland flow paths (and associated easements) to safeguard against their future development. As future land forming and drainage design are likely to occur, the provision of overland flow paths should be reconsidered at later design stages.

- The Site will require the provision of stormwater quality treatment systems to achieve Council requirements and objectives. There is unlikely to be any major restrictions on this being satisfactorily achieved and preliminary MUSIC modelling and site design has been undertaken to assist in considerations of site design approaches and space allocations. Generally, while the site is steep there remain a variety of approaches to capture, convey and treat stormwater which would be suited to the Site. The shape of the Site promotes drainage towards Azalea Street which would remain the logical lawful point of discharge.

- The requirements of stormwater quantity management (i.e. peak flow mitigation) are as yet unknown. Mullumbimby Creek downstream from the Site is tidal and Council's guidelines do not require that On-Site Storage Detention (OSD) be provided for Site that discharges via a trunk drainage system to a tidal waterway. The implications of not providing on-site OSD are that peak flow volumes downstream of the Site will be increased due to the substantial change in Site imperviousness that will occur during development. A review of the capacity of Council's existing drainage systems along Azalea Street connecting to Mullumbimby Creek will be required to ensure that they do not lead to nuisance flooding on adjoining lots or impacts to the trafficability of Azalea Street. Any required works to Mullumbimby Creek to support an upgrade and drainage systems and outlets, etc, would require the requisite approvals from external agencies.

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1 Introduction

A site inspection was completed on 6 April 2022 with a representative of the Byron Shire Council. The site inspection involved a walkover of the Site to view all areas of the development, including existing vegetation and drainage. A non-intrusive inspection of adjacent drainage systems was completed as part of the Site walkover.

1.1 Proposed Development

The details of the future Site development is conceptually included in the Site Strategy and Urban Design Protocol for the former Mullumbimby Hospital Site (BSC 2022). The Concept Structure Plan identifies that the Site will principally include a mix of residential and open space / protected vegetation areas, while supporting some areas of existing use. The proposed concept plan is shown in Figure 1.1.

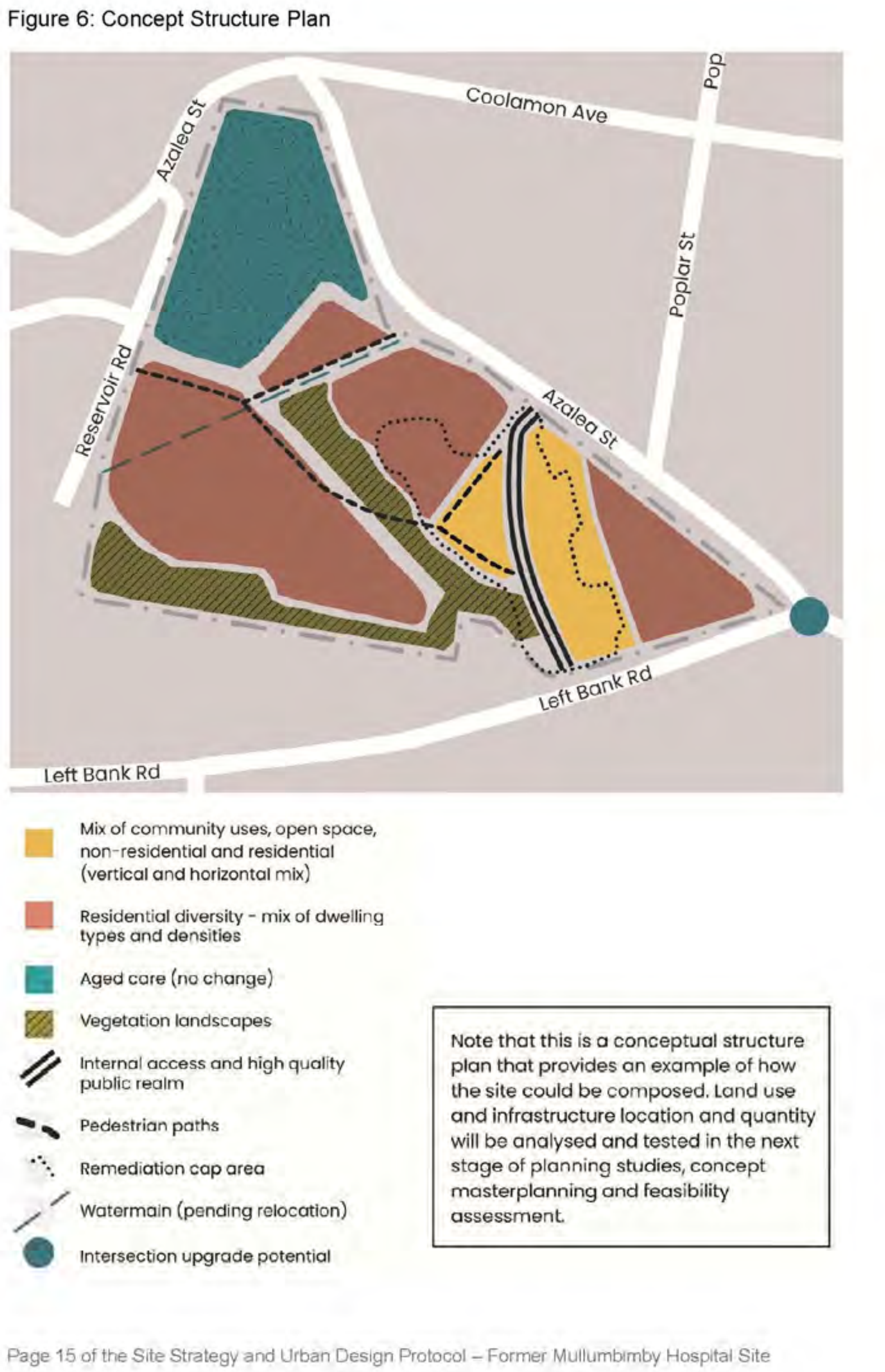


Figure 1.1 Proposed Site Concept Structure Plan

1.2 Topography and drainage

The site drains to Mullumbimby Creek which is at its closest is about 60m to the east and south of the Site. Maximum site elevations are around 48m AHD and lowest around 6m AHD. The Site has steep slopes in the south-west corner (up to 27%) and moderate slopes (about 7%) in its eastern extent.

There are no mapped hydrolines[1] or physical evidence of natural watercourses present on the Site (as determined via Site inspection). The physical distance of Mullumbimby Creek to the eastern extremity of the Site (around 60m) indicates there are no riparian setbacks applicable to the Site from this waterway. Development of the Site will not trigger the need for an application for a controlled activity approval to carry out actions on waterfront land. These requirements apply to certain activities (e.g. development) within 40m of the high bank of a waterway (unless exempt).

General site drainage is to the east and north-east extents of the Site where existing roadside drainage infrastructure was noted to exist as represented in Figure 1.2.

Stormwater systems generally include roadside drains at the ground surface and or below group along Azalea Street ultimately taking stormwater runoff into private lands or Mullumbimby Creek.

Figure 1.2 Stormwater Infrastructure adjacent Site (BSC 2023)

There were no existing stormwater management controls observed on the Site or in the vicinity of the Site.

1.3 Current and proposed land use

The existing site was observed to be primarily grass lands in the west (with perimeter vegetation mainly on the southern boundary). Some of this vegetation has been identified as having a high preservation value and as such will be preserved along with a dedicated buffer extent. Existing vegetation also occurs at locations through the Site (e.g., a line of vegetation exists in a northwest-southeast extent

[1] https://www.dpie.nsw.gov.au/water/licensing-and-trade/hydro-line-spatial-data

across the middle parts of the Site), and sporadic plantings exist throughout the eastern portions of the Site where the former hospital buildings were located.

The future use of the main parts of the Site will be for urban residential lands. Parts of the land will be retained to preserve vegetation and provide open space, access and egress routes. The Catholic Healthcare Coolamon Villa is an existing use of the Site to be retained and will be subdivided from Lot 188 DP 728535 as part of the proposal. Buildings forming part of Coolamon Villa are located in the northern corner of the Site.

1.4 Indicative Soil Conditions

A review of soil maps for the region[2] identify that the site may contain a mixture of the following soil landscapes. These included mainly the Billinudgel soil landscape on the more elevated and steeper portions of the Site, and Mullumbimby on the lower, flatter portions in the far east of the Site. Descriptions of these soil landscapes are provided below:

- 9540bi – Billinudgel. Low rolling hills on metamorphics of the Neranleigh-Fernvale Group. Soils are shallow to moderately deep (100cm), moderately well-drained Podzolic Soils and Yellow podzolic Soil/Soloth intergrades on crest and slope. Deep (>100cm) moderately well-drained yellow Podzolic Soils and Red Podzolic Soil/Red Earths on siltstone. The soil types are recognised as hardsetting, shallow, stony and erodable soils of lower fertility. Steep slopes and localised mass movement. The topsoil (or A horizon soils) are recognised as moderately permeable.

- 9540mu – Mullumbimby. Level to gently undulation alluvial plains and terraces of the Brunswick River and its tributaries. Predominantly metamorphic and rhyolitic derived sediment. Extensively cleared closed forest. Soil deep > 3m, moderately well drained brown structured alluvial clay on flood plain. Very deep >5m moderately well drained structured alluvial clays on terraces. Limitations, flood hazard, localised seasonal waterlogging and moderately erodible soil materials with high shrink-swell.

During the site inspection it was generally observed that the site was extensively grassed/vegetated and no obvious locations of poor vegetative growth or poor soils was evident. The site inspection was not exhaustive and was generally focused on gaining a general site appreciation.

Areas of site remediation were evident in the building footprint extents of the former hospital buildings in the eastern portion of the Site.

1.5 Groundwater

No information for groundwater conditions on the Site has been identified. However, given the relief of the site and the presence of watercourses near the Site, the groundwater table is likely to be present within several metres of the ground surface. The Site did not appear boggy or marshy in any location visited during the Site walkover.

[2] https://www.environment.nsw.gov.au/eSpade2Webapp/

2 Flooding Considerations

2.1 Site Features

Mullumbimby Creek runs in a southwest to northeast direction to the east of the Site and joins the Brunswick River just upstream of Federation Bridge. The headwaters of Mullumbimby Creek are in the Koonyum Range several kilometres to the west of the Mullumbimby township.

Flood modelling has been completed by Byron Shire Council (with support from NSW Department Planning and Environment), for the Brunswick River and major tributaries as part of the North Byron Flood Study (BMT WBM 2016) and associated Floodplain Risk Management Study and Plan (WMA 2020).

2.2 Flood Mechanisms

An animation was prepared for a 1% AEP flood event of 24 hour duration event as part of the North Byron Floodplain Risk Management Study (WMA 2020). The animation illustrates that in the first few hours of the flood event flood waters appear to 'back-up' along the major channels and tributaries including the Brunswick River and Mullumbimby Creek. Floodwaters break out to the west of the Site into low lying areas (south of Left Bank Road). A short time later, flood levels continue to rise in the main channels and tributaries leading to further inundation low lying areas on their banks. After several hours floodwaters begin to cover areas of the floodplain including areas of the Mullumbimby CBD and residential areas to its north, and rural areas along Kings and Saltwater Creek to the east of the Site. As the flood wave moves downstream over the next several hours, it inundates rural areas to the east of Mullumbimby before eventually receding.

2.3 Flood Mapping

Flood mapping has been prepared for the Site and is provided in Annex A. The mapping illustrates that the Site has a low propensity for regional flooding in frequent or rare events and is only partly inundated during the Probable Maximum Flood (PMF) event in the mostly easterly extent of the Site.

Mapping has been prepared to illustrate peak flood levels, peak flood depth and hazard.

2.4 Implications for the Development

Flood mapping indicates that the Site is only inundated in the PMF flood event. Byron Shire Council's current development standards (refer DCP Chapter C2) indicate that the flood planning level (FPL) would likely be the project 2100 Flood Planning Level (this in predicated on the basis that the rezoning and nature of the proposed developed puts it in the class of a 'New Release Area').

Table 2.1 outlines the relevant requirements from the flood planning matrix included in Chapter C2 of the Byron DCP 2014.

Table 2.1 Flood Planning Matrix

Controls	Primary Constraint	
Land use suitability and fill level	SF2	Consider for development subject to the controls below. Minimum fill to the 2100 Flood Planning Level.
Floor level (habitable)	FL3	All floor levels to be greater than or equal to the Projected 2100 Flood Planning Level (FPL3).
Floor level (non-habitable, e.g., carport)	FL1	All floor levels to be greater than or equal to the 10 year flood level plus 0.3m.
Building components	BC1	Buildings to have flood compatible material below the relevant flood planning level according to development/building type.
Structural soundness	SS1	No structural soundness requirements for the force of floodwater, debris & buoyancy. Must still comply with Building Code of Australia requirements.
Flood effect	FE2	The flood impact of the development to be considered by Council, with Council having the right to request and engineer's report.
Evacuation and Access	EA1	Council to provide information on flood evacuation strategy.

On the basis that the Site is only marginally inundated at its most eastern extent for an extreme flood event, the natural existing level of the Site exceeds Councils typical requirements for this type of development. It is suggested that a flood impact study would not be required to assess impacts of the development for regional flood events based on Council's current DCP requirements.

2.5 Local flooding and overland flows

In the vicinity of the Site, peak flood levels are likely to be dominated by the longer duration regional flood events which also significantly affect much of Mullumbimby and surrounds.

The Site has a number of internal catchments which will collect runoff during rain events. Overland flooding typically occurs in response to shorter duration higher intensity rainfall and is sometimes referred to as 'flash flooding'. Overland flows can have high energy and can damage infrastructure such as buildings and roads.

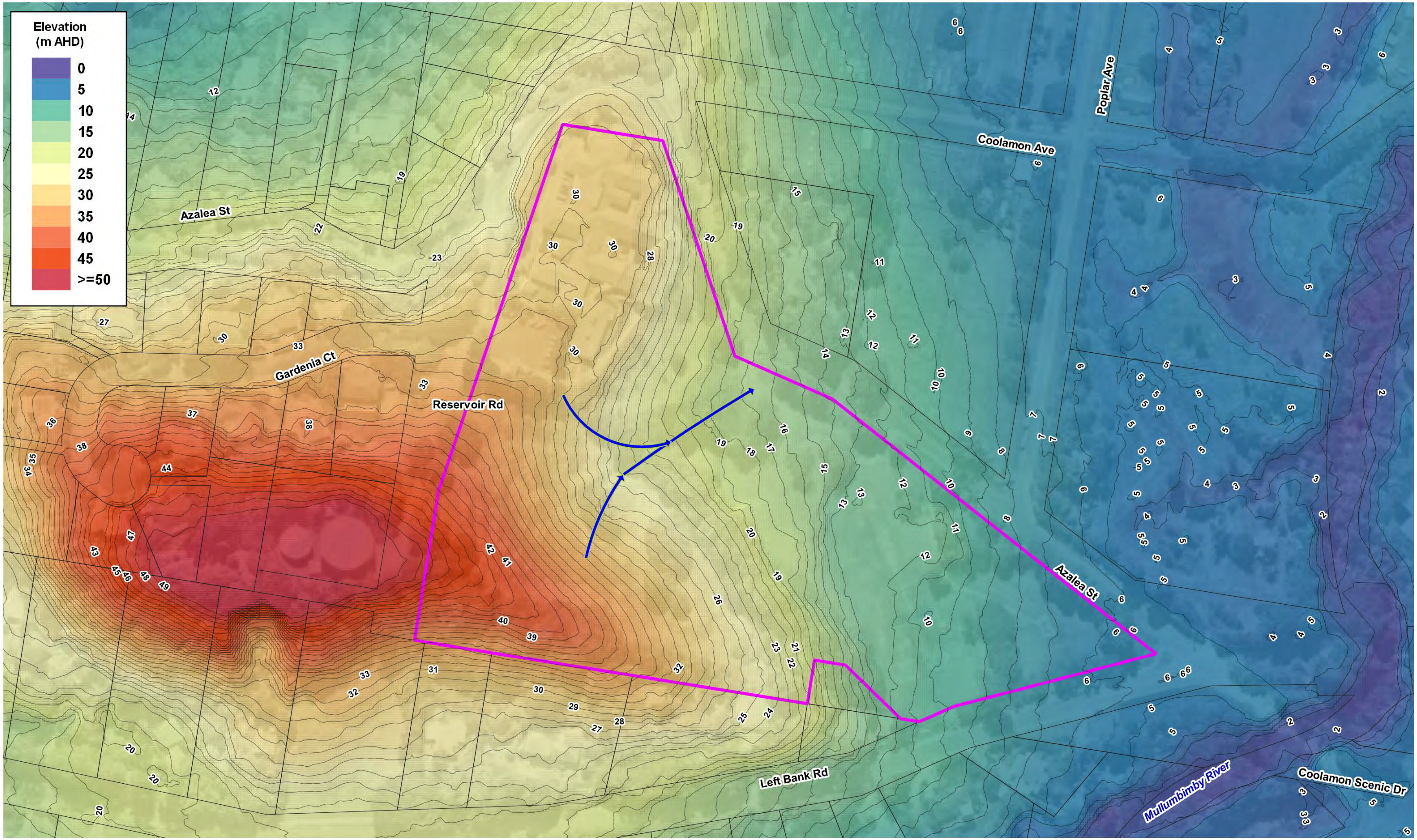
The Byron Shire's 'Comprehensive Guidelines for Stormwater Management' provides details of minimum floor levels of structures including dwellings above the top water level of detention storages and overland flow paths. Generally, the guidelines suggest that dwelling floor levels should be a minimum of 0.3m above the peak level in the overland flow path.

The Northern Rivers Local Government NSW Development Design Specification D5 Stormwater Drainage Design manual identifies that the Site's major flowpath system shall provide a safe and well-defined overland flow path for rare and extreme storm runoff events. Typically, such a flowpath would be reserved in a drainage easement to be managed by Council.

On this basis, it is recommended an overland flow path is allowed for in the locations shown in Figure 2.1, subject to confirmation during detailed design. The flowpath should allow for the passage of extreme flood flows, which is interpreted to be the PMF runoff volumes. A local hydrology model would need to be established for the catchment of the overland flow path and PMF peak flow to be derived.

This PMF peak flow can be used to size an overland flow channel which should be set aside in an easement in benefit of Byron Shire Council.

There are no other obvious existing overland flow paths on Site, however, if they are created through landform changes during development then similar easement allocation should be provided to ensure that development does not occur too close to a flow path.



Legend

- Site Boundary
- likely overland flow path
- Lot
- Contours @ 1m Interval

Title:

Potential Overland Flow Path Locations

Drawing: 2.1

Rev: A

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

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2.6 Lawful Point of Discharge

Section B3.2.3 'Services' of Chapter B3 of the Byron DCP 2014 provides details regarding lawful points of discharge. Generally, these may be to:

- Locations under the lawful control of Council or other statutory authority from whom permission has been obtained, and that will not cause and actionable nuisance.

- Where not available in the vicinity, drainage may need to be constructed and an easement acquired to direct stormwater to a lawful point of discharge. Depending on downstream land ownership, negotiations with landowners may be required to determine route feasibility.

The capacity of existing Council roadside drainage systems along Azalea St should be confirmed during detailed design stages once flow rates have been determined as this would present the most logical flow path for site stormwater discharges. The development is obligated to not introduce (new), impede or divert stormwater runoff in such a manner as to increase stormwater flow across a boundary onto adjoining properties, that is not a lawful point of discharge.

2.7 Flood Risk Management

Evacuation for Mullumbimby is triggered when Federation Bridge reaches 3.5m AHD (WMA Water, 2020). The primary evacuation centre is the Mullumbimby Ex-Servicemen's Club, Dalley Street and the alternative evacuation centre is the Mullumbimby Civic Memorial Hall. Evacuation for west Mullumbimby is via local roads to Main Arm Road, Coolamon Scenic Drive, Tincogan Street to Dalley Street. Figure 2.2 shows the evacuation routes and evacuation centre locations for Mullumbimby.

Figure 2.2 Mullumbimby Evacuation Routes (Source: NSW SES, 2013)

The majority of the Mullumbimby township area is classified as a low flood island with the majority of roads within the area being inundated early in a flood event.

Plots of water level over time (hydrographs) have been prepared at the road bridge over Azalea Street to illustrate local flood response for a series of modelled flood events, as shown in Figure 2.3. These should be considered alongside plan based flood mapping for these events included in Annex A, which serve to illustrate peak inundation extents for these design flood events.

Figure 2.3 illustrates that Azalea Street at the location of the bridge would be unpassable for the 1% AEP, 0.2% AEP and PMF flood events due to the depth of inundation and likely high velocity providing for higher hazard flood waters. The duration of inundation at the bridge varies from around 12 hours for the 1% AEP event up to around 20 hours for the PMF flood event. This would indicate that for a rare to extreme event the Site would be separated from Mullumbimby township for a minimum of 12 hours increasing to around one day for an extreme event.

Note that while the draft NSW Shelter-in-Place (SIP) guidance does not support SIP for periods longer than 6 hours, this is felt to be unnecessarily restrictive and impractical, particularly if appropriate infrastructure and resources are in place. The guidance provided by the Australian Red Cross for immediate shelter being provided between 1 and 18 hours is considered to be more practical and broadly acceptable. This somewhat matches the durations of isolation likely to be experienced by these rare and extreme flood events.

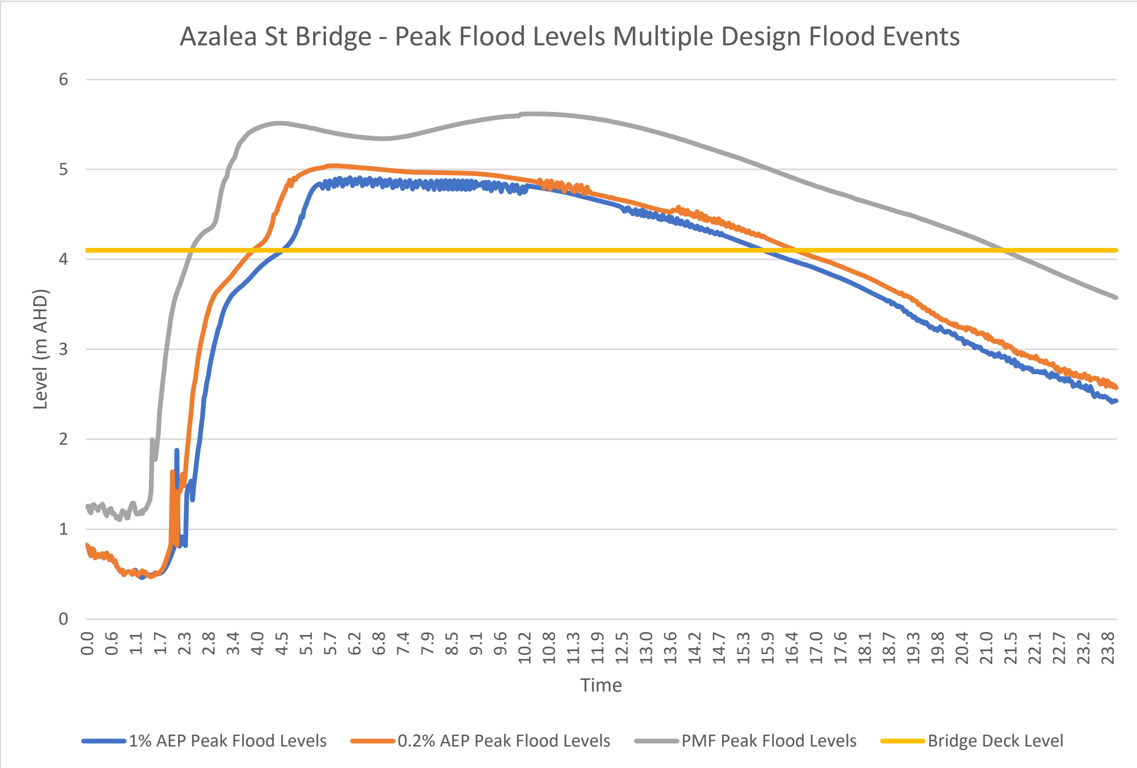


Figure 2.3 Flood hydrographs at Azalea St Bridge for 1% AEP, 0.2% AEP and PMF Events

On this basis it is not recommended that healthy, able-bodied residents of the Site evacuate in a time of flood, as Site is above the PMF level and flood waters result in a relatively short period of inundation. However, it may be necessary for certain residents to consider evacuation prior to flood events (even moderate to major flood events) to ensure that they have access to any specialised resources that they may require if inundation durations of 8 to 12 hours or more may increase their health risk. Evacuation from the Site may also expose evacuees to other risks and factors beyond the local area which may not be accountable for in the decision to evacuate.

The Bureau of Meteorology hosts on its website details of water levels at the Azelia St bridge[3] and also for Federation Bridge a few kilometres downstream - closer to Mullumbimby[4]. The Federation Bridge gauge provides details on minor, moderate and major flood levels for Mullumbimby.

Local Flood Plans are due for renewal and update every five years. It is expected that the Byron Local Flood Plan documents will be overhauled in light of the recommendations of the Floodplain Risk Management Study (WMA, 2020) and the NSW Commission of Inquiry in the 2022 flood events.

[3] http://www.bom.gov.au/fwo/IDN60231/IDN60231.558111.plt.shtml
[4] http://www.bom.gov.au/fwo/IDN60231/IDN60231.558006.plt.shtml

3 Stormwater Management Considerations

3.1 Overview

Management objectives for this Stormwater Concept Plan are provided in Section 3.4 of the Comprehensive Guidelines for Stormwater Management (BSC 2014). The concept plan must also address Section B3.2.3 'Services' of Chapter B3 of the Byron DCP 2014. This chapter identifies the minimum requirements necessary to adequately service the development for water, sewer, stormwater management, on-site effluent disposal and other necessary infrastructure.

In relation to stormwater, the guidelines provide 10 objectives for stormwater management to be considered (as relevant) within this concept plan:

1. To promote on-site stormwater management practices that support the 'predevelopment' hydrological regime (surface flow, streams and groundwater).

2. To ensure that new development does not reduce the effectiveness of existing drainage patterns (including built infrastructure).

3. To minimise the impacts of stormwater runoff from a site on adjoining properties.

4. To provide an acceptable level of protection against personal injury and property damage due to localised stormwater runoff.

5. To promote on-site retention, detention and infiltration of stormwater.

6. To promote stormwater harvesting and other forms of innovative water conservation.

7. To promote better integration of stormwater management into development proposals.

8. To ensure that on-site stormwater management facilities can be economically maintained, and that adequate arrangements are made for on-going maintenance.

9. To provide for the ongoing environmental health of receiving waters;

10. To ensure that stormwater management systems protect ground and surface water and other ecological values.

While there are no listed performance criteria the guideline identifies many prescriptive measures relating to development applications. Many aspects of this are discussed in locations throughout this report such as properties adjacent to or containing waterways (refer Section 1.2), site drainage, lawful points of discharge (refer Section 2.6), easements, on-site detention and stormwater quality and treatment (discussed in the following sections).

3.2 On-Site Detention (OSD)

The Site discharges ultimately via roadside drainage along Azalea St to Mullumbimby Creek which at the location of discharge is tidal. Council's DCP requirements do not require OSD where the Site drains directly to a trunk drainage system within the tidal reach of a river or stream.

Potential upgrades of the Azalea St roadside drainage system are yet to be determined. If trunk drainage is implemented, then provision of OSD on-site will not be required if this discharges direct to Mullumbimby Creek.

Alternatively, OSD will need to be provided within the proposed Site development in accordance with the Northern Rivers Local Government Development Design and Construction Manuals, Byron Shire Council Comprehensive Guidelines for Stormwater Management and relevant Australian Standards.

The guidelines generally identify that the total post-development stormwater flow is controlled to be no greater than the pre-development flow for all storm events up to the 1 in 100 year ARI.

This would be demonstrated with the use of hydrologic or hydraulic models (such as a rain-on-grid model) for critical flow durations for a range of design events from a 5 year to 100 year ARI. Suitable modelling practices and locally specific factors such as Intensity, Frequency, Duration (IFDs) should be applied.

3.3 Key Pollutants and Stormwater Quality Objectives

Section B3.2.3 of Chapter B3 'Services' of the Byron DCP 2014 identifies that there are key pollutants that require management including (for Medium Density Residential):

- Litter
- Coarse Sediment
- Final Particles
- Total Phosphorus
- Total Nitrogen

In relation to stormwater quality and treatment, the proposed development is considered will be required to manage these key pollutants for all flows up to 25% of the 1-year ARI peak flow. The required stormwater quality objectives are outlined in Figure 3.1.

Figure 3.1 Stormwater quality objectives (BSC 2014)

Pollutant / Issue	Retention Criteria
Litter	70% of average annual load greater than 5mm.
Coarse Sediment	80% of average annual load for particles 0.5mm or less.
Fine Particles	50% of average annual load for particles 0.1mm or less.
Total Phosphorous	45% of average annual load.
Total Nitrogen	45% of average annual load.
Hydrocarbons, motor fuels, oils & grease	90% of average annual load.

3.4 Site Opportunities and Constraints

A site assessment has been used to define site opportunities and constraints for stormwater management. These are outlined as follows.

3.4.1 Opportunities

Identified site opportunities may include:

- The site while steep to moderately steep in a west to east direction, it may still be possible to integrate drainage/conveyance by following contours. If this is achievable, conveyance systems such as open swales become possible. Provided there is reasonable space for swales, they provide an accessible and economic means of water conveyance.
- There is likely be sufficient fall to adequately drain the Site without risk of excessive ponding (provided final site landforms maintain drainage).
- The Site is unconstrained by river flooding or riparian corridors.

3.4.2 Constraints

Identified site constraints may include:

- The site while steep to moderately steep in a west to east direction provide a constraint for some WSUD systems that are suited to gentle slopes.
- Valuable and retained ecological areas and their buffers may present some restrictions, although at surface drainage may be possible.
- Remediated areas may limit the depth of surface penetration in locations where capping is present (mainly in the east of the Site).

Note, groundwater conditions are largely unknown and may be a constraint to systems which require deeper excavation for provision of drainage media or drainage outlets.

3.5 Identification and Assessment of Management Options

To achieve the identified objectives for quality and or quantity it will be necessary to integrate a series of stormwater controls within the proposed development. The approach to achieve this is to initially develop a conceptual arrangement of these stormwater controls and then test them using the MUSIC tool.

MUSIC (described further in Section 3.5.2) is widely used to support the conceptual design of stormwater treatment systems at the pre-construction stages of development. Models are created to represent the proposed development site and assess the expected performance of selected stormwater control systems in managing stormwater quality impacts. MUSIC allows for design optimisation to meet multiple development considerations in respect of alternative styles or types of control systems, treatment train configuration, performance and sizing, etc.

Conceptual arrangements of stormwater controls have been prepared for the subject Site that includes controls arranged in a ‘treatment train’. Treatment trains presented include multiple stormwater treatment systems configured in a way that removes key water quality pollutants at appropriate stages/locations in the development layout. The conceptual design is intended to illustrate the layout and indicative sizing of stormwater controls on a development layout. MUSIC allows for the preliminary sizing of devices such that reasonable space allocations can be made within the site layout.

At this stage the requirements for OSD are not clear, and the conceptual arrangement considers the optional requirements for OSD. Stormwater controls typically focus on small frequent flow occurrences while OSD treatment typically focus on larger less frequent flow occurrences. Hence the use of flow splitting is a key hydraulic design requirement to ensure that specified stormwater controls receive are not hydraulically overloaded. Hydraulic overloading leads to poor system performance and damage, e.g. scouring of media, loss of vegetation, etc. Some gross pollutants traps (GPTs) can be utilised as a hydraulic control while also providing useful pre-treatment of flows (for litter, coarse sediments, etc) entering the various downstream stormwater controls.

The steeper western portions of the Site are limited primarily by topography providing lesser options for stormwater control, while the flatter eastern portions of the Site which may be subject to further landform modification to suit a later design outcome (particularly to avoid damage or interference with clearly demarcated remediated areas) are more suited to a variety of stormwater controls.

Provided a focus of the development on achieving higher development yield it is likely space intensive options for stormwater treatment are preferred as outlined below:

- In the western portions of the Site utilising swale capture and conveyance to a downstream bio-retention system. The system may require the use of a hydraulic control (e.g. GPT) between the swale and the bioretention system to ensure the bioretention system is not overloaded and damaged. An OSD devices such as a detention basin can be readily integrated in the design approach where the OSD takes the diverted high flows, alternatively the high flows are directed to external trunk drainage systems (refer Figure 3.2).

- In the eastern portions of the Site a similar arrangement could be achieved with the use of swales or pipe to convey stormwater to downstream treatment systems. Alternatively, a treatment at source approach could be adopted that focuses on treatment of stormwater runoff in the streetscape. This approach may require adoption of a slightly wider road easements and alternative road designs to facilitate the use of such systems. They can form an attractive and functional approach to treating stormwater runoff that also reduces or eliminates requirements for end-of-line treatment systems (refer Figure 3.3).

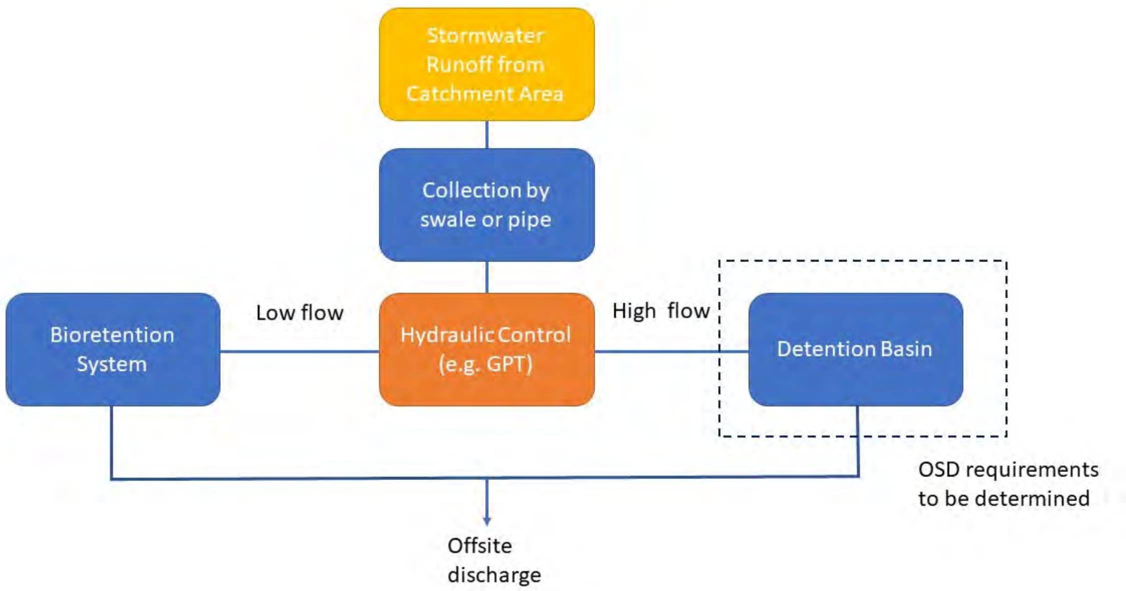


Figure 3.2 Schematic conceptual arrangement of stormwater controls – Western part of Site

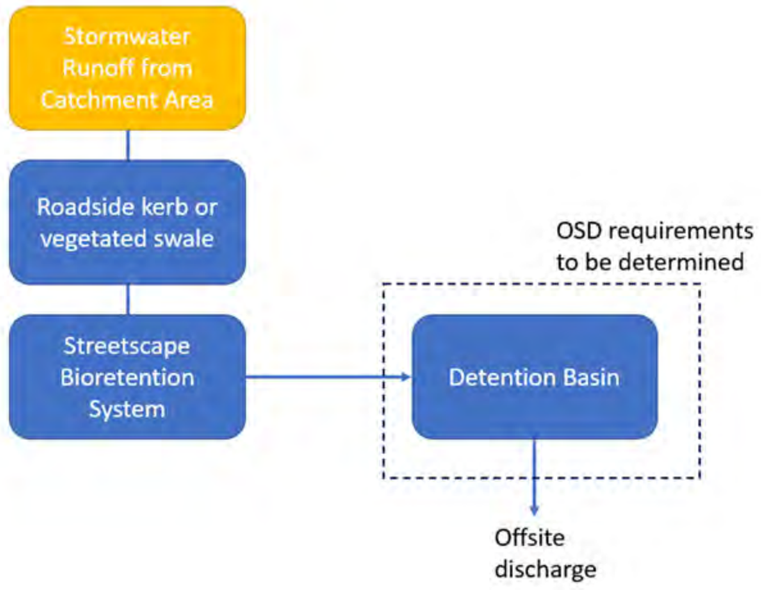


Figure 3.3 Schematic conceptual arrangement of streetscape stormwater control approach – Eastern portion of Site

3.5.2 Model Description

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is able to simulate urban stormwater systems over a range of temporal and spatial scales utilising historically representative rainfall data. MUSIC is considered within the engineering industry to be an appropriate conceptual design tool for the analysis of runoff water quality in the urban environment and has been in use for over 20 years.

Stormwater quality modelling was undertaken of the Site's proposed stormwater system using MUSIC to estimate generation of common stormwater pollutants (i.e. TSS, TP and TN). MUSIC includes algorithms to evaluate the concentrations / loads of pollutants in stormwater runoff from a variety of catchment land use types (e.g. urban, industrial, forestry, etc) as well as estimate the performance of selected stormwater management measures in capturing these pollutants and achieving load and/or concentration based reductions in pollutant discharges via stormwater.

The hydrologic algorithm in MUSIC is based on the model developed by Chiew & McMahon (1997). The model simplifies the rainfall-runoff processes and requires input of the following variables to perform the hydrological assessment:

- Rainfall data (time steps varying from 6 minutes to 1 day);
- Areal potential evapotranspiration (PET) rates;
- Catchment parameters (area, % impervious and pervious areas);
- Impervious and pervious area parameters (rainfall threshold, soil and groundwater parameters); and
- Storm event and base flow stormwater pollutant concentrations.

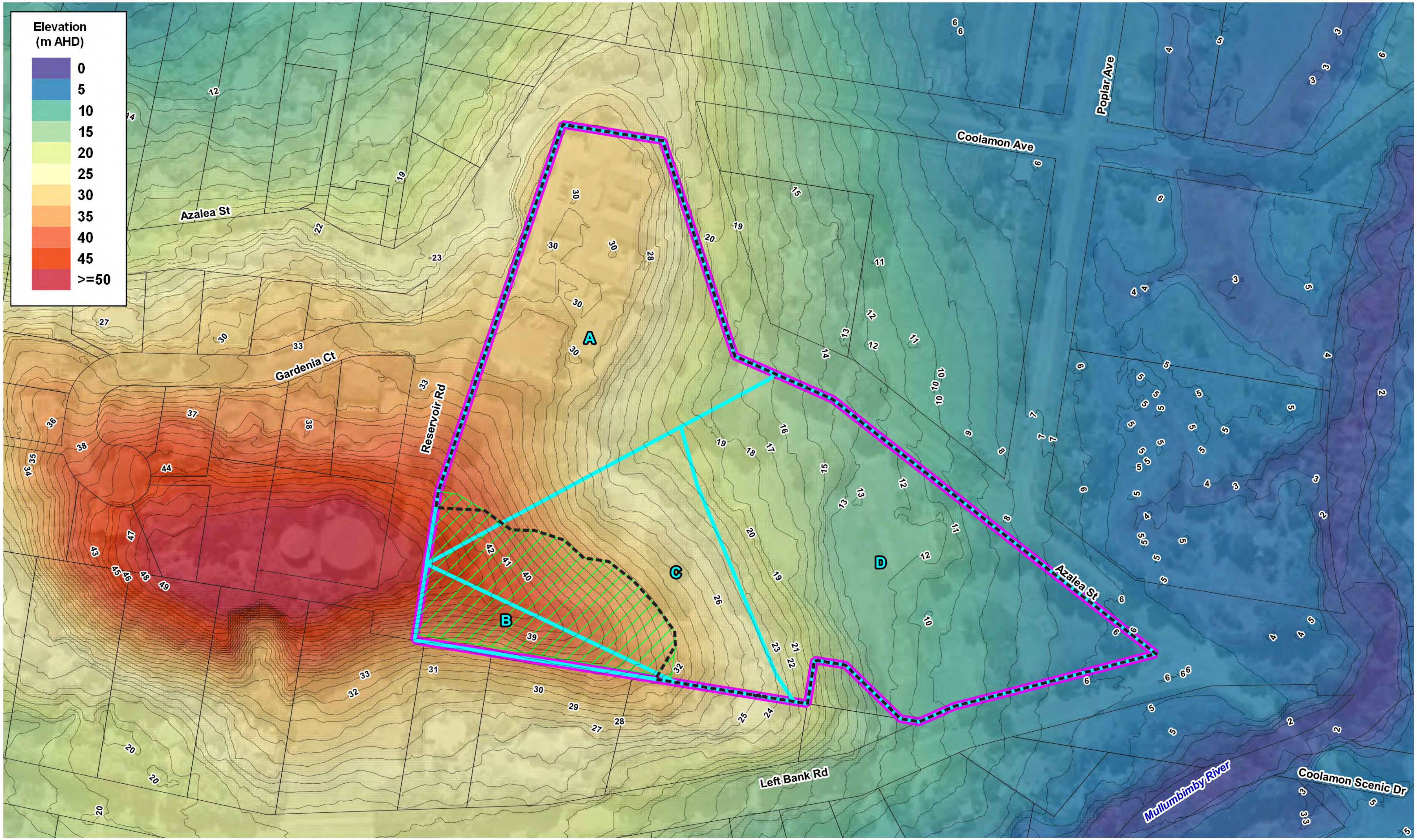
MUSIC can be applied for comparison of alternative scenarios that adopt the same base inputs. Although the magnitude of the estimates may not be equivalent to actual site conditions (due to limitations in available data for a particular site), the relative differences between scenarios is expected to be appropriate for decision making. This is the fashion in which MUSIC has been applied.

The application of MUSIC to the assessment of the proposed development has been achieved using the parameters in MUSIC modelling guidelines by Water by Design (SEQ Healthy Waterways Partnership, 2018).

Further MUSIC model configuration and input model data is included in Annex B.

3.5.3 Catchments

The Site has been discretised into sub-catchments for the purposes of drainage routing, as well as assignment of appropriate modelling factors. Figure 3.4 has been prepared to illustrate how the developed site has been discretised into sub-catchments for the purposes of modelling. This has been determined from site elevation data and implementation of potential drainage and associated stormwater controls.



Legend

- Site Boundary
- Lot
- Contours @ 1m Interval
- Indicate stormwater catchment boundary
- Residential land
- Forest

Title:

Discretised Sub-catchment with Land Use

Drawing: 3.4

Rev: A

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3.5.5 Integration of Selected Stormwater Management Measures

Selected stormwater management measures have been located to take advantage of identified Site opportunities and to maximise site functionality. Some of the key considerations in siting potential management measures have included:

- Co-locating drainage where possible in areas not likely to be utilised for development (i.e. within vegetation buffer areas) to preserve developable areas.
- Locating stormwater controls in natural low points, with conveyance systems such as swales provided at appropriate gradients to avoid damage.
- Locating stormwater controls adjacent existing external roads to facilitate later servicing.
- Minimising land take for stormwater treatment through consideration of space efficient controls, i.e. bio-retention systems for quality treatment.

A screen shot of the developed MUSIC model is provided in Figure 3.5.

Civil design will be required to produce a more detailed conceptual design, however, Figure 3.6 shows the general arrangement of treatment devices on Site. This will be further adapted and refined in later project stages.

Individual device specifications included in the MUSIC model are included in Annex B.

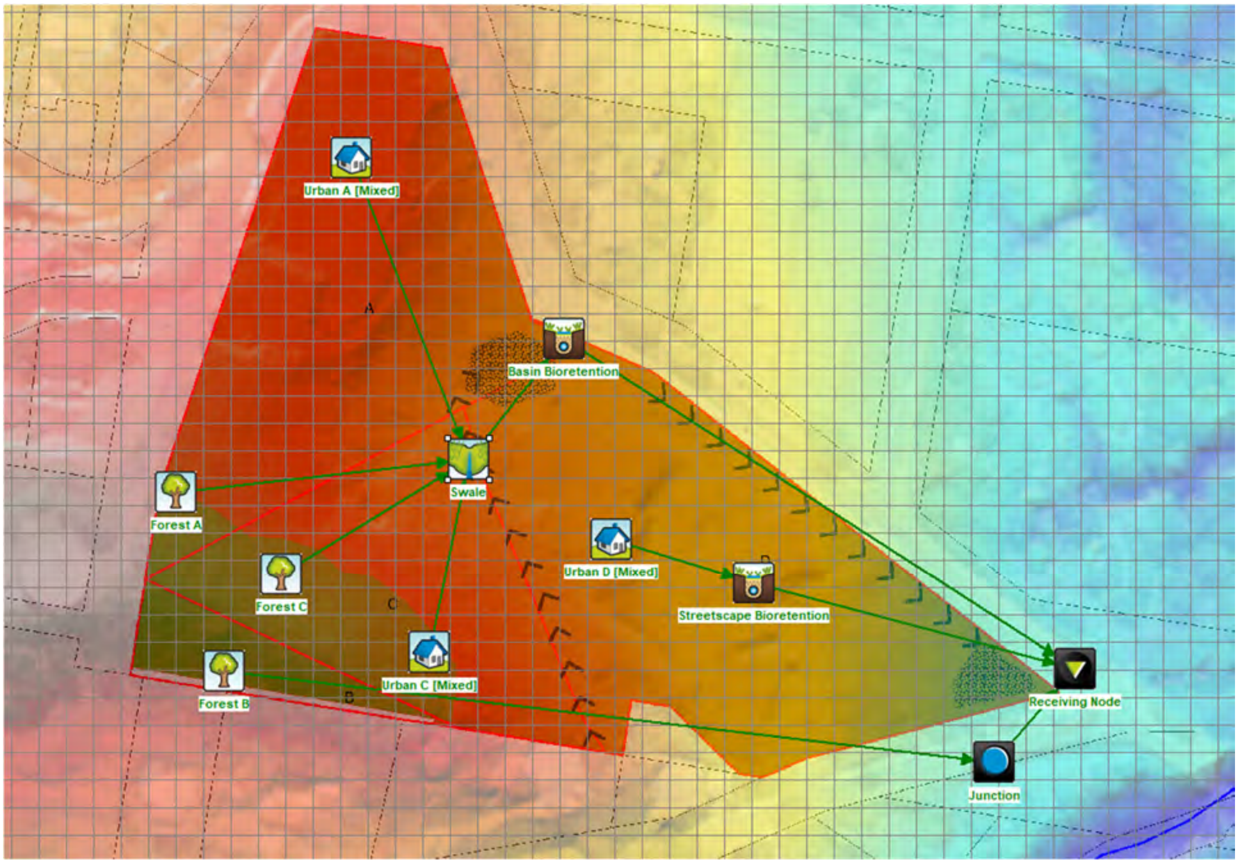
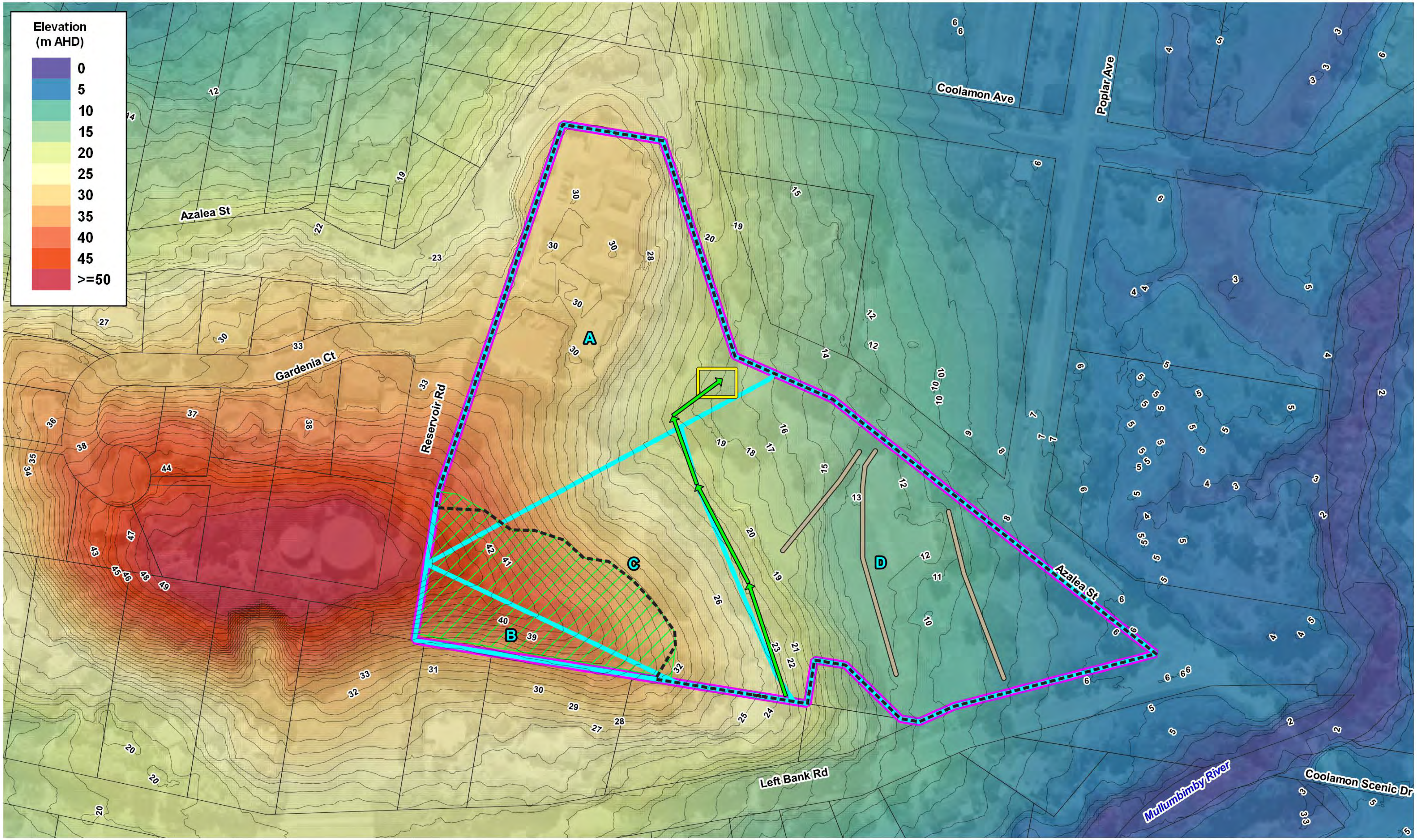


Figure 3.5 Indicative Stormwater Treatment Arrangement in MUSIC



Legend

- Site Boundary
- Lot
- Contours @ 1m Interval
- Indicate stormwater catchment boundary
- Residential land
- Forest
- Bio-retention Basin
- Indicative swale location
- Indicative bio-retention swale location

Title:	Drawing:	Rev:
Indicative Stormwater Treatment Arrangement	3.6	A

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3.5.7 Results

In terms of stormwater quality, the MUSIC results are outlined in Table 3.1.

Table 3.1 MUSIC model results

Parameter	Mean Annual Loads (unmitigated)	Mean Annual Loads (mitigated)	% Reduction
Total Suspended Solids (kg/yr)	9,520	1,430	85.0
Total Nitrogen (kg/yr)	19	4.77	74.9
Total Phosphorus (kg/yr)	94.1	52.9	43.8
Gross Pollutants (kg/yr)	1090	0.8	99.9

With respect to the results the following is noted:

- The performance of the conceptual site arrangement is noted to effectively achieve Council's stated performance objectives (refer Figure 3.1).
- The conceptual arrangement was modelled to only include a central swale and a bio-retention basin in the western catchments (A and C). The catchment area modelled includes Coolamon Villa presently. If this is removed the performance of the current system will improve.
- Basic rational method peak flow calculations have been determined to size a possibly high flow bypass for the purposes of this initial coarse assessment.
- The use of a swale to capture and convey runoff prior to the bio-retention basin provides useful stormwater pre-treatment, however, a hydraulic control will be required to divert flows higher than a 3 month flow around the bio-retention basin to protect it. A customised or proprietary gross pollutant trap (GPT) may be a suitable hydraulic control which can also achieve further pre-treatment of runoff prior to entering the bio-retention system which can reduce longer term maintenance requirements. The GPT has not been included in the current model.
- No OSD has been allowed for the in the current model. The inclusion of the OSD will have limited effect on stormwater quality outcomes as the OSD devices (i.e. detention basins) are typically off-line devices taking diverted high flows from stormwater controls for mitigation. Hence, they are primarily a stormwater quantity control system.
- In the eastern catchment area (D), it has been assumed that roadside linear or basin style bio-retention systems will be applied at suitable grades to achieve water quality improvement. These systems can be drained via underdrainage to new or existing Council sub-surface drainage. Higher flows can be conveyed along road corridors or formed drainage flow paths such as swales to an OSD (if required) or to off-site Council drainage systems.

3.5.8 Strategic Level Cost Assessment

The lifecycle costing tool for MUSIC has been used to estimate a strategic level cost estimate for the specified stormwater management controls which includes a swale and two bio-retention systems (note, that the streetscape systems if utilised would be distributed through the catchment but would have a similar total area to that modelled).

The assessment has the following key basic assumptions built into the costing:

- Inflation rate 3% (noting that inflation has been higher in 2022 and 2023, while it had been lower in preceding years and generally a 2 to 3% assumption for inflation is appropriate
- Real Discount Rate – 0.4%[5]
- Lifecycle assessment period – 50 years
- Base year of costing – 2023

The lifecycle costs generated by MUSIC are included in Table 3.2.

Table 3.2 Lifecycle Costing of Stormwater Controls

	Swale	Bio-retention Basin	Streetscape Bio-retention
Life Cycle (yrs)	50	50	50
Acquisition Cost	$105,792	$26,753	$26,753
Annual Maintenance Cost	$14,078	$7,678	$7,678
Annual Establishment Cost	$28,157	$15,356	$15,356
Establishment Period (yrs)	1	2	2
Renewal/Adaptation Cost	$90,527	$22,893	$22,893
Renewal Period (yrs)	25	25	25
Decommissioning Cost	$72,403	$18,310	$18,310
Real Discount Rate (%)	0.4	0.4	0.4
Annual Inflation Rate (%)	3	3	3
Life Cycle Cost of Swale ($2023)	$900,736	$434,208	$434,208
Equivalent Annual Payment Cost of the Asset ($2023/annum)	$18,015	$8,684	$8,684

The costings assume Council builds (including establishment period), maintains and operates these systems over a 50 year period including one full renewal during that time.

It should be noted that the underlying cost databases within MUSIC were extensive at the time of development but are likely to be relatively dated. A review of these cost estimates could be improved at a later design stage with confirmation of costs via quantity surveying or similar.

[5] https://www.ipart.nsw.gov.au/sites/default/files/cm9_documents/Fact-Sheet-Local-Government-discount-rate-February-2023.PDF

3.5.9 Limitations of Assessment

Limitations of the assessments completed include:

- Confirmation of OSD requirements
- Confirmation of site layouts and configurations
- Further detailed siting and configuration of treatment systems within the site layouts
- Improved understanding of site conditions to support detailed design of stormwater controls, particularly depth to groundwater and permeability
- The costing data provided in MUSIC is somewhat dated and may be best refined progressively via civil designers or quantity surveyors.

3.6 Water Supply

Regional population increases are expected to drive future demand for water supply. Climate variability will also impact on water security as outlined in the Future Water Project 2060 (Rous County Council 2020) which considers factors relating to the supply and demand of water to the Rous Water region.

The Future Water Project 2060 integrates actions from the earlier Future Water Strategy 2014 which had a key outcome of Water Efficiency. Generally, water efficiency in this context means a reduction in potable water demands which may be achieved through a variety of means including minimising loss of water (i.e. leaks), smart metering, use of recycled water, supporting rainwater tanks, community education, etc. Aspects of building use are addressed via the National Construction Code and other construction best practice requirements.

In respect of the proposed development, there are a number of actions which could be considered for future adoption within the Site including:

- Adoption of rainwater tanks to offset potable water demands. For instance, rainwater tanks can be plumbed to toilets, laundries and outdoor gardens where they can achieve a significant reduction in potable demand. Being a Site redevelopment presents opportunities for this to be achieved consistently across the development.

- Consideration of use of an external reclaimed water source for supply of suitable on-site uses. The availability of such a water source, volume and quality would need to be determined. For example, highly treated reclaimed water is available from the Byron Sewage Treatment Plan facility, however, it may not be being pumped as far as Mullumbimby.

- Smart metering to enable real-time understanding of water use overall, and in parts of the future development.

- Community education around the need to conserve water and what can be done, etc.

4 Summary and Conclusions

Assessments of flooding and stormwater have been completed to support the Planning Proposal. These assessments have been completed using development details commensurate with the level of site master planning and supporting data available. Key aims of the assessment has been to further knowledge of potential site constraints to development, as well as confirm the likely compliance of future Site development in respect of generally applied development controls.

Overall, there were few limitations identified, as detailed below:

- The Site is elevated above the PMF (there is only a very small portion of the far eastern site impacted by this extreme flood event). This indicates that there are no applicable flood planning levels to be achieved by future development. There will be no requirement for a flood impact assessment study or similar as the Site is effectively not flood prone.

- The Site will be isolated from the Mullumbimby township during rare and extreme flood events. The duration of the isolation may extent from around 12 to 20 hours. This is unlikely to be a major concern to healthy able-bodied residents who reside in their homes for the duration of the event. However, there may still be a need for some residents to evacuate prior to the onset of flooding to assist others, or to access personal supports as this time of isolation may be of concern. There are multiple rainfall and water level gauges in the region and in the vicinity of the Site, that may assist in the early provision of data to assist in this activity.

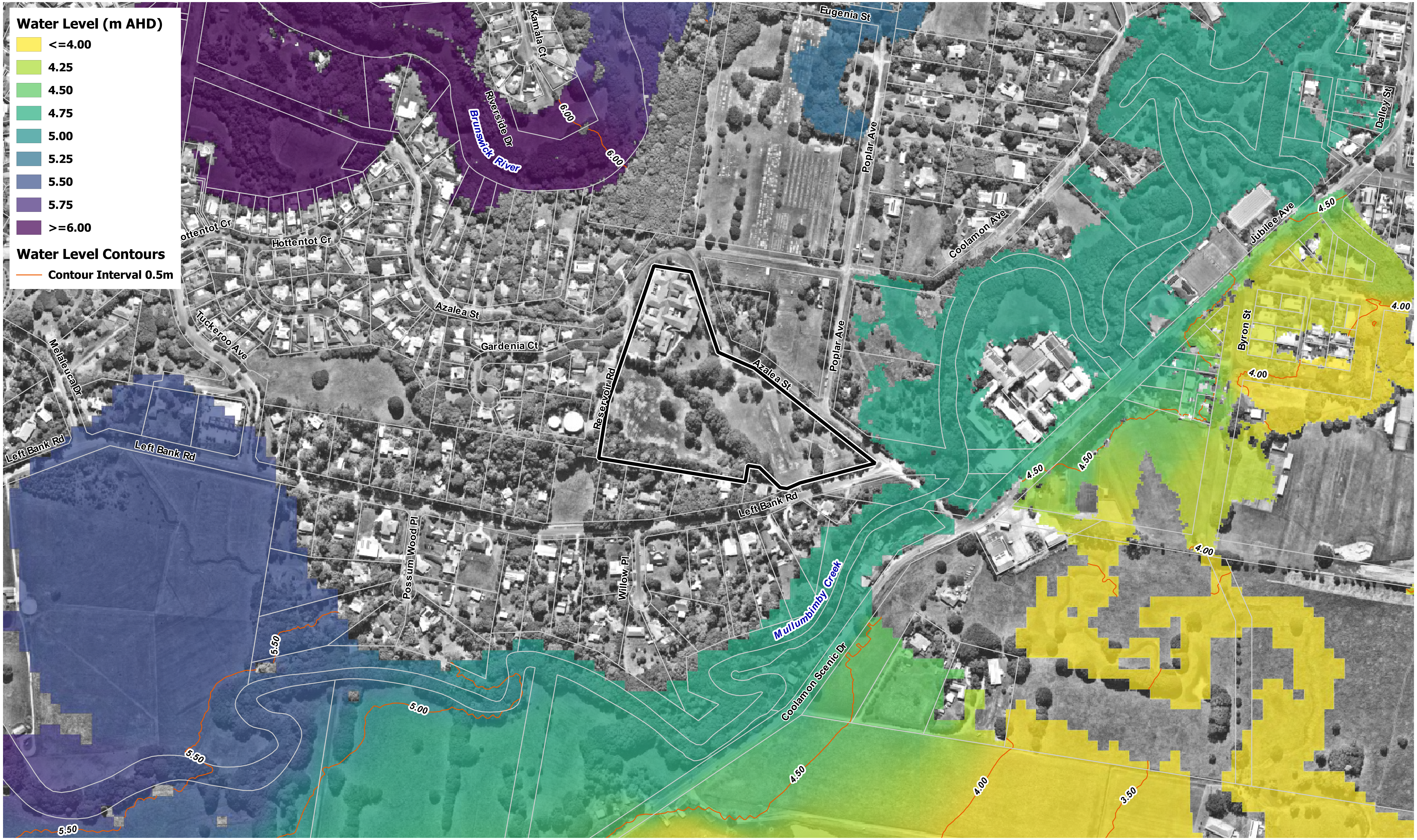
- The Site contains no watercourses, and no part of the Site may be considered as waterfront land owing to its distance from Mullumbimby Creek.

- The Site will likely require the provision of overland flow paths (and associated easements) to safeguard against their future development. As future land forming and drainage design are likely to occur, the provision of overland flow paths should be reconsidered at later design stages.

- The Site will require the provision of stormwater quality treatment systems to achieve Council requirements and objectives. There is unlikely to be any major restrictions on this being satisfactorily achieved and preliminary MUSIC modelling and site design has been undertaken to assist in considerations of site design approaches and space allocations. Generally, while the site is steep there remain a variety of approaches to capture, convey and treat stormwater which would be suited to the Site. The shape of the Site promotes drainage towards Azalea Street which would remain the logical lawful point of discharge.

- The requirements of stormwater quantity management (i.e. peak flow mitigation) are as yet unknown. Mullumbimby Creek downstream from the Site is tidal and Council's guidelines do not require that OSD be provided for Site that discharges via a trunk drainage system to a tidal waterway. The implications of not providing on-site OSD are that peak flow volumes downstream of the Site will be increased due to the substantial change in Site imperviousness that will occur during development. A review of the capacity of Council's existing drainage systems along Azalea St connecting to Mullumbimby Creek will be required to ensure that they do not lead to nuisance flooding on adjoining lots or impacts to the trafficability of Azalea Street. Any required works to Mullumbimby Creek to support an upgrade and drainage systems and outlets, etc, would require the requisite approvals from external agencies.

Annex A Flood Mapping



Legend

Site Boundary

Cadastral Boundaries

Title:

5% AEP Peak Flood Level

Drawing: A.1

Rev: A

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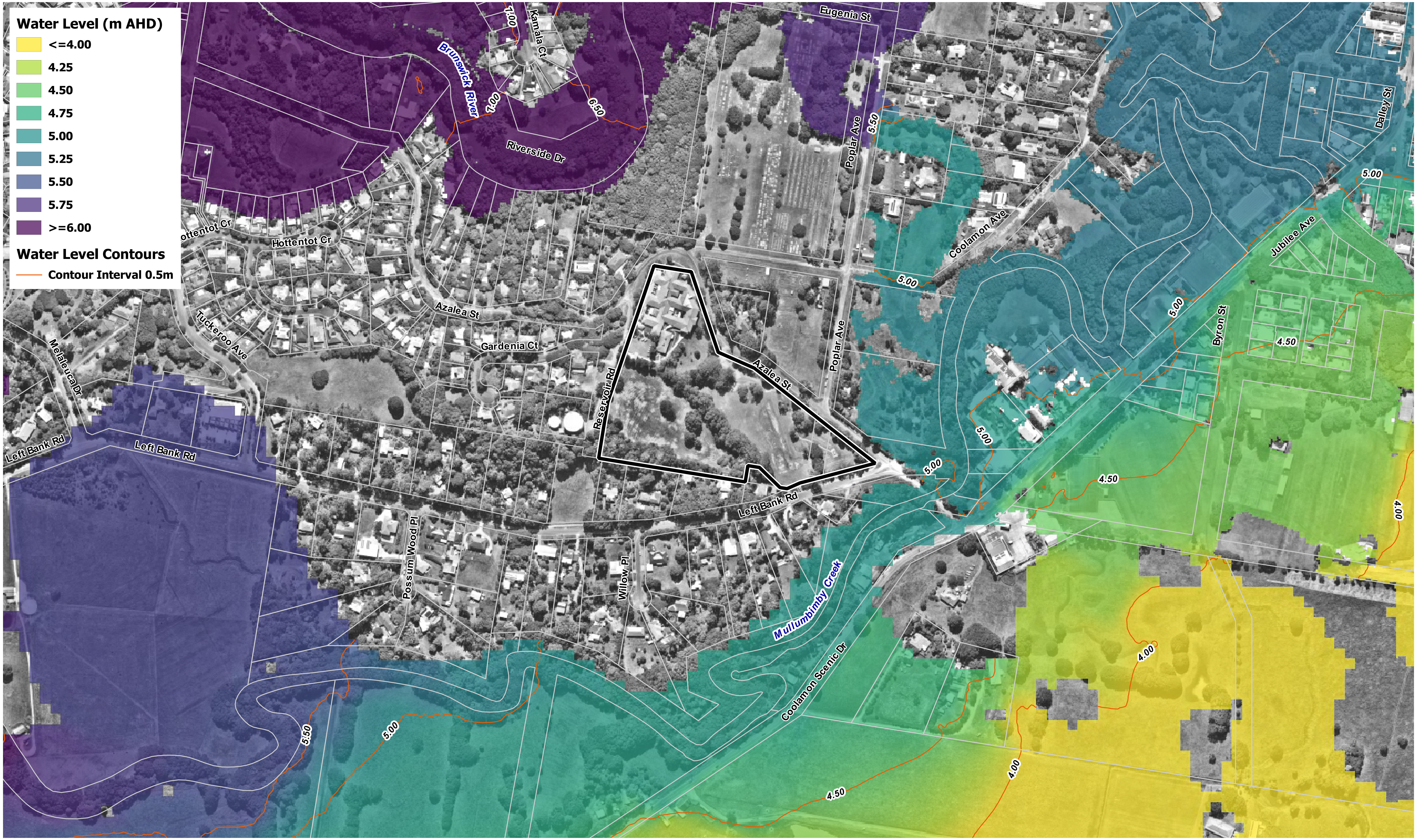

Legend

Site Boundary

Cadastral Boundaries

Title:	Drawing:	Rev:
1% AEP Peak Flood Level	**A.2**	**A**

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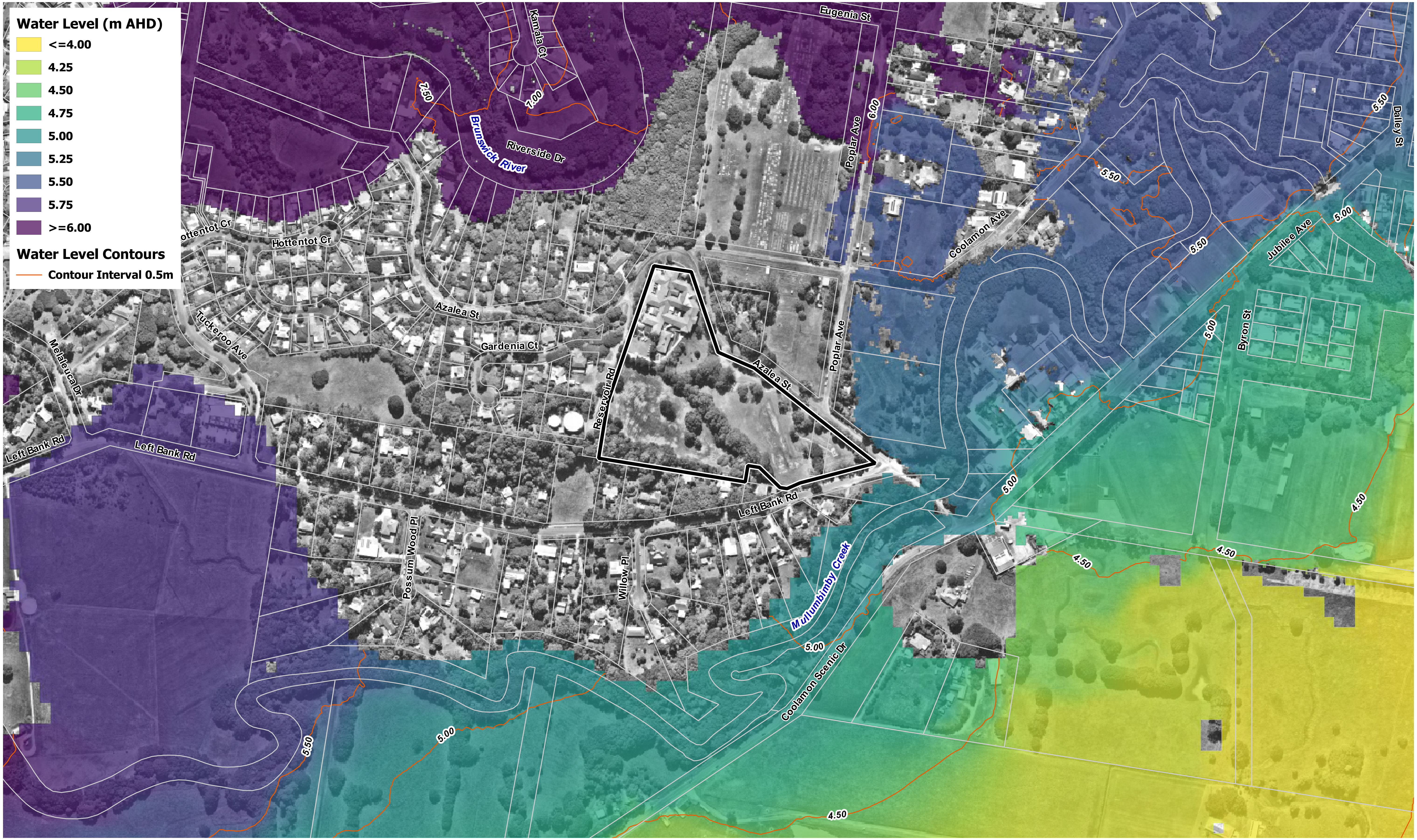

Legend

Site Boundary

Cadastral Boundaries

Title:

0.2% AEP Peak Flood Level

Drawing: A.3

Rev: A

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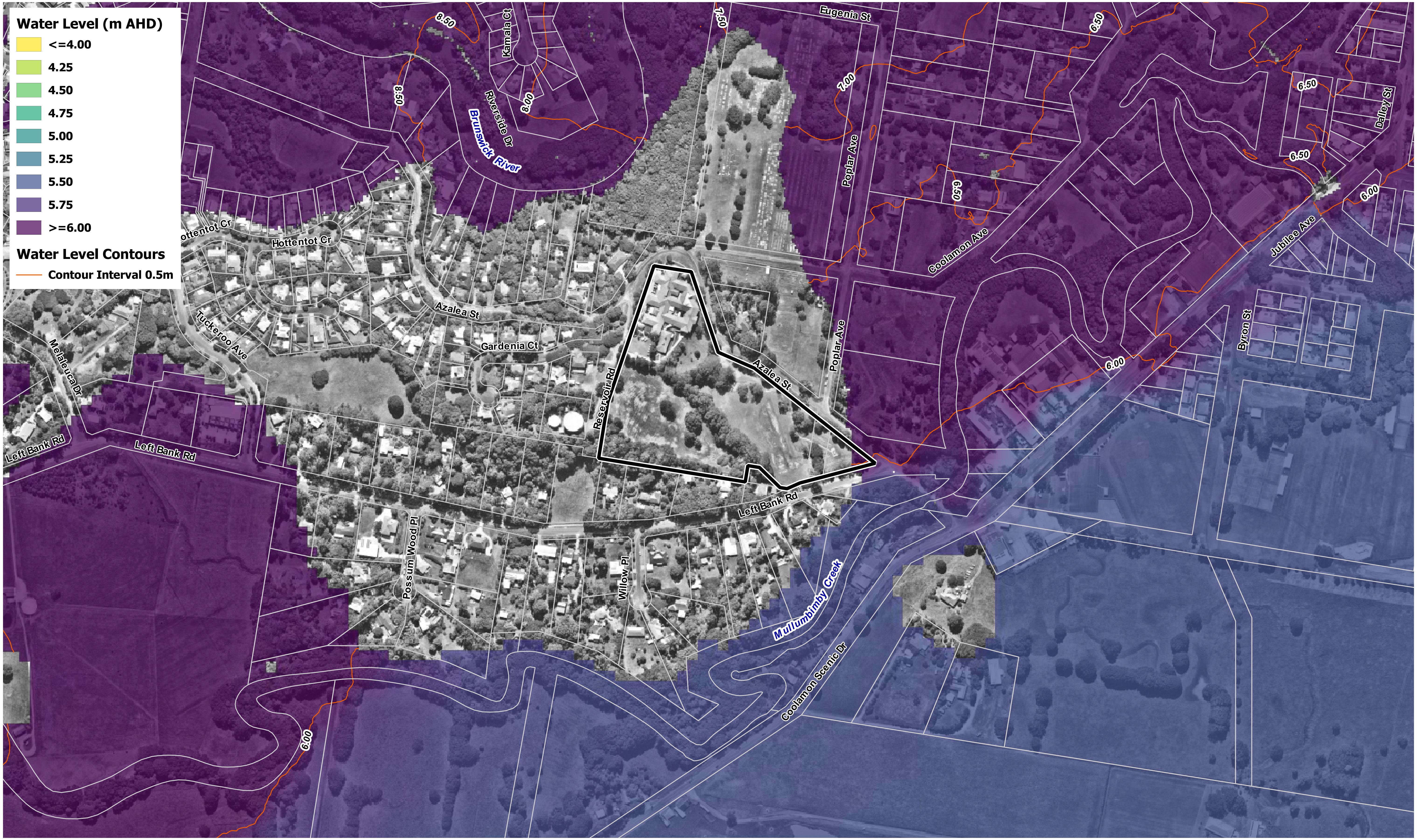

Legend

- Site Boundary
- Cadastral Boundaries

Title:

PMF Peak Flood Level

Drawing: A.4

Rev: A

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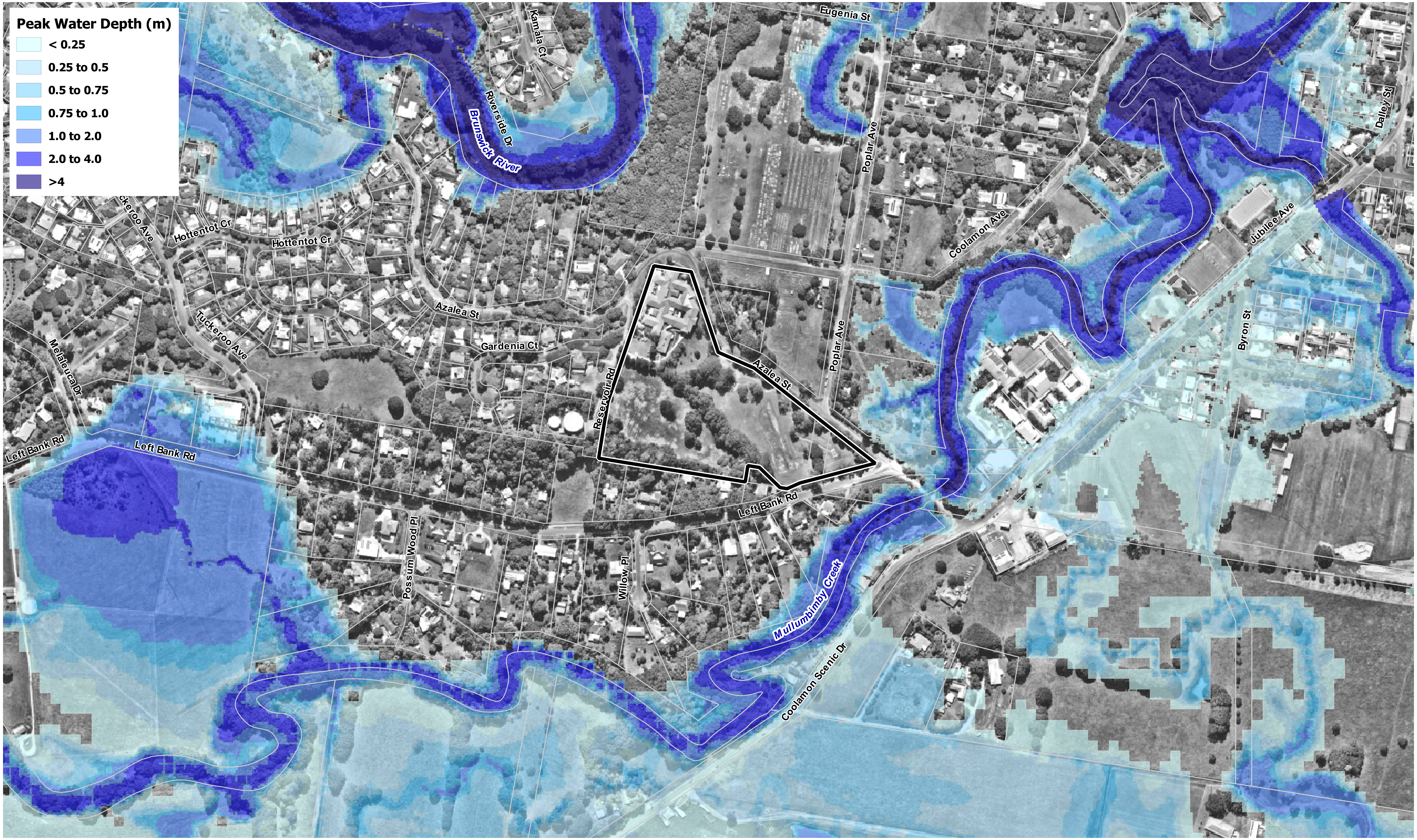

Legend

Site Boundary

Cadastral Boundaries

Title:

5% AEP Peak Flood Depth

Drawing: A.5

Rev: A

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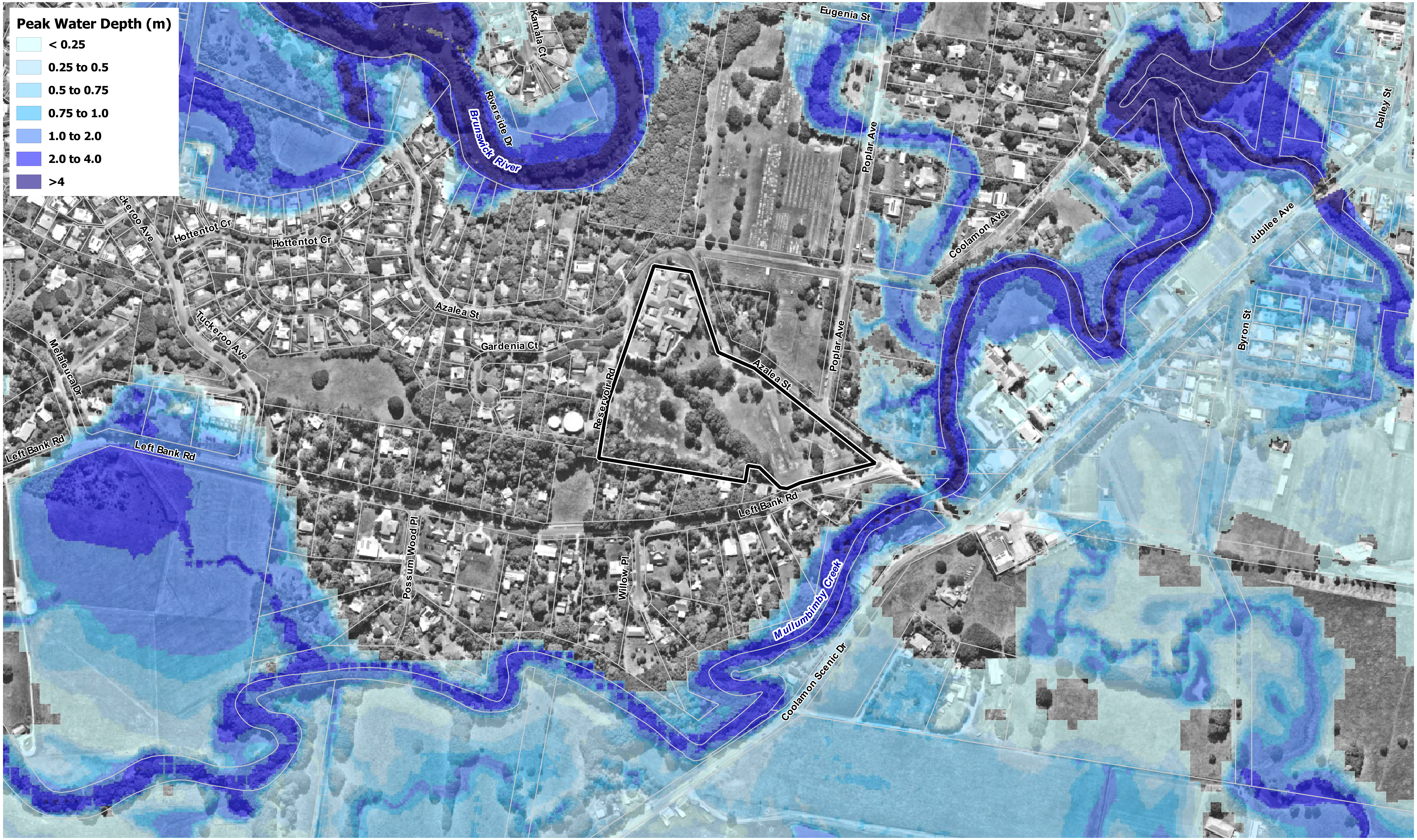

Legend

Site Boundary

Cadastral Boundaries

Title:

1% AEP Peak Flood Depth

Drawing: A.6

Rev: A

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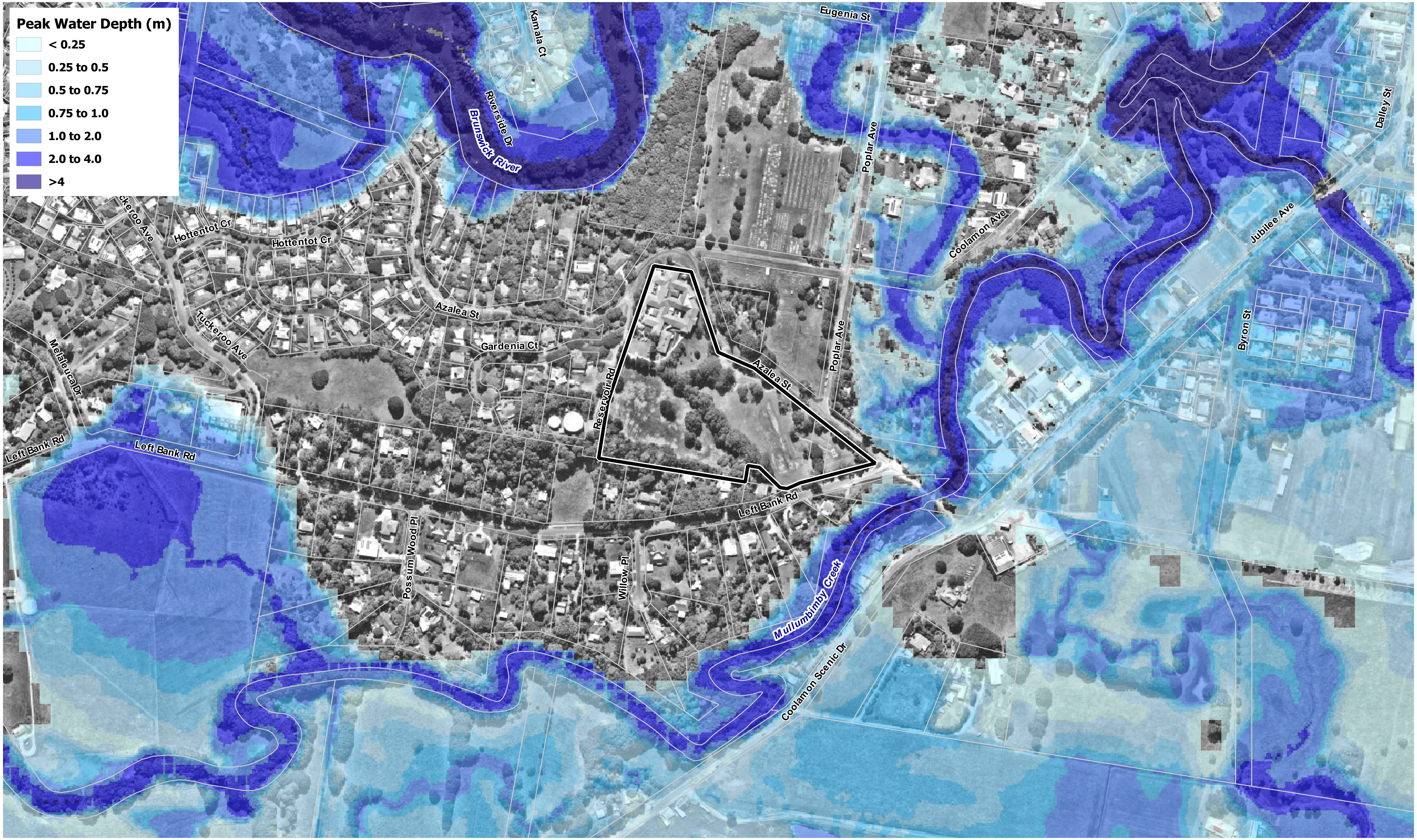

Legend

Site Boundary

Cadastral Boundaries

Title:

0.2% AEP Peak Flood Depth

Drawing: **A.7**

Rev: **A**

N

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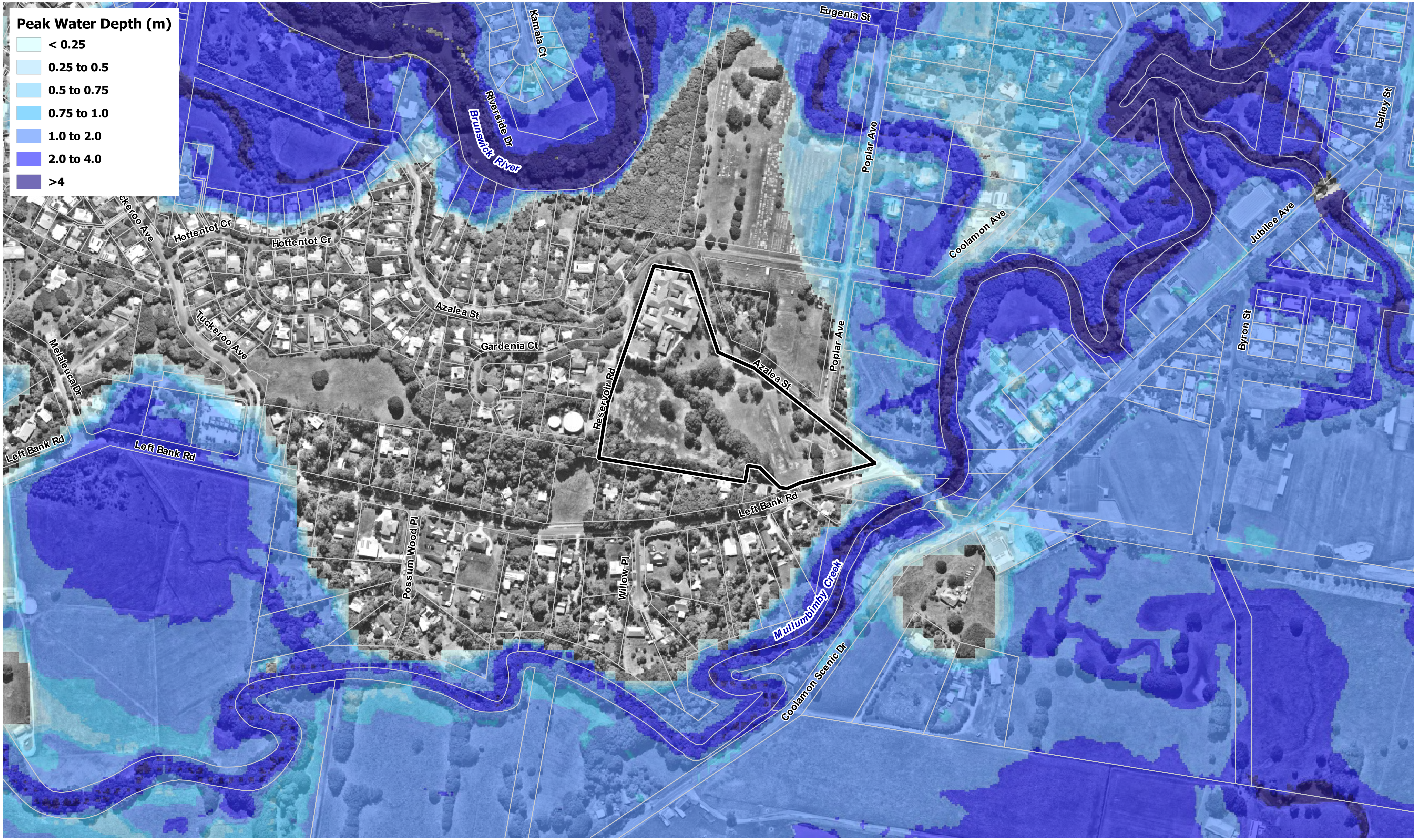

Legend

Site Boundary

Cadastral Boundaries

Title:

PMF Peak Flood Depth

Drawing: **A.8**

Rev: **A**

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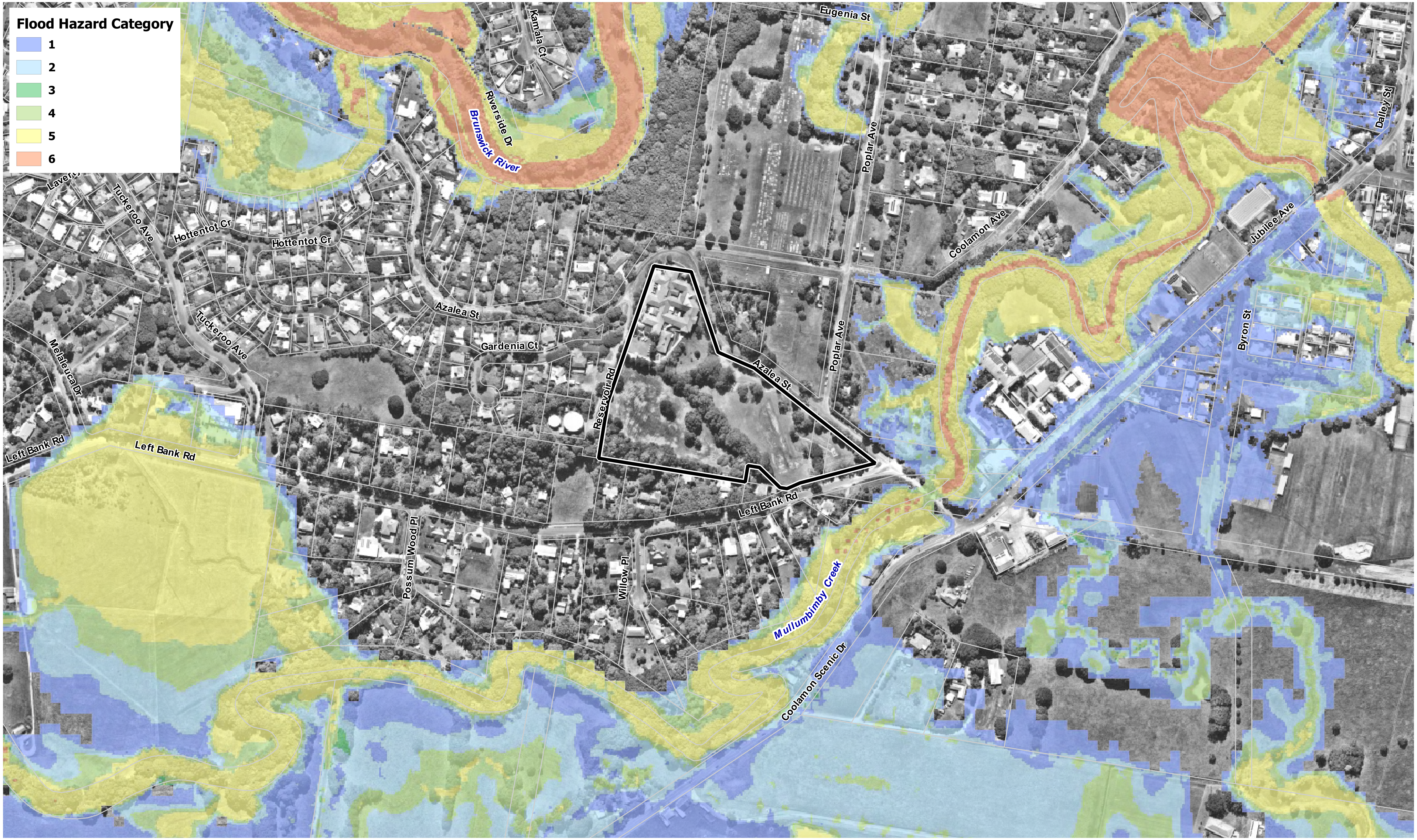

Legend

Site Boundary

Cadastral Boundaries

Title:

5% AEP Peak Flood Hazard

Drawing: A.9

Rev: A

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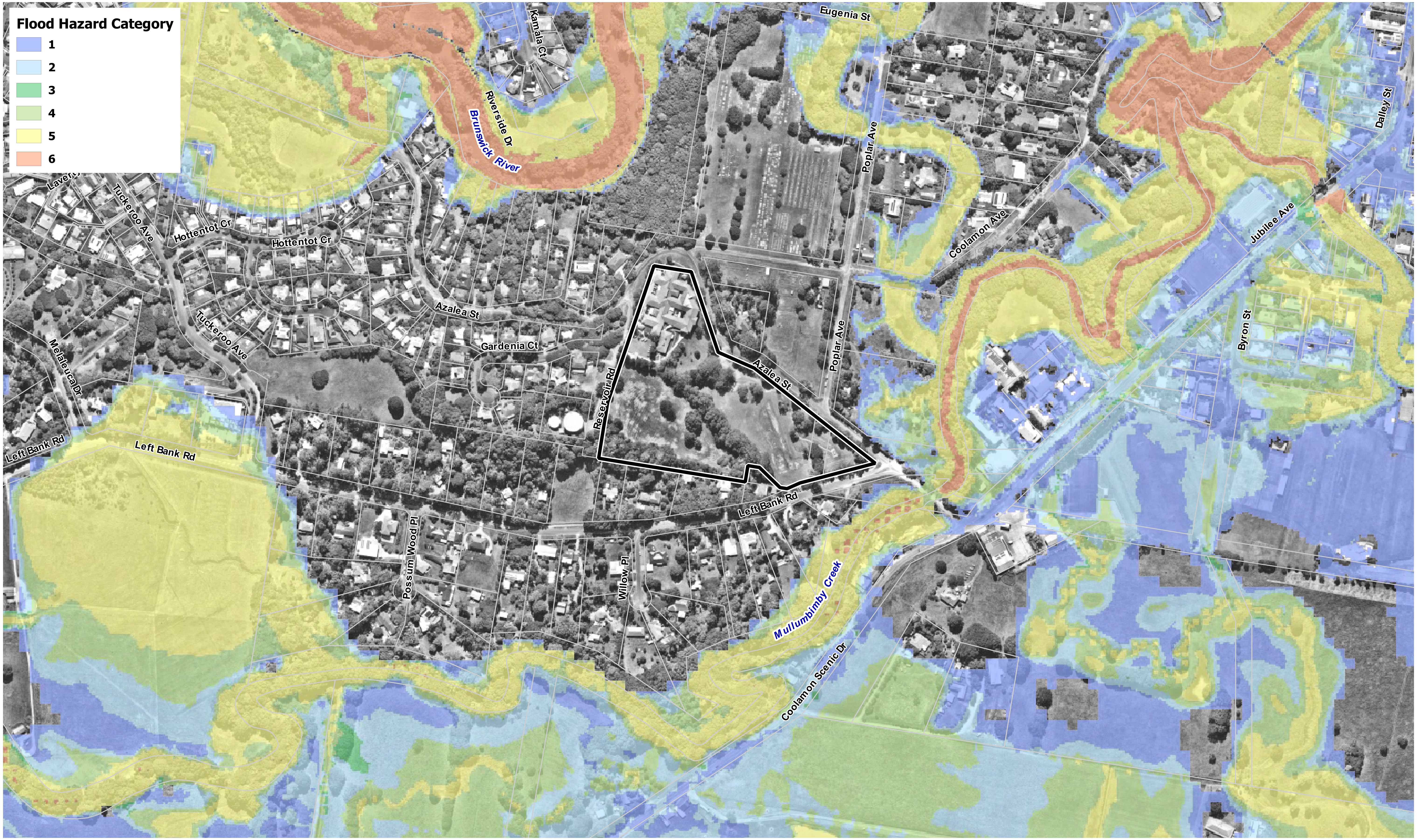

Legend

Site Boundary

Cadastral Boundaries

Title:

1% AEP Peak Flood Hazard

Drawing: **A.10**

Rev: **A**

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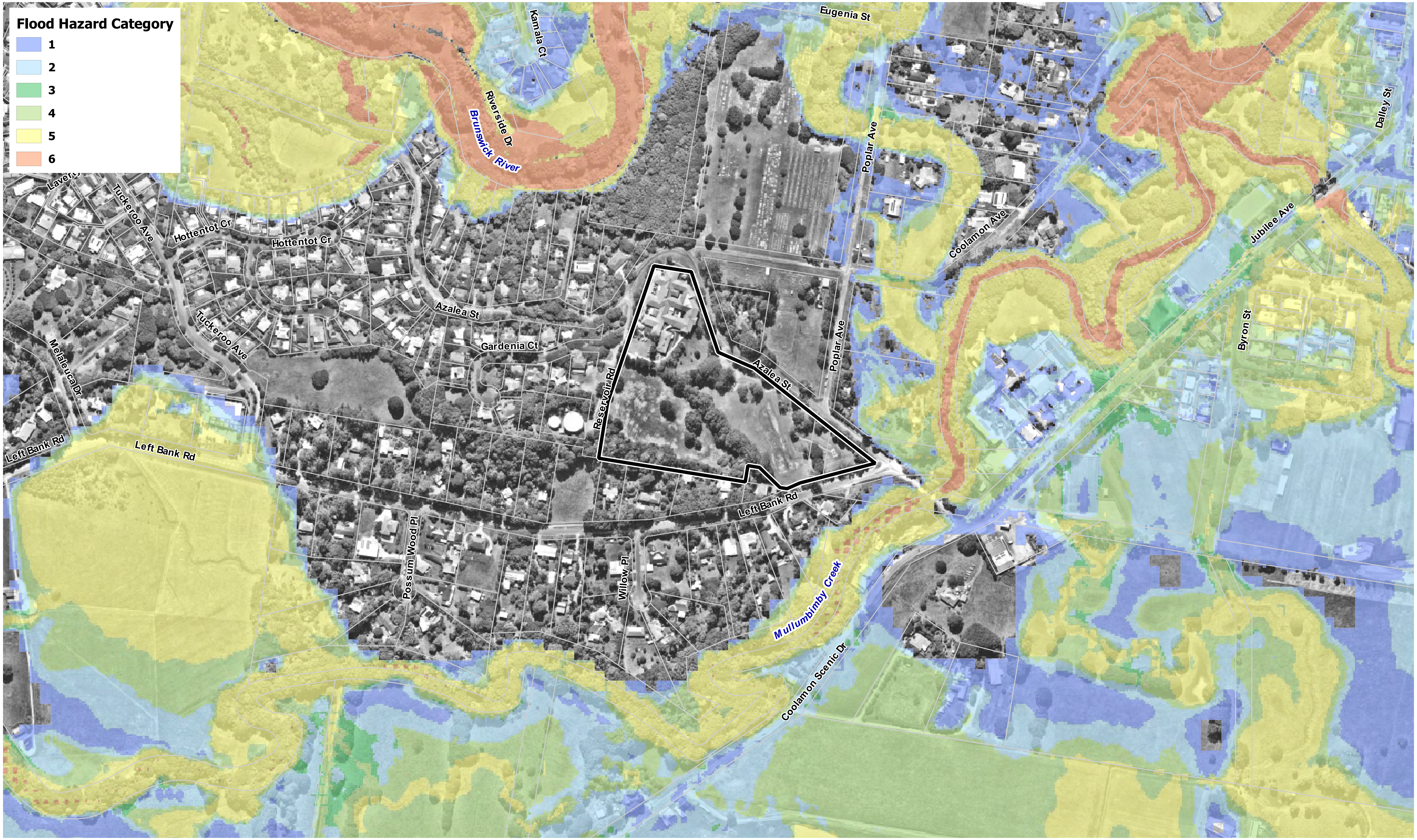

Legend

- Site Boundary
- Cadastral Boundaries

Title:

0.2% AEP Peak Flood Hazard

Drawing: A.11

Rev: A

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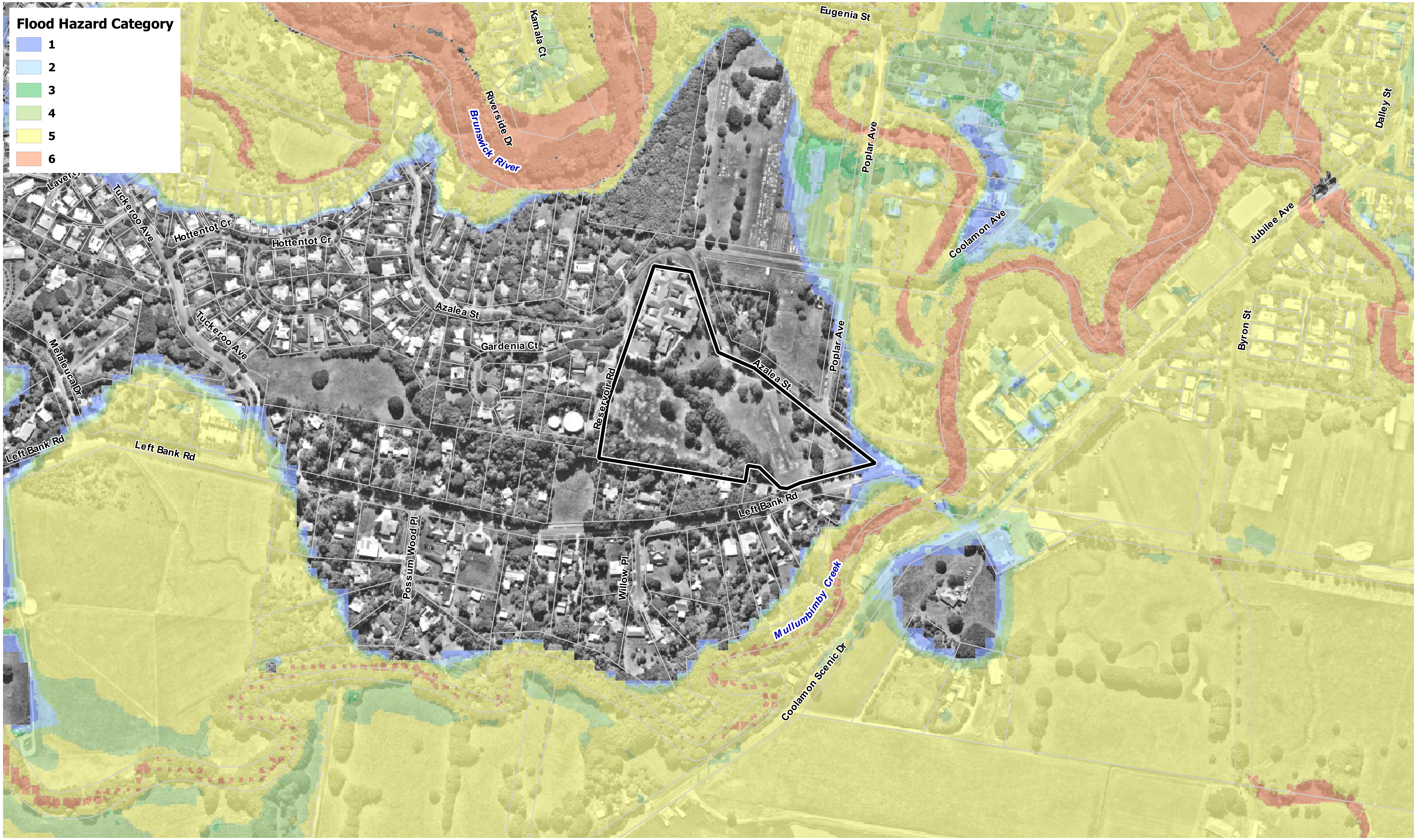

Legend

- **Site Boundary**
- **Cadastral Boundaries**

Title:

PMF Peak Flood Hazard

Drawing: **A.12**

Rev: **A**

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Annex B Stormwater Control Assumptions

B.1 Rainfall and APET

The meteorological template includes the rainfall and areal potential evapotranspiration (APET) data. These data form the basis for the hydrologic calculations within MUSIC.

The Bureau of Meteorology (BoM) rainfall data utilised for the assessments is the Alstonville Tropical Fruit Research Centre which is around 30km south of the Site. This gauge is commonly utilised for MUSIC assessments and is recommended by Ballina Shire for assessments across their Shire. It is considered acceptable to use the Alstonville data as rainfall patterns are generally similar to those of Mullumbimby as are average annual rainfall totals.

Review of the available dataset for Alstonville indicates that the 10 year period 1997 to 2006 inclusive was relatively free of data gaps and accumulated rainfall data. The mean annual rainfall for this period is 1,550 mm. As such this 10 year data period has been selected for use in modelling. Average monthly areal potential evapotranspiration (PET) rates adopted for the MUSIC modelling are summarised in Table B.1. . These values are specific also to the Alstonville gauge.

A 6-minute time step was adopted for the MUSIC modelling.

Table B.1. Monthly Areal Potential Evapotranspiration

Month	Mean daily areal PET (mm)	Mean monthly areal PET (mm)
January	6.41	199
February	5.99	169
March	5.04	156
April	3.56	107
May	2.29	71
June	1.75	53
July	1.76	55
August	2.24	69
September	3.39	102
October	4.91	152
November	5.90	177
December	6.68	207

B.2 Land Use

Land use categories that represent the existing and proposed site conditions (based on site inspection and concept site plans described in preceding sections) are the forest and urban residential land uses.

A lumped modelling approach has been applied at this planning proposal phase given the highly preliminary nature of the development planning, where insufficient detail exists to realistically split the catchment into components such as roof, road and ground (as per the split modelling approach).

At this preliminary stage of the development, runoff from the Coolamon Villa has been treated as being part of the current Site redevelopment.

B.3 Rainfall-Runoff Parameters

Modelling of the rainfall-runoff process in MUSIC requires the definition of one impervious surface parameter and eight pervious surface parameters. The impervious surface parameter (rainfall threshold) and pervious surface parameters utilised were the default MUSIC hydrologic parameters for urban residential and forest land use, as summarised in Table B.2. .

Table B.2. MUSIC Rainfall-Runoff Parameters

Impervious Area Parameters	Urban Residential	Forested
Rainfall Threshold (mm)	1	1
Pervious Area Parameters		
Soil Storage Capacity (mm)	1	1
Initial Storage (% of capacity)	500	120
Field Capacity (mm)	10	10
Infiltration Capacity Coefficient – a	200	80
Infiltration Capacity Exponent - b	211	200
Groundwater Properties	5	1
Initial Depth (mm)	50	50
Daily Recharge Rate (%)	28	25
Daily Baseflow Rate (%)	27	3
Daily Deep Seepage Rate (%)	0	0

B.4 Runoff Quality Parameters

MUSIC requires stormwater constituent concentrations for storm flow and base flow for the various site land uses. These concentrations are converted to logarithmic values for input into MUSIC. The adopted $\log_{10}$ values are summarised in Table B.3. .

Table B.3. umped Land Use Concentration Parameters (mg/L-log10)

	TSS		TP		TN	
	mean	std. dev	mean	std. dev	Mean	std. dev
Urban Residential Base Flow	1.00	0.34	-0.97	0.31	0.20	0.20
Urban Residential Storm Flow	2.18	0.39	-0.47	0.32	0.26	0.23
Forested Base Flow	0.51	0.28	-1.79	0.28	-0.59	0.22
Forested Stormwater Flow	1.90	0.20	-1.10	0.22	-0.075	0.24

In terms of adopted imperviousness, a 70% imperviousness (which is equivalent to around 50 dwellings per hectare) was adopted for Urban Residential and 0% imperviousness for Forested land uses.

B.5 Swales

There is a single proposed swale in the MUSIC model, although there existing potential for multiple swales to effect flow conveyance. Swales are normally designed to take major flows, i.e. 100 year ARI. A standard trapezoidal design has been applied for the purposes of MUSIC modelling. Side slopes of swales has been assumed at 1:4. Mannings values have been applied at 0.054 as it is assumed that the channels will have low erosion resistant planting in their base. Velocities below 1.5 m/s have been targeted to limit opportunities for erosion.

Table B.4. Adopted Swale Parameters

Parameter	1	Notes
Length (m)	120	Measured
Bed Slope (%)	2.5	Measured
Base Width (m)	2	Standard
Top Width (m)	6	Calculated
Depth (m)	0.5	Calculated
Exfiltration Rate (mm/hr)	0	Applied

B.6 Bioretention Systems

There are two bio-retention systems. One is a basin style system treating runoff from the western portion of the Site and would be located adjacent Azalea Road for ease of maintenance and to connect to existing drainage along Azalea Street.

The other system represents multiple potential streetscape linear bio-retention systems. These systems are normally integrated into a road easement where they treat both ground and road runoff.

The bio-retention systems divert flows larger than around a 3-month peak flow to a downstream OSD or outlet. Coarse estimation of a 1 year ARI peak flow has been used in preliminary modelling. Most runoff flows are below this bypass limit and will hence drain through the bio-retention systems.

As per Table B.5. a number of standard values have been applied as generally recommended in the MUSIC guidelines. The overall surface area and filter area have been adjusted to achieve the necessary discharge requirements.

The basins have initially been designed with underdrainage, however, if soil testing is completed for saturated hydraulic conductivity (e.g., double ring infiltrometer), then it may be possible remove the underdrainage provided infiltration rates are sufficiently high in the surrounding native soils. This should be confirmed at detailed design.

Table B.5. Adopted Bio-retention System Parameters

Parameter	Bio-basin	Streetscape Bio	Notes
Low Flow Bypass (m3/s)	0	0	
High Flow Bypass (m3/s)	0.4	0.4	Q1 from rational method calculation
Extended Detention Depth (m)	0.3	0.3	Standard
Surface Area (m2)	150	150	Calculated
Filter Area (m2)	120	120	Calculated
Unlined Filter Media Perimeter (m) *	0	0	Calculated
Saturated Hydraulic Conductivity (mm/h)	150	150	Adopted
Filter Depth (m)	0.5	0.5	Standard
TN Content of Filter Media (mg/kg)	400	400	Guidelines
Orthophosphate Content of Filter Media (mg/kg)	30	30	Guidelines
Exfiltration Rate (mm/hr)	0	0	Standard
Based Lined	Y	Y	Standard
Effective Vegetation	Y	Y	Standard
Underdrain	Y	Y	Standard

* The unlined filter perimeter indicates the extent of the basins vertical sides (below ground) that are not lined with an impermeable material

BMT is a leading design, engineering, science and management consultancy with a reputation for engineering excellence. We are driven by a belief that things can always be better, safer, faster and more efficient. BMT is an independent organisation held in trust for its employees.

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