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30/4/2020

Our ref: 18SYD_9907

Landcom c/o APP Corporation Pty Limited
Level 14,
60 Station Street
Parramatta NSW 2150

Attention: Georgia Welsh

Dear Georgia,

Re: Kellyville Station Precinct Riparian Assessment – Response to Submissions

In August 2019, Eco Logical Australia (ELA) submitted a Riparian Assessment (version 3, dated 19/08/2019) as part of the State Significant Development Application (SSDA) for the proposed Kellyville Station Precinct. In late 2019 the SSDA was placed on public exhibition. In January 2020 ELA received agency and public submissions.

An updated Riparian Assessment (version 5, dated 30/4/2020) has been prepared incorporating requested amendments from Department of Planning, Industry and Environment (DPIE) – Water and Natural Resources Access Regulator (NRAR). Agency submissions relating to the Riparian Assessment and corresponding ELA responses are summarised in Table 1.

Regards,

Claire Wheeler
Aquatic Ecologist

Table 1: ELA response to Riparian Assessment submissions

Agency	Comment	ELA Response	Section in Report
DPIE – Water and NRAR	The project proposes to impact on the inner fifty percent of the vegetated riparian zone. This proposal is not aligned with the Guidelines for Controlled Activities on Waterfront Land (NRAR 2018) and should make appropriate adjustments to ensure compliance.	The proposed development footprint has been adjusted to ensure that there is no impact to the inner 50% of the vegetated riparian zone (VRZ), apart from indirect impacts caused by shading from the proposed road bridge in the south of the study area. Figure 1 below shows the original encroachment into the inner and outer VRZs and Figure 2 below shows the encroachment into the inner and outer VRZs following adjustment of the development footprint. While the bridge will cause the watercourse to be shaded within this area, the field survey carried out in February 2019 observed that Elizabeth Macarthur Creek within this area was densely covered in *Typha orientalis*, which was restricting the amount of light reaching the water. The bridge construction would not prevent light from reaching a watercourse that is currently completely unshaded. The indirect impact to the inner VRZ as a result of shading from construction of the bridge is unlikely to be significant. The Vegetation Management Plan should include shade-tolerant vegetation to be planted within the area where the proposed bridge is to be constructed, in order to ensure that the vegetation within this area survives under new conditions.	Section 6.3 and 6.4
	The project proposes to offset riparian vegetation within the designated open spaces. This offset area should be fully structured riparian vegetation and consistent with the Guidelines for Controlled Activities on Waterfront Land (NRAR 2018).	The areas to be revegetated to offset any encroachment are adjacent to the riparian corridor and are shown in the Riparian Assessment. These areas are proposed to be revegetated as per the Guidelines for Controlled Activities on Waterfront Land (NRAR 2018) and Guidelines for vegetation management plans on waterfront land (DPI Water 2012).	Section 6.4

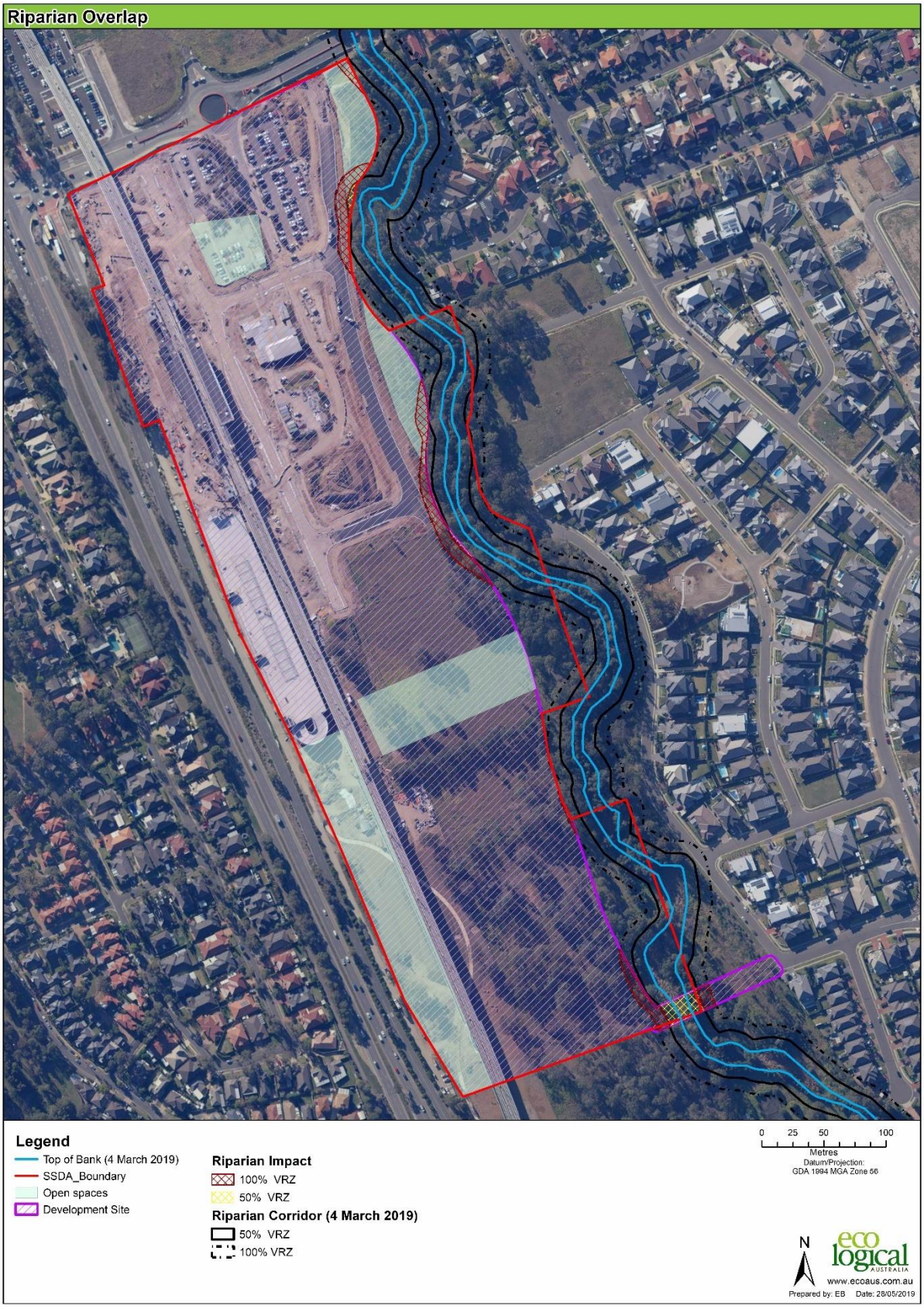

Figure 1: Encroachment into inner and outer vegetated riparian zones (as contained in Riparian Assessment version 3 dated 19/8/19).

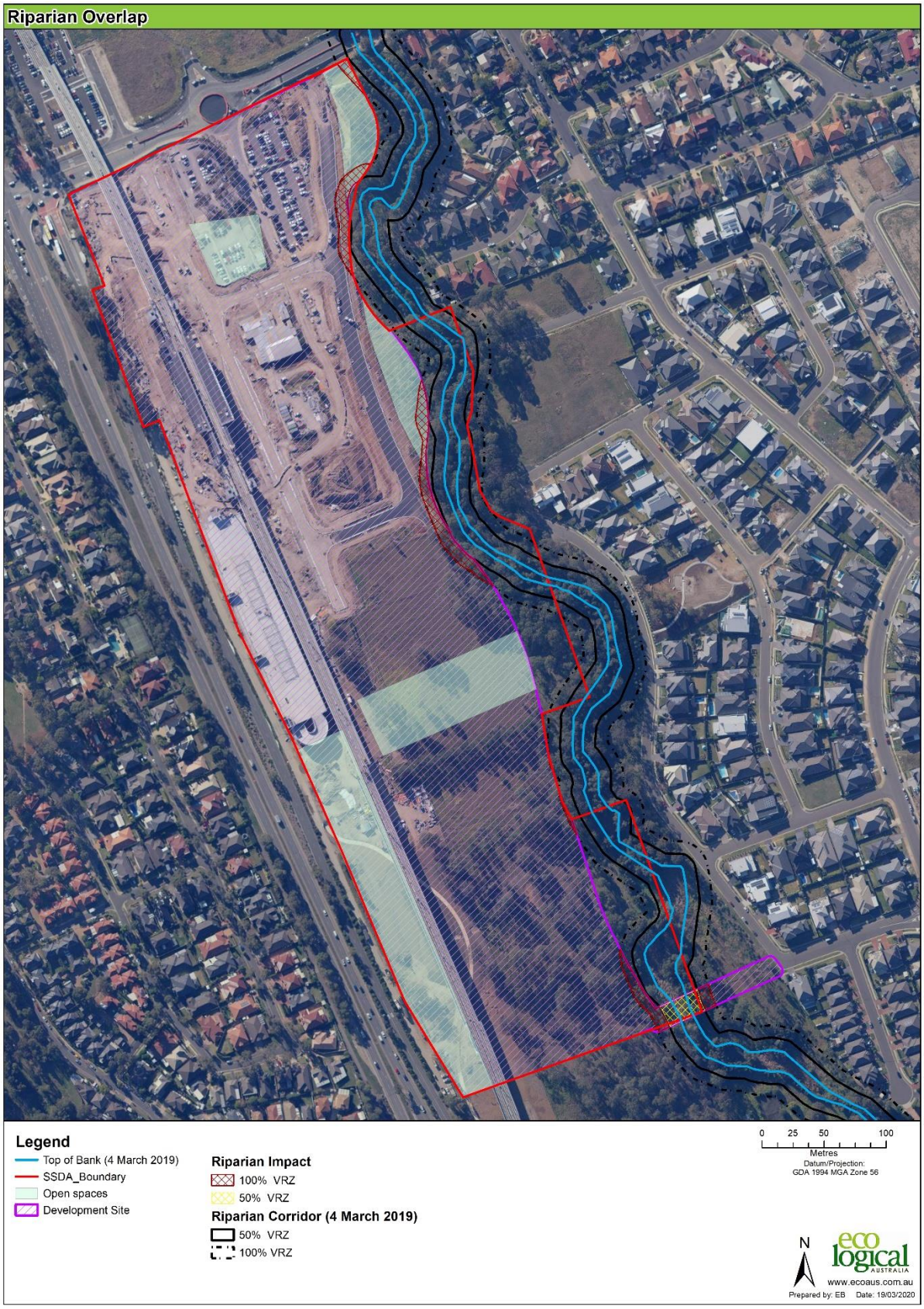

Figure 2: Encroachment into inner and outer vegetated riparian zones following adjustment of development footprint (as contained in Riparian Assessment version 5 dated 30/4/2020).

Kellyville Precinct State Significant Development Application - Riparian Assessment

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DOCUMENT TRACKING

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Template 2.8.1

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Abbreviations

Abbreviation	Description
CEMP	Construction Environmental Management Plan
EP&A Act	*Environmental Planning and Assessment Act 1979*
FM Act	*Fisheries Management Act 1994*
GFA	Gross Floor Area
NRAR	Natural Resources Access Regulator
RC	Riparian corridor
SMNW	Sydney Metro Northwest
SRD SEPP	*State Environmental Planning Policy (State and Regional Development) 2011*
SSDA	State Significant Development Application
ToB	Top of Bank
VMP	Vegetation Management Plan
VRZ	Vegetated Riparian Zone
WM Act	*Water Management Act 2000*

Executive Summary

The Kellyville Station Precinct forms part of a network of eight station precincts along the corridor of the NSW Government's $8.4 billion Sydney Metro Northwest. The Kellyville Station Precinct was identified by the NSW Government as a Priority Precinct to support and drive the urban renewal of rural residential land into a new urban environment.

Elizabeth Macarthur Creek is a tributary of Caddies Creek and is located within the Hawkesbury-Nepean River catchment. Within the State Significant Development Application (SSDA) boundary, Elizabeth Macarthur Creek extends for approximately 900 m, from Lot 1 DP1066762 in the south to where the creek flows under Samantha Riley Drive in the north.

Elizabeth Macarthur Creek in this location is a second order watercourse according to the Strahler system and therefore would require a 20 m riparian setback to be consistent with the NSW *Guidelines for Controlled Activities on waterfront land—Riparian corridors* (NRAR, 2018).

The current Masterplan generally protects the watercourse and the 20 m riparian setback other than in a few locations. The Masterplan includes a proposed road bridge which would increase shading of the inner Vegetated Riparian Zone (VRZ) by 0.056 ha. The Masterplan also encroaches into 0.309 ha of the outer VRZ. As per the *Guidelines for Controlled Activities on waterfront land—Riparian corridors* (NRAR, 2018), encroachment into the outer VRZ for non-riparian uses must be compensated at 1:1 elsewhere within the site. The Masterplan allows for this offset by providing an additional 0.43 ha of fully structured revegetated riparian zone as part of an open space network.

1. Introduction

Under the Sydney Metro Northwest (SMNW) Places program, Landcom and Sydney Metro are working collaboratively with the Department of Planning, Infrastructure and Environment, local councils, other government organisations and key stakeholders to develop the long-term vision and delivery program to guide the redevelopment and urban renewal of surplus government owned or controlled land around new SMNW station precincts.

SMNW Places will deliver vibrant and integrated precincts surrounding the new Bella Vista and Kellyville metro stations that will facilitate the renewal and delivery of a greater supply and diversity of housing, new employment opportunities and new public and community facilities.

This Riparian Assessment is required to support a State Significant Development Application (SSDA) for the Kellyville Station Precinct concept design and to determine potential impacts on riparian and aquatic ecology of Elizabeth Macarthur Creek as part of the proposed development and make recommendations to mitigate those impacts.

1.1 Location

Located in the Hills Shire Council Local Government Area, Elizabeth Macarthur Creek is a tributary of Caddies Creek and is located within the Hawkesbury-Nepean River catchment. Within the SSDA boundary, Elizabeth Macarthur Creek extends for approximately 900 m, from Lot 1 DP1066762 in the south to where the creek flows under Samantha Riley Drive in the north (Figure 1).

1.2 Kellyville Station Precinct description

The Kellyville Station Precinct forms part of a network of eight station precincts along the corridor of the NSW Government's $8.4 billion SMNW. The Kellyville Station Precinct was identified by the NSW Government as a Priority Precinct to support and drive the urban renewal of rural residential land into a new urban environment.

The Kellyville Station Precinct is envisaged to provide for up to 1,000 new jobs and the delivery of up to 8,400 new homes, shared between Kellyville and Bella Vista Station Precincts.

The Precinct spans the alignment of the SMNW corridor that consists of an approximate 900 m stretch of government owned land, extending from Samantha Riley Drive in the north towards Memorial Avenue in the south, and bound by Old Windsor Road to the west, existing Roads and Maritime Services land to the south and Elizabeth Macarthur Creek to the east (Figure 1).

Lands south of Wuban Avenue to the southern extent of the precinct remain largely undeveloped and in their existing rural residential state.

Land south of construction works, between the southern edge of the precinct and Wuban Avenue, contains stands of existing mature vegetation, particularly along the western bank of the Elizabeth Macarthur Creek riparian corridor.

1.3 Concept State Significant Development site description

The Kellyville Station Precinct concept SSD application site is defined as land owned by, or under the control of, Sydney Metro within the boundary of the Kellyville Station Precinct as defined by the Schedule 2 State Significant Development Sites Map of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

The site is made up of 16 allotments and has a total area of approximately 18.8 hectares. The legal description of the site is outlined below in Table 1**.**

Table 1: Kellyville Station Precinct Property Description

No.	Lot No.	Plan No.	House No.	Street	Owner	Ownership
1	1	DP1066762	N/A	Old Windsor Road	Sydney Metro	Government
2	2 – 3	DP1201591	N/A	Lewis Jones Drive	Sydney Metro	Government
3	–1-8	DP1184376	N/A	Old Windsor Road	Sydney Metro	Government
4	12-13	DP1184376	N/A	Old Windsor Road	Sydney Metro	Government
5	11	DP1063682	N/A	Old Windsor Road	Sydney Metro	Government
6	11	DP1201592	N/A	Lewis Jones Drive	Sydney Metro	Government
7	181	DP1248401	N/A		Sydney Metro	Government

1.4 Concept State Significant Development application scope

The Concept SSDA will set out the concept proposal for the future development of the station precinct. The application is only required to demonstrate and consider the likely impacts associated with concept proposal, not the likely impact of any development, as that would be subject to a separate development application.

Development consent will be sought for a concept development application pursuant to section 4.22(1) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) that sets out the concept proposal for the station precinct that comprises the following components:

- Land use strategy that identifies the overall allocation, quantum and location of land uses across the site including:
  - Residential dwellings comprising residential flat buildings and terraces
  - Non-residential land uses including retail and commercial
  - Public open space including public domain and parks
  - Community facilities.
- Urban Design Guidelines that includes built form design principles, guidelines and controls, including maximum building heights and street wall setbacks and heights.
- Allocation of maximum Gross Floor Area (GFA) across the site for each development block and for specific land uses, including allowable GFA transferred from roads and open space to identified development lots pursuant to clause 8.3 of *The Hills Local Environmental Plan 2012*.
- Street hierarchy and layout, including the identification of pedestrian and vehicular movement and access arrangements, and the indicative location and configuration of new streets and intersection connections to the existing road network.

- Identification of criteria or thresholds for subsequent development stages to be assessed as SSD pursuant to section 4.37 of the EP&A Act.

The Concept SSD application will not seek development consent for any physical works. All development set out in the concept proposal will be subject to a separate approval pathway.

Figure 1: Study area

2. Legislative context

The specific riparian and aquatic regulatory requirements and policies were reviewed to determine their application to the Kellyville Station Precinct. These included:

- *Fisheries Management Act 1994*
- *Water Management Act 2000*
- NSW Wetlands Management Policy
- Policy and guidelines for fish habitat conservation and management (Fairfull, 2013)
- *The Hills Local Environmental Plan 2012*
- The Hills Shire Council Development Control Plan 2012
- *Sydney Regional Environmental Plan No 20 – Hawkesbury Nepean River (No 2 – 1997)*
- Elizabeth Macarthur Creek Trunk Drainage Concept Design Report (AAJV, 2017).

2.1 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) governs the management of fish and their habitat in NSW. 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.

In accordance with Part 4, Division 1.7, Section 4.41 (b) of the EP&A Act, applications for separate permits under Sections 201, 205 or 219 of the FM Act are not required for SSD, but the offset policy still applies under the FM Act. In order to inform a comparative and acceptable assessment of impacts to aquatic habitat, the regulatory framework of the FM Act and associated guidelines have been adopted for this assessment.

A search of the Commonwealth Protected Matters Search tool, OEH BioNet database search and Fisheries Threatened Species distribution maps (Riches et al, 2016) identified two species of fish with potential to be found within the study area (Table 2). As there are no records within 5 km of the study area and a lack of suitable habitat, it is unlikely that these species would be found within the proposed development area.

Table 2: Likelihood of occurrence table for aquatic species

Scientific Name	Common Name	FM Act	EPBC Act	Habitat Associations	Records within 5 km	Likelihood of occurrence
Macquarie 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

Note: E = Endangered, V= Vulnerable.

2.2 Water Management Act 2000

The main objective of the *Water Management Act 2000* (WM Act) is to manage NSW water in a sustainable and integrated manner that will benefit current generations without compromising future generations' ability to meet their needs. The WM Act is administered by Natural Resources Access Regulator (NRAR) and establishes an approval regime for activities within waterfront land, defined as the land 40 m from the highest bank of a river, lake or estuary.

Under WM Act framework, activities and works proposed on waterfront land are regulated. These activities include:

- 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
- any activity that affects the quantity or flow of water in a water source.

In accordance with Part 4, Division 1.7, Section 4.41 (g) of the EP&A Act, a water use approval under Section 89, a water management work approval under Section 90 or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act is not required for SSD.

However, 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) 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). 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 3).

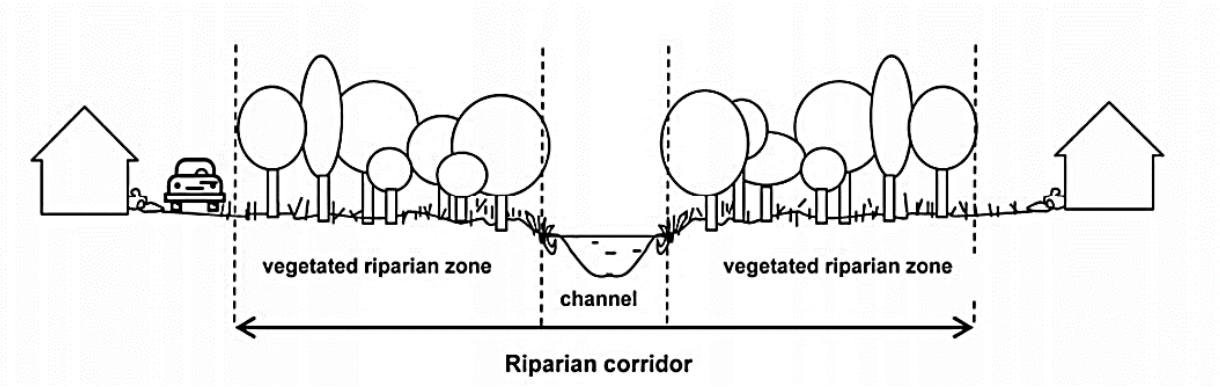

Figure 2: Vegetated Riparian Zone and watercourse channel comprising the riparian corridor (NRAR, 2018).

Table 3: Recommended riparian corridor widths relative to Strahler Order (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 (Table 4), as long compensation (1:1 offset) is achieved within the site. The outer VRZ that is impacted must be offset elsewhere on site using the 'averaging rule' (Figure 3).

Table 4: Riparian corridor (RC) matrix of permissible use (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	•	•	•		•			•	•

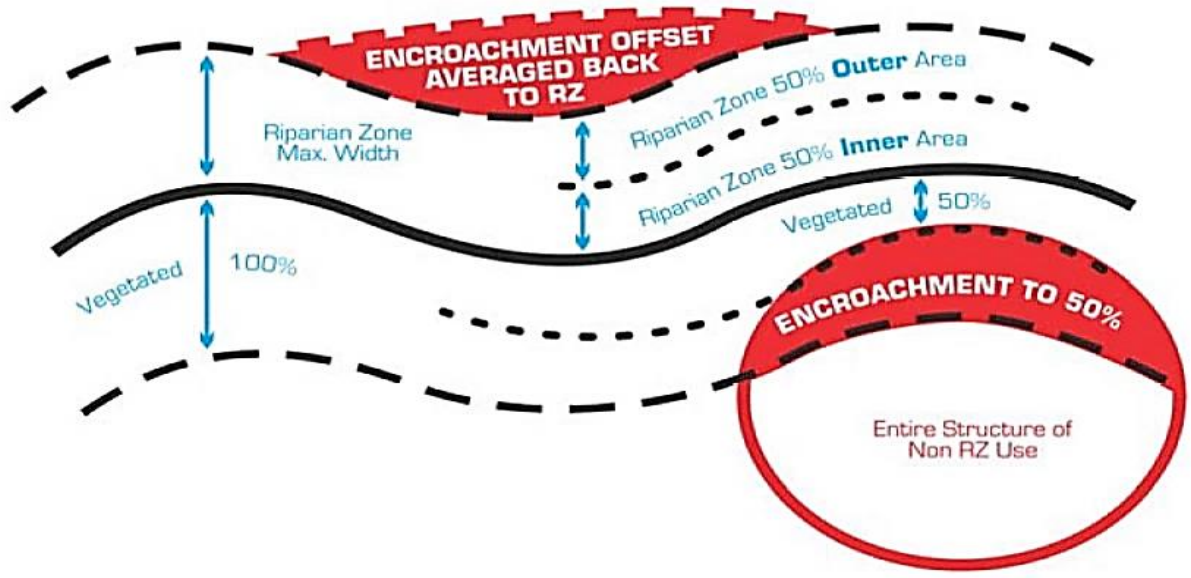

Figure 3: Riparian 'averaging rule' for offsetting encroachment into the outer 50% of the VRZ (NRAR 2018).

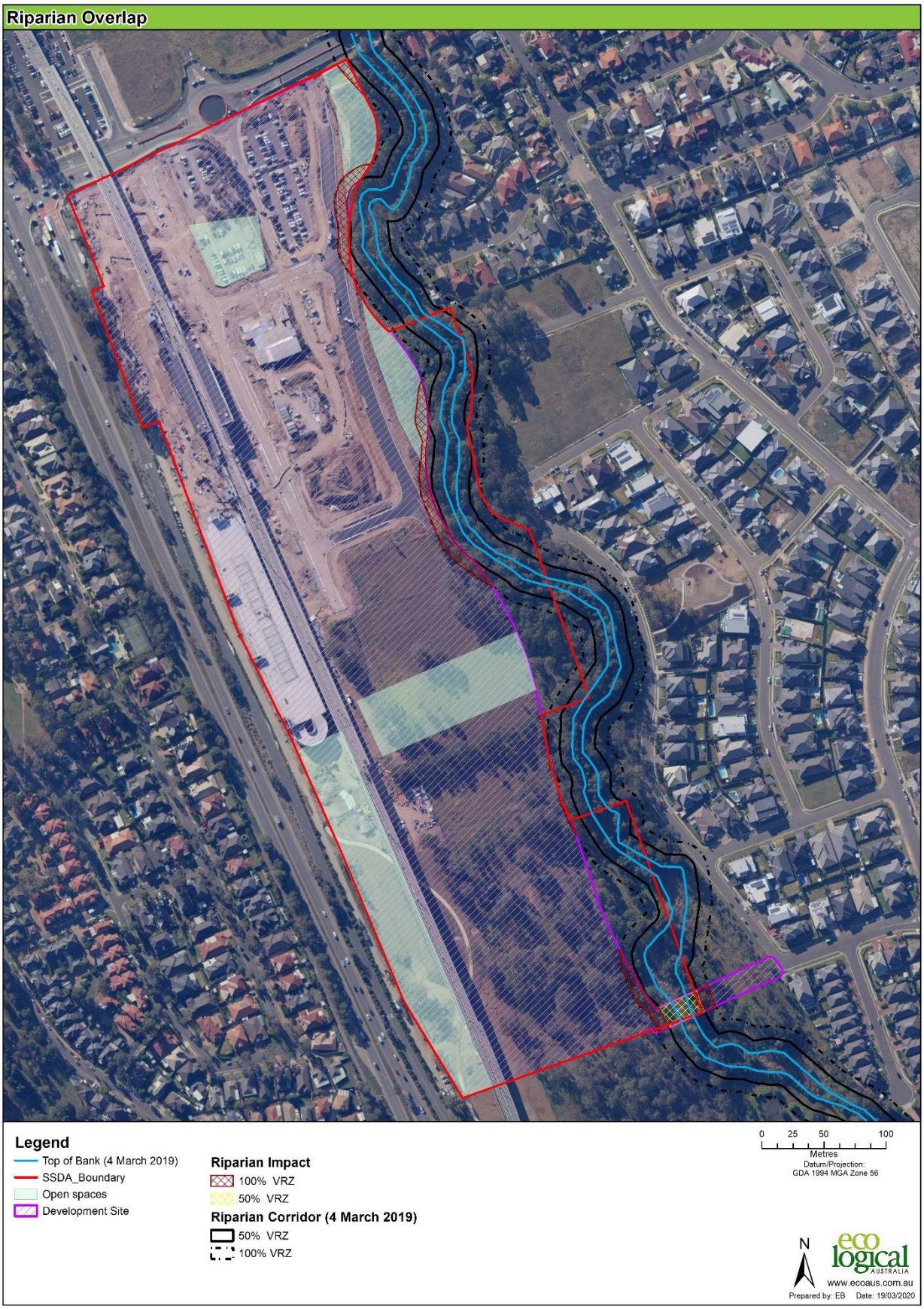

Figure 4: VRZ Map

2.3 NSW Wetlands Management Policy

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. For the sustainable management of wetlands, the NSW Government adopts 12 principles to guide decision-making. The themes of these 12 policies include:

- Catchment scale
- Water regimes
- Floodplain connectivity
- Wetlands of significance
- Land management practices
- Cultural values
- Rehabilitation
- Climate change
- Research
- Protection and offsetting
- Cooperation and incentives
- Monitoring and reporting.

Mitigation measures outlined in this impact assessment are in line with the policy's guiding principles.

2.4 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 were developed to maintain and enhance fish habitat and assist in the protection of threatened species. The Policy provides a definition of key fish habitat and provides guidance for assigning a rating for fish habitat sensitivity (Table 5) and the type of key fish habitat (Table 6).

Table 5: Classification of waterways for fish passage (Fairfull, 2013).

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 pools 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).

The Policy classifies waterways into three types of key fish habitat. While Elizabeth Macarthur Creek is likely to be considered a Type 2 habitat using the descriptions outlined in Table 6, the guidelines do note

that 1st and 2nd order streams on gaining streams are not considered to be Type 1 or Type 2 key fish habitat. The creek has not been mapped as key fish habitat by DPI Fisheries, however Caddies Creek, approximately 500 m downstream of the site is mapped as key fish habitat.

Table 6: Key fish habitat and associated sensitivity classification scheme (Fairfull, 2013).

Table 1 – 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:

- *Posidonia australis* (strapweed)
- *Zostera, Heterozostera, Halophila and Ruppia* species of seagrass beds >5m^2 in area
- Coastal saltmarsh >5m^2 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
- 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[2]
- 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
- 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:

- *Zostera, Heterozostera, Halophila* and *Ruppia* species of seagrass beds <5m^2 in area
- Mangroves
- Coastal saltmarsh <5m^2 in area
- Marine macroalgae such as *Ecklonia* and *Sargassum* 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 plan)
- 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:

- 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

2.5 Elizabeth Macarthur Creek Trunk Drainage Concept Design Report

AAJV prepared the Trunk Drainage Concept Design Plan in 2017 for Sydney Water to outline the preferred trunk drainage concept design for Elizabeth Macarthur Creek. The objectives of the Elizabeth Macarthur Creek trunk drainage concept plan are as follows:

<u>High priority</u>

- improved flood management design data and Rouse Hill Development Area Trunk Drainage Lands (RHD TDL) identification.

<u>Medium priority</u>

- to protect and enhance Cumberland Plain Woodland EEC;
- the protection of EECs during subdivision and residential development process;
- to control noxious and environmental weeds;
- to remediate erosion problems, especially where drainage infrastructure is threatened;
- to ensure TDL values and functions considered during planning and development of adjacent areas;
- to improve the on-ground definition of TDL, particularly in subdivision/development areas; and
- to provide for safe local access routes.

2.6 The Hills Local Environmental Plan 2012

Elizabeth Macarthur Creek is zoned SP2 Infrastructure (Stormwater Management) as per *The Hills Local Environmental Plan 2012*. The objectives of this zone are:

- To provide for infrastructure and related uses.
- To prevent development that is not compatible with or that may detract from the provision of infrastructure.

In this zone, roads are permitted without consent. Aquaculture and the purpose shown on the Land Zoning Map (Infrastructure – Stormwater Management), including any development that is ordinarily incidental or ancillary to development for that purpose is permitted with consent.

2.6.1 Sydney Regional Environmental Plan No 20 – Hawkesbury Nepean River (No 2 – 1997)

Part 3, Clause 11 of the Sydney Regional Environmental Plan No. 20 – Hawkesbury Nepean River lists development controls for land covered under this SREP. Sub-clause 15 relates to 'Land uses in or near the river' and outlines the following development controls:

> *Definition:*
> *All uses in the river or a tributary of the river, or within 40 metres of the high-water mark of the river or a tributary of the river where it is tidal or within 40 metres of the bank where it is non-tidal. This includes clearing and the construction and use of piers, wharves, boat sheds or other structures which have direct structural connection to the bank or bed of the river or a tributary of the river.*
> *Consent required.*
>
> *Additional matters for consideration by the consent authority:*
>
> a. *The need to locate access points where riverbanks are stable, away from river shallows and major beds of attached aquatic plants, away from fishing grounds and fish breeding areas, where the proposed activities do not conflict with surrounding recreational activities, and where significant fauna and wetland habitats will not be adversely affected.*
> b. *The need to require remedial works, such as the re-establishment of flora and fauna habitats.*
> c. *The potential for use of the land as a buffer to filter water entering the river.*
> d. *The need for an Erosion and Sediment Control Plan.*
> e. *The need for a Vegetation Management Plan*

3. Methods

The Strahler stream order classification was extracted from the Department's GIS dataset. Top of bank had previously been validated in the field by ELA in 2012 as part of the North West Rail Link project. Additional top of bank validation was undertaken on 21 February 2019 to fill gaps and refine the mapping. During this visit to the site, the length of Elizabeth Macarthur Creek within the Kellyville SSDA boundary was walked to map the waterway and determine the current condition and extent of riparian and aquatic habitat:

1. Top of Bank Mapping - The geomorphic Top of Bank (ToB) for the creek was mapped using a GPS-enabled tablet and cross-checked with 2 m contours and high-resolution aerial imagery. The ToB identifies the geomorphologic extent of the watercourse and forms the basis for measuring any VRZ.

2. Riparian habitat assessment - An assessment of riparian condition and recovery potential was conducted for the creek. This assessment considered native vegetation cover, connectivity, quality, bed and bank stability and habitat diversity.

3. Aquatic habitat assessment - An assessment of the aquatic habitat within the reach was completed, which examined the quality of aquatic habitats, including vegetation structure, regeneration, weed infestation, woody debris, fish habitat, patch size and connectivity potential.

To aid in the description of the waterway within the SSDA boundary, the site has been split into 13 reaches, starting from immediately south of the SSDA boundary (Figure 5). Photo location points have been mapped in Figure 7.

4. Existing environmental conditions

Elizabeth Macarthur Creek is a 2nd order creek that flows south to north through the east of the proposed Precinct site. The entire reach of the creekline within the SSDA boundary is classed as a Class 2 waterway (Table 5), due to the clearly defined bed and banks and connected nature of the water within the creek.

The field validated riparian corridors (VRZ +channel) of the rivers within the site are mapped in Figure 6**.** In total, there is 1.58 ha of riparian corridor in the study area.

Figure 5: Reach delineation

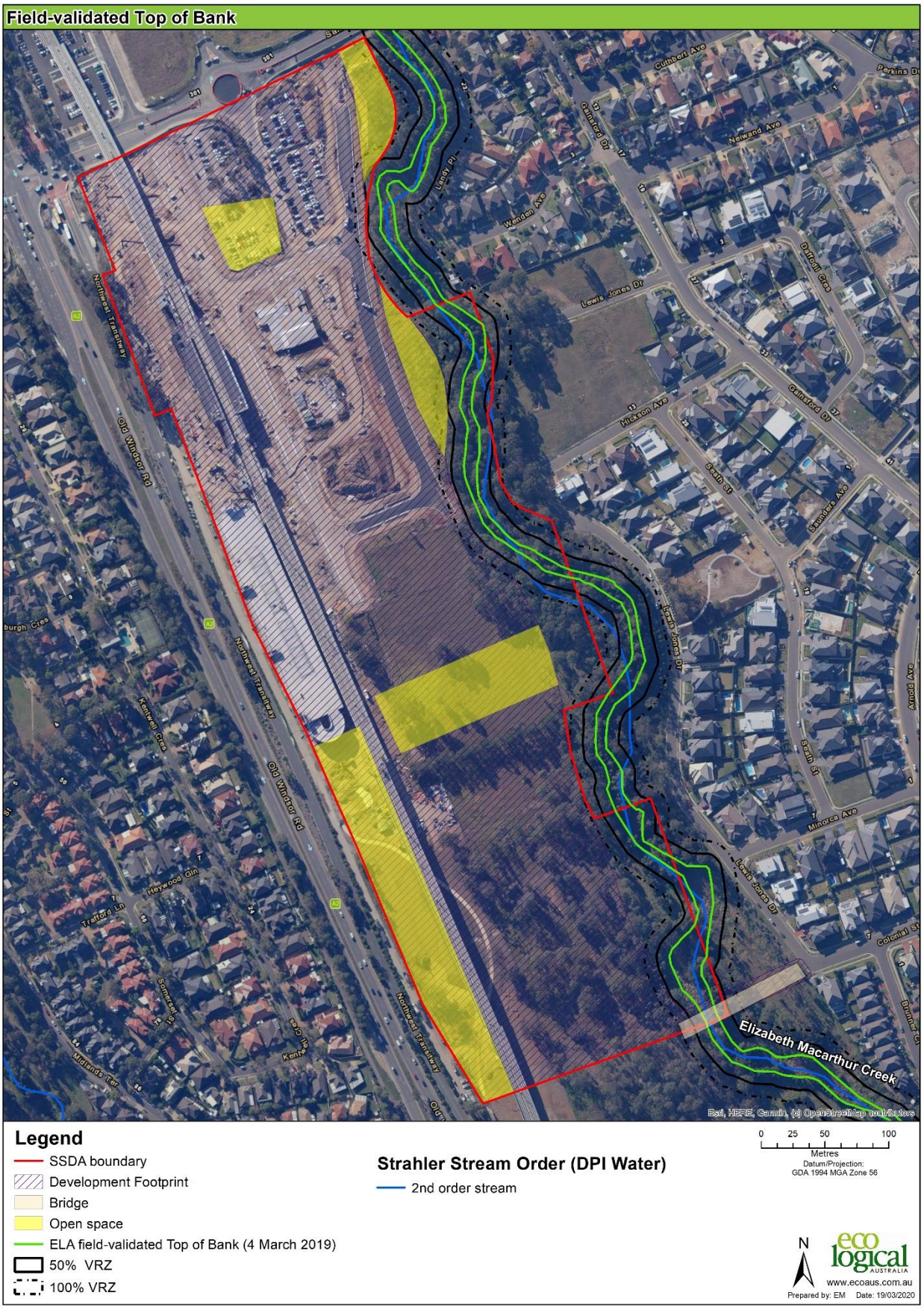

Figure 6: Field-validated top of bank mapping

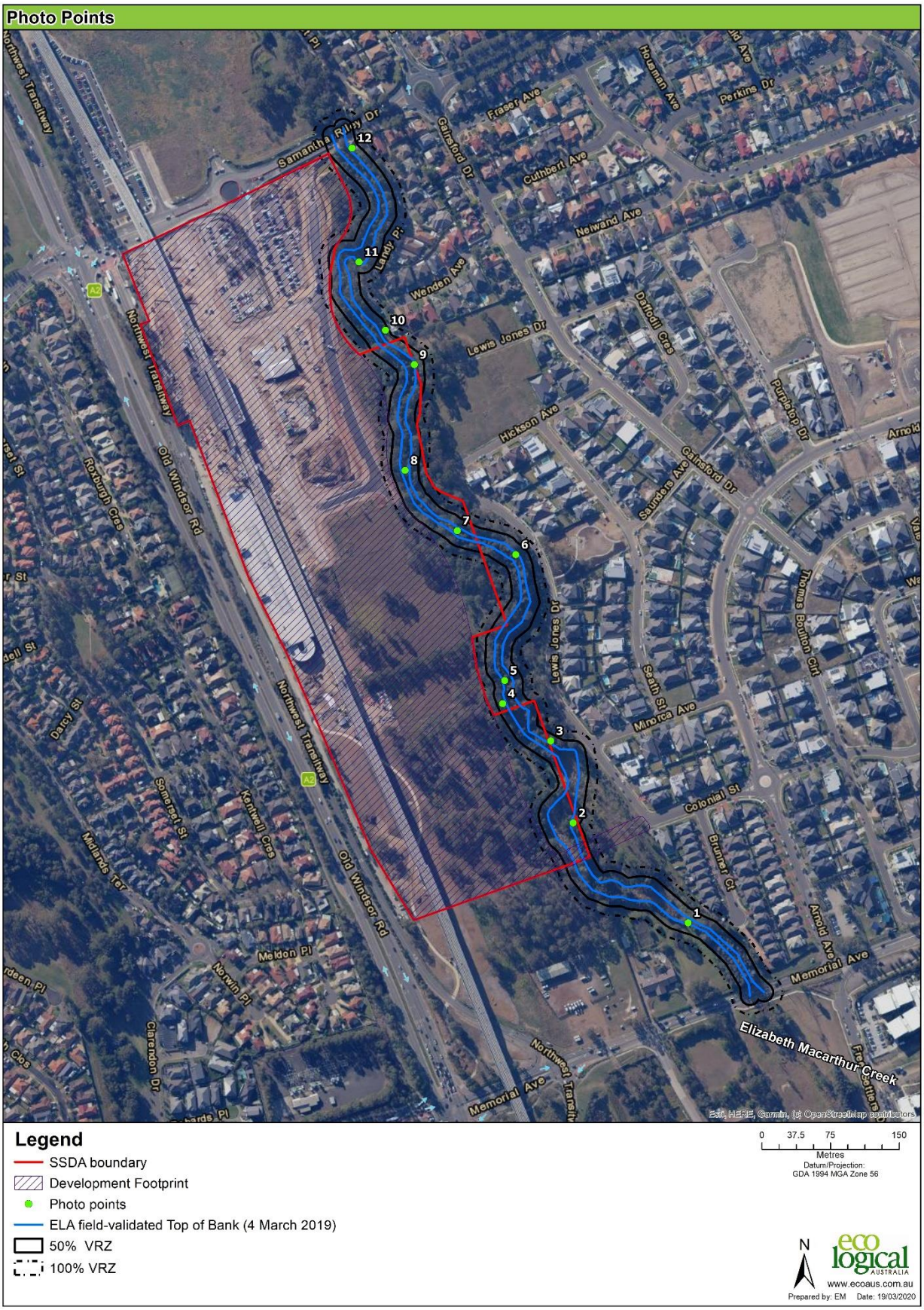

Figure 7: Photo points

4.1 Reach 1

Although Reach 1 is outside of the SSDA boundary, it has been included in this assessment in order to provide context of the area upstream of the site. Elizabeth Macarthur Creek flowed under Memorial Avenue through three box culverts, where it formed a narrow creekline that displayed evidence of sediment deposition and historical disturbance. The adjacent riparian zone was densely covered in exotic species including *Rubus fruticosus* (Blackberry), *Tradescantia fluminensis* (Trad), *Asparagus asparagoides* (Bridal Creeper) and *Asparagus aethiopicus* (Asparagus Fern). Downstream of this area, the channel was lined by *Casuarina* sp. trees and erosion around the roots of these trees was observed (Figure 8 and Figure 9).

Figure 8: Photo point 1, looking upstream

Figure 9: Photo point 1, looking downstream

4.1.1 Riparian habitat

Within Reach 1, riparian habitat was in poor to moderate condition. The outer section of the riparian zone on the right bank contained native riparian vegetation including *Glycine tabacina* (Glycine), *Einadia* sp. (Saltbush), *Persicaria decipiens* (Slender Knotweed) and *Bursaria spinosa* (Blackthorn). Exotic groundcovers were also present within this area, however this vegetation displayed good regeneration and recovery potential. The riparian vegetation on the left bank was highly disturbed, with a relatively thin vegetated riparian zone and a lack of diversity regarding vegetation species, as the area was predominantly *Casuarina* sp. of similar age ranges.

4.1.2 Aquatic habitat

Aquatic habitat within Reach 1 was limited, as in some areas this section of the waterway, the bed of the creekline was a concrete dish drain with no instream woody debris or rubble that would provide habitat for aquatic fauna or macroinvertebrates. The flow of the creekline had exceeded the width of the dish drain and bed erosion around the outside of the concrete was observed. The quality of the water in this reach was likely to be poor, as it was slightly turbid despite no rainfall immediately prior to the site visit.

4.2 Reach 2

At the upstream extent of this reach, at the southern extent of the SSDA boundary, Elizabeth Macarthur Creek was in the form of a swamp, with dense coverage of the emergent macrophyte *Typha orientalis* (Cumbungi) (Figure 10 and Figure 11). The water within this area was stagnant with a covering of surface algae in some areas, particularly on the edges of the swamp at the base of vegetation such as the *Casuarina* sp. trees. Dense *Casuarina* sp. leaf litter was present on the ground of the riparian area.

4.2.1 Riparian habitat

Adjacent to the right bank of this reach, the riparian vegetation was relatively dense and in moderate to good condition. Canopy trees were *Casuarina* sp. with dense *Juncus* sp. in the groundcover strata. The riparian vegetation on the left bank was much sparser than that on the right bank and in poor to moderate condition, with herbaceous weeds as groundcovers

4.2.2 Aquatic habitat

There was limited aquatic habitat variety within this reach, as it was predominantly swamp area with dense emergent macrophytes such as the Cumbungi. The water was stagnant and slightly turbid. The slope of the banks of the swamp were flat, with evidence of a wider floodplain area surrounding the top of bank within this area.

Figure 10: Photo point 2, looking upstream

Figure 11: Photo point 2, looking downstream

4.3 Reach 3

Reach 3 was a heavily shaded area of Elizabeth Macarthur Creek. The creek was well defined in this area with a relatively narrow channel of up to 2 m wide.

4.3.1 Riparian habitat

The riparian vegetation within this reach was quite dense, with thick *Casuarina* sp. canopy and predominantly Trad as the groundcover vegetation (Figure 12 and Figure 13). The condition of the vegetation within this reach was poor to moderate, as almost the entire ground layer was exotic species but with native canopy species.

4.3.2 Aquatic habitat

This was the first area along Elizabeth Macarthur Creek within the SSDA boundary that some variation in aquatic habitat was observed. There were sections with deep pools, riffles where the creek flowed over the roots of *Casuarina* sp. and a drop in the grade of the creek bed along some sections. Water quality appeared to be good, as it was clear with no evidence of surface algae or any oil or grease sheen. In some areas the creek banks were near-vertical, with incision of the channel evident. Submerged macrophytes within this area were also observed.

Figure 12: Photo point 3, looking upstream

Figure 13: Photo point 3, looking downstream

4.4 Reach 4

Reach 4 was another small swamp area that was densely covered in Cumbungi (Figure 14 and Figure 15). It was a wide section of the channel with the banks of the swamp, particularly on the western side, approximately 1.2 m high and steeply sloped.

4.4.1 Riparian habitat

Riparian vegetation on both banks surrounding this swamp was comprised of *Casuarina* sp. trees in the area immediately adjacent to the water. In the outer riparian zone on the western side of the swamp, the groundcover vegetation, including exotic herbaceous species had recently been mown and there were scattered Eucalypt species in the canopy layer.

4.4.2 Aquatic habitat

The swamp in Reach 4 was approximately 8 m wide and the water was stagnant but relatively clear. Frogs could be heard calling in this area. The adjacent *Casuarina* sp. trees provided shade over the edges of the water.

Figure 14: Photo point 4, looking upstream

Figure 15: Photo point 4, looking downstream

4.5 Reach 5

Reach 5 was an area where the channel became very defined again following the wide swamp area. The right bank was very high in some areas, with vertical faces up to 2 m high (Figure 16).

4.5.1 Riparian habitat

The riparian vegetation in Reach 5 was relatively intact immediately adjacent to the waterway on both sides of the creek, however it was not as dense as it was in locations upstream. *Casuarina* sp. trees were the primary canopy species with herbaceous exotic species including *Stenotaphrum secundatum* (Buffalo Grass), Passionfruit Vine and Trad making up the bulk of the groundcover vegetation. All of the canopy species within this area were of a similar age.

4.5.2 Aquatic habitat

Within Reach 5, the water was slow flowing but not stagnant. It was predominantly clear but there were small pools on the edge of this reach where the water was slightly turbid. The creek banks within this reach were heavily eroded and in some areas were near vertical. At the beginning of this reach it was the right bank that was heavily eroded, then downstream it was the left bank that exhibited signs of erosion, indicating a shift in the creek's thalweg within this reach. This erosion had exposed a clay soil and roots of *Casuarina* sp. trees (Figure 16). Flood debris of *Casuarina* sp. needles was deposited at the top of the banks and the channel contained a small amount of instream woody debris, which would provide good habitat for aquatic fauna.

Figure 16: Photo point 5, looking east to right bank

Figure 17: Photo point 5, looking upstream

4.6 Reach 6

Reach 6 was where the creek changed shape and geomorphologic features, in that it changed from the defined channel with incised banks of Reach 5 to an almost braided waterway, with multiple smaller channels flowing through a flat landscape (Figure 18).

4.6.1 Riparian habitat

The riparian vegetation within this reach was on the banks plus in some areas within the channel between braids. Some native shrubs including *Lomandra longifolia* and *Bursaria spinosa* were also growing within the riparian area, as well as the exotic groundcovers that had been seen in other reaches such as Trad and Bridal Creeper.

4.6.2 Aquatic habitat

Reach 6 provided a range of aquatic habitats, with pools of varying depths, instream debris (Figure 19), submerged aquatic vegetation, overhanging vegetation and emergent vegetation such as *Ludwigia peploides*. Creek banks in this reach were relatively flat and there was evidence of previous high flow events having overtopped the banks as there was flood debris within the riparian vegetation alongside the channels and isolated pools. There was a large headcut observed in this reach, where either overland flow over the right bank had eroded a section of the bank or water was eddying around the bank in this area, and a new channel was forming as the headcut retreated upstream.

Figure 18: Photo point 6, looking downstream

Figure 19: Photo point 6, looking upstream

4.7 Reach 7

Reach 7 signalled a shift back to a more incised, narrow channel. The banks were still lined with *Casuarina* sp. trees and there was a lot of instream woody debris and *Casuarina* sp. needles within and above the channel (Figure 20).

4.7.1 Riparian habitat

The left bank within this reach had a narrow riparian zone adjacent to it, with *Casuarina* sp. the dominant species of canopy tree.

4.7.2 Aquatic habitat

Near vertical banks with some undercutting was observed within this reach (Figure 21), with the left bank at one point almost 3 m high. While undercutting is a sign of bank erosion, it can provide good aquatic habitat for small fauna and macroinvertebrates. The water was turbid within this reach but there was no obvious input of sediment-laden water nor was there any sign of sediment deposition. The water was relatively stagnant or slow flowing. Gambusia fish were seen within this reach.

Figure 20: Photo point 7, looking downstream

Figure 21: Photo point 7, looking upstream

4.8 Reach 8

Reach 8 was adjacent to the current area of construction works adjacent to the left bank. The construction fencing came quite close to the ToB in one area and was within the inner VRZ. At the downstream extent of this reach, a newly constructed stormwater outlet was discharging into the creek from the left bank. Rock rip rap had been placed around the outlet, however it appeared to have been poorly constructed in that there were sandstone boulders that looked like they had been displaced and were entering the waterway. A sediment fence that had been constructed at the base of this rip rap had fallen over (Figure 23) and was not capturing any sediment that may have been leaving the stormwater pipe.

4.8.1 Riparian habitat

Riparian habitat on the left bank was rather limited as it was adjacent to the current construction fencing. Eucalypt species were sparsely located on top of the creek bank and there were exotic vine species including *Anredera cordifolia* (Madeira Vine) and Ivy surrounding and climbing these trees.

4.8.2 Aquatic habitat

There was evidence of erosion on both sides of the waterway within this reach. The left bank was eroded to near vertical (Figure 22) and there was also evidence of undercutting at the base of the bank. While the undercutting is a form of bank erosion, this area may also provide good quality habitat for aquatic fauna.

Figure 22: Photo point 8, looking downstream

Figure 23: Photo point 8, looking west at stormwater outlet

4.9 Reach 9

Reach 9 was an area that exhibited recent erosion on the right bank in the form of slumping. Tension cracking was seen on the surface of the top of bank.

4.9.1 Riparian habitat

The vegetation on the eastern side of the creek was predominantly native in all strata.

4.9.2 Aquatic habitat

There was a narrow riffle zone within this reach that extended for approximately 10 m downstream and was approximately 0.1 m deep. There was also a deep pool within this reach, so aquatic habitat within this area would be considered good, as there are a range of habitat types.

Figure 24: Photo point 9, looking downstream

Figure 25: Photo point 9, looking upstream

4.10 Reach 10

Reach 10 was highly disturbed, in that there was litter in the creekline, dumping of household garden waste on the right bank and a deeply eroded channel leading from the eastern end of Lewis Jones Drive into the creekline.

4.10.1 Riparian habitat

The left bank was thickly vegetated with native canopy species and was not as disturbed or narrow as the riparian area on the eastern side of the creek. The riparian vegetation on the eastern side of the creekline was very disturbed and narrow. Mown grass was adjacent to the eastern side of the creek.

4.10.2 Aquatic habitat

Water quality in this reach was poor as it was rather turbid. The sediment that had eroded from the channel leading from the end of Lewis Jones Drive would have been deposited within this reach and elsewhere downstream.

Figure 26: Photo point 10, looking west at end of drainage channel

Figure 27: Photo point 10, looking east

4.11 Reach 11

Reach 11 was characterised by dense Cumbungi growing in a wetland like area. It was a very disturbed area with dense exotic species and litter seen within the creekline.

4.11.1 Riparian habitat

Riparian habitat on both sides of the creek was limited due to the residential properties on the eastern side of the creek and the construction on the western side of the creek. Vegetation was predominantly exotic herbaceous species.

4.11.2 Aquatic habitat

Aquatic habitat was likely to be poor in this area. There were no open areas of water within this reach and the presence of litter would degrade water quality.

Figure 28: Photo point 11, looking downstream

Figure 29: Photo point 11, looking upstream

4.12 Reach 12

Reach 12 appeared to be an overgrown detention basin, potentially constructed at the same time as the adjacent residential properties on the eastern side of the creek. There was sandstone rock armouring of the right bank at an angle of approximately 45 degrees.

4.12.1 Riparian habitat

Riparian habitat within this reach was limited due to the proximity of development on the eastern bank. Some revegetation had taken place previously, identified due to the regular spacing of the vegetation along the side of the road and the young age of some of the species. This vegetation was in moderate to good condition with relatively few exotic species.

4.12.2 Aquatic habitat

There were few areas of visible water within this reach, especially at the upstream end where it was a wide detention basin, approximately 20 m wide. The reach was densely covered in emergent macrophytes including Cumbungi and Knotweed.

Figure 30: Photo point 12, looking downstream

Figure 31: Photo point 12, looking upstream

4.13 Reach 13

Reach 13 was the final reach within the SSDA boundary. Here the creek entered large box culverts that were approximately 3 m wide and 1.5 m high. Gabion baskets were on the right bank of the channel to stabilise the area adjacent to residential properties.

4.13.1 Riparian habitat

Canopy trees within the riparian area were a mix of *Casuarina* sp., *Melaleuca styphelioides* and *Melaleuca linearifolia.* The width of the riparian area within this reach was relatively narrow and severely constrained on the right bank due to the adjacent residential properties and pedestrian accessway.

4.13.2 Aquatic habitat

The waterway within this reach was densely covered in Cumbungi and there were no visible areas of open water. Knotweed was also growing densely within this area. Aquatic habitat was likely to be poor in this area due to the dense macrophyte coverage. A stormwater outlet was discharging runoff from the adjacent road into the waterway, so it is likely that the water quality in this area was of moderate to poor condition due to the origin of this water.

Figure 32: Photo point 13, looking downstream

Figure 33: Photo point 13, looking upstream

5. Impact Assessment

The Kellyville Station Precinct Masterplan has been used to identify potential impacts to the riparian and aquatic habitat as a result of the proposed development. These impacts could occur anywhere along the length of Elizabeth Macarthur Creek, with the exception of the watercourse crossing, as only one road bridge is proposed to be constructed over the creek in the southern portion of the SSDA boundary. Some areas of the creekline are already exhibiting impacts to the aquatic and riparian environments as a result of current development and adjacent and upstream land uses.

5.1 Encroachment into riparian buffer

The Masterplan footprint currently encroaches into the outer half of the VRZ (Figure 34). The total area of encroachment into the outer VRZ is 0.309 ha, including for the bridge. As per NRAR's guidelines for offsetting encroachments (Figure 3), this 0.309 ha must be offset elsewhere within the same reach at a 1:1 ratio to create an average 20 m VRZ width.

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 (with associated effects on the hydrology of the area, see Sections 5.8 and 5.9) and impacts on water quality.

5.2 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 naturally rocky areas, resulting in a loss of habitat where macroinvertebrates shelter in the spaces between rocks.

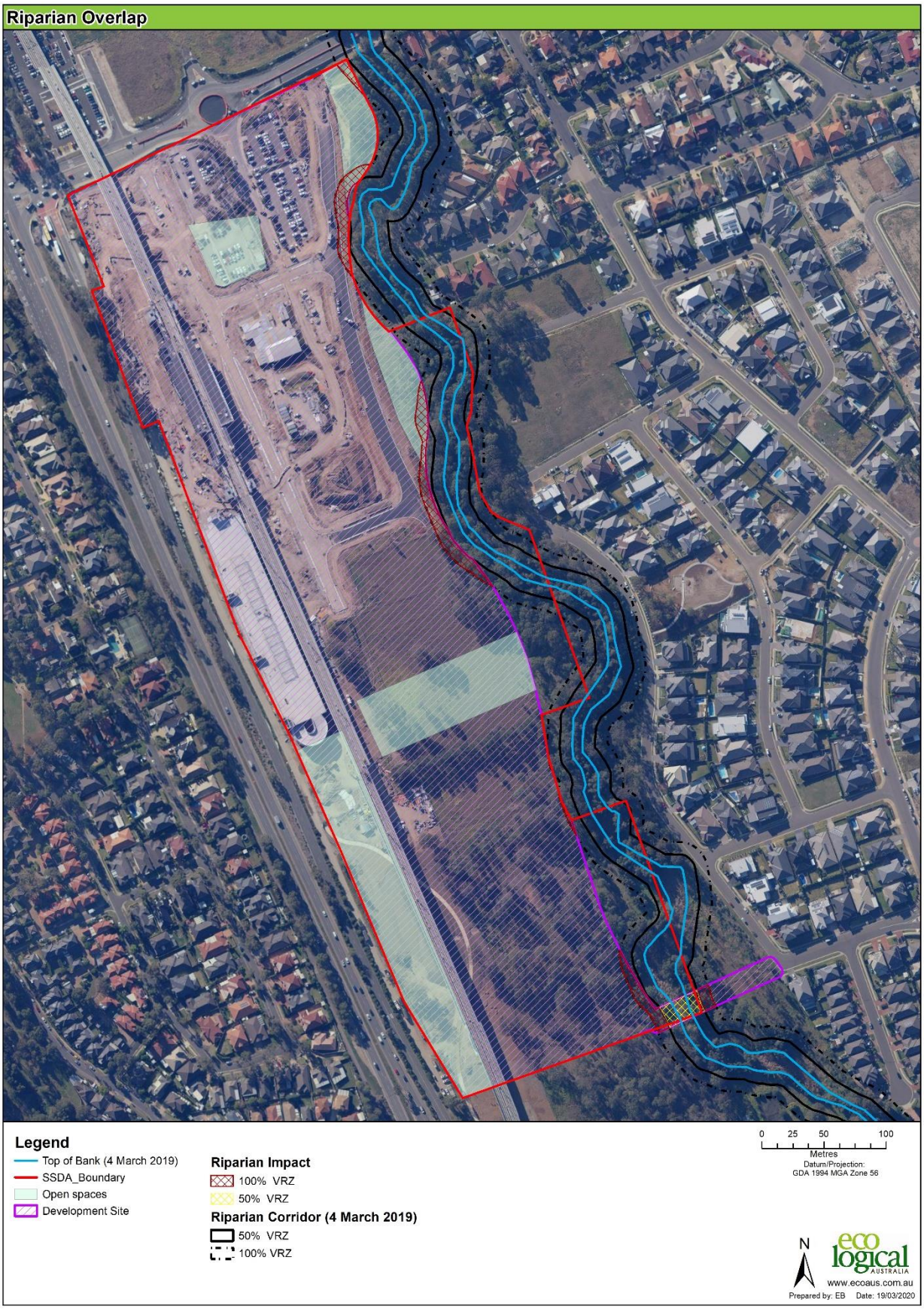

Figure 34: Riparian encroachment

5.3 Watercourse crossings

A road bridge is proposed to be constructed at the southern end of the SSDA boundary across the creek in order to connect Colonial Avenue on the eastern side of Elizabeth Macarthur Creek to the proposed residential area and playing fields on the western side of the creek (Figure 1). There are a number of potential impacts that could occur as a result of the construction of a bridge over the waterway:

5.3.1 Temporary blockage of fish passage

If the proposed bridge construction 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. This would require dewatering of the works area, which would temporarily block fish passage through the reach.

5.3.2 Degradation of water quality

There is the potential for sediment and waste material generated as part of the construction of the road bridge 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.

5.3.3 Destabilisation of creek banks

Removal of vegetation for the construction of the proposed road bridge may destabilise sections of the creek bank within this area, 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 this area.

5.3.4 Shading of creek line

Construction of a new bridge over the creek would cause shading of the waterway. Although the creekline is 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.

5.3.5 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.

5.4 Service Installation

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

5.5 Loss of Riparian Habitat

Where the proposed Masterplan footprint encroaches into vegetated riparian areas, this could involve the loss of established canopy trees and other vegetation that is currently providing 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.

5.6 Weed Invasion

Where disturbance from construction associated with the proposed Masterplan 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 area 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.

5.7 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 period of 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.

5.8 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 at railway stations). Impacts may include change 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.

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 waterway.

6.2 Timing and Location of Works

The proposed construction footprint encroaches into some areas of the riparian corridor of Elizabeth Macarthur Creek (Figure 34). 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).

6.3 Offset Riparian Encroachment

The current Masterplan footprint encroaches into the outer VRZ for 0.309 ha and indirectly the inner VRZ by 0.056 ha (where the proposed road bridge is likely to cause shading of the riparian corridor). This encroachment must be offset elsewhere within the site. The Masterplan has approximately 0.43 ha of open space adjoining the riparian corridor that will be adequate to offset this impact, where revegetation of a fully structured riparian vegetation community will take place.

While the bridge will cause the watercourse and inner VRZ to be shaded in the south of the site, the field survey carried out in February 2019 observed that Elizabeth Macarthur Creek within this area was densely covered in *Typha orientalis*, which would be limiting the amount of light reaching the water. The bridge construction would not prevent light from reaching a watercourse that is currently completely unshaded. Therefore, the indirect impact to the inner VRZ as a result of shading from construction of the bridge is unlikely to be significant.

Figure 35 shows the available areas within the SSDA boundary to offset the 0.309 ha encroachment into the outer VRZ.

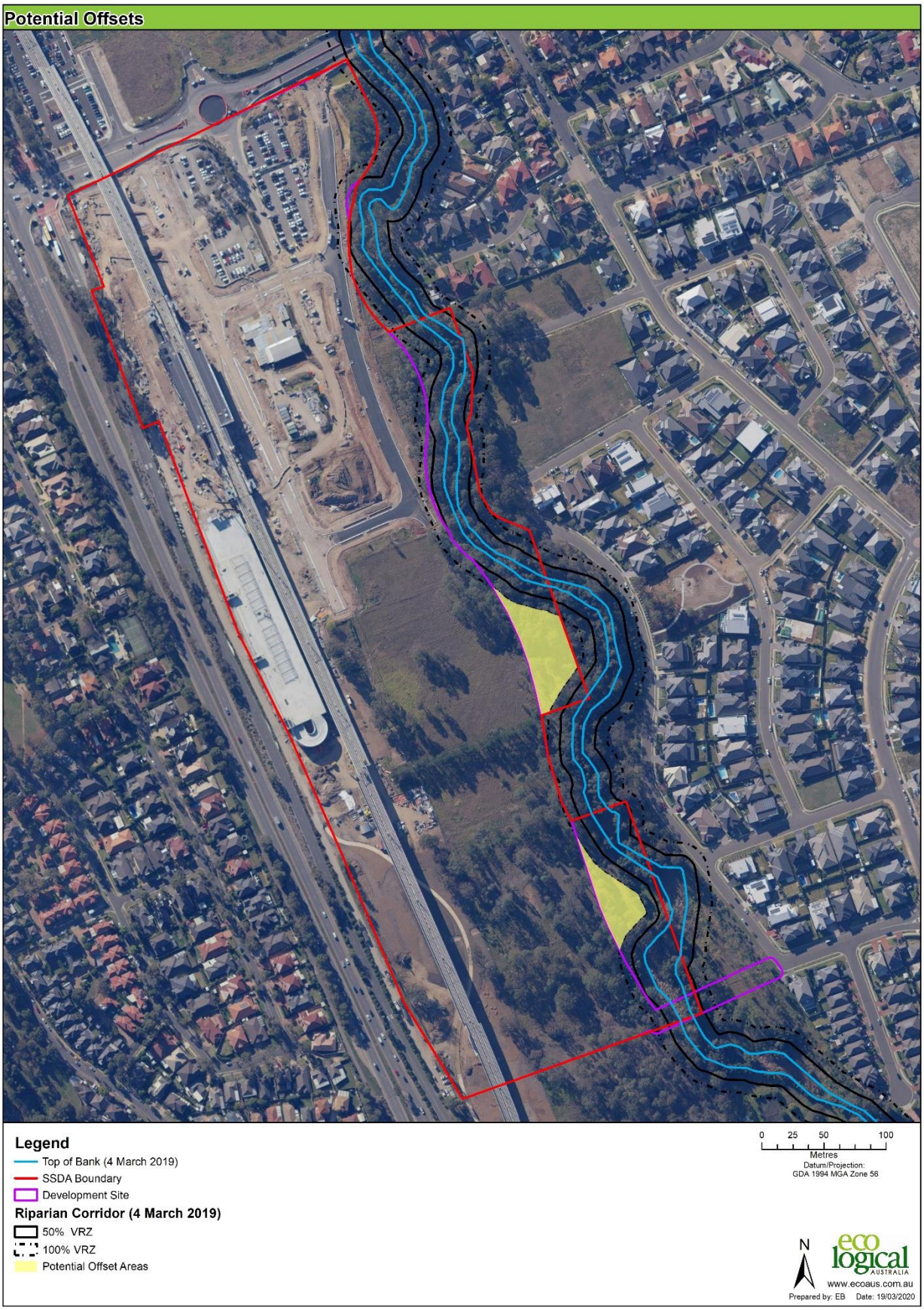

Figure 35: Potential riparian offset areas within SSDA boundary

6.4 Habitat Restoration and Weed Control

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 watercourse upstream. Preparation of a detailed Vegetation Management Plan (VMP), in accordance with the objectives of the Elizabeth Macarthur Creek Trunk Drainage Concept Design (AAJV,2017), would be required to cover the area within the VRZ within the precinct boundary. The VMP would also outline that the areas to be revegetated as part of the offset of the 0.309 ha encroachment into the outer VRZ would be fully structured vegetated areas as per *Guidelines for vegetation management plans on waterfront land* (DPI Water, 2012).

The VMP should also specify the need for shade-tolerant plants to be used to revegetate the areas surrounding the proposed road bridge in the south of the site. This would help ensure the success of revegetation works within this area.

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, especially towards the north of the SSDA Precinct boundary, where bank erosion is prevalent, 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.

6.5 Protection of Water Quality and Habitat Condition

Water quality protection measures are recommended for use where the Masterplan-related 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 Elizabeth Macarthur 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.
- Where excess water from the construction site or during operation of the Kellyville Station Precinct is to be released into Elizabeth Macarthur 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.

6.6 Water Quality Monitoring

Water released into Elizabeth Macarthur 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. These monitoring points are recommended to be located 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.

6.7 Design of Watercourse Crossings

To avoid adverse impacts to the aquatic and riparian habitat as a result of the construction of the road bridge, it should be designed and constructed as per DPI Water's *Controlled activities on waterfront land – Guidelines for watercourse crossings on waterfront land* (DPI Water, 2012). 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 guidelines for riparian corridors. Note: the required width for Elizabeth Macarthur Creek is 20 m on each side of the creek.
- 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 watercourse.

- The bridge design must be certified by a suitably qualified engineer.

6.8 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. Conclusion

The condition of the riparian and aquatic habitat varies along the approximately 900 m long reach of Elizabeth Macarthur Creek within and adjacent to the SSDA boundary. The riparian vegetation along the length of the creekline within the boundary 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. There are a variety of aquatic habitats throughout the reach and a range of geomorphic features such as deep and shallow pools, areas of swamp, runs and riffles that would provide good refuge for aquatic fauna. There are some sections of the bank of Elizabeth Macarthur Creek that are actively eroding, and it is recommended that these areas be stabilised to prevent ongoing sedimentation of the waterway and degradation of water.

The Masterplan includes a proposed road bridge which would increase shading of the inner Vegetated Riparian Zone (VRZ) by 0.056 ha, however due to the current dense growth of vegetation within this area, the indirect impact is unlikely to be significant. The Masterplan also encroaches into 0.309 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. This means that 0.309 ha of land outside of the mapped riparian zone must be revegetated in order to provide this offset and average 20 m VRZ.

8. References

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