Cleveland Road, West Dapto - Riparian Assessment

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Template 2.8.1

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Abbreviations

Abbreviation	Description
Coastal Management SEPP	State Environmental Planning Policy (Coastal Management) 2018
CRZ	Core Riparian Zone
DCP	Development Control Plan
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
FM Act	NSW *Fisheries Management Act 1994*
KFH	Key Fish Habitat
LEP	Local Environmental Plan
NRAR	Natural Resources Access Regulator
VRZ	Vegetated Riparian Zone
WCC	Wollongong City Council
WM Act	NSW *Water Management Act 2000*

Executive Summary

Eco Logical Australia Pty Ltd was engaged by Newquest Property Pty Ltd to prepare a Riparian Assessment to address waterway and riparian matters for a Planning Proposal at Cleveland Road, West Dapto. There were 16 1st order, five 2nd order, one 3rd order and one 4th order watercourse mapped within the study area. Following field validation of these watercourses, eight 1st order and two 2nd order watercourses were considered not a 'river' under the *Water Management Act 2000* (WM Act), with no defined bed or banks. Of these, NRAR have advised that piping one 2nd order and all or part of six of the 1st order streams would be generally acceptable. Concurrence on the status of the remaining watercourses not considered 'rivers' under the WM Act would need to be gained from Natural Resources Access Regulator (NRAR). Of the creeks with defined bed and banks, condition of the riparian and aquatic habitat varied. The riparian vegetation in the study area ranges from good to poor condition, with some areas relatively intact and others showing evidence of historical disturbance by clearing and exotic species invasion.

The proposed footprint encroaches into 0.92 ha of the outer VRZ when recommended riparian corridor widths under the WM Act are applied and an additional 1.43 ha of the outer VRZ when Wollongong City Council riparian corridor widths are applied. As per the guidelines for controlled activities on waterfront land, encroachment into the outer VRZ for non-riparian uses must be compensated at 1:1 elsewhere within the site. There is a total of 1.95 ha of land that would be able to be revegetated and act as offset in compensation for this encroachment in order to provide this offset and obtain an average VRZ in accordance with NRAR and Council guidelines.

1. Introduction

Eco Logical Australia Pty Ltd (ELA) was engaged by Newquest Property Pty Ltd to prepare a Riparian Assessment for the Cleveland Road, West Dapto Planning Proposal to be submitted to Wollongong City Council (WCC).

This Riparian Assessment is required to support the Planning Proposal for the Cleveland Road proposed lot layout and to determine potential impacts on riparian and aquatic ecology of the tributaries of Mullet Creek within and adjacent to the study area as part of the proposed development and make recommendations to mitigate those impacts. The report also takes into consideration comments from WCC in response to previously completed assessments for the study area by Ecoplanning (2019) and ELA (2018).

1.1 Location

Located in West Dapto, the Cleveland Road precinct is bordered to the north and south by 1st, 2nd, 3rd and 4th order tributaries of Mullet Creek (Figure 1). The Mullet Creek catchment is predominantly rural residential and drains an area of approximately 72 km^2 (Bewsher, 2010) before discharging into Lake Illawarra.

The Cleveland Road precinct is made up of 18 lots on the northern and southern side of Cleveland Road. Together, these lots make up the 'study area' referenced in this report:

- Lot 1 DP 1126171
- Lot 100 DP 1086479
- Lot 1 DP 999485
- Lot 1 DP 741423
- Lot 1 DP 194419
- Lot A DP 156446
- Lot 313 DP 1188000
- Lot 312 DP 1188000
- Lot 310 DP 1188000
- Lot 401 DP 1254873
- Lot 402 DP 1254873
- Lot 1 DP 532391
- Lot 1 DP 156208
- Lot 59 DP 1125379
- Lot 2 DP 730326
- Lot 1 DP 730326
- Lot 200 DP 803810
- Lot 201 DP 803810.

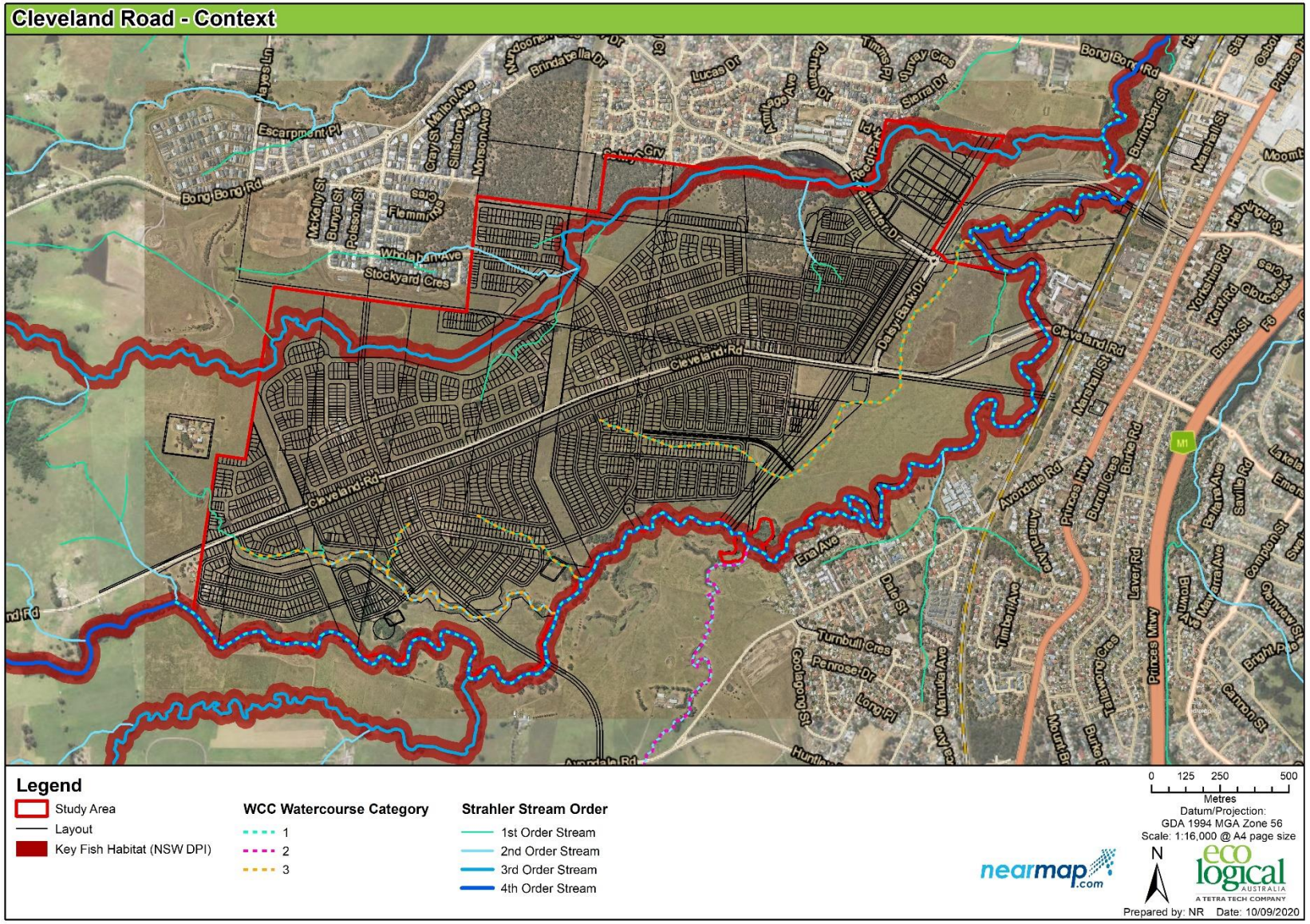

Figure 1: Study area

2. Legislative context

The following riparian and aquatic regulatory requirements and policies were reviewed to determine their application to the proposed development:

- NSW *Fisheries Management Act 1994* and Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update) (Fairfull, 2013)
- NSW *Water Management Act 2000* and Guidelines for controlled activities on waterfront land – Riparian corridors (NRAR, 2018)
- Wollongong City Council Local Environmental Plan (LEP) 2009
- Wollongong City Council Development Control Plan (DCP) 2009
- Illawarra Shoalhaven Regional Plan 2015
- West Dapto Vision – Wollongong City Council 2018.

2.1 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) governs the management of fish and their habitat in NSW. The FM Act applies to waterways defined as 'key fish habitat' and threatened fish species, and therefore requires a separate assessment from the NSW *Biodiversity Conservation Act 2016* (BC Act). The objectives of the FM Act are to conserve fish stocks and key fish habitats, conserve threatened species, populations and ecological communities of fish and marine vegetation and to promote ecologically sustainable development. The FM Act also regulates activities involving dredging and / or reclamation of aquatic habitats, obstruction of fish passage, harming marine vegetation and use of explosives within a waterway. To assess impacts to aquatic habitats, the regulatory framework of the FM Act and associated guidelines have been applied for this assessment.

A search of the Commonwealth Protected Matters database, OEH BioNet database, NSW Department of Primary Industries Primefacts and Fisheries Threatened Species distribution maps (Riches et al, 2016) identified four species of aquatic fauna with potential to be found within the study area (Table 1). As there are no records within 5 km of the study area and a lack of suitable habitat or connectivity to suitable habitat, it is unlikely that these species would be found within the proposed development area.

Table 1: Likelihood of occurrence for aquatic species

Scientific Name	Common Name	FM Act	EPBC Act	Habitat Associations	Records within 5 km of site	Likelihood of occurrence
Archaeophya adamsi	Adams Emerald Dragonfly	E		Adam's Emerald Dragonfly larvae have been found in narrow, shaded riffle zones with moss and abundant riparian vegetation (often closed canopy) in small to moderate sized creeks with gravel or sandy bottoms. Adult dragonflies generally fly away from the water to mature before returning to breed. Males fly actively at breeding sites and often guard a territory. Females probably lay their eggs into the water.	0	No, no suitable habitat within development area.
Epinephelus daemelii	Black Rockcod	V	V	Adult Black Rockcod are usually found in caves, gutters and beneath bommies on rocky reefs, from near shore environments to depths of at least 50 m. Small juveniles are often found in coastal rock pools, and larger juveniles around rocky shores in estuaries.	0	No, no suitable habitat and no records within 5 km of site.
Macquaria australasica	Macquarie Perch	E	E	Habitat for this species is bottom or mid-water in slow-flowing rivers with deep holes, typically in the upper reaches of forested catchments with intact riparian vegetation. Macquarie Perch also do well in some upper catchment lakes. In some parts of its range, the species is reduced to taking refuge in small pools which persist in midland–upland areas through the drier summer periods.	0	No, no suitable habitat and no records within 5 km of site.
Prototroctes maraena	Australian Grayling	E	V	Historically, this species inhabited coastal streams from the Grose River southwards through NSW, VIC and TAS. On the mainland, this species has been recorded from rivers flowing east and south of the main dividing range. This species spends only part of its lifecycle in freshwater, mainly inhabiting clear, gravel-bottomed streams with alternating pools and riffles, and granite outcrops. Grayling migrate between freshwater streams and the ocean and as such it is generally accepted to be a diadromous species (migratory between fresh and saltwaters).	0	No, no suitable habitat and no records within 5 km of site.

Note: E = Endangered, V= Vulnerable.

2.2 Policy and guidelines for fish habitat conservation and management

The *Policy and guidelines for fish habitat conservation and management* (Fairfull, 2013) (herein referred to as the 'Policy') is a supplementary document that outlines the requirements and obligations under the FM Act and the *Fisheries Management (General) Regulation 2010* and was developed to maintain and enhance fish habitat and assist in the protection of threatened species. The Policy defines Key Fish

Habitat (KFH) and provides guidance for assigning a rating for fish habitat sensitivity (Table 2) and the type of key fish habitat (Table 3).

Table 2: Key Fish Habitat and associated sensitivity classification scheme (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:	**TYPE 2 – Moderately sensitive key fish habitat:**
Posidonia australis (strapweed)	*Zostera, Heterozostera, Halophila* and *Ruppia* species of seagrass beds <5 m^2 in area
Zostera, Heterozostera, Halophila and *Ruppia* species of seagrass beds >5 m^2 in area	Mangroves
Coastal saltmarsh >5 m^2 in area	Coastal saltmarsh <5 m^2 in area
Coral communities	Marine macroalgae such as *Ecklonia* and *Sargassum* species
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)	Estuarine and marine rocky reefs
Marine park, an aquatic reserve or intertidal protected area	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)
SEPP 14 coastal wetlands, wetlands recognised under international agreements (e.g. Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia	Aquatic habitat within 100 m of a marine park, an aquatic reserve or intertidal protected area
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 metres in length, or native aquatic plants	Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna
Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act	Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1
Mound springs	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:
	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

The Policy classifies waterways into three types of key fish habitat. The main channels of Mullet Creek within and adjacent to the study area have been mapped as KFH by DPI Fisheries and would be considered Type 2 KFH using the descriptions outlined in Table 2 and Class 3 using the classifications and characteristics in Table 3.

Table 3: Classifications and characteristics of waterway class

Classification	Characteristics of waterway class
CLASS 1 **Major key fish habitat**	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'.
CLASS 2 **Moderate key fish habitat**	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.
CLASS 3 **Minimal key fish habitat**	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.
CLASS 4 **Unlikely key fish habitat**	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).

2.3 Water Management Act 2000

The Natural Resources Access Regulator (NRAR) administers the NSW *Water Management Act 2000* (WM Act) and is required to assess the impact of any proposed work on waterfront land. This includes the bed and bank of any river, lake or estuary and land within 40 m of the highest bank. Certain activities within waterfront land are defined as 'controlled activities' and are subject to approval from NRAR. In order to inform a comparative and acceptable assessment of riparian impacts, the regulatory framework of the WM Act and associated guidelines have been adopted for this assessment.

NRAR's *Guidelines for controlled activities on waterfront land – Riparian corridors* (NRAR, 2018) outline 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 watercourse to the highest bank) constitute the 'riparian corridor' (Figure 2). NRAR recommends a VRZ width 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 4).

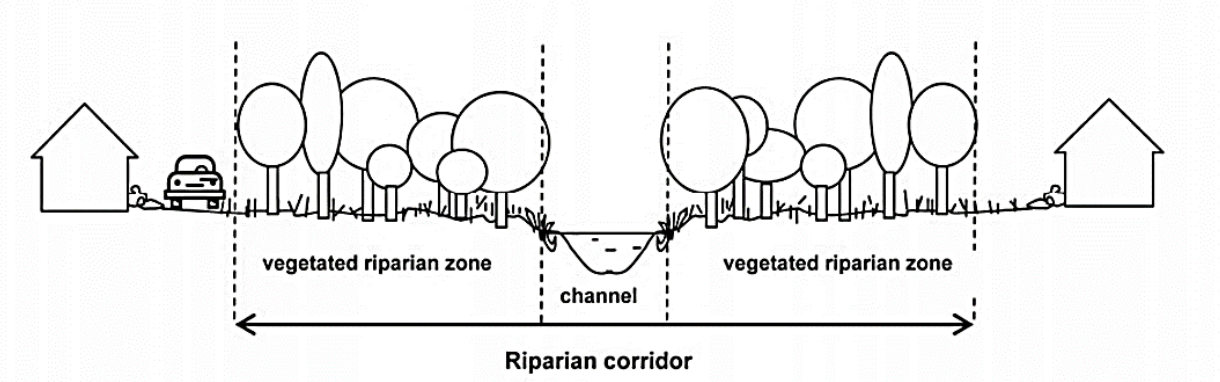

Figure 2: VRZ and watercourse channel comprising the riparian corridor (NRAR, 2018)

Table 4: Recommended riparian corridor widths (NRAR, 2018)

Watercourse type	VRZ width (each side of watercourse)	Total riparian corridor width
1st order	10 m	20 m + channel width
2nd order	20 m	40 m + channel width
3rd order	30 m	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 m	80 m + channel width

Non-riparian uses can be authorised by NRAR within the outer 50% of the VRZ, as long as compensation (1:1 offset) is achieved within the site, with the exception of permissible uses listed in Table 5. The outer VRZ that is impacted must be offset elsewhere on site using the 'averaging rule' (Figure 3). The inner 50% of the VRZ must be maintained and vegetated with fully structured native riparian vegetation communities.

Table 5: Riparian corridor (RC) matrix showing permissible uses within the riparian corridor (NRAR, 2018)

Stream order	Vegetated Riparian Zone (VRZ)	RC off-setting for non RC uses	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	10m	•	•	•	•	•	•	•		
2nd	20m	•	•	•	•	•		•		
3rd	30m	•	•	•		•			•	•
4th +	40m	•	•	•		•			•	•

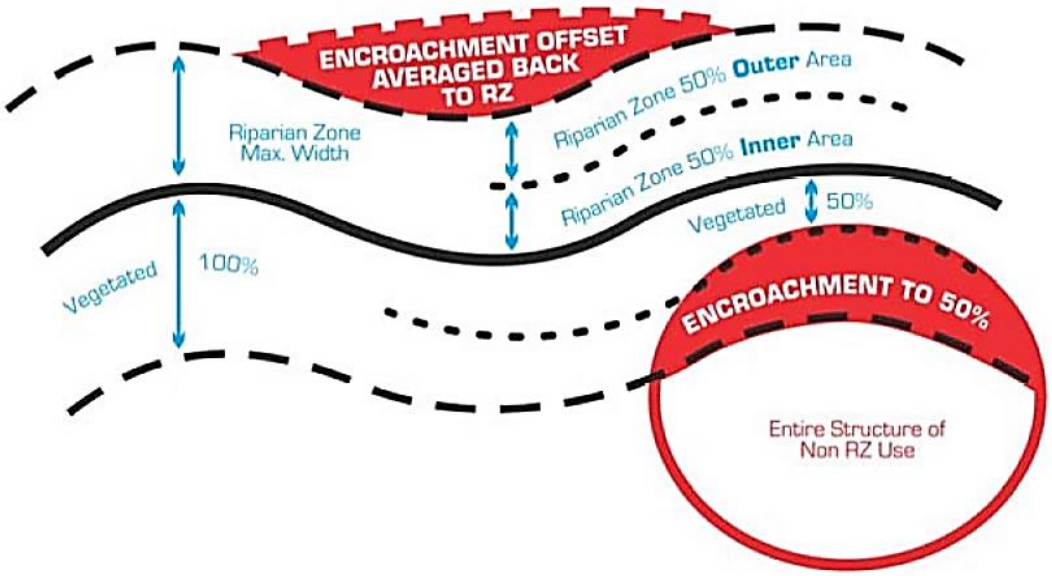

Figure 3: Riparian 'averaging rule' for offsetting encroachment into the outer 50% of the VRZ (NRAR, 2018)

The *Guidelines for controlled activities on waterfront land – Riparian corridors* also 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 WM Act, but this does not alter the downstream watercourse Strahler classification.

2.4 State Environmental Planning Policy (Coastal Management) 2018

The State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP) aims to manage development within coastal zones and protect the environmental assets of the coast. In accordance with Section 5 of the *Coastal Management Act 2016*, the term coastal zone is defined as any area of land that is comprised of the following coastal management areas:

- Coastal wetlands and littoral rainforests
- Coastal vulnerability areas
- Coastal environment areas
- Coastal use areas.

As shown in Figure 4, the study area contains areas mapped as Coastal Wetlands and Proximity to Coastal Wetlands under the Coastal Management SEPP. The management objectives for coastal wetlands, as outlined in the *Coastal Management Act 2016* are to:

a. protect coastal wetlands and littoral rainforests in their natural state, including their biological diversity and ecosystem integrity
b. promote the rehabilitation and restoration of degraded coastal wetlands and littoral rainforests
c. improve the resilience of coastal wetlands and littoral rainforests to the impacts of climate change, including opportunities for migration
d. support the social and cultural values of coastal wetlands and littoral rainforests

e. promote the objectives of State policies and programs for wetlands or littoral rainforest management.

Clause 10 (2) of the Coastal Management SEPP states development for which consent is required, other than development for the purpose of environmental protection works, is declared to be designated development under the *Environmental Planning and Assessment Act 1979* (EP&A Act). Under Section 4.12 (8) of the EP&A Act, a development application for designated development is to be accompanied by an Environmental Impact Statement (EIS). Furthermore, prior to approval of development of land within coastal wetlands, the consent authority must not grant consent unless they are satisfied that sufficient measures have been, or will be, taken to protect, and where possible enhance, the biophysical, hydrological and ecological integrity of the coastal wetland.

As there is proposed development in a coastal wetland zone, this development would be determined designated development and require an EIS to support the development application. Additionally, measures to protect and potentially enhance the coastal wetland should be explored as part of the EIS.

There is also proposed development in the 'proximity to coastal wetland' zone. Clause 11 (1) of the Coastal Management SEPP states that *Development consent must not be granted to development on land identified as "proximity area for coastal wetlands" or "proximity area for littoral rainforest" on the Coastal Wetlands and Littoral Rainforests Area Map unless the consent authority is satisfied that the proposed development will not significantly impact on:*

a. the biophysical, hydrological or ecological integrity of the adjacent coastal wetland or littoral rainforest, or
b. the quantity and quality of surface and ground water flows to and from the adjacent coastal wetland or littoral rainforest.

As there is proposed development on land in proximity to the coastal wetlands, the development should avoid or mitigate significant impacts to the adjacent wetland.

Whilst not relevant in a statutory planning sense, the NSW Wetlands Policy (DECCW, 2010) is informative in defining a wetland. The NSW Wetlands Policy includes a section on 'What is a Wetland':

Wetlands are areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving except in distributary channels such as tidal creeks which may have higher peak flows.

Examples of wetlands include lakes, lagoons, estuaries, rivers, floodplains, swamps, bogs, billabongs, marshes, coral reefs and seagrass beds. Many wetlands are ephemeral, that is, they are not always wet. As a result, the temporary absence of water will not necessarily be used to exclude particular areas of land from the definition of 'wetland' under this policy. This issue is especially relevant for demarcating wetlands on floodplains, where wetland extent may vary according to the size and duration of the last flood, as well as local rainfall and the degree of groundwater connectivity. Ephemeral wetlands occur on many riverine systems where temporary flood retention leads to significant flood supported

ecosystems. These areas are particularly susceptible to development as they often are difficult to define on ephemeral river and creek systems. Under this policy, areas of the floodplain that pond with water after the passage of major floods peaks are included in the definition of a wetland. Areas of the floodplain which drain naturally and continuously following a major flood and do not have distinctive wetland plants or soils, are excluded from the definition of 'wetland' for the purposes of this policy.

An investigation has not been carried out into whether the mapped wetlands on the subject site meet the above definition. It may aid future discussions to investigate the condition of the mapped wetlands, gain and understanding of their surface and groundwater connectivity and determine the nature of some of the ecosystem impacts that might result from their removal.

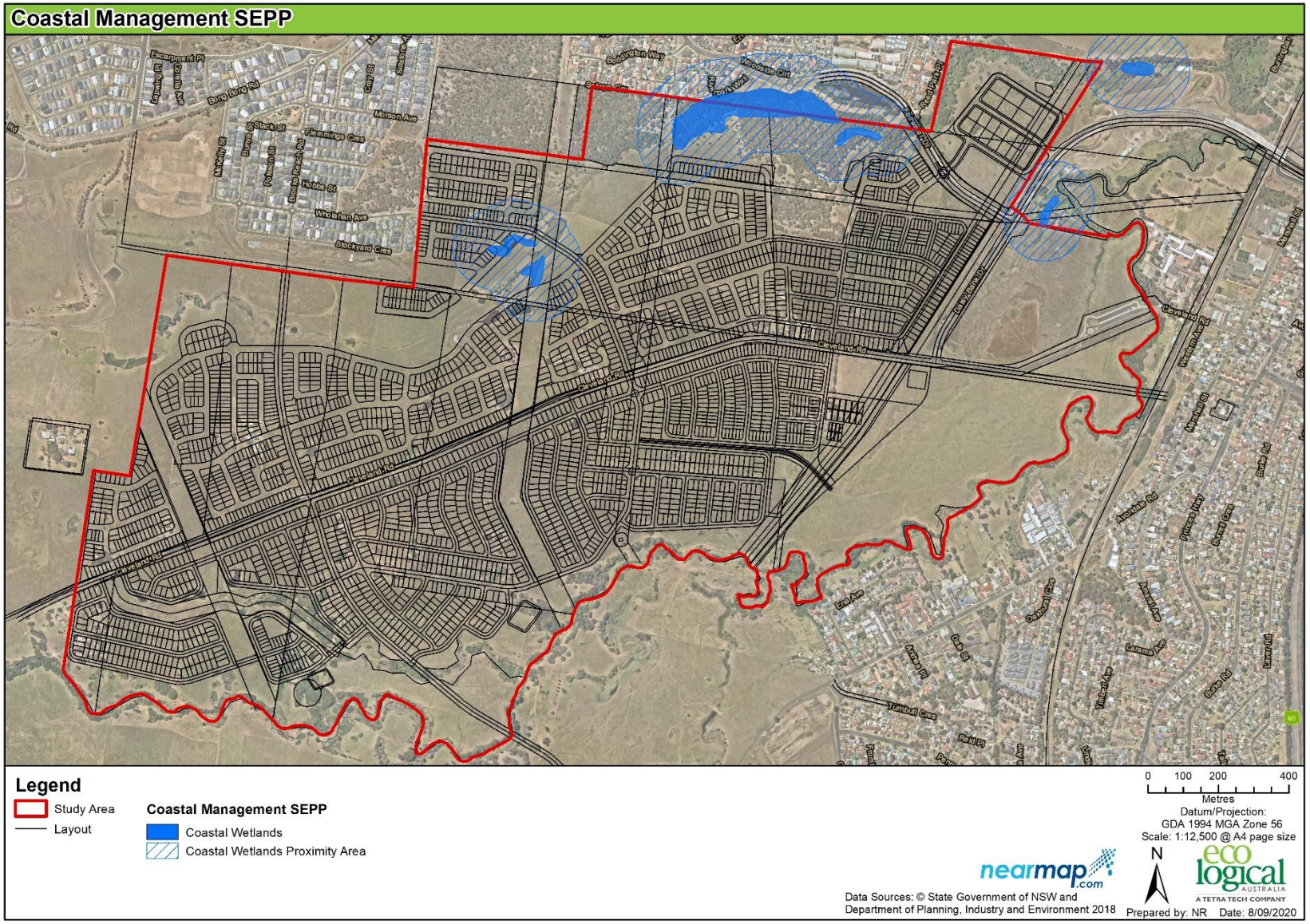

Figure 4: Coastal Management SEPP zones within the study area

2.5 Wollongong City Council Local Environmental Plan (LEP) 2009

The study area is mapped on the Riparian Land Map within the Wollongong LEP. Part 7, Clause 7.4 lists the objectives for these areas:

1. *The objective of this clause is to ensure that development does not adversely impact upon riparian lands.*
2. *This clause applies to land shown as "riparian land" on the Riparian Land Map.*
3. *Despite any other provision of this Plan, development consent must not be granted for development on land to which this clause applies unless the consent authority has considered the impact of the proposed development on the land and any opportunities for rehabilitation of aquatic and riparian vegetation and habitat on that land.*

2.6 Wollongong City Council Development Control Plan (DCP) 2009

Controls relevant to the study area for waterways and riparian areas are listed in two chapters of the Wollongong City Council DCP. Chapter D16 is specifically for the West Dapto Release Area. The relevant objective of this chapter is to:

Protect, conserve and enhance riparian and environmentally sensitive areas and only allow for development compatible with the conservation values of these areas.

Section 6.2 Bridge and culvert design includes the requirement that construction over or within waterways should have regard to the Fish Passage Guidelines developed by NSW Fisheries. Principles 4, 6, 7, 9 and 10 of Section 7 Water Management lists outcomes relevant to development in the vicinity of waterways and riparian areas. Section 8.3 relates to Riparian Corridors in the West Dapto Release Area.

The WCC DCP also has a section solely focused on riparian and watercourses. Chapter E23: Riparian Land Management includes a number of objectives designed to protect watercourses and riparian land:

a. *Protect urban creeks and riparian corridors from further degradation and improve their environmental function.*
b. *Conserve, enhance and protect existing native riparian vegetation and associated habitat.*
c. *Protect and enhance viability of endangered ecological communities and threatened species populations listed under the Threatened Species Conservation Act 1995.*
d. *Restore and rehabilitate degraded, fragmented and modified riparian corridors where possible.*
e. *Maintain and enhance the stability of the bed and bank of a watercourse and protect assets from accelerated rates of erosion.*
f. *Enhance the aesthetic qualities and educational values of the local creek landscape.*
g. *Ensure riparian management is compatible with, and does not adversely affect, floodplain risk management objectives in urban areas.*
h. *Protect water quality.*
i. *Protect and enhance any cultural heritage values of the riparian corridors.*

The DCP categorises watercourses within the LGA into three categories depending on the nature and function of the watercourse and connectivity of green corridors from the escarpment to the coast.

These streams have designated riparian widths made up of a Core Riparian Zone (CRZ) plus a vegetated buffer, as per the category ranking (Table 6). Any development in or adjacent to the riparian land must be designed to achieve the minimum riparian corridor width, as illustrated in Figure 5.

Table 6: Recommended riparian widths (WCC, 2009)

Creek Category	CRZ Recommended Width (m)	Vegetated Buffer(m)	
Creek Category	**CRZ Recommended Width (m)**	**Vegetated Buffer (m)**	**Total Width Requirement for each side of the watercourse (m)**
Category 1	40*	10*	50*
Category 2	20*	10*	30*
Category 3	10	-	10

*Council may consider changes to the minimum riparian corridor width, as long as the variation would not result in adverse impact to the functions of the riparian corridor. However, the absolute minimum riparian corridor width shall be 10 m from the top of bank. Any variation to width requires the written support of NRAR prior to WCC accepting the modification.

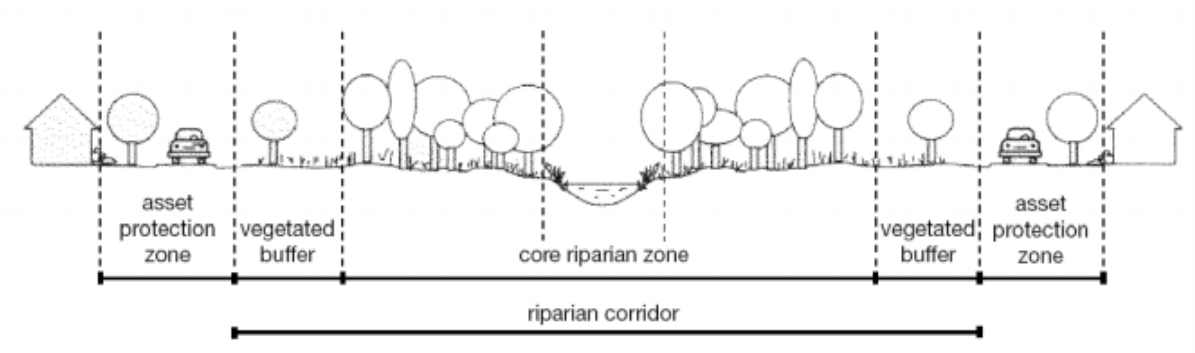

Figure 5: Indicative riparian corridor (WCC, 2009)

2.7 Illawarra Shoalhaven Regional Plan 2015

The Illawarra Shoalhaven Regional Plan provides a strategic outline to guide the sustainable growth of the Illawarra over a 20-year period. Goal 5 (a region that protects and enhances the natural environment), Direction 5.1.4 aims to create a consistent approach to protect important riparian areas in planning and development controls. This goal and action have been considered in the assessment of the riparian corridors as part of the proposed development.

2.8 West Dapto Vision 2018

The West Dapto Vision 2018 includes water management principles to integrate the management of floodplains and stormwater. Principle 4 outlines the need to conserve the natural function of floodplains, natural waterways and riparian corridors. As a guiding tool, the West Dapto Vision is high level and has been considered in the following assessment.

3. Methods

To assess the watercourses within the study area in accordance with NRAR requirements, Strahler stream order was extracted from the Department of Primary Industry's GIS dataset. Riparian corridor width requirements for WCC were reviewed under the Council's DCP and LEP. Watercourse categories (1, 2 or 3) were assigned, as per the Council's Planning and Constraints Map.

The top of bank for waterways within and adjacent to Lot A DP 156446, Lot 1 DP 194419 and Lot 313 DP 1188000 was initially estimated using aerial photographs and 2 m contours, before being validated on 10 and 16 May 2018. For the lots in the northern and western areas of the Cleveland Road precinct, top of bank was estimated using aerial photographs and 1 m contours before being field validated on 22 January 2020 by an aquatic ecologist. Some areas, such as Lot 1 DP 1126171 were unable to be field-validated due to access restrictions. These areas have been mapped using aerial photographs (NearMap and Google Earth), 1 m contours and adjacent field data as a guide.

Each watercourse that met the definition of a 'river' under the WM Act was assigned the appropriate riparian corridor width in accordance with the stream order and category. Riparian width requirements under the WM Act and DCP were then mapped on ArcPro. Online dams were excluded from the VRZ as NRAR would support their removal, so top of bank was estimated through the dam to resemble future channel reconstruction. Watercourses within the study area have been labelled to aid in their description.

The watercourses and riparian zone were visually assessed regarding their condition of riparian habitat (riparian condition, recovery potential, native vegetation cover, connectivity, quality, bed and bank stability and habitat diversity) and aquatic habitat (including vegetation structure, regeneration, weed infestation, woody debris, benthic substrate, fish habitat, patch size and connectivity potential).

4. Results

Both State and Council requirements have been considered for the site, as they have different setback requirements. We have applied State and Council's riparian buffers to only those areas defined as a 'river' under the WM Act. The status of the watercourses that do not meet the definition of a 'river' requires concurrence from NRAR.

Reach descriptions for 1st order watercourses are detailed in Table 7. More detailed assessments of larger 1st order watercourses and all 2nd, 3rd and 4th order watercourses have been provided.

The field-validated riparian corridors requirements for State (VRZ + channel) and Council (CRZ + vegetated buffer) for the 'rivers' onsite are mapped in Figure 6 – overview, Figure 7 – north eastern extent, Figure 8 – north western extent, Figure 9 – south eastern extent and Figure 10 – south western extent. The 1st, 2nd and 3rd-order streams have the same riparian corridor width requirements under both Council and State guidelines. Reach 4A has additional riparian requirements because it is classed by WCC as Category 1 (shown in yellow in Figure 7, Figure 9 and Figure 10), triggering broader set-backs than the State requirements. In total, 59.88 ha of riparian corridor occurs within the study area under the WM Act and an additional 1.84 ha of riparian corridor occurs under Council's DCP.

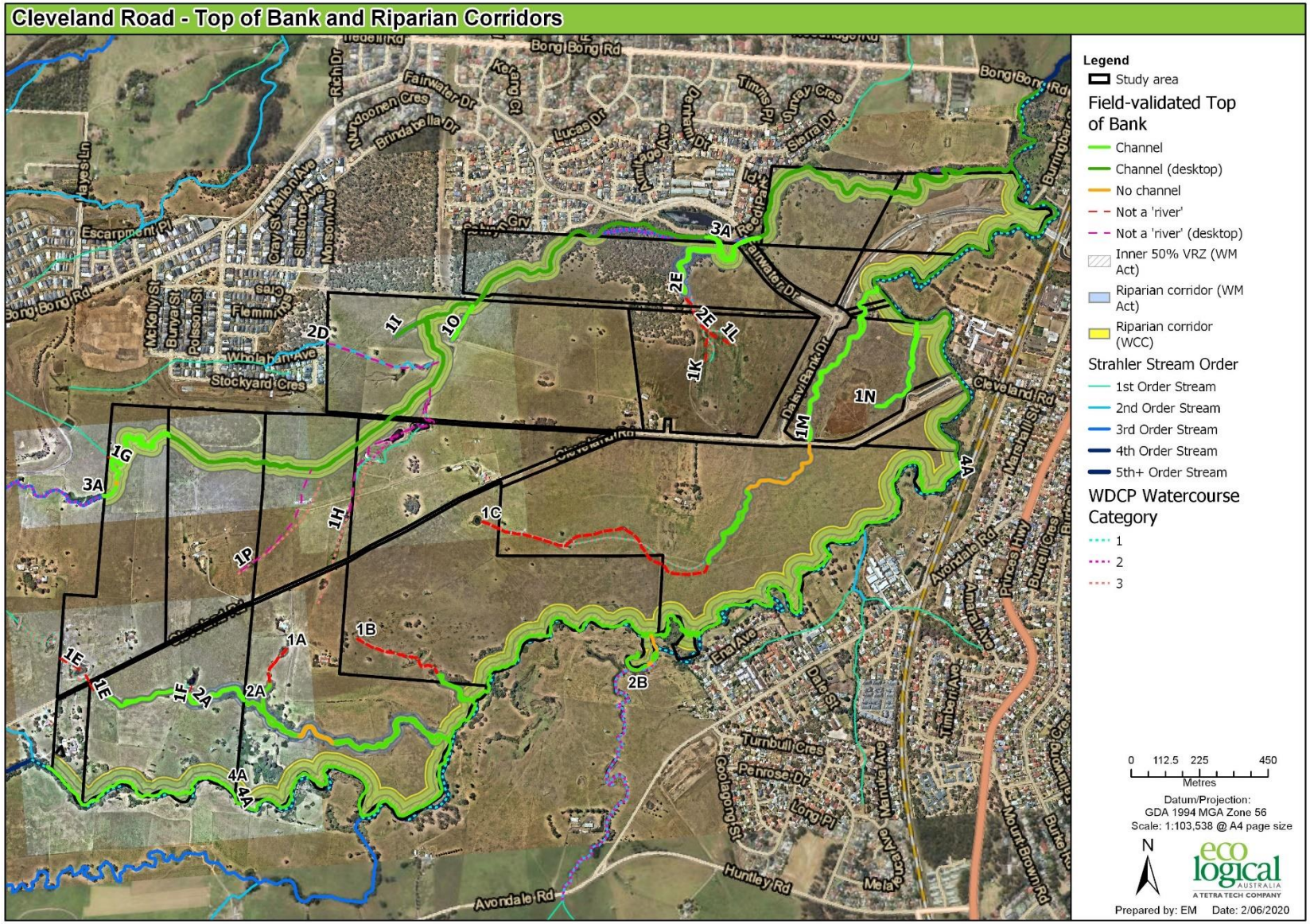

Figure 6: Overview of top of bank and riparian corridor widths within the Cleveland Road study area

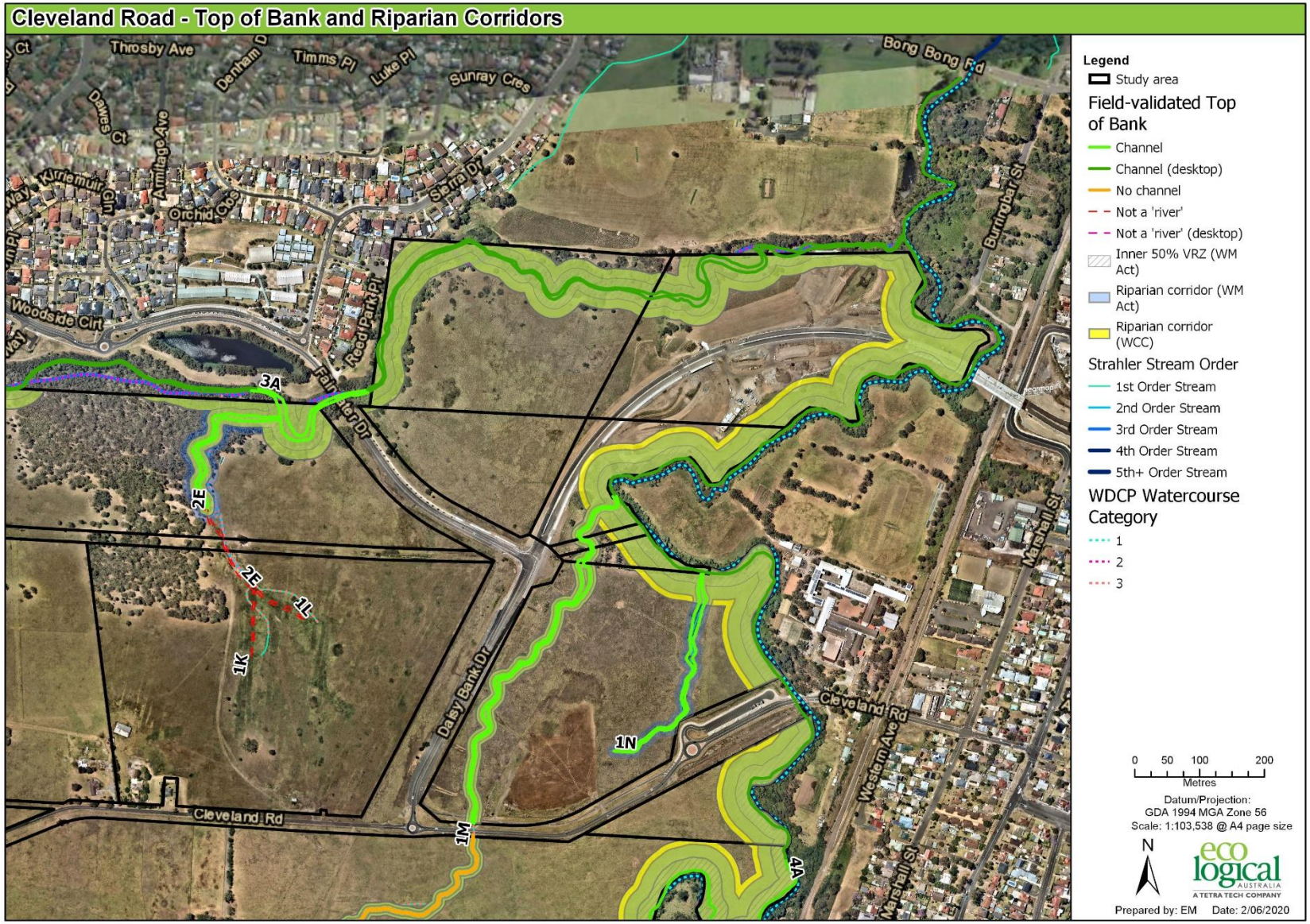

Figure 7: ELA validated top of bank and riparian corridor widths within the north east section of the study area

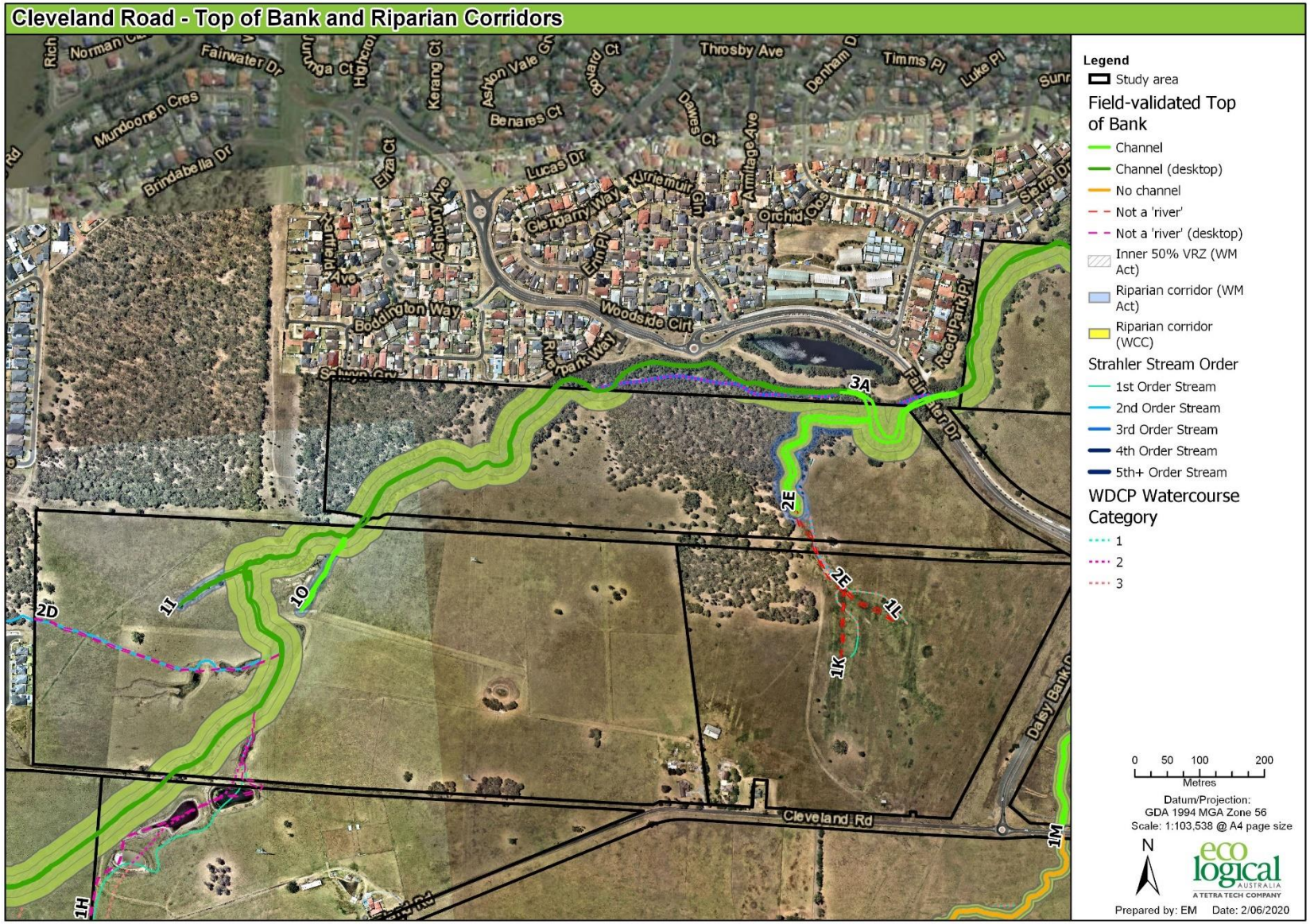

Figure 8: ELA validated top of bank and riparian corridor widths within the north west section of the study area

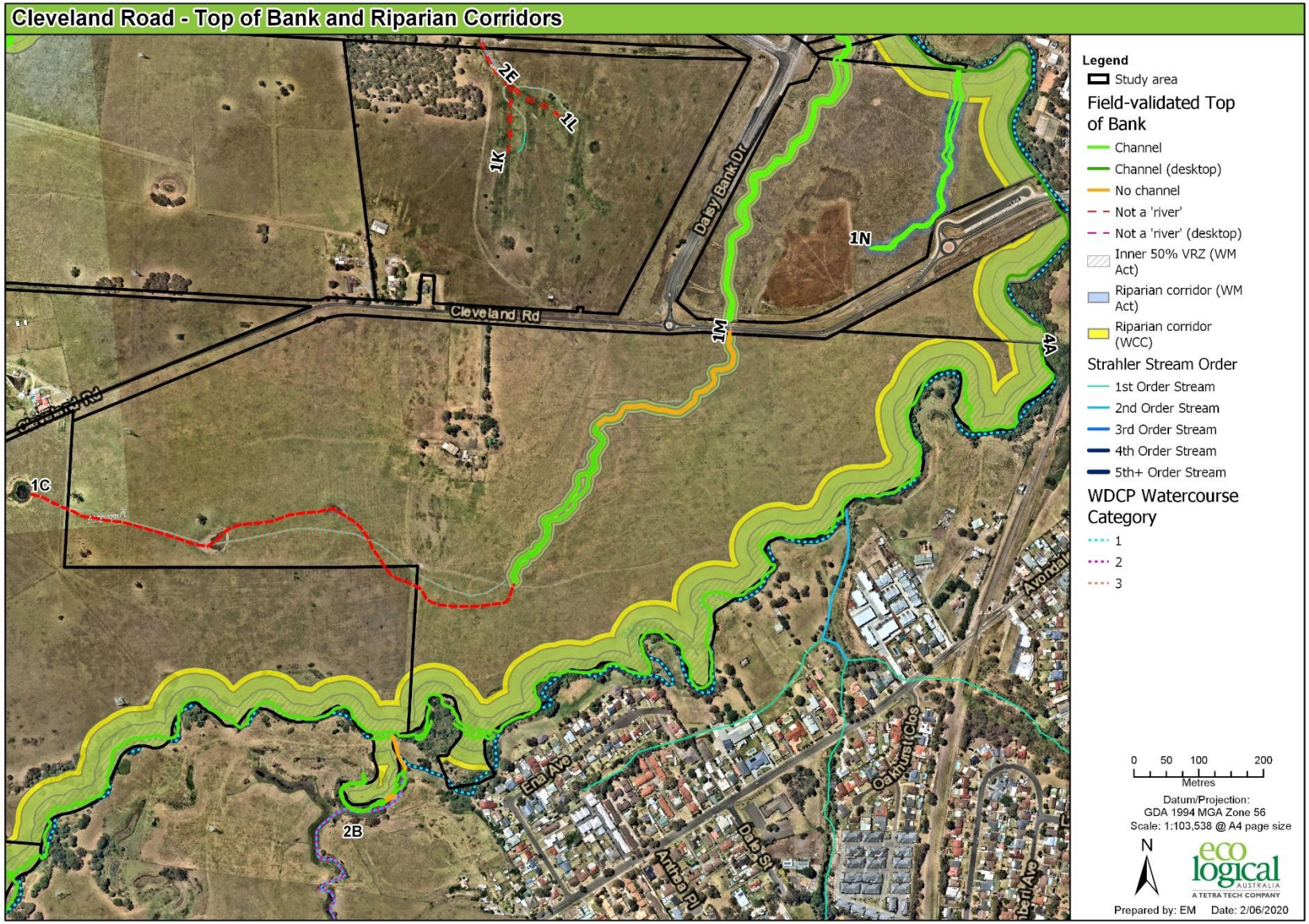

Figure 9: ELA validated top of bank and riparian corridor widths within the south east section of the study area

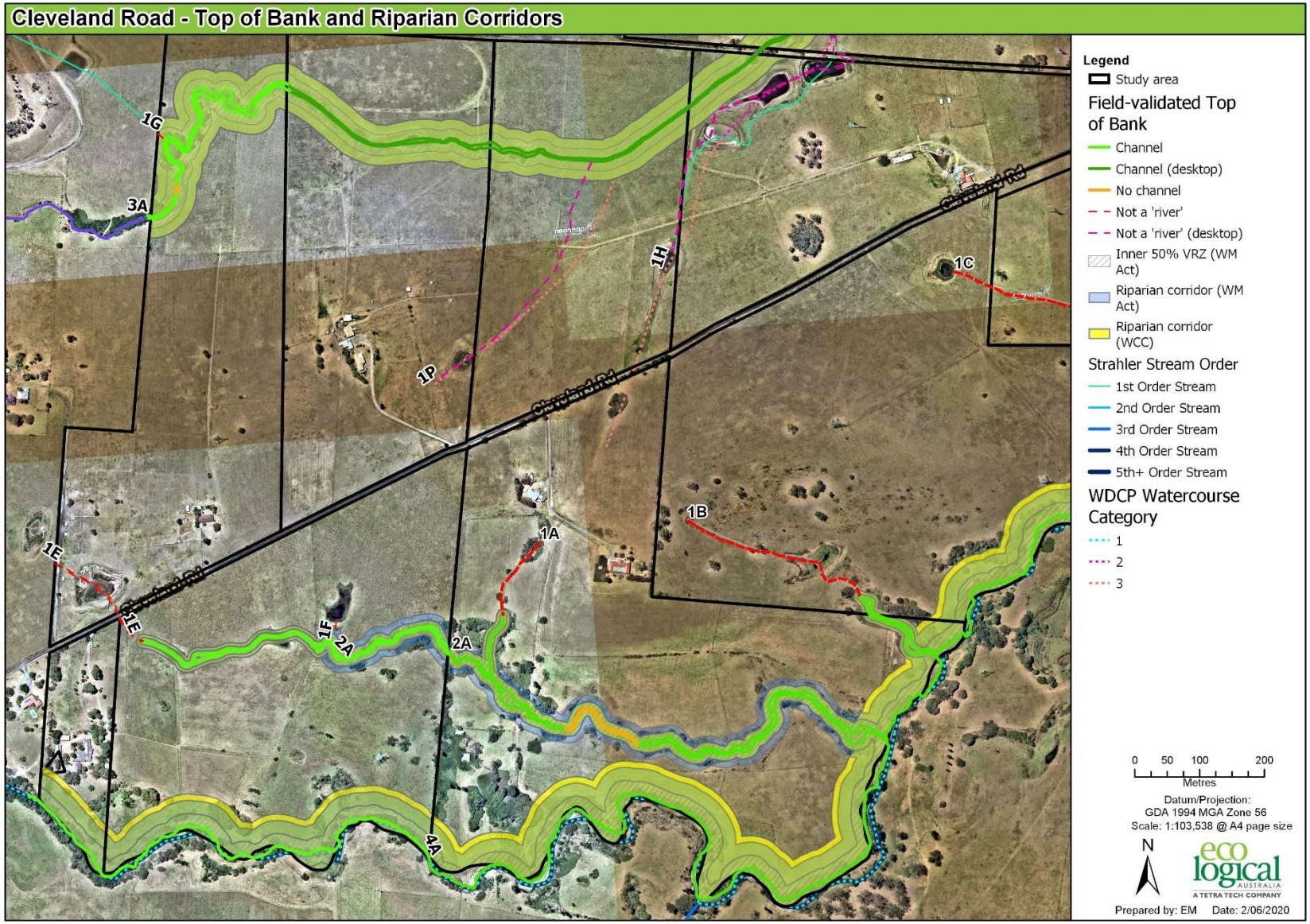

Figure 10: ELA validated top of bank and riparian corridor widths within the south west section of the study area

Table 7: First order and minor streams

Reach	Strahler	WCC category	Result	Photo facing upstream	Photo facing downstream
1F	-	3	Desktop assessment only. Not a 'river' under the WM Act. Unlikely to have defined bed, banks or geomorphic processes.	-	-
1G	1	-	Not a 'river' under the WM Act. No defined bed, banks or geomorphic processes.		
1H	1	3	Desktop assessment only. Not a 'river' under the WM Act. Unlikely to have defined bed, banks or geomorphic processes.	-	-
1I	1	-	Desktop assessment only. Defined channel from aerial imagery. Unlikely to provide habitat for fauna. Riparian habitat was pasture grass with scattered paddock trees.	-	-
1K	1	3	Not a 'river' under the WM Act. No defined bed, banks or geomorphic processes.		

Reach	Strahler	WCC category	Result	Photo facing upstream	Photo facing downstream
1L	1	3	Not a 'river' under the WM Act. No defined bed, banks or geomorphic processes.		
1M	1	3	Defined bed and banks. Aquatic vegetation *Typha orientalis* (Typha) present downstream. Riparian vegetation was pasture.		
1N	1	-	Defined bed and banks. Aquatic vegetation *Typha orientalis* present throughout the reach. Riparian vegetation was pasture.		

Reach	Strahler	WCC category	Result	Photo facing upstream	Photo facing downstream
1O	1		Desktop assessment only. Examination of contours and aerial photos indicate defined channel present.		
2D	2	-	Desktop assessment only. Not a 'river' under the WM Act. Unlikely to have defined bed, banks or geomorphic processes.	-	-
2E	2	3	The first 150 m had no defined bed or bank and has been mapped as not a 'river'. The channel began downstream of the pipe culvert. Moving downstream the channel defined by the extent of dense *Typha orientalis*. There was shallow (<10 cm), stagnant water present with an oily sheen and foam. No aquatic fauna was observed. Riparian habitat was Coastal Swamp Oak Forest.	 	 

Reach 1A: Classed as Category 3 as per WCC and 1st order under WM Act. The upper 175 m of this reach did not have a defined bed, banks or geomorphic processes. It was a grassy depression between dense patches of exotic vegetation. Where the channel began, it was straight, highly incised, with steep banks and a predominately silty bed. Moving downstream, the channel widened (1 – 2 m) and meandered throughout the vegetation. The channel was dry at the time of the survey and no aquatic flora or fauna occurred. The riparian zone was dominated by dense weeds including *Erythrina x sykesii* (Coral Tree), *Lantana camara* (Lantana), *Rubus fruticosus* (Blackberry) and *Urtica dioica* (Stinging Nettle). The channel was filled with Coral Tree leaf litter and woody debris. At the time of the survey there was no habitat for fish, frogs or wading birds.

Facing upstream – no defined channel

Facing downstream – no defined channel

Facing upstream – start of channel

Facing downstream

Reach 1B: Classed as Category 3 as per WCC and 1st order under WM Act. This creek had no defined bed, banks or geomorphic processes until approximately 80 m downstream of the dam. Until this point the stream was a cleared grassy depression that may flow during heavy rainfall. The riparian zone was cleared pasture with scattered Blackberry. Downstream of the dam the channel was wide with gently-sloping banks. The benthic sediment was predominately silt. The water was shallow, stagnant and turbid. No fish or frogs were observed. A single *Ardea pacifica* (White-necked Heron) was observed wading in the water. The riparian zone in this downstream stretch was vegetated with scattered native

trees (*Melaleuca styphelioides* (Tea Tree) and *Eucalyptus* spp.). The mid-storey consisted of dense exotic species (Lantana and Blackberry). The groundcover was dominated by dense pasture grasses and herbs.

Facing upstream – no defined channel

Facing downstream – no defined channel

Facing upstream – dry channel

Facing downstream – wide channel with pools

Reach 1C: Classed as Category 3 as per WCC and 1st order under WM Act. This creek had no defined bed, banks or geomorphic processes for the upper 800 m. The creek was a grassy depression that may convey flows in times of heavy rainfall through the cleared pasture. The channel began downstream of a pipe culvert. The channel width was approximately 2 – 3 m wide and meandered through the grassy paddock. There was evidence of trampling by livestock in both the channel and on the banks. There was no aquatic vegetation, or habitat for fish, frogs or birds at the time of the survey.

Facing upstream – no defined channel

Facing downstream – no defined channel

Facing upstream – defined channel

Facing downstream – channel eroded by cattle

Reach 1E: Classed as Category 3 as per WCC and 1st order under WM Act. The upper 70 m of this reach did not have a defined bed, banks or geomorphic processes. It was a grassy depression between the road and the dam. The channel has been mapped from the western side of the first dam, where aquatic habitat was present. There was a defined channel between the first and second dam. The channel, excluding the dams, was dry at the time of the survey and no aquatic flora was observed in the creek. Both dams provided aquatic habitat with water and aquatic vegetation including *Ludwigia peploides* (Water Primrose), *Eleocharis* sp., *Azolla pinnata* (Azolla) and *Typha orientalis* present. There were two *Porphyrio porphyrio* (Purple Swamphen) using the *Typha orientalis* as habitat. The riparian vegetation either side of the creek was pasture.

Facing upstream – no defined channel

Facing downstream – no defined channel

Facing downstream of dam –channel defined

Dam providing habitat

Reach 1F: Not mapped as a watercourse under WCC mapping and 1st order under WM Act. This creek is mapped to flow south from a dam and join with 1E. At the time of the survey, there was no defined bed, banks or geomorphic processes.

Facing upstream – no defined channel

Facing downstream – no defined channel

Reach 2A: Classed as Category 3 as per WCC and 2nd order under WM Act. The channel in the upstream section was on average 1 – 2 m wide, with a few shallow (10 cm) turbid pools. Aquatic vegetation present in pools was mostly dense *Spirodela polyrhiza* (Duckweed) and scattered *Zantedeschia aethiopica* (Arum Lily). The banks were predominately lined with vegetation and sloped gently. On the outer bends the banks were steeper and undercut. The benthic substrate was predominately silt. Riparian vegetation was mostly exotic, with species such as Coral Tree, Lantana, Blackberry and Stinging Nettle growing in dense patches. Downstream of where 1A joined the creek, the channel was wide with small shallow pools. The channel was smothered by Coral Trees and their dead branches. The banks were lined with dense Lantana. Downstream of this vegetation the channel became less defined, flowing into an open grassy swale where the water would disperse overland. There were no defined bed or banks throughout this section of the creek. Clumps of native *Juncus usitatus*, *Juncus subsecundus* and exotic *Juncus acutus* (Sharp Rush) were scattered throughout this area. Further downstream, the channel became defined again with a broad bed and gently-sloping banks through a dense patch of vegetation. From here, the channel had an average width of 4 – 5 m, with predominately exotic vegetation including *Salix babylonica* (Willow), Lantana, Blackberry and Coral Trees lining the banks. Native *Casuarina cunninghamiana* (She-oak) and Eucalypt trees were also scattered throughout the riparian zone. A *Pseudechis porphyriacus* (Red-bellied Black Snake) was observed in this vegetation. There were a few small, stagnant narrow pools throughout the reach. All had evidence of trampling by cattle. No fish, frogs or wading birds were observed during the field survey, although there was potential habitat for all three in times of flow.

Facing upstream

Facing downstream – small shallow pool

Facing upstream – channel stops after vegetation

Facing downstream – grassy swale

Facing upstream – channel impacted by livestock

Facing downstream – shallow turbid pool

Reach 2A (cont'd): The channel in the upstream section was on average 3 – 4 m wide and dry. The banks sloped gently and were vegetated with pasture and patches of dense *Rubus fruticosus*. There was evidence of cattle being in the creek with trampling observed in the bed. Downstream, the channel width narrowed to 1 – 2 m. A long shallow pool was present adjacent to the left bank, the water was stagnant with an oily sheen. Adjacent to the pool along the right bank, the native macrophyte *Persicaria decipiens* (Slender Knotweed) dominated the groundcover and beyond this was extremely dense Blackberry, *Erigeron bonariensis* (Flaxleaf Fleabane), *Ageratina adenophora* (Crofton Weed), and *Lantana camara* (Lantana). The left bank was vertical with overhanging Lantana. A *Pseudechis porphyriacus* (Red-bellied Black Snake) was observed slithering into the Lantana. Where the channel entered the adjacent lot, *Erythrina x sykesii* (Coral Trees) were growing in the bed. The roots would disperse the water in times of flow. No fish, frogs or wading birds were observed during the field survey, although there was potential habitat for all three in times of flow.

Facing upstream – grassed bed with blackberry

Facing downstream – cattle trampling evident

Facing upstream – shallow pool with dense weeds

Facing downstream – dense Coral Trees

Reach 2B: Classed as Category 2 as per WCC and 2nd order under WM Act. This stream joins Mullet Creek on the southern boundary of the site. Upstream the channel was defined, with a narrow run that flowed into a large wide pool. The pool was lined with Willows and exotic grasses. *Typha orientalis* was present in the pool, as was the exotic lily *Nymphaea mexicana* (Yellow Waterlily). There was no defined channel between this pool and the fourth order creek. Here it was a grassy overland depression that would flow in times of heavy rain but had no defined channel or banks.

Facing upstream – large deep, turbid pool

Facing downstream – no defined channel

Reach 3A: Classed as Category 2 as per WCC, 3rd order under WM Act and 'key fish habitat' as per DPI Fisheries mapping. This creek had defined bed and banks. The surveyed upstream portion of the creek had deeply incised banks over 2 m high. The bed was heavily shaded by the exotic species *Lantana camara* (Lantana), *Rubus fruticosus* (Blackberry) and *Ligustrum sinense* (Privet). Mature native *Melaleuca styphelioides, Eucalyptus* sp. and *Angophora floribunda* were scattered between the weeds. No aquatic flora or fauna was observed. Moving downstream the banks increased in slope. Blackberry was present in the channel and the riparian vegetation was predominately pasture. Typha was present at the eastern extent of the reach.

Facing upstream

Facing downstream

Facing upstream

Facing downstream

Reach 3A (cont'd): The eastern portion of the creek was relatively inaccessible. The portion that was surveyed had shallow, clear water. *Persicaria decipiens* (Slender Knotweed) was present throughout the reach. The riparian vegetation within this area of the site was validated as Plant Community Type 1232 *Swamp Oak floodplain swamp forest, Sydney Basin Bioregion and South East Corner Bioregion* during field surveys by ELA as part of the Flora and Fauna Assessment completed for the site in 2020 (ELA, 2020a).

Facing upstream

Facing downstream

Facing upstream

Facing downstream

Reach 4A: Classed as Category 1 as per WCC, 4th order under WM Act and 'key fish habitat' as per DPI Fisheries mapping. Mullet Creek runs along the southern boundary of the site. The creek had an average width of 6 – 8 m with some wider braided sections where Willows had diverted the water. The bed consisted of predominately fine sediment with gravel, cobbles and occasionally instream woody debris. In the upstream reach the water was clear and flowing slowly. Aquatic plants were common including filamentous algae and *Azolla pinnata*. The flow alternated between narrow runs and wide pools. There were no riffles present in the creek. The banks were steep on the outer bends, up to 2 m high and undercut. The inner bends had a lower gradient, with accumulations of sediment in the channel. Both banks were dominated by weed species. Moving downstream, after the first order tributary 1B joined the creek, the channel narrowed with an average width of 4 – 6 m. The water became turbid and there was evidence of erosion from cattle. Cattle were observed crossing the creek at numerous points during the survey. The banks were slumped either side of these crossings. Downstream of where reach 2B joined, a long stretch of Cumbungi was present. The water flowing through the Cumbungi was clear. Approximately 200 m downstream, *Eichhornia crassipes* (Water Hyacinth), a weed of national significance was observed. Initially it was scattered throughout the channel, but moving downstream the weed became very dense, and blocked the entire channel for over 100 m.

Along the entire reach the banks were dominated by exotic species including *Bidens pilosa* (Cobblers Peg), Coral Trees, Lantana*, Onopordum acanthium* (Scotch Thistle), Blackberry*,* Stinging Nettle and Willows. The vegetation alternated between extremely dense sections and open pasture. There were mature native trees scattered throughout the riparian zone also, including included She-oaks, Eucalypts and Tea Trees.

Facing upstream

Facing downstream

Facing upstream – slow flowing, turbid water

Facing downstream – livestock crossing


Dense Eichhornia crassipes (Water Hyacinth) clogging the stream

Reach 4A (cont'd): The water throughout the reach was clear and flowing, alternating between narrow runs and wider pools. No riffles were present. The benthic habitat was gravel and cobbles with fine sediment. Native aquatic vegetation was present throughout the reach, with Azolla, *Potamogeton crispus* (Crispy Pondweed), Typha, *Lemna disperma* (Duckweed), Slender Knotweed and *Nasturtium officinale* (Watercress) consistently observed. The left bank along the reach was steep and up to 3 m high. The outer bends were eroded and vertical. The inner bends had a gentler slope, with accumulations of sediment. Riparian vegetation along the reach was predominately weed species including Coral Trees, Lantana, Blackberry, Flaxleaf Fleabane and pasture grasses. Native trees and shrubs, such as *Acacia longifolia* (Wattle), *Hibiscus heterophyllus* (Hibiscus), *Melaleuca styphelioides* (Prickly-leaved Paperbark) were scattered amongst the weeds. The vegetation alternated between extremely dense sections and open pasture, where cattle had accessed the creek. Native aquatic fauna observed included two *Chelodina longicollis* (Eastern Long-necked Turtle) and three *Anguilla australis* (Short-finned Eel). The exotic fish, *Gambusia holbrooki* (Mosquitofish) were observed in each pool.


Facing upstream *Facing downstream*

Facing upstream – slow flowing, turbid water

Facing downstream – livestock crossing

5. Impact assessment

5.1 Encroachment into riparian buffer – WM Act riparian corridor

The footprint currently encroaches into the outer half of the VRZ in several locations (Figure 11 to Figure 17). This encroachment includes the intended APZ areas, which are a non-riparian use. When using the WM Act to calculate recommended riparian corridor widths, the total area of encroachment into the outer VRZ is 0.92 ha. As per NRAR's guidelines for offsetting encroachments (Figure 1), this must be offset elsewhere within the site at a 1:1 ratio to create an average VRZ width. Under the existing footprint, there is up to 1.95 ha recommended for offsetting all encroached areas as shown in Figure 11 and Figure 13.

Encroachment into the riparian corridor has the potential to impact on the connectivity and condition of riparian vegetation, introduce impervious surfaces to a previously vegetated or permeable area and impacts on water quality. This would also require a merit-based assessment from NRAR. As NRAR have provided in-principle support for the removal of undefined waterways within the study area and the reconstruction and rehabilitation of watercourse 3A (NRAR, 2020), it is assumed that the NRAR corridor widths would be adopted.

5.2 Encroachment into riparian buffer – WCC riparian corridor

As mentioned previously, the WCC DCP requires riparian corridors that are greater in width than recommended under the WM Act. When the WCC riparian corridor widths are applied, the proposed footprint encroaches more of the riparian corridor along Mullet Creek. This would require offsetting elsewhere within the site at a 1:1 ratio. Under the existing footprint, there areas available for offsetting this encroachment, similar to what is shown in Figure 11 to Figure 13. The DCP has less flexibility for offsetting than the WM Act, and the proposed encroachment and offset areas should be confirmed with Council. Potential offset areas outlined are generally degraded with a high recovery potential, after rehabilitation they would provide a greater vegetated buffer between the development and the creek.

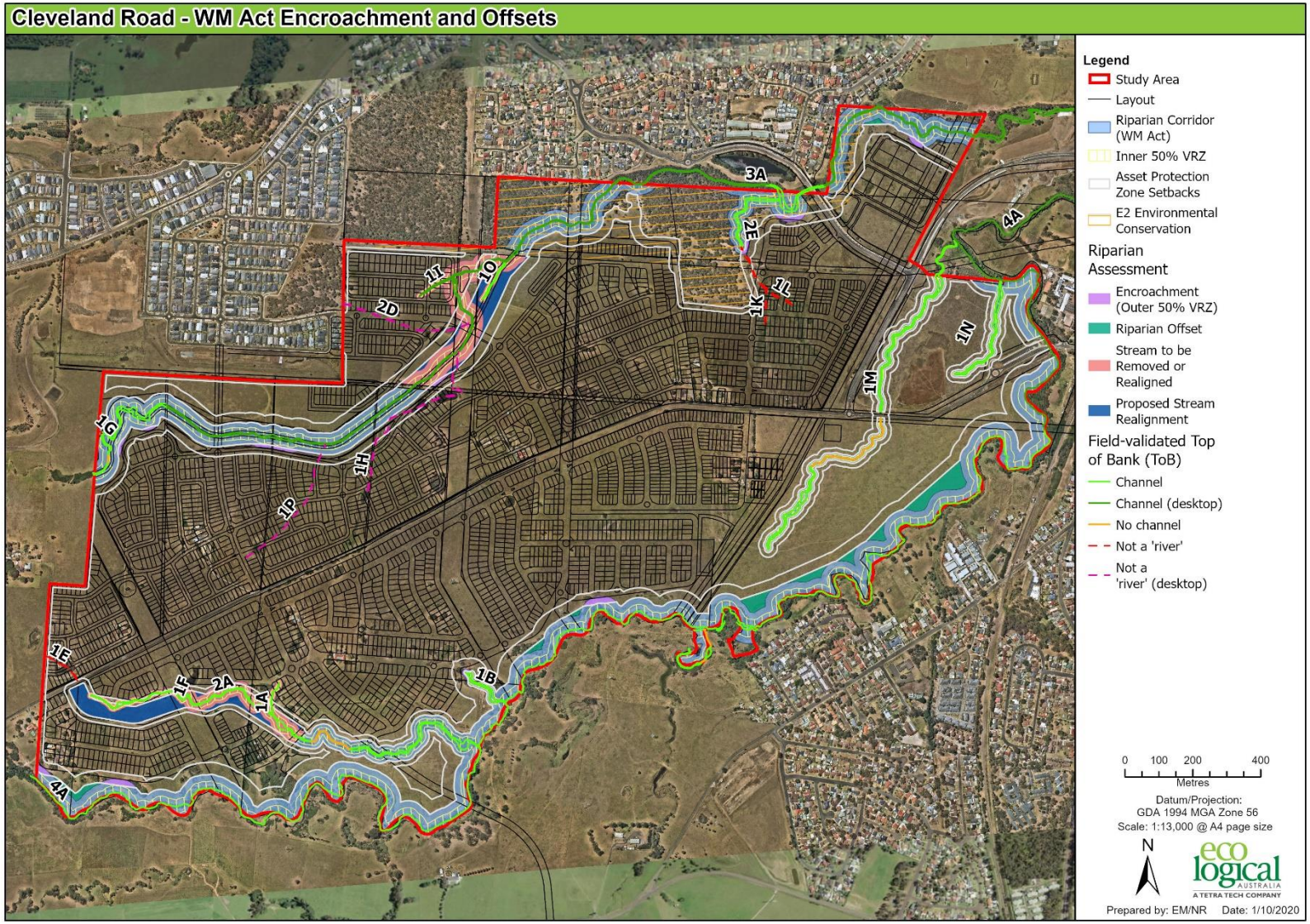

Figure 11: Impacts to WM Act riparian corridors and available offset areas

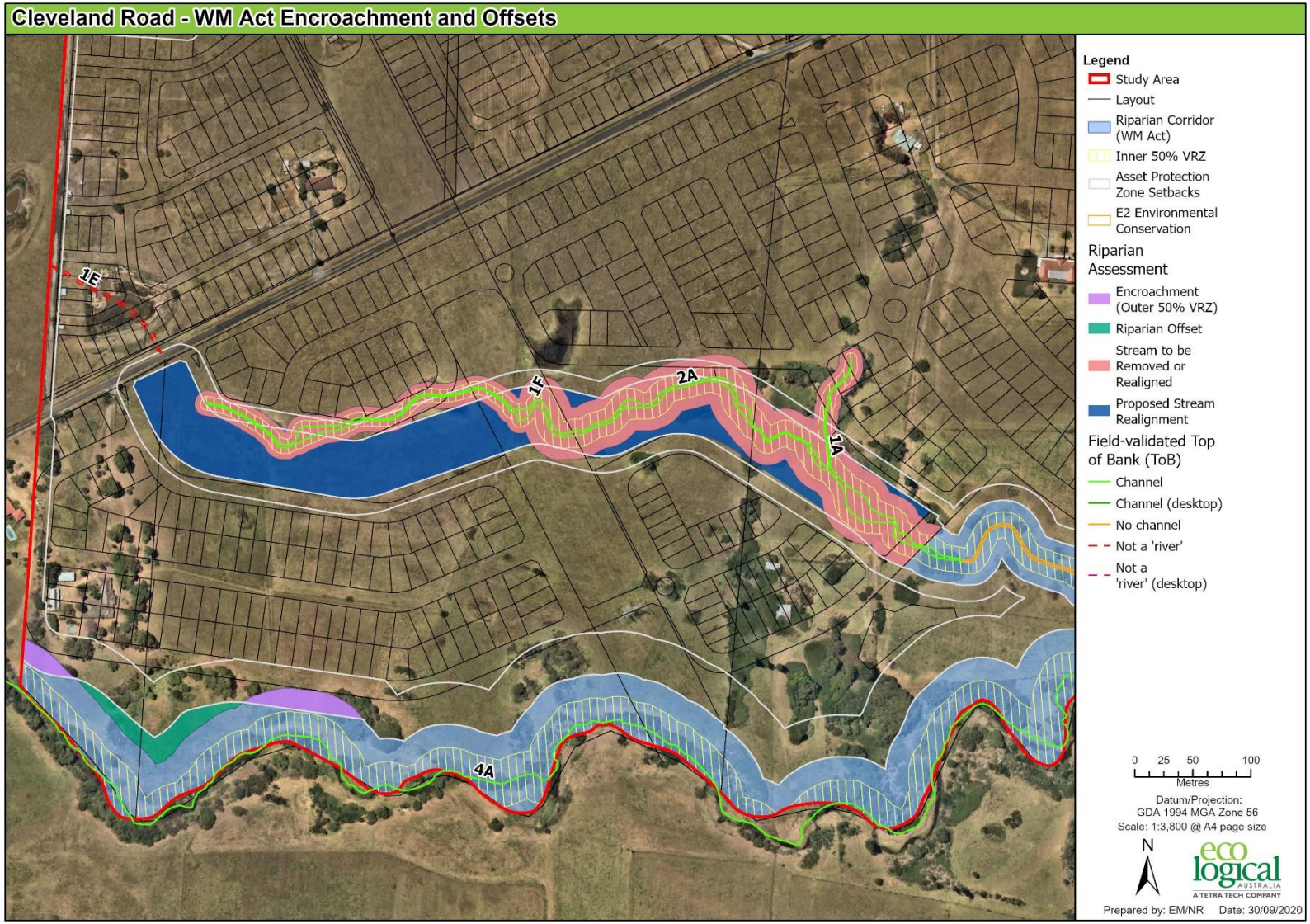

Figure 12: Impacts to riparian corridors along Mullet Creek and realignment of creeks 1A, 1F and 2A

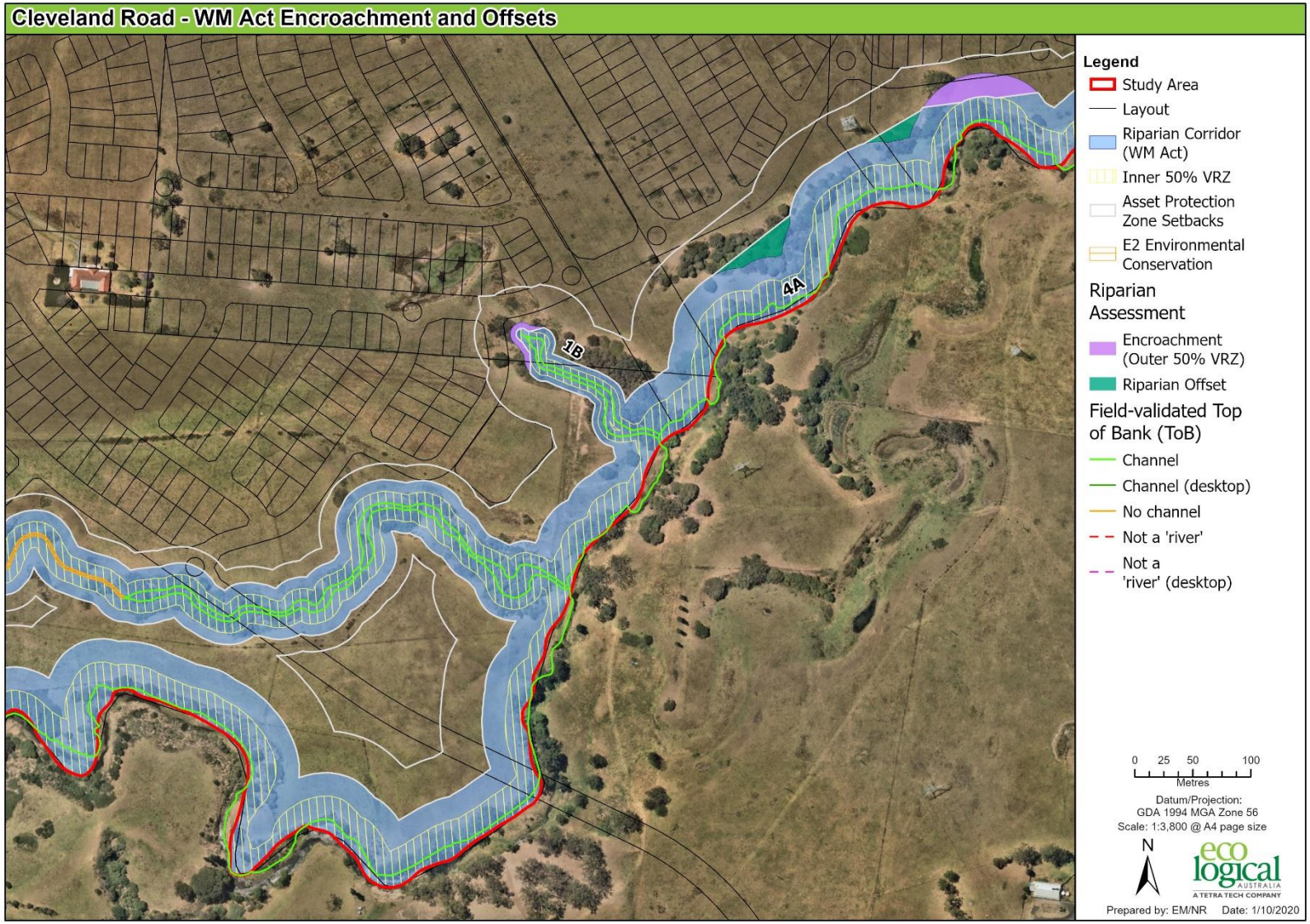

Figure 13: Impacts to riparian corridors along Mullet Creek (4A) and 1B

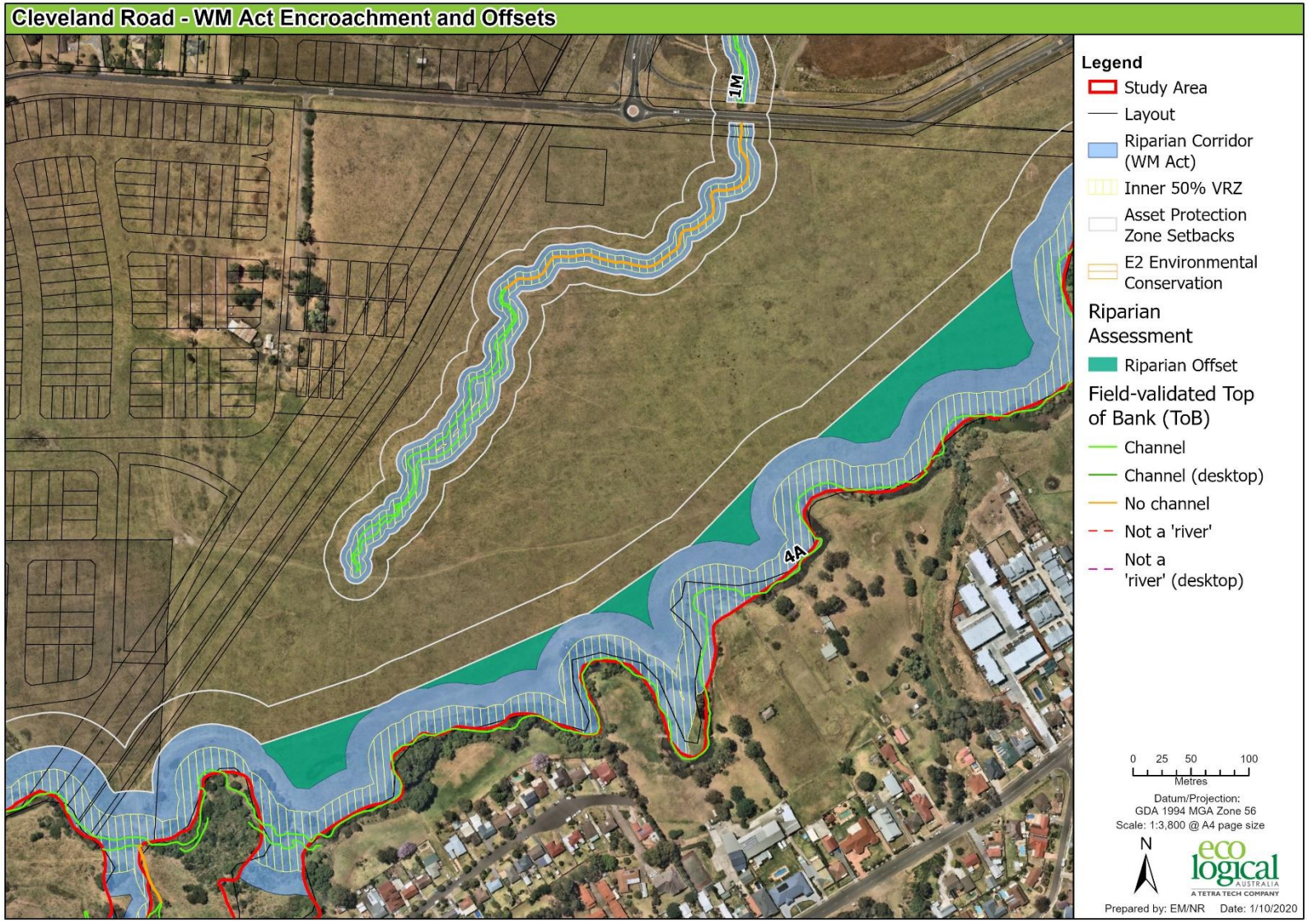

Figure 14: Impacts to riparian corridor widths and proposed offset areas – Mullet Creek and 1M

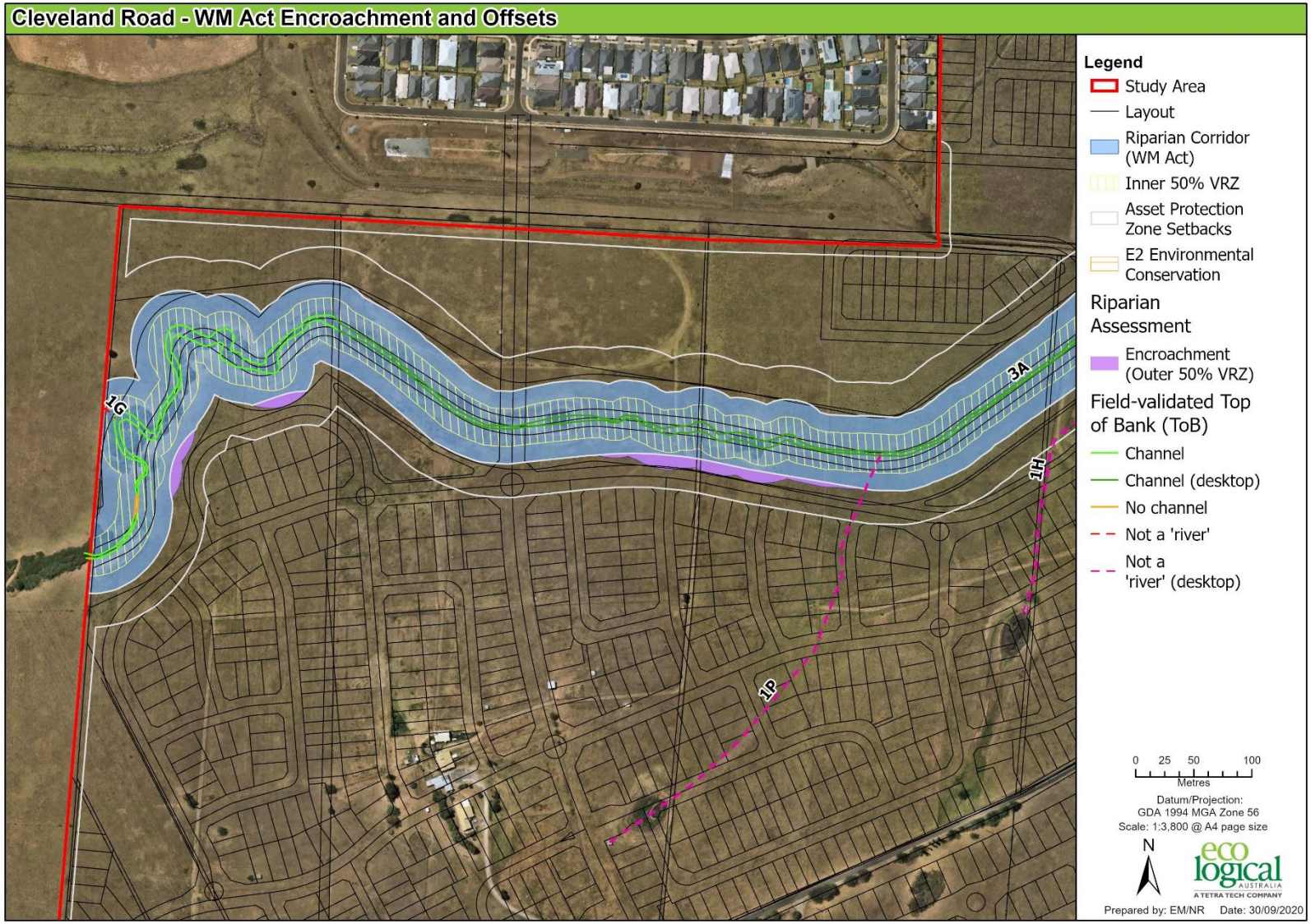

Figure 15: Impacts to riparian corridor widths along 3A

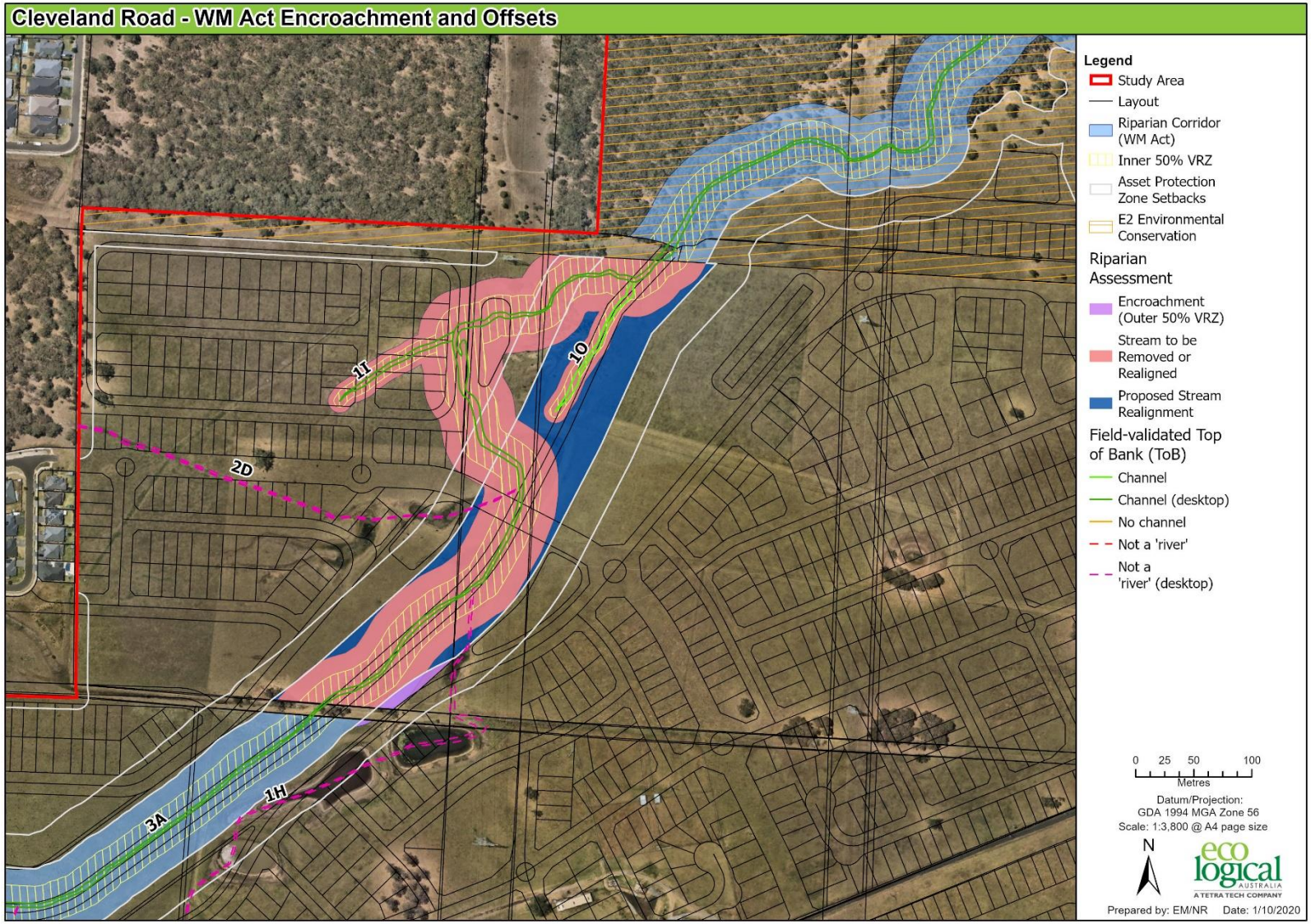

Figure 16: Impacts to riparian corridors along 3A, 1I and 1O

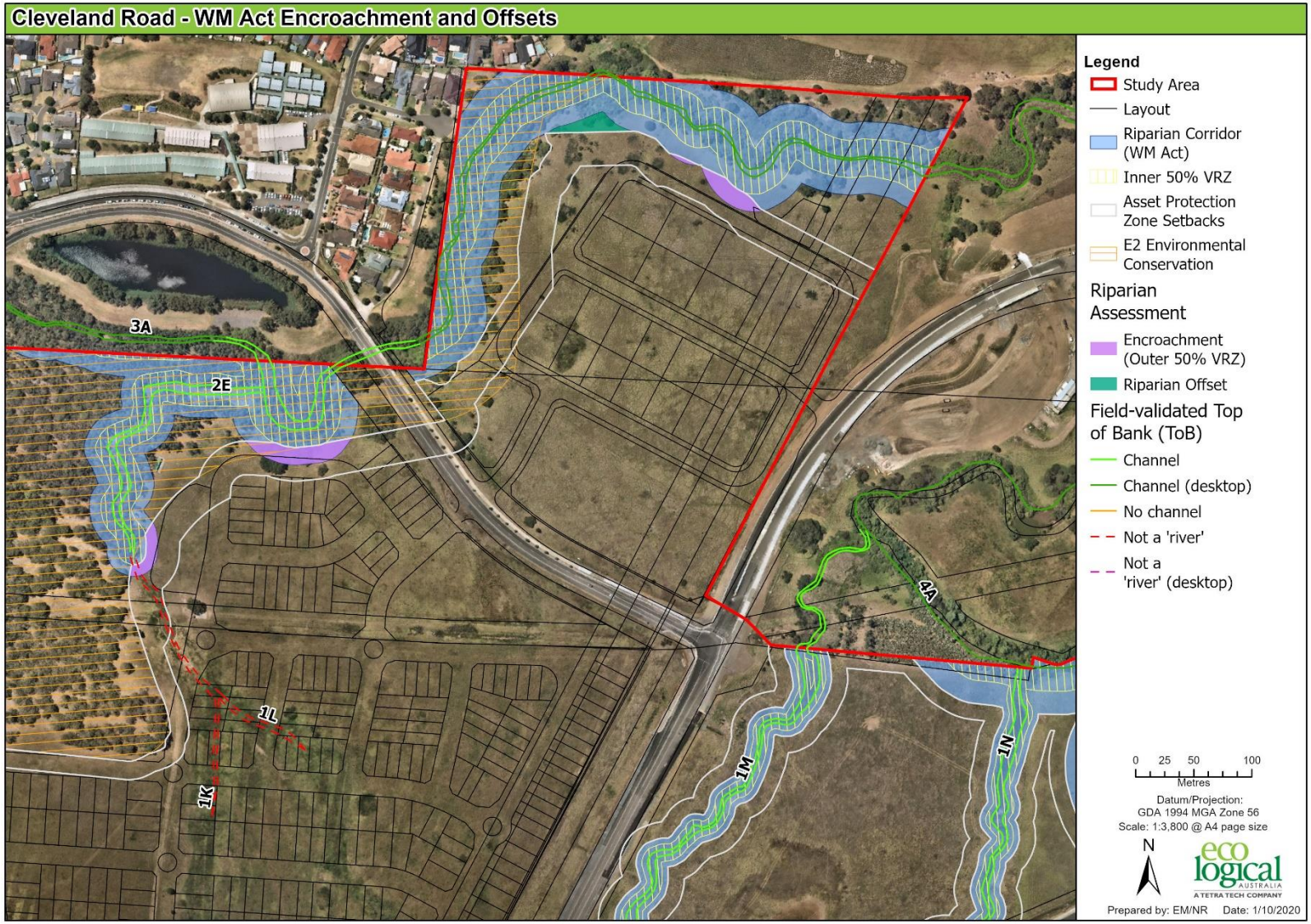

Figure 17: Impacts to riparian corridors along 3A and 2E

5.3 Surface erosion and sedimentation

Any clearing of vegetation within the riparian zone can result in lack of soil stability. This may cause surface erosion (sheet and gully erosion) and transportation of sediment overland into the nearby creek. Impacts may include increased water turbidity, which would disrupt light penetration through the water column and impact on primary (plant) production, with flow on effects through the food web. Increased sediment loads may settle in downstream pools, causing a loss of deep habitat, promotion of dense reeds and changes to hydrologic connectivity. Sediment could also smother benthic habitat.

5.4 Watercourse crossings

Road bridges are proposed to cross reaches 1F, 1G, 2A, 3A and 4A. 1M has an existing road crossing which may need to be upgraded to service the proposed development. There are a number of potential impacts that could occur as a result of the construction of a bridge over the waterways:

5.4.1 Temporary blockage of fish passage

If the proposed construction of bridges requires pylons to be installed within the creekline or close to the bank, there may be the need to ensure that the immediate works area is dry to allow machinery to move freely within the area as well as to prevent waste material and dust entering the water. These creeks, with the exception of 4A (Mullet Creek), are ephemeral so works should be conducted during dry periods or dewatering may be required. Dewatering of the works area would temporarily block fish passage through the reach.

5.4.2 Degradation of water quality

There is the potential for sediment and waste material generated as part of the construction of the crossings to enter the waterway. This would increase the turbidity of the water and potentially introduce chemicals to the creek, and ultimately degrading the water quality not only in the immediate works area but also in downstream environments.

5.4.3 Destabilisation of creek banks

Removal of vegetation for the construction of the proposed road bridges may destabilise sections of the creek bank within these areas, if the vegetation and its roots are acting as stabilisers of the soil. If the creek banks are destabilised, this could lead to erosion of the banks and subsequent sedimentation of the water. This may increase the turbidity of the water within the waterway and limit the amount of sunlight penetrating the water column and affect fish health. If bank erosion was left to continue, this could lead to the loss of riparian land and potentially impact any assets within these areas.

5.4.4 Shading of creek line

Construction of new bridges over creeks would cause shading of the waterway. Although creeklines in some areas are currently partly shaded by vegetation, additional shading would decrease the amount of light available for growth of instream and riparian vegetation and aquatic fauna. The higher the bridge, the less shading impact would occur.

5.4.5 Hydrological impacts

The construction of a creek crossing can affect the hydrology and instream water movement upstream and downstream of where the bridge is located. This specifically refers to footings, pylons or

embankments that support the crossing. Impacts may include changes in flood water extent (outwards and back upstream) and back-eddies causing bank erosion. This may affect recruitment and stability of riparian vegetation and bed and bank stability, with flow on effects of loss of instream and riparian habitat and sedimentation. Changes in local waterflow can lead to changes in the geomorphology of the waterway, such as increased erosion and / or deposition within the waterway.

5.5 Service installation

If any services such as a sewer main, drinking water pipeline or power lines are required to be installed across the creeklines, there can be impacts to bed stability, water quality and aquatic habitat depending on the construction method utilised.

5.6 Loss of riparian habitat

Where the proposed footprint encroaches into vegetated riparian areas, this could involve the loss of established canopy trees and other vegetation which may provide habitat for native fauna species. This may result in loss of habitat and riparian vegetation connectivity and increased fragmentation of habitat areas, introduction of exotic species, increased sedimentation and water quality issues.

5.7 Weed invasion

Where disturbance from construction associated with the proposal results in bare ground or increased sunlight penetration into riparian areas, there is the potential for invasion of exotic flora species. The movement of construction vehicles in and around the riparian areas can also act as a vector for weed propagules. Impacts include introduction of new weeds to the area and extended penetration of weeds into native plant communities. This may result in a loss of biodiversity and habitat value, smothering of native juvenile plants, harbouring of feral animals and alteration of vegetation structure and riparian function.

5.8 Polluted surface water runoff

In areas where the proposed development includes the construction of new car parks, roads and other impervious surfaces there is an increased risk of motor vehicle oils, litter and warmer surface water to enter the creek. Subsequent impacts may include water quality issues (heavy metals, oil and grease pollution from vehicles), inorganic clogging of aquatic habitats (litter / rubbish) and destruction of macroinvertebrate communities (warm water inflows). Another impact common in urban areas is when mass leaf drops from deciduous street trees wash into the creek. Large amounts of non-native leaves deposited in a short time create water quality issues during decomposition. These leaves are also not a suitable food resource for macroinvertebrates, which prefer slow-decomposing native leaves that are evenly deposited throughout the year.

5.9 Increase velocity of surface water runoff

Similar to the impact of pollution from the construction and ongoing use of impervious surfaces, the proposed development can also impact on the velocity of water entering the creekline where impermeable surfaces are constructed over existing vegetation (e.g. proposed car parks). Impacts may include changes to instream flow velocity which can change the aquatic habitat for macroinvertebrates and other small aquatic fauna (e.g. some macroinvertebrates and macrophytes prefer slow water),

increased bank erosion from fast discharge resulting in bed and bank erosion, loss of riparian vegetation, loss of edge habitat and sedimentation of downstream environments.

5.10 Water Management Act 2000

The footprint proposes to realign or remove a section of 1A, 1F, 1I, 1O, 2A and 3A. Realigning first-order watercourses is consistent with guidelines (Table 5). Creeks 1I and 1O would become part of the 3A watercourse, which is considered removal. 1A would become part of 2A and 1F would be realigned.

When providing feedback on a previous assessment, NRAR outlined that reconstruction of 3A is generally acceptable but advised that further assessment is required for proposed works to 2A. The proposed realignment of this 2nd order watercourse within the development area is not consistent with the *Guidelines for Controlled Activities on Waterfront Land* (NRAR, 2018). In this case, the principles of the WM Act can guide activities that are to take place on waterfront land and be used to support 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.*

A high level assessment of watercourses in the proximity of the proposed development at Cleveland Road was prepared by Rienco Consulting in May 2020. This assessment, titled '*Survey of Existing Watercourses – Planning Proposal at Cleveland Road, Cleveland*', was reviewed by NRAR in September

2020. NRAR stated that the reconstruction and rehabilitation of 3A was supported and that this reconstruction and establishment of a riparian corridor should extend to the boundary of the site to provide connectivity with the existing remnant bushland area. Where 3A is proposed to be realigned and 1I and 1O would be removed, riparian vegetation is not continuous and the vegetation within this area is predominantly exotic pasture. The current corridor for the three creeks is 4.25 ha and the new alignment would provide 3.61 ha. The lost 0.64 ha has been compensated through riparian offsets across the site.

The Rienco assessment outlined that where watercourses 1A, 1F and 2A are located, the proposed development would seek to reconstruct the watercourses in this area, including incorporating Water Sensitive Urban Design measures and riparian planting. NRAR requested an additional assessment and protection of riparian values for the watercourses in this area In its current state, 2A is devoid of aquatic habitat and lacking in native riparian species. The current riparian corridor along 1E and 2A is 2.86 ha, and the new realigned watercourse would provide 3.6 ha of riparian corridor, an increase in 0.74 ha.

The realignment of the 2nd and 3rd order watercourses allow for a protected and rehabilitated watercourse to be established A Vegetation Management Plan (VMP) (or plans) would be required for revegetation and maintenance of riparian areas within the study area. Typically, VMPs are be prepared for any riparian corridors present in each stage of the development. VMPs would accompany each DA where applicable. As a result, these vegetated channels will become protected waterways within the new development area which is a marked improvement on the current condition these watercourses are in, as they receive no observable maintenance and are providing limited habitat connectivity for aquatic or terrestrial fauna.

The realignment of the watercourses would allow for an improvement in water quality within these tributaries of Mullet Creek, as stable beds and banks would be created and the revegetation of the riparian areas would allow for a buffer between the residential areas proposed for the site and the waterway itself.

The realigned channels would allow for the increase in the amount of native vegetation within the development area, which will improve the amenity and habitat values of the areas. The condition of 2A, and similarly 3A, is that it is surrounded predominantly by exotic flora species, whereas a realigned and revegetated channel and riparian zone would be fully vegetated with native species and maintained for the period as specified in the overarching VMP prepared for the development area (ELA, 2020b). The planned reconstruction of this 3rd order watercourse is supported by NRAR (NRAR, 2020).

While the realignment of this watercourse is a controlled activity, there would be no impacts to other water users downstream, as mitigation measures described in Section 6 would be incorporated into the design, construction and ongoing management of the site.

The proposed works also include the removal of existing online basins, including a large dam on watercourse 3A. If constructed today, these dams would be considered contrary to NRAR's guidelines (outlined in Table 5). Dams act as artificial barriers to aquatic fauna movement upstream and downstream and impede natural flows. Removal of these dams would be considered a positive step towards ensuring barriers to movement of aquatic fauna are removed and more natural hydrological regimes are reinstated.

5.11 State Environmental Planning Policy (Coastal Management) 2018

The proposed development is in areas mapped as Coastal Wetland and Proximity to Coastal Wetland under the Coastal Management SEPP (Figure 4). In the north eastern area of the study area, the Proximity to Coastal Wetland mapping extends into the proposed development area where Coastal Wetlands are located outside of the development footprint. In the central north area of the study area, there are proposed development lots in the mapped coastal wetland, with a large number of lots mapped in the proximity to coastal wetlands.

Where possible, lot design and development should avoid impacting coastal wetlands. Where this is not possible and the proposed development is to impact areas mapped as Coastal Wetlands, the development is considered designated development under the EP&A Act and an EIS would be required to demonstrate that sufficient measures have been, or will be taken, to protect, and where possible enhance, the biophysical, hydrological and ecological integrity of the coastal wetland. Additionally, development in the proximity to coastal wetlands, should not impact the adjacent coastal wetland or the quality and quantity of surface and ground water flows to and from the coastal wetland. The development application should demonstrate avoidance and mitigation measures to minimise impacts to the adjacent wetland.

6. Mitigation measures

6.1 Construction Environmental Management Plan

A Construction Environmental Management Plan (CEMP) should be prepared prior to commencement of any construction works to address measures required be implemented prior to, during and after works to minimise impacts on the environment. This CEMP should include a Sediment and Erosion Control Plan, prepared in accordance with *The Blue Book – Managing Urban Stormwater: Soils and Construction* (Landcom, 2004) and implemented prior to works, with the aim of achieving an outcome of 'no visible turbid plumes migrating through the waterway'. The Plan must include, as a minimum, the locations and type of erosion and sediment controls to be erected within and adjacent to the waterways.

6.2 Timing and location of works

The proposed construction footprint encroaches into some areas of the riparian corridor. Actual works within these areas are yet to be fully documented, however it is recommended that higher-disturbance activities (such as noisy machinery, flood lights, generators and compounds) be located as far from the riparian buffer as practically possible. This is to avoid disturbance to fauna that rely on the riparian corridor for refuge, roosting, foraging and breeding. Likewise, the construction of the road bridge within the riparian corridor zone should be minimised at night (i.e. reduction of floodlights and noise that may disturb nocturnal fauna such as mammals and bats). Works for crossings should take place in dry periods, when ephemeral creeks have no water.

6.3 Land zoning

To ensure ongoing protection of riparian areas, consideration should be given to the allocations of land zones to watercourses and riparian areas. Currently, watercourses are mapped within the LEP but are zoned as RU2. The rezoning of riparian areas as W1 could ensure that they are protected and managed in perpetuity. This would be in line with recommendations from NRAR, who prefer that riparian corridors are in public ownership to allow long term protection and maintenance of these areas (NRAR 2020).

6.4 Offset riparian encroachment

The current footprint encroaches into the outer VRZ for 0.92 ha under the WM Act. This encroachment must be offset elsewhere within the site. The proposed layout has approximately 1.95 ha of open space adjoining the riparian corridor, with a good recovery potential that has been recommended to offset this impact, where revegetation of a fully structured riparian vegetation community will take place (see Figure 11, Figure 12, Figure 13 and Figure 14). This 1.95 ha is greater than 1:1 ratio required by the NRAR guidelines.

6.5 Vegetation Management Plan

In order to maintain the connectivity of the riparian corridors, rehabilitation and revegetation of the vegetation is required along the creekline up to the project boundary. Initial weed control would be required to limit the impact of the widespread weed species that are currently growing onsite. The riparian zones will then require ongoing maintenance to ensure areas remain relatively weed free. The amount of maintenance work will, in part, be dictated by the land use and associated condition of the

watercourses upstream. VMPs would need to be prepared to accompany any DAs where there are adjoining riparian corridors. For each riparian corridor, preparation of a detailed VMP in accordance with the objectives of the Wollongong DCP (Chapter E23) and NRAR guidelines would be required to cover the area within the VRZ within the precinct boundary. Each VMP would also outline that the areas to be revegetated as part of the offset of the encroachment into the outer VRZ would be fully structured vegetated areas as per *Guidelines for vegetation management plans on waterfront land* (DPI Water, 2012) and line with Riparian Vegetation Rehabilitation Guidelines listed in Appendix 1 of Chapter E23 of the WCC DCP. Each VMP would be developed in line with the overarching VMP prepared for the subdivision (ELA, 2020).

Each VMP should also specify the need for shade-tolerant plants to be used to revegetate the areas surrounding the proposed road bridges. This would help ensure the success of revegetation works within these areas.

The first phase of revegetation would include primary weed control which can be achieved through mechanical removal, hand removal and where appropriate, broadscale herbicide application. Creek banks lacking native cover would require revegetation works to provide immediate stabilisation. In some areas, a high density of planting would be required to provide rapid bank stabilisation. Restoration of damaged creeks needs to also replicate habitat variety and micro-habitats, including riffles, runs, pools, fringing reeds, riparian vegetation, natural shading, variable depths, variable widths, large woody debris, and a variety of gravel, pebble, cobble and boulder substrate. Species to be utilised and the density required are to be provided in a VMP. Regular maintenance would be required to continue to control emerging weeds, such as pasture grasses, herbaceous species, aquatic weeds and woody weeds.

6.6 Protection of water quality and habitat condition

Water quality protection measures are recommended for adherence where the proposed activities require:

- Clearing of groundcover (grasses, herbs and shrubs, including exotic species) to bare earth
- Clearing of any native vegetation or mechanical weed removal within the riparian buffer zone
- Construction of any permanent car parks and roads
- Temporary staging areas, compounds and storage areas of oils and chemicals
- Wastewater discharge points, including pumping of groundwater from any below-ground excavation and vehicle wash down bays.

Key protection measures suitable to mitigate the above activities include:

- Gross Pollutant Traps to capture litter from car parks and roads.
- Sediment fences to slow overland flow and trap sediments created from surface erosion.
- Identify opportunities for re-use of water from any on-site dewatering activities (e.g. basement excavation) on site including dust suppression.
- Off-line settling ponds as a transition point between disturbance areas and discharge into Mullet Creek.
- Construction and maintenance of sediment detention and water quality ponds vegetated with macrophytes help filter and uptake nutrients and pollutants bound to sediment. Ponds may

need periodic cleaning to remove excessive sediment, especially in the early stages of development. Overflow points should lead through a secondary pond and / or slow channel planted with dense reeds rather than directly into the creekline. The location of these basins in relation to the need for maintaining required widths of vegetated riparian zones has been taken into consideration as part of the initial planning process.

- Where excess water from the construction site or during operation of the Cleveland Road area is to be released into the tributaries of Mullet Creek, constructed storage ponds should be used to first capture and settle the water before discharge. The discharge point should be at a stable point on the creek bank or across riparian vegetation at the upstream end of a large pool, to allow slowing of water before travelling further downstream. Where feasible, the velocity of downstream flows should not exceed natural seasonal flow velocities. Water released in dynamic pulses will give reprieve for fauna travelling upstream.
- Flow modelling of local creeks would help identify areas downstream that may be inundated from additional water discharge from site. Water should first be stored in constructed settling ponds to regulate the discharge volume and velocity. Where feasible, timed releases should mimic the natural flow regime with consideration given to high and low flows. Areas identified for increased inundation require monitoring for bank erosion and weed invasion. A riparian and aquatic vegetation planting program and management plan will reduce the lag time of natural re-colonisation due to the sudden shift in habitat conditions.

Urban design should aim to reduce organic pollutants entering the waterway, such as:

- Use native street trees where leaves may enter the stormwater system. Deciduous trees should only be used if leaf drop is contained within a parkland environment.
- Provide a small buffer between mown lawns in public space and stormwater drains. This aims to reduce grass clippings entering the creek.

6.7 Water quality monitoring

Water released into Mullet Creek needs to comply with requirements of the *Protection of the Environment Operations Act 1997*. At a minimum, water quality should mimic or improve on that in the creek. Differences in water quality will be diluted further downstream. The creation of a water quality monitoring plan should be prepared to enable ongoing monitoring of waterway health. Monitoring points are recommended upstream (control site) and downstream of construction and operational activities, such as any stormwater outlets into the creek, car parks that are located near the riparian buffer zone, temporary support and amenities sites, material storage locations and construction plants. Inspection of water quality mitigation controls (e.g. sediment fences, GPT, settling ponds) should be undertaken on a regular basis as well as before and after rainfall to detect any breach in performance. Strategic monitoring points downstream are to be compared with a location immediately upstream of the discharge point/s.

6.8 Design of watercourse crossings

To avoid adverse impacts to the aquatic and riparian habitat as a result of the construction of road bridges, it should be designed and constructed as per DPI Water's *Controlled activities on waterfront*

land – Guidelines for watercourse crossings on waterfront land (DPI, 2012a). These guidelines outline a number of factors that should be considered during the design and construction of these structures:

- Identify the width of the riparian corridor in accordance with the NRAR and WCC guidelines for riparian corridors.
- Consider the full width of the riparian corridor and its functions in the design and construction of crossings. Where possible, the design should accommodate fully structured native vegetation.
- Minimise the design and construction footprint and extent of proposed disturbances within the watercourse and riparian corridor.
- Maintain existing or natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse.
- Demonstrate that where a raised structure or increase in the height of the bed is proposed there will be no detrimental impacts on the natural hydraulic, hydrologic, geomorphic and ecological functions.
- Maintain natural geomorphic processes:
    - Accommodate natural watercourse functions.
    - Maintain the natural bed and bank profile.
    - Ensure the movement of sediment and woody debris is not inhibited.
    - Do not increase scour and erosion of the bed or banks in any storm events.
    - Avoid locating structures on bends in the channel.
    - Where bed degradation has occurred, address bed degradation to protect the structure and restore channel and bed stability.
- Maintain natural hydrological regimes:
    - Accommodate site hydrological conditions.
    - Do not alter natural bank full or floodplain flows or increase water levels upstream.
    - Do not change the gradient of the bed except where necessary to address existing bed and bank degradation.
    - Do not increase velocities by constricting flows, for example filled embankments on approaches.
- Protect against scour:
    - Provide any necessary scour protection, such as rock rip-rap and vegetation.
    - Ensure scour protection of the bed and banks downstream of the structure is extended for a distance of either twice the channel width or 20 metres, whichever is the lesser.
    - If cutting into banks, protect cuttings against scour.
- Stabilise and rehabilitate all disturbed areas including topsoiling, revegetation, mulching, weed control and maintenance in order to adequately restore the integrity of the riparian corridor.
- Ideally, bridges shall be elevated and span the riparian corridor, or at least the channel and wider than the top of banks.
- Bridge piers or foundations should not be located within the main channel of the watercourses.
- The bridge designs must be certified by a suitably qualified engineer.

6.9 Methods for services installation

To avoid adverse impacts to the aquatic and riparian habitat as a result of the installation of underground services, they should be designed and installed as per DPI Water's *Controlled activities on waterfront land – Guidelines for laying pipes and cables in watercourses on waterfront land* (DPI, 2012b). These guidelines outline a number of factors that should be considered during the design and construction of these structures:

- Consider the full width of the riparian corridor and its functions in the location and installation of any pipes and cables. Where possible, the design should accommodate fully structured native vegetation.
- Minimise the design and construction footprint and proposed extent of disturbance to soil and vegetation within the watercourse or waterfront land.
- Utilise existing easements. Pipes and cables should be incorporated within existing cleared or disturbed areas with or adjacent to other crossing points such as roads, particularly if future maintenance and on-going access is required.
- Maintain existing or natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse. Demonstrate that the pipe and cable installations will not have a detrimental impact on these functions.

Directional boring under a watercourse is preferred over trenching through a watercourse. Proposals for directional boring should seek to:

- Minimise or avoid disturbance to channel bed and banks
- Minimise or avoid rehabilitation, maintenance and on-going costs after construction to minimise risks associated with cave-ins, bed collapse or frac-outs during boring
- Ensure depth does not result in exposure of assets if channel experiences bed or bank degradation
- Locate bore entry and exit points outside designated riparian corridors and existing vegetation
- Address the recovery and removal of construction plant and materials, including drilling mud.

7. Recommendations

Multiple first order creeks did not meet the definition of a 'river' under the WM Act, as there were no defined bed, banks or evidence of geomorphic processes. NRAR stated that creeks 1B (upstream of the farm dam), 1C (upstream extent), 1E (upstream of Cleveland Road), 1H, 1L and 2D were undefined channels and that the removal or piping of overland flows where these creeks are mapped was generally acceptable (NRAR, 2020). These creeks may be removed as a constraint to the site and would have no waterfront land in respect to the WM Act if consultation with NRAR and Council is undertaken. NRAR did not comment on the status of creeks 1A, 1K and the upstream extent of 2E as part of the review of the Rienco assessment, so consultation with NRAR regarding the status of these waterways is recommended. All other creeks met the definition of a 'river' under the WM Act. Therefore, if works are proposed within 40 m of the top of bank of these creeks (i.e. waterfront land), a *Controlled Activity Approval* (CAA) would be required through an integrated development application. Conditions of a CAA would outline the need for a VMP to restore the riparian zone along the 'rivers' to a functional native community, whilst ensuring that revegetation type is consistent with the Illawarra Shoalhaven Regional Plan and West Dapto Vision by protecting and enhancing the natural function of riparian corridors and natural waterways.

The locations of proposed basins have been considered as part of this planning proposal and have been located within the outer VRZ, as per NRAR guidelines. Development and encroachment in the outer 50% of the VRZ is consistent with the guidelines if a 1:1 riparian offset compensation is applied elsewhere on site using the averaging rule. The APZ as well as development lots have been accounted for as a non-riparian use, and their encroachment has been offset elsewhere in the site. The averaging rule has generally been applied to land already lacking tree cover (the majority of the outer 50% VRZ was cleared or weed species) and seeks to preserve any natural vegetation.

In total, 59.88 ha of riparian corridor occurs within the study area in accordance to the WM Act; and an additional 1.84 ha of overlapping riparian corridor occurs within the study area in accordance to the Wollongong DCP. The footprint also encroaches into 0.92 ha of the outer VRZ when recommended riparian corridor widths under the WM Act are applied. As per the guidelines for controlled activities on waterfront land, encroachment into the outer VRZ for non-riparian uses must be compensated at 1:1 elsewhere within the site. There is a total of 1.95 ha of land that has been recommended for revegetation and as an offset in compensation for this encroachment in order to obtain an average VRZ in accordance with NRAR and Council guidelines.

Contrasting this, the DCP requirements do not offer much flexibility in encroachment and offsets. One exception described in 7.2(a) of Chapter E23 of the DCP is: *The inclusion of an APZ within an area of Category 2 or 3 riparian corridor may be permitted in those parts of the corridor that are revegetated/rehabilitated as part of a proposed development.*

Notably in the Illawarra Shoalhaven Regional Plan, action 5.1.4 is to create a consistent approach to protect important riparian areas in planning and development controls. A collaborative consultation with both NRAR and WCC is recommended to determine a consistent approach for riparian widths and offsets for the draft planning proposal.

There is the opportunity to rehabilitate the riparian corridors within the study area with native riparian species which would ultimately improve the instream habitat. The considerations above should be explored during preparation of the Neighbourhood Plan, and when negotiating riparian corridors with NRAR and Council.

Regarding the Coastal Management SEPP zones, as this area was not able to be field validated as part of this assessment, it is recommended that the in the central north of the site wetland be assessed to characterise the wetlands biophysical, hydrological and ecological function. Additionally, a Model for Urban Stormwater Improvement Conceptualisation (MUSIC Model) or equivalent, should be used to model pre and post development conditions to determine the likely change in quality and quantity of water entering the coastal wetland. Groundwater modelling should also be undertaken to determine impacts to groundwater that may support the coastal wetland. The outputs of these assessments should be considered to protect or minimise the impact to the coastal wetland.

8. Conclusion

The desktop review identified 16 1st order, five 2nd order, one 3rd order and one 4th order watercourses mapped within the study area. Following field validation, of these watercourses, eight 1st order and two 2nd order watercourses were considered not to meet the definition of a 'river' under the WM Act, as there were no defined bed, banks or evidence of geomorphic processes.

The condition of the riparian and aquatic habitat varies along watercourses within the study area. The riparian vegetation along the length of the creeks within the study area ranges from good to poor condition, with some areas remaining relatively intact and others showing evidence of historical disturbance by clearing and exotic species invasion.

The proposed footprint encroaches into 0.92 ha of the outer VRZ. As per the guidelines for controlled activities on waterfront land, encroachment into the outer VRZ for non-riparian uses must be compensated at 1:1 elsewhere within the site. There is a total of 1.95 ha of land that would be able to be revegetated and act as offset in compensation for all riparian encroachment in order to provide this offset and average VRZs across the site. The footprint also proposes to realign or remove sections of 1F, 1I, 1O, 1A, 2A and 3A. Creeks 1I and 1O would become part of the 3A watercourse, which has been considered as removal of these 1st order streams. Realigning first-order watercourses is consistent with guidelines, however, realigning second and third-order watercourses isn't. NRAR have advised that the reconstruction of 3A is generally acceptable, however they stated that further assessment of creek 2A and the surrounding smaller tributaries is required (NRAR, 2020). This assessment contains a detailed assessment on the condition of this 2nd order watercourse, the 1st order streams upstream and the main channel of Mullet Creek downstream. The realigned corridor for 2A provides an additional 0.74 ha of riparian corridor than what is currently present and there is a 'loss' of 0.64 ha less riparian corridor with the realignment of 3A. Following realignment and the implementation of a VMP, the riparian corridors would be rehabilitated to fully structured vegetation communities, which is a marked improvement on the current condition.

9. References

Bewsher (2010). *Mullet and Brooks Creeks Floodplain Risk Management Study & Plan*. Prepared for Wollongong City Council.

Department of Environment, Climate Change and Water (DECCW) (2010). *The NSW Wetlands Policy.* Available from https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Wetlands/nsw-wetlands-policy-100039.pdf

DPI (2012a). *Controlled activities on waterfront land - Guidelines for watercourse crossings on waterfront land.* Available from https://www.industry.nsw.gov.au/__data/assets/pdf_file/0019/160471/licensing_approvals_controlled_activities_watercourse_crossings.pdf

DPI (2012b) *Controlled activities on waterfront land – Guidelines for laying pipes and cables in watercourses on waterfront land.* Available from https://www.industry.nsw.gov.au/__data/assets/pdf_file/0019/160462/licensing_approvals_controlled_activities_laying_pipes_cables.pdf

DPI (2012c). *Controlled Activities on Waterfront Land – Guidelines for vegetation management plans on waterfront land*. Available from https://www.industry.nsw.gov.au/__data/assets/pdf_file/0006/160467/licensing_approvals_controlled_activities_veg_mgt_plans.pdf

Eco Logical Australia (2018). *Riparian Constraints Assessment – Lot A, DP 156446, Lot 1 DP 194419 and Lot 313 DP 1188000*

Eco Logical Australia (2020a). *Cleveland Road, West Dapto Planning Proposal - Flora and Fauna Assessment*. Prepared for Newquest Property Pty Ltd.

Eco Logical Australia (2020b). *Cleveland Rd Nth and South Overarching VMP*. Prepared for Newquest Property Pty Ltd.

Ecoplanning (2019). *Flora and Fauna Assessment – Multiple Lots, 144-148 Cleveland Road, West Dapto, NSW*. Prepared for Cardno Pty Ltd.

Fairfull, S. (2013). *Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (2013 update*). Available online: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/634694/Policy-and-guidelines-for-fish-habitat.pdf

Natural Resources Access Regulator (NRAR) (2018). *Guidelines for controlled activities on waterfront land – Riparian corridors*. Available online: https://www.industry.nsw.gov.au/__data/assets/pdf_file/0004/156865/NRAR-Guidelines-for-controlled-activities-on-waterfront-land-Riparian-corridors.pdf

NRAR (2020). *Planning Review – Watercourse Identification and Riparian Corridor Assessment - Cleveland Road North and South. Review of Survey of Existing Watercourses Proposed Development at Cleveland Road, Cleveland Report, prepared by Rienco Consulting.*

Riches, M., Gilligan, D., Danaher, K. and Pursey, J. (2016). *Fish Communities and Threatened Species Distributions of NSW.* NSW Department of Primary Industries

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