



The Belmore Road Precinct

Riparian Land Assessment

CKDI Bringelly Pty Ltd

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Template 2.8.1

Contents

1. Introduction	1
1.1 Description of the Project	1
1.2 Study Area and Context	1
2. Statutory and Strategic Framework	3
1.1. Statutory Framework	3
2.1 Strategic Plans	4
2.2 Relevant Guidelines	5
2.2.1 Guidelines for Controlled Activities on Waterfront Land – Riparian Corridors	5
2.3 Policy and Guidelines for Fish Habitat Conservation and Management	8
2.4 Wetlands Management Policy 2010	8
3. Methods	11
3.1 Stream Categorisation	11
3.2 Condition Assessment	11
3.3 Groundwater Dependant Ecosystems	11
4. Results	12
4.1 Aquatic and Riparian Habitat Condition Assessment	12
4.2 Confirmation of ‘rivers’	12
4.3 Riparian Reach Descriptions	15
4.3.1 First-order Creeks	16
4.3.2 Second order creek	21
4.4 Riparian Habitat	32
4.5 Groundwater Dependant Ecosystems	34
5. Recommendations	36
5.1 Indicative Layout Plan	36
5.2 Watercourses	43
5.3 Groundwater Dependant Ecosystems	43
5.4 Riparian Management Strategy	43
5.4.1 Averaging rule	44
5.4.2 Recovery potential	44
5.4.3 Management Zones	47
5.4.4 Zoning, Development Controls, Ownership and Management	49
6. Conclusions	51

List of Figures

Figure 1-1: Study area	2
Figure 2-1: Vegetated riparian corridor widths relative to Strahler stream order (DPE 2022)	6
Figure 2-2: Riparian ‘averaging rule’ for offsetting encroachment into the outer 50% of the VRZ (DPE, 2022)	8
Figure 4-1: Watercourse reaches within study area	13
Figure 4-2: Recommended riparian corridor widths.....	14
Figure 4-3: Validated vegetation communities and condition.....	33
Figure 4-4: Potential Groundwater Dependent Ecosystems mapped within study area	35
Figure 5-1: Detention basin time of inundation map for 50% AEP developed conditions (J. Wyndham Prince, 2023)	40
Figure 5-2: Detention basin time of inundation map for 1% AEP developed conditions (J. Wyndham Prince, 2023)	41
Figure 5-3: Draft Indicative Layout Plan (Urbis, 2023)	42
Figure 5-4: Recovery potential of areas within study area	46
Figure 5-5: Riparian Management Strategy zones	48

List of Tables

Table 2-1: Statutory framework and relevance to this study	3
Table 2-2: Strategic plans and relevance to this study	4
Table 2-3: Recommended riparian corridor widths relative to Strahler stream order (DPE 2022)	6
Table 2-4: Riparian corridor (RC) matrix of permissible use (DPE 2022)	7
Table 2-5: Classification of waterways for fish passage and crossing type (Fairfull 2013)	8
Table 2-6: Key fish habitat types (Fairfull 2013).....	9
Table 4-1: First-order reach descriptions	16
Table 4-2: Habitat in dams	27
Table 5-1: Total riparian zone areas.....	37
Table 5-2: NRAR guidelines requirements for online basins.....	38

Abbreviations

Abbreviation	Description
AEP	Annual Exceedance Probability
BC Act	NSW <i>Biodiversity Conservation Act 2016</i>
BOM	Bureau of Meteorology
CEEC	Critically Endangered Ecological Community
DCP	Development Control Plan
DotEE	Department of the Environment and Energy
DPIE	Department of Planning, Industry and Environment
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
ELA	Eco Logical Australia Pty Ltd
ENV	Existing Native Vegetation
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
FM Act	NSW <i>Fisheries Management Act 1994</i>
GDE	Groundwater Dependent Ecosystem
ILP	Indicative Layout Plan
LGA	Local Government Area
MNES	Matters of National Environmental Significance
NRAR	Natural Resources Access Regulator
NVR	Native Vegetation Retention
RPA	Riparian Protection Area
SEPP	State Environmental Planning Policy
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>
VRZ	Vegetated Riparian Zone
WM Act	NSW <i>Water Management Act 2000</i>

Executive Summary

Eco Logical Australia Pty Ltd (ELA) was engaged by CKDI Bringelly Pty Ltd atf (CKDI) to undertake a Riparian Land Assessment for Precinct Planning of the Belmore Road Precinct. The NSW Government aim to provide new sustainable, liveable and connected communities in the South West Growth Area to accommodate Sydney's population growth. The Belmore Road Precinct provides opportunities for development and the study area is being nominated by CKDI to be released for development ahead of the Department of Planning and Environment's (DPE) timeline, through the Precinct Acceleration Protocol. The aim of this report is to identify key ecological and riparian land constraints to assist the design of an Indicative Layout Plan (ILP).

ELA field-validated watercourses and riparian zones along watercourses, predominately along the southern and central portions of the site, where access was available. The creek lines were mostly altered from their natural state, with removal of native riparian vegetation for agricultural uses.

In total, there were 11 first order and two second-order watercourses that were accessible and assessed. Of the 11 first order reaches assessed, eight did not meet the definition of a 'river' under the *Water Management Act 2000* (WM Act), as they had no channel with defined bed and banks. All other reaches met the definition of a 'river'. The first order watercourses were generally in poor condition, with ephemeral or intermittent flow only and limited habitat features. The second order watercourses were in moderate condition, with geomorphic features such as pool, riffle and run sections. There was 12.2 ha of riparian corridor mapped within the Belmore Road Precinct, including desktop mapped first order creeks, of which 9.2 ha was field validated. The remainder of the site was mapped using desktop analysis only, using 0.5 m contours and guidance from field-validated areas.

The primary watercourse through the centre of the study area had riparian vegetation in good condition that was characteristic of *Cumberland Plain Woodland in the Sydney Basin Bioregion*, a Critically Endangered Ecological Community under the *Biodiversity Conservation Act 2016* (BC Act). This vegetation provided good habitat, contributed to bank stability, and shaded parts of the watercourse. It is recommended that a Riparian Protection Area be implemented along this primary creek line, with the riparian corridor being fully revegetated in accordance with a vegetation management plan.

Two areas within the study area were mapped on the Bureau of Meteorology Groundwater Dependent Ecosystem atlas as having high potential for terrestrial Groundwater Dependent Ecosystem (GDE). Field validation of these areas showed a consistency between the mapped GDE vegetation type and the vegetation on site. Assessment of the groundwater connectivity with these ecosystems is recommended, however it is unlikely that development activities would interfere with the groundwater table, as there is unlikely to be significant areas of excavation below the water table. Potential impacts may however include, increases in impervious surfaces in turn impacting water table recharge and depth and groundwater flows.

An ILP has been prepared that provides 12.52 ha of riparian area, of which 0.36 ha is proposed to be 'Raingardens'. Based on the results of the desktop study and field validation where access was granted, there is a total of 12.2 ha of riparian zone on the site. Note this includes the first order watercourses within the northern portion of the site that are unlikely to be a watercourse, however, have not been field validated. Subject to field validation of the north-east part of the site and NRAR review, if these

first order watercourses do not meet the definition of a watercourse, there is 10.8 ha of riparian zone on the site.

This report recommends that the protection and management of the riparian zone be achieved through:

- The use of an E2 Environmental Conservation zone
- The use of the Riparian Protection map in the *State Environmental Planning Policy (Precincts – Western Parkland City) 2021* (Western Parkland City SEPP), linked to the Camden Growth Centres Precincts Development Control Plan (DCP) clauses relating to water cycle management and native vegetation
- Preparation and implementation of Vegetation Management Plans (VMPs) concurrently with development of land adjoining the riparian corridor. The VMP is to be consistent with the objectives of the E2 zone, NRAR *Guidelines for Vegetation Management Plans on Waterfront Land*, and should allow for recreation infrastructure that does not have a significant impact on riparian values
- Vegetation management to be generally in accordance with the Riparian Management Strategy contained in this report
- Where possible, major riparian zones should be in public ownership so that public access for recreation is possible.

1. Introduction

1.1 Description of the Project

Eco Logical Australia Pty Ltd (ELA) was engaged by CKDI Bringelly Pty Ltd atf (CKDI) to undertake a Riparian Land Assessment for Precinct Planning of the Belmore Road Precinct within the South-West Growth Area. The Belmore Road Precinct study area is being nominated by CKDI to be released for development ahead of the Department of Planning and Environment's (DPE) timeline, through the Precinct Acceleration Protocol. The aim of this assessment is to identify key ecological and riparian features and constraints of the site to inform the rezoning process, as well as to provide recommendations with respect to terrestrial and aquatic ecosystem management.

Specific objectives of this project are to:

- Undertake a Riparian Corridors Assessment to inform the precinct planning process and development of the Indicative Layout Plan (ILP).
- Work in collaboration with the Water Cycle Management Service Provider, to map riparian corridors using the Strahler system and provide recommendations and planning controls for riparian lands.
- Work in collaboration with the Water Cycle Management Service Provider to identify suitable locations for stormwater management such as detention basins, stormwater outlet structures and constructed wetlands.

1.2 Study Area and Context

Figure 1-1 illustrates the broad location of the study area. The study area lies within the Hawkesbury-Nepean Catchment. The Hawkesbury-Nepean is the second largest in NSW and has its headwaters located within largely pristine regions including the Blue Mountains World Heritage Area and Sydney Catchment Authority's lands in the NSW Southern Highlands. These upper reaches provide over 90% of Sydney's drinking water. Once into flatter, floodplain country, the Hawkesbury River flows eastward towards the ocean through rural and semi-rural areas of western Sydney. These middle and lower reaches of the system are highly impacted and degraded, both directly through waterway modifications and indirectly through adjacent land-use practises. Hydrological and sediment regimes have been dramatically altered due to vegetation clearance and increasing urbanisation. Increasing impervious surfaces in the catchment are causing changes to hydrology which has greatly altered the geomorphology and ecology of the watercourses.

The study area is in the South Creek / Wianamatta sub-catchment. Numerous first, second and third order tributaries are mapped within the study area. The first order watercourse at the north of the site is a tributary of Thompsons Creek that flows from south to north and the first order watercourse in the southeast corner of the study area is a tributary of Lowes Creek. The remainder of the watercourses in the study area are tributaries of South Creek / Wianamatta and flow through the site from southwest to east. The downstream extent of the third order tributary of South Creek within the site is mapped as Key Fish Habitat (Figure 1-1) by DPI Fisheries.



Figure 1-1: Study area

2. Statutory and Strategic Framework

A substantial array of strategic plans, legislation, policies, and guidelines apply to the planning and management of biodiversity issues within the study area. This information was reviewed and used to identify priority issues and approaches for the study area and are summarised below.

1.1. Statutory Framework

Table 2-1 summarises the relevant legislation and policies that apply to the study area, which are required to be considered within the Planning Proposal.

Table 2-1: Statutory framework and relevance to this study

Legislation / Policy	Relevance
Commonwealth	
<i>Environment Protection & Biodiversity Conservation Act 1999</i> (EPBC Act)	<p>The Commonwealth EPBC Act establishes a process for assessing the environmental impact of activities and developments where Matters of National Environmental Significance (MNES) may be affected. The EPBC Act lists endangered ecological communities, threatened and migratory species that have the potential to occur, or are known to occur on a site.</p> <p>On 28 February 2012, the Commonwealth Minister for the Environment announced the program of development related activities within the Growth Centres that had been approved under the Growth Centres Strategic Assessment. Specifically,</p> <p><i>“All actions associated with the development of the Western Sydney Growth Centres as described in the Sydney Region Growth Centres Strategic Assessment Program Report (Nov 2010) have been assessed at the strategic level and approved regarding their impact on the following matters of national environmental significance (MNES):</i></p> <ul style="list-style-type: none"> • <i>World Heritage Properties</i> • <i>National Heritage Places,</i> • <i>Wetlands of International Importance,</i> • <i>Listed threatened species, populations, and communities, and</i> • <i>Listed migratory species.”</i> <p>This approval essentially means that the Commonwealth is satisfied that the conservation and development outcomes that will be achieved through development of the Growth Centres Precincts will satisfy their requirements for environmental protection under the EPBC Act. Therefore, provided development activity proceeds in accordance with the Growth Centres requirements (such as the Biodiversity Certification Order, <i>the State Environmental Planning Policy (Precincts – Western Parkland City) 2021</i> (Western Parkland City SEPP), Development Control Plans (DCPs) and Growth Centres Development Code), then there is no requirement to assess the impact of development activities on MNES and hence no requirement for referral of activities to the Commonwealth. The requirement for assessment and approval of threatened species and endangered ecological communities and the other MNES issues listed above under the EPBC Act has now been ‘turned off’ by the approval of the Strategic Assessment.</p>
State	
<i>Fisheries Management Act 1994</i> (FM Act)	<p>The FM Act aims to conserve, develop, and share the fishery resources of NSW for the benefit of present and future generations. The FM Act defines ‘fish’ as any marine, estuarine, or freshwater fish or other aquatic animal life at any stage of their life history. This includes insects, molluscs (e.g., oysters), crustaceans, echinoderms, and aquatic</p>

Legislation / Policy	Relevance
	<p>polychaetes (e.g., beachworms), but does not include whales, mammals, reptiles, birds, amphibians, or species specifically excluded (e.g., some dragonflies are protected under the <i>Biodiversity Conservation Act 2016</i> (BC Act) instead of the FM Act).</p> <p>Any activity that will block fish passage, involve dredging or reclamation of channel bed or banks or involve use of explosives in the waterway within key fish habitat, will require a permit under Part 7 of this Act.</p>
<i>Water Management Act 2000</i> (WM Act)	<p>The WM Act controls the extraction of water, the use of water, the construction of works such as dams and weirs and the carrying out of activities in or near water sources in New South Wales. 'Water sources' are defined very broadly and include any river, lake, estuary, place where water occurs naturally on or below the surface of the ground and coastal waters.</p> <p>If a 'controlled activity' is proposed on 'waterfront land', an approval is required under the WM Act (s91). 'Controlled activities' include:</p> <ul style="list-style-type: none"> the construction of buildings or carrying out of works; the removal of material or vegetation from land by excavation or any other means; the deposition of material on land by landfill or otherwise; or any activity that affects the quantity or flow of water in a water source. <p>'Waterfront land' is defined as the bed of any river or lake, and any land lying between the river or lake and a line drawn parallel to and 40 m inland from either the highest bank or shore (in relation to non-tidal waters) or the mean high-water mark (in relation to tidal waters). It is an offence to carry out a controlled activity on waterfront land except in accordance with an approval.</p> <p>The riparian corridors that exist within the Belmore Precinct have been mapped according to their stream order.</p>

2.1 Strategic Plans

Table 2-2 summarises the relevant strategic assessments that apply to the study area, which should be considered within the Planning Proposal.

Table 2-2: Strategic plans and relevance to this study

Strategic Plan	Biodiversity / Sustainability Objectives
The Greater Sydney Region Plan, <i>A Metropolis of Three Cities</i> (Greater Sydney Commission, 2018)	<p>The Greater Sydney Region Plan, <i>A Metropolis of Three Cities</i> (Greater Sydney Commission, 2018) is built on a vision of three cities where most residents live within 30 minutes of their jobs, education and health facilities, services, and great places. To meet the needs of a growing and changing population the vision seeks to transform Greater Sydney into a metropolis of three cities:</p> <ul style="list-style-type: none"> The Western Parkland City. The Central River City. The Eastern Harbour City. <p>The Plan includes directions and objectives for liveability and sustainability, productivity, and infrastructure within Greater Sydney, including two sustainability objectives, which are most relevant to this study, being:</p> <ul style="list-style-type: none"> The coast and waterways are protected and healthier. A cool and green parkland city in the South Creek corridor; and the Green Grid links parks, open spaces, bushland and walking and cycling paths.

Strategic Plan	Biodiversity / Sustainability Objectives
	<p>The Plan is supported by five District Plans, which provide greater details regarding conservation objectives, including the Western Sydney District Plan.</p>
<p>Our Greater Sydney 2056 – Western Sydney District Plan (Greater Sydney Commission, 2018)</p>	<p>The Western Sydney District Plan is a 20-year plan to manage economic, social, and environmental growth and provides a guide for implementing the Greater Sydney Region Plan at a district level. The Plan outlines two relevant sustainability planning priorities, which coincide and build on the objectives listed within the Greater Sydney Region Plan, being:</p> <ul style="list-style-type: none"> • Protecting and improving the health and enjoyment of the district’s waterways. • Creating a Parkland City urban structure and identity, with South Creek as a defining spatial element.
<p>Greener Places - An Urban Green Infrastructure Design Framework for New South Wales (Government Architect NSW, 2020) and Draft Greener Places Design Guide (Government Architects NSW, 2020)</p>	<p>Greener Places is a design framework to guide the planning, design, and delivery of green infrastructure in urban areas across NSW. It aims to create a healthier, more liveable, and sustainable urban environment by improving community access to recreation and exercise, supporting walking, and cycling connections and improving the resilience of urban areas.</p> <p>The Draft Greener Places Design Guide framework provides information on how to design, plan, and implement green infrastructure in urban areas throughout NSW. The draft guide provides a consistent methodology to help State and local government, and industry create a network of green infrastructure. This study focuses on one of the three major components of the green infrastructure network, being bushland and waterways.</p> <p>Five key strategies have been developed to connect, protect, restore, enhance, and create urban habitat as an integral part of how urban areas are planned, constructed, and maintained, which include:</p> <ul style="list-style-type: none"> • protect and conserve ecological values; • restore disturbed ecosystems to enhance ecological value and function; • create new ecosystems; • connect people to nature; and • connect urban habitats.

2.2 Relevant Guidelines

2.2.1 Guidelines for Controlled Activities on Waterfront Land – Riparian Corridors

The NSW Government Natural Resources Access Regulator’s *Guidelines for Controlled Activities on waterfront land—Riparian corridors* (DPE guidelines) published in May 2022 outlines the need for a Vegetated Riparian Zone (VRZ) adjacent to the channel to provide a transition zone between the terrestrial environment and watercourse. This vegetated zone helps maintain and improve the ecological functions of a watercourse whilst providing habitat for terrestrial flora and fauna. The VRZ plus the channel (bed and banks of the watercourse to the highest bank) constitute the ‘riparian corridor’ (Figure 2-1). To be consistent with the DPE guidelines, VRZ widths should be based on watercourse order as classified under the Strahler system of ordering watercourses and using Hydroline Spatial Data which is published on the department’s website (Table 2-3).

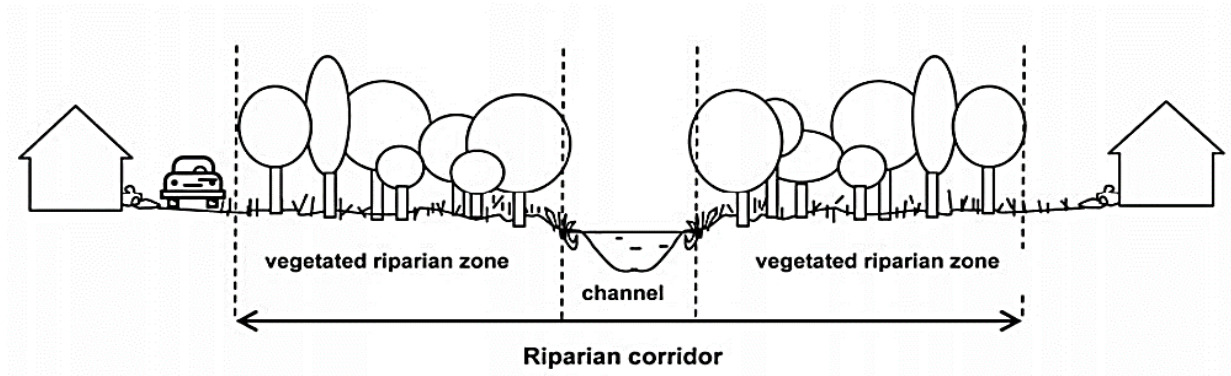


Figure 2-1: Vegetated riparian corridor widths relative to Strahler stream order (DPE 2022)

Table 2-3: Recommended riparian corridor widths relative to Strahler stream order (DPE 2022)

Watercourse Type	VRZ Width (Each Side of Watercourse)	Total Riparian Corridor Width
1 st order	10 m	20 m + channel width
2 nd order	20 m	40 m + channel width
3 rd order	30 m	60 m + channel width
4 th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 m	80 m + channel width

Certain works are permissible within the riparian zone if specific design criteria are met (Table 2-4 and key below). Non-riparian uses in the outer 50% of the VRZ are permitted as long as compensation (1:1 offset) is achieved within the site using the ‘averaging rule’ (Figure 2-2).

Table 2-4: Riparian corridor (RC) matrix of permissible use (DPE 2022)

Stream Order	Vegetated Zone (VRZ)	Riparian RC	Offsetting for Non-RC Uses	Cycleways and Paths	Detention Basins		Stormwater Structures and Essential Services	Outlet and Stream Realignment	Road Crossings		
					Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1 st	10 m		•	•	•	•	•	•	•		
2 nd	20 m		•	•	•	•	•		•		
3 rd	30 m		•	•	•		•			•	•
4 th +	40 m		•	•	•		•			•	•

KEY TO RIPARIAN CORRIDOR MATRIX

STREAM ORDER: THE WATERCOURSE ORDER AS CLASSIFIED UNDER THE STRAHLER SYSTEM BASED ON HYDROLINE SPATIAL DATA PUBLISHED ON THE DEPARTMENT'S WEBSITE¹

VEGETATED RIPARIAN ZONE (VRZ): THE REQUIRED WIDTH OF THE VRZ MEASURED FROM THE TOP OF THE HIGH BANK ON EACH SIDE OF THE WATERCOURSE.

RIPARIAN CORRIDOR (RC) OFF-SETTING FOR NON RC USES: NON-RIPARIAN USES, SUCH AS BUSHFIRE ASSET PROTECTION ZONES, ROADS AND URBAN DEVELOPMENT ARE ALLOWED WITHIN THE OUTER 50% OF THE VRZ, SO LONG AS OFFSETS ARE PROVIDED IN ACCORDANCE WITH THE AVERAGING RULE AS SEEN IN FIGURE 2-2.

CYCLEWAYS AND PATHS: CYCLEWAYS OR PATHS NO WIDER THAN FOUR METRES TOTAL DISTURBANCE FOOTPRINT CAN BE BUILT IN THE OUTER 50% OF THE VRZ.

DETENTION BASINS: DETENTION BASINS CAN BE BUILT IN THE OUTER 50% OF THE VRZ OR ONLINE WHERE INDICATED. ONLINE BASINS MUST: BE DRY AND VEGETATED, BE FOR TEMPORARY FLOOD DETENTION ONLY WITH NO PERMANENT WATER HOLDING, HAVE AN EQUIVALENT VRZ FOR THE CORRESPONDING WATERCOURSE ORDER AND NOT BE USED FOR WATER QUALITY TREATMENT PURPOSES.

STORMWATER OUTLET STRUCTURES AND ESSENTIAL SERVICES: STORMWATER OUTLETS OR ESSENTIAL SERVICES ARE ALLOWED IN THE RC. WORKS FOR ESSENTIAL SERVICES ON A FOURTH ORDER OR GREATER STREAM ARE TO BE UNDERTAKEN BY DIRECTIONAL DRILLING OR TIED TO EXISTING CROSSINGS.

STREAM REALIGNMENT: INDICATES THAT A WATERCOURSE MAY BE REALIGNED.

ROAD CROSSINGS: INDICATES PERMITTED ROAD CROSSING METHODS. ALSO REFER TO DPI FISHERIES POLICY AND GUIDELINES FOR FISH FRIENDLY WATERWAY CROSSINGS (FAIRFULL 2013, DISCUSSED BELOW).

¹ <https://www.industry.nsw.gov.au/water/licensing-trade/hydroline-spatial-data>

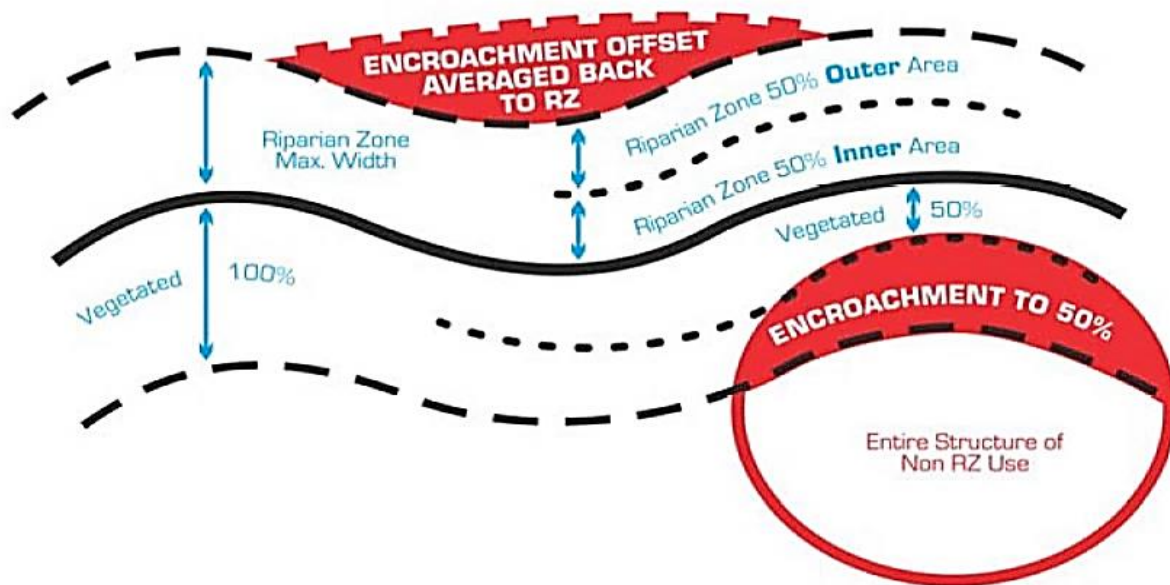


Figure 2-2: Riparian 'averaging rule' for offsetting encroachment into the outer 50% of the VRZ (DPE, 2022)

2.3 Policy and Guidelines for Fish Habitat Conservation and Management

The DPI Policy and guidelines for fish habitat conservation and management (Fairfull, 2013) (DPI Policy and Guidelines) is a supplementary document that outlines the requirements and obligations under the FM Act and the Fisheries Management (General) Regulation 2010 and were developed to maintain and enhance fish habitat and assist in the protection of threatened species. The DPI Policy and Guidelines provides a definition of key fish habitat and provides guidance for assigning a classification of waterways for fish passage, which informs the types of infrastructure suitable for the creek line (Table 2-5) and sensitivity of the key fish habitat present, which determines the potential disturbance and offsetting required for development.

2.4 Wetlands Management Policy 2010

The NSW Wetlands Management Policy (DECCW 2010) aims to provide for the protection, ecologically sustainable use, and management of NSW wetlands. Wetlands include lakes, lagoons, estuaries, rivers, floodplains, swamps, bogs, billabongs, marshes, coral reefs, and seagrass beds. Wetlands within the study area occur within the riparian corridor.

Table 2-5: Classification of waterways for fish passage and crossing type (Fairfull 2013)

Classification	Characteristics of Waterway Class and Preferred Crossing Type
CLASS 1 Major key fish habitat	<ul style="list-style-type: none"> Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g., river or major creek), habitat of a threatened or protected fish species or 'critical habitat'. Bridge, arch structure, or tunnel. Bridges are preferred to arch structures.
CLASS 2 Moderate key fish habitat	<ul style="list-style-type: none"> Non-permanently flowing (intermittent) stream, creek, or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pool or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present. Bridge, arch structure, culvert ^[1] or ford.

Classification	Characteristics of Waterway Class and Preferred Crossing Type
	<ul style="list-style-type: none"> Bridges are preferred to arch structures, box culverts and fords (in that order).
CLASS 3 Minimal key fish habitat	<ul style="list-style-type: none"> Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (e.g., fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other CLASS 1-3 fish habitats. Culvert^[2] or ford. Box culverts are preferred to fords and pipe culverts (in that order).
CLASS 4 Unlikely key fish habitat	<ul style="list-style-type: none"> Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or freestanding water or pools post rain events (e.g., dry gullies or shallow floodplain depressions with no aquatic flora present). Culvert^[3], causeway or ford. Culverts and fords are preferred to causeways (in that order).

KEY TO CROSSING TYPE

[1] HIGH PRIORITY GIVEN TO THE 'HIGH FLOW DESIGN' PROCEDURES PRESENTED FOR THE DESIGN OF THESE CULVERTS—REFER TO THE "DESIGN CONSIDERATIONS" SECTION OF FAIRFULL AND WITHERIDGE 2003.

[2] MINIMUM CULVERT DESIGN USING THE 'LOW FLOW DESIGN' PROCEDURES; HOWEVER, 'HIGH FLOW DESIGN' AND 'MEDIUM FLOW DESIGN' SHOULD BE GIVEN PRIORITY WHERE AFFORDABLE—REFER TO THE "DESIGN CONSIDERATIONS" SECTION OF FAIRFULL AND WITHERIDGE (2003).

[3] FISH FRIENDLY WATERWAY CROSSING DESIGNS POSSIBLY UNWARRANTED. FISH PASSAGE REQUIREMENTS SHOULD BE CONFIRMED WITH NSW DPI.

AS NOTED IN FAIRFULL AND WITHERIDGE 2003, THERE ARE ADDITIONAL FACTORS THAT MUST BE TAKEN INTO CONSIDERATION BY THOSE INVOLVED IN WATERWAY CROSSING DESIGN AND CONSTRUCTION, INCLUDING PUBLIC SAFETY, SOCIAL AND BUDGETARY CONSTRAINTS. EACH CROSSING IS THEREFORE ASSESSED BY NSW DPI ON A CASE-BY-CASE BASIS.

Table 2-6: Key fish habitat types (Fairfull 2013)

Key fish habitat and associated sensitivity classification scheme (for assessing potential impacts of certain activities and developments on key fish habitat types)	
TYPE 1 – Highly sensitive key fish habitat	<ul style="list-style-type: none"> <i>Posidonia australis</i> (strapweed). <i>Zostera</i>, <i>Heterozostera</i>, <i>Halophila</i> and <i>Ruppia</i> species of seagrass beds >5 m² in area. Coastal saltmarsh >5 m² in area. Coral communities. Coastal lakes and lagoons that have a natural opening and closing regime (i.e., are not permanently open or artificially opened or are subject to one off unauthorised openings). Marine Park, an aquatic reserve or intertidal protected area. Coastal wetlands mapped under the <i>State Environmental Planning Policy (Resilience and Hazards) 2021</i>, wetlands recognised under international agreements (e.g., Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia. Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 m in length, or native aquatic plants. Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act. Mound springs.
TYPE 2 – Moderately sensitive key fish habitat	<ul style="list-style-type: none"> <i>Zostera</i>, <i>Heterozostera</i>, <i>Halophila</i> and <i>Ruppia</i> species of seagrass beds <5 m² in area. Mangroves. Coastal saltmarsh <5 m² in area. Marine macroalgae such as <i>Ecklonia</i> and <i>Sargassum</i> species. Estuarine and marine rocky reefs. Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g., managed in line with an entrance management program).

Key fish habitat and associated sensitivity classification scheme (for assessing potential impacts of certain activities and developments on key fish habitat types)

			<ul style="list-style-type: none"> • Aquatic habitat within 100 m of a marine park, an aquatic reserve or intertidal protected area. • Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna. • Freshwater habitats and brackish wetlands, lakes, and lagoons other than those defined in TYPE 1. • Weir pools and dams up to full supply level where the weir or dam is across a natural waterway.
TYPE 3	–	Minimally sensitive key fish habitat may include:	<ul style="list-style-type: none"> • Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna. • Coastal and freshwater habitats not included in TYPES 1 or 2. • Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

3. Methods

3.1 Stream Categorisation

The Strahler stream order classification was extracted from the State Government's GIS dataset. Top of bank was estimated using aerial photographs and 0.5 m contours before being field-validated on 14th February and 15th and 16th October 2020 by two aquatic ecologists, using a GPS-enabled tablet. Each watercourse that met the definition of a 'river' under the WM Act was assigned the appropriate riparian corridor width in accordance with the Strahler stream order. Riparian widths were then applied using ArcPro.

3.2 Condition Assessment

The watercourses and riparian zones were visually assessed for ecological value regarding physical form, benthic substrate, fish habitat, instream woody debris and vegetation condition.

The condition assessment was undertaken to recognise key components of watercourse health and function. The level of assessment conducted was chosen to assist with future management of watercourse and riparian environments within the study area by highlighting current values, threats, and limits to potential improvements along the watercourse. All dams were inspected for habitat, with time spent listening for frogs and observing birds at each.

Field surveys were conducted along the length of the watercourse wherever access was permitted. There were areas of the study area that were unable to be accessed due to restrictions by landholders. Figure 1-1 shows the area accessed and surveyed.

3.3 Groundwater Dependant Ecosystems

Groundwater Dependant Ecosystems (GDEs) were initially identified by reviewing the GDE Atlas (BOM 2020) for the site. There were no aquatic GDEs mapped in the site. There were two areas where there was high potential for terrestrial GDEs to exist.

4. Results

4.1 Aquatic and Riparian Habitat Condition Assessment

The creek lines in the study area have been altered from their natural state due to works along the creek (creation of dams and crossings), removal of native riparian vegetation to facilitate agricultural land uses, increase in impervious surfaces in the upstream catchments, increases in sediment and nutrient transport through the system and various other factors.

Nonetheless, all tributaries have value as a component of the catchment and riparian corridors that exist in the region. Where present, the tributaries of each creek also provide instream habitat for local fish species, aquatic macrophytes and aquatic macroinvertebrates all of which contribute to local ecosystem health. Programs that encourage improvements in these ecosystem values will be crucial to improving the condition of downstream environments.

There were 13 first-order, two second order and one third order creeks mapped in the study area. Of these, 11 first order watercourses and two second order watercourses were able to be assessed. Creeks bordering the site were assessed, where possible, to determine if their riparian buffers would encroach. The location of each reach and whether it was a defined channel is shown in Figure 4-1. The current condition of the creeks is summarised in Section 4.3.

4.2 Confirmation of ‘rivers’

The Guidelines for Riparian Corridors on Waterfront Land (Natural Resources Access Regulator (NRAR) 2018) acknowledge that some hydro-lines on topographic maps may not meet the definition of a river under the WM Act. This is generally the case where there is no defined bed or bank and no evidence of channelised flow or geomorphic processes such as erosion and deposition. ELA has identified several hydro lines which do not have the characteristics of a river and should not require protection in the precinct (Figure 4-1). Consultation with NRAR is recommended to confirm whether NRAR support the findings described below.

NRAR must be consulted if there is intention to remove any hydro-lines which do meet the definition of a river.

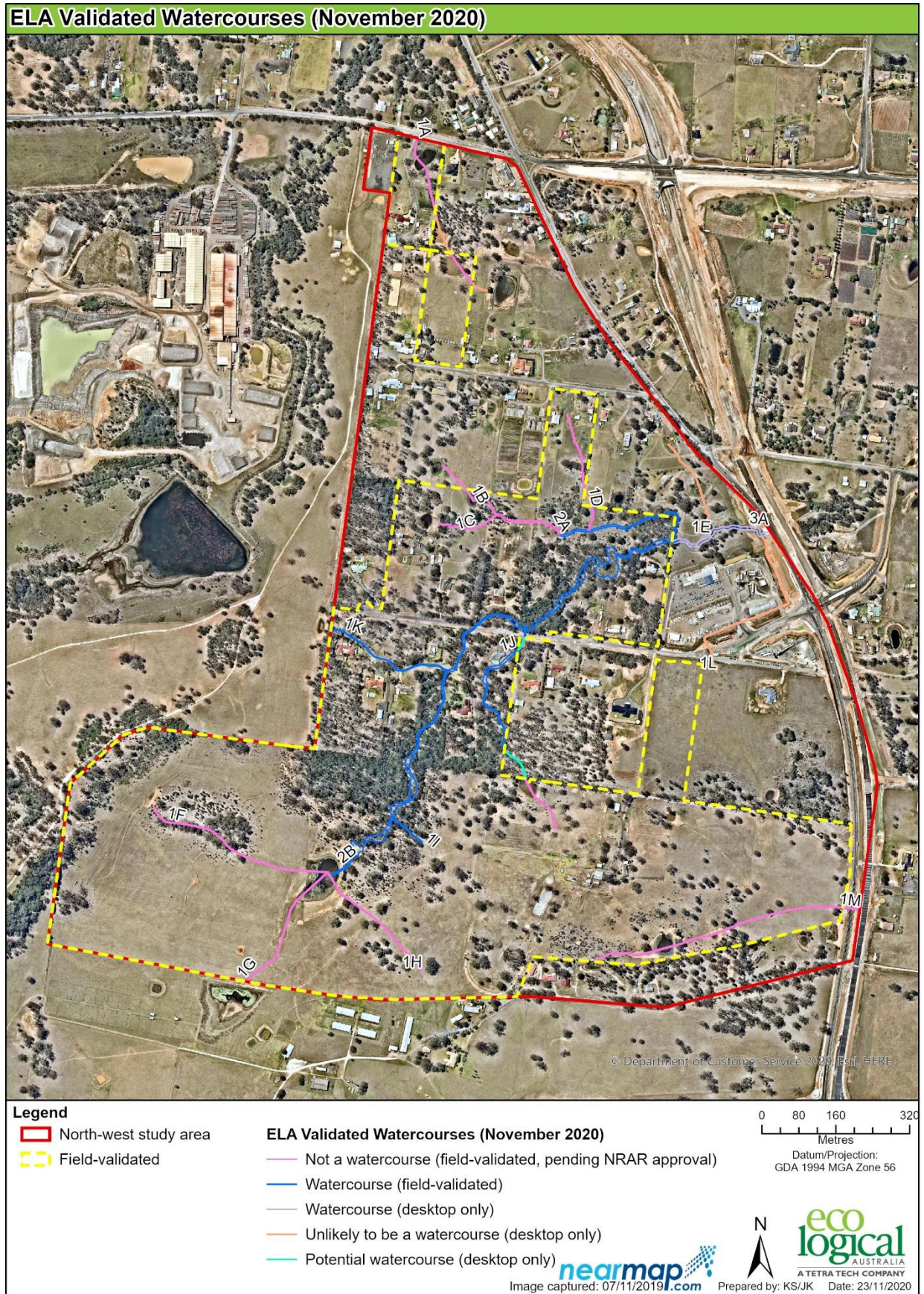


Figure 4-1: Watercourse reaches within study area

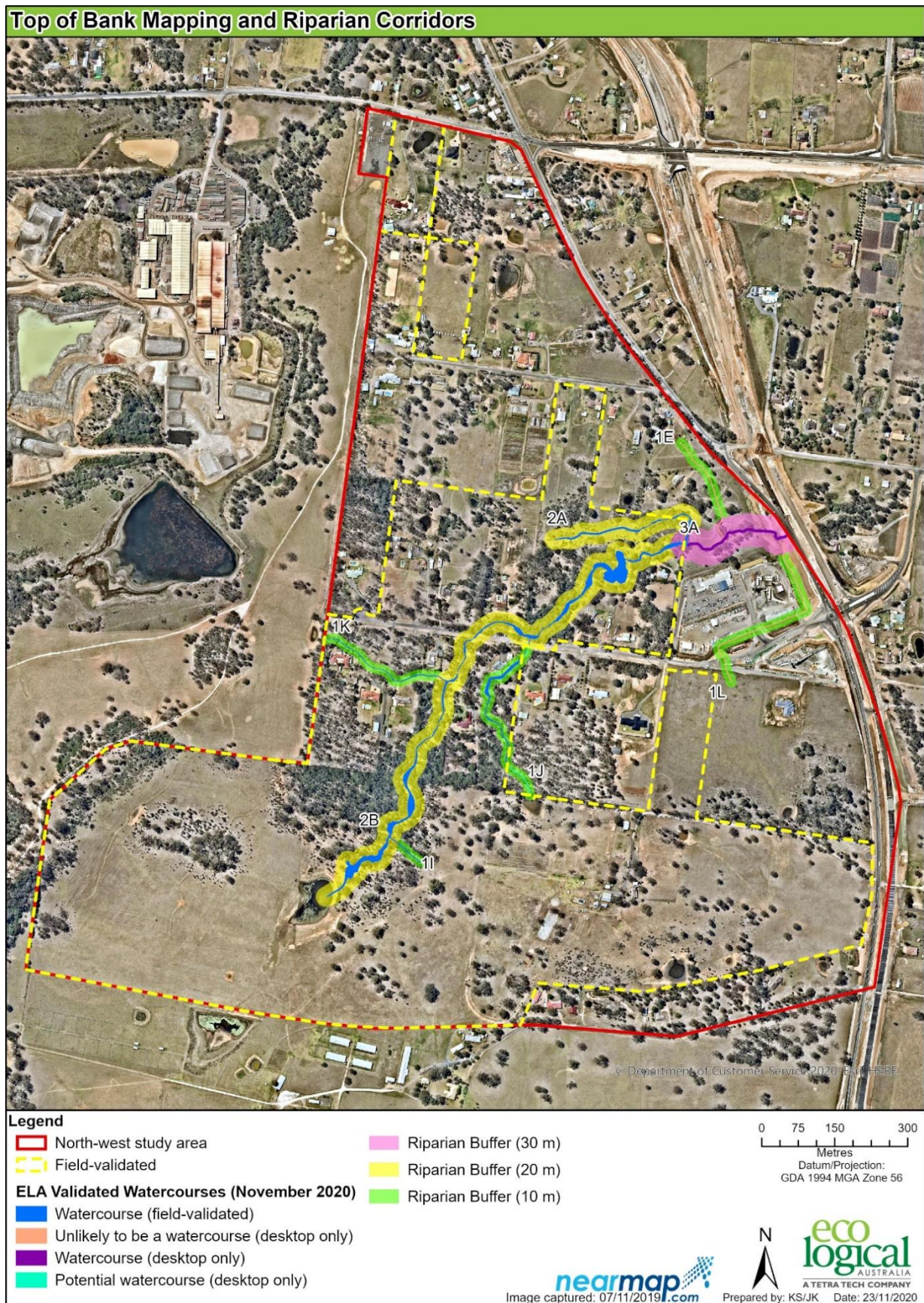


Figure 4-2: Recommended riparian corridor widths

4.3 Riparian Reach Descriptions

Only reaches that were field validated have been described below. Reach descriptions for first-order creeks are detailed in Table 4-1. Where a watercourse had defined bed and banks upstream, the downstream mapped watercourse was classified as a 'river', regardless of the presence of bed and banks. For each reach, a condition of good, moderate, or poor was applied based on the following attributes:







- Stream shape and size
- Frequency of flow (ephemeral or perennial)
- Presence of aquatic habitat (pools, riffles, large woody debris, vegetation)
- Potential for threatened or protected fish species or fauna
- Connection with other habitats.







Watercourses in good condition had clearly defined bed and banks with intermittent to semi-permanent water in pools with aquatic vegetation present. Large woody debris was present, with a range of geomorphological features such as pools and riffles that would provide good aquatic habitat. Watercourses in moderate condition had clearly defined bed and banks with ephemeral or intermittent flow after a rain event. Aquatic vegetation may or may not be present, with less instream features such as woody debris and limited or no variety of geomorphological features. These creeks would provide fish passage during rain events and refuge for fauna such as turtles. Poor condition watercourses had poorly or no defined bed and banks and were typically a dry gully or depression, lacking aquatic vegetation with no habitat for fish or other fauna.





Dams were present throughout the site and have been described in Table 4-2. Overall, dams provided habitat for fish, frogs, turtles and water and wader birds.







4.3.1 First-order Creeks

Table 4-1: First-order reach descriptions

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1A	Not a river	No defined bed or banks. Overland flow path in times of overtopping dam	Poor		
1B	Not a river	No defined bed or banks	Poor		
1C	Not a river	No defined channel, bed or banks	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1D	Not a river	No defined bed or banks. Mown grass for almost entire length of mapped location.	Poor		
1F	Not a river	No defined bed or banks. Overland flow path at a low point only.	Poor		
1G	Not a river	No defined bed or banks. Areas of saturated soil following recent heavy rain.	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1H	Not a river	No defined channel. Informal track near mapped location of this watercourse, likely created by stock accessing dam.	Poor		
1I	River	Defined channel approximately 1 m wide that started at a head cut about 60 m to the south east of the main channel 2B. Densely covered in <i>Olea europaea</i> subsp. <i>cuspidata</i> (African Olive) and no groundcover vegetation, allowing for easy erosion of banks and bed of channel. Right bank steeply sloped, approximately 0.5 m high. Household rubbish visible within this channel.	Poor		
1J - upper	Not a river	No defined channel upstream of the dam on this watercourse.	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1J - lower	River	Defined channel at Belmore Road. Single concrete box culvert approximately 1.5 m wide and 0.75 m high carries flow under Belmore Road to confluence with 2B.	Moderate		
1K	River	Near the top of this watercourse, the channel had been rock lined within multiple properties. The channel was less defined as it neared the confluence with 2B.	Poor - moderate		
1L (at Belmore Road)	River	Upstream of Belmore Road there was no defined channel, however, there appears to be a constructed drainage line within the property downstream of Belmore Road where access was restricted.	Poor		

Reach	Proposed WM Act Status (pending NRAR approval)	Description	Condition	Photo Facing Upstream	Photo Facing Downstream
1M	Not a river	No defined channel. Overland flow paths across pasture were observed following recent rain.	Poor		

4.3.2 Second order creek

4.3.2.1 2A

Reach 2A started further downstream than was mapped on the Strahler layer. It started as a wet depression with a variety of sedges before becoming a well-defined creek where it flowed through three large pipes. On the downstream side of these pipes, the creek was heavily disturbed, with evidence of bed and bank erosion observed and building rubble within the creek line.



Facing upstream – large pipes near top of 2A



Facing downstream – eroded channel

The channel narrowed as it continued downstream, with pools of standing water observed in the creek following recent rain. The channel was shallow and narrow with no aquatic flora observed. Riparian vegetation was predominantly native, with a continuous band between the right bank of 2A and left bank of 2B.



Facing upstream



Facing downstream

Where the channel neared the confluence with 3A, it became a wide, less-defined channel. The creek is likely to have been previously modified in this area, as it had a sharp turn in it as it flowed south towards the confluence with 3A.



Facing upstream – upstream of confluence with 3A



Facing downstream

4.3.2.2 2B

Reach 2B was only field validated where it was within Lot 6 DP1216926 and where it crossed Belmore Road, where access was available.

The upstream extent of 2B was a large dam at the base of sloping fields lacking in canopy cover and densely covered in exotic pasture grasses. The dam was overflowing around the north-eastern side at a low point, rather than through a defined spillway. Downstream of the dam the channel of 2B was approximately 20 m wide in some areas. Water sheeted across this area, which was covered in short exotic grass including *Cynodon dactylon* (Couch). Some small gravels (3 – 5 mm diameter) were observed on the channel bed in this wide section of watercourse and the banks showed signs of historical erosion, likely during very high flows, and were approximately 1.5 m high. The riparian vegetation was sparse and patchy alongside this section of 2B and did not form a continuous strip of vegetation alongside the dam and overflow area.



Facing upstream – below large dam



Facing downstream – wide channel.

Approximately 100 m downstream of the dam on this reach, the dispersed flow converged at head cut within the channel. The head cut was shallow, in that it was approximately 0.3 m high, however erosion in this area had exposed large pieces of slate and tree roots. Water flowing over the head cut created a small riffle area and scattered *Juncus usitatus* was observed on the edge of the channel downstream of this riffle.

*Facing upstream**Facing downstream – head cut*

Upstream of the confluence of 2B and 1I, a head cut was observed on the right bank and a flood runner was evident parallel to the left bank. The channel was shallow, and the channel banks were low with a gentle grade. Leaf litter was observed on the channel bed and this litter was covered in a fine silty deposit. The channel was wide through this area, up to 15 m wide in some areas. The water was tannin-stained and still but not stagnant and there was a small amount of vegetation overhanging the edges of the channel. No aquatic vegetation was observed in this part of 2B.

*Facing upstream**Facing downstream*

Opposite the confluence of 2B and 1I, a well-defined overland flow path joined the main channel of 2B. There was no mapped watercourse in the location of this overland flow area, however it was approximately 3 m wide in most areas, up to 5 m at its widest point, with banks approximately 1.5 m high. No aquatic vegetation was observed in this area and the bed had scattered gravel on the clay substrate bed.

Approximately 100 m upstream of the boundary fence between Lot 6 DP 1216926 and Lot 94 DP 864637, 2B existed as a braided channel, in that the flow was split around small instream islands containing juvenile *Eucalyptus tereticornis* (Forest Red Gum). A small area of undercutting of the right bank was observed in this area. Water in the channel was stained by tannins. The channel itself was partly shaded at the time of survey (9:30 am).



Facing upstream



Facing downstream



Facing upstream



Facing downstream

At the downstream end of the accessible portion of 2B, this watercourse was a wide, shallow creek following recent rain. A large amount of instream woody debris was present and flood debris was observed against the fence line at the northern end of this Lot. Visibility through the shallow water column was good on the day of the site survey and no odour or sheen were evident. The creek had a silty substrate, and no active areas of erosion were observed. The creek banks sloped gradually away from the channel. Riparian vegetation alongside this section of the watercourse was dense and was comprised of a native canopy with a disturbed shrub layer dominated by *Olea europaea* subsp. *cuspidata* (African Olive).



Facing upstream



Facing downstream

Two concrete box culverts, each approximately 1 m high and 1.5 m wide carried the flow under Belmore Road. No geomorphic features were observed downstream of this area, with the water flowing through a defined channel that had sandstone boulders armouring the left bank and a more gradual sloping right bank. No aquatic vegetation was observed in this area of the channel, whilst riparian vegetation was comprised of scattered *Eucalyptus* sp. with *Agapanthus praecox* subsp. *orientalis* (Agapanthus) growing on the top of the sandstone-boulder bank. Overall, this watercourse was in moderate condition, as it had a variety of instream geomorphological features and limited bed and bank erosion was observed, however macrophytes within the channel were non-existent.



Facing upstream



Facing downstream

At the rear of properties along Belmore Road, 2B was a 10 m wide channel in some areas. Emergent macrophytes including *Ludwigia peploides* were observed growing on the edge of the channel and several large fallen trees have created good aquatic habitat within this area. Water in the channel was tannin-stained but not turbid. At the rear of 58 Belmore Road, the creek became a wetland up to 40 m wide and covered in dense *Typha orientalis* and *Azolla* sp. *Rubus fruticosus* (Blackberry) was observed in dense clumps along the right bank of the channel.



Facing upstream



Facing downstream – large woody debris in channel






Facing upstream – wetland area









Facing downstream



Table 4-2: Habitat in dams

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
1A	1	Large dam near the upstream mapped extent of reach 1A. No defined spillway and a few sparse <i>Eucalyptus moluccana</i> on the edges of the dam.	<i>Platalea regia</i> (Royal Spoonbill) was observed near this dam.	No aquatic flora	
1A	2	Large dam near Greendale Road. At time of survey, water in the dam was clear with no oil sheen or odours.	No aquatic fauna observed.	Emergent macrophytes including <i>Persicaria strigosa</i>	
1F	1	No defined spillway but evidence of overflow after recent rain.	Frog eggs attached to submerged grasses.	Submerged <i>Typha orientalis</i> (Cumbungi).	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
N/A		Small dam in between mapped reaches 1G and 1F. At capacity at time of site survey, overflowing to north behind artificial swale perpendicular to slope. Water was turbid and stagnant, with slight odour.	Frog eggs attached to submerged grasses.	No aquatic flora.	
1G	1	Dam located to south west of mapped location of 1G. Small dam with no fringing vegetation and raised dam wall on eastern side of dam but no defined spillway. Turbid water with submerged pasture grasses and emergent macrophytes. Vegetative debris floating on surface of water.	Frog eggs attached to submerged grasses.	No aquatic flora.	
1M	1	Dam located at top of this mapped watercourse, outside accessible area. Surrounded by scattered <i>Olea europaea</i> subsp. <i>cuspidata</i> , <i>Bursaria spinosa</i> and exotic pasture grasses.	No fauna observed.	No aquatic flora observed.	No photo available

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
1M	2	Dam at capacity following recent rain, water slightly turbid and no fringing vegetation present. Clay substrate and no defined spillway on downstream side.	<i>Porphyrio porphyrio</i> (Purple Swamphen) and <i>Phalacrocorax sulcirostris</i> (Little Black Cormorant).	<i>Ludwigia peploides</i> .	
1M	3	There were no defined banks to this dam, which appeared to be nearing capacity. No macrophytes were observed in this dam and visibility through the water column was good.	<i>Porphyrio porphyrio</i> (Purple Swamphen), <i>Anas castanea</i> (Chestnut Teal) and <i>Phalacrocorax sulcirostris</i> (Little Black Cormorant).	No aquatic flora observed.	
1M	4	Dam near bottom of mapped location of 1M, outside of accessible area. Dam nearing capacity and fringed by <i>Casuarina</i> sp.	<i>Porphyrio porphyrio</i> (Purple Swamphen) and <i>Litoria peronii</i> (Peron's Tree Frog).	No aquatic flora observed.	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
N/A		Dam within Lot 5 DP1216926, at base of grassy slope with cattle grazing on edges of dam. Dam overflowing to the south on day of survey, evidence of erosion in this area. Scattered <i>Eucalyptus</i> sp. around dam.	No aquatic fauna.	Floating macrophytes observed but species could not be identified due to access.	
N/A		Dam located to south of driveway on Lot 6 DP 1216926. Not on a mapped watercourse, fenceline bisected dam with no fringing vegetation and a few scattered <i>Eucalyptus</i> sp. on western side of dam. Clay substrate with turbid water on day of survey.	No aquatic fauna.	No aquatic flora.	
1J	1	No defined edges of dam and no defined channel upstream or downstream of dam. Turbid water observed and dam near capacity on day of site survey.	<i>Porphyrio porphyrio</i> (Purple Swamphen) and <i>Anas castanea</i> (Chestnut Teal).	<i>Lemna disperma</i> (Duckweed).	

Reach	Dam Number*	Description	Aquatic Fauna Observed	Aquatic Flora Observed	Representative Photo
2B	1	<p>Large dam at capacity on day of site survey, overflowing at low point on northeastern side. No defined spillway. Visibility through the water column was approximately 0.5 m. The downstream edge of the dam had a few scattered <i>Olea europaea</i> subsp. <i>cuspidata</i>. There was no dense fringing vegetation around this dam. Cattle were in the south-western end of dam at time of site survey.</p>	<p><i>Cygnus atratus</i> (Black Swan), <i>Phalacrocorax sulcirostris</i> (Little Black Cormorant) and <i>Egretta novaehollandiae</i> (White-faced Heron).</p>	<p><i>Marsilea mutica</i> (Rainbow Nardoo), scattered sparse <i>Juncus usitatus</i>.</p>	
2B	2	<p>Small online dam within Lot 12 Section 8 DP2650. Good aquatic habitat, with emergent macrophytes present in dam.</p>	<p>No aquatic fauna observed.</p>	<p><i>Persicaria orientalis</i> (Slender Knotweed) and <i>Juncus usitatus</i>.</p>	

*DAMS ARE NUMBERED IN ORDER ALONG CREEK: UPSTREAM TO DOWNSTREAM

4.4 Riparian Habitat

The condition of riparian vegetation throughout the site was predominantly good. The central creek line, watercourse 2B, had a continuous vegetated riparian corridor, except for in the vicinity of the dam at the upstream extent of this channel. Along watercourse 2B, the riparian vegetation was part of the BC Act listed Critically Endangered Ecological Community (CEEC) *Cumberland Plain Woodland in the Sydney Basin Bioregion* (Figure 4-3). Vegetation within this area was characterised by a canopy dominated by *Eucalyptus tereticornis* (Forest Red Gum) and *Eucalyptus moluccana* (Grey Box). The midstorey was dominated by *Olea europaea* subsp. *cuspidata* and scattered occurrences of *Bursaria spinosa*. The groundcover was dominated by native species including *Paspalidium distans*, *Sporobolus creber* (Western Rat-tail Grass), *Glycine tabacina* and *Einadia nutans* (Climbing Saltbush). On the western side of channel 2B, the vegetated riparian corridor was up to 160 m wide and up to 50 m wide on the eastern side of the watercourse.

In some areas, such as the riparian corridor along 1J, the lack of fully structured vegetation was contributing to the erodibility of the channel bed and banks and the deeply incised nature of the watercourse. Vegetation alongside 1J was predominantly *Olea europaea* subsp. *cuspidata* with no groundcovers providing stability to the channel bed and banks, and the resultant incised channel shape was likely due to high velocity flows over the riparian land.

Vegetation surrounding the dams on site was very limited. Most of the dams within the field-validated areas had little to no vegetation on the fringes. The water in the dams was often turbid, likely due to flows into the dams passing over bare or poorly vegetated areas and allowing for sediment to be entrained in these flows.

Following field validation of the accessible watercourses, it was calculated that approximately 14.5 ha of riparian area currently exists within the Belmore Road Precinct. This does not include riparian areas of hydro lines that are unlikely to be a river (subject to validation).

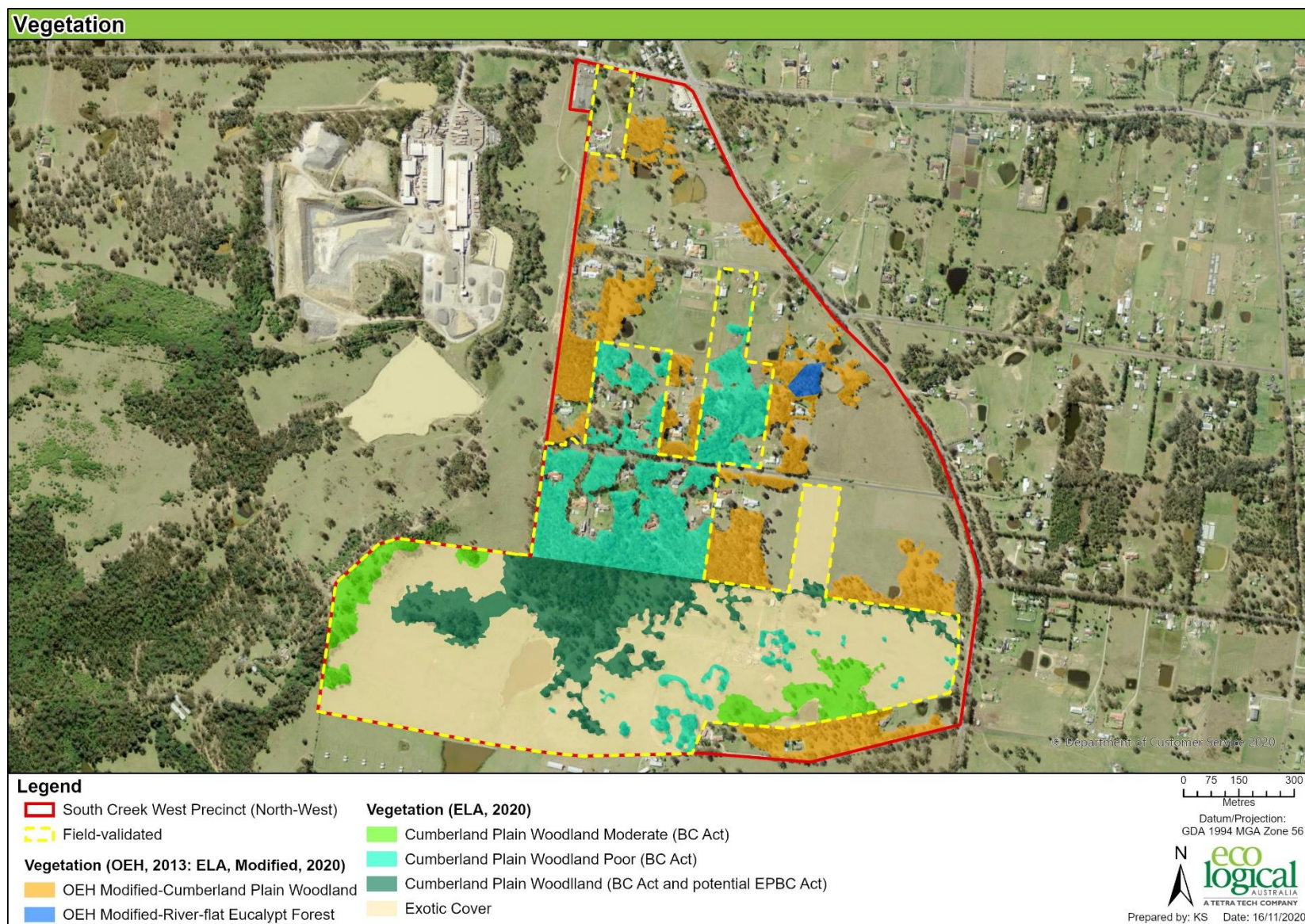


Figure 4-3: Validated vegetation communities and condition

4.5 Groundwater Dependant Ecosystems

There were two areas of GDE mapped in the study area (Figure 4-4). The BOM GDE Atlas identified that the vegetation within these areas was Cumberland Shale Plains Woodland and Cumberland Shale Hills Woodland, both of which are part of the CEEC *Cumberland Plain Woodland in the Sydney Basin Bioregion*. Vegetation validation within these areas identified that this vegetation community was present where the Atlas mapping indicated a high likelihood of GDEs to be present. However, definitive determination regarding the reliance on groundwater would require a hydrological survey to determine the level of the groundwater table.

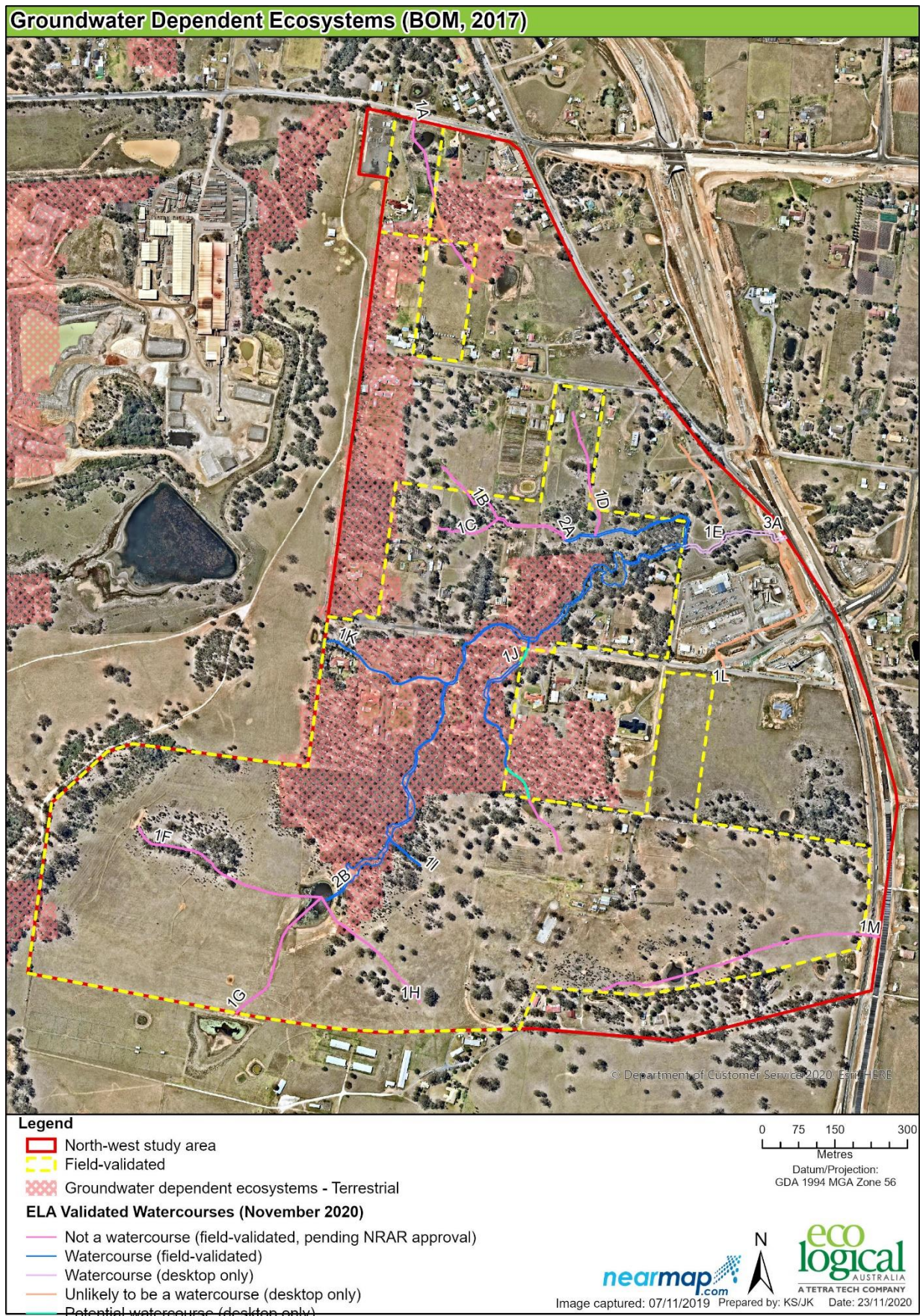


Figure 4-4: Potential Groundwater Dependent Ecosystems mapped within study area

5. Recommendations

5.1 Indicative Layout Plan

As outlined within the Western City District Plan (Greater Sydney Commission, 2018), improving sustainability is at the forefront of future strategic planning and development. Such improvements are focused on incorporating natural landscape features into the urban environment and protecting and managing natural systems. It is recognised that all aspects of sustainability rely on maintaining and managing green infrastructure such as waterways and remnant patches of native vegetation. Therefore, optimising and protecting existing assets will be essential in ensuring the ongoing health and sustainability of the Belmore Road Precinct.

An ILP has been prepared (Figure 5-3) that provides 12.52 ha of riparian area, of which 0.36 ha is proposed to be 'Raingardens'. It is understood that the removal of any existing vegetation will be required to construct the 'Raingardens', which will then be revegetated with wetland species that can withstand regular inundation.

The primary creek corridor, consisting of 2A, 2B and 3A in the centre of the site has been proposed to be retained and rehabilitated. The ILP proposes removal of all other creeks and dams. The proposed ILP will therefore provide an opportunity to:

- Improve the necessary health and quality of the existing waterways and riparian corridors within the Precinct.
- Improve public access to, and along, the riparian corridors, providing connected green space.
- Protect and enhance flora, fauna, and urban bushland.
- Reduce erosion and sedimentation and improve bank stability.
- Provide riparian vegetation buffers, allowing the recovery and reinstatement of more natural conditions within currently highly modified waterways.

The ILP proposes to retain the areas of watercourse and riparian land that were in moderate to good condition at the time of the survey and have the highest recovery potential.

Based on the results of the desktop study and field validation where access was granted, there is a total of 12.2 ha of riparian zone on the site. Note this includes the first order watercourses within the northern portion of the site that are unlikely to be a watercourse, however, have not been field validated. Subject to field validation of the northern part of the site and NRAR review, if these first order watercourses do not meet the definition of a watercourse, there is 10.8 ha of riparian zone on the site. The ILP proposes to protect 12.52 ha (of which 0.36 ha is proposed as 'Raingardens'). If the 'Raingardens' are included as part of the overall riparian land, the ILP meets the NRAR averaging rule. However, if these are not included, there would be a deficit of 0.04 ha. This is summarised in Table 5-1 below.

Table 5-1: Total riparian zone areas

	Riparian Zone (ha)	ILP Riparian Protection (ha)	Averaging Rule Met (Y/N)
Option One: If non-field validated watercourses <u>meet</u> the definition of a watercourse	12.2	12.52 (Including Raingardens)	Yes (0.32 ha surplus)
		12.16 (Not including Raingardens)	No (0.04 ha deficit)
Option Two: If non-field validated watercourses <u>do not meet</u> the definition of a watercourse	10.8	12.52 (Including Raingardens)	Yes (1.72 ha surplus)
		12.16 (Not including Raingardens)	Yes (1.36 ha surplus)

In addition, these existing riparian areas are not actively managed as vegetated riparian zones. Under the proposed ILP, these retained riparian areas would be maintained and revegetated where applicable as part of a Riparian Management Strategy and future vegetation management plans.

Where proposed works are not consistent with the *Guidelines for Controlled Activities on Waterfront Land* (DPE, 2022), the principles of the WM Act can guide activities that are to take place on waterfront land and be used to provide a merit-based assessment of the proposed development.

The principles set out in this section are the water management principles of this Act.

Generally:

- a. *water sources, floodplains, and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded, and*
- b. *habitats, animals, and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored, and*
- c. *the water quality of all water sources should be protected and, wherever possible, enhanced, and*
- d. *the cumulative impacts of water management licences and approvals and other activities on water sources and their dependent ecosystems, should be considered and minimised, and*
- e. *geographical and other features of Aboriginal significance should be protected, and*
- f. *geographical and other features of major cultural, heritage or spiritual significance should be protected, and*
- g. *the social and economic benefits to the community should be maximised, and*
- h. *the principles of adaptive management should be applied, which should be responsive to monitoring and improvements in understanding of ecological water requirements.*

In relation to controlled activities:

- a. *the carrying out of controlled activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and*
- b. *the impacts of the carrying out of controlled activities on other water users must be avoided or minimised.*

While the total area of riparian corridors to be retained under the ILP is less than what exists on site currently (assuming the first order watercourses that were not field validated meet the definition of a watercourse), the ILP allows for protected and rehabilitated watercourses to be established. Under the Riparian Management Strategy and future vegetation management plans, these vegetated channels will become protected waterways within the new Precinct which is an improvement on the current condition, as they receive no observable maintenance and exotic flora species dominate some areas of the riparian buffer.

Watercourse protection also allows for an improvement in water quality within the precinct, as stable beds and banks would be created and the revegetation and weed control of riparian areas would allow for a buffer between the residential areas proposed for the site and the waterway itself.

Within the proposed riparian corridor shown on the ILP (the majority of which is a second order watercourse), online detention basins are proposed. No excavation is required in the channels to allow these basins to be developed. In accordance with Table 2 of the *Guidelines for Controlled Activities on Waterfront Land* (DPE, 2022), an online basin on a second order watercourse is permissible if the requirements in Table 5-2 are met.

Table 5-2: NRAR guidelines requirements for online basins

Requirement	Comment
Online detention basins must be dry and vegetated.	The proposed basins will operate as dry detention basins and will be fully vegetated. Current riparian vegetation includes both the Cumberland Plain Woodland and River-flat Eucalypt Forest vegetation communities, and the existing watercourses are predominantly ephemeral. The hydraulic model allows for a fully structured riparian corridor to form part of the new development with a Manning's n value of 0.12 for flood levels less than 0.5 m deep and 0.03 for flood levels greater than 0.5 m deep, when it is likely that shrub and grass vegetation would fold over and offer limited resistance. The VRZ is expected to be periodically inundated as shown in Figure 5-1 and Figure 5-2 below. This may result in a change in species composition to include species that are adapted to longer periods of inundation, such as those typically found in within the River-flat Eucalypt Forest vegetation community. It is possible that species in both the Melaleuca and Casuarina genus may establish in the future. It is therefore recommended that revegetation works in the currently cleared areas within the riparian corridor consist of species typically found within the River-flat Eucalypt Forest vegetation community.
Online detention basins must be for temporary flood detention only, with no permanent water holding.	Modelling for 1% and 50% Annual Exceedance Probability (AEP) events has been completed by J Wyndham Prince (2023). Modelling shows the basins empty relatively quickly, with only the natural low points within the watercourse at the outlet structure remaining inundated for more than 4 hours in the more frequent 50% AEP event (Figure 5-1). In a rarer 1% AEP, only the lower portion of the downstream extent of the riparian corridor would be inundated for more than 2 hours, and the entire basin would empty within 14.2 hours (Figure 5-2).
Online detention basins must have an equivalent VRZ for the corresponding watercourse order.	The existing VRZ area is 12.2 ha, assuming that all mapped first order watercourses that haven't been able inspected meet the definition of a 'river' under the WM Act. The area of VRZ proposed to be retained under the ILP is 12.56 ha, which is greater than the existing VRZ area. However, if the proposed

Requirement	Comment
	'Raingardens' are not included, the VRZ proposed to be retained is 12.16 ha, resulting in a deficit of 0.04 ha.
Online detention basins must not be used for water quality treatment purposes.	The water quality management is undertaken in separate stand-alone devices outside the outer 50% VRZ. The location of these structures is shown in Figure 5-3.

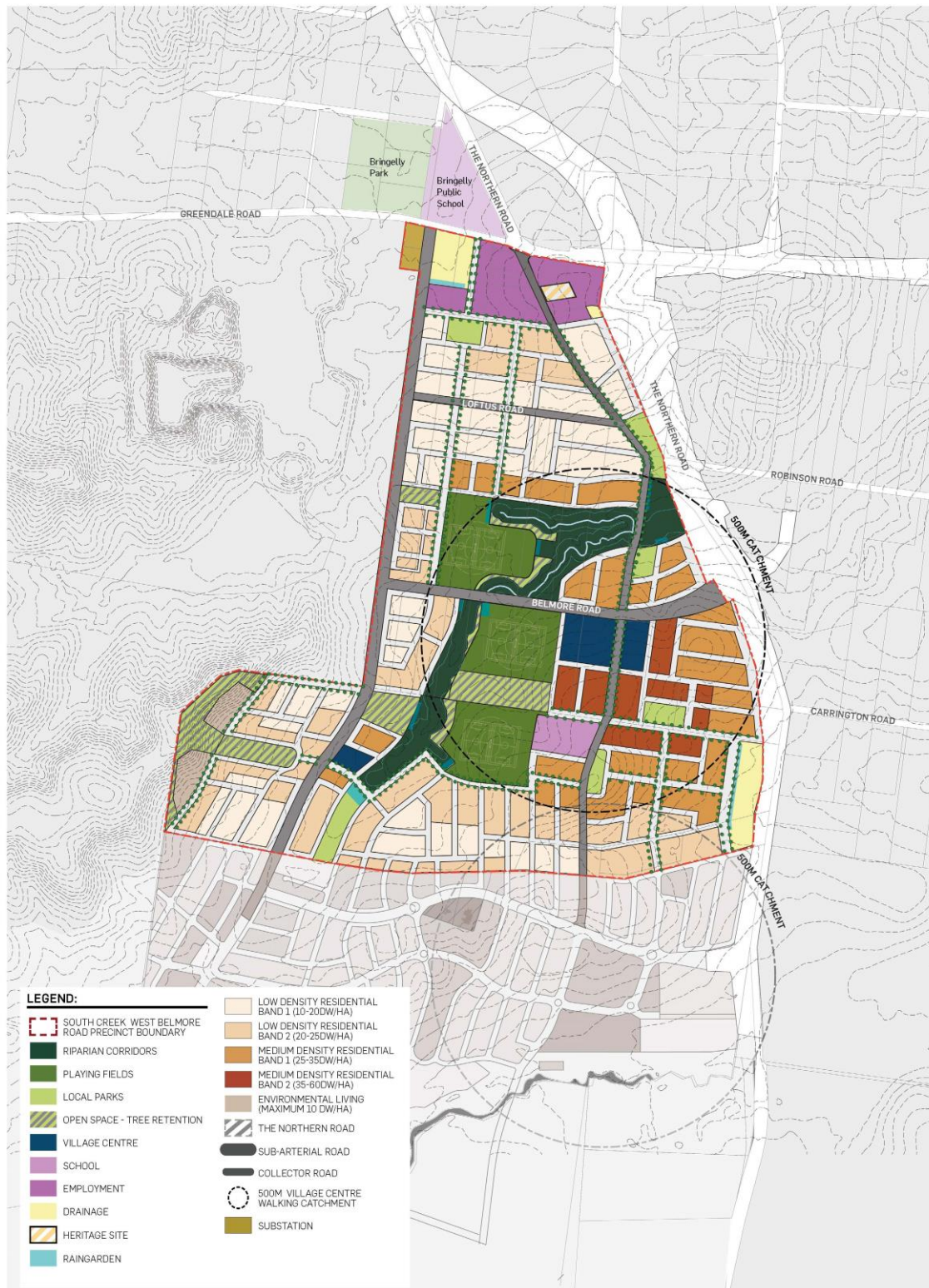
In general, the ILP is consistent with the objectives of the WM Act and aims to apply the principles of ecological development by rehabilitating areas with the highest recovery potential to restore natural ecological processes along the primary watercourses. It considers the site in terms of the broader catchment and focusses on rehabilitating areas that have the highest potential for recovery.



Figure 5-1: Detention basin time of inundation map for 50% AEP developed conditions (J. Wyndham Prince, 2023)



Figure 5-2: Detention basin time of inundation map for 1% AEP developed conditions (J. Wyndham Prince, 2023)



SOUTH CREEK WEST - BELMORE ROAD PRECINCT REVISED FINAL ILP

DATE: 25-09-2023
JOB NO: P0030401
DWG NO: -
REV: H

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Figure 5-3: Draft Indicative Layout Plan (Urbis, 2023)

5.2 Watercourses

The aim of this report is to identify key riparian constraints to assist the design of the ILP and the principles of the legislation addressed in Section 2, are to provide for the sustainable and integrated management of the waterways of the state.

There were 13 first order reaches in the study area, of which eight did not meet the definition of a ‘river’ under the WM Act, as they had no defined bed and banks. NRAR should be consulted to confirm that these do not require protection under the WM Act.

Assuming the above ‘watercourses’ are removed from the mapping, there would be 12.2 ha of riparian corridor within the north-west site. This includes first-order watercourses that may not meet the definition of a river but have not been field-validated. Watercourses that meet the definition of a river in moderate or good condition should be retained where possible. The ILP aligns with this current position, by retaining the central creek system which had the highest habitat value of assessed watercourses.

In general, NRAR’s policy requires management and rehabilitation of the riparian land to a functional community, fully protected and vegetated with native endemic riparian plant species, creating a VRZ. If, however, the intention is to manage the vegetation for non-riparian purposes, such as ‘Raingardens’ in the outer 50%, the riparian offsetting guidelines would apply to compensate the reduced VRZ. The inner 50% would still require protection. If offsets are required elsewhere, the average width of the riparian zone would need to be maintained to meet the NRAR’s guidelines. There is the opportunity to rehabilitate the VRZ with native riparian species which will ultimately improve the instream habitat.

It is noted that all proposed ‘Raingardens’ are outside of the inner 50% of the existing VRZs. However, there would be a 0.04 ha deficit in accordance with the averaging rule.

5.3 Groundwater Dependant Ecosystems

The mapped GDEs were confirmed to be vegetated areas of Cumberland Plain Woodland on site, as was mapped in the GDE Atlas. The degree to which these ecosystems rely on groundwater for their survival is unknown and additional groundwater assessment is recommended. In areas where the Cumberland Plain Woodland is to be retained under the ILP (primarily along the second order watercourses) activities that involve interception of the water table, such as deep excavation, should be avoided to prevent changes in the groundwater characteristics.

5.4 Riparian Management Strategy

The subject site is dominated by Cumberland Plain Woodland in varying conditions. The southern portion of the site also contains large areas of Exotic Cover, predominantly where the land has been used for grazing stock.

While all the Cumberland Plain Woodland within the subject site meets the description of the critically endangered ecological community listed under the BC Act, 15.66 ha meets the definition of the federally listed Cumberland Plain Shale Woodland and Shale Gravel Transition Forest. This potentially EPBC Act listed vegetation is located along the main creek line, where a vegetated riparian corridor is to be retained. The overarching riparian management strategy outlines future restoration potential of native

vegetation along riparian zones in the precinct with broad objectives to re-establish characteristic diversity of indigenous plants and communities whilst reducing exotic weed cover.

5.4.1 Averaging rule

As discussed in Section 5.2, NRAR's guidelines provide an Averaging Rule, which allows non-riparian works / activities to be carried out within the outer riparian corridor provided that the average width of the riparian zone can be achieved over the length of the watercourse within the development site. Under this rule, the outer 50% of the riparian corridor may be used for development lots, infrastructure, and other non-riparian uses provided that an equivalent area connected to the riparian corridor is offset on the site. The inner 50% of the riparian corridor must be protected and fully revegetated.

The future 'Riparian Corridor' is based on the locations of existing riparian corridors, that have the highest likelihood of full rehabilitation. The inner 50% of the riparian corridor will be protected and fully revegetated. When considering the proposed 'Raingardens', which is a non-riparian use, there is a deficit of 0.04 ha in relation to the averaging rule.

5.4.2 Recovery potential

Recovery potential relates to the degree, manner, and pace of an area to recovery after disturbance or stress and is impacted by factors including vegetation composition, structure, and function of remaining vegetation, biodiversity, and presence of key weed species. A moderate to good recovery potential allows the land to be managed for an improvement in the condition of the remnant vegetation and to increase linkages (wildlife corridor) between extant stands of vegetation.

With appropriate management actions, areas identified as having a moderate recovery potential would improve the condition of threatened species habitat and ecosystem connectivity within the precinct. Management actions would need to be on-going and facilitate the natural regeneration of the overstorey and/or regeneration of native species (grasses, herbs, and forbs) in the seed bank.

The following four classes of recovery potential have been identified within the subject site (Figure 5-4):

- High Recovery Potential – native vegetation mapped as areas which generally have native canopy cover of greater than 10% and contained native species in each structural layer.
- Moderate Recovery Potential – other areas of native vegetation with some canopy, less structural complexity, and a higher level of weed infestation or ongoing disturbance.
- Low Recovery Potential – areas which show some potential for natural regeneration. Some native species present in some structural layers, very high level of weed infestations, not all structural layers present.
- Very Low Recovery Potential – all other areas including cleared and heavily cultivated and/or pasture improved areas.

Areas along the central creek line have high recovery potential which indicates that rehabilitating the riparian corridor along watercourses 2A, 2B and 3A has a high feasibility of obtaining a functioning, fully structured native vegetated corridor. The recommended areas of rehabilitation target the watercourses that already have moderate to good condition vegetation established, for example around 2A, 2B and 3A. Actively managing these vegetated areas through weed control and revegetation where required

connectivity of wildlife corridors and overall creek condition. This would incidentally facilitate the recovery of the creek systems to a high-functioning natural waterway.

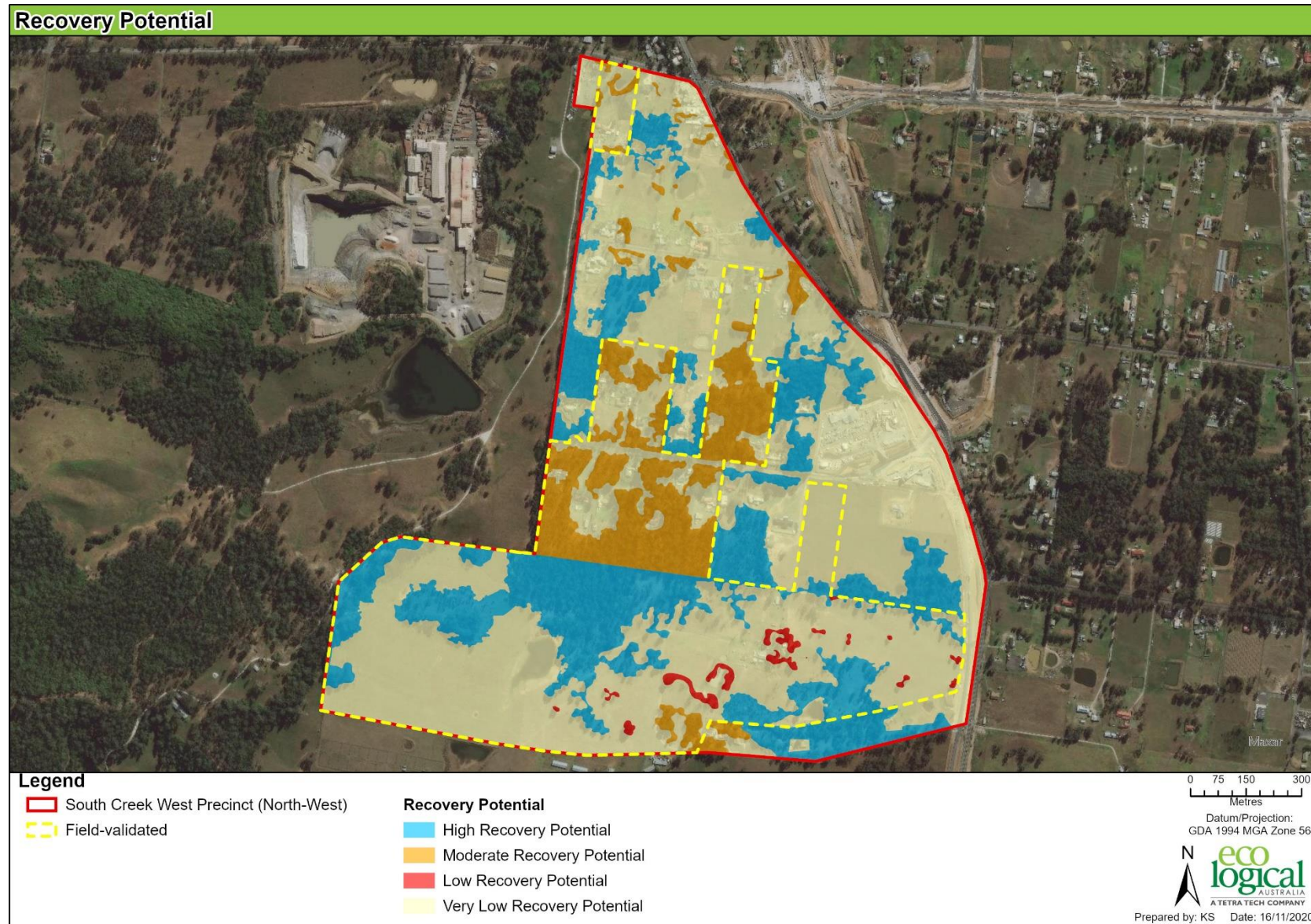


Figure 5-4: Recovery potential of areas within study area

5.4.3 Management Zones

The area of the riparian corridor proposed to be retained within the ILP is approximately 12.16 ha and is proposed to be entirely managed. The rehabilitation works for the riparian corridor will be focused on weed control, assisted regeneration and revegetation. The riparian corridor consists of two management zones (not including the proposed 'Raingardens' or 'Open Space (Tree Retention)' areas) as identified below and in Figure 5-5.

- Zone 1: Weed Control and Rehabilitation
- Zone 2: Weed Control and Revegetation.

An assessment of the native resilience and weed densities was conducted during field surveys. The vegetation within the riparian corridor is generally in moderate condition with high weed densities in the shrub layer where African Olive was present. At the interface between good quality Cumberland Plain Woodland and areas of exotic cover, ongoing management would be required to suppress the spread of these exotic species into good quality riparian vegetation.

5.4.3.1 Management Zone 1 (MZ1): Weed Control and Rehabilitation

The key management priorities and required management actions are:

- Target removal of priority and environmental weeds
- Control of exotic grasses and other exotic species
- Monitor native vegetation and weed densities.

5.4.3.2 Management Zone 2 (MZ2): Weed control and Revegetation

The key management priorities and required management actions are:

- Target removal of priority and environmental weeds
- Control of exotic grasses and other exotic species
- Tubestock planting following weed control in areas of low resilience. Tubestock planting in areas of regular inundation should be diagnostic of the River-flat Eucalypt Forest vegetation community.
- Monitor native vegetation and weed densities.



Figure 5-5: Riparian Management Strategy zones

5.4.4 Zoning, Development Controls, Ownership and Management

Using previous precincts within the Growth Centres as examples, riparian corridors proposed for conservation are generally mapped within a native vegetation protection layer and either considered ENV or Native Vegetation Retention (NVR). The following development controls may therefore be relevant:

Existing Native Vegetation

The consent authority must not grant development consent for development on land to which this clause applies unless it is satisfied that the proposed development will not result in the clearing of any existing native vegetation (within the meaning of the relevant biodiversity measures under Part 7 of Schedule 7 to the *Threatened Species Conservation Act 1995*).

Native Vegetation Retention

Development consent under this clause is not to be granted unless the consent authority is satisfied of the following in relation to the disturbance of native vegetation—

- a. that there is no reasonable alternative available to the disturbance of the native vegetation,
- b. that as little native vegetation as possible will be disturbed,
- c. that the disturbance of the native vegetation will not increase salinity,
- d. that native vegetation disturbed for the purposes of construction will be reinstated where possible on completion of construction,
- e. that the loss of remnant native vegetation caused by the disturbance will be compensated by revegetation on or near the land to avoid any net loss of remnant native vegetation,
- f. that no more than 0.5 hectares of native vegetation will be cleared unless the clearing is essential for a previously permitted use of the land.

Riparian corridors are also generally mapped as Riparian Protection Areas (RPA). The development controls for these areas differ between precincts, however, generally have the following same objectives within the relevant Growth Centre Development Control Plans (DCPs):

- Within land that is in a RPA, native vegetation is to be conserved and managed in accordance with the Guidelines for riparian corridors on waterfront land prepared by the NRAR
- Development on land that adjoins land zoned Environmental Conservation is to ensure that there are no significant detrimental impacts to the native vegetation and ecological values of the Environmental Conservation zone.

Areas of ENV, NVR or RPA are generally also zoned as Environmental Conservation in other Precinct Plans. However, there are also cases where mapped RPA is zoned as Public Recreation or Infrastructure. The permissible uses within the Environmental Conservation zones are shown below.

Zone	Permitted without consent	Permitted with consent	Prohibited
Environmental Conservation	Nil	Drainage; Environmental facilities; Environmental protection works; Flood mitigation works; Information and education facilities; Kiosks; Recreation areas; Roads; Signage; Waterbodies (artificial)	Business premises; Hotel or motel accommodation; Industries; Multi dwelling housing; Recreation facilities (major); Residential flat buildings; Restricted premises; Retail premises; Seniors housing; Service stations; Warehouse or distribution centres; Any development not specified in item 2 or 3.

6. Conclusions

The aim of this report is to identify key riparian constraints to assist the design of an ILP. The principles of the legislation addressed in Section 2 are to provide for the sustainable and integrated management of the waterways of the state.

There were 13 first-order, two second order and one third order creeks mapped in the study area. Of these, 11 first order watercourses and two second order watercourses were able to be assessed. Of these 11 watercourses, eight did not meet the definition of a 'river' under the WM Act, as they had no defined bed and banks and no evidence of geomorphological processes. There were two second order watercourses within the study area, both of which were able to be assessed for condition and habitat. The third order watercourse within the study area was not able to be assessed due to access restrictions. NRAR should be engaged to support the removal of creeks which did not meet the definition of a 'river', and therefore, the need to address these areas as waterfront land would be negated.

Two areas within the study area were mapped on the BOM GDE atlas as having high potential for terrestrial GDE. Field validation of these areas showed a consistency between the mapped GDE vegetation type and the vegetation on site. Assessment of the groundwater connectivity with these ecosystems is recommended, however it is unlikely that development activities would interfere with the groundwater table, as there is unlikely to be significant areas of excavation below the water table.

There is 12.2 ha of riparian corridor mapped within the entire Belmore Road Precinct site. There is a possibility that the existing riparian corridor area could be lower than this figure, if first-order creeks that were desktop mapped as watercourses don't meet the definition of a river under the WM Act and therefore can have their riparian corridor removed from the mapping. This would reduce the existing riparian area by 1.4 ha, to 10.8 ha. The ILP plans to retain 12.56 ha of riparian corridor (of which 0.36 ha is proposed as 'Raingardens'. Excluding the 'Raingardens', there would be a 0.04 ha deficit in accordance with NRAR's averaging rule. Retained riparian corridors in the ILP would be actively managed as vegetated riparian zones under a Riparian Management Strategy, whereas currently there is no active management of riparian corridors.

Other areas of the ILP are consistent with NRAR's guidelines and meet the objectives of the WM Act, by enhancing and rehabilitating riparian corridors along degraded watercourses to restore their natural function and improve their habitat for endemic flora and fauna.

