Water Cycle Management Strategy Report

Walker Corporation

Appin (Part) Precinct

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EXECUTIVE SUMMARY

J. Wyndham Prince have been engaged by Walker Corporation Pty Ltd and Walker Group Holdings Pty Ltd (together the Proponent) to prepare a Water Cycle Management Strategy (WCMS) to support a Precinct Plan for the Appin (Part) Precinct.

The Appin (Part) Precinct is situated within the core of the Appin & North Appin Precinct. It is bound by Wilton Road to the east, the Nepean River to the west and Ousedale Creek to the The Appin (Part) Precinct located in the wider Wollondilly Shire Local Government Area (LGA) contains approximately 1,378 ha of land.

The WCMS report presents details on the planning proposal for the Appin (Part) Precinct. The assessment includes hydrologic analysis, water quality analysis, riparian corridor assessment and consideration of the potential ecological impacts of the development.

Water quality will be managed by a variety of controls in order to deliver the adopted water quality objectives. Devices have been sized indicatively based on a 10-ha typical catchment assumption for both the low-density and commercial areas proposed within the precinct plan. Further discussion on the water quality approach can be found in Section 5 of the report.

Our hydrologic assessment demonstrates that the proposed development of the precinct plan will result in peak post-development discharges being restricted to less than the pre-development levels within the major receiving waterways (i.e. Nepean River and Cataract River). Preliminary modelling of detention basins within the site shows that introducing blanket detention across the development will actually increase flows in Nepean and Cataract Rivers. Conversely, the urbanisation of the local sub-catchments within the precinct plan means that local creeks and tributaries experience some localised increases in peak flows. Majority of the local increases in peak flows occur within the proposed environmental conservation zones which border the development edge (within the rezoning assessment area). As such, a detention strategy is proposed that focuses on providing focused detention for areas of the precinct plan that discharge to sensitive or higher order watercourses. Details of the hydrologic assessment is provided in Section 6.

The impacts of the merit-based detention strategy have been carefully considered from an ecology and habitat management perspective. Various factors have been explored including peak flows, regular (frequent) runoff, pollutant reductions, velocity management, geomorphology and flooding impacts. It is anticipated that while peak flows will be increased locally at the sites discharge points, the impacts on ecology will be manageable given the improvements that will be achieved in regular stormwater runoff and increased management of pollutants together with the resilience of the natural ecosystems that exist downstream of the development.

The Water Cycle Management Strategy proposed for the Appin (Part) Precinct rezoning is therefore functional; it delivers the required technical performance, lessens environmental degradation and pressure on downstream ecosystems and infrastructure and provides for a ‘soft’ sustainable solution for water cycle management. The rezoning can be supported in its current form.

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1. THE APPIN PROJECT

Greater Sydney's population is projected to grow to approximately 6.1 million by 2041 – over a million more people than currently live in the region.

The NSW Government has identified Growth Areas as major development areas that will assist in accommodating this growth. The Greater Macarthur Growth Area (GMGA) is one such growth area and is a logical extension of the urban form of south-west Sydney. The GMGA is divided into precincts. The Appin Precinct and North Appin Precincts are the southernmost land release precincts of the GMGA. The goal is to deliver 21,000+ dwellings.

The land is to be rezoned and released for development to achieve this goal. A submission has been prepared by Walker Corporation Pty Limited and Walker Group Holdings Pty Limited (the Proponent) to rezone 1,378 hectares of land (the site) within the Appin Precinct from RU2 Rural Landscape to the following zones:

- Urban Development Zone
  - Zone 1 Urban Development (UD)
- Special Purposes Zone
  - Zone SP2 Infrastructure (SP2)
- Conservation Zone
  - Zone C2 Environmental Conservation (C2)

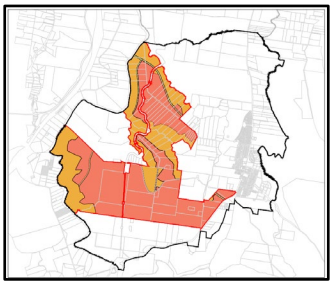
The zonings are shown on the Appin (Part) Precinct Plan (the precinct plan). 'The precinct plan' will be incorporated into the State Environmental Planning Policy (Precincts – Western Parkland City) 2021 and contain the provisions (clauses and maps) that will apply to 'the site.' 'The precinct plan' envisages the delivery of 12,000+ new homes.

A structure plan has been prepared for the site and is shown on the Appin (Part) Precinct Structure Plan (the structure plan). It identifies staging and the first stage to be developed – Release Area 1. Release Area 1 is anticipated to deliver 3,500+ dwellings.

The submission is aligned with strategic land use planning, State and local government policies and infrastructure delivery. The development potential is tempered by a landscape-based approach that protects the environment and landscape values, shaping the character of new communities. A series of residential neighbourhoods are to be delivered within the landscape corridors of the Nepean and Cataract Rivers, supported by local amenities, transit corridors and community infrastructure.

The submission includes a hierarchy of plans. The plans and their purpose are summarised in Table 1-1.

Table 1-1 – Title and Purpose of Plans

(1) APPIN & NORTH APPIN PRECINCTS INDICATIVE PLAN	(2) APPIN (PART) PRECINCT PLAN (THE PRECINCT PLAN)	(3) APPIN (PART) PRECINCT STRUCTURE PLAN (THE STRUCTURE PLAN)
Broader context and for information purposes only. It has no statutory weight. It identifies: • Higher-order transport network • Centres hierarchy • School sites • Conservation areas • Residential areas • Cultural sites and connections	It shows the land proposed to be rezoned and incorporated into a new schedule in the Western Parkland City SEPP 2021. The precinct plan contains the development provisions (clauses and maps) applicable to the site and is used in assessing development applications.	Structure plan for the site, showing staging of release areas. Development is to be generally consistent with the structure plan. It illustrates land use components including (but not limited to): • Low and medium-density residential • Retail and employment centres • School • Open space • Drainage network/basins • Transport network
 (21,000+ dwellings)	 (12,000+ dwellings)	 (12,000+ dwellings) (Inc. Release Area 1 - 3,500+ dwellings)

2. INTRODUCTION

J. Wyndham Prince have been engaged by the Proponent to prepare a Water Cycle Management Strategy Report to support the Appin (Part) Precinct Plan (the precinct plan) and Appin (Part) Precinct Structure Plan (the structure plan).

The precinct and structure plan boundaries are Wilton Road to the east, the Nepean River to the west and Ousedale Creek to the north. Refer to Plate 2-1 and Table 2-1 for key attributes of the precinct plan and structure plan area.

The Appin (Part) Precinct Plan zones land for conservation, urban development and infrastructure and establishes the statutory planning framework permitting the delivery of a range of residential typologies, retail, education, business premises, recreation areas, and infrastructure services and provides development standards that development must fulfil. Within the proposed urban development zone, 12,000+ dwellings can be delivered.

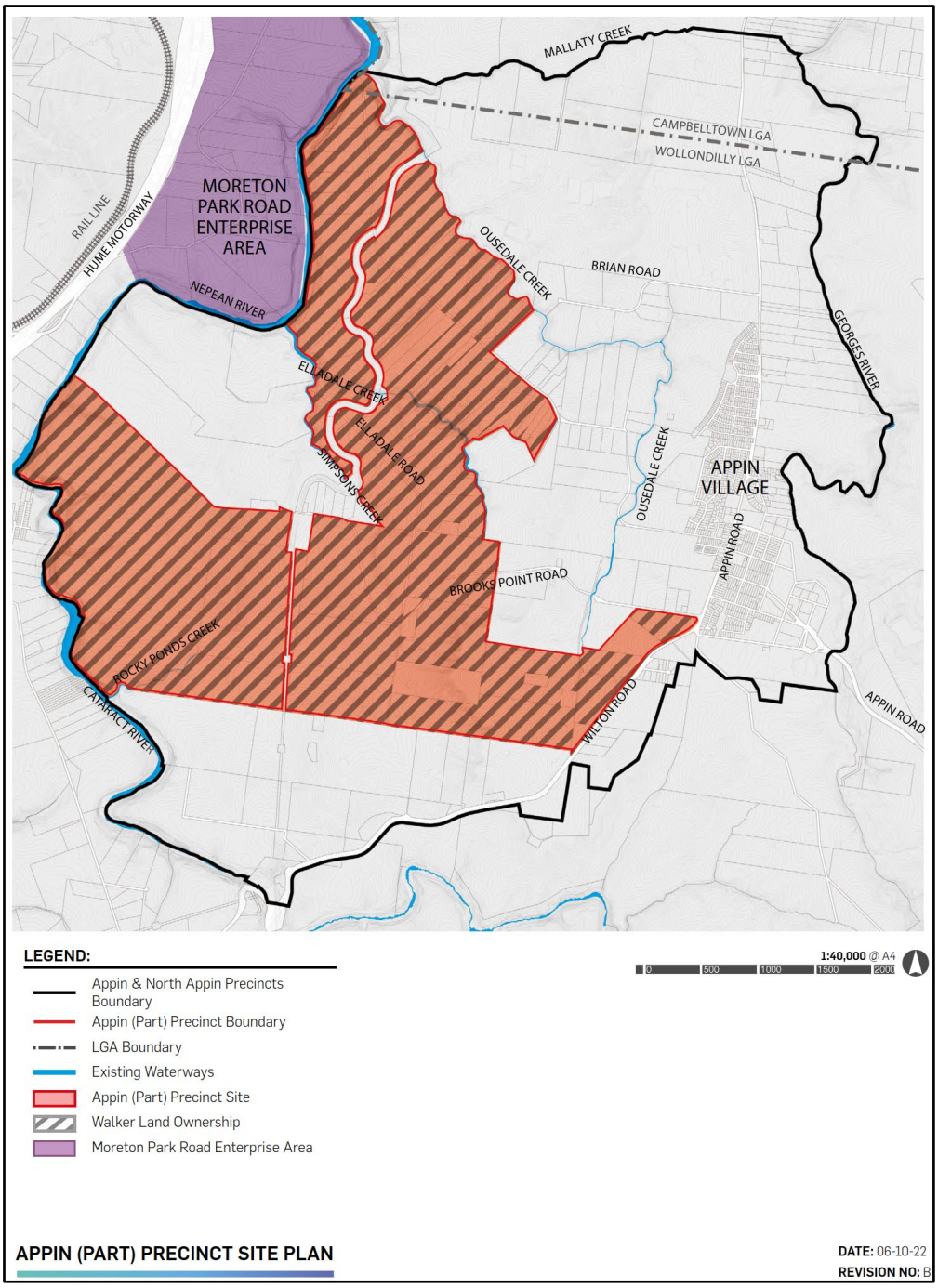
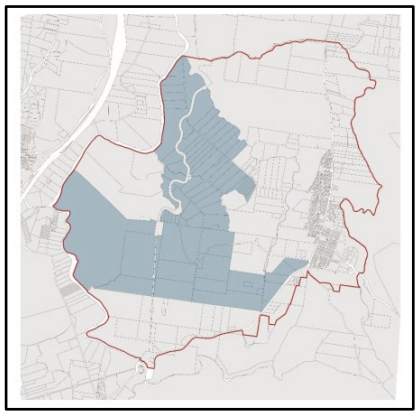


Plate 2-1 – Boundary of Appin (Part) Precinct Plan

Table 2-1 – Appin (Part) Precinct – Summary of Key Attributes

Location		Key Attributes	
Appin (Part) Precinct		**Area**	Total - 1,378 ha Walker - 1,248 ha Private Ownership - 94 ha
		LGA	Primarily Wollondilly LGA
		Proposed Dwellings	12,000+
		Proposed Population	36,000+

2.1. Objectives

This report summarises the assessments of stormwater quantity and quality management to ensure that there are manageable local impacts and no impacts external to the site. The objectives of the report are:

- To ensure that flows discharging to sensitive downstream waterways are not increased as a result of the development,
- To ensure that the water quality targets set out in Wollondilly Shire Council's Integrated Water Management Strategy and Policy (IWMS) are achieved,
- To maximise the reuse of non potable water,
- To ensure that the downstream environment and ecology is not degraded by the urbanisation of the catchment, and
- To provide a framework which will inform the future development applications (DA) for the staged delivery of the precinct plan.

3. PREVIOUS STUDIES AND RELEVANT GUIDELINES

The following control documents have been considered in the development of the Water Cycle Management Strategy for the precinct:

- WSC Integrated Water Management Policy and Strategy (Wollondilly Shire Council, 2020);
- NSW MUSIC Modelling Guidelines (BMT WBM, 2015).

Details of the stormwater related objectives pertaining to this site are provided below.

3.1. Integrated Water Management Policy (2020)

Wollondilly Shire Council's Integrated Water Management Policy (IWMP) provides an overview of the objectives of the integrated water management strategy, outlining the overarching principles to be applied to new developments in the Wollondilly Local Government Area (LGA). The policy aims to deliver an integrated water solution for Wollondilly that protects the pristine waterways, endangered species, maintains and improves the condition of waterways, in the context of a growing population and changing land use. The policy lists the following objectives:

- Ensure stormwater and wastewater from urban development has a zero impact on local waterways;
- Decrease the use of potable water;
- Increase the amount of public and private water reuse and recycling;
- Use all sources of water to support sustainable development including community liveability, biodiversity, local economies including agriculture and climate resilience;
- Ensure water sensitive urban design elements are incorporated within public infrastructure and private development;
- Improve the condition of natural waterways, to remain swimmable, all year round;
- Ensure that residential, industrial, commercial and agricultural development doesn't affect the tributaries of the Georges and Nepean River within Wollondilly Local Government Area and downstream; and
- To support the water quality targets and associated treatment methods of urban water that are located in the Integrated Water Management Strategy.

3.2. Integrated Water Management Strategy (2020)

Wollondilly Shire Council's Integrated Water Management Strategy (IWMS) provides details of the proposed water management strategy to be implemented for new developments within the Wollondilly LGA. An alternate management approach is described in the IWMS which is aimed at achieving "zero impact" on the water cycle as a result of urban development. This approach is described in further detail in the IWMS and is also supported by a Water Sensitive Urban Design (WSUD) Guidelines which are newly adopted.

Importantly, the new Integrated Water Management Strategy outlines the new water quality and flow targets to be achieved by new developments (applied per hectare of new urban development area) in the Wollondilly LGA. They are listed as follows:

- Have between 2.5 and 3 ML of runoff on average, per year
- Reduce TN, TP and TSS by the ideal stormwater outcomes (85%, 95%, 95%) respectively
- Have either:
  - Five hundred square metres of green infrastructure to filter and infiltrate runoff
  - Two (2) megalitres of reuse of water per year
  - A combination of the above two (2) criteria
- Require zero downstream water quality assets, as all runoff and stormwater treatment are managed within development lots and precincts.

3.3. Wilton Growth Area Development Control Plan (2021)

In 2021, the NSW Department of Planning, Industry and Environment (DPIE) released the Wilton Growth Area Development Control Plan (DCP) which outlines the aims and objectives for new developments in the Wilton Growth Area which neighbours the Greater Macarthur Growth Area (GMGA). It is expected that similar controls and objectives will be adopted for the Appin (Part) Precinct (within the GMGA). Therefore, the objectives relating to flooding and water cycle management that have been considered in this strategy and are as follows:

- To manage the flow of stormwater from urban parts of the Precinct to replicate, as closely as possible, pre-development flows.
- To promote, at Precinct and Growth Area scale, an integrated approach to the provision of potable water, and the management of wastewater and stormwater.
- To ensure an integrated approach to drinking water, wastewater and stormwater services is considered to drive more sustainable water management outcomes
- To ensure that water management measures for development incorporate key principles of water sensitive urban design to help protect, maintain or restore waterway health of identified high value waterways with a minimum requirement of maintaining current health. This involves:
  - protecting existing hydrological and ecological processes of natural features and systems including watercourses, wetlands, lagoons and aquatic, riparian and groundwater dependant ecosystems
  - maintaining the natural hydrological behaviour of the catchment
  - where applicable, protecting the water quality of surface and groundwaters
  - minimising demand on reticulated water supply system
  - integrating water into the landscape to enhance ecological, visual, social, economic and cultural values.

Furthermore, this document outlines the water quality targets for the Wilton Growth Area which can be seen in Table 3-1 below.

Table 3-1 – Water Quality and Environmental Flow Targets

Element	Water quality % reduction in pollutant loads Gross Pollutants (>5mm)	Water quality % reduction in pollutant loads Total suspended solids; Total phosphorous; Total nitrogen	ENVIRONMENTAL FLOWS Stream erosion control ratio
Stormwater Management Objective	90	Neutral or Beneficial Effect on Water Quality - meaning loads of pollutants from future development must be equivalent to or less than that from the existing rural land use prior to development'	1:1

4. RIPARIAN CORRIDOR ASSESSMENT

The proposed rezoning area of the Appin (Part) Precinct is intersected by a series of existing watercourses, many of which are located within environmental conservation areas within the site. In accordance with the Guidelines for controlled activities on waterfront land (NRAR, 2018), the watercourses have each been identified to range between 1st to 4th order riparian corridors based on the Strahler classification system using available 1:25,000 topographic maps. The guidelines state that where a watercourse does not exhibit the features of a defined channel with bed and banks, the NRAR may determine that the watercourse is not waterfront land for the purposes of the Water Management Act (2000) (WM Act).

Details of the riparian assessment, including the riparian mapping and matrix, are provided in Appendix A. Figures 4-1 to 4-4 in Appendix B provides supporting illustration of the riparian areas.

Given the poor condition of a small number of watercourses in the site, an assessment has been undertaken to determine whether these watercourses can be reclassified to not be considered waterfront land and thus remove the need for riparian corridor considerations. To support the proposed reclassification of these watercourses as waterfront land, a series of maps supported by a riparian assessment matrix, has been prepared to show the Strahler classifications and watercourses proposed to be reclassified. The outcomes of the riparian assessment have been reached with consideration of the Waterfront land tool (NRAR, 2020) which has been developed to aid in the classification of “waterfront land” in accordance with the WM Act.

A site inspection was undertaken on 23rd July 2020 by the project team which involved recording observed riparian characteristics and taking site photos at each of the visited watercourses. Each watercourse has been assessed against the Waterfront land tool to determine whether valuable riparian function exists. The watercourses not visited at the site visit have been assessed using available aerial imagery. The riparian assessment concludes that some of the mapped watercourses across the site are not what would be classified as “rivers” under the WM Act. These watercourses do not display riparian characteristics and there is no defined creek bed / banks or preservable vegetation with biodiversity value.

See Plate 4-1 for an overview of the watercourses.

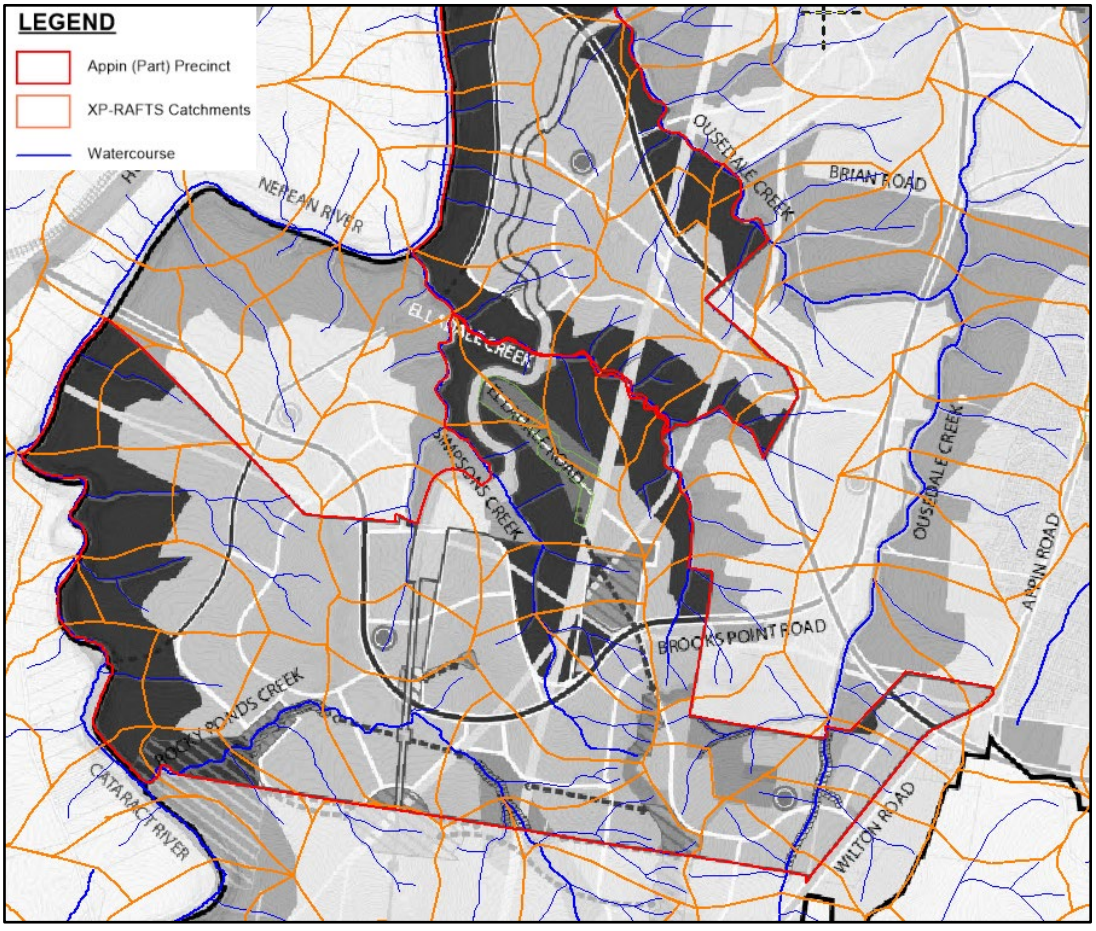


Plate 4-1 – Appin (Part) Precinct Watercourses

It is noted in the 'Guidelines for controlled activities on waterfront land - Riparian corridors' (NRAR, 2018) that 1st order watercourses are able to be realigned/reengineered. Refer to Table 4-1 below. The 1st order watercourses that are located on urban capable land in the Appin (Part) Precinct development are proposed to be removed and replaced by street drainage networks (pit and pipe networks). In addition, any watercourse within 50m of the urban capable land of Appin (Part) Precinct is also proposed to be replaced by street drainage networks where suitable.

Table 4-1 – Riparian Corridor Matrix (NRAR, 2018)

Stream order	Vegetated riparian zone(VRZ)	RC offsetting for non-RC users	Cycleways and paths	Detention basins		Stormwater outlet structures and essential services	Stream realignment	Road crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1st	10 m	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
2nd	20 m	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No
3rd	30 m	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes
4th	40 m	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes

5. WATER QUALITY ASSESSMENT

The stormwater quality analysis for this study was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology which is based at Monash University and was first released in July 2002. Version 6.3 was adopted for this study.

MUSIC modelling provides the following features which are relevant to this assessment:

- Determines the source pollutant loads which are generated from a variety of land uses (i.e. commercial, roads, residential, rural residential, etc.)
- Ability to model the potential nutrient reduction benefits associated with Water Quality devices such as gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems and ponds. MUSIC includes mechanisms which enable stormwater re-use to be used as a treatment technique
- Provides a mechanism to evaluate the attainment of mean annual runoff volume (MARV), pollutant load/concentration reductions and Stream Erosion Index (SEI) assessment.

The proposed WCMS assessed in MUSIC includes a “treatment train” of Water Quality Control devices to treat runoff from the proposed residential development areas prior to discharge to the downstream environment. This indicative “treatment train” includes proprietary vortex style gross pollutant traps and bio-retention raingardens to be located at each development discharge point.

While we note that “end of pipe” solutions are inconsistent with Wollondilly Shire Councils IWMS, the strategy provides limited details on how the new approaches (i.e. centralised road swales with increased infiltration) can be implemented on steep sites (>5%) together with the challenges with delivering the elevated pollutant removal targets using the available treatment approaches. The Appin (Part) Precinct development has used traditional treatment measures to strive toward the elevated water management targets in the IWMS. Further discussion during the rezoning and subsequent DA process will be needed to ensure a constructable and economical water quality solution can be achieved for the Appin (Part) Precinct development.

The adopted water quality objectives for this development are consistent with the Integrated Water Management Strategy (2020). In addition to this, we have also assessed stream erosion index (SEI) and neutral or beneficial effect (NorBE) which are included in the Wilton Growth Area DCP (2021) which provides an indication of the possible (future) West Appin DCP. These objectives and targets are detailed in Section 3.

5.1. Modelling Inputs and Assumptions

The MUSIC model setup has been undertaken consistent with Councils ‘MUSIC Template’ (2020), ‘Integrated Water Management Strategy (2020) and ‘WSUD Guidelines’ (2020) as well as the ‘NSW MUSIC Modelling Guidelines’ (BMT WBM, 2015). For further detail about the modelling inputs and assumptions that have informed the modelling process, please refer to Appendix C.

As the development grading within Appin (Part) Precinct is unknown at this stage, a typical 10 ha low density residential catchment has been modelled to inform the anticipated size of the water sensitive urban design (WSUD) devices. These areas were then split to reflect the anticipated lot, road and open space areas within the typical urban development catchments.

In accordance with the NSW MUSIC Modelling Guidelines (2015), each of these areas has been further defined based on land uses including “Roof”, “Roads,” “Open Space,” “General Urban Impervious” and “General Urban Pervious” which constitute the different source node types in the model. The overall fraction impervious for the typical catchments aligns with those specified in Appendix A of Council’s IWMS (2020).

The existing conditions have been represented in a single 10 ha “agricultural” source node for the purpose of comparing pollutant loads and flows between existing and developed conditions. This catchment has been assigned a conservative fraction impervious value of 0% for the purpose of assessing stream erosion index (SEI) and neutral or beneficial effect (NorBE).

Further details on land use areas, modelling assumptions and parameters are summarised in Appendix C.

An overview of the model layout is shown in Plate 5-1.

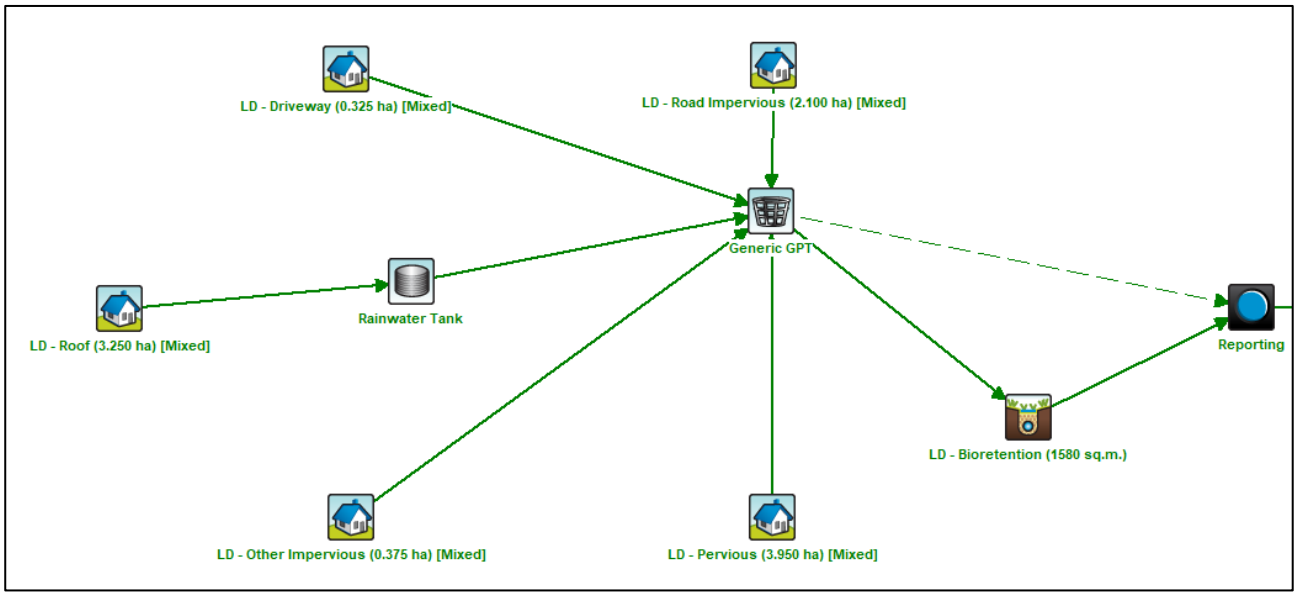


Plate 5-1 – MUSIC Model Layout
(Model Ref: 110628-02 MU02 IWMS.sqz)

5.2. Water Quality Management Measures

It is proposed that stormwater quality in Appin (Part) Precinct be managed using a treatment train approach. The treatment train of water quality devices that has been identified to achieve the water quality targets is as follows:

Residential land uses

- 5 kL rainwater tanks on each residential lot;
- Generic Gross Pollutant Traps (GPT) to pre-treat runoff prior to discharge into bioretention raingardens; and
- Bioretention Raingarden which will receive flows from the GPTs.

Commercial land uses

- For all commercial areas within Appin (Part) Precinct there will be a need for each development lot to deliver water quality management within the lot prior to discharge to the adjoining public road. Each commercial lot will need to account for their portion of the road reserves will need to be compensated for with their treatment measures.

Further details regarding the adopted parameters for Gross Pollutant Trap(s) and Bioretention Raingarden(s) are provided in Appendix C.

It is important to note that this treatment train is only indicative and series of alternate arrangements such as open water bodies/wetlands, swales or proprietary devices for commercial areas, can deliver a similar water quality outcome and would form part of future consideration as the Appin (Part) Precinct develops over the next 5-10 years.

5.3. Modelling Results

Appin (Part) Precinct aims to achieve mean annual runoff volume (MARV) and pollutant load reduction requirements outlined in the WSC IWMS. The MUSIC Model was run using the stochastically generated estimated pollution loads from the source catchments.

5.3.1 MARV and Pollutant Loads

A comparison of the pollutant loads being generated on the site has been made between existing and developed conditions. Total annual pollutant loads being generated by the developed site have been derived from the MUSIC modelling and the pollutant load reductions and mean annual runoff results are presented in Table 5-1 below.

Table 5-1 - Summary of Pollutant Load Reductions for a Typical 10 ha Low-Density Residential Catchment

Pollutant	Total Developed Source Nodes	Total Residual Load from Site	Target Reduction Required	Total Reduction Achieved
	(kg/yr)	(kg/yr)	(%)	(%)
Total Suspended Solids	9200	949	95.0%	89.7%
Total Phosphorus	18.1	4	95.0%	78.5%
Total Nitrogen	129	39	85.0%	69.8%
Gross Pollutants	1240	3	90.0%	99.8%
MARV Results				
Flow (ML/yr)	32.3			
Flow Target (ML/yr/ha)	2.5 to 3.0			
Flow (ML/yr/ha)	3.23			
Raingarden Sizing				
Filter Area (m²)	1,580			
Pipe Flow (ML/yr)	21.96			
Hydraulic Loading Rate (m³/m²/yr)	13.90			

The results show that the pollutant reduction targets outlined in the IWMS are not achieved, however, it is noted that the results far exceed the typical statutory pollutant reductions which are widely accepted across the state. Many iterations of the water quality modelling have been undertaken with increasing treatment train sizes and it has shown that the target reductions from the IWMS cannot be achieved. The mean annual runoff volume (MARV) which has been achieved is 3.23 ML/yr/ha which is slightly greater than the IWMS targets of 2.5 to 3.0, however, is considered to be a suitable outcome, especially considering that neutral or beneficial effect (NorBE) targets are being achieved for the site. The resulting raingarden sizing for a typical 10 ha catchment is 1,580 m² or 1.58% of the contributing catchment.

5.3.2 NorBE

Neutral or beneficial effect (NorBE) forms part of the water quality targets in the Wilton Growth Area DCP (2021). An assessment of the NorBE outcomes achieved by the proposed Appin (Part) Precinct treatment train has been undertaken.

Pollutant Loads

A comparison of the pollutant loads being generated on the site has been made between existing and developed conditions. A summary of the mean annual pollutant load for existing and developed conditions are shown below in Table 5-3 for a typical 10 ha Low Density Residential catchment.

Table 5-2 – NorBE Pollutant Load Comparison

Pollutant	Mean Existing Source Loads	Mean Developed Source Loads	Target Reduction Required	Total Reduction Achieved
	(kg/yr)	(kg/yr)	(%)	(%)
Total Suspended Solids	4540	949	≥10%	79.1%
Total Phosphorus	17.9	4	≥10%	78.2%
Total Nitrogen	87.8	39	≥10%	55.7%

Pollutant Concentrations

A comparison of the pollutant concentrations has also been undertaken in accordance with the requirements of a NorBE assessment. A NorBE assessment requires pollutant concentrations for TP and TN in the post-development case to be equal to or less than the pollutant concentrations for the pre-development case within the 50th to 98th percentile range when runoff occurs.

The pollutant concentration reductions are shown in Plate 5-2 for total phosphorus and Plate 5-3 for total nitrogen. The graphs show that reductions are achieved for both nutrients.

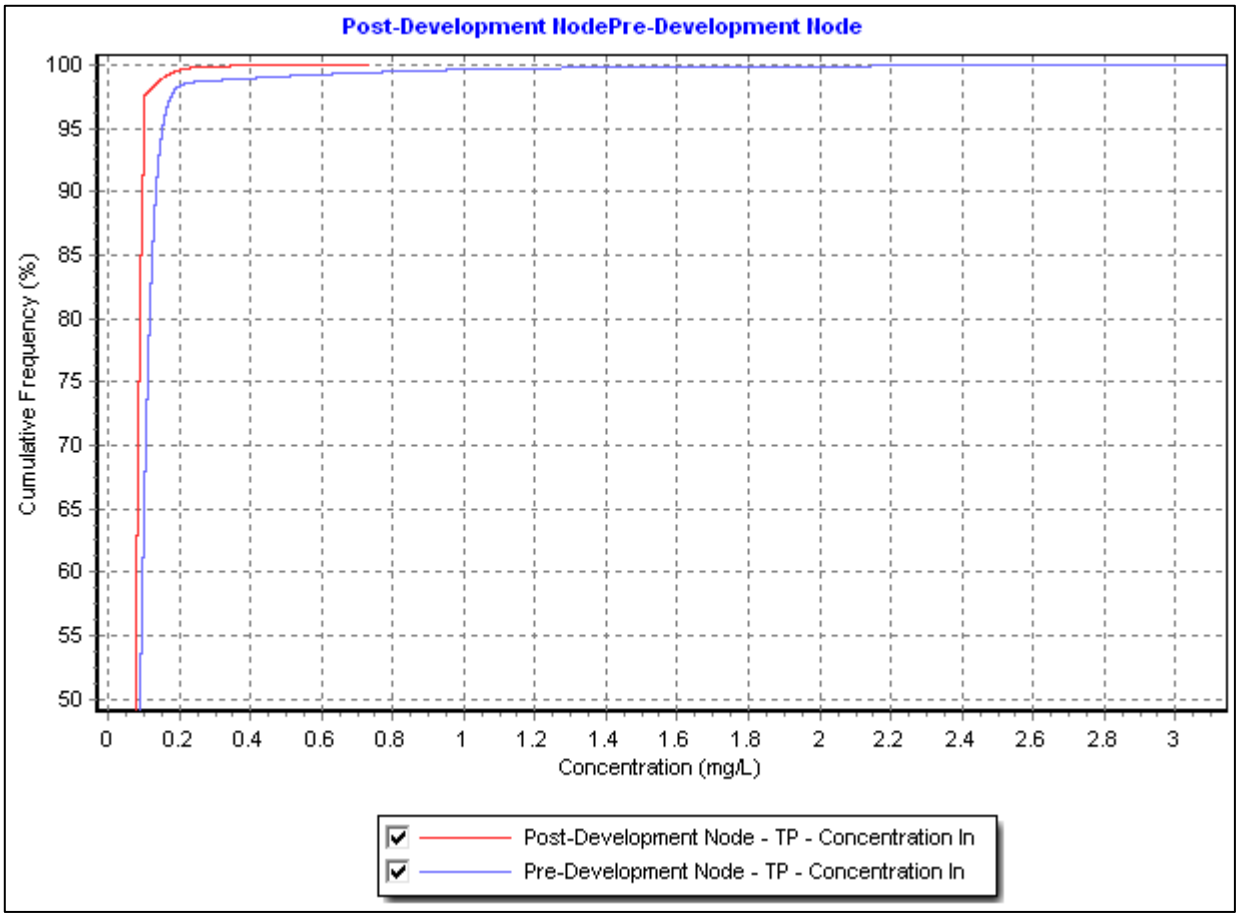


Plate 5-2 – Total Phosphorus – Pollutant Concentration Reduction

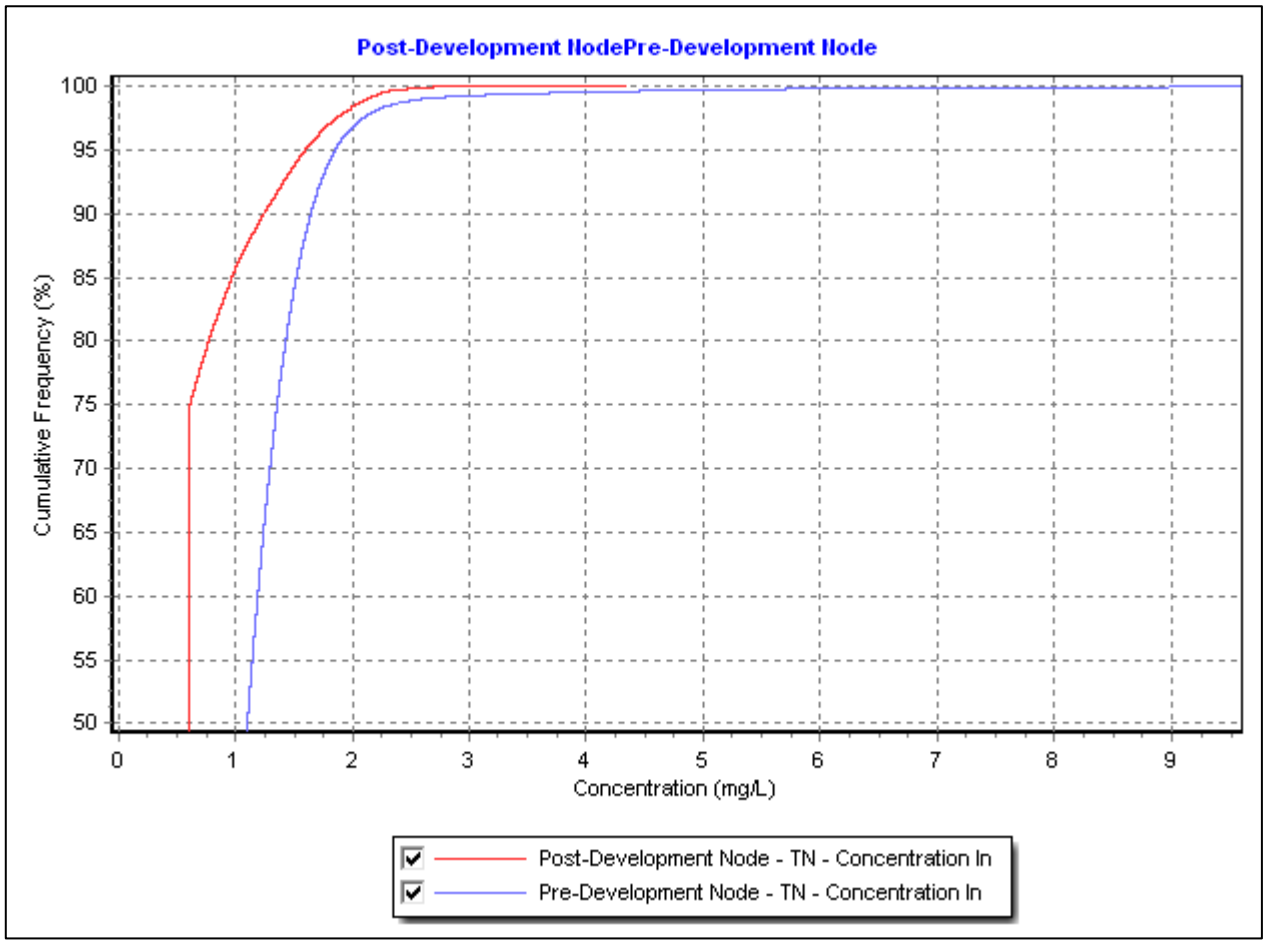


Plate 5-3 – Total Nitrogen – Pollutant Concentration Reduction

5.3.3 Results Discussion

An important part of this WCM Strategy involves the design of stormwater treatment systems that ensures the runoff from the urban development does not result in the pollution of the natural watercourse downstream. Nutrients such as Nitrogen and Phosphorus are potentially harmful pollutants to flora and fauna in natural ecosystems.

Significant reductions will be seen in the pollutants that are discharged to the natural streams due to the stringent water quality targets that have been adopted in this WCMS. The results of the water quality assessment shows that while the targets outlined in Council's Integrated Water Management Strategy (IWMS) have not been achieved, a solution has been provided that protects the pristine waterways by ensuring a significant reduction in the existing pollutants discharging to the downstream environment. This outcome is highlighted by the neutral or beneficial effect that has been achieved in the water quality solution which aligns with the objectives of Councils Integrated Water Management Policy (IWMP).

It is important to note that the NorBE targets which will also be achieved at Appin (Part) Precinct which are normally applied to catchments discharging to the Sydney Drinking Water Catchment. NorBE targets are more stringent than the typical objectives of other growth areas in NSW (such as the North West and South West Growth Centres) and current standard industry practice (TN 45%, TP 65% and TSS 85%). The typical targets for water quality in these areas generally involve achieving a pollutant load reduction from the developed catchment (without consideration of the existing loads). Therefore, the pollutant load removal and pollutant concentration reduction that will be achieved in Appin (Part) Precinct exceeds the standards of most developments across NSW and will result in a net reduction in pollutant impacts to the natural systems downstream of the site compared to the current land uses. This is aligned with the objectives outlined in Councils Integrated Water Management Policy.

5.3.4 Rainwater Tank Demand

It is understood that the water servicing strategy for Appin (Part) Precinct may include a recycled water scheme (purple pipe) to low-density residential dwellings. It is anticipated purple pipes can be delivered in conjunction with the rainwater tanks and fill the reuse demand not met by the rainwater tanks alone.

The rainwater tank supply and demand for the residential catchment modelled in the MUSIC model is summarised in Table 5-3.

Table 5-3 – Rainwater Tanks Supply and Demand

	ML/yr	L/day/dwelling
Reuse Supplied	17.7	224
Reuse Requested	70.9	896
Shortfall (potable demand)	53.2	672
% Reuse Demand Met	25.0%	
% Reuse Demand Not Met	75.0%	

Table 5-2 shows that there is a 75% (53.2 ML/yr) shortfall of the available stormwater that could be reused for a typical 10 ha residential catchment. This means that there is an opportunity for Sydney Water's recycled water scheme to supply residential dwellings with an alternate water supply in order to meet the demands of households across the precinct and achieve a combined use system.

5.4. Stream Erosion Index

A Stream Erosion Index (SEI) assessment has been undertaken to ensure that the indicative treatment reduces the duration of post-development stream forming flows to no greater than the duration of pre-development stream forming flows. This is another requirement set out in the Draft Wilton Growth Area DCP (2020) which gives a potential indication of the future development controls which may pertain to this rezoning. The target specified in the Draft Wilton Growth Area DCP is 1.0.

The modelling setup to assess the SEI has remained consistent with the assumptions and parameters that are outlined in Section 5.1.

The MUSIC modelling guidelines require the stream forming flow for the site to be determined using either the Probabilistic Rational Method (PRM) or Flood Frequency Analysis. As there are no stream gauge records available for Appin (Part) Precinct, the PRM method has been adopted. We note that the Rational method is no longer considered valid under the Australian Rainfall and Runoff (ARR 2016) guideline, however, we have utilised this method in accordance with Council's Design Specifications (2016) as the modelled catchments are classified as 'relatively small (approximately 10 ha)'.

The SEI for the typical catchment has been assessed against a range of downstream environment conditions. Specifically, the impacts of urbanisation on different soil types in the receiving creeks have been assessed. Given that the downstream conditions of all the receiving creeks are unknown at this stage, the SEI has considered the various soil conditions and the stream forming flow magnitudes (critical flows) for each soil type. The critical flows have been adopted in accordance with the NSW MUSIC Modelling Guidelines (2015). At the future DA stage, the receiving environments will be subject to separate and detailed environmental/ecological investigations to determine the sensitivity of the creek systems that the development will discharge to.

A summary table of the SEI assessment and results is provided in Table 5-4 and Table 5-5, respectively.

Table 5-4 – SEI Calculations

			Determination of Critical Flow					
Catchment	**Soil Type**	**Critical Flow**	**Area (km^2)**	**t_c (minutes)**	**I_2 (mm/hr)**	**C_2**	**Q_2 (m^3/s)**	**Q_{crit} (m^3/s)**
Low Density	Silty clays	25% of 2 year ARI flow	0.10	15	76.1	0.444	0.94	0.23
Low Density	Medium-heavy clays	50% of 2 year ARI flow	0.10	15	76.1	0.444	0.94	0.47
Low Density	Bedrock (assumed)	100% of 2 year ARI flow	0.10	15	76.1	0.444	0.94	0.94

Table 5-5 – SEI Results

			Stream Erosion Index		
Catchment	**Soil Type**	**Critical Flow**	**Pre Dev Outflow (ML/yr)**	**Post Dev Outflow (ML/yr)**	**SEI**
Low Density	Silty clays	25% of 2 year ARI flow	7.11	4.41	0.62
Low Density	Medium-heavy clays	50% of 2 year ARI flow	3.28	1.76	0.54
Low Density	Bedrock (assumed)	100% of 2 year ARI flow	0.82	0.36	0.44

The SEI results indicate that the proposed stormwater quality treatment train will ensure that the duration of post development stream forming flows would be no greater than the duration of existing conditions stream forming flows which is a requirement specified in the Wilton Growth Area DCP (2021). This is true for the various soil types that are likely to be present across the site. Notwithstanding this assessment, all development applications should undertake an SEI assessment at the design stage to confirm that the statutory SEI requirements are achieved for the specific site conditions.

5.5. Construction Stage

Erosion and sediment control measures across the site are an essential component that must be implemented during the construction phase in accordance with the requirements of Council and the guidelines set out in the "Blue Book" (2004).

The indicative treatment train for Appin (Part) Precinct includes 'bio-retention' (raingarden) water quality treatment systems which are sensitive to the impact of sedimentation. Thus, it is recommended that construction phase controls should generally be maintained until the majority of site building works (approximately 80% of the catchment) are complete to ensure the longevity of the devices.

5.6. Long Term Management

Regular maintenance of the stormwater quality treatment devices is required to control weeds, remove rubbish and monitor plant establishment and health (for raingardens). Some sediment build-up may occur on the surface of the raingardens and may require removal to maintain the high standard of stormwater treatment. Regular management and maintenance of the water quality control systems will ensure long-term, functional stormwater treatment. It is strongly recommended that a site-specific Operation and Maintenance (O & M) Manual is prepared for the system as part of future Development Applications. The O & M manual will provide information on the Best Management Practices (BMP's) for the long-term operation of the treatment devices. The manual will provide site-specific management procedures for:

- Maintenance of the GPT structures including rubbish and sediment removal;
- Management of the raingarden including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal); and
- Indicative costing of maintenance over the life of the device.

6. WATER QUANTITY ASSESSMENT

The hydrologic analyses for the Appin (Part) Precinct rezoning was undertaken using AR&R 2019 methodologies within XP-RAFTS hydrologic modelling software. XP-RAFTS is a non-linear runoff routing model that generates runoff hydrographs from rainfall data. The objective of the hydrologic analysis was to assess the peak existing and post-development flows at key locations to determine whether detention management is needed to ensure no flow impacts occur in the adjoining major water courses.

Sub catchments have been delineated to assess the broad 1270 km² Nepean River catchment to which the Precinct discharges. Figure 6-1 in Appendix B provides an illustration of the broader Nepean River catchment. XP-RAFTS models have been created to represent both “Existing” and “Developed” site conditions for a range of storm events.

Our approach as part of this Precinct planning process is to ‘book end’ the assessment requirements by reporting flows in the 0.5 EY and 1% AEP storm events. A series of key locations have been identified in order to assess the potential impacts of developing the Precinct. Details of the key locations located across the Precinct are shown in Plate 6-1 below.

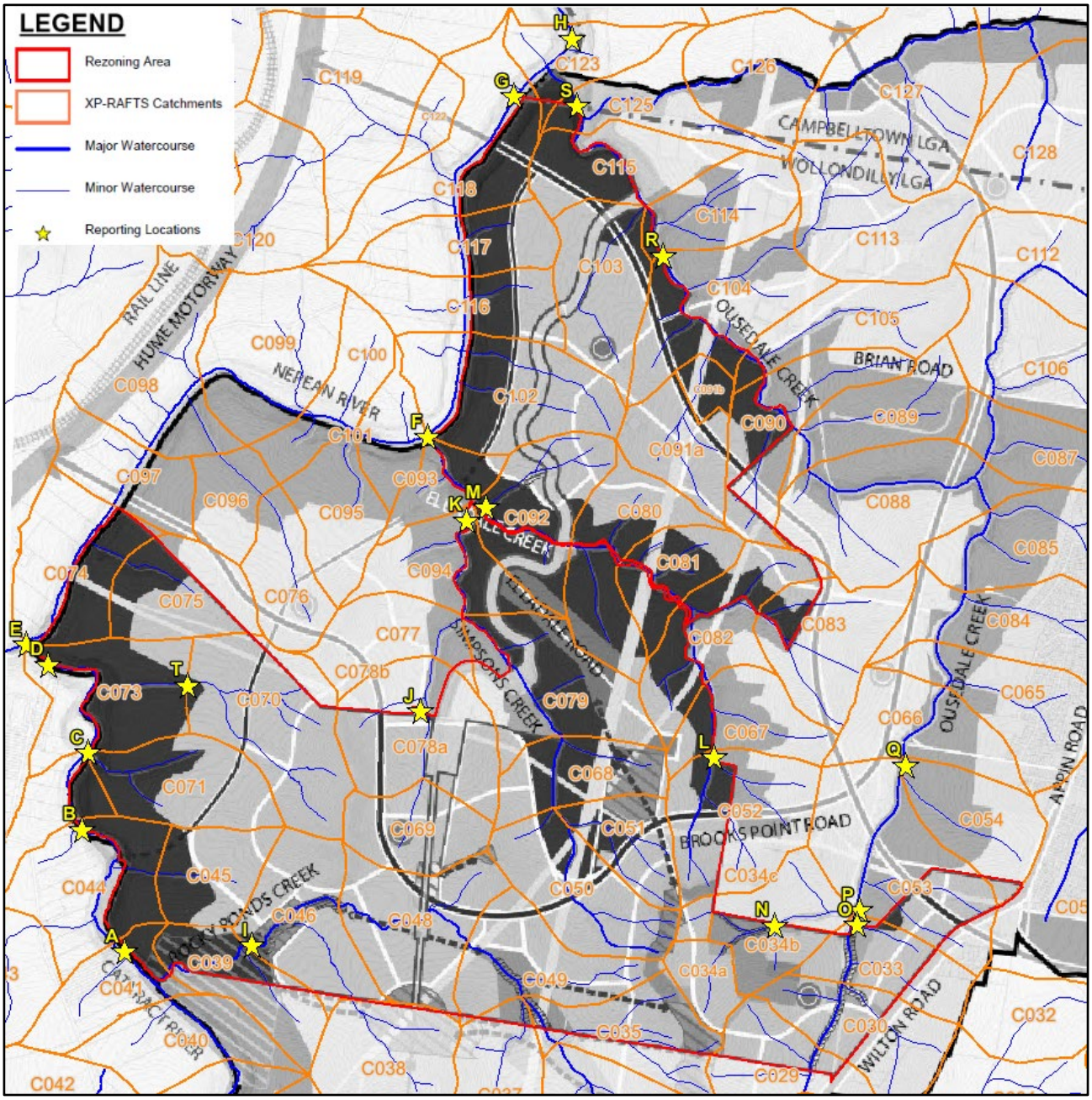


Plate 6-1 – XP-RAFTS Catchments and Reporting Locations

6.1. Existing Site Conditions

An existing conditions XP-RAFTS model has been prepared to assess the 'base conditions' within the catchment. Sub-catchments for existing site conditions have been derived from LiDar information obtained from NSW Government Spatial Services (surveyed in 2019). The model has been built with consideration of Councils Design Specifications (2016) and other similar neighbouring projects.

Figure 6-2 in Appendix B provides an illustration of the catchments in the locality of the Appin (Part) Precinct. The majority of the reporting locations are situated at the edge of Appin (Part) Precinct rezoning area in order to assess the specific impact (if any) of this future development.

A summary of the parameters that have been adopted in the modelling are provided below:

- Rainfall data for the catchment has been sourced from the AR&R Data Hub (Oct 2019). Point data was obtained for the centroid of the total catchment to be applied in the model. Pre burst rainfall was also included to reflect antecedent rainfall in the catchment. Details of the AR&R Data Hub information is provided in Appendix D.
- The losses adopted are consistent with the reconciled losses as determined through a flood frequency analysis in the 'Review of ARR Design Inputs for NSW' prepared by WMA Water 2019. This study assessed several catchments across NSW including the upper reaches of the Nepean River which form part of the broader catchment of this WCMS. The pervious losses specified in this study have been adopted for this assessment.

  The initial and continuing loss for the impervious portions of the catchment have been adopted based on the requirements set out in Councils Design Specifications.

  A summary of the adopted loss values are shown in Table 6-1.

Table 6-1 – Adopted Initial / Continuing Losses

Catchment Condition	Value
Pervious	
Initial Loss	29.5 mm
Continuing Loss	4.8 mm/hr
Impervious	
Initial Loss	1 mm
Continuing Loss	0 mm/hr

- The Manning's roughness coefficients adopted for the site are shown in Table 6-2.

Table 6-2 – Adopted Manning's Coefficients

Catchment Condition	Adopted PERN Value
Urban Impervious	0.015
Urban Pervious	0.025
Open Space Pervious	0.035
Rural Pervious	0.045
Bushland Pervious	0.1

- All areas, slopes and fraction impervious have been measured digitally based on LiDAR survey data and aerial imagery.
- All time lagging links are assumed to have an average velocity of 1 m/s.

6.1.1 Existing Model Validation

The existing model has been validated as a means of providing confidence in the accuracy of the assessment. A stream gauge exists on the Nepean River ("Nepean River at Wallacia") which has recorded flow data over extended 43-year period. The context of the location of the stream gauge can be seen in Plate 6-2.

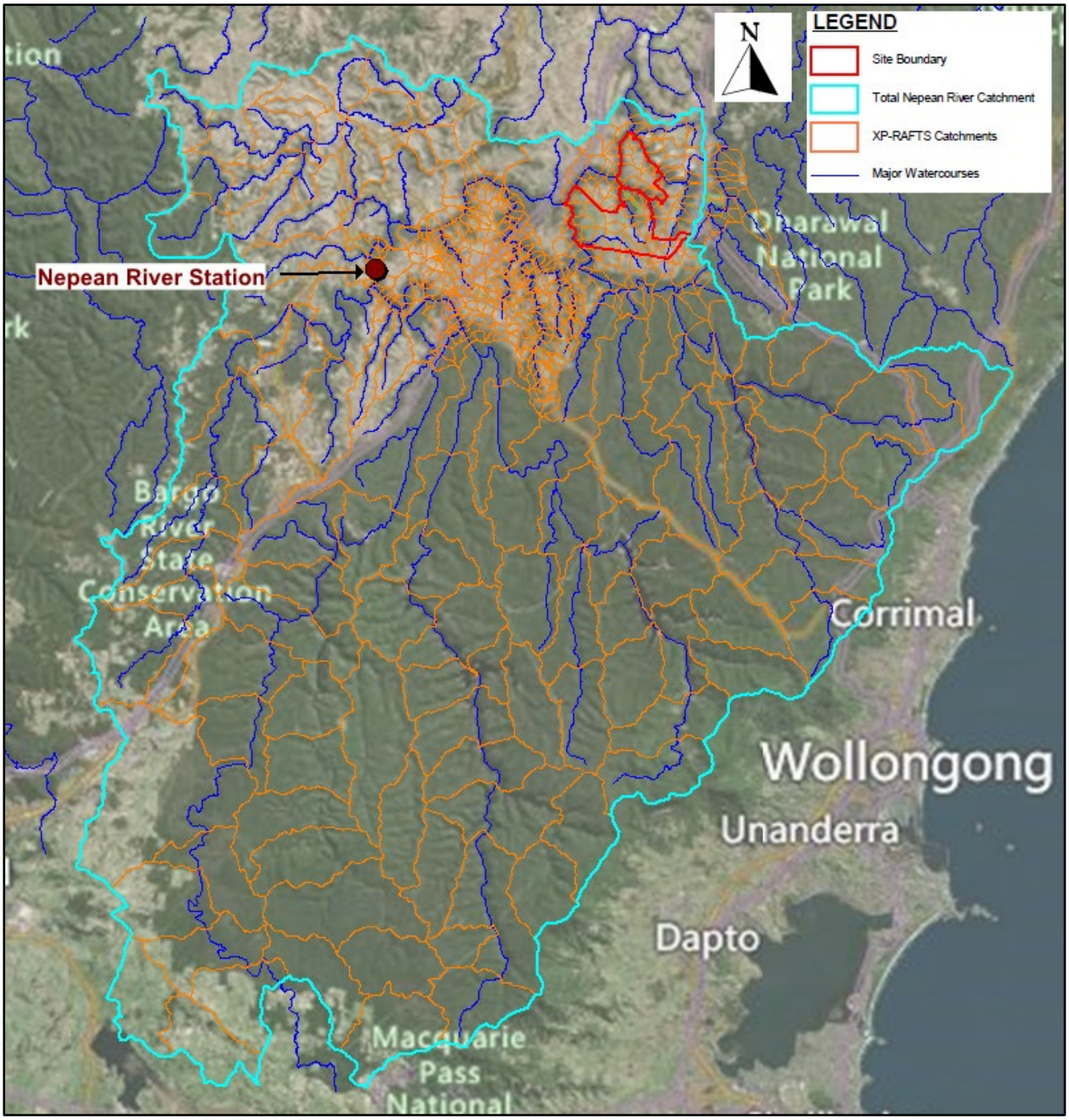


Plate 6-2 – Nepean River Station (Stream Gauge) Locality

Flood frequency analysis (FFA) has been undertaken at various rainfall gauges across NSW as a part of the Australian Rainfall and Runoff Revision Project 5: Regional Flood Methods (Rahman et al. 2015) including at the Nepean River station. Measured flows at this location are reported in the 'Review of ARR Design Inputs for NSW' (WMA Water 2019) which have been verified with flood frequency analysis. Table 6-3 below shows the flow tables from the study which have been calibrated to for this modelling. Plate 6-3 graphically illustrates the flow estimates.

Table 6-3 – Flood Frequency Analysis and Design Flood Estimates

Table C1 Metadata and at-site flood frequency estimates for water level gauges used in this study

Station	Station Number	Station Name	Station Longitude	Station Latitude	Length of record (years)	AMS	Peak Flow (m^3/s)					
							50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
NEPEAN	NEPEAN	Nepean River at Wallacia	150.4177	-34.1363	43	43	273	983	1525	2106	2958	3680

Table C2 Metadata and flood frequency estimates associated with the application of the standard ARR 2016 method for catchments investigated in this study

Station	Catchment Centroid Longitude	Catchment Centroid Latitude	Catchment Area (km^2)	Shape Factor	Peak Flow (m^3/s)					
					50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Nepean	150.6611	-34.3485	1247	0.92	324	1023	1611	2243	3044	3636

Table C3 Metadata and design flood estimates associated with the FFA-Reconciled Losses method for catchments investigated in this study with good quality At-site FFA fits

Station	Fit Quality	Critical Duration 10% AEP (hr)	IL (mm)	CL (mm/hr)	Peak Flow (m^3/s)					
					50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
Nepean	Good	1080	30	4.8	354	984	1526	2106	2864	3446

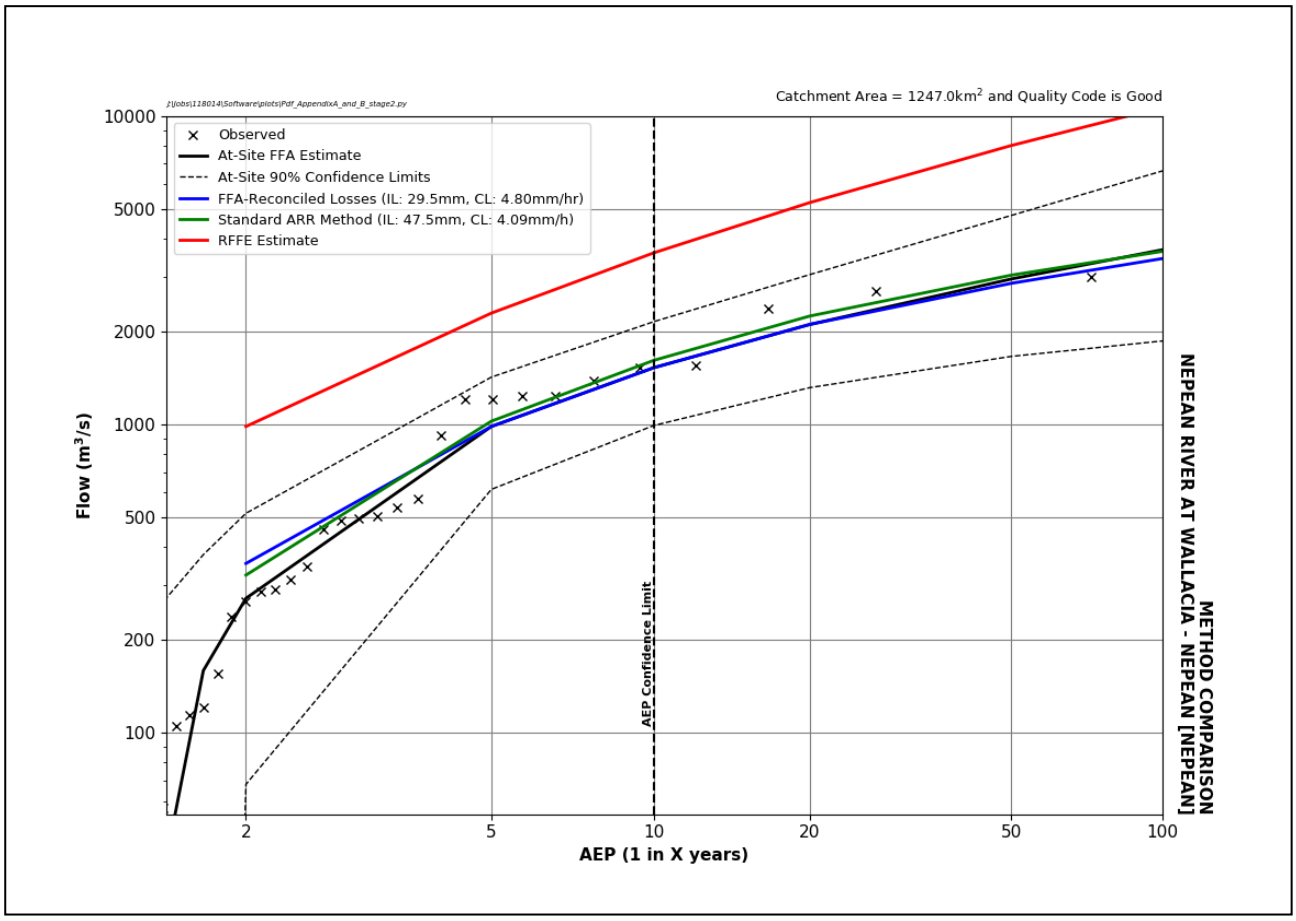


Plate 6-3 – Flood Frequency Analysis and Flow Estimates

The calibration factor (Bx) in XP-RAFTS has been adjusted to ensure the design flood estimates outlined in the WMA Water study are replicated in this modelling. A sub catchment near to the station was selected and the Bx factor was iterated until a flow value similar to those presented in Table 6-3 were achieved. It was found that a Bx factor of 2.5 was required to achieve a flow of 3692 m³/s in the 1% AEP event at the equivalent comparison node. Details of the various Bx factors tested is illustrated in Plate 6-4 which compares hydrographs recorded in XP-RAFTS with the design flow estimates outlined in Table 6-3.

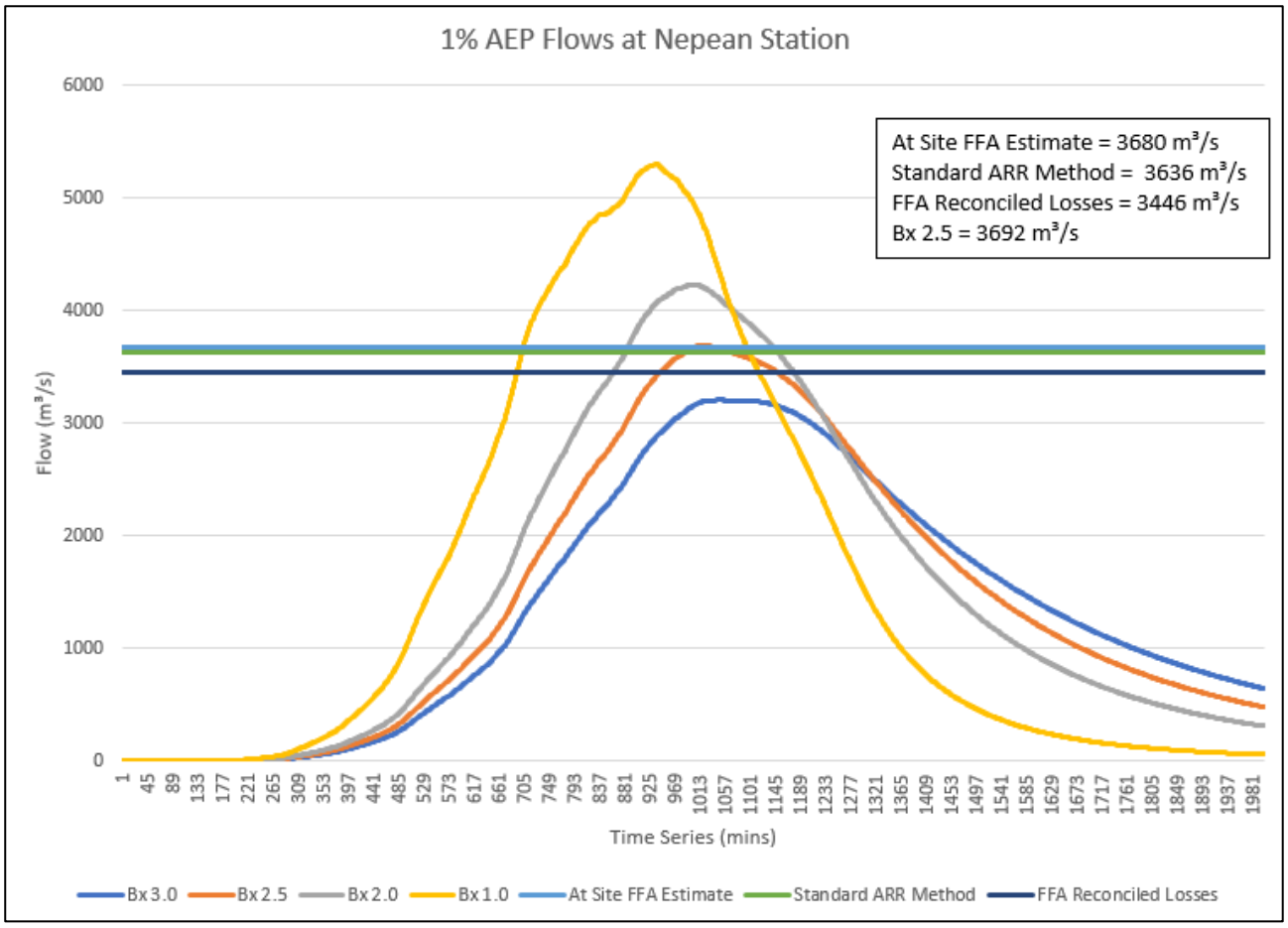


Plate 6-4 – 1% AEP Flow Validation at Nepean Station

A Bx factor of 2.5 is considered to be an appropriate factor to be adopted in the model for both existing and developed conditions in support of this rezoning.

6.2. Developed Site Conditions

A "Developed" site conditions model has been created by updating the existing site conditions model to represent the draft Appin and North Appin Precincts Indicative Plan with the following changes made:

- The existing conditions catchment delineation remained generally unchanged.
- In accordance with Council Design Specifications, fraction impervious values were applied based on the proposed land-use zoning within the draft Appin and North Appin Precincts Indicative Plan. Details of Councils percentage impervious values are shown in Table 6-4.

Table 6-4 – Fraction Impervious Values

Landuse	Fraction Impervious
Residential Lot	60%
Road Reserve	70%
Industrial/Commercial	90%
Public Recreation Area	10%

It should be noted that for ease of application the developed conditions modelling a fraction impervious value of 70% has conservatively been adopted to reflect all residential catchments (combining residential lots and road reserves into a single land use). It is anticipated that the fraction impervious for the urban catchments will be closer to 60% in reality which would reduce local discharges from the site.

The fraction impervious for catchments that are partially developed in the Appin and North Appin Precincts Indicative Plan have been proportioned as required.

- Lag links within the riparian corridors and catchment slopes have been maintained as per the existing conditions while lag links through future urban drainage infrastructure has been amended to a velocity of 2 m/s.
- Manning's 'n' of 0.025 and 0.015 has been adopted for pervious and impervious catchment areas respectively within the rezoning area. Partially developed catchments have been proportioned as necessary.

6.1. Results

The existing and developed conditions catchment peak flow for the 0.5 EY and 1% AEP storm events were derived from the XP-RAFTS model. A full range of storm durations and ensemble temporal patterns were assessed for each event. Table 6-5 shows a comparison between "existing" and "developed" condition peak flows at each of the key comparison locations shown in Plate 6-1.

Table 6-5 – Comparison of Existing and Developed Flows (No Detention)

Reporting Node	0.5 EY					1% AEP				
	Ex	Durn	Dev	Durn	Dev/Ex	Ex	Durn	Dev	Durn	Dev/Ex
A	146	12h_5	146	12h_5	1.0	910	12h_1	907	12h_1	1.0
B	147	12h_5	146	12h_5	1.0	912	12h_1	909	12h_1	1.0
C	147	12h_5	147	12h_5	1.0	913	12h_10	909	12h_1	1.0
D	147	12h_5	147	12h_5	1.0	913	12h_10	910	12h_1	1.0
E	915	12h_1	914	12h_1	1.0	5320	12h_10	5316	12h_1	1.0
F	916	12h_1	915	12h_1	1.0	5321	12h_10	5319	12h_1	1.0
G	917	12h_1	916	12h_1	1.0	5321	12h_10	5320	12h_10	1.0
H	919	12h_1	918	12h_1	1.0	5324	12h_10	5322	12h_10	1.0
I	14.0	4.5h_1	17.3	4.5h_1	1.2	57.2	12h_6	61.1	12h_6	1.1
J	3.70	4.5h_1	14.2	10m_10	3.8	14.9	12h_6	40.1	10m_3	2.7
K	14.6	4.5h_1	25.3	20m_3	1.7	58.9	12h_6	72.8	20m_10	1.2
L	2.63	4.5h_1	4.21	10m_1	1.6	10.5	12h_6	12.3	12h_3	1.2
M	13.3	4.5h_1	13.2	6h_8	1.0	53.5	12h_6	54.2	12h_6	1.0
N	1.91	6h_7	5.81	10m_8	3.0	7.94	12h_3	16.03	10m_3	2.0
O	6.88	4.5h_1	9.14	20m_1	1.3	27.3	12h_6	29.5	12h_6	1.1
P	9.80	4.5h_1	14.0	20m_7	1.4	38.9	12h_6	44.4	12h_3	1.1
Q	13.5	4.5h_1	17.1	6h_8	1.3	54.5	12h_6	61.1	12h_6	1.1
R	35.3	4.5h_1	37.4	4.5h_1	1.1	124	12h_2	134	12h_6	1.1
S	47.5	4.5h_1	46.3	4.5h_6	1.0	169	12h_2	172	12h_2	1.0
T	2.93	4.5h_1	15.3	10m_1	5.2	11.6	12h_6	41.4	10m_10	3.6

It is noted that there are some peak flow increases within the local catchments of the site. These local flow increases are generally located within the proposed environmental conservation areas of the precinct. Once these flows reach the main waterways (Nepean and Cataract River), the localised increases are combined with flows from a significant larger catchment and do not result in overall flow increases.

Figure 6-3 in Appendix B provides more detail and context of the reporting locations and flow results.

Given that there is no increase in flows within the major watercourses (Nepean and Cataract River), a merit-based detention approach is considered suitable for further investigation as the staged delivery of the Precinct occurs.

6.2. Merit Based Detention Approach

The detention basin approach for the rezoning area will involve a merit-based approach in applying detention to the urbanised catchments of the site. The hydrologic assessment (Table 6-5) for the site demonstrates that the urbanisation of the precinct does not have a reportable flow impact in the receiving rivers. However, due to the localised increases that will occur within the rezoning site (mostly within the environmental conservation areas) it is proposed that a considered investigation is undertaken during the future detailed design phase to determine the level of sensitivity in the receiving environments.

All detention approaches will include integrated WSUD devices located locally throughout the catchment. Mean annual runoff volume (MARV) targets will be achieved by the use of management devices to ensure that frequent runoff discharging to the downstream environment is managed to suitable levels. Similarly, stream forming flows have been assessed and managed to suitable levels by the proposed WSUD devices to ensure that the risk of stream erosion is not increased as a result of urbanisation.

The detention strategy for the future release areas will consist of one of the following strategies which will aim at providing a suitable outcome for the catchment conditions rather than a blanket approach for all areas. The different approaches that are proposed across Appin (Part) Precinct are as follows:

6.2.1 Detention Management Required (Business as Usual)

- **Full detention**

This approach will follow a standard Business as Usual (BAU) detention approach. Detentions basins sized to attenuate all flows up to and including the 1% AEP peak flows to existing levels. Suitable flow distribution systems to be incorporated at the outlets (level spreaders) to ensure that flows are not concentrated as a result of development. This approach will be aimed at attenuating peak flows for catchments which discharge to well established and sensitive riparian corridors which are likely to also be higher order streams (i.e. third order and greater). These corridors will typically display signs of instability in the bed and banks of the creeks. There is opportunity to incorporate permanent ponds in the detention basins to assist with the urban heat island impacts of the development.

- **Partial detention**

This approach will deliver a partial detention approach which will see detention basins sized to attenuate the more frequent events (i.e. 0.5 EY) peak flows to existing levels. Peak flows in excess of the 0.5 EY event will overtop the management devices via a suitably sized weir or similar. Developed flows in excess of the 0.5 EY will locally exceed existing condition flows.

Catchments requiring partial detention will be identified as more detailed modelling is prepared for each future release area.

6.2.2 No Detention Approach

The geomorphology for the majority of watercourses and gorges within the Appin (Part) Precinct site have generally evolved into the stream bed being founded in hard rock. These areas are currently stable and are not readily eroded in peak storm events. Many of the existing minor creeks on the site are characterised by shale landscape and are unlikely to be impacted by a change in flow conditions described in Table 6-5. For these areas of the catchment that have the ability to cater for the local peak flows a “no detention” approach is recommended.

Velocity increases that may occur as a result of development can be suitably managed by incorporating flow dissipators and scour protection at the discharge points of all WSUD elements into the future conservation areas. This will ensure that flows from the contributing urban catchments are not concentrated at the discharge locations, and instead, sheet flows are evenly distributed to the downstream environment, replicating natural conditions and promoting seepage of flows into the conservation lands. Formal bush regeneration will be incorporated into the future stewardship sites (i.e. E2 zones) to assist with velocity and flow management and enhance the health of these portions of the site. These measures will alleviate the risk of damage to the ecology that exists in the local creeks and ensure the long-term protection of the watercourses.

This approach will be proposed for development catchments which discharge to poorly established riparian areas with limited sensitive vegetation and having stable stream bed and banks which are unlikely to be susceptible to erosion (e.g. watercourses with rock outcrops).

6.2.3 Ecology Assessment

Part of the merit base approach will include a detailed ecological assessment to determine at the detailed design stage of each future release area, to determine:

- If riparian function is evident in the downstream environment
- If there is existing sensitive ecology and habitats that will need to be protected
- Detailed assessment of the impact of localised flow increases on any existing ecology.

Table 6-6 outlines the different detention approaches that are intended to be applied to each stage of the rezoning area.

Table 6-6 – Detention Management Approach Matrix

Watercourse Order (Strahler)	Sensitive Habitat / Vegetation Downstream	Existing Stream Condition	Management Approach
1st order	Yes	Stable, bedrock foundation	No detention
		Unstable	Detention required (BAU)
	No	Stable, bedrock foundation	No detention
		Unstable	Further assessment required. Partial Detention Likely
2nd order	Yes	Stable, bedrock foundation	Further assessment required. Partial Detention Likely
		Unstable	Detention required (BAU)
	No	Stable, bedrock foundation	No detention
		Unstable	Further assessment required. Partial Detention Likely
3rd order	Yes	Stable, bedrock foundation	Further assessment required. Partial Detention Likely
		Unstable	Detention required (BAU)
	No	Stable, bedrock foundation	No detention
		Unstable	Further assessment required. Partial Detention Likely

The impacts that flow change may have on the local ecology are further discussed in the following section of the report.

6.3. Application of the Merit Based Detention Approach

A more detailed assessment has been prepared for Appin (Part) Precinct Release Area 1 and 2 to establish an example of the application of the merit-based approach for detention management. Release Area 1 will be the first stage of the Appin (Part) Precinct to be delivered and is situated adjacent to Wilton Road in the south eastern portion of the precinct. Release Area 2 will be the second stage of Appin (Part) Precinct to be delivered and is situated in the north west of the precinct where it is bordered by Ousedale Creek and Nepean River. Refer to Plate 6-5 for details.

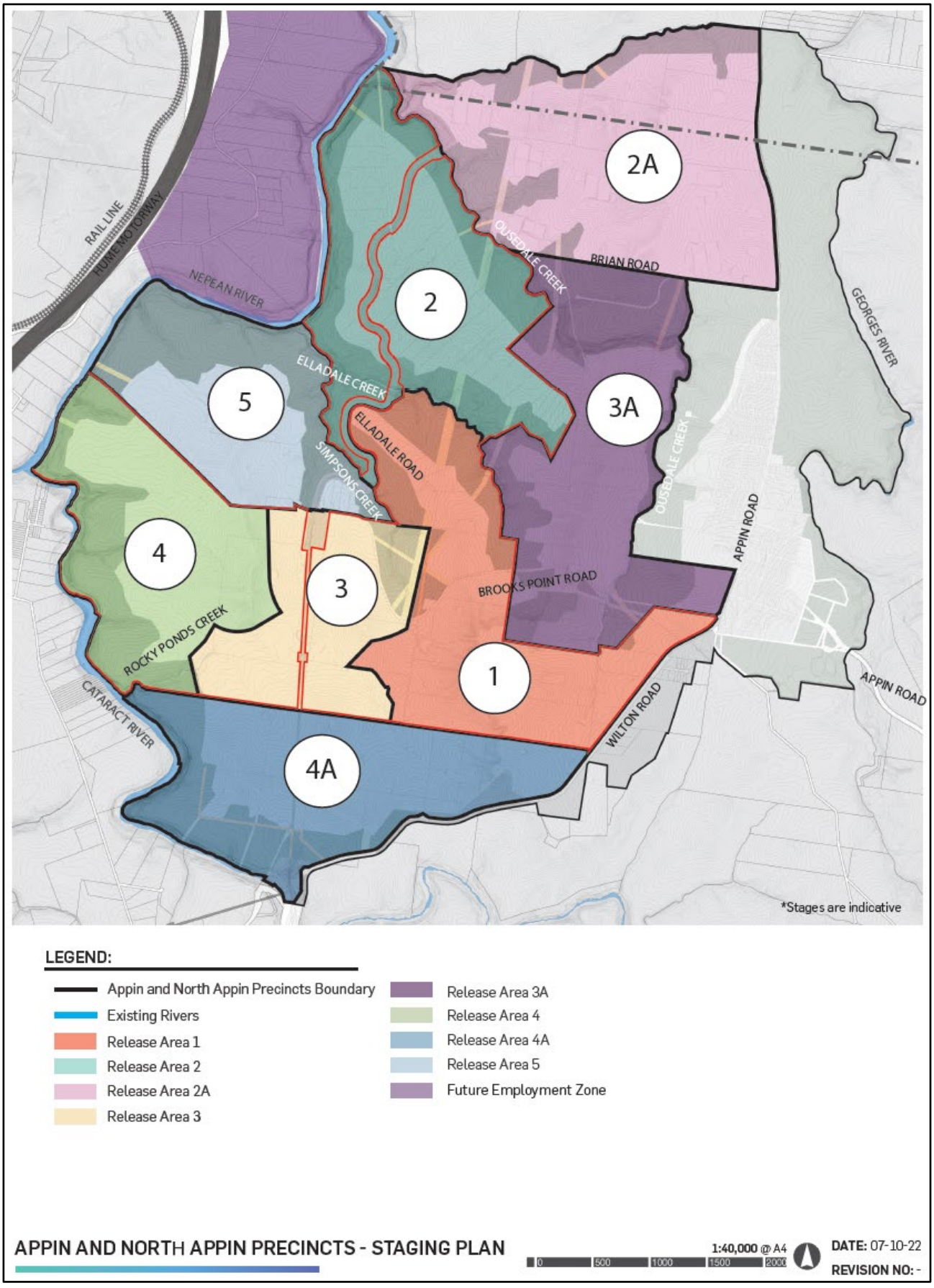


Plate 6-5 – Appin and North Appin Precincts Staging Plan

6.3.1 Appin (Part) Precinct Release Area 1

A large portion of Release Area 1 discharges to Ousedale Creek which is a perennial 3rd order watercourse that is considered to be a well established riparian corridor which are likely to contain sensitive habitats and/or vegetation. Preliminary investigation of the watercourse indicates that the bed and banks are likely to be susceptible to erosion caused by substantial flows. Based on these details and the matrix shown in Table 6-6, the detention management approach for the catchments in Release Area 1 includes full detention management.

Other areas of the release area discharge to environmental conservation areas which contain large gorges and which consist of predominantly hard rock stream bed and banks. These areas are proposed to remain undetained due to this resilient environment existing downstream of the development edge.

A local detention approach has been developed for the eastern draining catchments which discharge to Ousedale Creek in order to achieve pre-post flow management for the 0.5 EY and 1% AEP. This results in six (6) detention basins across Release Area 1. Refer to Figure 6-4 in Appendix B for an illustration of the Release Area 1 detention strategy. This Release Area 1 strategy provides an example of how the implementation of the merit-based approach can still deliver traditional flow management measures where this is a benefit in balancing local impacts with regional flow outcomes.

6.3.2 Appin (Part) Precinct Release Area 2

Release Area 2 discharges to a series of 1st and 2nd order watercourses which primarily drain to Ousedale Creek to the north and Nepean River to the west, with a small portion of the catchment draining to Elladale Creek to the South. Preliminary site investigations have shown that these watercourses are poorly established, with exposed areas of hard rock and minimal riparian vegetation. The watercourse profiles in this area are likely to be more resilient to the infrequent peak flow increases that are likely to occur as a result of urban development. See an example image in Plate 6-6 of one of the watercourses in the northern portion of Release Area 2 which drains to Ousedale Creek.

Plate 6-6 – Exposed Rock Outcrops in Release Area 2 Watercourse

Using the matrix provided in Plate 6-6, it can be determined that Release Area 2 can deliver a no detention approach due to the condition of the receiving watercourses. This is subject to a more detailed site investigation and ecological assessment which will form part of the Release Area 2 detailed design process.

7. ECOLOGY AND HABITAT MANAGEMENT

Given that a merit-based detention strategy is being proposed for the Appin (Part) Precinct, appropriate consideration has been given to the potential impacts this might have on local creeks and tributaries within the site. It has been shown that flows in the major receiving waterways (Cataract and Nepean Rivers) are reduced once the Appin (Part) Precinct is developed, however, local increases are experienced in the network of smaller creek systems within the site if a no detention approach is delivered. The following sections explore how the potential impacts on the ecology and habitat in these intermediate areas (between the development edge and the major rivers) will be managed.

7.1. Peak (Infrequent) Flow Management

The water quantity assessment detailed in Section 6 has found that the development of Appin (Part) Precinct results in a reduction in peak flows in Cataract and Nepean Rivers. This is a common occurrence for developments that are located downstream of a much larger catchment on the same receiving watercourse. The urbanisation (without detention basins) of the local sub-catchments creates a difference in timing of peak flows whereby local peaks from the new development portion occur sooner (due to increased imperviousness) than the peak flows from the larger upstream catchment and enter the watercourse earlier in the storm event.

Conversely, the urbanisation of the local sub-catchments means that local creeks and tributaries within the Precinct experience some increases in peak flows. The context of these increases can be seen in Figure 6-3 in Appendix B. It is expected that these increases in local peak flows will have minimal impact on the ecological and environmental communities that exist in the receiving waterways due to the infrequent nature at which they occur. Future detailed ecological investigations will confirm whether the natural streams will be resilient to the impacts of local peak flow increases (potential damage to flora and fauna habitats) due to the short duration that peaks last for and the likely time that elapses between significant peak events which will allow for the landscape to recover.

7.2. Regular Runoff Management

Formal detention basins are typically designed to attenuate design flows up to and including the 1% AEP storm event. Typically, the 0.5 EY (formerly known as the 2-year ARI) storm event is used as a minor target event as it is generally accepted as the “bank full / stream forming” flows in natural creeks. Attenuation of this minor event was generally aimed at protecting the natural creeks from erosive flow increases as a result of urbanisation. In more recent times the stream erosion index (SEI) has been widely accepted as a measure for the impacts that a development may have on the frequency of regular flows discharging to the riparian corridor or downstream watercourses. This has seen SEI form a part of many DCPs across Growth Centre areas throughout NSW including the Draft Wilton Growth Area DCP (2020) which also uses SEI as a measure of impact.

The SEI method of flow assessment provides a means to determine the increases in frequent “stream forming flows” that have the potential to cause downstream creek erosivity. This method of assessment is therefore seen as a replacement of the need for targeted management of frequent design storm events (such as the 0.5 EY) through attenuation measures such as detention basins. SEI assessments provide a more accurate understanding of the frequent flow regimes in the catchment through the use of real rainfall data measured over 6-minute timestep intervals whereas traditional detention methodologies (hydrological models) target singular storm events based on “design” scenarios and synthetic storm patterns.

The SEI target that has been adopted in the WCMS for the Precinct involves achieving a 1:1 ratio of post development to pre development stream forming flows. This means that the developed catchment stormwater volumes that exceed the stream forming flow within the watercourse will be less than the pre development catchment stormwater volume exceeding the stream forming flow. In other words, the development will not increase the frequency of exceedance of stream forming flow thresholds. This has been tested across various soil types in the receiving waterways to reflect the likely variation of geology in the creek beds and banks as illustrated in Section 5.4.

The SEI target provides a means of ensuring that the ecology in the downstream waterways will be protected from frequent runoff from the proposed urbanisation. The reduced frequency and duration of elevated flows will minimise the stream erosion that occurs in the local creeks thus ensuring the ecosystem downstream are protected by offsetting the urbanisation of the catchment. This is demonstrated in Plate 7-1 below, which compare the existing and developed outflows from a typical (10 ha) catchment, which achieves the adopted SEI target ratio of 1:1. The graph depicts the results of the SEI for the silty clay soil type. The graph shows that considerable decreases in flows occur across the entire rainfall dataset as a result of the SEI target being achieved.

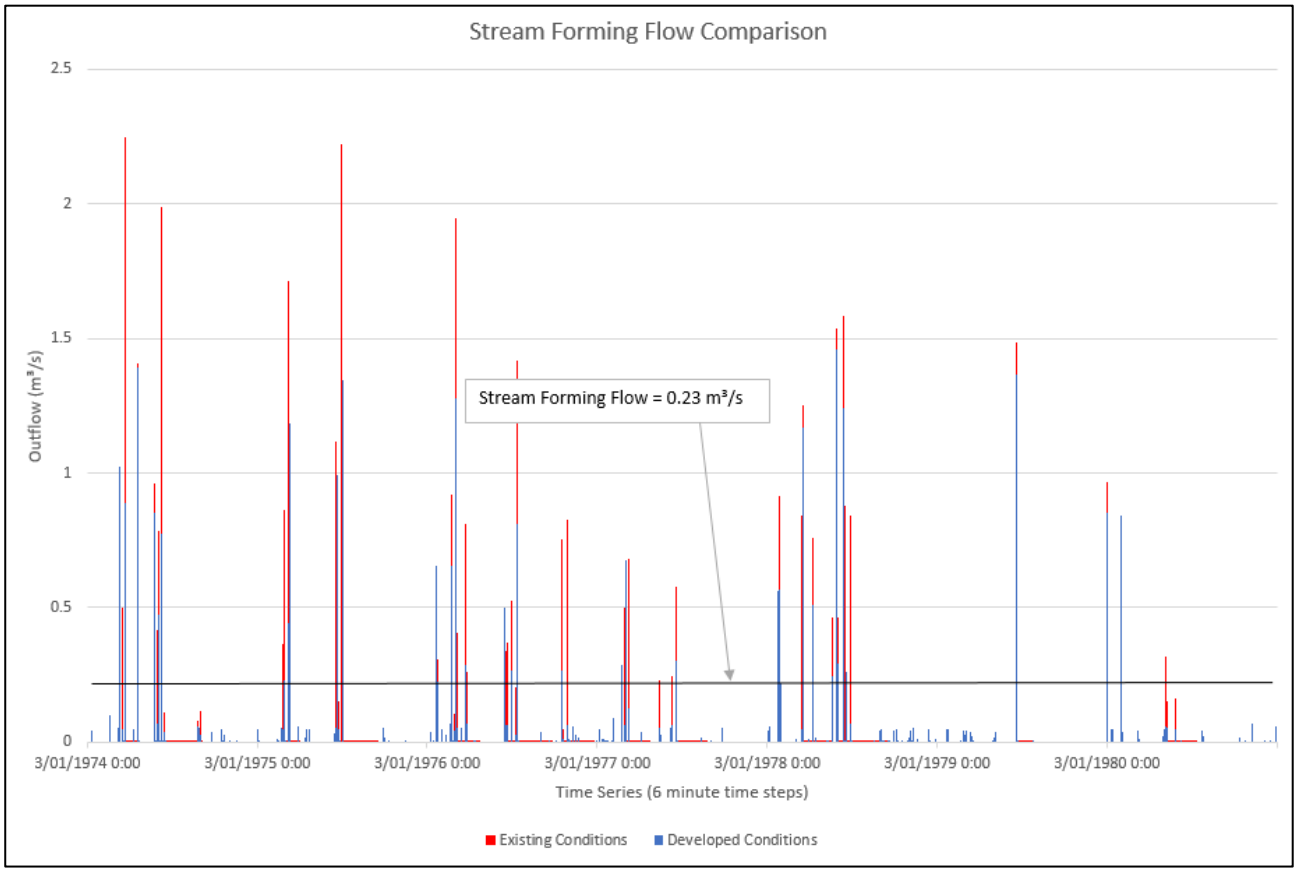


Plate 7-1 – Comparison of Stream Forming Flows (Existing vs Developed)

8. FLOODING

The “Wollondilly Shire Flood Study – Broad Scale Assessment” (the Flood Study) was prepared by Advisian on behalf of Wollondilly Shire Council in October 2021 to provide understanding of the existing flood risk across the LGA. The Flood Study provides a basis from which flood planning controls can be applied to the proposed Appin (Part) Precinct.

The Flood Study assesses a range of flood events including the 10% AEP, 1% AEP, 1 in 500 AEP and PMF. In the vicinity of the Appin (Part) Precinct the flood mapping shows that the flood extents are contained in the well-defined creeks that traverse the site. Wollondilly Shire Council’s flood mapping portal has been used to produce flood maps in the vicinity of the Appin (Part) Precinct. The 1% AEP flood depths are shown in Plate 8-1 and the PMF flood depths are shown in Plate 8-2.

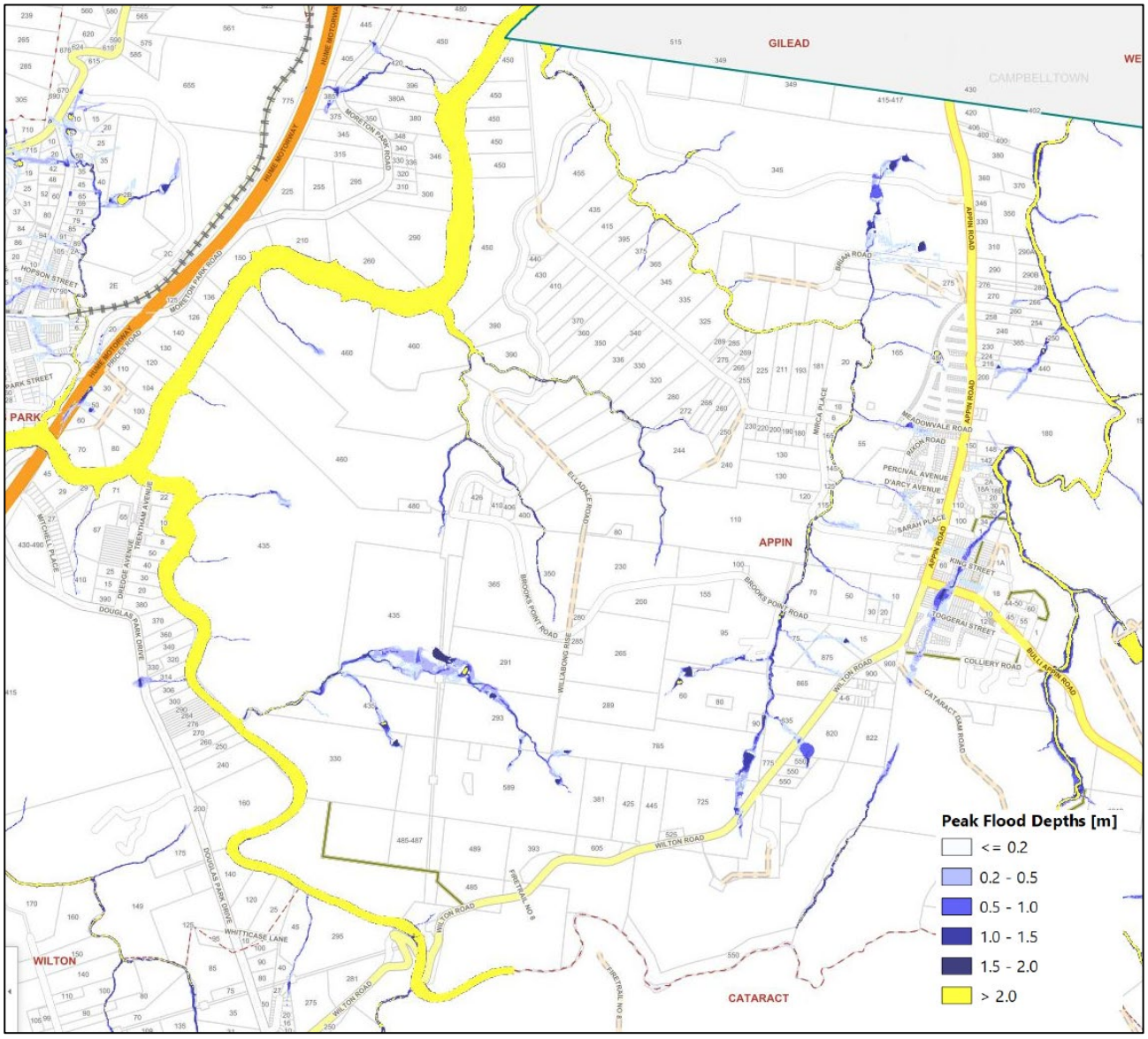


Plate 8-1 – 1% AEP Flood Depth Mapping (Wollondilly Online Mapping System)

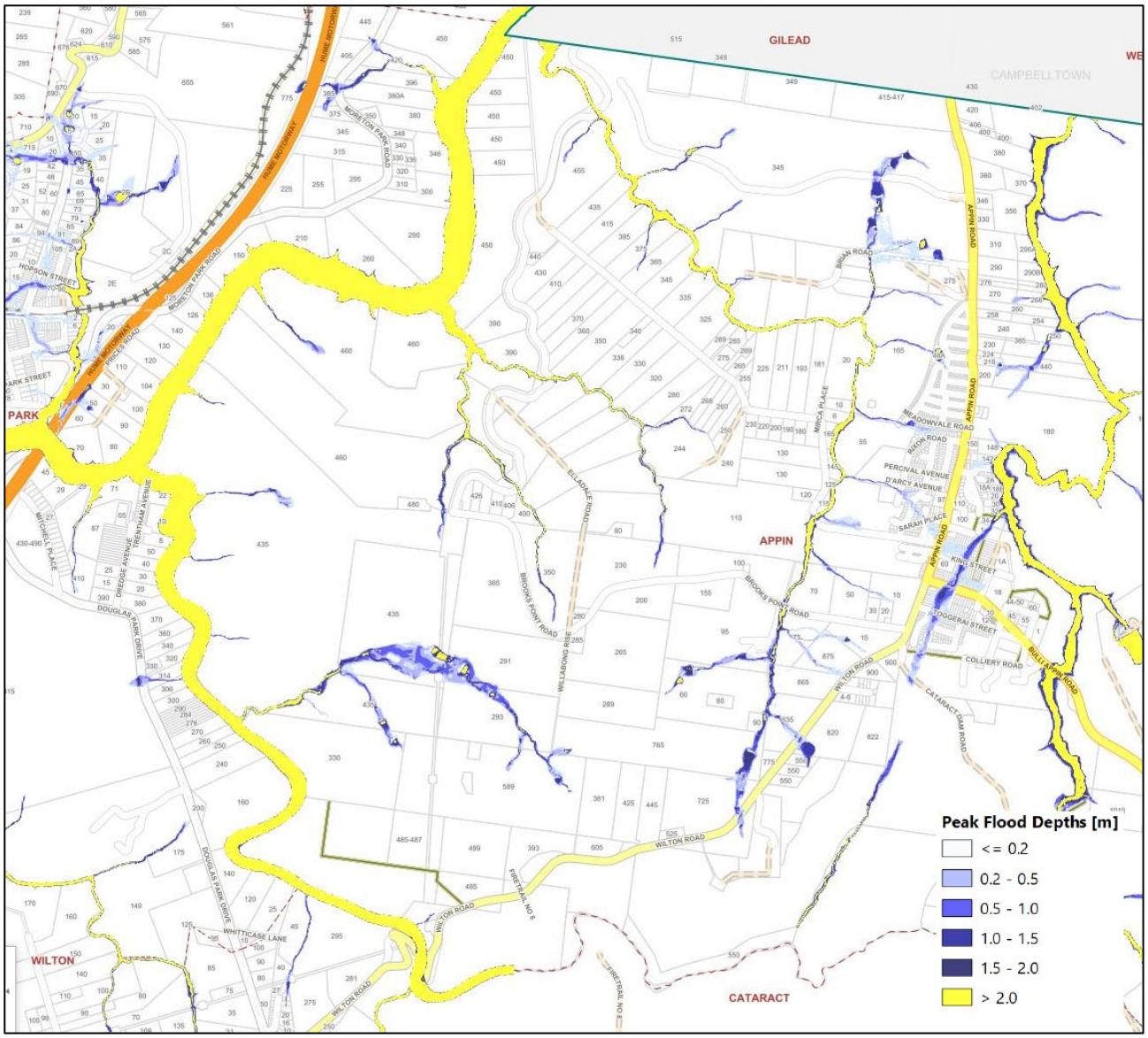


Plate 8-2 – PMF Flood Depth Mapping (Wollondilly Online Mapping System)

The nature of the site comprises numerous short, steep-sided watercourses draining catchments directly to major the watercourses (Nepean River and Cataract River) surrounding the project area. In addition, the Flood Study mapping shows that the majority of flooding within the catchment is contained within the Cataract and Nepean Rivers riparian corridor suggesting that the development on Appin (Part) Precinct will not be impacted during the major flooding event. As such, it was considered that detailed post development hydraulic flood assessment is not required.

We have assessed the catchments across the site in developed conditions and have determined that prior to discharge, most of the catchment areas are likely to be less than 40 ha. However, there are two (2) catchment areas greater than 40 ha, including along Rocky Ponds Creek and Ousedale Creek. Careful consideration will be needed in the detailed design of the road layouts and associated street drainage infrastructure so that these catchments are limited to around 40 ha wherever possible. This will ensure that a traditional road and street drainage system will deliver the safe passage of flood flows to the sites major watercourses. This approach will also ensure that acceptable size and cost of pipe infrastructure can be delivered and that trunk drainage reserves are avoided.

The increases that are likely to be experienced in peak flows from the Appin (Part) Precinct device have been assessed at a high level to determine the impacts that the development may have on the flood extents in the natural creek systems and adjoining conservation areas. Site discharges are expected to quickly drain from the site and will not be influenced by backwater from the Nepean River or Cataract River.

Various cross sections have been assessed at locations downstream of the development edge. Manning's equation has been used to compare the existing and developed normal depth of flooding at each cross section in the 1% AEP event. The flows are derived from the hydrological assessment. Refer to the cross sections in Appendix E for an illustration of the flood level changes. Each cross-section correlates to different flow reporting locations shown in Figure 6-2 in Appendix B.

The cross sections show that the contributing catchments that experience the greatest increase in impervious conditions result in the greatest change in flood depths at the reporting locations (for example, locations "T" and "J" produce up to 1m increases in flood depth). Catchments that consist of existing / undeveloped portions typically show that increases are minor flood depth changes of up to 0.3m only.

Based on the information provided in the Wollondilly Flood Study, the proposal can be supported in its current form.

9. REFERENCES

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2. Design Specifications 2016. *Wollondilly Design Specifications*, Wollondilly Shire Council
3. CRCCH, (2005) - CRC For Catchment Hydrology (2005). *MUSIC Model for Urban Stormwater Improvement Conceptualisation*, User Guide Version 3
4. BMTWBM (2015). Draft NSW MUSIC Modelling Guidelines
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6. Willing & Partners Pty. Ltd. (1994). *Runoff Analysis & Flow Training Simulation*. Detailed Documentation and User Manual, Version 4.0
7. WMA Water (2019). Review of ARR Design Input for NSW Final Report
8. ARR 2019. Australian Rainfall and Runoff 2019
9. Wollondilly Shire Council (2020), *Integrated Water Management Strategy*, prepared by Wave Consulting
10. Wollondilly Shire Council (2020), *Memo: MUSIC Template*, prepared by Wave Consulting
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10. GLOSSARY

Term	Definition
Annual Exceedance Probability (AEP)	The chance or probability of a natural hazard event (usually a rainfall or flooding event) occurring annually. Normally expressed as a percentage.
Australian Rainfall and Runoff (AR&R)	Refers to the current edition of Australian Rainfall and Runoff published by the Institution of Engineers, Australia.
Exceedances per Year (EY)	The number of times a year that statistically a storm flow is exceeded.
Floodplain Planning Level (FPL)	The FPL is a height used to set floor levels for property development in flood-prone areas. It is generally defined as the 1% AEP flood level plus 0.5m freeboard.
Floodplain Development Manual (FDM) and Guidelines (April 2005)	The FDM is a document issued by the Department of Environment Climate Change and Water (DECCW) that provides a strategic approach to floodplain management. The guidelines have been issued by the NSW Department of Planning (DoP) to clarify issues regarding the setting of FPL's. This document is also the framework for the development of Floodplain Risk Management Studies and Plans.
Hydrograph	Is a graph that shows how the stormwater discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
J. Wyndham Prince Pty Ltd (JWP)	Consulting Civil Infrastructure Engineers and Project Managers undertaking these investigations
MUSIC	A modelling package designed to help urban stormwater professionals visualise possible strategies to tackle urban stormwater hydrology and pollution impacts. MUSIC stands for Model for Urban Stormwater Improvement Conceptualisation and has been developed by the Cooperative Research Centre (CRC),
Peak Discharge	Is the maximum stormwater runoff that occurs during a flood event
Probable Maximum Flood (PMF)	The greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends.

Term	Definition
TUFLOW	A computer program that provides two-dimensional (2D) and one dimensional (1D) solutions of the free surface flow equations to simulate flood and tidal wave propagation. It is specifically beneficial where the hydrodynamic behaviour, estuaries, rivers, floodplains and urban drainage environments have complex 2D flow patterns that would be awkward to represent using traditional 1D network models.
XP-RAFTS	Is a runoff routing model that uses the Laurenson non-linear runoff routing procedure to develop a sub catchment stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or a design storm utilising Intensity-Frequency-Duration data together with dimensionless storm temporal patterns as well as standard AR&R 1987 data.

APPENDIX A – RIPARIAN ASSESSMENT MATRIX

AREA 1

Location 1 (Looking downstream)

Location 1 (Looking upstream)

Description	The photos at Location 1 show that a riparian function exists in the watercourse. Clearly defined banks are evident in this area with scouring and erosion having occurred, leaving exposed rocks.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 3a – Laterally Unconfined Continuous – Bank Confined
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Erosion, Riffle
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 3a – Laterally Unconfined Continuous – Bank Confined
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

Location 2 (Looking upstream)

Location 3 (Looking downstream)

Location 3 (Looking upstream)

Location 4 (Looking upstream)

Description	Visible transition from watercourse with defined banks and erosion/rock formations to open pasture with minor depression (no bed/bank or watercourse features upstream of Location 3).
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present upstream of Location 3

AREA 2

Location 1 (Looking upstream)

Location 2 (Looking downstream)

Location 3 (Looking upstream)

Description	Open clearing with scattered trees. No defined banks or bed. Isolated, man-made farm dam with no riparian function.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Isolated farm dam (man-made)

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 3

Location 1 (Looking downstream)

Location 1 (Looking upstream)

Location 2 (Looking downstream)

Location 2 (Looking upstream)

Description	Defined creek with riparian features. Bed and banks present with isolated pools and riffles.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 1 – Confined Valley Headwater
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pool, Riffle, Erosion & Deposition
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 1 – Confined Valley Headwater
Are the proposed works located within 40 metres of the high bank?	Yes
Result: Controlled activity approval is required	

Location 3 (Looking downstream)

Location 4 (Looking upstream)

Description	Location 3 (looking downstream) shows the discontinuation of the defined bedbanks present further downstream. Location 4 (looking upstream) shows no defined banks and overgrowth of vegetation (mostly weeds with limited riparian vegetation) with limited connectivity up to the Upper Sydney Water Canal.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 4

Location 1 (Looking downstream)

Location 2 (Looking downstream)

Location 3 (Looking upstream)

Location 4 (Looking downstream)

Description	Defined banks and bed with visible erosion leaving rock riffles. Discharges to farm dam. Change of vegetation evident in area surrounding farm dam.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 3b – Laterally Unconfined Continuous – Low Sinuosity
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Riffle, Erosion, Farm dam
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 3b – Laterally Unconfined Continuous – Low Sinuosity
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

Location 5 (Looking upstream)

Description	Clear discontinuation of defined creek bed and banks up towards Sydney Water Upper Canal.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 5

Location 1 (Looking downstream)

Location 2 (Looking downstream)

Description	No defined creek bed or banks. Open pasture with minor depression.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 6

Location 1 (Looking downstream)

Location 1 (Looking downstream)

Location 1 (Looking upstream)

Description	No defined creek bed or banks. Minor depression with some vegetation but no riparian function. Shallow dam/pool upstream.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 7

Location 1 (Looking downstream)

Location 2 (Looking upstream)

Description	No defined creek bed or banks. Chain of farm dams with poor connectivity.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 8

Location 1 (Looking downstream)

Location 1 (Looking upstream)

Description	Defined banks with vegetation. Poor connectivity upstream and downstream.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 3a – Laterally Unconfined Continuous – Bank Confined
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Erosion
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 3a – Laterally Unconfined Continuous – Bank Confined
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

Location 2 (Looking downstream)

Location 2 (Looking upstream)

Description	No defined creek bed or banks. Poor connectivity from upstream farm dam to downstream environment.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

Location 3 (Looking downstream)

Location 4 (Looking upstream)

Description	No defined creek bed or banks. Poor connectivity to downstream environment.
Watercourse order	1st/2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

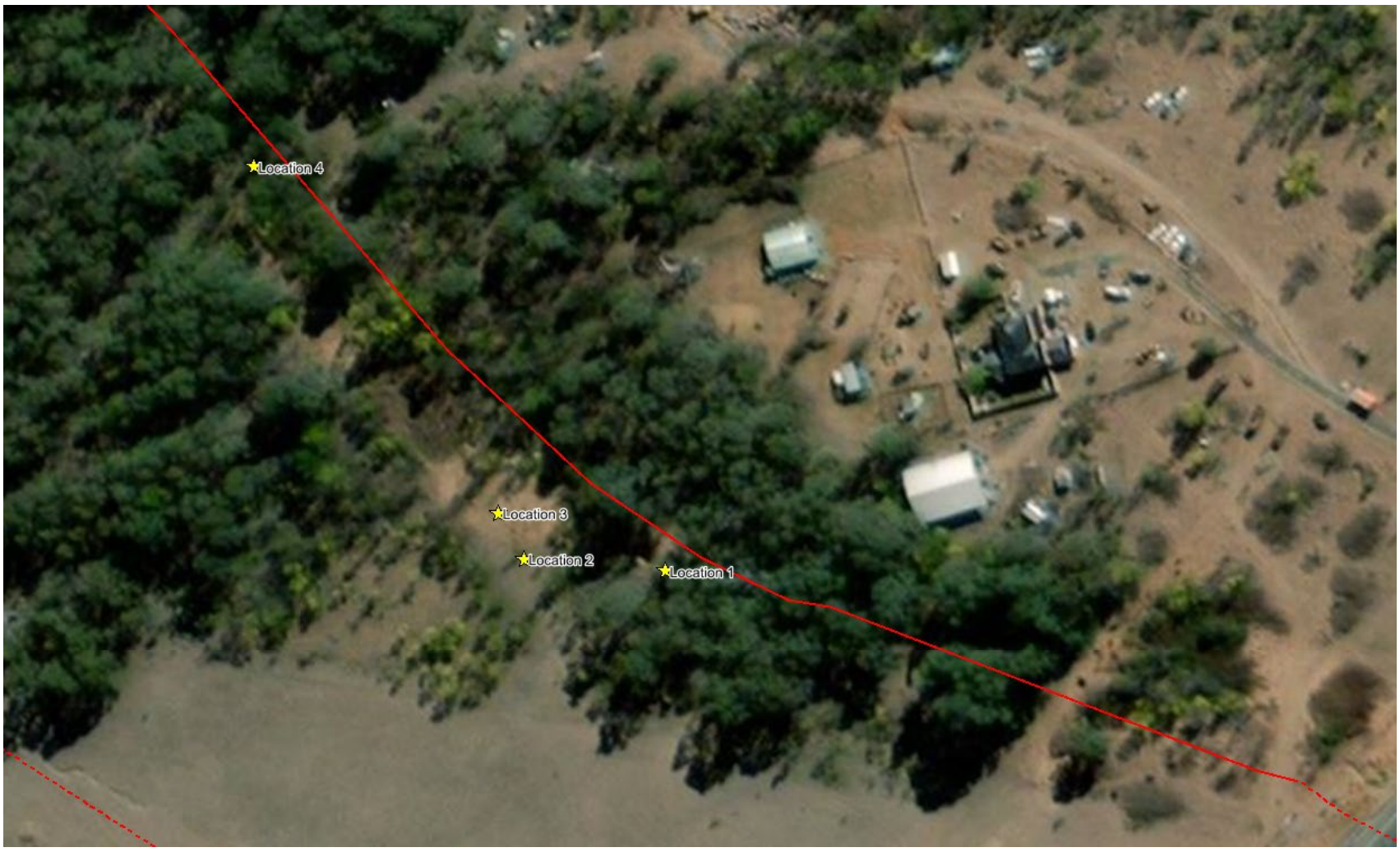
AREA 9

Location 1 (Looking downstream)

Description
No defined creek bed or banks. No riparian vegetation or features.
Watercourse order
1st order
Does the watercourse have a defined bed or bank?
No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)
None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 10



Location 1 (Looking downstream)

Location 1 (Looking upstream)

Description	Defined creek bed with overgrown vegetation and isolated pools. Creek banks unclear due to overgrown vegetation.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 1 – Confined Valley Headwater

Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pool, Erosion & Deposition
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 1 – Confined Valley Headwater
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

Location 2 (Looking downstream)

Location 2 (Looking upstream)

Location 3 (Looking downstream)

Description	Localised wetland clearing.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Lake of wetland present?	Wetland
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

Location 4

Description	No visible creek bed due to overgrowth of vegetation. Dense vegetation surrounding banks.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 1 – Confined Valley Headwater
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pool, Riffle, Erosion & Deposition, Inside & Outside Bend
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 1 – Confined Valley Headwater
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

AREA 11

Location 1 (Looking downstream)

Description	No visible creek bed or defined banks. Dense vegetation/shrubs.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

Location 2 (Looking downstream)

Location 2 (Looking upstream)

Description	No visible creek bed or defined banks. Dense vegetation/shrubs. Poor connectivity downstream of farm dam.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 12

Location 1 (Looking downstream)

Location 1 (Looking downstream)

Location 1 (Farm dam)

Location 2 (Looking upstream)

Location 4 (Looking downstream)

Location 4 (Looking upstream)

Location 5 (Looking downstream)

Location 5 (Looking upstream)

Description	Defined banks and visible erosion / exposed rock. Dense tree cover and vegetation.
Watercourse order	2nd / 3rd order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 3c – Laterally Unconfined Continuous - Meandering
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pool, Riffle, Erosion
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 3c – Laterally Unconfined Continuous - Meandering
Are the proposed works located within 40 metres of the high bank?	No

Result: Controlled activity approval not required – the proposed works are more than 40 metres from the high bank

Location 3 (Looking downstream)

Location 3 (Looking upstream)

Description	No visible creek bed or defined banks. Minimal vegetation in depression. Poor connectivity downstream of farm dam.
Watercourse order	1st order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	None

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 13

Location 1 (Looking downstream)

Location 1 (Looking upstream)

Location 2 (Looking downstream)

Location 3 (Looking downstream)

Location 3 (Looking upstream)

Location 4 (Farm dam)

Location 5 (Looking downstream)

Location 5 (Looking upstream)

Location 6 (Looking downstream)

Location 6 (Looking upstream)

Location 7 (Looking downstream)

Location 7 (Looking upstream)

Location 8 (Looking downstream)

Description	Visible erosion / exposed rock in various locations along water course. Minimal vegetation.
Watercourse order	3rd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pool, Riffle, Erosion

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 14

Location 1 (Farm dam)

Location 2 (Looking downstream)

Location 2 (Looking upstream)

Description	Visible erosion / exposed rock in various locations along water course. Minimal vegetation. No connectivity between upstream and downstream environment.
Watercourse order	3rd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Erosion

Result: Controlled activity approval not required – No watercourse, lake or wetland present

Location 3 (Looking downstream)

Location 3 (Looking upstream)

Description	Exposed rock in various locations along water course. Minimal vegetation in bed. Depression with no defined banks.
Watercourse order	2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Erosion

Result: Controlled activity approval not required – No watercourse, lake or wetland present

Location 4 (Looking upstream)

Location 4 (Looking upstream)

Description	Exposed rock and visible erosion in various locations along water course. Permanent pools in bed. Debris/tree branches in creek bed.
Watercourse order	3rd order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 1 – Confined Valley Headwater
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Riffle, Pool, Erosion
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 1 – Confined Valley Headwater
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

AREA 15

Location 1 (Farm dam)

Location 1 (Looking upstream)

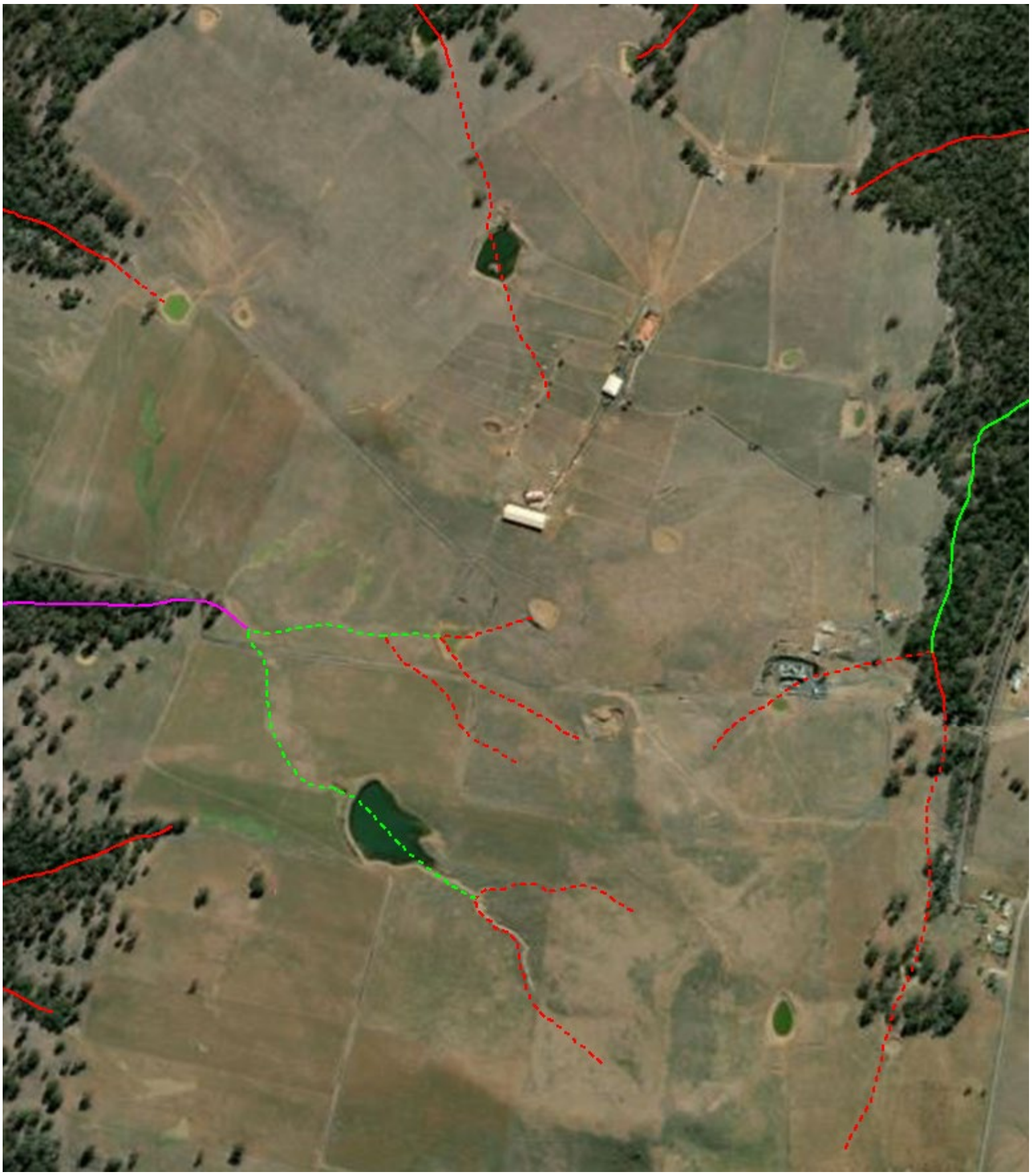
Location 2 (Looking downstream)

Location 2 (Looking upstream)

Description	No defined creek bed or banks. Poor connectivity between farm dams. No riparian vegetation or features.
Watercourse order	1st / 2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Farm dam

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 16



Description	No defined creek bed and banks. Minimal riparian vegetation. Mostly grassed grazing land with natural depressions / ditches.
Watercourse order	1st / 2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Farm dams

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 17

Description	No defined creek bed and banks. Minimal riparian vegetation. Mostly grassed grazing land with natural depressions / ditches.
Watercourse order	1st / 2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Farm dams

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 18

Location 1 (Looking downstream)

Location 1 (Looking upstream)

Location 2 (Looking downstream)

Location 2 (Looking upstream)

Location 3 (Looking upstream)

Location 4 (Looking downstream)

Location 4 (Looking upstream)

Location 5 (Looking downstream)

Location 5 (Looking upstream)

Location 6 (Looking downstream)

Location 6 (Looking upstream)

Location 7 (Looking upstream)

Description	No defined creek bed and banks. Minimal riparian vegetation. Mostly grassed grazing land with natural depressions / ditches.
Watercourse order	3rd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pools, Farm dam

Result: Controlled activity approval not required – No watercourse, lake or wetland present

AREA 19

Description	Upper portion - No defined creek bed and banks. Minimal riparian vegetation. Mostly grassed grazing land with natural depressions / ditches.
Watercourse order	2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Farm dams

Result: Controlled activity approval not required – No watercourse, lake or wetland present

Description	Lower portion – defined banks with permanent water pool.
Watercourse order	2rd order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	N/A
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Pool, Erosion
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	N/A
Are the proposed works located within 40 metres of the high bank?	Yes

Result: Controlled activity approval is required

AREA 20

Description	Upstream of canal - No defined creek bed and banks. Minimal riparian vegetation. Mostly grassed grazing land with natural depressions / ditches.
Watercourse order	1st / 2nd order
Does the watercourse have a defined bed or bank?	No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Farm Dam

Result: Controlled activity approval not required – No watercourse, lake or wetland present

Description	Downstream of canal – dense vegetation / bushland.
Watercourse order	2rd order
Does the watercourse have a defined bed or bank?	Yes
Watercourse type (NRAR Waterfront Land Tool – Appendix 5)	Type 1 – Confined Valley Headwater
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)	Nil
High bank of the watercourse (NRAR Waterfront Land Tool – Appendix 8)	Type 1 – Confined Valley Headwater
Are the proposed works located within 40 metres of the high bank?	Yes

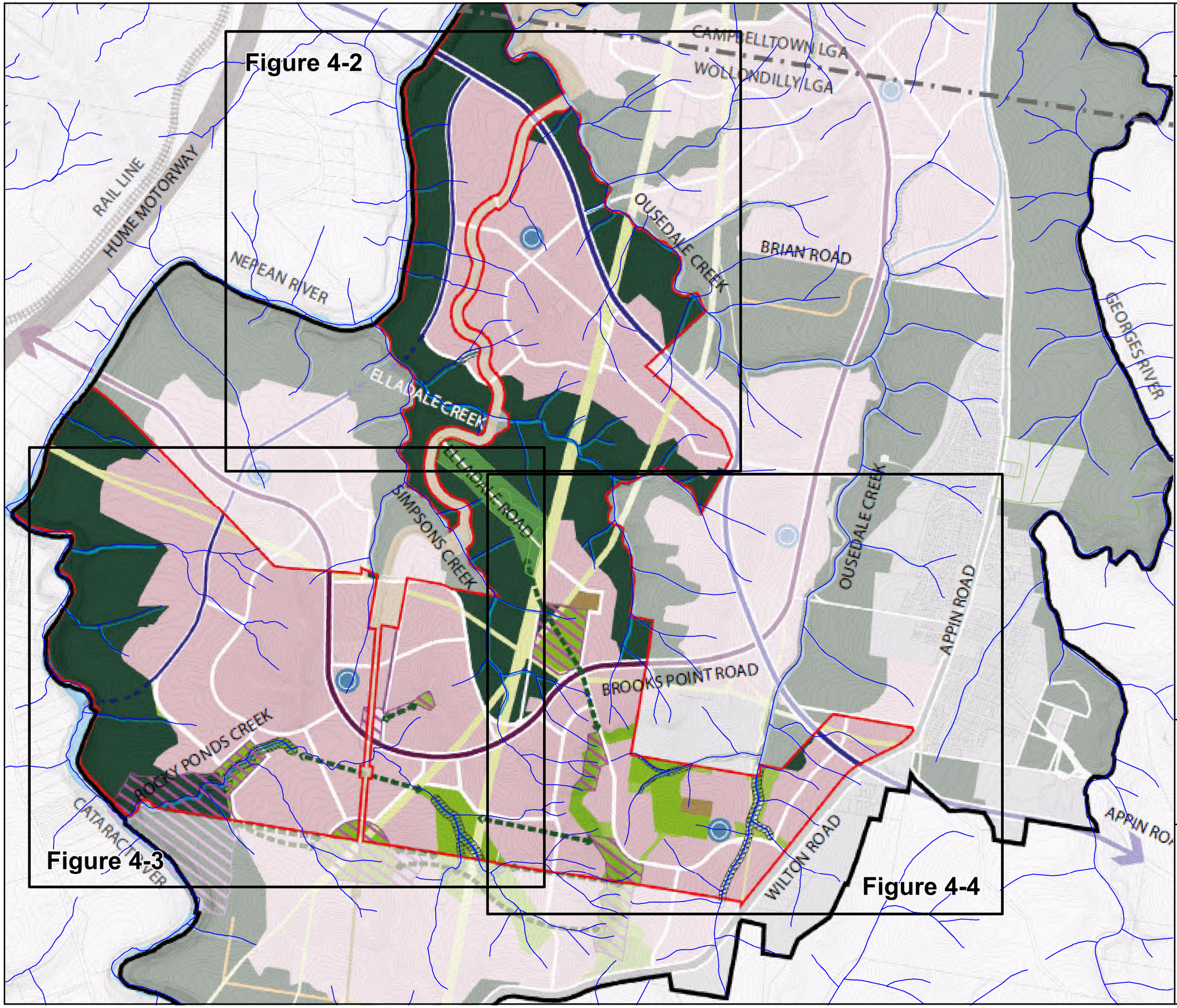
Result: Controlled activity approval is required

AREA 21

Description
No defined creek bed and banks. Minimal riparian vegetation. Mostly grassed grazing land with natural depressions / ditches.
Watercourse order
1st / 2nd order
Does the watercourse have a defined bed or bank?
No
Watercourse Features (NRAR Waterfront Land Tool – Appendix 6)
Farm dams

Result: Controlled activity approval not required – No watercourse, lake or wetland present

APPENDIX B – FIGURES



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LEGEND

- Site Boundary
- Watercourse

N

0 920

metres
Scale 1:23,000 @ A3

Projection: GDA 1994 MGA Zone 56

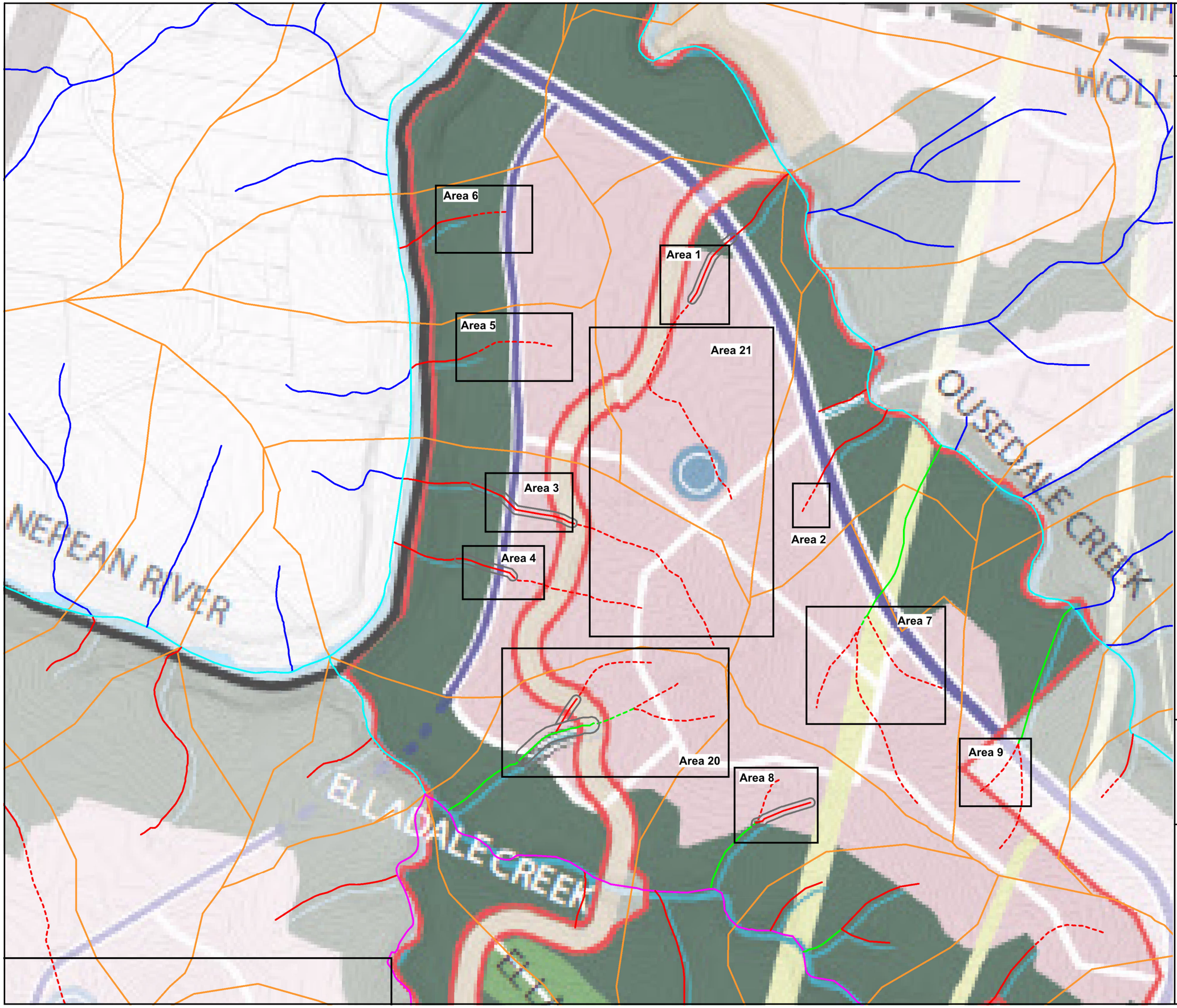
Figure 4-1

Appin (Part) Precinct: Water Cycle Management Strategy

Site Overview and Key

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&E\MapInfo\Figures\WCMS\110668_Fig4-1_Site Overview_B.wor"



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LEGEND

- Site Boundary
- Catchments
- External Watercourse
- Riparian Assessment Area
- Vegetated Riparian Zone (VRZ)

STRAHLER STREAM ORDER

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)
- 4th Order Watercourse (40m VRZ Buffer)

PROPOSED FOR REMOVAL

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)

NOTES

- Creek beds assumed to be 5 metres in width for the purpose of VRZ buffer calculations

N

0 400
metres
Scale 1:10,000 @ A3

Projection: GDA 1994 MGA Zone 56

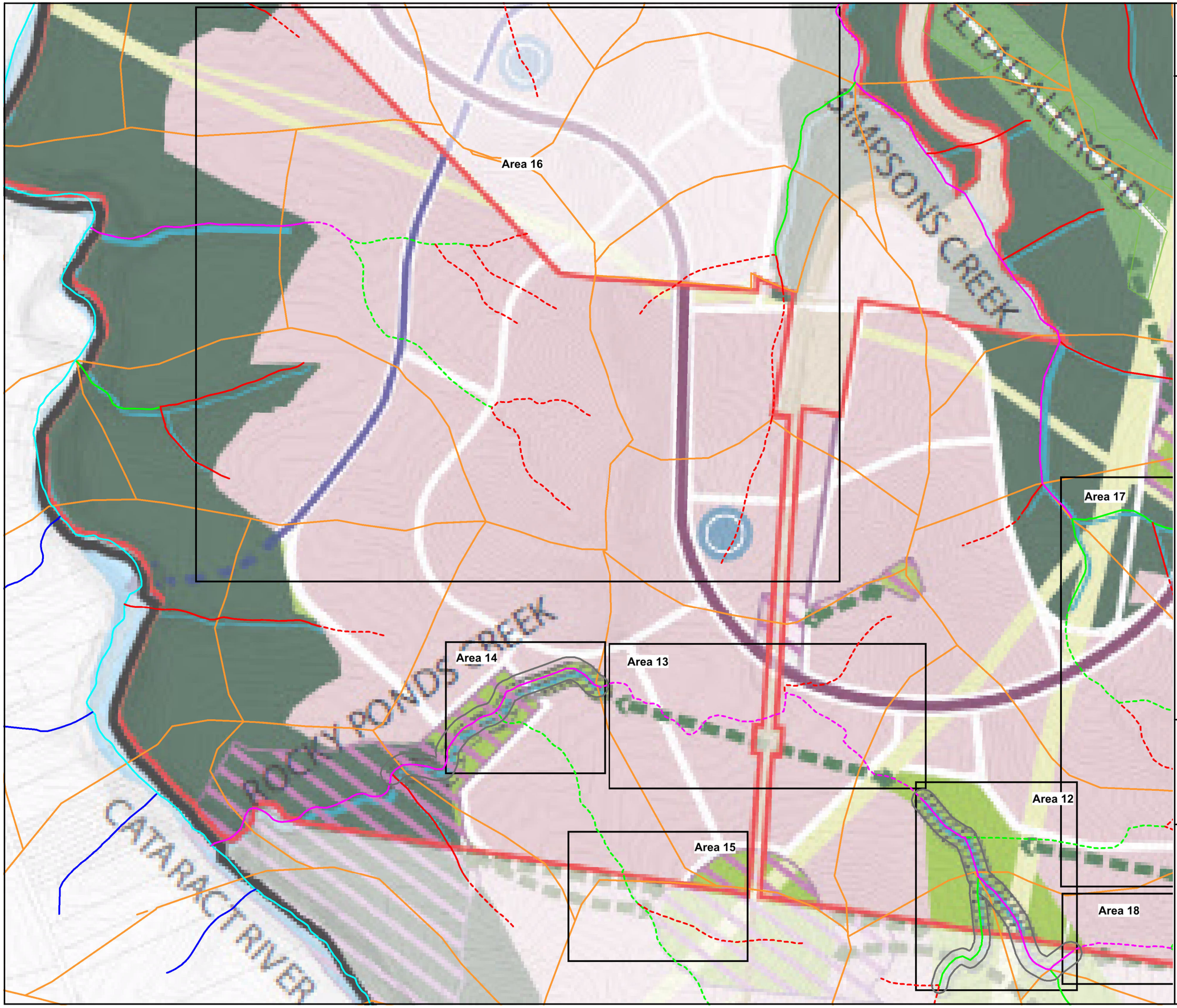
Figure 4-2

Appin (Part) Precinct: Water Cycle Management Strategy

Riparian Assessment Plan

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&EMapInfo\Figures\WCMS\110668_Fig4-2_Riparian Assessment_B.wor"



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LEGEND

- Site Boundary
- Catchments
- External Watercourse
- Riparian Assessment Area
- Vegetated Riparian Zone (VRZ)

STRAHLER STREAM ORDER

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)
- 4th Order Watercourse (40m VRZ Buffer)

PROPOSED FOR REMOVAL

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)

NOTES

- Creek beds assumed to be 5 metres in width for the purpose of VRZ buffer calculations

N

0 400
metres
Scale 1:10,000 @ A3

Projection: GDA 1994 MGA Zone 56

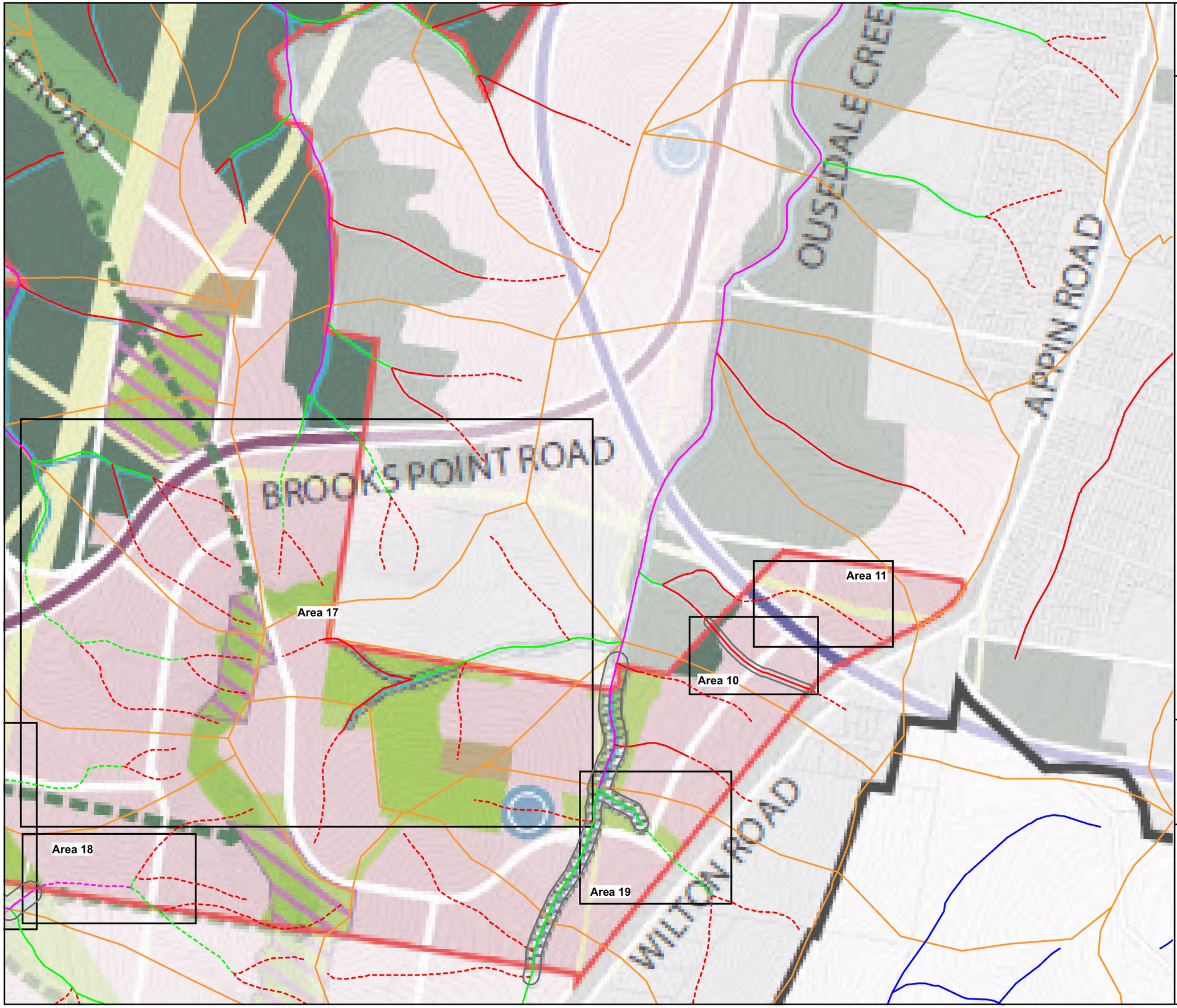
Figure 4-3

Appin (Part) Precinct: Water Cycle Management Strategy

Riparian Assessment Plan

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&E\MapInfo\Figures\WCMS\110668_Fig4-3_Riparian Assessment_B.wor"



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LEGEND

- Site Boundary
- Catchments
- External Watercourse
- Riparian Assessment Area
- Vegetated Riparian Zone (VRZ)

STRAHLER STREAM ORDER

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)
- 4th Order Watercourse (40m VRZ Buffer)

PROPOSED FOR REMOVAL

- 1st Order Watercourse (10m VRZ Buffer)
- 2nd Order Watercourse (20m VRZ Buffer)
- 3rd Order Watercourse (30m VRZ Buffer)

NOTES

- Creek beds assumed to be 5 metres in width for the purpose of VRZ buffer calculations

N

0 400
metres
Scale 1:10,000 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 4-4

Appin (Part) Precinct: Water Cycle Management Strategy

Riparian Assessment Plan

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&EIMapInfo\Figures\WCMS\110668_Fig4-4_Riparian Assessment_B.wor"

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LEGEND

- Site Boundary
- Total Nepean River Catchment
- XP-RAFTS Catchments
- Major Watercourses

N

0 7200
metres
Scale 1:180,000 @ A3

Projection: GDA 2020 MGA Zone 56

Figure 6-1

Appin (Part) Precinct: Water Cycle Management Strategy

Nepean River Catchment Plan

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&E\MapInfo\Figures\WCMS\110668_Fig6-1_Broad Catchment Plan.wor"

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LEGEND

- Site Boundary
- Rezoning Area
- XP-RAFTS Catchments
- Major Watercourse
- Minor Watercourse
- Reporting Locations

N

0 1000
metres
Scale 1:25,000 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 6-2

Appin (Part) Precinct: Water Cycle Management Strategy

Local Catchment Plan

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&E\MapInfo\Figures\WCMS\110668_Fig6-2_Local Catchment Plan_B.wor"

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LEGEND

- Site Boundary
- Rezoning Area
- XP-RAFTS Catchments
- Major Watercourse
- Minor Watercourse
- Reporting Locations
- XXX Flow Comparisons - Achieve both targets
- XXX Flow Comparisons - achieves one target
- XXX Flow Comparisons - doesn't achieve targets

N

0 1000
metres
Scale 1:25,000 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 6-3

Appin (Part) Precinct: Water Cycle Management Strategy

XP-RAFTS Flow Comparisons

No Detention

Date: 12/10/2022 Issue: A

Filename: "J:\110668 - West Appin\02 - WCMS\SW&EIMapInfo\Figures\WCMS\110668_Fig6-3_XP-Rafts Flow Comparisons_No Det_B.wor"

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LEGEND

- Site Boundary
- Release Area 1
- Catchments
- Major Watercourse
- Minor Watercourse
- Raingardens
- Basins

N

0 400
metres
Scale 1:10,000 @ A3

Projection: GDA 1994 MGA Zone 56

Figure 6-4

Appin (Part) Precinct: Water Cycle Management Strategy

Water Cycle Management Plan Release Area 1

Date: 12/10/2022 Issue: A

Filename: "J:\1110668 - West Appin\02 - WCMS\SW&E\MapInfo\Figures\WCMS\1110668_Fig6-4_WCMP RA1_C.wor"

APPENDIX C – MUSIC MODEL DATA

Modelling Inputs and Assumptions

The proposed rezoning area of the West Appin Precinct is intersected by a series of existing watercourses, many of which are located within environmental conservation areas within the site. In accordance with the Guidelines for controlled activities on waterfront land (NRAR, 2018), the watercourses have each been identified to range between 1st to 4th order riparian corridors based on the Strahler classification system using available 1:25,000 topographic maps. The guidelines state that where a watercourse does not exhibit the features of a defined channel with bed and banks, the NRAR may determine that the watercourse is not waterfront land for the purposes of the Water Management Act (2000) (WM Act).

The MUSIC Modelling has used a series of default assumptions and parameters consistent with NSW MUSIC Modelling Guidelines (WBM BMT, 2015). Details are provided below.

- Commercial areas are assumed to provide on-lot stormwater quality treatment measures that achieve statutory pollutant removal targets prior to discharge to the regional system;
- The MUSIC model catchments have been split into the roof, driveways, road, urban previous and urban impervious;
- The soil / groundwater parameters and pollutant loading rates adopted for all “source nodes” in the modelling are based on the recommended parameters in the NSW MUSIC Modelling Guidelines (2015). 'Light Clay' parameters have been adopted from the guidelines which is consistent with the desktop geotechnical study undertaken by Douglas Partners for the wider Wilton Junction site which is adjacent to the West Appin Precinct.

Rainfall & Evapotranspiration Data

The MUSIC model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. In accordance with the recommendations from the Memo: MUSIC Template prepared by Wave Consulting on behalf of Wollondilly Shire Council (2020), a 6 minute rainfall data set has been selected from the Rookwood Station (no. 066164).

The 6 minute data obtained for Rookwood Station between the years 1975 – 1984 was analysed and found to be a fair representation of the long term statistical data for the mean annual rainfall within Wollondilly Shire and was therefore adopted in this study.

The evapotranspiration data used in the mode was also source from those suggested in Councils MUSIC Template. The evapotranspiration data used in the modelling is summarised in Table C-1 below.

The rainfall and evapo-transpiration data for the period analysed is shown on the graph which is provided in Plate C-1 below.

Table C-1 – Daily mean PET data

Month	Daily Mean PET (mm)
January	5.35
February	4.63
March	3.85
April	2.55
May	1.58
June	1.27
July	1.28
August	1.83
September	2.68
October	4.00
November	4.78
December	5.18

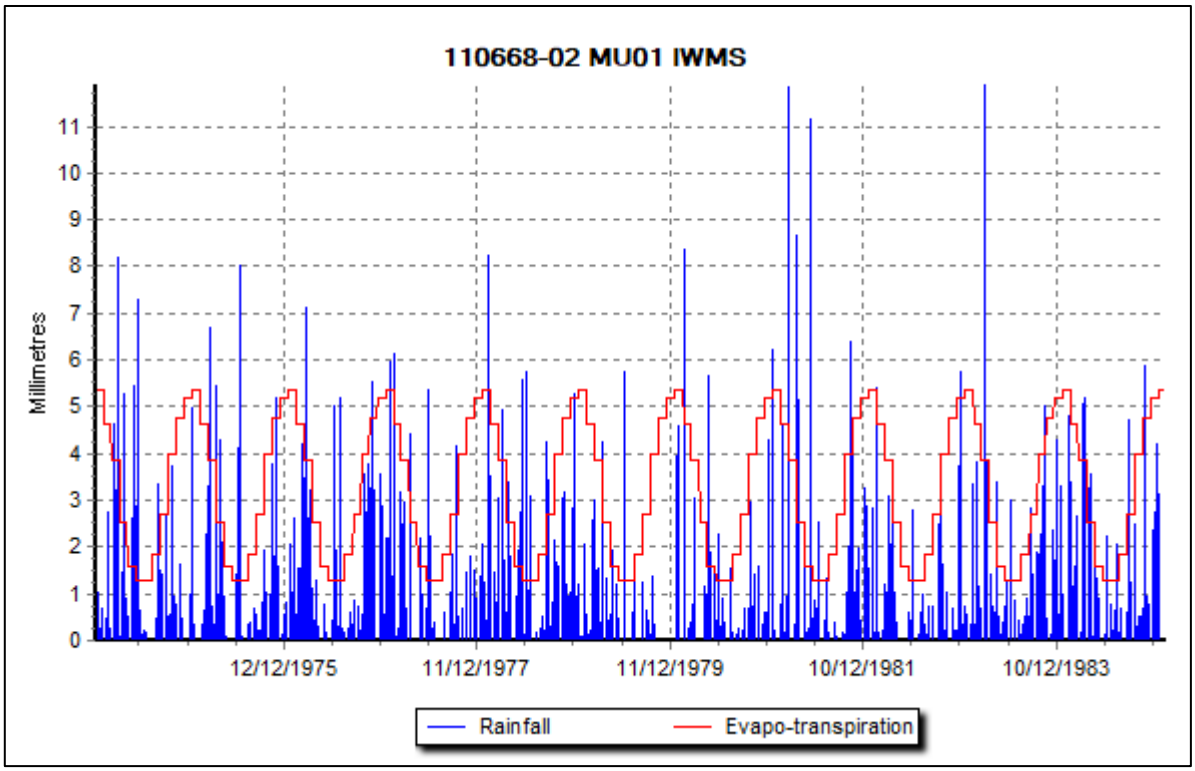

Plate C-1 – Rainfall and Evapo-transpiration Data for Rookwood Station

MUSIC MODELLING WORKSHEET Input
West Appin - IWMS WQ Assessment MUSIC Input
110668-02 MU02 IWMS.sqz

	Catchment Division						Node Inputs Catchment Split for MUSIC							
Catchment	**Total Catchment Area (ha)**	**Lot Area (ha)**	**R2 No. of Lots**	**Avg Lot Size (m²)**	**Road Reserve Area (ha)**	**Active Open Space**	**Road Impervious (ha)**	**Driveways (ha)**	**Roof to Tank (ha)**	**Roof bypass (ha)**	**Other Impervious (ha)**	**Pervious (ha)**	**Road Pervious (ha)**	**Effective % Impervious**
Typical 10 ha Low-Density	10.000	6.500	217	300	3.000	0.500	2.100	0.325	3.250		0.375	3.950	--	61%

	Node Inputs Rainwater Tanks					
Catchment	**Hi Flow Bypass**	**Equivalent Pipe dia (mm)**	**Daily Demand (kL)**	**Annual Demand (kL/yr)**	**Total Tank Volume (m^3)**	**Tank Surface Area (m^2)**
Low Density Residential	1.679	737	195.3	0	868.0	368.9

	Cat. Area (ha)	**Treatable Flow Calculation**				
		Flow Path Length (m)	**Tc* (min)**	**%Imperv.**	**1yr Flow (m^3/s)**	**3mth Flow (m^3/s)**
GPT Treatable flow (low density)	10.000	300	6	61%	1.231	0.640

*Tc calculated based on Kinematic wave equation for a typical lot plus flowpath travel time @ 2 m/s

	RWT	
Overflow Pipe Diameter	50	mm
PET - Rain for landscape area		L/m²/day
Assumed daily demand	900	L/day
Adopted tank size	5	kL
Assumed 80% is usable (w/o topups)	80	%
Useable tank	4	kL
Tank surface area per dwelling	1.7	m2
I5min/10yr	186	mm/hr

%Impervious	
R2 Lots	60%
Commercial	90%
Road Reserve	70%
Active Open Space	10%

% Breakdown Low Density		**% Breakdown Commercial**	
Roof	50%	Roof	60%
Driveways	5%	Driveways	20%
Other Impervious	5%	Other Impervious	10%
Pervious Areas	40%	Pervious Areas	10%

Water Quality Management Measures

Details as to the Gross Pollutant Traps and Bioretention Raingarden are provided below.

Gross Pollutant Traps

Gross Pollutant Traps (GPTs) have been provided to filter stormwater prior to discharge into the bioretention raingardens. A generic GPT has been adopted with the pollutant removal rates as specified in Table C-2.

Table C-2 – GPT Input Parameters

Pollutant	Input	Output
TSS (mg/L)	0	0
	100	100
TP (mg/L)	0	0
	100	100
TN (mg/L)	0	0
	50	50
GP (kg/ML)	0	0
	100	2

A 4 EY (3-month ARI) treatable flow rate has been adopted. A high flow bypass link within the MUSIC model reflects flows in excess of the treatable flow bypassing both the bio-retention raingarden and GPT. The final hydraulic arrangement for each device will be subject to a detailed design process to support the future development application.

Bioretention Raingarden

The design parameters adopted for the bioretention raingarden are shown in Table C-3. The filter media receives flow having firstly being treated by the GPT at each outlet.

Table C-3 – Raingarden Input Parameters

Raingarden Parameter	10 ha Residential Catchment
High Flow Bypass (m^3/s)	100
Extended Detention Basin (m)	0.3
Surface Area (m^2)	1580
Filter Area (m^2)	1580
Filter Depth	0.5
Unlined Filter Media Perimeter (m)	0.01
Saturated Hydraulic Conductivity (mm/h)	100
TN Content of Filter Media (mg/kg)	400
Orthophosphate Content of Filter Media (mg/kg)	40
Exfiltration Rate (mm/hr)	0.36
Overflow Weir Width (m)	6.50
Base Lined	No
Vegetated with effective Nutrient removal Plants	Yes
Underdrain Present	Yes
Submerged Zone with Carbon Present	No

APPENDIX D – AR&R DATA HUB

ATTENTION: This site was updated recently, changing some of the functionality. Please see the changelog (./changelog) for further information

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	150.708
Latitude	-34.34
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Probability Neutral Burst Initial Loss (./nsw_specific)	show

Data

River Region

Division	South East Coast (NSW)
River Number	12
River Name	Hawkesbury River

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2016_v1

ARF Parameters

$$ARF = Min\{1, [1 - a(Area^b - c\log 10 Duration)Duration^{-d+e Area^f Duration^{g(0.3+\log 10 AEP)+h}} 10^{i Area Duration}{1440^{(0.3+\log 10 AEP)}}]\}$$

Zone	a	b	c	d	e	f	g	h	i
SE Coast	0.06	0.361	0.0	0.317	8.11e-05	0.651	0.0	0.0	0.0

Short Duration ARF

$$ARF = Min[1, 1 - 0.287(Area^{0.265 - 0.439\log 10(Duration)}).Duration^{-0.36 + 2.26 \times 10^{-3} \times Area^{0.226}.Duration^{0.125(0.3+\log 10(AEP))} + 0.0141 \times Area^{0.213} \times 10^{-0.021(Duration-180)^2}}{1440^{(0.3+\log 10(AEP))}}]$$

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	18962.0
Storm Initial Losses (mm)	42.0
Storm Continuing Losses (mm/h)	4.0

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECsouth.zip)

code	ECsouth
Label	East Coast South

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECsouth.zip)

code	ECsouth
arealabel	East Coast South

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-34.34&longitude=150.708&sdmin=true&sdhr=true&sdday=true&u to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	23 October 2020 02:56PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	12.3 (0.395)	10.2 (0.233)	8.8 (0.165)	7.5 (0.118)	3.2 (0.041)	0.0 (0.000)
90 (1.5)	13.0 (0.353)	10.1 (0.194)	8.1 (0.129)	6.3 (0.083)	2.7 (0.029)	0.0 (0.000)
120 (2.0)	7.8 (0.186)	8.0 (0.135)	8.1 (0.112)	8.2 (0.096)	4.0 (0.038)	0.8 (0.007)
180 (3.0)	12.8 (0.253)	16.2 (0.226)	18.4 (0.212)	20.5 (0.200)	12.9 (0.103)	7.2 (0.050)
360 (6.0)	16.3 (0.228)	21.8 (0.213)	25.5 (0.205)	29.0 (0.198)	18.8 (0.107)	11.2 (0.056)
720 (12.0)	14.6 (0.145)	27.2 (0.186)	35.6 (0.199)	43.6 (0.206)	42.9 (0.170)	42.4 (0.149)
1080 (18.0)	12.6 (0.105)	23.7 (0.133)	31.1 (0.142)	38.1 (0.147)	55.8 (0.180)	69.1 (0.199)
1440 (24.0)	8.7 (0.064)	18.6 (0.093)	25.1 (0.101)	31.4 (0.106)	54.3 (0.153)	71.4 (0.180)
2160 (36.0)	1.3 (0.009)	5.3 (0.023)	8.0 (0.028)	10.5 (0.030)	47.4 (0.114)	75.0 (0.160)
2880 (48.0)	0.0 (0.000)	1.4 (0.006)	2.3 (0.007)	3.2 (0.008)	17.7 (0.038)	28.5 (0.055)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	6.4 (0.012)	11.2 (0.019)

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.4 (0.014)	0.3 (0.006)	0.1 (0.002)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.7 (0.019)	0.4 (0.008)	0.2 (0.003)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.3 (0.005)	0.2 (0.002)	0.1 (0.001)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.7 (0.004)	1.1 (0.006)	1.5 (0.007)	0.6 (0.003)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	2.1 (0.012)	3.6 (0.016)	4.9 (0.019)	2.5 (0.008)	0.6 (0.002)
1440 (24.0)	0.0 (0.000)	0.1 (0.000)	0.1 (0.000)	0.2 (0.001)	3.8 (0.011)	6.4 (0.016)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	12.1 (0.029)	21.2 (0.045)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.9 (0.002)	1.6 (0.003)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.000)	0.2 (0.000)

Layer Info

Time Accessed	23 October 2020 02:56PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	42.0 (1.351)	39.6 (0.905)	38.1 (0.713)	36.6 (0.575)	32.1 (0.408)	28.8 (0.315)
90 (1.5)	54.3 (1.471)	48.1 (0.925)	43.9 (0.695)	40.0 (0.532)	34.8 (0.376)	30.8 (0.289)
120 (2.0)	51.2 (1.219)	56.8 (0.961)	60.6 (0.844)	64.2 (0.755)	55.5 (0.533)	49.0 (0.408)
180 (3.0)	46.5 (0.916)	70.6 (0.984)	86.5 (0.995)	101.8 (0.992)	93.3 (0.746)	86.9 (0.607)
360 (6.0)	65.1 (0.909)	86.7 (0.847)	101.0 (0.813)	114.7 (0.785)	142.0 (0.807)	162.5 (0.814)
720 (12.0)	62.5 (0.621)	79.4 (0.542)	90.6 (0.506)	101.4 (0.480)	143.7 (0.569)	175.4 (0.616)
1080 (18.0)	37.3 (0.310)	65.1 (0.366)	83.5 (0.382)	101.2 (0.390)	139.5 (0.451)	168.3 (0.483)
1440 (24.0)	41.5 (0.308)	65.1 (0.324)	80.8 (0.326)	95.8 (0.324)	121.5 (0.343)	140.8 (0.354)
2160 (36.0)	20.0 (0.130)	47.2 (0.204)	65.2 (0.226)	82.5 (0.237)	119.3 (0.286)	146.8 (0.312)
2880 (48.0)	10.2 (0.062)	22.5 (0.089)	30.5 (0.097)	38.3 (0.100)	108.7 (0.236)	161.4 (0.311)
4320 (72.0)	0.1 (0.001)	14.1 (0.051)	23.4 (0.068)	32.3 (0.076)	79.3 (0.155)	114.5 (0.198)

Layer Info

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Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	97.5 (3.138)	120.2 (2.744)	135.2 (2.530)	149.6 (2.349)	128.7 (1.635)	113.1 (1.237)
90 (1.5)	151.8 (4.111)	134.7 (2.592)	123.5 (1.952)	112.6 (1.500)	110.9 (1.200)	109.6 (1.026)
120 (2.0)	110.7 (2.637)	166.2 (2.811)	203.0 (2.827)	238.3 (2.801)	190.6 (1.829)	154.8 (1.289)
180 (3.0)	110.2 (2.170)	165.9 (2.313)	202.9 (2.333)	238.3 (2.321)	209.7 (1.678)	188.3 (1.315)
360 (6.0)	148.8 (2.079)	172.0 (1.680)	187.3 (1.508)	202.0 (1.382)	241.5 (1.372)	271.2 (1.358)
720 (12.0)	133.2 (1.324)	156.2 (1.065)	171.5 (0.958)	186.1 (0.880)	200.4 (0.793)	211.0 (0.741)
1080 (18.0)	73.0 (0.606)	136.6 (0.768)	178.7 (0.818)	219.0 (0.845)	254.1 (0.820)	280.4 (0.805)
1440 (24.0)	86.5 (0.641)	162.3 (0.809)	212.5 (0.857)	260.7 (0.881)	271.3 (0.767)	279.3 (0.702)
2160 (36.0)	55.1 (0.357)	110.8 (0.478)	147.7 (0.511)	183.1 (0.527)	242.6 (0.582)	287.3 (0.611)
2880 (48.0)	47.2 (0.283)	79.8 (0.317)	101.4 (0.322)	122.2 (0.320)	194.3 (0.423)	248.3 (0.478)
4320 (72.0)	9.4 (0.052)	44.5 (0.162)	67.8 (0.196)	90.1 (0.213)	145.2 (0.284)	186.6 (0.322)

Layer Info

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Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Layer Info

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Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	31.8	16.2	16.0	17.8	18.0	18.5
90 (1.5)	30.7	16.6	17.6	20.0	20.8	19.8
120 (2.0)	32.7	17.9	17.5	18.4	18.0	15.9
180 (3.0)	30.5	18.9	18.0	17.6	16.7	13.1
360 (6.0)	28.4	21.2	20.8	18.8	18.4	9.2
720 (12.0)	32.5	25.4	23.4	20.4	20.4	6.1
1080 (18.0)	39.4	28.9	26.8	22.3	21.9	5.5
1440 (24.0)	39.6	30.9	30.4	24.9	25.0	6.9
2160 (36.0)	49.4	38.3	36.7	29.9	27.5	7.6
2880 (48.0)	53.1	44.1	42.0	43.5	29.7	8.9
4320 (72.0)	61.3	48.8	45.9	50.7	38.8	16.8

Layer Info

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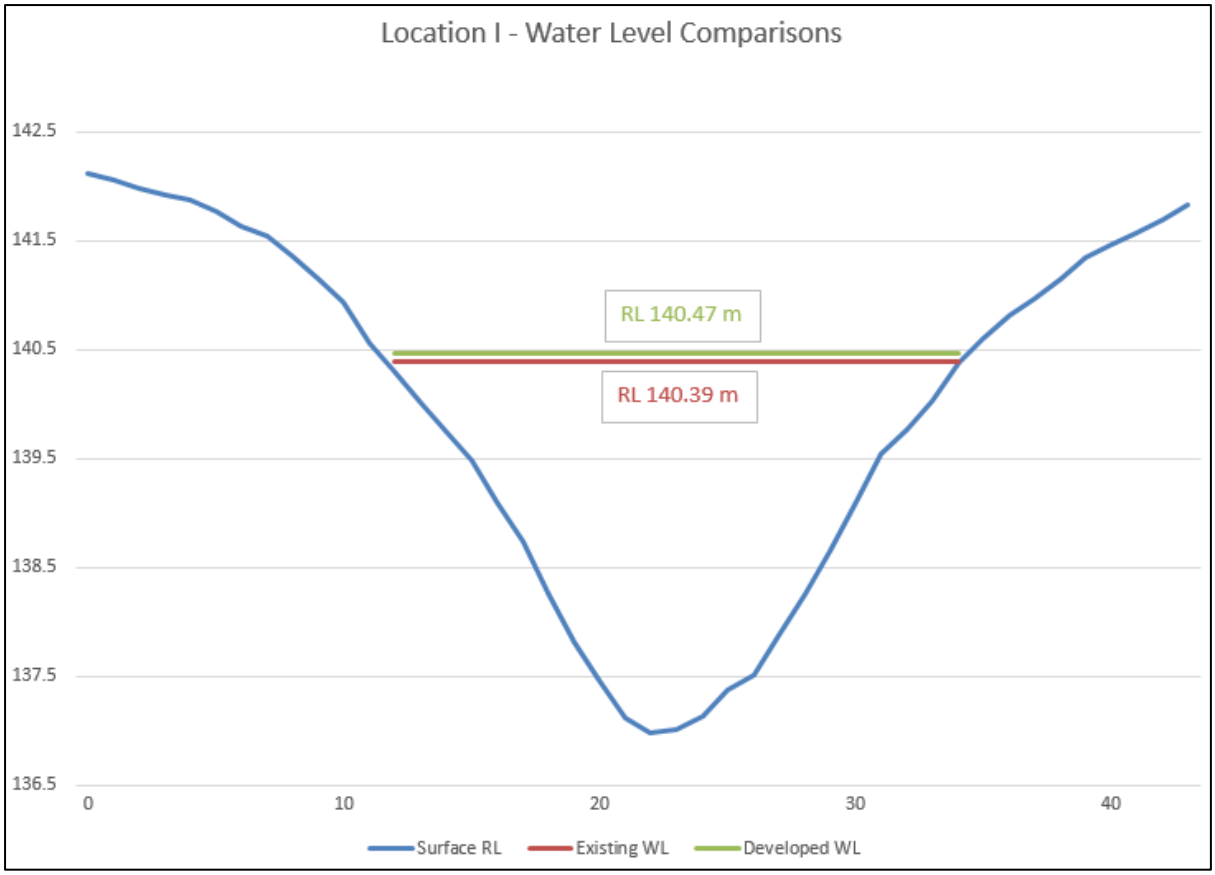
Note	As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub (./nsw_specific) is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. Probability neutral burst initial loss values for NSW are to be used in place of the standard initial loss and pre-burst as per the losses hierarchy.

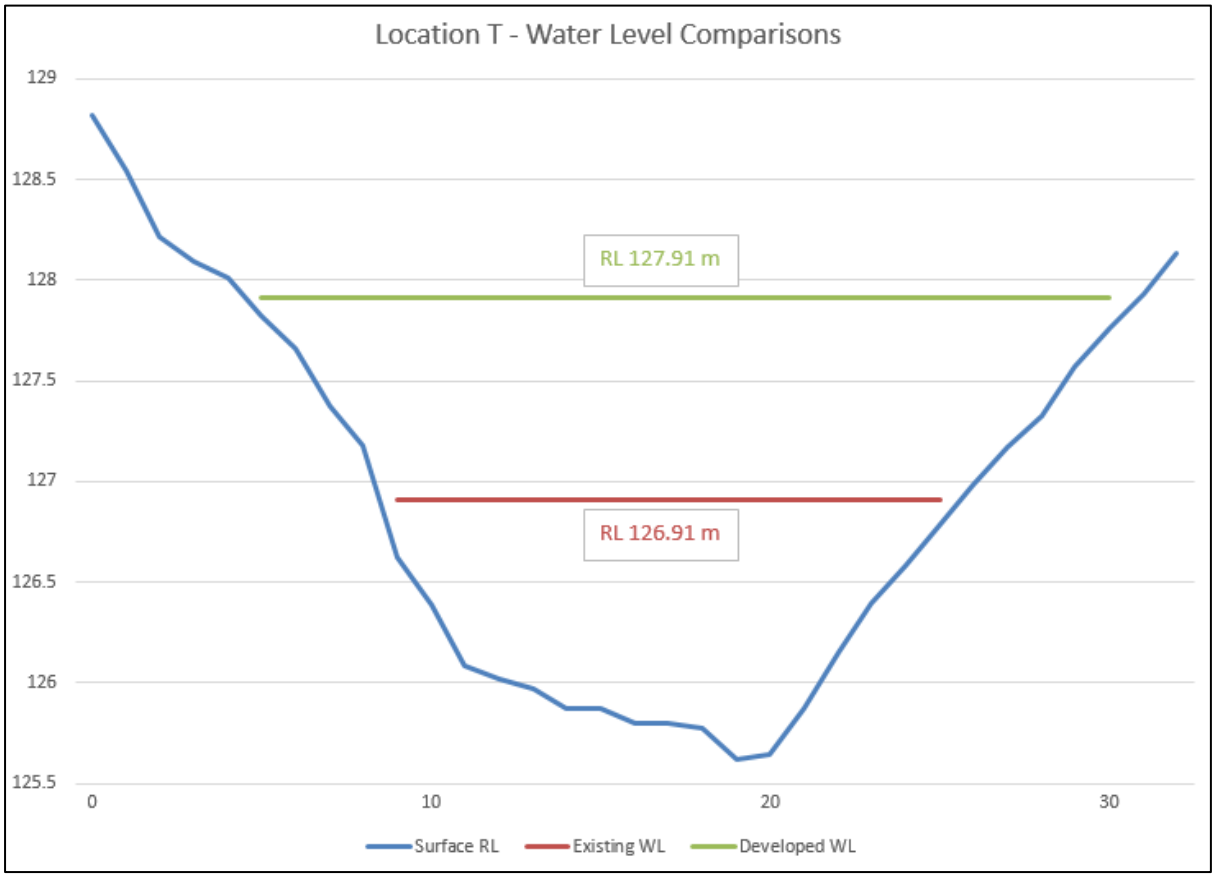
Download TXT (downloads/b996a2a1-c82c-424f-ae2b-9fd9c8476de5.txt)

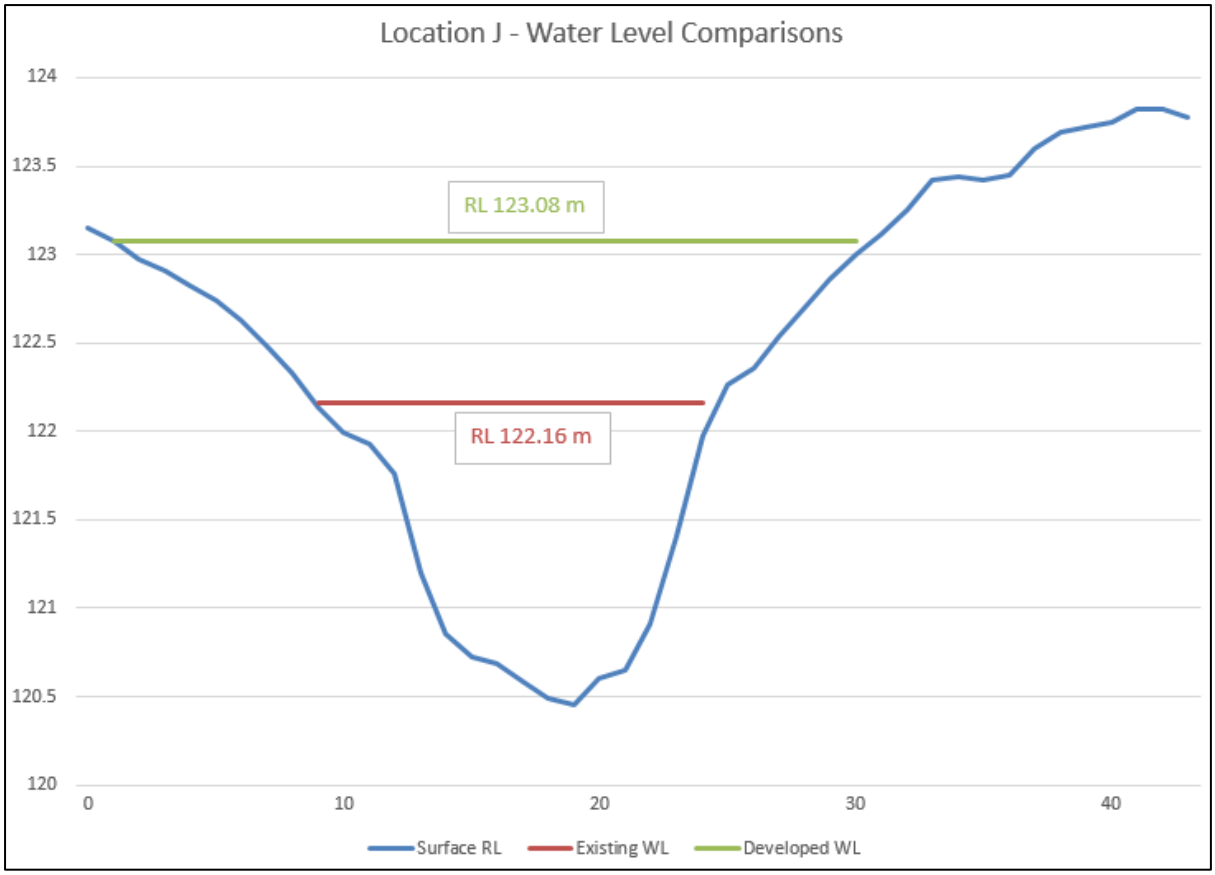
Download JSON (downloads/a2a3aea8-5abb-4941-a8fb-e774c66745f0.json)

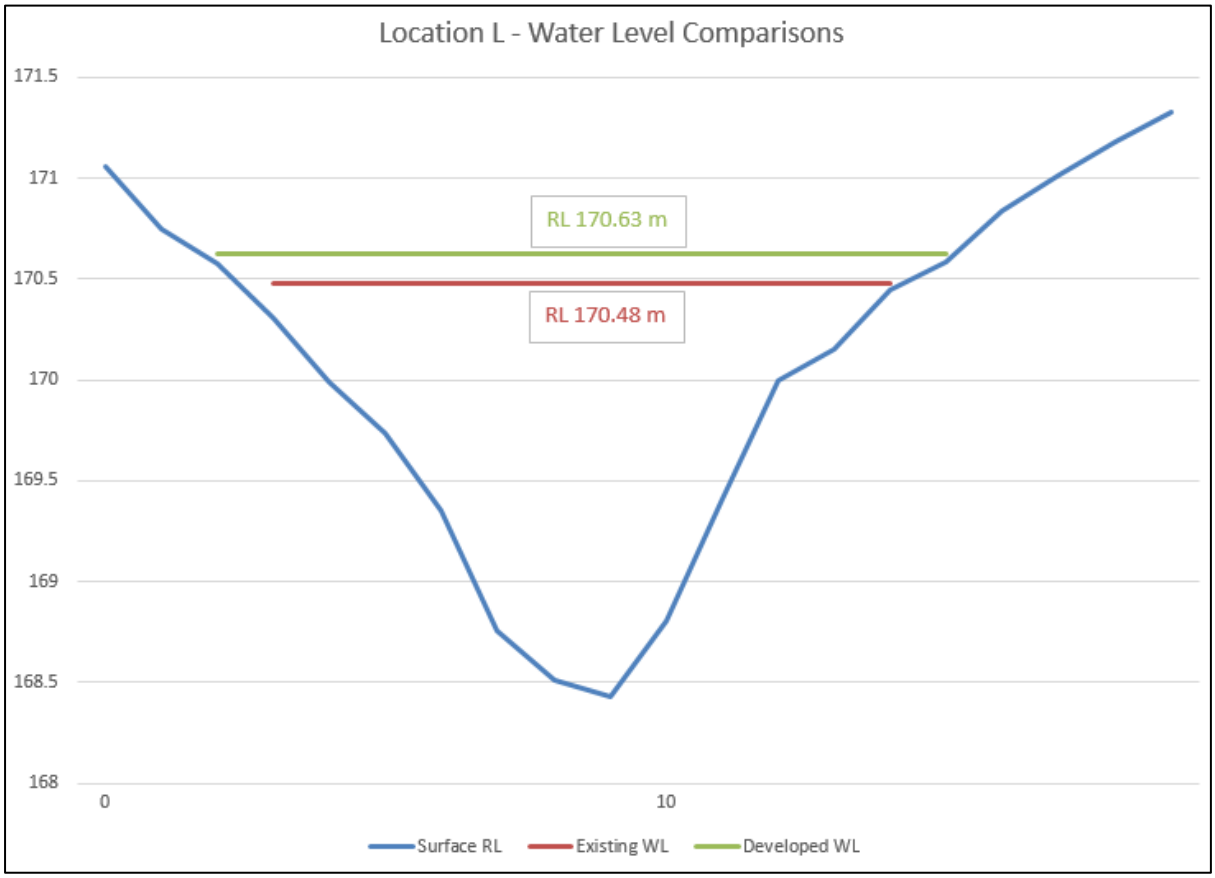
Download PDF ()

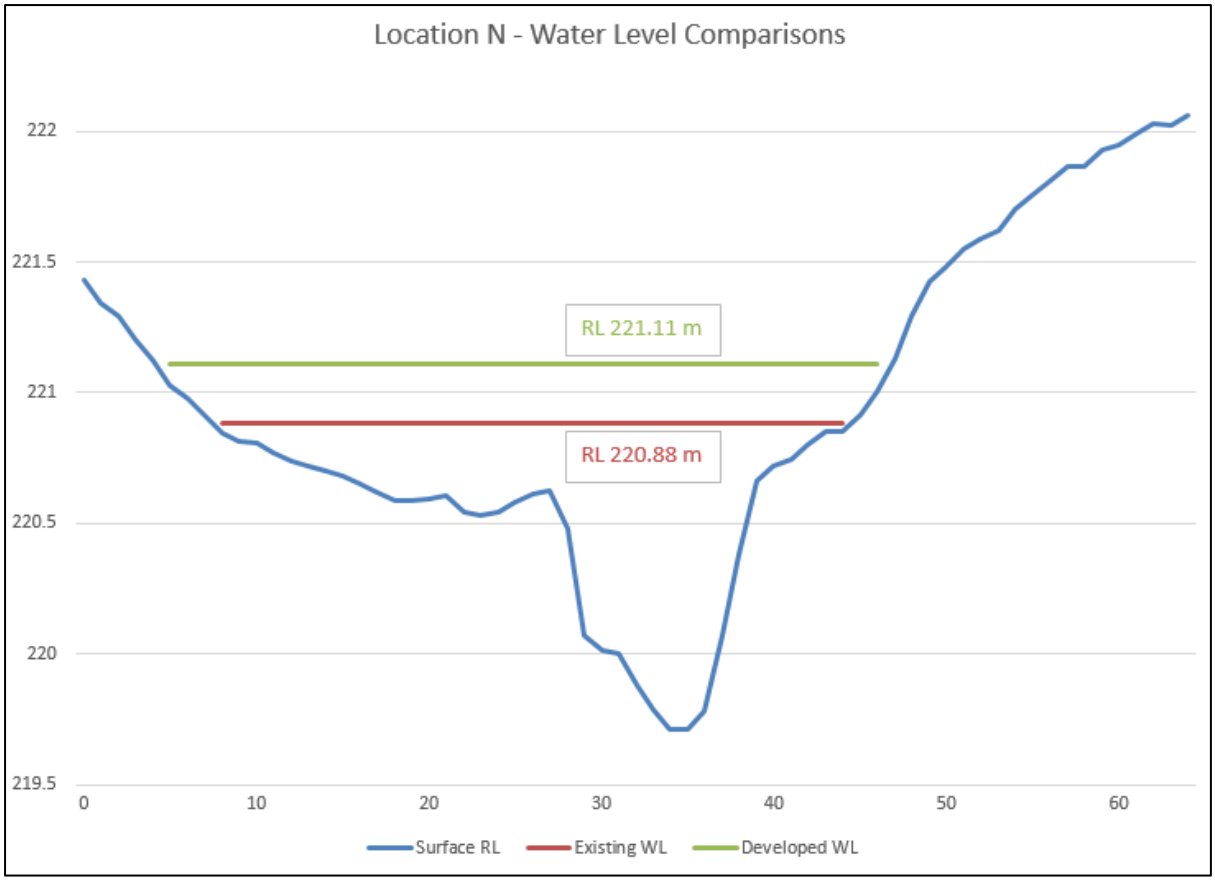
APPENDIX E – FLOOD CROSS SECTIONS

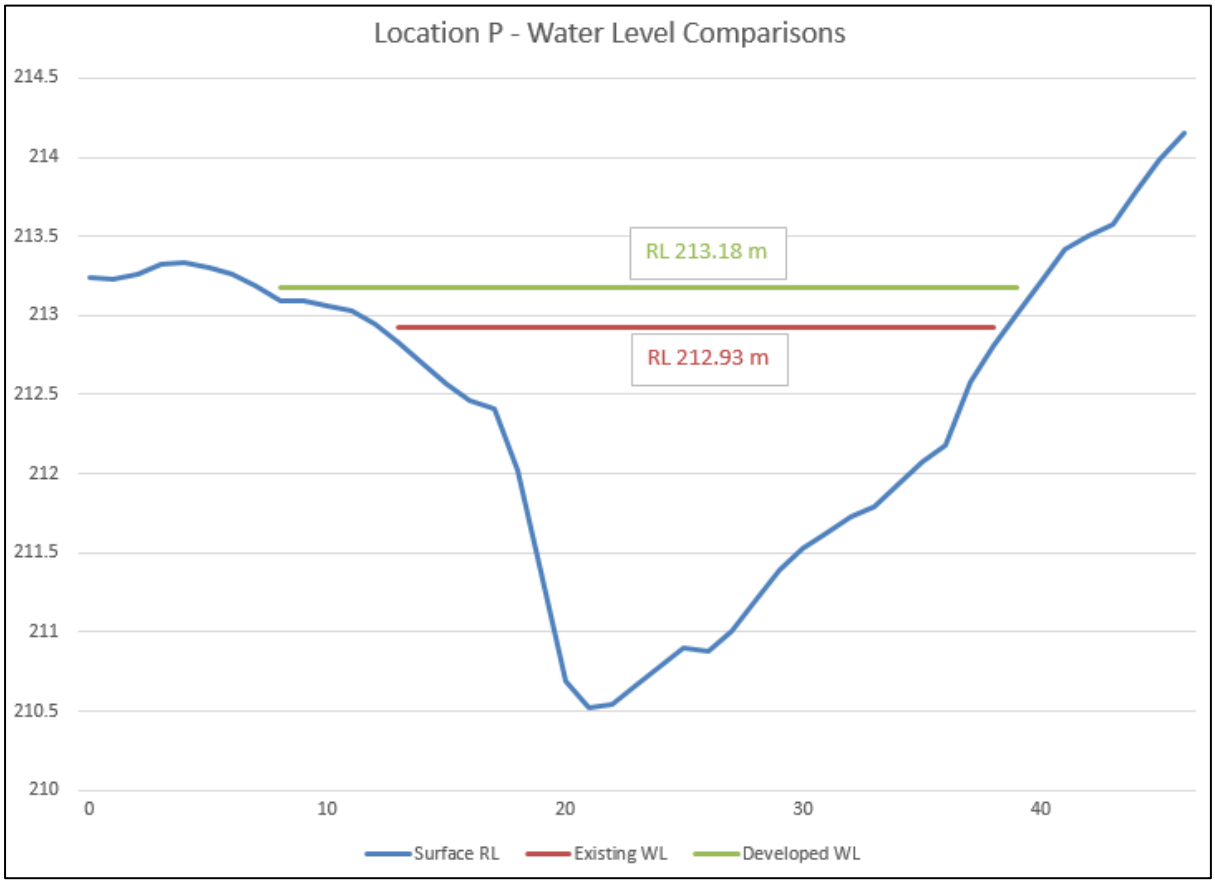

Location I - Water Level Comparisons
142.5
141.5
140.5
139.5
138.5
137.5
136.5
0
10
20
30
40
RL 140.47 m
RL 140.39 m
Surface RL
Existing WL
Developed WL


Location T - Water Level Comparisons
129
128.5
128
127.5
127
126.5
126
125.5
0
10
20
30
RL 127.91 m
RL 126.91 m
Surface RL
Existing WL
Developed WL


Location J - Water Level Comparisons
124
123.5
123
122.5
122
121.5
121
120.5
120
0
10
20
30
40
RL 123.08 m
RL 122.16 m
Surface RL
Existing WL
Developed WL


Location L - Water Level Comparisons
171.5
171
170.5
170
169.5
169
168.5
168
0
10
RL 170.63 m
RL 170.48 m
Surface RL
Existing WL
Developed WL


Location N - Water Level Comparisons
222
221.5
221
220.5
220
219.5
0
10
20
30
40
50
60
RL 221.11 m
RL 220.88 m
Surface RL
Existing WL
Developed WL


Location P - Water Level Comparisons
214.5
214
213.5
213
212.5
212
211.5
211
210.5
210
0
10
20
30
40
RL 213.18 m
RL 212.93 m
Surface RL
Existing WL
Developed WL