Sydney Science Park State Significant Development SSD#1
Biodiversity Development Assessment Report

Celestino Developments SSP Pty Limited

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Project Name	Sydney Science Park State Significant Development #1 Biodiversity Development Assessment Report
Project Number	600-23SYD-5432
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Reviewed by	**Alex Gorey**
Approved by	**Alex Gorey**
Accredited Assessor Certification	 Belinda Failes BAAS18077 I certify that this report has been prepared on the basis of the requirements of, and information provided under, the Biodiversity Assessment Method and s.6.15 of the BC Act. In preparing this assessment I have acted in accordance with the Accredited BAM Assessor Code of Conduct. I declare that I have considered the circumstances and there is no actual, perceived, or potential conflict of interest.
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Template 2.8.1

Executive Summary

Eco Logical Australia Pty Limited (ELA) was engaged by Celestino Developments SSP Pty Limited to prepare a Biodiversity Development Assessment Report (BDAR) for the proposed Sydney Science Park development within 565-601 and 601a Luddenham Road, Luddenham (referred to as 'subject land'). Celestino Developments SSP Pty Limited proposes to submit a State Significant Development Application (SSDA) under Part 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the concept proposal and detailed design for Stage 1 of the proposed Sydney Science Park development.

The proposed development automatically triggers the requirement for a BDAR as the proposed approvals pathway is State Significant Development under Part 4.7 of the EP&A Act. This report has been prepared to meet the requirements of the Biodiversity Assessment Method 2020 (BAM) established under Section 6.7 of the *Biodiversity Conservation Act 2016* (BC Act).

It describes the biodiversity values within the subject land, describes the impacts and outlines the measures to be taken to avoid, minimise and mitigate impacts to the Plant Community Types (PCTs) and threatened species habitat within the subject land. The report provides the number of biodiversity credits that would be required to be retired to offset the residual loss of biodiversity from the impacts of the development. The report also satisfies the Planning Secretary's Environmental Assessment Requirements (SEARs) for the State Significant Development (SSD) 78774218, issued 9 February 2025.

The development footprint is comprised of remnant native vegetation, planted native vegetation. cleared land, built environment and exotic vegetation which lack biodiversity values. Utilisation of these areas for the proposed development demonstrates efforts to avoid and minimise impacts to biodiversity values. Three PCTs were recorded within the development footprint:

- PCT 3320 *Cumberland Shale Plains Woodland*
- PCT 4023 *Coastal Valley Riparian Forest*
- PCT 3975 *Southern Lower Floodplain Freshwater Wetland.*

The occurrence of PCT 3320 within the subject land is consistent with the Threatened Ecological Community (TEC) *Cumberland Plain Woodland in the Sydney Basin Bioregion,* listed as critically endangered under the BC Act. It did not meet the criteria for listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The occurrence of PCT 4023 within the subject land is consistent with the TEC *Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregion,* listed as endangered under the BC Act. It did not meet the criteria for listing under the EPBC Act. PCT 3975 has one associated TEC listed in BioNet Vegetation Information System (VIS). However, the vegetation mapped as PCT 3975 within the subject land occurs within artificial environment (i.e. dams) and does not represent part of a TEC.

A total of **17 ecosystem credits** are required to offset residual impacts associated with the proposed development (Table 1).

Table 1: Ecosystem credits required

PCT ID	PCT name	Area (ha)	Credits required
3975	Southern Lower Floodplain Freshwater Wetlands	0.53	17
3320	Cumberland Shale Plains Woodland	1.35	0 – VI score <15
4023	Coastal Valley Riparian Forest	1.39	0 – VI score <15

No threatened flora species were recorded within the subject land or are likely to persist in the soil profile. The vegetation within the subject land was deemed highly degraded. No species credits are required for threatened flora.

Several threatened species listed under the BC Act and/or EPBC Act were recorded during surveys:

- *Myotis macropus* (Southern Myotis) - vulnerable under the BC Act
- *Haliaeetus leucogaster* (White-bellied Sea Eagle) – vulnerable under the BC Act and Marine under the EPBC Act (foraging only)
- *Calidris acuminata* (Sharp-tailed Sandpiper) – migratory under the EPBC Act, foraging only
- *Gallinago hardwickii* (Latham's Snipe) – vulnerable and migratory under the EPBC Act, foraging only.

A total of **17 species credit species** are required to offset residual impacts associated with the proposed development (Table 2).

Table 2: Species credit summary

Species	Common name	Direct impact to habitat (ha)	Credits required
Myotis macropus	Southern Myotis	2.19	17
Haliaeetus leucogaster	White-bellied Sea Eagle	0 – no breeding habitat confirmed	0
Calidris acuminata	Sharp-tailed Sandpiper	0 – EPBC Act listed species only	0
Gallinago hardwickii	Latham's Snipe	0 – EPBC Act listed species only	0

The development footprint contains one candidate for Serious and Irreversible Impact (SAII), *Cumberland Plain Woodland in the Sydney Basin Bioregion*. An assessment of this candidate SAII has been included in this report.

The following Matters of National Environmental Significance (MNES) were identified as having potential to be affected by the proposed subdivision:

- *Calidris acuminata* (Sharp-tailed Sandpiper) listed as vulnerable and migratory under the EPBC Act
- *Gallinago hardwickii* (Latham's Snipe) listed as vulnerable and migratory under the EPBC Act
- *Tringa nebularia* (Common Greenshank) listed as endangered and migratory under the EPBC Act
- *Pteropus poliocephalus* (Grey-headed Flying-fox) listed as vulnerable under the EPBC Act.

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The project was referred (2025/10276) to the Commonwealth DCCEEW under the EPBC Act 1999 to determine whether it would be a controlled action. On the 18 November 2025 the Commonwealth determined that the project is not a controlled action and therefore no further assessment or approval under the EPBC Act is required.

Mitigation measures have been proposed to address residual impacts to native vegetation at the subject land before, during and after construction.

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Abbreviations

Abbreviation	Description
BAM	Biodiversity Assessment Method
BAM-C	Biodiversity Assessment Method Calculator
BC Act	NSW *Biodiversity Conservation Act 2016*
BDAR	Biodiversity Development Assessment Report
CEEC	Critically Endangered Ecological Community
DAWE	Commonwealth Department of Agriculture, Water and the Environment (Now DCCEEW)
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DCCEEW NSW	NSW Department of Climate Change, Energy, the Environment and Water
DCP	Development Control Plan
DPE	Former NSW Department of Planning and Environment (now NSW DCCEEW)
DPIE	Former NSW Department of Planning, Industry and Environment (now NSW DCCEEW)
ELA	Eco Logical Australia Pty Limited
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FM Act	NSW *Fisheries Management Act 1994*
GIS	Geographic Information System
GPS	Global Positioning System
IBRA	Interim Biogeographic Regionalisation for Australia
LEP	Local Environmental Plan
LGA	Local Government Area
LLS	Local Land Service
NSW	New South Wales
NOW	NSW Office of Water
PCT	Plant Community Type
SEPP	State Environmental Planning Policy
SSD	State Significant Development
SSDA	State Significant Development Application
TBDC	Threatened Biodiversity Data Collection
TEC	Threatened Ecological Community
VI	Vegetation Integrity
VMP	Vegetation Management Plan
WM Act	NSW *Water Management Act 2000*

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1. Stage 1: Biodiversity assessment

1.1. Introduction

Eco Logical Australia Pty Limited (ELA) was engaged by Celestino Developments SSP Pty Limited to prepare a Biodiversity Development Assessment Report (BDAR) to support the submission of a State Significant Development Application (SSDA) under Part 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The SSDA is for the proposed Sydney Science Park concept design and detailed design and development of stage 1, which will be submitted to the NSW Department of Planning, Housing and Infrastructure (NSW DPHI) as the consenting authority.

This BDAR has been prepared by Belinda Failes an Accredited Person (BAAS #18077) to apply the Biodiversity Assessment Method (BAM) under the NSW *Biodiversity Conservation Act 2016* (BC Act). This report has been reviewed by Alex Gorey who is an Accredited Assessor (BAAS #22003) under the BC Act. All credit calculations have been undertaken using the BAM Calculator (BAM-C) version 82 in case number 00047261.

Definitions of terminology used throughout this report are presented in Appendix A.

1.2. General description of the subject land and development footprint

The subject land refers to the land which comprises of the Sydney Science Park boundary as displayed in Figure 1. The subject land includes lots 1-3 /DP 1276320 and Lot 206/DP 1280188. The development footprint refers to the direct impacts from the proposed works.

For the purposes of this assessment, Lots 201, 203 and 205 DP1280188 are excluded from the subject land. These lots are associated with the construction footprint for the Sydney Metro Western Airport link and are not proposed for development under the current SSDA (Figure 1).

The subject land and development footprint are shown on the Site Map (Figure 1) and the Location Map (Figure 2).

The subject land is within the Penrith City Council Local Government Area (LGA) and is zoned under the State Environmental Planning Policy (Western Parklands City) (SEPP) 2021 as the following:

- The site is primarily zoned Mixed Use (MU) with portions of the site over the riparian corridors and recreational spaces zoned Environment and Recreation (ENZ).
- The western portion of the site is zoned ENT with areas of ENZ along the riparian corridor. Note. The land zoned Enterprise (ENT) is not identified as Sydney Science Park (SSP) under Section 4.28A of the Western Parkland City SEPP.

The subject land is mapped as excluded land and does not form land to which the Cumberland Plain Conservation Plan (CPCP) applies, however, it is subject to the provisions in Western Sydney Aerotropolis Development Control Plan (DCP) Phase 2 (Northern Gateway Precinct) (Figure 3). Specific controls for the Sydney Science Park is included in Section 5.2.5 of the DCP (refer to Table 6).

The total size of the subject land is approximately 297.89 ha. The subject land comprises of exotic grasses, cleared areas (gravel access tracks), planted native vegetation and fragmented remnant native

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vegetation in poor condition. The subject land also contains numerous streams and human made dams. Of which the majority of the vegetation is in poor condition. The subject land has an extensive history of use for agricultural purposes including ongoing cattle grazing and improved pasture. This has contributed to the overall poor condition of the ecological values present.

The subject land also contains existing human-made structures such as internal access roads and an Integrated Water Recycling Hub in the south-west of the subject land. The Warragamba Prospect Water Supply Pipeline is located adjacent to the northern boundary and does not intersect with the subject land.

1.3. Description of the proposal and the development footprint

The proposal comprises a concept proposal to guide the staged development of the subject land as well as a detailed proposal for the first stage of development. For clarity, it is noted that the SSDA does not seek approval for land use or built form. A description of the components of the proposed development is provided in the table below.

Table 3: Proposal description

Element	Area / legal description	Description	Stage
Concept Proposal			
Concept Plan	Entire site (Lots 1, 2 and 3 DP 1276320 Lots 206 DP 1280188)	The concept proposal comprises the following: • A concept urban structure plan based on a site wide approach for the development of urban blocks/super lots, including site-wide open space and riparian corridors and key transport infrastructure links (sub-arterial, indicative collector and local roads, and associated intersections). • Staging plan, setting out the development stages, and • Guidelines for the future stages of development. The SSDA will seek approval for the following site-wide strategies: • Connecting with Country Design Response • Open Space Strategy that details that six (6) different categories of open space areas that are proposed throughout the site as per the below: o Key destinations o Local open spaces o Cultural spaces o Wetlands and riparian o Green loops o Streetscape • Integrated Water Cycle Management (IWCM) and flooding Strategy • Civil and Bulk Earthworks Strategy • Biodiversity and Ecology • Environmental Site Assessment (Contamination) • Site Infrastructure and Servicing	All stages

Element	Area / legal description	Description	Stage
Stage 1 Precinct	Lot 1 DP 1276320 (part lot) Lot 206 DP 1280188	The Stage 1 Precinct, which will primarily be located on the south-eastern portion of the site and will include the following: • Clearing, tree removal, bulk and detailed earthworks, including cut/fill, grading, and benching. • Construction of structural support, including retaining walls and batters. • Staged construction of civil and infrastructure works, including temporary works associated with roadworks and IWCM. • Landscaping and streetscape. • Provision and augmentation of services (potable water, sewer, recycled water, electricity, and telecommunications), and • Associated environmental management works, including erosion and sediment control.	Stage 1
Stage 1 Estate Works	Lots 1, 2 and 3 DP 1276320 Lot 206 DP 1280188	The Stage 1 Estate Works will primarily comprise the following and will be executed in a staged manner: • Clearing, tree removal and earthworks, including cut and fill, benching and stabilisation (batters and/or retaining walls) to achieve appropriate site levels across the site. • Stormwater and other related civil work, including the provision of utility services. • Public domain work such as the provision of footpaths from Stage Precinct 1 to the Metro Station and associated signage, and • Internal reticulation of services and utilities, including connections to and from the existing Sydney Integrated Water Recycling Hub.	Stage 1
Stage 1 Subdivision	Lots 1, 2 and 3 DP 1276320 Lot 206 DP 1280188	Staged subdivision of Stage 1 Development area, creating a total of 18 lots, comprising: ▪ five (5) development lots and ▪ thirteen (13) residue lots.	Stage 1

This BDAR considers all development stages including the concept and stage 1.

The proposal has considered options to retain existing native vegetation, however, the majority of the native vegetation within the subject land is in poor condition. The proposed SSDA requires substantial earthworks to facilitate development, hence, the existing native vegetation along the riparian corridors could not be retained. However, one patch of native vegetation (0.71 ha), with some retention values (due to the presence of hollow-bearing trees) was identified to be retained within the subject land and subject to revegetation works in accordance with a Vegetation Management Plan (VMP) (ELA 2025a).

1.4. Planning Secretary's Environmental Assessment Requirements

This report satisfies the Planning Secretary's Environmental Assessment Requirements (SEARs) for the State Significant Development (SSD) 78774218, issued 9 February 2025. A breakdown of the response to SEARs is provided below.

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Table 4: DPHI SEARs requirements

No.	Comments	Response
13. Biodiversity	Assess any biodiversity impacts associated with the development in accordance with the Biodiversity Conservation Act 2016 and the Biodiversity Assessment Method 2020, including the preparation of a Biodiversity Development Assessment Report (BDAR), unless a waiver is granted, or the site is on biodiversity certified land. If the development is on biodiversity certified land, provide information to identify the site (using associated mapping) and demonstrate the proposed development is consistent with the relevant biodiversity measure conferred by the biodiversity certification. Address the requirements listed in SEARs advice Penrith City Council dated 17 January 2025, prepared by Penrith City Council. Address the requirements listed in SEARs advice DCCEEW BCS dated 24 January 2025, prepared by DCCEEW BCS. Address the requirements listed in SEARs advice WSA dated 13 January 2025, by WSA Co.	This report has been prepared in accordance with the BC Act and the BAM and addresses SEARs item No. 13. The subject land is not located on biodiversity certified land Refer to Table 5.

Table 5: Government Authority Advice

Government authority advice	Summary response	Report section reference
Penrith City Council 17 January 2025	5. Biodiversity considerations a) The EIS will need to include various supporting reports, which have been prepared by suitably qualified ecological consultants, demonstrating that the proposal is able to be undertaken in a manner consistent with the relevant provisions with respect to the management and protection of biodiversity. The following should be provided in support of the overall proposal and included within the EIS. i. Biodiversity Development Assessment Report (BDAR). ii. Riparian assessment of all waterways and Ecological Assessment of Farm Dams. iii. Dam Dewatering Plan. iv. Vegetation Management Plan. v. Wildlife Risk Assessment and Management Plan.	This BDAR responds to item 5(i). Item 5(iI) to V will be prepared as separate deliverables.
Conservation Programs, Heritage and Regulation (CHPR) 24 January 2025	1. Biodiversity impacts related to the proposed development are to be assessed in accordance with Section 7.9 of the *Biodiversity Conservation Act 2016* (BC Act), the Biodiversity Assessment Method 2020 (BAM) and documented in a BDAR. The BDAR must include information in the form detailed in the BC Act (s.6.12), *Biodiversity Conservation Regulation 2017* (s.6.8) and the Biodiversity Assessment Method (BAM), including an assessment of the impacts of the proposal (including an assessment of impacts prescribed by the regulations). 2. The BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the BAM. 3. The BDAR must	Impacts to biodiversity values are detailed in Section 7. The entire document has been prepared to meet the requirements of the BC Reg, and has been prepared consistent with the BAM. Avoid and Minimise criteria are addressed in Section 6.1.

Government authority advice	Summary response	Report section reference
	include details of the measures proposed to address the offset obligation as follows: a. The total number and classes of biodiversity credits required to be retired for the development/project. b. The number and classes of like-for-like biodiversity credits proposed to be retired. c. The number and classes of biodiversity credits proposed to be retired in accordance with the variation rules. d. Any proposal to fund a biodiversity conservation action. e. Any proposal to conduct ecological rehabilitation (if a mining project). f. Any proposal to make a payment to the Biodiversity Conservation Fund. If seeking approval to offset in accordance with the Biodiversity Offset Scheme (BOS), the BDAR must contain details of the reasonable steps that have been taken to obtain requisite like-for-like biodiversity credits. 4. The BDAR must be submitted with all spatial data associated with the survey and assessment as per the BAM. 5. The BDAR must be prepared by a person accredited in accordance with the Accreditation Scheme for the Application of the Biodiversity Assessment Method Order 2017 under s.6.10 of the BC Act.	The offset obligation is detailed in Section 8.5 and Appendix H. The submission of the BDAR with spatial data is completed in the BAM-C. An accredited assessor declaration has been included on the inside cover page of this report.
Western Sydney Airport 13 January 2025	It is noted that a Wildlife Hazard Assessment Report will be prepared. Given the site location in relation to future flight paths and the extent of future landscaping, stormwater infrastructure and riparian corridors, a Wildlife Hazard Assessment Report should address the following to minimise wildlife attraction: • Design, management and monitoring of the onsite stormwater infrastructure including any detention basins and temporary bio retention and sediment basins. • Landscaping species selection and maintenance. • The design and management of waste storage areas/receptacles during construction. • External handling and storage of organic materials. • Monitoring and management of any wildlife.	A Wildlife Hazard Assessment Report has been prepared to address these matters (ELA 2025f). Where these measures interact with sections of this BDAR, such as mitigation measures, any relevant design, management or landscaping features have been referenced.

1.5. Sources of information used

The following data sources were reviewed as part of this report:

- BioNet Vegetation Classification (VIS) (DPE 2024a)
- BioNet Atlas (DPE 2025b)
- Threatened Biodiversity Data Collection (TBDC) (2024c)

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool 5 km database search (DCCEEW 2024a)
- NSW Government Biodiversity Values Map and Threshold Tool (DPE 2024d)
- NSW State Vegetation Type Map (DPE 2023) – Sharing and Enabling Environmental Data in NSW
- Department of Sustainability, Environment, Water, Population and Communities. (SEWPAC). 2013. Interim Biogeographic Regionalisation for Australia (IBRA), Version 7 (Regions). Bioregional Assessment Source Dataset. August 2021.
- Department of Planning, Industry and Environment (DPE) 2016. NSW (Mitchell) Landscapes – version 3.1.
- Aerial mapping (NearMaps)
- Additional Geographic Information System (GIS) datasets including soil, topography, geology and drainage
- Biodiversity Assessment Method Calculator (Version 82) (BAM-C)
- National Flying-fox monitor viewer (DCCEEW 2024b)
- Department of Planning and Environment (DPE) (2022d) Register of Declared Areas of Outstanding Biodiversity Value
- NSW Survey Guide for Threatened Frogs – a guide for the survey of threatened frogs and their habitats for the Biodiversity Assessment Method (DPIE 2020)
- 'Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method (OEH 2018)
- Surveying threatened plants and their habitats – NSW survey guide for the Biodiversity Assessment Method (DPIE 2020)
- Surveying threatened plants and their habitats (DPIE, 2020)
- Survey Guidelines for Australia's Threatened Birds (Commonwealth of Australia 2010)
- NSW Survey Guide for Threatened Frogs A guide for the survey of threatened frogs and their habitats for the Biodiversity Assessment Method (DPIE 2020)
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities Working Draft (Department or Environment and Conservation (DEC) 2004)
- State Environmental Planning Policy (Precincts – Western Parkland City) 2021 Aerotropolis Precinct Plan.

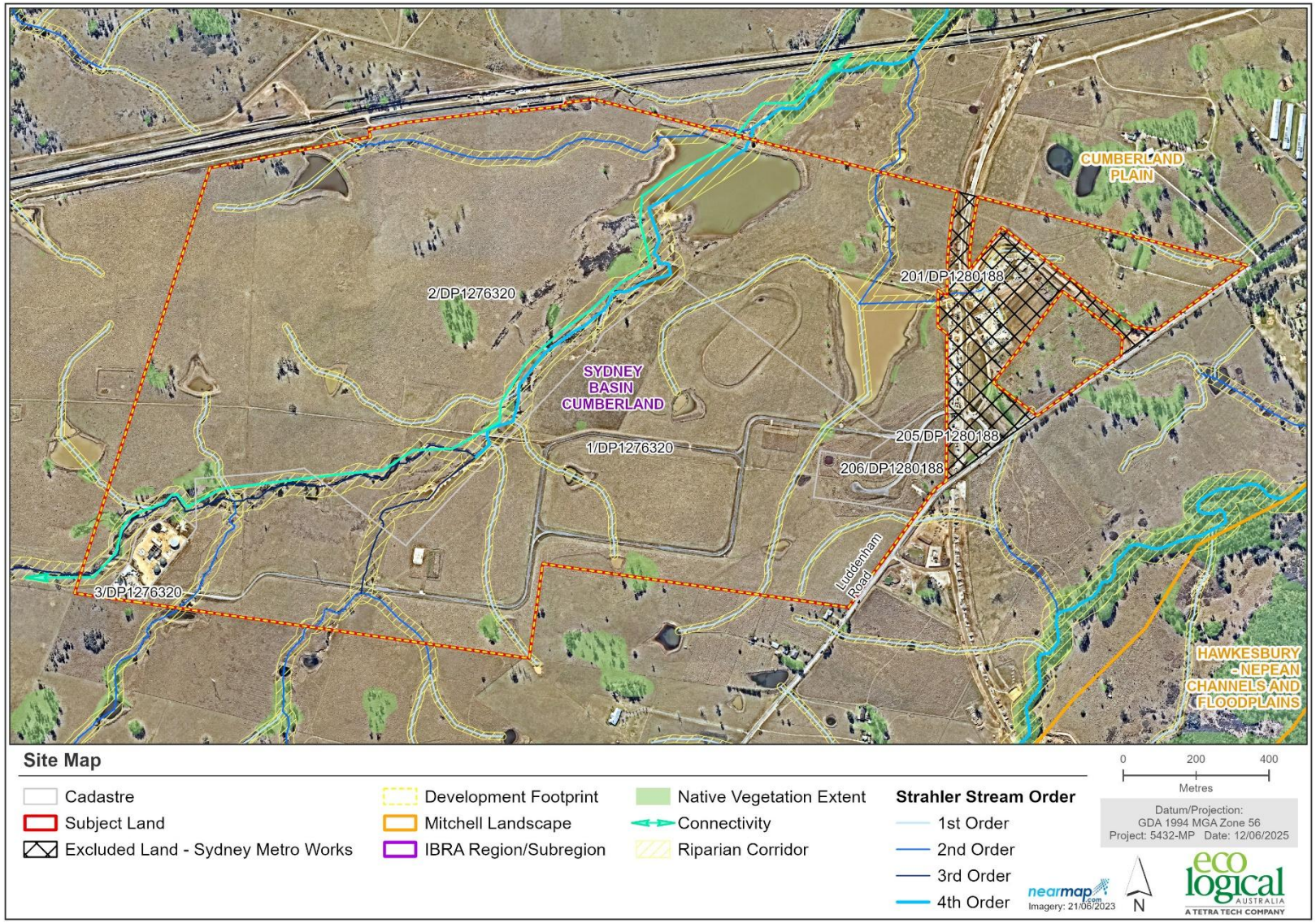

Figure 1: Site Map

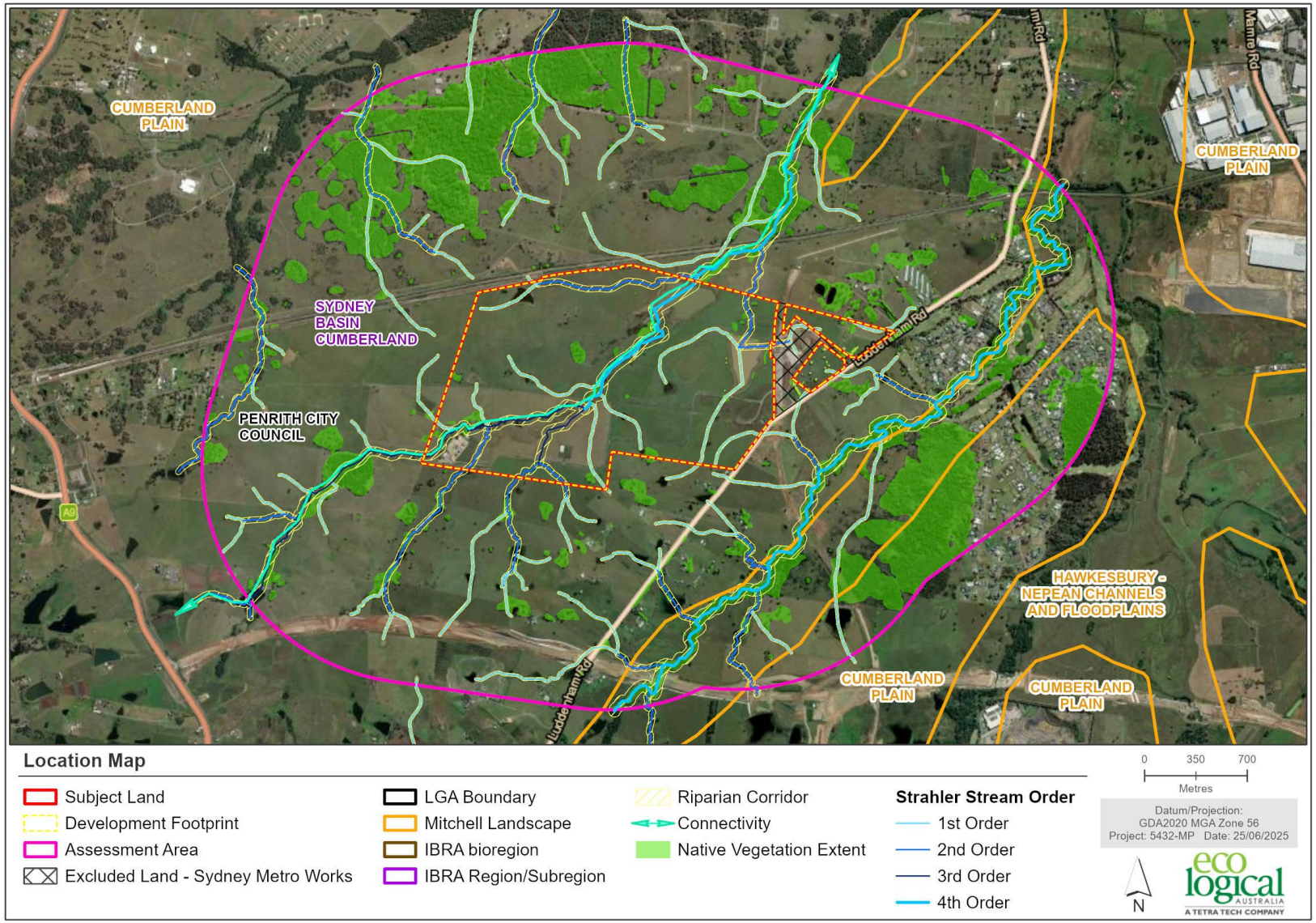

Figure 2: Location Map

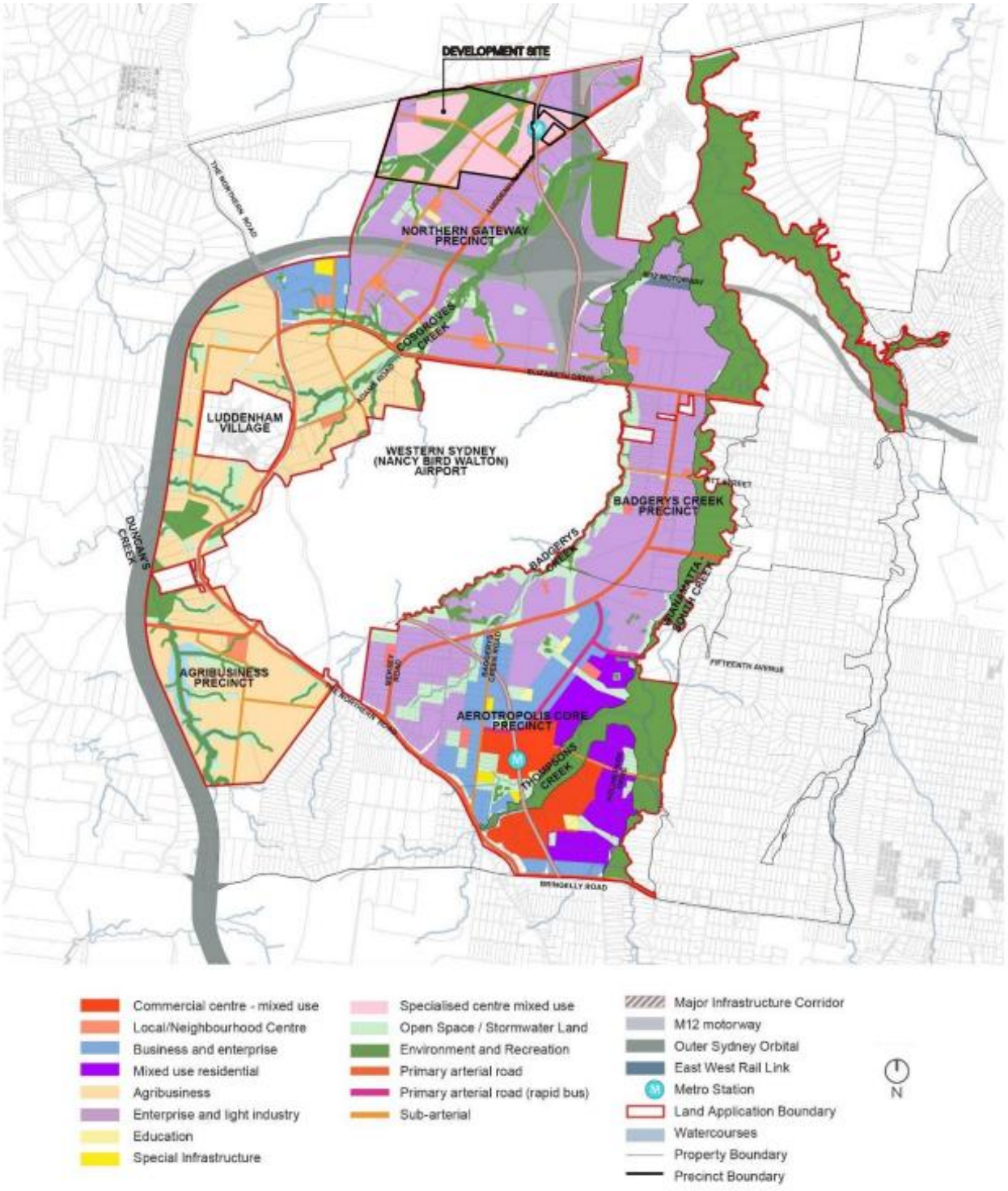

Figure 3: The subject land within the Aerotropolis Precinct Plan, September 2024

1.6. Legislative context

Table 6: Legislative context

Name	Relevance to the project	Report Section
Commonwealth		
Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Matters of National Environmental Significance (MNES) have been identified on or near the development footprint, including: • *Gallinago hardwickii* (Latham's Snipe) – known • *Calidris acuminata* (Sharp-tailed Sandpiper) – known • *Tringa nebularia* (Common Greenshank) - known • *Pteropus poliocephalus* (Grey-headed Flying-fox) – likely. A separate Referral (number 2025/10276) under the EPBC Act was made to the Commonwealth, which assessed impacts to the MNES identified above. On the 18 November 2025 the Commonwealth determined that the project is not a Controlled Action and therefore no further assessment or approval under the EPBC Act is required.	N/A
State		
Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act is the principal planning legislation for NSW. It provides a framework for the overall environmental planning and assessment for development proposals. The proposed development is State Significant Development (SSD) and is to be assessed under Part 4.7 of the EP&A Act. Secretary's Environmental Assessment Requirements (SEARs) have been received. This BDAR responds to Agency Requirements, specifically Item No. 13 Biodiversity of the SEARs and addresses the EP&A Act and BC Act.	This report
Biodiversity Conservation Act 2016 (BC Act)	The proposed development automatically triggers the requirement for a BDAR as the proposed approvals pathway is State Significant Development under Part 4.7 of the EP&A Act. A BDAR Waiver was deemed unsuitable, due to the presence of remnant native vegetation and known threatened species habitat throughout the development footprint.	Entire report.
Fisheries Management Act 1994 (FM Act)	The development involves dredging and reshaping of the streams by the developer (a 'person') and requires a permit under s201 of the FM Act.	Addressed in the Riparian Assessment (ELA 2025b).
Local land Services Amendment Act 2016 (LLS Act)	The LLS Act does not apply to areas of the state to which the SEPP Vegetation applies. The Vegetation SEPP applies to the Penrith local government area.	N/A
Water Management Act 2000 (WM Act)	The project involves works on waterfront land and therefore requires a Controlled Activity Approval under s91 of the WM Act.	Addressed in the Riparian Assessment (ELA 2025b).
Planning Instruments		
Cumberland Plain Conservation Plan 2022 (CPCP)	The Cumberland Plain Conservation Plan (the CPCP) is one of the largest strategic conservation plans to be undertaken in Australia. It identifies strategically important biodiversity areas within the Cumberland subregion to offset the biodiversity impacts of future urban development to facilitate a green and liveable city. The CPCP provides for biodiversity certification within certain land categories. Works in certified-urban capable or major transport corridor land does not require further site by site biodiversity assessment or approval under the BC Act, if consistent with the CPCP and its approvals. The subject land is located within the CPCP Area, within excluded	N/A

Name	Relevance to the project	Report Section
	land (non-certified). Assessment of biodiversity under the BC Act has been undertaken within this report.	
State Environmental Planning Policy (Resilience and Hazards) 2021	The proposed development is mapped as excluded land and therefore is not located on land to which this SEPP applies.	N/A
State Environmental Planning Policy (Biodiversity and Conservation) 2021	The Minister for Planning and Public Spaces announced that on 1 March 2022 the commencement of the new Biodiversity and Conservation SEPP. The Biodiversity and Conservation SEPP consolidates 11 SEPPs into one new theme-based focus SEPP. The following chapters are relevant for this project: • Chapter 2 Vegetation in non-rural areas. • Chapter 4 Koala Habitat Protection 2021 • Chapter 6 Water Catchments Chapter 2 Vegetation in non-rural areas applies to development that does not require consent. As the proposed works requires consent under the EP&A Act, Chapter 2 does not apply. Chapter 4 Koala Habitat Protection 2021 of the SEPP is not relevant to the project as Penrith City Council is not listed as one of the Local Government Areas (LGAs) specified in Schedule 2 of the SEPP. Chapter 6 Water Catchments applies to the development as the land is located within the Hawkesbury-Nepean Catchment. Development controls under Section 6.6 and 6.7 relating to aquatic ecology apply to the development.	Matters relating to Chapter 6 Water Catchment will be addressed in the separate riparian assessment (ELA 2025b)
State Environmental Planning Policy (Precincts Western Parklands City 2021) SEPP	The subject land is subject to the Western Sydney Parklands SEPP and is listed as part of a key site, Sydney Science Park. The subject land forms part of the Northern Gateway Precinct under the Western Sydney Aerotropolis Precinct Plan and Chapter 4 applies to the proposed development.	This report (Figure 3)
Western Sydney Aerotropolis Precinct Plan 2022 (under the Western Parkland City SEPP)	The precinct plan provides further direction for development within the Aerotropolis. The Western Aerotropolis Precinct Plan establishes the strategic vision and general objectives, proposed land uses, performance criteria for development of land and the approach to both infrastructure and water cycle management. The subject land is located within the 8 km Wildlife buffer zone as such, a separate Wildlife Management Plan will be prepared for the development.	Addressed in the Wildlife Hazard Management Plan (ELA 2025f).
Western Sydney Aerotropolis Development Control Plan 2022	The subject land is located within the Aerotropolis boundary. The Western Sydney Aerotropolis DCP applies to the subject land. The Western Sydney Aerotropolis DCP provides the planning, design and environmental objectives and controls for the future preparation of development applications and Masterplans. Section 2.3 *Stormwater, Water Sensitive Urban Design and Integrated Water Management* applies to the subject land but will be addressed in the Water Management Strategy. Section 2.4.2 *Protection of Biodiversity* relates to the subject land. Its objectives are: • Ensure consistency with the requirements of the relevant biodiversity certification for the subject land where applicable. • Ensure construction and operational works avoid and minimise impacts to native vegetation and ecological communities. • Retain and protect native vegetation areas, particularly those with Aboriginal cultural value, and provide for areas with a size and configuration that will	Section 6.1 of this report

Name	Relevance to the project	Report Section
	allow for the survival and improvement of the native vegetation communities. • Implement the Sydney Region Growth Centres Biodiversity Certification Order where applicable. • Implement the Cumberland Plain Conservation Plan (CPCP) where applicable. • Manage fire risk by regimes that protect biodiversity and habitats in the long term. The subject land is not located within land subject to biodiversity certification. This BDAR Section 6.1 addresses the avoid and minimise impacts to biodiversity values. The subject land is mapped as excluded land under the CPCP. Bushfire and Aboriginal assessments have not been included in this assessment.	

2. Streamlined Assessment Module

2.1. Planted Native Vegetation

Section 2.2 of the Biodiversity Assessment Method 2020 (BAM) contains a streamlined assessment module for planted native vegetation. The streamlined assessment can be used where the native vegetation was planted for purposes such as street trees and other roadside plantings, windbreaks, landscaping in parks and gardens, and revegetation for environmental rehabilitation.

The streamlined assessment module for planted native vegetation has been applied to part of the subject land where areas of planted native vegetation will be impacted. A total of 0.46 ha of planted native vegetation was identified during field validation within the subject land. The vegetation includes species which are not part of a local PCT. The planted native vegetation within the subject land has been planted for the purpose of landscape plantings along roads and around dams. Appendix D of the BAM provides a decision-making key for the assessment of the planted native vegetation. This decision-making key was applied to the sections of planted native vegetation mapped within the subject land. This assessment is displayed in Table 7.

Table 7: Decision-making key for planted native vegetation

Question	Response
A1: Does the planted native vegetation occur within an area that contains a mosaic of planted and remnant native vegetation and which can be reasonably assigned to a PCT known to occur in the same IBRA subregion as the proposal?	• **No** – Planted native vegetation was located around dams and along an existing road. It is disconnected from remnant vegetation via hard surfaces such as roads and extensive areas of open exotic grasslands. Planted native vegetation did not include species which represent part of a local indigenous PCT.
A2: Is the planted native vegetation: planted for the purpose of environmental rehabilitation or restoration under an existing conservation obligation listed in BAM Section 11.9(2.), and the primary objective was to replace or regenerate a plant community type or a threatened plant species population or its habitat?	• **No** – Planted native vegetation does not include representative species which are part of a local PCT. Planted native vegetation includes linear plantings of mature *Eucalyptus microcorys*. According to the PlantNET, this species occurs north of Cooranbong (i.e. west of Morisset) which is approximately 150 km north of the subject land. As such, *E. microcorys* does not represent part of a local PCT and has been established through planting.
A3: Is the planted/translocated native vegetation individuals of a threatened species or other native species planted/translocated for the purpose of providing threatened species habitat under one of the following: • species recovery project • *Saving our Species* project • other types of government funded restoration project • condition of consent for a development approval that required those species to be planted or translocated for the purpose of providing threatened species habitat • legal obligation as part of a condition or ruling of court. This includes regulatory directed or ordered remedial plantings (e.g. Remediation Order for	• **No** – the native species present are not listed as threatened under the BC Act or EPBC Act. They have not been planted for rehabilitation works and have not been planted or translocated for the purposes listed.

Question	Response
clearing without consent issued under the BC Act or the Native Vegetation Act) • ecological rehabilitation to re-establish a PCT or TEC that was, or is carried out under a mine operations plan, or • approved vegetation management plan (e.g. as required as part of a Controlled Activity Approval for works on waterfront land under the NSW *Water Management Act 2000*)?	
A4: Was the planted native vegetation (including individuals of a threatened flora species) undertaken voluntarily for revegetation, environmental rehabilitation or restoration without a legal obligation to secure or provide for management of the native vegetation?	• **No** – the planted native vegetation forms part of the landscaping along roads and around dams within the subject land. The planted native vegetation does not include species with threatened flora species and does not include species which represents part of a PCT. The vegetation has not been established as part of rehabilitation or restoration works.
A5: Is the native vegetation (including individuals of a threatened flora species) planted for functional, aesthetic, horticultural or plantation forestry purposes? This includes examples such as: windbreaks in agricultural landscapes, roadside plantings (including street trees, median strips, roadside batters), landscaping in parks, gardens and sport fields/complexes, macadamia plantations or teatree farms?	• **Yes** – the planted native vegetation has been planted for functional purposes associated with aesthetics for landscaping. • **Go to D.2 Assessment of planted native vegetation for threatened species habitat (the use of Chapters 4 and 5 of the BAM are not required to be applied)**
A6: Is the planted native vegetation a species listed as a widely cultivated native species on a list approved by the Secretary of the Department (or an officer authorised by the Secretary)?	• N/A

Section D.2 of Appendix D of the BAM requires that the planted native vegetation is assessed for threatened species habitat. If evidence of threatened species utilising planted native vegetation, then Section 8.4 of the BAM is required to mitigate and manage impacts to threatened species. However, species credits are not required to offset these impacts to planted native vegetation.

Opportunistic survey and habitat assessment for threatened flora species and fauna habitat was undertaken as part of the field survey. One hollow, with approximately 0 -10 cm entrance size which has potential to provide habitat for threatened microbat species was identified (Figure 4) (Figure 7). Targeted surveys for microbat species were undertaken near the planted *Eucalyptus microcorys* near the dam. It was determined that planted native vegetation has potential to provide roosting habitat for threatened microbat species. Management actions are provided in Table 35 to mitigate impacts on hollows in planted native vegetation for threatened microbat species.

The habitat assessment determined that the planted native vegetation is unlikely to provide suitable habitat for threatened flora species.

Figure 4: Hollow-bearing trees

3. Landscape features

The site-based method was applied for this assessment; therefore, the assessment area is the 1,500 m buffer surrounding the outside edge of the boundary of the subject land.

The landscape features considered for this assessment are presented in Table 8, Figure 1 and Figure 2.

Table 8: Landscape features

Landscape feature	Subject Land/development footprint	Assessment Area	Data source
IBRA Region(s)	Sydney Basin	Sydney Basin	Interim Biogeographic Regionalisation for Australia, Version 7
IBRA subregion(s)	Cumberland	Cumberland	Interim Biogeographic Regionalisation for Australia, Version 7
Rivers and streams	The development footprint contains 1st, 2nd 3rd and 4th Strahler Streams	The assessment area has 1st, 2nd 3rd and 4th Strahler Streams.	NSW LPI Waterway mapping
Estuaries and wetlands	No local or Important Wetlands mapped within the subject land.	Absent	NSW directory of important wetlands
Connectivity of different areas of habitat	The subject land and development footprint lack connectivity to the surrounding landscape. The majority of the subject land is cleared with limited connectivity between habitat patches.	There is limited connectivity between the subject land and throughout the assessment area due to extensive historic clearing for agricultural purposes. The 2nd and 4th order streams running through the centre of the subject land provides patchy connectivity to the north and south.	Aerial imagery
Geological features of significance and soil hazard features	There are no geological features of significance in the subject land.	There are no areas of geological significance in the assessment area.	Aerial imagery
Areas of Outstanding Biodiversity Value	There are no areas of outstanding biodiversity value in the subject land.	There are no areas of outstanding biodiversity value in the assessment area.	Register of Declared Areas of Outstanding Biodiversity Value (DPIE 2020)
NSW (Mitchell) Landscapes	Cumberland Plain	Cumberland Plain	NSW (Mitchell) Landscapes - version 3.1 (DPIE 2016)
Percent (%) native vegetation extent	The actual percent native vegetation extent was determined to be 19.13%. Therefore 19% was entered into the BAMC. Which is the same as previously mapped vegetation.	2,198.61 ha Native vegetation extent is 420.64 ha	Calculated using aerial imagery and ArcGIS software

Landscape feature	Subject Land/development footprint	Assessment Area	Data source
Patch size	The patch size was calculated using available mapping for all patches of intact native vegetation within or adjoining the subject land. The subject land is located within predominately cleared agriculture area subject to intense grazing. Small patches of remnant vegetation are scattered within the subject land including patches along the creekline. The patch size for each Plant Community Type was less than 1 ha, therefore, <5 ha was entered into the BAMC.	The vegetation within the subject land is disconnected from areas of intact native vegetation. Major arterial roads are located adjoining the subject land. A large tract of native vegetation is located to the north within Orchard Hills defence site which contains Cumberland Plain Woodland. However, a large pipeline and cleared lands disconnect the subject land with intact native vegetation.	Calculated using aerial imagery and ArcGIS software.

3.1.1. Use of local data

The use of local data is not proposed for this assessment.

3.1.2. Expert reports

An expert report was prepared for *Litoria aurea* (Green and Golden Bell Frog) and was used as part of this assessment (Appendix G). The expert report was completed in addition to two rounds of targeted survey completed across the subject land for this species. The survey effort and method are described in Sections 5.3 and 5.4 respectively.

4. Native vegetation

The subject land is comprised of small, isolated patches of remnant native vegetation and cleared areas (gravel access tracks and exotic grazing land). The majority of the subject land has been previously cleared and pasture improved for cattle grazing. Where remnant native vegetation was present, it was in poor condition, lacked structural complexity and was dominated by exotic ground cover species. The canopy, although native, was generally of poor health and exhibited signs of dieback. The topography across the subject land is gently undulating, with natural depressions around riparian corridors. There has been limited historic modification to the landform, with the exception of the dams and the recent construction of the Sydney Metro link in the eastern portion of the subject land and Integrated Water Recycling Hub in the south-west of the subject land.

4.1. Survey effort

4.1.1. Background - initial surveys 2016 - 2018

Previous ecological surveys were completed in 2016 to 2018 across the broader subject land to validate the type, condition and extent of Plant Community Types (PCT). Vegetation validation was initially conducted by two ecologists on 28 and 30 September 2016 to validate the vegetation. One Biometric vegetation plot was conducted, and the subject land was also traversed to identify the presence of any Derived Native Grassland (DNG).

The initial surveys also included the following targeted surveys outlined in (Table 9) and were conducted between January 2016 and January 2018 totalling over 300 person hours. Additional targeted surveys were conducted in early 2018 to satisfy the requirements of the EPBC survey requirements for Green and Golden Bell Frog. The results were documented in the Flora and Fauna Assessment report (ELA 2017). As the surveys are more than 5 years old, additional surveys were conducted for the BDAR and in accordance with the BAM (see section 5).

Table 9: Initial field surveys conducted across 2016 and 2017 within the subject land

Survey date	Target species	Task
18 – 21 April 2016	Green and Golden Bell Frog survey	Diurnal survey, conducting searches along waterbodies and vegetation for suitable habitat and listening for amphibians. Call playback 8 – 9pm at five sites for three nights according to the DECC 2009 survey guidelines.
27 September 2016 28 September 2016 30 September 2016	*Persicaria elatior* survey	Parallel transect 2 m apart along water courses, drainage lines and damp areas for 22 person hours.
28 September 2016 30 September 2016	Biometric plots / vegetation validation	One Biometric plot conducted and two days of vegetation validation.
7 December 2016 21 December 2016 9 January 2017 23 January 2017	Migratory and raptor bird surveys such as Black-tailed Godwit, Eastern Osprey, Latham's Snipe, White-bellied Sea-eagle	Ten sites over five mornings for one hour each around waterbodies including dams and drainage lines with fringing vegetation. Approximately 22 person hours

Survey date	Target species	Task
2 February 2017		
9 – 11 December 2016	Microbats - echolocation survey Southern Myotis, Large Bent-winged Bat and Little Bent-winged Bat	Four Anabat echolocation recorders were placed around dams and left to record from 7pm until 6am for three nights. Total effort - 12 survey nights.
10 – 13 January 2017	Microbats - stag watching	Four sites surveyed over two consecutive nights for each site. Survey conducted to identify microbats exiting hollow bearing trees. Surveys commenced 8pm until 9:30pm. Effort – 8 nights / 24 person hrs
10 – 13 January 2017	Microbats - harp trapping	Two sites were surveyed near tree hollows near dams. Each site had five harp traps for two nights. Total of 10 harp traps over four survey nights.
26 February 2018 27 February 2018 1 March 2018 5 March 2018	Green and Golden Bell Frog survey	Nocturnal survey and call playback at five sites over four nights after rain (>50 mm) according to the DEWHA 2010 guidelines. Each site was surveyed four times for one person hour.

4.1.2. Recent surveys 2023 - 2024

Full floristic vegetation plots were required with the introduction of the Biodiversity Assessment Method in 2020 (BAM). The surveys completed in 2023 and 2024 focused on ensuring that any change in the condition or extent of the previously mapped PCTs was captured, and re-collection of full floristic vegetation integrity plots consistent with the BAM.

Three full vegetation integrity plots were undertaken in 2023 in accordance with the BAM to assess the composition, structure, and function components of each vegetation zone (Table 4). A second day of survey was undertaken on 8 April 2024 to complete two additional vegetation integrity plots.

A modified version of a 20 m x 50 m BAM plot was conducted for the plot in PCT 3975 to fit within the vegetation zone. The 20 x 50 m transect was not conducted as freshwater wetland PCTs do not include the function data in the BAM-C. The plot was reconfigured into a 10 x 40 m, instead of the standard 20 x 20 m plot. The 2024 survey also included a 20 x 20 m floristic plot in exotic grass to provide justification that the grass was exotic and does not represent part of a PCT such as DNG. The plot within exotic grassland was not a requirement of the BAM and therefore, was not entered into the BAM-C.

The vegetation survey effort is provided in Table 10. All field data collected at full-floristic and vegetation integrity plots is included in Appendix B.

Table 10: Survey effort

Survey type	Surveyors	Date
Vegetation integrity plots (BAM)	Alex Gorey Tim Maher	2 June 2023
Vegetation integrity plots (BAM)	Belinda Failes Cornelia Ersson	8 April 2024

Table 11: Full floristic and vegetation integrity plots within the development footprint

PCT #	PCT Name	Area (ha)	No. of plots required	No. of plots surveyed
3320	Cumberland Shale Plains Woodland	1.35	1	1
4023	Coastal Valley Riparian Forest	1.39	1	2
3975	Southern Lower Floodplain Freshwater Wetland	0.53	1	1
-	Exotic grass (not part of PCT)	260	0	1
		Total	**3**	**5**

4.2. Plant Community Types present

A total of three native PCTs were identified within the development footprint (Figure 7). A description of each PCTs is provided in the following sections.

The development footprint also contained vegetation which does not represent part of a PCT. These include exotic grasslands (260 ha), as well as exotic vegetation (7.17 ha) and planted native vegetation (0.46 ha).

Justification for the selection of PCTs occurring within the development footprint is based on a quantitative analysis of full-floristic plot data and is provided in Table 13.

Table 12: Plant Community Types within the development footprint

PCT ID	PCT Name	Vegetation Class	Vegetation Formation	Area (ha)	Percent cleared
3320	Cumberland Shale Plains Woodland	Coastal Valley Grassy Woodlands	Grassy Woodlands	1.35	93
4023	Coastal Valley Riparian Forest	Coastal Floodplain Wetlands	Forested Wetlands	1.39	78
3975	Southern Lower Floodplain Freshwater Wetland	Coastal Floodplain Wetlands	Forested Wetlands	0.53	93

All PCTs may have an affiliation with Threatened Ecological Communities (TECs) under the BC and/or EPBC Act, however, only PCT 3320 and 4023 were considered part of a TEC (see Section 4.4 and Table 14 for justification of TECs and displayed in Figure 9).

4.2.1. Planted native vegetation

The development footprint contains 0.46 ha of *Eucalyptus microcorys* (Tallowwood) planted in rows (Figure 5) in the south-east of the subject land. *Eucalyptus microcorys* is not a locally indigenous species listed as part of the local PCTs. According to the PlantNET, this species occurs north of Cooranbong (i.e. west of Morisset) which is approximately 150 km north of the subject land. As such, *E. microcorys* does not represent part of a local PCT and has been established through planting. An assessment of planted native vegetation according to the Streamline Assessment Module was conducted in accordance with the BAM and provided in Section 2.1.

The patches of *E. microcorys* lacked a midstorey. The groundcover consisted of patches of bare ground and exotic groundcover species, including *Cenchrus clandestinus* (Kikuyu Grass), *Sida rhombifolia* and *Senecio madagascariensis* (Fireweed). This community is not considered to provide important habitat for threatened fauna known except for the presence of hollow-bearing trees. Hollow-bearing trees were considered to provide potential habitat for tree-roosting microbats which may include threatened species.

Figure 5: Example of planted natives in the subject land

4.2.2. Exotic vegetation

Exotic pastures represent the majority of the subject land (Figure 6). The vegetation community was found to be heavily impacted by previous clearing of native vegetation and cattle grazing activities. The canopy and midstorey layers were absent, with the ground comprised of exotic species including *Senecio madagascariensis*, *Cenchrus clandestinus*, *Plantago lanceolata, Modiola caroliniana, Sida rhombifolia, Chloris gayana* (Rhodes Grass)*, Trifolium repens* (White Clover)*, Cirsium vulgare* and *Paspalum dilatatum* (Paspalum). One vegetation plot was undertaken which confirmed the presence of exotic vegetation and absence of native groundcover species.

Figure 6: Exotic grass within the subject land

4.3. Plant Community Type selection justification

In determining the PCTs for the subject land, various attributes were considered in combination to assign vegetation to the best fit PCT. Attributes included dominant species in each stratum and relative abundance, community composition, soils and landscape position. Reference was made to the PCT descriptions in the BioNet Vegetation Classification and the final scientific determinations for TECs. Possible PCT options are provided in Table 13.

4.3.1. Literature review – soil landscapes

A literature review of the subject land identified that the majority of the site is mapped on Blacktown Soil Landscapes. A small portion of the subject land in the north-west was mapped as South Creek Soil Landscapes.

Blacktown (residual) Soil Landscapes is associated with Wianamatta Group—Ashfield Shale. It consists of clay soils on gently undulating topography. Vegetation structure consists of open-forest or woodlands with *Eucalyptus tereticornis, E. crebra, E. moluccana or Corymbia maculata* the most common (Chapman and Murphy 1989).

South Creek (alluvial) Soil Landscapes occur along drainage and active floodplains of the Cumberland Plain. The geology includes Quaternary alluvium derived from either Wianamatta Group shales or Hawkesbury Sandstone. South Creek Soil Landscapes occur at low elevations along alluvial plains.

Vegetation includes canopy species such as *Casuarina glauca* and *Eucalyptus subvelutina* (Chapman and Murphy 1989).

4.3.2. Literature review – vegetation mapping datasets

The current vegetation mapping was reviewed as part of the PCT selection process. The State Vegetation Type Map (DPE 2024) vegetation dataset has mapped the following PCTs in the subject land:

- PCT 3320 Cumberland Shale Plains Woodland
- PCT 4025 Cumberland Red Gum Riverflat Forest.

4.3.3. Analysis of plot data

The BioNet Plant Community Type database - Power Query (DPE 2024b) was used to assist in assigning the best-fit PCTs for native vegetation within the subject land using filters for IBRA, IBRA subregion, Mitchell Landscapes, Vegetation Formation (Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests) to identify potential PCTs within the subject land.

The potential PCTs were also reviewed against previous vegetation mapping for the subject land. PCTs that were filtered during the application of the Power Query tool that were not within the IBRA region and / or subregion were immediately excluded from consideration. These PCTs are not shown or discussed in Table 13 below. The following general principles were used when considering potential PCTs:

- Overlap in IBRA Region and IBRA Subregion
    - No overlap = PCT was ruled out from consideration.
- Vegetation formation
    - Incorrect vegetation formation = PCT was ruled out from consideration.
- Floristic composition
    - Floristic composition did not match = PCT was ruled out from consideration.
    - Floristic composition matched or contained a partial match – see next point
- Mitchell Landscape, position in the landscape and geographic limitations (if any)
    - Consideration of soil profiles, position in the landscape (hill side, slope, gully, escarpment etc) and any geographic limitations (only occurs within a certain LGA, for example).

ELA determined that the native vegetation within the subject land contained three PCTs. The subject land also contained vegetation type that did not conform to a native PCT such as exotic grassland and planted native vegetation. Justification of the selected PCTs and exclusion of PCTs are provided in Table 13.

ELA notes that PCT analysis is complex and can be difficult in areas where the vegetation has been historically disturbed, or soil profiles and landscape changes have occurred. Often, the criteria outlined above are considered collectively in determining the best fit PCT.

Table 13: PCT selection justification

PCT ID	PCT Name	Species relied upon for identification of vegetation type	Other PCT options and reason for exclusion
3320	Cumberland Shale Plains Woodland	*Eucalyptus moluccana* and *E. tereticornis*	PCT 3318 Cumberland Moist Shale Woodland PCT 3318 can be described as a tall sclerophyll woodland with ferns and vines on steep shale hills and rises. It occurs in warm moist environments on sheltered sites. It is generally distributed around Cecil Hills and southern Cumberland Plains region. Its main distinguishing floristic features to PCT 3320, according to the VIS, is the presence of soft-leaved forbs, ferns, vines and grasses. The vegetation mapped within the subject land was not located on steep hills and rises. The subject land did not match the geographic habitat described for this PCT and did not contain ferns, vines and other soft groundcover species represented in PCT 3318. PCT 3318 was not a good fit for vegetation represented by *E. moluccana* or *E. tereticornis* within the subject land. PCT 4025 Cumberland Red Gum Riverflat Forest PCT 4025 is associated with alluvial flats alongside drainage lines on the Cumberland Plain at elevations below 60 m. Canopy species includes a variety of species namely, *E. tereticornis, E. amplifolia, Angophora floribunda, A. subvelutina.* This PCT was not a good fit for the PCT 3320 mapped within the subject land as the vegetation was not located on alluvial flats. Additionally, the dominate canopy species recorded within the subject land was *Eucalyptus moluccana* which is not considered a characteristic species of PCT 4025. Therefore, PCT 4025 was not a good-fit PCT for vegetation represented by *E. moluccana* or *E. tereticornis* within the subject land. PCT 3319 Cumberland Shale Hills Woodland According to the VIS PCT 3319 occurs on upper slopes within the Campbelltown, Camden and Wollondilly LGAs. There are overlapping characteristic species in the canopy between PCT 3319 and PCT 3320, which both include *Eucalyptus moluccana* and *E. tereticornis*. The main distinguishing characteristic of PCT 3319 with PCT 3320 is the location in the landscape. PCT 3319 occurs at higher elevations and ridges, generally 90-300 m elevation. The vegetation mapped within the subject land does not occur in the correct landscape position for this PCT. The elevation of the subject land is approximately 50 – 84 m. Given the low elevation where *Eucalyptus moluccana* was mapped, PCT 3320 was the selected PCT for the subject land. Therefore, PCT 3319 was not a good fit for the subject land. **PCT 3320 Cumberland Shale Plains Woodland** This PCT was mapped in the subject land and contained a canopy of *Eucalyptus moluccana* and *Eucalyptus tereticornis* at foothills and on shale soils. The VIS describes this PCT as always containing a canopy of *Eucalyptus moluccana* or *Eucalyptus tereticornis* these species were represented in patches of vegetation away from the drainage lines. This PCT

PCT ID	PCT Name	Species relied upon for identification of vegetation type	Other PCT options and reason for exclusion
			is a good fit due to the presence of characteristic species in the vegetation zone, location in landscape, soils and geographic distribution.
4023	Coastal Valleys Riparian Forest	*Casuarina glauca*	PCT 4025 Cumberland Red Gum Riverflat Forest According to the VIS, this PCT rarely contains *Casuarina glauca*, instead, it contains a mixed canopy of *Eucalyptus amplifolia* and *Angophora floribunda*. Although PCT 4025 occurs along drainage lines on similar landscape and geographic distribution as the vegetation within the subject land, the canopy species were the distinguishing features which determined that PCT 4025 was not a good fit PCT. The vegetation along the drainage lines within the subject land were dominated by *Casuarina glauca* and did not contain eucalypt species. Given that *Casuarina glauca* rarely occurs within PCT 4025, it was determined that PCT 4025 was not a suitable fit for the patches of *Casuarina glauca* within the subject land. PCT 4028 Estuarine Swamp Oak Twig-rush Forest According to the VIS, PCT 4028 is associated with tidal estuarine flats and tidal creek flats. The subject land is not located along tidal flats or estuaries. Although *Casuarina glauca* was recorded within the subject land and is consistent with PCT 4028, the geographic location is not consistent with the subject land. Therefore, PCT 4028 was not a good-fit for the vegetation along the creeks dominated by *Casuarina glauca*. PCT 3320 Cumberland Shale Plains Woodland Although PCT 3320 was mapped within the subject land, vegetation mapped along drainage lines dominated by *Casuarina glauca* was not considered as part of PCT 3320. *Casuarina glauca* is not listed as a species present in PCT 3320. Although PCT 3320 and 4023 share the same IBRA region, IBRA subregion and soil profile, the characteristic canopy species of PCT 3320 were not present in the subject land (*Eucalyptus moluccana, E. tereticornis, E. crebra*) where PCT 4023 was mapped. PCT 3320 is a grassy woodland / Coastal Valley Grassy Woodland which does not match the vegetation formation and class of PCT 4023 in the subject land. As such, PCT 3320 was not a good fit for vegetation which contained *Casuarina glauca* along drainage lines on alluvial flats. **PCT 4023 Coastal Valleys Riparian Forest** PCT 4023 was selected as the best fit PCT for *Casuarina glauca* along drainage lines within the subject land based on the comparison of the floristics, soils and geographic distribution which was consistent with VIS description. The VIS states this PCT occurs within the South Creek catchment below 70 m and always represented by a dominant canopy of *Casuarina glauca* which was represented within the subject land.

PCT ID	PCT Name	Species relied upon for identification of vegetation type	Other PCT options and reason for exclusion
3975	Southern Lower Floodplain Freshwater Wetland	*Typha orientalis, Juncus usitatus* and *Persicaria decipiens and Paspalum distichum*	PCT 3962 Coastal Floodplain Phragmites Reedland According to the VIS, PCT 3962 forms a dense mat of *Phragmites australis* on alluvial backswamps on coastal floodplains below 5 m elevation. The vegetation mapped around dams within the subject land was dominated by *Typha orientalis* and not *Phragmites*. Additionally, the subject land had a higher elevation that 10 m elevation. As such, PCT 3962 did not fit the vegetation around the dams due to incorrect floristics and elevation. PCT 4023 Coastal Valleys Riparian Forest PCT 4023 was not considered a good fit PCT for the semi-aquatic vegetation recorded around the dams within the subject land. PCT 4023 is associated with a canopy of *Casuarina glauca* which was not recorded within the vegetation zone. PCT 4023 may represent a successional state following clearing, however, *Typha* spp. and *Persicaria* spp. which were the main species around the dam in the subject land are not listed as part of PCT 4023. As such, PCT 4023 is not a good fit for the semi-aquatic species recorded around the dams in the subject land. **PCT 3975 Southern Lower Floodplain Freshwater Wetlands** The VIS states PCT 3975 is a non-woody vegetation zone which occur on Quaternary alluvium soils and are not dominated by *Phragmites australis* or *Eleocharis equisetina*. It may occur below 10 m, however, it can occur at higher elevations with prolonged inundation and is commonly represented by *Typha orientalis* and *Persicaria decipiens*. Farm dams and drainage lines within the subject land contained patches of *Juncus usitatus, Paspalum distichum, Lachnagrostis filiformis, Dichondra repens, Typha orientalis* and *Persicaria decipiens* which are consistent with PCT 3975. PCT 3975 was selected as a good fit for the vegetation mapped around the dams due to floristic composition, soils and location in landscape.

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4.4. Threatened Ecological Communities

A description of PCT associations with TECs are provided below and summarised in Table 14. PCT 3975 has one associated TEC listed in BioNet Vegetation Information System (VIS). However, the vegetation mapped as PCT 3975 within the development footprint occurs within artificial environment (i.e. dams) and does not represent part of a TEC (see Section 4.4.3 below for more details). Information regarding each of the PCTs and their associated TECs listed under the BC Act and EPBC Act is provided below.

Table 14: Threatened Ecological Communities within the development footprint

PCT ID	BC Act			EPBC Act		
	Listing	Name	Area (ha)	Listing	Name	Area (ha)
3320	CE	Cumberland Plain Woodland in the Sydney Basin Bioregion	1.35	CE	Cumberland Shale Plains Woodland and Shale Gravel Transition Forest	0*
4023	E	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregion	1.39	CE	Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	0*

CE = CRITICALLY ENDANGERED E = ENDANGERED
* VEGETATION DID NOT SATISFY THE CRITERIA FOR LISTING UNDER THE EPBC ACT

4.4.1. Cumberland Plain Woodland

The BioNet Classification lists PCT 3320 as associated with the following TECs under the BC Act and EPBC Act:

- *Cumberland Plain Woodland in the Sydney Basin Bioregion* – critically endangered under the BC Act OR
- *Shale Gravel Transition Forest in the Sydney Basin Bioregion* – endangered under the BC Act
- *Cumberland Shale Plains Woodland and Shale Gravel Transition Forest* – critically endangered under the EPBC Act.

4.4.1.1. *BC Act listing*

According to the BioNet Vegetation Classification PCT 3320 maybe associated with one of two TECs:

- *Cumberland Plain Woodland in the Sydney Basin Bioregion* – critically endangered under the BC Act
  OR
- *Shale Gravel Transition Forest in the Sydney Basin Bioregion* – endangered under the BC Act

According to the BioNet Vegetation Classification these two TECs can be distinguished by paragraph 2 and 7 of the final determination for Cumberland Plain Woodland (NSW Scientific Committee 2023).

The final determination for Cumberland Plain Woodland states it is associated with clay soils of the Wianamatta Group geology and dominated by *Eucalyptus moluccana* (Grey Box). While Shale Gravel Transition Forest in the Sydney Basin Bioregion occurs on gravel soils and is dominated by *Eucalyptus fibrosa* (Broad-leaved Ironbark). The subject land occurs on clay soils of Wianamatta group, and the main species recorded within the subject land is *Eucalyptus moluccana*. As such, PCT 3320 within the

subject land corresponds to Cumberland Plain Woodland in the Sydney Basin Bioregion TEC and not Shale Gravel Transition Forest.

The Final Determination for Cumberland Plain Woodland includes criteria relating to geographic distribution, landscape position and floristic composition; however it does not list condition thresholds that patches must meet to be considered part of the TEC. All patches of PCT 3320 in the subject land met the BC Act definition for the following reasons:

- The subject land is in the IBRA Sydney Basin Bioregion and Cumberland IBRA Subregion
- The patches of the community occur on the Cumberland Plain and are underlain by Wianamatta Shale
- The community was present on flats and low hills
- Although degraded, the community contained diagnostic canopy species including *Eucalyptus moluccana* and occasional *E. tereticornis*.

4.4.1.2. *Cumberland Shale Plains Woodland and Shale Gravel Transition Forest – EPBC Act listing*

The EPBC Act listing advice for *Cumberland Shale Plains Woodland and Shale Gravel Transition Forest* contains specific condition thresholds that must be met for a patch to be considered part of the EPBC Act community. These include patch size, percentage of native species in the groundcover, presence of large trees above benchmark or hollow bearing trees. PCT 3320 mapped within the subject land did not meet the criteria for listing under the EPBC Act for Cumberland Shale Plains Woodland and Shale Gravel Transition Forest (DEWHA 2010, DEWHA 2009) for the following reasons:

- The groundcover contained <30% native perennial species (0% recorded within the 20 x 20 m plot)
- The patch size was <0.5 ha.

4.4.2. Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community

The BioNet VIS lists PCT 4023 as associated with the following TECs under the BC Act and EPBC Act:

- Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions - endangered under the BC Act.
- *Coastal Swamp Oak (Casuarina glauca) Forest of the New South Wales and South East Queensland* listed - endangered under the EPBC Act.

4.4.2.1.1. BC Act listing

The Scientific Committee (2021) states that this TEC includes vegetation which fits the geographic distribution, landscape position and floristic composition. There are no condition threshold for this TEC under the BC Act. Therefore, highly degraded patches of this TEC may be considered as part of the criteria for listing under the BC Act. All patches of PCT 4023 mapped within the subject land were considered part of the TEC for the following reasons:

- The vegetation occurs on saline or subsaline periodically inundated flats and drainage lines.
- Forms an open forest to low woodlands, scrubs or reedlands with scattered trees.
- Occurs in Penrith LGA which is included as part of the known distribution of this TEC.
- Includes characteristic species listed in Paragraph 1 of the final determination (NSW Scientific Committee 2021).

It is noted that the first paragraph of the final determination states this TEC "*generally occurs below 20 m (rarely above 10 m) elevation.*" However, the word "generally" refers to acceptance of circumstances outside of this rule. As such, PCT 4023 has been considered part of the TEC for the purpose of this assessment.

4.4.2.2. *EPBC Act listing*

The EPBC Act conservation advice for Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community (DEWA 2018) contains specific condition thresholds that must be met for a patch to be considered part of the EPBC Act community. Section 3.2 of the Conservation Advice (DEWA 2018) lists the criteria for listing under the EBPC Act, including patch size, percentage of native species in the groundcover, foliage cover.

All patches of PCT 4023 in the subject land were small, isolated stands of single species (i.e. *Casuarina glauca*), generally less than 0.5 ha. The groundcover did not contain native species and the midstorey was absent. PCT 4023 in the subject land did not meet the EPBC definition because:

- The patches of PCT 4023 were generally less than 0.5 ha in size.
- The native understorey comprises less than 20% of total understorey vegetation cover.
- The vegetation patch does not meet the key diagnostics for this TEC.
- The patches were < 2 ha, or where patches were ≥ 0.5 ha, they were not contiguous with a larger area of native vegetation > 5 ha in size.
- < 20% of the total understorey vegetation was comprised of native species (0.1% recorded within the 20 x 20 m plot).

Additionally, the key diagnostics for this TEC under the EBPC Act state that the vegetation occurs within 30 km of the coast unless along tidal rivers. The subject land is not located on a tidal river. The coastline is >50 km from the subject land. As such, the vegetation mapped within the subject land as PCT 4023 did not satisfy the criteria for listing under the EBPC Act for the forementioned reasons.

4.4.3. Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner bioregions

The VIS lists PCT 3975 as associated with *Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and SE Corner bioregions* if it meets the final determination for the TEC.

The NSW Scientific Committee lists Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and SE Corner bioregions as associated with the following:

- Periodic or semi-permanent inundation by freshwater.
- On silt, muds, humic loams in depressions, flats, drainage lines, backswamps, lagoons and lakes on coastal floodplains.
- Occurs below 20 m elevation.
- Forms sedgelands, reedlands to herbfields and occasionally contains woody species.
- Includes characteristics species of paragraph 1 of the final determination.
- Occurs within a LGA listed under the final determination.

The subject land does not occur below 20 m elevation. The above criteria describes the vegetation mapped around the dam in the south-west of the subject land.

Paragraph 4 of the final determination states "*Artificial wetlands created on previously dry land specifically for purposes such as sewerage treatment, stormwater management and farm production, are not regarded as part of this community, although they may provide habitat for threatened species*."

As the dams have been constructed for agricultural purposes it does not represent a natural environment. Therefore, PCT 3975 mapped within the subject land does not represent vegetation which is part of the Freshwater Wetlands on Coastal Floodplains TEC.

4.5. Vegetation integrity assessment

4.5.1. Vegetation zones

A total of three vegetation zones were identified in the subject land (Table 15). Descriptions of vegetation zones are provided in Table 17 to Table 17.

Table 15: Vegetation zones and vegetation integrity survey plots collected in the development footprint

Vegetation Zone	PCT ID	PCT Name	Condition	Area (ha)	Patch Size
1	3320	Cumberland Shale Plains Woodland	Low	1.35	<5
2	4023	Coastal Valley Riparian Forest	Low	1.39	<5
3	3975	Southern Lower Floodplain Freshwater Wetland	Low	0.53	<5
			Total	**3.27**	**-**

4.6. Assessing vegetation integrity

A vegetation integrity assessment using the Credit Calculator (BAMC) was undertaken and the results are outlined in Table 16.

Table 16: Vegetation integrity

Veg Zone	PCT ID	Condition	Area (ha)	Composition Condition Score	Structure Condition Score	Function Condition Score	Current vegetation integrity score
1	3320	Low	1.35	1	13.8	36.4	7.9
2	4023	Low	1.39	1.8	17.5	57.5	12.2
3	3975	Low	0.53	69.6	38.4	-	51.7

Table 17: Zone 1 PCT 3320 Low Condition

3320 - Cumberland Shale Plains Woodland	
Vegetation formation/class	Grassy Woodlands/ Coastal Valley Grassy Woodlands
Conservation status	BC Act: Critically Endangered - Cumberland Plain Woodland in the Sydney Basin Bioregion Does not meet EPBC Act listing criteria due to small patch size and absence of native species in the midstorey and ground cover layers
Area (ha)	1.35 ha
Description	This community occurred in small patches in low condition and has been previously cleared of a native midstorey and groundcover layer. The native canopy, where present, lacked species diversity and was in poor condition with some canopy trees dead or dying. The groundcover has been pastured improved and is comprised entirely of exotic species and subject to ongoing cattle grazing.
Characteristic canopy trees	Previous disturbance to the vegetation has altered both the structure and species diversity of this community. The canopy cover consisted of *Eucalyptus moluccana* and very occasional *Eucalyptus tereticornis*. Some canopy species were in poor health with evidence of significant percentage of dead foliage.
Characteristic mid-storey	A native midstorey was absent and contained an occasional exotic species *Lycium ferocissimum*.
Characteristic groundcovers	The groundcover was comprised of entirely exotic species.
Mean native richness	1
Exotic species / HTW cover	The groundcover was comprised of >18 % high threat weeds. Exotic species include: *Senecio madagascariensis, Cenchrus clandestinus, Plantago lanceolata, Modiola caroliniana, Sida rhombifolia, Chloris gayana, Trifolium repens, Stellaria media* and *Paspalum dilatatum.*
Condition	Low
No. sites sampled	1 (plot 3)
Threatened flora species	No threatened flora species identified, and none predicted as likely to occur due to extensive historic and ongoing disturbance.
Fauna habitats	Potential foraging habitat for woodland birds and microbats.

Composition	Structure	Function	Vegetation Integrity Score
1	13.8	36.4	7.9

Table 18: Zone 2 PCT 4023 Low condition

4023 - Coastal Valley Riparian Forest	
Vegetation formation/class	Forested Wetlands/Coastal Floodplain Wetlands
Conservation status	BC Act: Endangered *Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions* Does not meet EPBC Act listing criteria due to small patch size and absence of native mid and ground cover.
Area (ha)	1.39
Description	This community occurred as fragmented, degraded patches of canopy species. The vegetation has been previously cleared and pasture improved with a long history of cattle grazing. A native midstorey were absent. Occasional unpalatable native ground cover species (*Juncus usitatus*) were present. Native canopy was in poor condition with many individual trees showing signs of stress.
Characteristic canopy trees	The canopy was dominated by *Casuarina glauca*. No other canopy species were present.
Characteristic mid-storey	A native midstorey was absent.
Characteristic groundcovers	Only one native species was present in one plot *Juncus usitatus*.
Mean native richness	2
Exotic species / HTW cover	The groundcover was comprised of >90% exotic species cover including *Cenchrus clandestinus, Senecio madagascariensis, Plantago lanceolata, Modiola caroliniana, Sida rhombifolia, Chloris gayana, Trifolium repens, Stellaria media* and *Paspalum dilatatum.*
Condition	Low
No. sites sampled	2 (plots 1, 2)
Threatened flora species	None present and none predicted to occur due to highly degraded nature of the zone.
Fauna habitats	Potential foraging habitat for woodland birds and microbats.

Composition	Structure	Function	Vegetation Integrity Score
1.8	17.5	57.5	12.2

Table 19: Zone 3 PCT 3975 Low condition

3975 - Southern Lower Floodplain Freshwater Wetlands	
Vegetation formation/class	Forested Wetlands/Coastal Floodplain Wetlands
Conservation status	N/A This vegetation zone was represented around dams which are considered artificial environment and did not represent part of a TEC under the BC Act or EPBC Act.
Area (ha)	0.53
Description	This vegetation zone was located within fringing vegetation around dams and moist depressions scattered within the subject land.
Characteristic canopy trees	The canopy was absent. This is common for this vegetation type.
Characteristic mid-storey	The midstorey was absent.
Characteristic groundcovers	The native ground cover includes several semi-aquatic and fringing vegetation in moist environments. Native species includes: *Juncus usitatus, Paspalum distichum, Lachnagrostis filiformis, Dichondra repens, Typha orientalis* and *Persicaria decipiens*
Mean native richness	9
Exotic species / HTW cover	High threat weeds represented >30% of the cover within the plot. *Juncus acutus, Chloris gayana, Paspalum dilatatum, Senecio madagascariensis* were scattered within this vegetation zone and extended into adjacent cleared areas.
Condition	Low
No. sites sampled	1 (plot 4)
Threatened flora species	None present and none predicted to occur due to highly degraded nature of the zone.
Fauna habitats	Potential foraging habitat for shorebirds.

Composition	Structure	Function	Vegetation Integrity Score
69.6	38.4	-	51.7

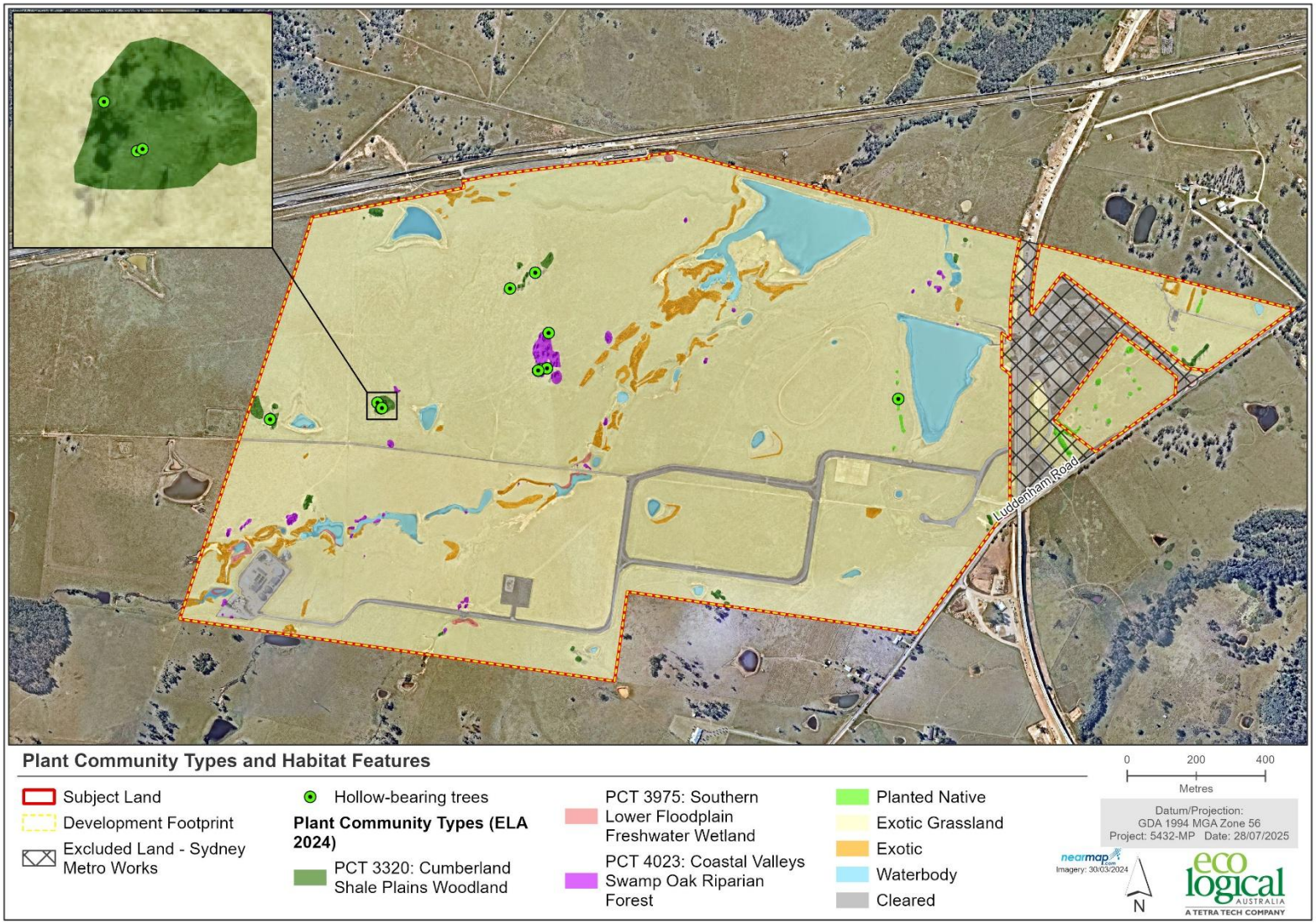

Figure 7: Plant Community Types and Habitat Features

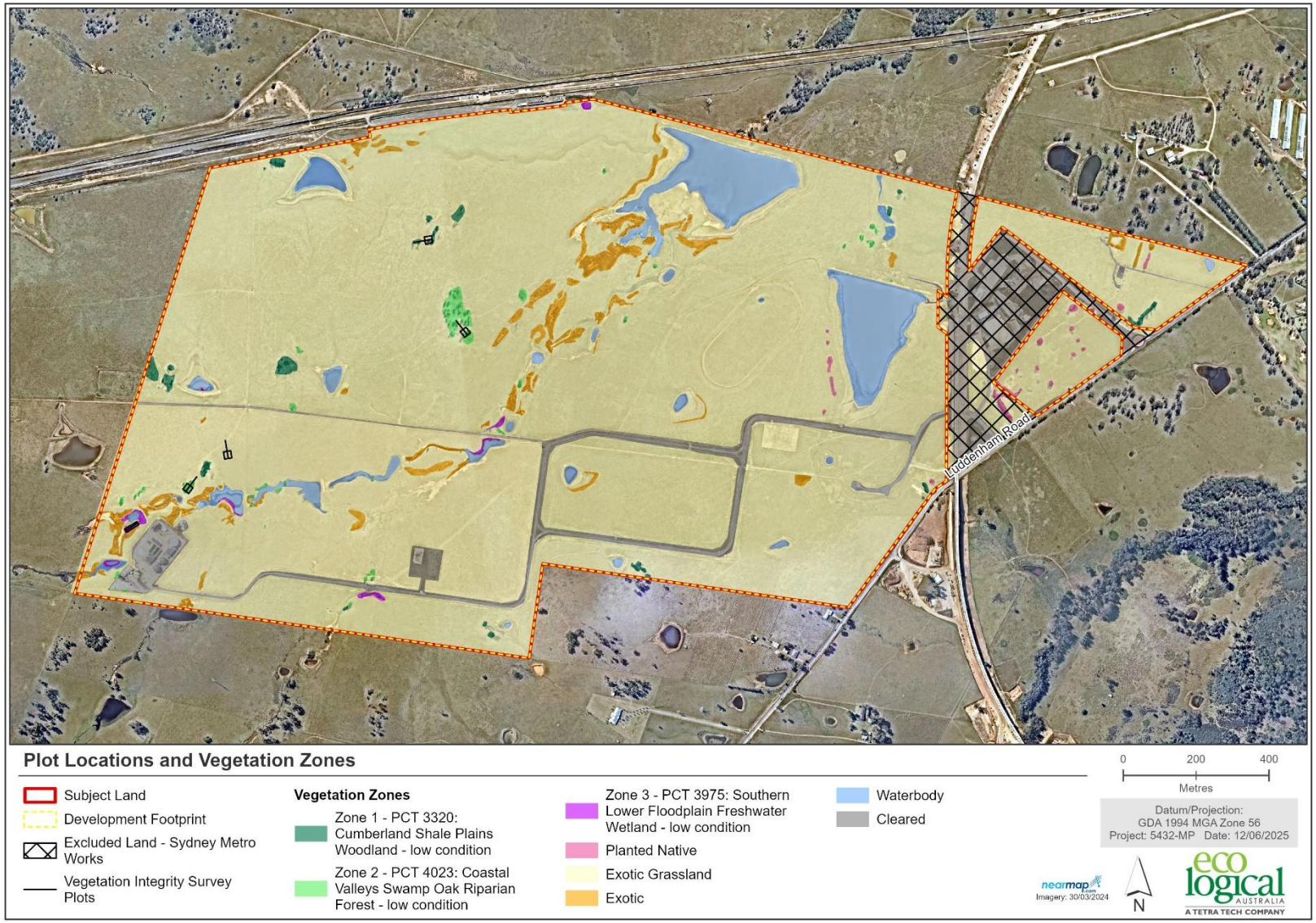

Figure 8: Plot locations

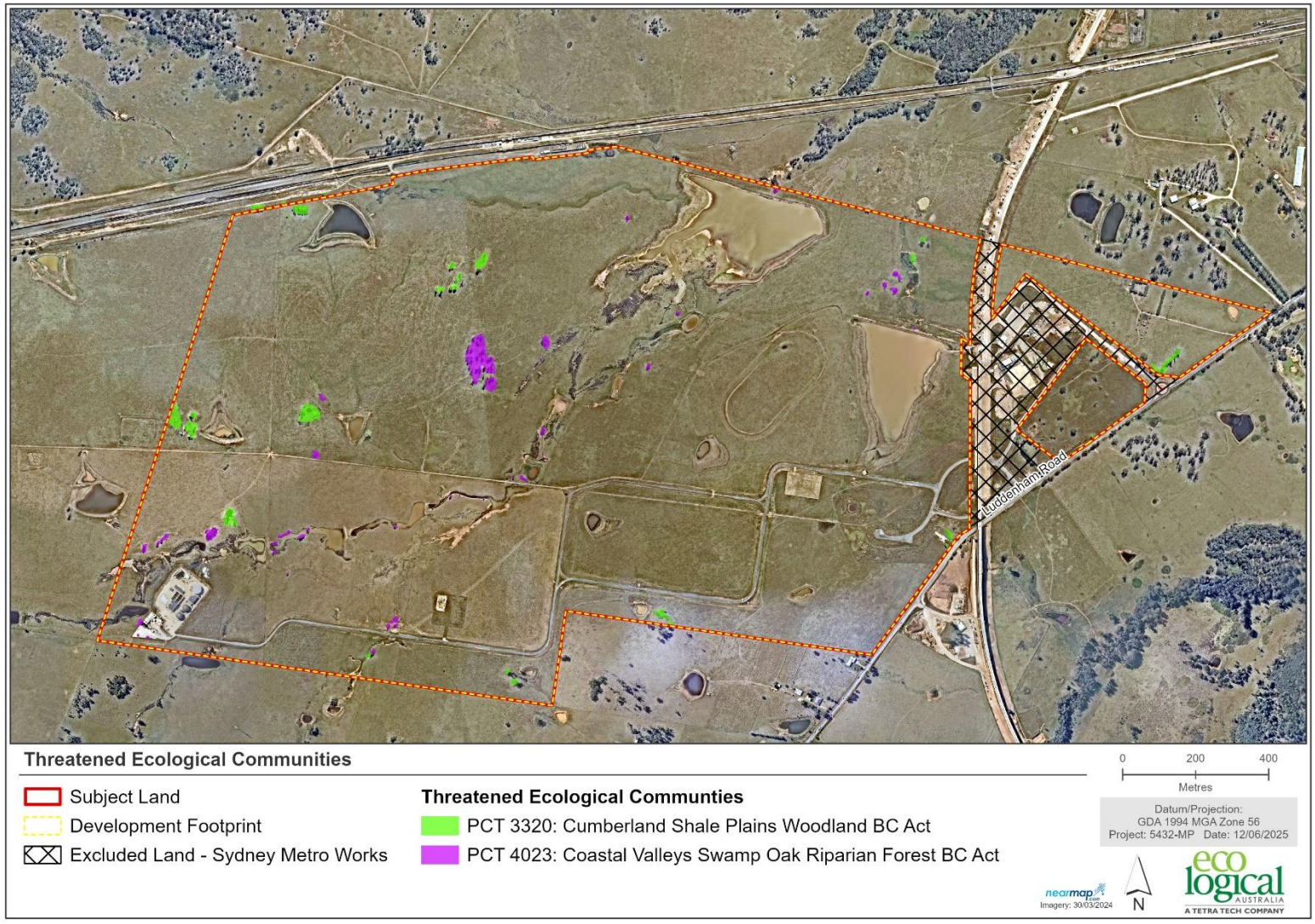

Figure 9: Threatened Ecological Communities

5. Threatened species

5.1. Ecosystem credit species

Ecosystem credit species predicted to occur within the development footprint are generated by the BAMC following the input of vegetation integrity (VI) data and the PCTs identified within Chapter 3. Ecosystem credit species predicted to occur at the development footprint, their associated habitat constraints, geographic limitations and sensitivity to gain class and the relevant justification for species inclusion / exclusion is included in Table 20.

Table 20: Predicted ecosystem credit species

Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Anthochaera phrygia	Regent Honeyeater	(Foraging)	--	High Sensitivity	Critically Endangered	Critically Endangered	**Included** Marginal habitat in PCT 3320 and PCT 4023
Artamus cyanopterus cyanopterus	Dusky Woodswallow	--	--	Moderate Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Botaurus poiciloptilus	Australasian Bittern	Waterbodies Brackish or freshwater wetlands	--	Moderate Sensitivity	Endangered	Endangered	**Included** Marginal habitat present in dams associated with PCT 4023 and PCT 3975
Calidris ferruginea	Curlew Sandpiper (Foraging)	-	-	High	Critically Endangered	Critically Endangered	**Included** Marginal habitat present in PCT 4023 and PCT 4023
Callocephalon fimbriatum	Gang-gang Cockatoo (Foraging)	-	-	Moderate	Endangered	Endangered	**Included** Marginal habitat present in PCTs 3320 and 4023

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Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Calyptorhynchus lathami lathami	South-Eastern Glossy Black-Cockatoo (Foraging)	Other Presence of Allocasuarina and casuarina species	--	High Sensitivity	Vulnerable	Vulnerable	**Included** Marginal habitat present in PCT 4023
Chthonicola sagittata	Speckled Warbler	--	--	High Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3320 and 4023
Circus assimilis	Spotted Harrier	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	--	--	High Sensitivity	Vulnerable	Vulnerable	**Included** Marginal habitat present in PCT 3320 and 4023
Daphoenositta chrysoptera	Varied Sittella	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Dasyurus maculatus	Spotted-tailed Quoll	--	--	High Sensitivity	Vulnerable	Endangered	**Included** Subject land highly degraded and required connectivity of habitat, however included in this assessment.

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Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Ephippiorhynchus asiaticus	Black-necked Stork	Swamps Shallow, open freshwater or saline wetlands or shallow edges of deeper wetlands within 300m of these swamps Waterbodies Shallow lakes, lake margins and estuaries within 300m of these waterbodies	--	Moderate Sensitivity	Endangered	Not Listed	**Included** Marginal habitat present in all PCTs
Epthianura albifrons	White-fronted Chat	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3975.
Falco subniger	Black Falcon	--	--	Moderate Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Glossopsitta pusilla	Little Lorikeet	--	--	High Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3320 and 4023
Haliaeetus leucogaster	White-bellied Sea-Eagle (Foraging)	Waterbodies Within 1km of rivers, lakes, large dams or creeks, wetlands and coastlines	--	High Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs

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Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Hieraaetus morphnoides	Little Eagle (Foraging)	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Hirundapus caudacutus	White-throated Needletail	-	-	High	Not Listed	Vulnerable	**Included** Marginal habitat present in all PCTs
Irediparra galllinacea	Comb-crested Jacana	Waterbodies Freshwater wetlands with a good surface cover of floating aquatic vegetation	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 4023 and PCT 3975
Ixobrychus flavicollis	Black Bittern	Waterbodies Land within 40 m of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3975.
Lathamus discolor	Swift Parrot (Foraging)	-	-	Moderate	Endangered	Critically Endangered	**Included** Marginal habitat present in PCT 3320 and 4023.
Limosa limosa	Black-tailed Godwit (Foraging)	-	-	High	Vulnerable	Endangered	**Included** Marginal habitat present in PCT 4023 and PCT 3975

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Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Lophoictinia isura	Square-tailed Kite (Foraging)	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs.
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	-	-	High	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Miniopterus australis	Little Bent-winged Bat (Foraging)	-	-	High	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Miniopterus orianae oceanensis	Large Bent-winged Bat (Foraging)	-	-	High	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Neophema pulchella	Turquoise Parrot	-	-	High	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Oxyura australis	Blue-billed Duck	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs

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Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Pandion cristatus	Eastern Osprey (Foraging)	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Petroica boodang	Scarlet Robin	--	--	Moderate Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in all PCTs
Petroica phoenicea	Flame Robin	--	--	Moderate Sensitivity	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3320
Pteropus poliocephalus	Grey-headed Flying-fox (Foraging)		--	High Sensitivity	Vulnerable	Vulnerable	**Included** Marginal habitat present in PCT 3320 and PCT 4023
Rostratula australis	Australian Painted Snipe	--	--	Moderate Sensitivity	Endangered	Endangered	**Included** Marginal habitat present in PCT 4023 and PCT 3975
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	-	-	High	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3320
Stagonopleura guttata	Diamond Firetail	--	--	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3320 and 4023

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Scientific name	Common name	Habitat Limitations	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Stictonetta naevosa	Freckled Duck	-	-	Moderate	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3975

5.2. Species credit species

5.2.1. Identification of species credit species

Species credit species predicted to occur at the development footprint (i.e. candidate species), their associated habitat constraints, geographic limitations and sensitivity to gain class is included in Table 21. An assessment of habitat constraints and vagrant species for each predicted species credit species is included in Table 21.

Table 21 candidate species credit species

Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Acacia pubescens	Downy Wattle	-	-	High	Vulnerable	Vulnerable	Excluded Associated with PCT 3320, however habitat is highly degraded and no native midstorey was present. The vegetation within PCT 3320 does not represent suitable habitat for this species.
Anthochaera phrygia	Regent Honeyeater (Breeding)	As per Important Habitat Map.	--	High	Critically Endangered	Vulnerable	Excluded Subject land is not mapped on the Important Habitat Map (13 June 2025).
Burhinus grallarius	Bush Stone-curlew	Fallen/standing dead timber including logs	-	High	Endangered	Not Listed	**Included** Fallen/standing dead timber present near dams.
Calidris ferruginea	Curlew Sandpiper (Breeding)	As per Important Habitat Map	-	High	Critically Endangered	Critically Endangered	Excluded Subject land is not mapped on the Important Habitat Map (13 June 2025).

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Callocephalon frimbriatum	Gang-gang Cockatoo (Breeding)	Eucalyptus tree species with hollows at least 3 m above the ground and with hollow diameter of 7cm or larger	-	High	Vulnerable	Endangered	**Included** Suitable trees with hollows present in the subject land. This species was included in targeted surveys.
Calyptorhynchus lathami	Glossy Black-Cockatoo (Breeding)	Hollow bearing trees Living or dead tree with hollows > 15 cm diameter and > 8 m above ground	--	High	Vulnerable	Vulnerable	Excluded No suitable hollow bearing trees present. Some hollows were >15 cm diameter, however none were > 8 m above the ground. According to the TBDC this species requires larger patches of intact vegetation for breeding habitat. The vegetation within the subject land contains small patches of disturbed vegetation in a highly fragmented environment. As such, the subject land does not represent suitable habitat for this species.
Cercartetus nanus	Eastern Pygmy-possum	-	-	High	Vulnerable	Not Listed	Excluded The vegetation within the subject land was substantially degraded due to intensive grazing by livestock. This species has a strong preference for *Banksia* spp. (for food) and *Eucalyptus* and *Xanthorrhoea* spp. (for shelter) (Tulloch and Dickman 2006). The subject land contains highly fragmented

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							patches of vegetation which either lacks Banksia or Acacia species or midstorey with dense nectar producing vegetation which is required by this species. There are no BioNet records within a 5 km radius of the subject land.
Chalinolobus dwyeri	Large-eared Pied Bat	Cliffs Within 2km of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices or within 2km of old mines or tunnels	-	Very High	Endangered	Endangered	Excluded Potential breeding habitat (i.e. cliffs, caves, rocky areas with outcrops, overhangs, escarpments or crevices) is present within a two km radius of the subject land. However, a review of literature identified that roost and foraging habitat for this species were limited to western facing cliff faces along sandstone escarpments 10-15 m high (Williams and Thomson 2018) and breeding habitat contains dome caves. The Threatened Biodiversity Data Collection (TBDC) states that "potential breeding habitat is PCTs associated with the species within 100 m of rocky areas containing caves, or overhangs or crevices, cliffs or escarpments, or old mines, tunnels, culverts, derelict concrete buildings". The subject land lacks suitable habitat for this species.

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Commersonia prostrata	Dwarf Kerrawang	-	-	High	Endangered	Endangered	Excluded According to the threatened species profile for this species, its known distribution is restricted to the Southern Highlands and Southern Tablelands and North Coast (near Newcastle) (DPE 2023). The subject land is not within the known distribution for this species. The subject land does not contain suitable sandy soils which is required by this species. There are no BioNet records within a 5 km radius of the subject land.
Deyeuxia appressa	-	--	--	High	Endangered	Endangered	Excluded The known distribution of this species is highly restricted, with only two records in the Sydney area, both of which were recorded before 1942. The records are from Killara in 1941, and Herne Bay in 1941. The potential habitat present (PCT 3320) is highly degraded and no native groundcover species were present. There are no BioNet records for this species within a 5 km radius of the subject land. Therefore, there are no potential habitat for this species within the subject land.

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Dillwynia tenuifolia	Dillwynia tenuifolia	--	--	High	Vulnerable	Not listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land.
Eucalyptus benthamii	Camden White Gum	--	--	Moderate	Critically Endangered	Vulnerable	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. This species was not recorded during field validation and no suitable habitat was identified. As such, no habitat was recorded within the subject land.
Eucalyptus glaucina	Slaty Red Gum	--	--	High	Vulnerable	Vulnerable	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. This species was not recorded during field validation and no suitable habitat was identified. There are no BioNet records for this species within a 5 km radius of

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							the subject land. As such, no habitat was recorded within the subject land.
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	--	--	High	Vulnerable	Not listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. This species is easily identified, and no individuals were observed during 2016, 2023 or 2024 surveys. As such, no habitat was recorded within the subject land.
Gyrostemon thesioides	-	Sandy, alluvial or colluvial soils within 50 m of a water course	-	High	Endangered	Not Listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. There are no BioNet records for this species within a 5 km radius of the subject land. As such, no habitat was recorded within the subject land.

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Haliaeetus leucogaster	White-bellied Sea-Eagle (Breeding)	Living or dead mature trees within suitable vegetation within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines	--	High	Vulnerable	Not listed	**Included** Targeted surveys were conducted within PCT 3320 and PCT 4023 for this species to identify the presence of stick nests and confirm the presence of breeding individuals (see Section 5.4).
Hibbertia puberula	Hibbertia puberula	--	--	High	Endangered	Not listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. There are no BioNet records for this species within a 5 km radius of the subject land. As such, no habitat was recorded within the subject land.
Hieraaetus morphnoides	Little Eagle (Breeding)	Nest tree – live (occasionally dead) large old trees within vegetation	-	Moderate	Vulnerable	Not Listed	**Included** Targeted surveys were conducted within PCT 3320 and PCT 4023 for this species to identify the presence of stick nests and confirm the presence of breeding individuals (see Section 5.4).
Lathamus discolor	Swift Parrot (Breeding)	As per Important Habitat Map	--	Moderate	Endangered	Critically Endangered	Excluded

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							Subject land is not mapped on the Important Habitat Map (13 June 2025).
Limosa limosa	Black-tailed Godwit (Breeding)	As per Important Habitat Map	--	Moderate	Vulnerable	Endangered	Excluded Subject land is not mapped on the Important Habitat Map (13 June 2025).
Litoria aurea	Green and Golden Bell Frog	Semi-permanent/ephemeral wet areas Within 1km of wet areas, Swamps, Waterbodies within 1km of waterbodies	--	High	Endangered	Vulnerable	**Included** Marginal habitat available in the form of highly degraded dams. Targeted surveys and an Expert Report was prepared for this species which concluded species is not present within the Subject land (Appendix E).
Lophoictinia isura	Square-tailed Kite (Breeding)	Nest trees	-	Moderate	Vulnerable	Not Listed	**Included** Targeted surveys were conducted within PCT 3320 and PCT 4023 for this species to identify the presence of stick nests and confirm the presence of breeding individuals (see Section5.4).
Marsdenia viridiflora subsp. *viridiflora* - *endangered population*	Marsdenia viridiflora R. Br. subsp. viridiflora population in the Bankstown, Blacktown, Camden, Campbelltown,	--	Blacktown, Camden, Campbelltown, Canterbury-Bankstown, Cumberland, Fairfield, Liverpool and Penrith LGAs (as	High	Endangered Population	Not listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. As

Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
	Fairfield, Holroyd, Liverpool and Penrith local government areas		amended from the Determination))				such, no habitat was recorded within the subject land.
Maundia triglochinoides	-	Riparian areas / drainage lines, water ponding, man-made dams and drainage channels up to 1m deep. Semi-permanent / ephemeral wet. Shallow swamps up to 1 m deep. Shallow waterbodies up to 1m deep	-	High	Vulnerable	Not Listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. A significant proportion of the ground cover was represented by exotic species *Juncus acutus* which is highly invasive in the riparian areas in the subject land. There are no BioNet records for this species within a 5 km radius of the subject land. As such, no habitat was recorded within the subject land.
Meridolum corneovirens	Cumberland Plain Land Snail	--	--	High	Endangered	Not Listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey or ground layer and

Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							limited accumulated leaf litter or logs were present. Vegetation patches were disconnected and fragmented by exotic grass which does not provide connectivity between vegetation patches. As such, no habitat was recorded within the subject land.
Micromyrtus minutiflora	-	--	--	High	Endangered	Vulnerable	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. There are no BioNet records for this species within a 5 km radius of the subject land. As such, no habitat was recorded within the subject land.
Miniopterus australis	Little Bent-winged Bat (Breeding)	Caves Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records in BioNet with microhabitat code 'IC – in cave'	--	High	Vulnerable	Not Listed	Excluded Excluded from 2023 survey. Surveyed in 2016 and not identified during survey. Consideration of habitat constraints were during completed during previous 2016 surveys, and it was determined that no suitable habitat was present in the subject land. There are no known caves, karsts, cliffs, culverts or other

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
		observation type code 'E nest-roost' with numbers of individuals >500 or from the scientific literature					structures within a 100 m radius of the subject land.
Miniopterus orianae oceanensis	Large Bent-winged Bat (Breeding)	Caves Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records with microhabitat code "IC - in cave " observation type code "E nest-roost " with numbers of individuals >500	--	Very High	Vulnerable	Not Listed	Excluded Excluded from 2023 survey. Surveyed in 2016 and not identified during survey. Consideration of habitat constraints were during completed during previous 2016 surveys, and it was determined that no suitable habitat was present in the subject land. There are no known caves, karsts, cliffs, culverts or other structures within a 100 m radius of the subject land.
Myotis macropus	Southern Myotis	Waterbodies Waterbodies with permanent pools/stretches 3m or wider, including rivers, large creeks, billabongs, lagoons,	--	High	Vulnerable	Not Listed	**Included** Marginal habitat available in PCT 3320, 4023 and 3975 and previously recorded within the subject land during 2016 surveys.

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
		estuaries, dams and other waterbodies, on or within 200m of the site					
Ninox connivens	Barking Owl	Hollow bearing trees A living or dead tree with a hollow >20cm diameter that occurs >4m above the ground	-	High	Vulnerable	Not Listed	Excluded Habitat surveys were conducted to record hollows and size entrance class. No suitable hollows with an entrance > 20 cm and > 4 m above ground. Therefore, this species was not considered a candidate species credit species and was excluded from further surveys.
Ninox strenua	Powerful Owl	Hollow bearing trees A living or dead tree with a hollow >20cm diameter that occurs >4m above the ground	-	High	Vulnerable	Not Listed	Excluded Habitat surveys were conducted to record hollows and size entrance class. No suitable hollows with an entrance > 20 cm and > 4 m above ground. Therefore, this species was not considered a candidate species credit species and was excluded from further surveys.
Pandion cristatus	Eastern Osprey	Presence of stick-nests in living and dead trees (>15m) or artificial structures within	--	High	Vulnerable	Not Listed	**Included** Marginal habitat present in PCT 3320 and 4250. Targeted surveys were conducted to identify presence of stick nests (see Section 0).

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
		100m of a floodplain for nesting					
Persicaria elatior	Tall Knotweed	Semi-permanent/ephemeral wet areas or within 50 m, Swamps or within 50 m, Waterbodies including Wetlands, or within 50 m	-	High	Vulnerable	Vulnerable	Excluded Previous surveys were conducted over two days 28 and 30 September 2016 and no suitable habitat or individuals were recorded. Surveys in 2023 and 2024 did not record the presence of suitable habitat for this species. The vegetation within the riparian areas within the subject land are highly degraded due to prolonged grazing pressure, absence of native vegetation and presence of highly invasive exotic species *Juncus acutus* which outcompetes native species. There are no BioNet records for this species within a 5 km radius of the subject land.
Persoonia nutans	Nodding Geebung	--	--	High	Endangered	Endangered	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing. No native vegetation was identified within the midstorey and ground layer. As

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							such, no habitat was recorded within the subject land.
Petaurus norfolcensis	Squirrel Glider	--	--	High	Vulnerable	Not Listed	Excluded No suitable habitat present in PCT 3320 due to levels of habitat degradation, grazing and previous clearing of vegetation. According to the TBDC this species relies heavily on vegetation with bipinnate acacia, autumn winter flowering trees and shrubs such as *Eucalyptus robusta* and *Banksia* sp. The vegetation does not contain any *Acacia* or *Banksia* or *E. robusta* species.
Phascolarctos cinereus	Koala	Presence of koala use trees - refer to Survey Comments field in TBDC	--	High	Endangered	Endangered	Excluded No suitable habitat present in PCT 3320 due to high and consistent levels of degradation. The subject land is highly fragmented, with patches of vegetation in low condition.
Pimelea curviflora var. *curviflora*	Pimelea curviflora var. curviflora	--	--	High	Vulnerable	Vulnerable	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							within the midstorey and ground layer. As such, no habitat was recorded within the subject land. There are no BioNet records within 5 km radius of the subject land.
Pimelea spicata	Spiked Rice-flower	--	--	High	Endangered	Endangered	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land.
Pomaderris brunnea	Brown Pomaderris	--	--	High	Endangered	Vulnerable	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land. There are no BioNet records within 5 km radius of the subject land.

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Pomaderris prunifolia - endangered population	P. prunifolia population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith LGAs	--	LGAs in the Determination listing	High	Endangered Population	Not Listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land. There are no BioNet records within 5 km radius of the subject land.
Pteropus poliocephalus	Grey-headed Flying-fox	- Other Breeding camps	-	High	Vulnerable	Vulnerable	Excluded No known breeding camps present within the subject land.
Pterostylis saxicola	Sydney Plains Greenhood	-	-	Moderate	Endangered	Endangered	Excluded This species is associated with PCT 3320. The species profile states this species has a highly restricted geographic distribution, limited to western Sydney where it occurs on the Cumberland Plain on Ashfield Shale (DPE 2022). According to the final determination this species is only known from five locations – Georges River National Park, Ingleburn, Holsworthy, Peter Meadows Creek and St Marys Tower (NSW Scientific

Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
							Committee 1997). The subject land is located more than 30 km from these locations. There are no BioNet records for this species within a 5 km radius of the subject land.
Pultenaea parviflora	-	-	-	Moderate	Endangered	Vulnerable	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land.
Pultenaea pedunculata	Matted Bush-pea	-	-	High	Endangered	Not Listed	Excluded This species is associated with PCT 3320. The patches of PCT 3320 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land. There are no BioNet records for this species within a 5 km radius of the subject land.

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Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
Senna acclinis	Rainforest Cassia	-	-	High	Endangered	Not Listed	Excluded This species is associated with PCT 4023. The patches of PCT 4023 mapped within the subject land were highly degraded and subject to intense grazing and previous clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land. There are no BioNet records for this species within a 5 km radius of the subject land.
Tyto novaehollandiae	Masked Owl	Hollow bearing trees A living or dead tree with a hollow >20cm diameter that occurs >4m above the ground	-	High	Vulnerable	Not Listed	Excluded Habitat surveys were conducted to record hollows and size entrance class. No suitable hollows with an entrance > 20 cm and > 4 m above ground. Therefore, this species was not considered a candidate species credit species and was excluded from further surveys.
Wahlenbergia multicaulis – endangered population Tadgell's Bluebell in the local	-	-	Check for updated LGA names	High	Endangered population	Not listed	Excluded This species is associated with PCT 3320 and PCT 4023. The patches of PCT 3320 and PCT 4023 mapped within the subject land were highly degraded and subject to intense grazing and previous

Species	Common Name	Habitat Constraints	Geographic Limitations	Sensitivity to Gain Class	BC Act Status	EPBC Act Status	Justification for inclusion / exclusion
government areas of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield							clearing of native vegetation. No native vegetation was identified within the midstorey and ground layer. As such, no habitat was recorded within the subject land. There are no BioNet records for this species within a 5 km radius of the subject land.

5.3. Targeted survey methods

Targeted surveys for species credit species were undertaken across the subject land in 2023 and 2024. The targeted survey effort methods and results are discussed in more detail in Appendix G and previous surveys summarised in the literature review in Section 4.1.1. The location of recent targeted surveys are shown on Figure 15, with the results of the surveys shown on Figure 16. A summary of the survey effort is provided below (and in Table 22):

- Spotlighting for amphibians and microbats
- Call playback for amphibians
- Diurnal migratory bird surveys
- Echolocation surveys for microbats (Figure 10)
- Nest surveys for raptors
- Parallel transects for threatened flora around watercourses (2016 only).

Targeted surveys were completed consistent with the following guidelines:

- Surveying threatened plants and their habitats (DPIE, 2020)
- 'Species credit' threatened bats and their habitats (DPIE, 2021)
- Survey Guidelines for Australia's Threatened Bats (DEWHA 2010a)
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010b)
- NSW Survey Guide for Threatened Frogs A guide for the survey of threatened frogs and their habitats for the Biodiversity Assessment Method (DPIE 2020)
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (DEC 2004).

Table 23 includes a list of targeted surveys for candidate species and results.

No targeted surveys were conducted for threatened flora as limited native vegetation was present within the subject land. Additionally, areas of native vegetation including riparian corridors were highly degraded, mostly comprised of exotic flora species and subject to ongoing and intense disturbance from cattle grazing.

Table 22: Summary of survey effort

Target species	Date	Surveyors	Survey effort and method
White-bellied Sea Eagle Eastern Osprey Little Eagle Square-tailed kite	1 September 2023	Elliott Poulier and Jake Webb	Searches for activity in stick nests identified across the subject land. 2 ecologists each survey for 2 person hours = **4 person hours**
Latham's Snipe, Bush Stone-curlew,	1 September 2023 8 September 2023	Elliott Poulier Jake Webb;	Dawn wetlands bird surveys using area count method with two ecologists for ~ 2 person hours at two dams each morning (Table 46).

Target species	Date	Surveyors	Survey effort and method
Gang-gang Cockatoo	10 November 2023 15 November 2023 21 December 2023 18 January 2024 29 January 2024	Frank Lemckert Belinda Failes Claudia Santori; Tom Kelly.	Replicated for seven mornings. **14 surveys and ~14 person hours.**
Green and Golden Bell Frog	8 September 2023	Frank Lemckert and Elliott Poulier	Initial habitat assessment for Green and Golden Bell Frog to record potential habitat within the subject land.
Threatened microbat surveys	10 – 15 November 2023	Belinda Failes Elliott Poulier	Five echolocation devices (3 anabat swifts and 2 mini song meters) were deployed near the largest dams for 5 nights = total of 25 survey nights. According to the BAM bat survey guidelines only 16 survey nights are required so only 16 nights of data was analysed.
Green and Golden Bell Frog	21 December 2023	Elliott Poulier Frank Lemckert	Call Playback and spotlighting at four locations 5:45 - 9:00 pm. **1 survey night / 3.25 person hours**
Green and Golden Bell Frog	29 February 2024	Frank Lemckert and Melaina Chapman	Call Playback and spotlighting. The bankline of each waterbody was searched. There was an initial listening period of five minutes and then the walk along the banks stopping as needed to listen for calling frogs and at least every 50 m of suitable breeding habitat to broadcast the calls. **1 survey night / 7 person hours**
Green and Golden Bell Frog	5 March 2024	Frank Lemckert and Claire Plunkett	Call Playback and spotlighting. The bankline of each waterbody was searched. There was an initial listening period of five minutes and then the walk along the banks stopping as needed to listen for calling frogs and at least every 50 m of suitable breeding habitat to broadcast the calls. **1 survey night / 7 person hours**
Green and Golden Bell Frog	28 March 2024	Frank Lemckert and Claire Plunkett	Call Playback and spotlighting. The bankline of each waterbody was searched. There was an initial listening period of five minutes and then the walk along the banks stopping as needed to listen for calling frogs and at least every 50 m of suitable breeding habitat to broadcast the calls. **1 survey night / 7 person hours**

Table 23: Targeted flora survey effort and results

Target species	Common Name	Survey Method	Survey effort	Survey Dates	BAM survey period	Species recorded during survey	Species credits required / species polygon justification
Burhinus grallarius	Bush Stone-curlew	Dawn surveys and spotlighting	14 surveys = 14 person hours	1 September 2023 8 September 2023 10 November 2023 15 November 2023 21 December 2023 18 January 2024 29 January 2024	All year	No	Not required
Callocephalon frimbriatum	Gang-gang Cockatoo (Breeding)	Diurnal bird surveys	14 surveys = 14 person hours	1 September 2023 8 September 2023 10 November 2023 15 November 2023 21 December 2023 18 January 2024 29 January 2024	Oct - Jan	No	Not required
Haliaeetus leucogaster	White-bellied Sea-Eagle (Breeding)	Searches for large stick nests within PCT 3320 and PCT 4023	4 person hours	1 September 2023	Jul - Dec	Yes, this species was observed foraging over the large dams and resting on large stags.	No. Although this species was recorded foraging within the subject land, no breeding habitat in the form of large stick nests were recorded during targeted surveys. Therefore, no species polygon is required for breeding habitat.
Hieraaetus morphnoides	Little Eagle (Breeding)	Searches for large stick nests within	4 person hours	1 September 2023	Aug - Oct	No	Not required

Target species	Common Name	Survey Method	Survey effort	Survey Dates	BAM survey period	Species recorded during survey	Species credits required / species polygon justification
		PCT 3320 and PCT 4023					
Litoria aurea	Green and Golden Bell Frog	Along waterbodies and around dams	4 nights Habitat assessments were conducted outside of survey period over one day on 8 September 2023	21 December 2023 29 February 2024 5 March 2024 28 March 2024	Nov - Mar	No	Not required
Lophoictinia isura	Square-tailed Kite (Breeding)	Searches for large stick nests within PCT 3320 and PCT 4023	4 person hours	1 September 2023	Sep - Jan	No	Not required
Myotis macropus	Southern Myotis	Echolocation surveys	4 echolocation recording devices across 4 survey nights = 16 survey nights	10 – 15 November 2023	Oct – Mar	Yes	Yes. Refer to Table 25
Pandion cristatus	Eastern Osprey (Breeding)	Searches for large stick nests within PCT 3320 and PCT 4023	4 person hours	1 September 2023	Aug - Oct	No	Not required. Species not identified during targeted survey

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Table 24: Weather observations for survey dates (Bureau of Meteorology 2024*)

Survey Date	Rainfall (mm)	Min. daily temperature (°C)	Max. daily temperature (°C)
18 April 2016	0.2	13.0	24.2
19 April 2016	0	14.4	25.9
20 April 2016	0	12.7	26.9
21 April 2016	0	13.8	28.8
9-12 December 2016	Data not available	Data not available	Data not available
21 December 2016	0	15.1	31.3
9 January 2017	0	18.0	35.7
10 January 2017	0	21.0	38.4
11 January 2017	2.4	20.9	42.8
12 January 2017	0	20.4	31.5
13 January 2017	0	20.6	45.1
23 January 2017	0	17.2	39.3
2 February 2017	0.6	20.5	29.2
26 February 2018	46.8	15.5	21.3
27 February 2018	0.4	14.9	25.8
28 February 2018	0	12.5	33.9
1 March 2018	0	17.7	27.8
2 March 2018	0	18.8	27.0
3 March 2018	0	18.1	32.5
4 March 2018	0	19.1	28.6
5 March 2018	0	19.8	24.0
1 September 2023	0.2	5.8	20.3
8 September 2023	2.8	12.6	18.9
10 November 2023	5.6	15.8	29.2
11 November 2023	0.2	15.2	35.4
12 November 2023	0	16.1	32.0
13 November 2023	0	16.0	25.4
14 November 2023	0	13.9	31.1
15 November 2023	0	17.9	27.5
21 December 2023	18.4	16.8	24.9
18 January 2024	15	20.0	31.6
29 January 2024	Data not available	Data not available	33.1

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Survey Date	Rainfall (mm)	Min. daily temperature (°C)	Max. daily temperature (°C)
5 March 2024	0	14.8	27.3
28 March 2024	0	17.1	27.4
8 April 2024	0	12.8	26.2

*Records from Badgerys Creek AWS ID 067108

Figure 10: Echolocation device next to one of the dams

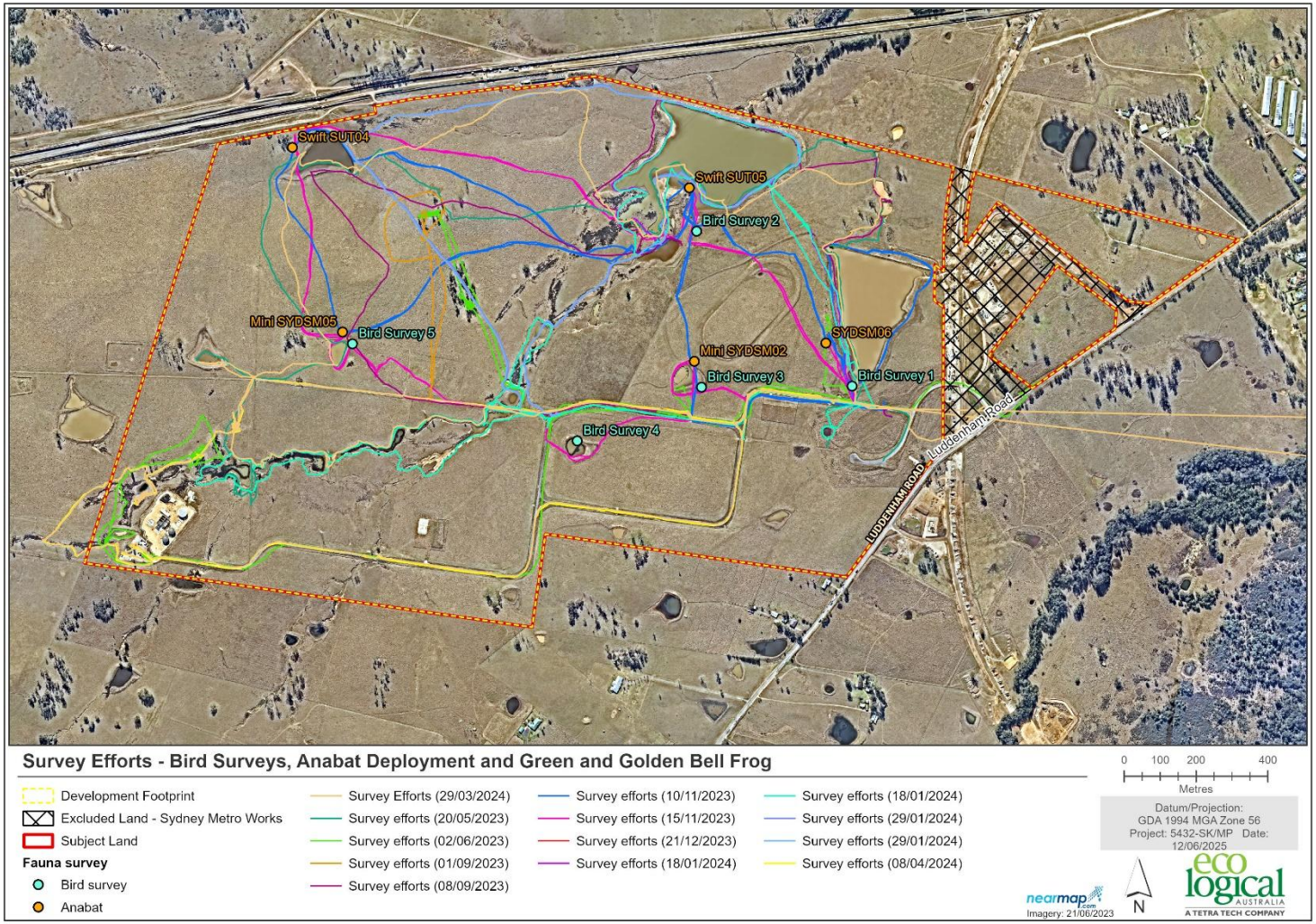

Figure 11: 2023 – 2024 survey effort

5.4. Targeted survey results

Following completion of targeted surveys, the species credit species recorded within the development footprint are outlined in Table 25. In addition to the species credit species recorded during targeted surveys, one dual ecosystem/species credit species (Large Bent-winged Bat) and two migratory species (Latham's Snipe and Sharp-tailed Sandpiper) listed under the EPBC Act were recorded and have been included in the results table below. The literature review also recorded the presence of *Tringa nebularia* (Common Greenshank) from 2006 BioNet recorded within the subject land. This species is listed under the EBPC Act. The BAM-C did not provide options to add EPBC Act listed species as part of the assessment. Therefore, these species are considered in a separate EPBC referral (ELA 2025e). They are also assessed as part of the prescribed impacts in the Section 5.5 of this report. A list of fauna species observed within the development footprint is provided in Appendix E.

Table 25: Species credit species included in the assessment

Species	Common Name	Species presence	Geographic limitations	Number of individuals / Habitat (ha)	Biodiversity Risk Weighting	Species polygon
Calidris acuminata	Sharp-tailed Sandpiper	Present (Figure 12)	-	-	N/A Listed EPBC Act. Not listed under BC Act	One individual was recorded foraging multiple times along the mud flats of the larger dams during dawn bird surveys in January 2024. No species polygon is required. This species was recorded foraging in the subject land. It is a non-breeding migratory species. The BAM-C did not allow this EPBC Act species to be entered into the case and assessed. A separate EPBC Referral has been prepared for this species. Assessments of significances have been provided as a separate document.
Gallinago hardwickii	Latham's Snipe	Present (Figure 13)	-	-	N/A Listed under EPBC Act. Not	One individual was recorded on four occasions during Green and Golden Bell Frog nocturnal surveys in March 2024. And previously in 2016 surveys.

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Species	Common Name	Species presence	Geographic limitations	Number of individuals / Habitat (ha)	Biodiversity Risk Weighting	Species polygon
					listed under BC Act	No species polygon is required. This species was recorded foraging in the subject land. It is a non-breeding migratory species. The BAM-C did not allow this EPBC Act species to be entered into the case and assessed. A separate EPBC Referral has been prepared for this species. Assessments of significances have been provided as a separate referral.
Haliaeetus leucogaster	White-bellied Sea Eagle	Present foraging (Figure 14).	-	-	2	One adult was recorded foraging on four occasions during January and February 2024. This species was observed utilising the large dam as foraging habitat. No breeding habitat in the form of a large stick nest was observed. This species is only a species credit species for breeding habitat. As no breeding habitat was recorded, no species polygon is required.
Miniopterus orianae oceanensis	Large Bent-winged Bat	Present. Recorded from one Echolocation device near a dam during targeted surveys	-	-	3	One definite call and six potential calls were identified for this species during November 2023 targeted surveys. This species is a dual credit species and only a species credit species for breeding habitat. No breeding habitat in the form of maternity caves are present in the subject land or within 200 m of the subject land, therefore, no further assessment for this species is required in

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Species	Common Name	Species presence	Geographic limitations	Number of individuals / Habitat (ha)	Biodiversity Risk Weighting	Species polygon
						accordance with the BAM. The subject land contains suitable non-breeding habitat and over-wintering habitat for this species.
Myotis macropus	Southern Myotis	Present. Recorded from Echolocation device near the dams during targeted surveys	-	PCT 3320 – 1.06 ha PCT 4023 – 0.75 ha PCT 3795 – 0.38 ha TOTAL – 2.19 ha	2	This species was identified during the November 2023 echolocation survey. A 200 m buffer was applied to all waterbodies >3 m wide, and areas of suitable habitat (PCTs 4023, 3975 and 3320) within the buffer was mapped as the species polygon (Figure 16).

Figure 12: Sharp-tailed Sandpiper EPBC listed species and not a candidate species credit species under the BAM

Figure 13: Latham's Snipe EPBC species and not a candidate species credit species under the BAM

Figure 14: White-bellied Sea-eagle recorded foraging within the subject land. No breeding habitat present.

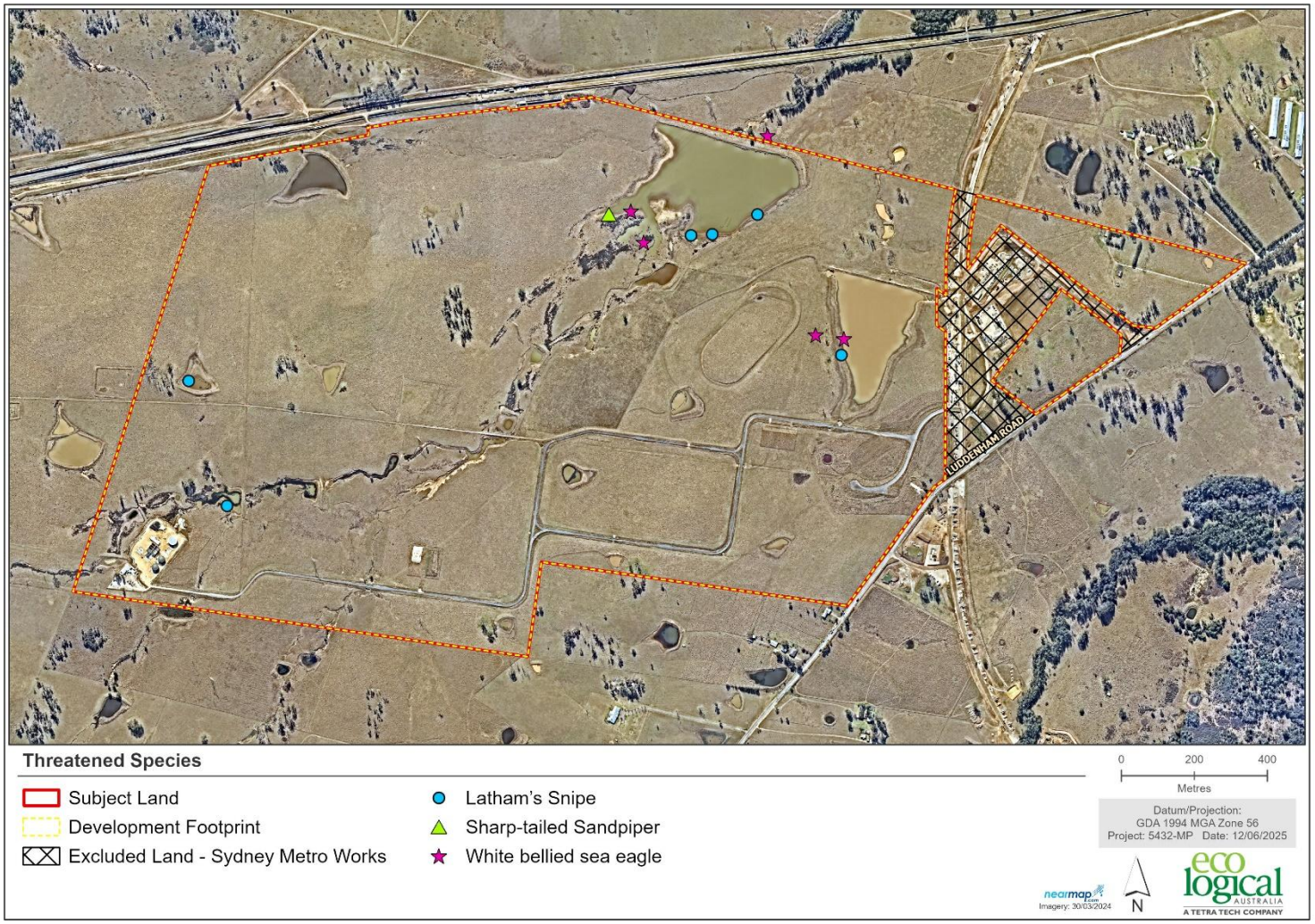

Figure 15: Survey results

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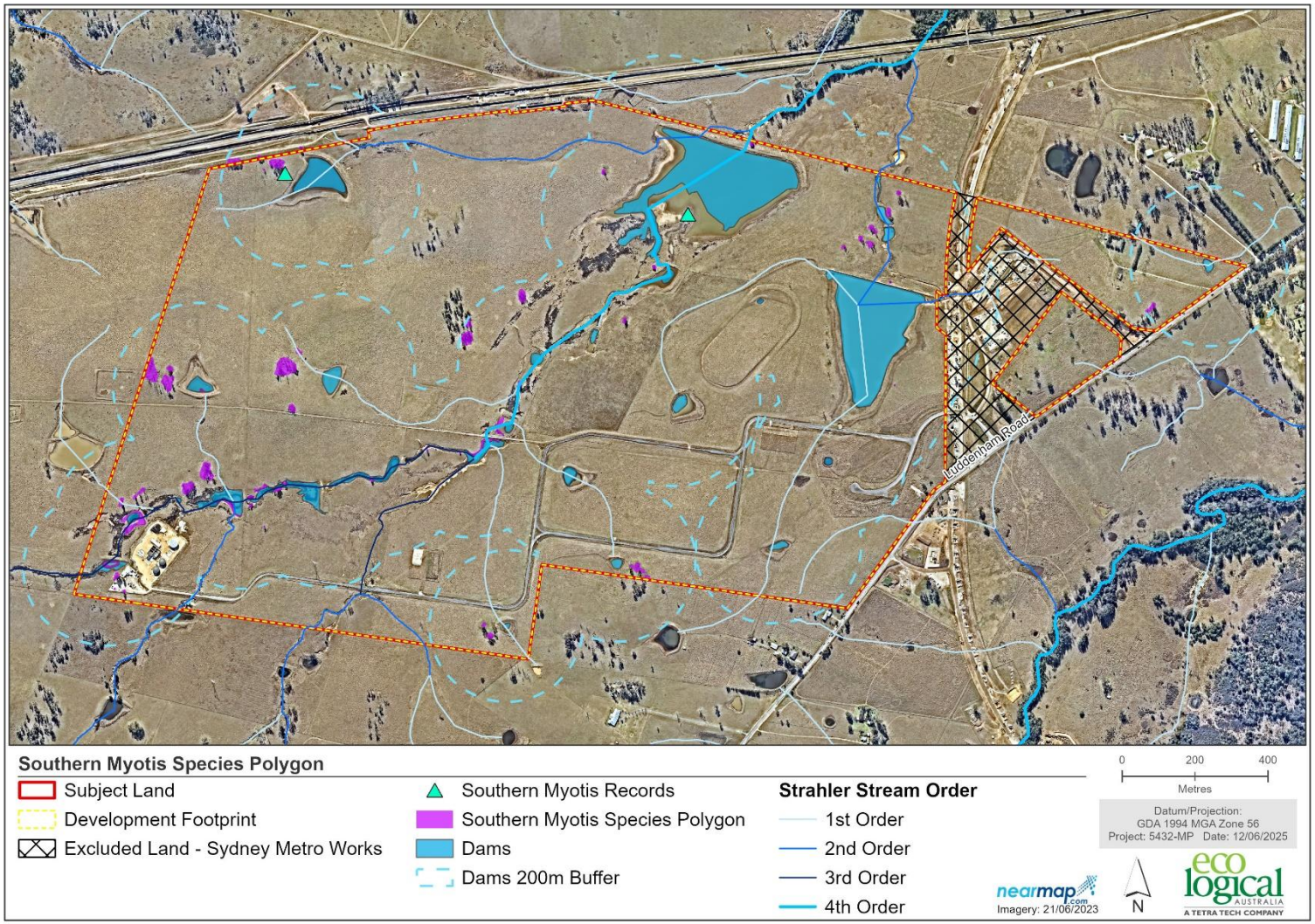

Figure 16: Species polygons for Southern Myotis

5.4.1. Expert reports

An Expert report was prepared for the Green and Golden Bell Frog (Appendix E).

Targeted surveys were conducted in accordance with the EPBC guidelines (refer to section 5.3). No Green and Golden Bell Frogs were recorded during the field surveys. The expert report identified that the subject land does not contain a viable population of Green and Golden Bell Frogs and there are no viable populations nearby. The expert report summary states:

"*As there are no records for the subject land and as it is considered that there are no frogs currently using the subject land, the GGBF is considered absent from the study area. Furthermore, it is not realistic to expect a viable population to establish in or close to the subject land for the foreseeable future. Hence there is no reason to produce a polygon to protect PCTs within a 200 m radius of the available ponds*" (Appendix E).

5.4.2. Use of local data

The use of local data is not proposed as part of this BDAR.

5.5. Identification of prescribed additional biodiversity impact entities

5.5.1. Karst, caves, crevices, cliffs, rocks and other geological features of significance

There are no karsts, caves, crevices, cliffs, rocks or other geological features of significance in the subject land.

5.5.2. Human-made structures and non-native vegetation

The development footprint includes recently constructed buildings associated with the Integrated Water Recycling Hub. The recently constructed buildings do not provide habitat for threatened species such as microbats. The infrastructure lacks suitable habitat features which microbat require to utilise human-made structures such as insulation on the roof and small gaps into the roof crevices. The buildings are in cleared lands which lack native vegetation cover. Preferred habitat for microbats includes abandoned buildings near intact native vegetation which contain small cracks suitable for microbats to enter/exit the building. These features were not recorded within the development footprint.

The development footprint contains non-native vegetation. Non-native vegetation includes exotic grasses and weeds (*Juncus acutus*) (Figure 17) and may provide sheltering habitat for threatened species including migratory species listed under the EPBC Act such as Latham's Snipe, the Sharp-tailed Sandpiper and Common Greenshank. These species were recorded within the subject land during the field surveys or for the Common Greenshank, it was recorded from previous BioNet records from 2006.

An assessment of non-native vegetation is provided in Table 26.

Figure 17: Example of large extent of exotic vegetation dominated by *Juncus acutus*

Table 26: Assessment of prescribed impacts to human-made structures and non-native vegetation

Criteria in accordance with BAM 2020 Section 6.1.2	Response
2. If human-made structures (e.g. bridges, culverts, abandoned buildings) and non-native vegetation (e.g. camphor laurel trees) provides habitat for threatened species, the assessor must:	
a. provide a description of the type of human-made structure or non-native vegetation habitat	There are several recently constructed structures present in the development footprint which do not provide habitat for threatened species. Non-native vegetation present in the subject land includes environmental weeds such as *Juncus acutus, Olea europaea* subsp. *cuspidata* (African Olive) and *Lycium ferocissimum* (African Boxthorn). Open exotic grasslands used for agriculture also feature within the development land.
b. prepare a list of threatened species that use these features as habitat	The human-made structures do not provide suitable habitat for threatened species such as microbats. Exotic vegetation including *Olea europaea* subsp. *cuspidata* (African Olive) and *Lycium ferocissimum* are

Criteria in accordance with BAM 2020 Section 6.1.2	Response
	not listed as foraging items for *Pteropus poliocephalus* (Grey-headed Flying Fox. Dense swales of *Juncus acutus* were mapped along dams and drainage lines. This exotic vegetation may provide sheltering habitat for ground dwelling birds such as migratory species such as Latham's Snipe, the Sharp-tailed Sandpiper and Common Greenshank. Open grasslands may provide foraging habitat for the following species: • *Hieraaetus morphnoides* (Little Eagle) • *Lophoictinia isura* (Square-tailed Kite). There are eight BioNet records for Little Eagle and two BioNet records for Square-tailed Kite within a 5 km radius of the subject land.
c. describe how each threatened species could, or does, use the human-made structure or non-non-native vegetation as habitat (based on published literature and other reliable sources).	Microbat species have been known to utilise abandoned buildings as non-breeding roosting habitat if suitable habitat is present in the development footprint. However, the buildings present do not provide suitable habitat for microbat species or other threatened species. As mentioned above, the non-native vegetation may provide supplementary foraging habitat for Grey-headed Flying-fox. However, woody weeds (such as *Olea europaea* subsp. *cuspidata*) are not listed as potential foraging resource for Grey-headed Flying-fox (DCCEEW 2021). The Little Eagle prefers to forage in open areas including open fields and may utilise trees for perching during foraging (Marchant and Higgins 1993). Square-tailed Kite utilises the ecotones between timbered and open habitats (Debus and Czechura 1989). Both species have potential to utilise the open areas and non-native vegetation within the development footprint.

5.5.3. Habitat connectivity

There is limited habitat connectivity across the development footprint. The native vegetation, where present, exists as isolated patches separated by exotic pasture grasses. The riparian corridors which include exotic rushes, *Juncus acutus* (Figure 17) provide some connectivity features across the development footprint. However, the streams were highly degraded and native vegetation was recorded in disconnected patches and in low condition. The streams have also been dammed and, in many areas, did not contain permanent water flow with erosion observed along many of the channel beds. The waterbodies could provide connectivity for mobile species, such as birds (including raptors and migratory species) and microbats that utilise water for foraging. However, it is noted that the landscape plans and design of the dams were prepared

in accordance with the Aerotropolis DCP which does not support the formation of habitat for birds and bats due to the risk of aircraft strike.

An assessment of prescribed impacts to habitat connectivity is presented in Table 27.

Table 27: Assessment of prescribed impacts to habitat connectivity

Criteria in accordance with BAM 2020 Section 6.1.3	Response
2. Where corridors or other areas of connectivity link habitat for threatened entities, the assessor must:	
a. prepare a list of threatened entities that are likely to use or are a part of the connectivity or corridor	Highly mobile, threatened birds and bats that are likely to utilise the scattered patches of vegetation and dams within the development footprint (mostly for supplementary foraging) and were included in this assessment. Mega bats: • *Pteropus poliocephalus* (Grey-headed Flying Fox) Microbats: • *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) • *Miniopterus australis* (Little Bent-winged Bat) • *Miniopterus orianae oceanensis* (Large Bent-winged Bat) • *Scoteanax rueppellii* (Greater Broad-nosed Bat) • *Myotis macropus* (Southern Myotis). Migratory / wetland (birds): • Latham's Snipe • Sharp-tailed Sandpiper Common Greenshank Raptor (birds): • *Haliaeetus leucogaster* (White-bellied Sea-eagle) • *Pandion cristatus* (Eastern Osprey) • *Hieraaetus morphnoides* (Little Eagle) • *Lophoictinia isura* (Square-tailed Kite).
b. describe the importance of the connectivity to threatened entities, particularly for maintaining movement that is crucial to the species' life cycle	The scattered patches of native vegetation within the development footprint and dense cover of exotic groundcover species contains potential connectivity features which extends across the development footprint and into adjacent agriculture lands. The connectivity features end at the major arterial roads which border the broader landscape around the development footprint. The removal of native vegetation has potential to reduce habitat for threatened species known to occur within the development footprint including Southern Myotis.

Criteria in accordance with BAM 2020 Section 6.1.3	Response
	Raptor species may utilise the vegetation or dams within the development footprint as part of a larger foraging home range. The removal of exotic vegetation is unlikely to reduce connectivity for other species as much of the vegetation consists of open grassland with limited connectivity. The removal of this vegetation is unlikely to impact movement of highly mobile species such as Little and Large Bent-wing bats and migratory shorebirds.

5.5.4. Water bodies, water quality and hydrological processes

The development footprint contains numerous streams and human made dams of varying size. The majority of the dams were in poor condition. The ground has been subject to regular drying and wetting periods, compaction of soils from cattle and clearing of native vegetation (Figure 18). The proposed works will rehabilitate and replace the current creeks and dams within the development footprint to improve existing conditions.

The works aims to restore and rehabilitate the function of the streams and improve the water quality. A separate draft Stormwater Management Strategy (Enspire 2025) is in the process of completion for the SSDA.

The proposed stormwater management strategy will consist of:

- Primary treatment controls such as gross pollutant traps at lot and road level.
- Secondary treatment control through permanent sediment collection basins.
- Tertiary treatment control through bio-filtration basins, wetlands, storage ponds and stormwater harvesting reuse.

The plan aims to achieve higher than average stormwater quality. Additionally, the proposed post-development stormwater quality targets will greatly improve the current stormwater quality.

The plan aims to limit post-development stormwater flow rates to the current levels. This achievement is above the required standard. Typical development standards aims for a flow of 5-6 ML/ha/year, however the current strategy aims for 2 ML/ha/year. This will greatly improve the water quality and protect downstream biodiversity values.

Additional works includes the revegetation works to be conducted in accordance with Vegetation Management Plan (VMP) (ELA 2025a).

An assessment of prescribed impacts to water bodies, water quality and hydrological processes is presented in Table 28.

Figure 18: Typical condition of the dams which contain unpalatable species and disturbed soil profile

Table 28: Assessment of prescribed impacts to water bodies, water quality and hydrological processes

Criteria in accordance with BAM 2020 Section 6.1.4	Response
1. Where water bodies or any hydrological processes that sustain threatened entities occur on the subject land, the assessor must:	
a. prepare a list of threatened entities that may use or depend on water bodies or hydrological processes for all or part of their life cycle, or b. prepare a list of threatened entities that will be, or are likely to be impacted by changes to existing water bodies or hydrological processes or the construction of a new water body	Species with waterbodies as habitat constraints, including: • Southern Myotis, Latham's Snipe, Sharp-tailed Sandpiper and White-bellied Sea-eagle have been identified from targeted surveys and are likely to utilise the waterbodies as foraging habitat. The Common Greenshank was previously recorded from BioNet records within the subject land. The Latham's Snipe, Sharp-tailed Sandpiper and Common Greenshank are migratory birds and may roost in fringing vegetation. Roosting habitat for the Southern Myotis is located within 200 m of waterbody and breeding habitat includes caves within 10-15 m from waterbody. No breeding habitat for the White-bellied Sea-eagle was observed in the development footprint (i.e. no stick nests). Eastern Osprey is also a potential species which may utilise the large dams for foraging, however, no individuals

Criteria in accordance with BAM 2020 Section 6.1.4	Response
	were recorded during targeted surveys and no stick nests indicating the presence of breeding habitat was recorded during surveys. • PCT 3975 and PCT 4023 are water dependent ecosystems. These PCTs will be impacted through reshaping of the creeklines and changes to the hydrological processes due to the proposed riparian corridor works. Additionally, the construction of new roads and buildings adjacent to the riparian corridor, will result in an increase in impervious surfaces. In turn, this may result in changes to the health or species composition of the vegetation downslope (i.e. PCT 3975 and 4023). However, it is noted that the current condition of the two vegetation communities are very low and are highly fragmented and impacted by historical land use. The proposed works also involve extensive restoration of the vegetation communities and long-term conservation of the water dependent ecosystem.
c. describe the habitat provided for each threatened entity by the water body or hydrological process, including consideration of water quality, volume, flow paths and seasonal patterns	The proposed works will involve changes to hydrological flows in the development footprint as a result of changes to the natural water flow which may impact adjacent vegetation (PCT 4023 listed as a TEC and PCT 3975 non-TEC) and impacts to foraging habitat for Southern Myotis, Latham's Snipe, Sharp-tailed Sandpiper and White-bellied Sea-eagle recorded within the development footprint. The Common Greenshank was previously recorded within the development footprint from BioNet records. There is potential that other migratory species and raptors may utilise the development footprint on occasion and may be impacted by the proposed works, however, no other species have been identified during surveys. No offsite impacts would occur. <u>Southern Myotis</u> According to the TBDC Southern Myotis relies on waterbodies >3 m wide for foraging and habitat surrounding waterbodies are used for breeding and foraging. The proposed works will require reshaping of the riparian corridor and redevelopment of the adjacent landscape including the removal of hollow-bearing trees. The proposal has potential to impact upon foraging habitat. However, the Stormwater Management Strategy states that the flow rates will achieve pre-development rates and the water quality will be significantly improved as part of the proposal. The proposal may result in impacts during the construction process, including minor changes to hydrological flow and a decrease in water quality which reduces availability of food items (i.e. fish). <u>PCT 4023 and PCT 3975</u> Changes to the species composition of PCT 4023 and PCT 3975 are likely to occur due to removal of vegetation and reshaping of the riparian corridor. Construction of hardstand (i.e. development) and new roads may occur as a result of an increase in impervious surfaces. Changes may include the establishment of additional weed species, erosion, sedimentation and a reduction in water quality of the unnamed tributary. However, it is noted that the current condition of the two vegetation communities

Criteria in accordance with BAM 2020 Section 6.1.4	Response
	are very low and are highly fragmented and impacted by historical land use. The proposed works also involve extensive restoration of the vegetation communities and long-term conservation of the water dependent ecosystem. Migratory Shorebirds Latham's Snipe and Sharp-tailed Sandpiper were observed foraging around the dams and roosting in dense groundcover vegetation. The Common Greenshank was previously recorded from BioNet records from 2006 within the development footprint. The Sharp-tailed Sandpiper, Common Greenshank and Latham's Snipe are non-breeding migratory species which visits Australia during late Spring-Summer. The farm dams and drainage line provide daytime roosting in dense Juncus cover and foraging habitat along the muddy banks. Potential changes to the water quality along the creeks and removal of the dams have potential to remove degraded non-breeding habitat for these species. According to the Water Management Strategy, (Espire 2024), the proposed riparian corridor will reduce peak flows and reduce erosion risk. It will also result in better water quality due to the establishment of revegetation works. White-bellied Sea-eagle and Eastern Osprey White-bellied Sea-eagle was observed utilising the large dam for foraging. The Eastern Osprey have potential to utilise the large dams for foraging, however, was not recorded during field surveys. Breeding habitat, for both species, consists of stick nests in living or dead mature trees within suitable vegetation within 1 km of a rivers, lakes, large dams or creeks, wetlands and coastlines. No stick nests were observed within the development footprint. The farm dams and drainage lines provide potential foraging habitat for both species. Changes to the water quality, during construction works along the creeks and removal of the dams, have potential to remove important habitat for these species. Post-construction works aims to improve water quality and flow.

5.5.5. Wind farm developments

This development is not a wind farm.

5.5.6. Vehicle strikes

The construction of the proposed development is unlikely to result in an increase in the likelihood of vehicle strike given that the subject land contains limited habitat for threatened fauna species and species which are part of a TEC. There may be some risk of vehicle strikes to nocturnal or migratory species which are listed as threatened under the EPBC Act which are known to utilise the fringing vegetation around the dams (see Table 29). However, given that these species are a non-breeding migratory species, it is likely that these species will avoid the subject land during construction and therefore, are unlikely to be impacted by vehicle strike. Threatened microbats and raptor species are unlikely to be at risk of vehicle strikes as these species generally fly higher than a vehicles height.

Table 29: Threatened fauna or animals that are part of a TEC at risk of vehicle strike.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Comment
Calidris acuminata	Sharp-tailed Sandpiper	-	Vulnerable and migratory	There is a very low risk that this species may be impacted by vehicle strike. This species is a shy and cryptic species and is likely to avoid the subject land during construction and operational phase. This is a migratory species which is likely to utilise adjacent dams as foraging habitat.
Gallinago hardwickii	Latham's Snipe	-	Vulnerable and migratory	There is a very low risk that this species may be impacted by vehicle strike. This species is likely to avoid the subject land during construction and operational phase. This is a migratory species which is likely to utilise adjacent dams as foraging habitat.
Tringa nebularia	Common Greenshank	-	Endangered and migratory	There is a very low risk that this species may be impacted by vehicle strike. This species is likely to avoid the subject land during construction and operational phase. This is a migratory species which is likely to utilise adjacent dams as foraging habitat.

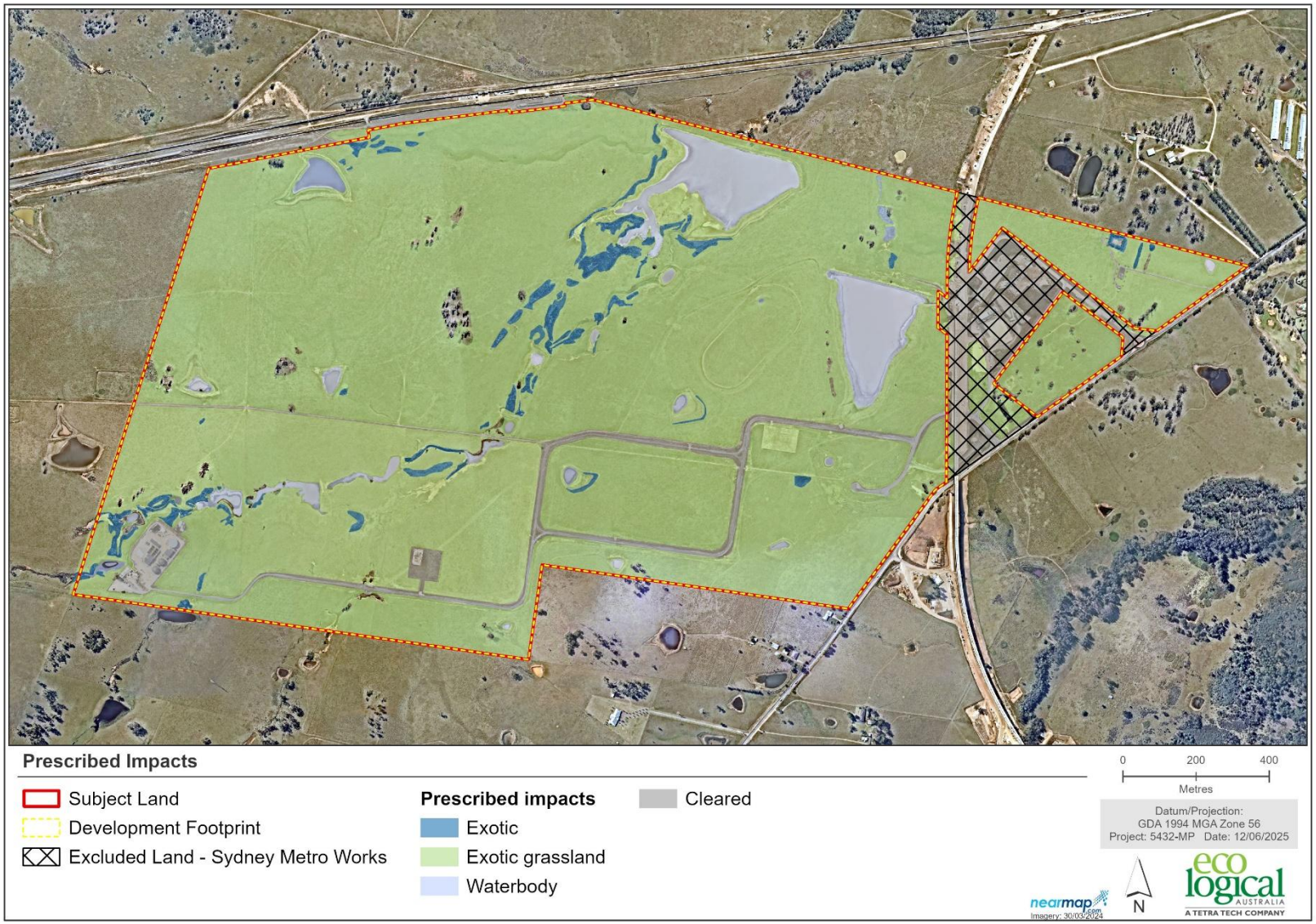

Figure 19: Prescribed Impacts

Figure 20: Example of waterbodies within the development footprint. Suitable foraging habitat for Southern Myotis.

6. Stage 2: Impact assessment (biodiversity values)

6.1. Avoiding impacts

6.1.1. Project background

The proposed development has considered and incorporated measures to avoid and minimise impacts to biodiversity values. The location and design of the proposed development footprint has also responded to various planning instruments and associated requirements under the State Environmental Planning Policy (Precincts – Western Parkland City) 2021 WSA Precinct Plan and the Aerotropolis DCP. The avoid and minimise measures include:

- Concentration of the development footprint in areas where biodiversity values are absent or in very low condition
- Retention of threatened ecological communities containing hollow bearing trees
- Reshaping and revegetation of riparian corridors throughout the action area.

These measures have responded to the following constraints:

- Stormwater management
- Biodiversity values
- Planning constraints associated with the SEPP, Precinct Plan and Aerotropolis DCP

Design history

In 2018 the action area was identified within the Aerotropolis precinct as part of the proposed new airport (Willowtree Planning 2024) as part of the State Environmental Planning Policy - Western Sydney Aerotropolis 2020. The action area was identified for future mixed-use development due to its strategic location near the airport and the metro link with rezoning occurring under the Penrith LEP area. The Western Sydney Aerotropolis 2020 SEPP was repealed in 2022 and replaced with the Western Parklands City SEPP (herein referred to as 'the SEPP'). The action area is currently subject to the requirements of the Western Parklands City SEPP which also support the use of the land as a mixed-use development through the establishment of the masterplan for the subject land.

Initial designs were completed which responded to the requirements of the SEPP. Following the completion of specialist reports, including biodiversity, riparian and flooding, the proposed footprint underwent substantial rework to respond to these various constraints, whilst meeting the requirements of the SEPP. These various iterations resulted in the final design as assessed in this referral.

Stormwater management and flooding

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A stormwater management strategy (Enspire 2025) has been prepared for the proposed development. The plan will manage peak flow, flood depths, and reduce post-development stormwater runoff volumes to minimise accelerated geomorphology of downstream waterways and impact on established vegetation. The stormwater management strategy aims at a higher-than-average stormwater quality. Additionally, the proposed post-development stormwater quality targets will greatly improve the current stormwater quality and remove potential downstream impacts.

The plan aims to limit post-development stormwater flow rates to the current levels. This achievement is above the required standard. Typical development standards aim for a flow of 5-6 ML/ha/year; however, the current strategy aims for 2 ML/ha/year. This will likely improve the water quality and protect downstream biodiversity values, ensuring there are no downstream impacts.

Specifically, the strategy includes the following measures which will reduce impacts to biodiversity:

- recycling waste water to remove the need for on-lot rainwater tanks and irrigate street trees and for other non-potable uses
- installing gross pollutant traps at stormwater locations
- installation of permanent sediment collection basins to control the diversion of concentrated overland flow away from bio-filtration basins and wetlands in larger storm events
- wetlands to provide stormwater treatment and some stormwater retention for stormwater harvesting and reuse while also improving ecological diversity and amenity values.

Biodiversity values

Terrestrial biodiversity values

The action area is 297.44 ha and is mostly (278.04 ha) comprised of exotic pasture, exotic planted vegetation and cleared land. Where native vegetation was present it was in very low condition (with a VI score less than 15) with no native groundcover or midstorey and a native canopy that was deteriorating and slowly dying. These patches were considered highly unlikely to provide habitat for native species, except one patch that contained three (3) hollow bearing trees. The patches of native vegetation met the BC Act listed threatened ecological communities of Cumberland Shale Plains Woodland and River-flat Eucalypt Forest, however, did not meet EPBC Act criteria.

Where biodiversity values exist within the development footprint, they occur in low condition vegetation, specifically in vegetation zones 1 and 2 producing a VI score of 7.9 and 12.2 respectively. Vegetation zones with a VI score of <15 indicate that the condition of these zones is of low condition compared to their benchmark conditions and do not require offset.

The development footprint has been designed and located to retain 0.71 ha of PCT 4023 which meets the BC Act listed community River-flat Eucalypt Forest as part of a linear park. This patch also contains three hollow bearing trees. This patch was considered the best patch to retain due to its size and presence of hollow bearing trees. The patch forms 22 % of mapped PCTs within the action area. The remaining native vegetation could not be retained due to land form modifications required to facilitate Mixed Use development, consistent with the land use zone.

Aquatic biodiversity values

The dams and waterbodies across the action area formed 15.67 ha and were in poor, degraded condition due to historical agricultural practices and cattle grazing. Although the dams contained limited native vegetation, they were confirmed to provide foraging habitat for some wader birds. Numerous design iterations were considered to try and retain some dams, however due to flooding constraints this was not achievable.

The proposed development would reshape and revegetate the central riparian corridor which is a 4th order Strahler stream. The reshaping was necessary to mitigate against potential future flooding events and to manage water quality (Northrop 2025). The reshaping and revegetation would result in the revegetation of approximately 38 ha of land and reforming waterbodies and creeklines throughout the action area. The reshaping would ultimately improve the quality of the creeklines and re-establish native vegetation. Although all waterbodies would be removed, the impacts are considered temporary with the final outcome being an overall improvement to the quality of the water resources across the action area.

The development footprint has been designed to incorporate open space adjacent to the riparian corridors which would also include some level of restoration. The strategic placement of open space adjacent to the riparian corridor would minimise potential impacts such as rubbish dumping and unauthorised access / use. The revegetation of the riparian corridors would also significantly improve connectivity across the landscape through the establishment of approximately 38 ha of vegetated, connected land.

Planning constraints

The design of the proposed development footprint has responded to the strict requirements in the Aerotropolis DCP and WSA Precinct Plan, including but not limited to:

- the action area is within the Northern Gateway Precinct of the Aerotropolis Precinct Plan which includes a Land Use and Structure Plan that outlines areas to be developed and retained and associated land zoning
- stormwater management requirements to improve water quality, mitigate and manage flood risk and improve flows
- restrictions on revegetation to discourage establishment of avifauna populations in the action area to manage strike risk and hazards at the Nancy Bird-Walton airport (ELA 2025c).

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AVOID AND MINIMISE SUMMARY

Avoidance and mitigation measures have been incorporated into the final development footprint which have resulted in the following avoidance of impacts to biodiversity values across the action area:

- retaining a patch of PCT 4023 (0.71 ha) which includes three hollow-bearing trees to be incorporated within a linear park within the action area
- concentration of 93 % of the development footprint in areas where there are no biodiversity values (cleared land or exotic cover)
- improving water quality by controlling flow rates and peak flows through a series of lakes, wetlands and basins
- retaining pre-development flow rates to minimise impact downstream
- re-establishing native vegetation through revegetation works along the riparian corridor in accordance with the VMP (ELA 2025b)
- improving connectivity through the action area through revegetation works
- retaining habitat for threatened species such as retaining the large dam and the PCT 4023 (0.71 ha) patch of native vegetation with hollows

7. Assessment of Impacts

7.1. Direct impacts

The direct impacts of the development on:

- PCTs and threatened ecological communities are outlined in Table 30
- threatened species and threatened species habitat is outlined in Table 31
- prescribed biodiversity impacts is outlined in Section 7.4.

Direct impacts including the final project footprint (construction and operation) are shown on Figure 21.

Table 30: Direct impacts to native vegetation

PCT ID	PCT Name	Vegetation Class	Vegetation Formation	Direct impact (ha)	Associated TEC
3320	Cumberland Shale Plains Woodland	Coastal Valley Grassy Woodlands	Grassy Woodlands	1.35	Cumberland Plain Woodland (BC Act – CE)
4023	Coastal Valleys Riparian Forest	Coastal Floodplain Wetlands	Forested Wetlands	1.39	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (BC Act – E)
3975	Southern Lower Floodplain Freshwater Wetland	Coastal Freshwater Lagoons	Freshwater Wetlands	0.53	Does not meet the criteria under the BC Act

Table 31: Direct impacts on threatened species and threatened species habitat

Species	Common Name	Direct impact number of individuals / habitat (ha)	NSW listing status	EPBC Listing status
Myotis macropus	Southern Myotis	2.19 ha	V	-

7.2. Change in vegetation integrity

The change in vegetation integrity as a result of the development is outlined in Table 32.

A separate management zone was added to 0.71 ha patch of PCT 4023 vegetation zone 2, to account for the canopy will be retained within a park. The ground layer will be subject to landscaping and will result in changes to the soil profile. The future integrity score assumes that the canopy will remain in management zone 2, however, the groundcover and midstorey will be reduced to zero (see Table 45 in Appendix B). The combined change to the vegetation integrity score for vegetation zone 2 is -7.2.

Table 32: Change in vegetation integrity

Veg Zone	PCT ID	Condition	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	Change in vegetation integrity
1	3320	Low_direct	1.35	7.9	0	-7.9
2a	4023	Low_direct	0.69	12.2	0	-12.2
2b	4023	Low_canopy	0.71	12.2	10.1	-2.2 (currently mapped for retention)
3	3975	Low_direct	0.53	51.7	0	-51.7

7.3. Indirect impacts

The construction footprint is provided in Figure 21. The indirect impacts of the development are outlined in Figure 22 and provided in Table 33.

Figure 21: Final construction footprint including construction and operation

Figure 22: Indirect impact (10 m buffer)

Table 33: Indirect impacts

Indirect impact	Description (nature, extent and frequency)	Biodiversity value affected	Duration/Timing	Consequence
Inadvertent impacts on adjacent vegetation or habitat	Damage to vegetation outside the approved construction/development footprint during construction and operational phases.	Native vegetation, threatened ecological community	Short term impacts Construction and operational phase	Minor loss of vegetation, loss of potential foraging and roosting habitat for threatened species
Reduced viability of adjacent habitat due to spread of weed species	Removal of vegetation along the creekline may result in the spread of weed propagules. Reduced viability of specialist and/or threatened species. Most likely to occur during the construction phase.	Native vegetation, threatened ecological community and native fauna	Short term impacts Construction phase.	Increase in the spread of weed species causing reduction in habitat for some flora and fauna species
Reduced viability of adjacent habitat due to noise, dust or light spill	Noise and dust created from machinery during daytime construction. Night work is not expected as part of the construction works therefore, no light spill associated with night works. However, it is expected that outdoor night lighting will be used as part of the operational phase. Any permanent lighting will be managed consistent with the Aerotropolis DCP requirements.	Native fauna, native vegetation	Short term impacts (construction phase) Ongoing impacts (life of project)	Noise and dust deter native fauna from the subject land in the short term. Night lighting may influence fauna behaviour in the long-term, e.g. attraction of invertebrates to lighting, therefore species such as microbats may be increasingly attracted to the area. Night lighting may also disrupt fauna movement and activity, including foraging.
Transport of weeds and pathogens from the site to adjacent vegetation	New weeds and pathogens introduced into subject land and adjacent retained vegetation, resulting from transport of topsoil or machinery. Or spread of weeds from within the subject land.	Native vegetation, threatened ecological community	Construction phase. May cause long-term impacts.	Potential for weed spread into adjacent habitat and affect quality of vegetation for native flora and fauna. Potential for pathogens to be introduced into the subject land through

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Indirect impact	Description (nature, extent and frequency)	Biodiversity value affected	Duration/Timing	Consequence
				use of machinery. Entry is prohibited to the adjacent retained lands and therefore weed encroachment would be limited
Increased risk of starvation or exposure and loss of shade or shelter	Removal of habitat for native fauna. Minor due to limited native vegetation present in development footprint (3.27 ha) and works will be staged.	Native fauna	Only during construction	Minor loss of foraging habitat for highly mobile species
Trampling of threatened flora species	No threatened flora present	Native flora	N/A	N/A
Inhibition of nitrogen fixation and increased soil salinity	The project is unlikely to inhibit nitrogen fixation or increase soil salinity outside the development footprint.	N/A	N/A	N/A
Fertiliser drift	Fertilisers may be used post-construction for landscaping purposes, however as this would be applied to specific areas and not applied aerially, this potential impact is unlikely to occur.	Native vegetation, threatened ecological community	Ongoing impacts Post-construction	Decreased plant diversity and increased exotic cover, as invasive species take advantage of additional nutrients. Fertiliser is unlikely to be used and the risk of fertiliser and associated nutrient enrichment is low. If this did occur, it could increase weed growth throughout the adjacent lands
Rubbish dumping	Within and adjacent to the subject land during construction and operational phases.	Native riparian corridor and, threatened ecological community	Short-term and long-term impacts	Rubbish dumping may impact on quality and health of fauna or flora species and habitat retained adjacent to the development footprint. Dumped rubbish may have

Indirect impact	Description (nature, extent and frequency)	Biodiversity value affected	Duration/Timing	Consequence
				downwind or downstream effects where it is loose and makes its way into sensitive ecosystems or suffocates fauna. Minor aesthetic loss and disruption to adjacent land for this project.
Wood collection	Removal of wood from development footprint	Native vegetation, threatened ecological community	Short-term and long-term impacts Life of project, including construction phase	Wood collection is unlikely to occur, given the limited native vegetation present.
Removal and disturbance of rocks including bush rock	Removal of bushrock within or adjacent to the development footprint.	Native fauna and native vegetation habitat	Construction phase	Bush rock not in abundance in the development footprint or lands immediately surrounding the development footprint.
Increase in predators	Increased predation on native fauna. Resulting from development and opportunistic increase in predators. Negligible likelihood of impact occurring due to the existing agricultural infrastructure surrounding the development footprint. The scale and type of works are unlikely to exacerbate any existing predatory species	N/A	Construction / operation	N/A
Increase in pest animal populations	Negligible likelihood of impact occurring due to the existing agricultural land surrounding the development footprint. The scale and type of works are unlikely to exacerbate pest animal populations	Native vegetation, native fauna	Construction / operation	N/A

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Indirect impact	Description (nature, extent and frequency)	Biodiversity value affected	Duration/Timing	Consequence
Increased risk of fire, including human-made fire	During construction, working machinery and/or chemicals have the potential to spark fire during drought conditions. Potential fire hazard associated with industrial activities post-construction.	Native vegetation, native fauna	Life of project including construction. Short-term and long-term impacts.	Highly unlikely to alter fire regimes as no current fire regime present.
Disturbance to specialist breeding and foraging habitat, e.g. nesting for owls	Disturbance/removal of foraging habitat for highly mobile species (such as Grey-headed Flying-fox). Ongoing light and/or noise impacts to native fauna associated with the operational phase (i.e. Southern Myotis).	Native fauna	Short-term and long-term impacts. Life of project.	Reduced numbers of species in vicinity.
Sedimentation and contaminated and/or nutrient rich run-off	Runoff containing high nutrients and/or contamination into adjacent vegetation during construction and operational phases.	Native vegetation, threatened ecological community	Short-term and long-term impacts. Life of project. Construction phase higher risk (due to machinery/refuelling)	Change in vegetation quality. Habitat loss downwind, stream or downslope of subject land.
Vehicle strike	Potential for native fauna to be struck by working machinery and moving vehicles during construction and operational phases	Native fauna	Short-term (construction) Long-term (operational)	Loss of native fauna species. Potential reduction in fauna population numbers.

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7.4. Prescribed biodiversity impacts

The subject land has the prescribed biodiversity impacts as outlined in Table 34.

Table 34: Direct impacts on prescribed biodiversity impacts

Prescribed biodiversity impact	Description (Nature, extent and frequency)	Consequences	Justification
Karst, caves, crevices, cliffs, rocks and other geological features of significance	There are no karsts, caves, crevices, cliffs, rocks or other geological features of significance in the development footprint.	N/A	N/A
Human made structures or non-native vegetation	The development footprint contains internal roads, wastewater treatment plant which will be retained. There are no human-made structures which provides habitat for threatened entities. Exotic grasses represent the majority of the development footprint. These areas provide foraging habitat for threatened raptors, such as Little Eagle or Square-tailed kite. No breeding habitat (i.e. in the form of stick nests) or individuals were recorded within the development footprint.	Loss of supplementary / marginal foraging for some mobile species	Impacts to exotic vegetation will occur as part the project.
Habitat connectivity	There is limited habitat connectivity across the development footprint. The native vegetation, where present, exists as isolated patches separated by exotic pasture grasses and invasive *Juncus acutus*. The riparian corridors provide the greatest amount of connectivity across the development footprint; however, the	The potential disruptions to habitat connectivity are limited, given that that native vegetation is isolated patches separated by exotic pasture.	Re-establishment of connectivity of vegetation along riparian corridors will occur following the completion of the project in accordance with the VMP and landscape plans.

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Prescribed biodiversity impact	Description (Nature, extent and frequency)	Consequences	Justification
	streams were highly degraded, lacked native vegetation, had been dammed and in many areas did not contain permanent water flow with erosion observed along many of the channel beds. The waterbodies would provide connectivity for highly mobile species only, such as migratory birds that utilise water for foraging.		
Water bodies, water quality and hydrological processes	There are several water bodies including dams and streams within the development footprint which will be removed or reshaped. The project involves clearing of native vegetation for construction and removal of dams.	The construction result in changes to the hydrological flow of the streams and decrease in water quality. The construction may reduce water quality in the dams and reduce the foraging habitat for Southern Myotis. PCT 3975 and PCT 4023 are water dependent ecosystem and may be impacted through changes to the hydrological processes. Migratory birds such as Latham's Snipe, Common Greenshank and Sharp-tailed Sandpiper may utilise the muddy substrate to forage and roost in fringing vegetation. No breeding habitat is present for migratory species.	The streams and dams are generally in poor condition due to significant erosion, compaction of soils and an absence of native vegetation. The proposed works will result in better hydrological flows and improved water quality through revegetation of native vegetation to filter the water, reduction of erosion and sedimentation and better flow of the hydrological processes. A sediment and erosion control plan has been prepared to prevent impacts downstream during construction works.
Wind turbine strikes on protected animals	There are no wind turbines proposed for this project.	N/A	N/A
Vehicle strikes	The construction of the project is unlikely to result in an increase the likelihood of	There is a very low potential for vehicle strike with fauna species within the	Mitigation measures have been provided to reduce vehicle strikes.

Prescribed biodiversity impact	Description (Nature, extent and frequency)	Consequences	Justification
	vehicle strike. The vegetation within the development footprint is currently fragmented and separated by large pastoral grasses. In a broader landscape, the development footprint is not connected to large patches of intact native vegetation. There are a low risk of vehicle strikes.	development footprint. The exotic pastoral grasses provide limited habitat for threatened species.	

7.5. Mitigating and managing impacts

Measures proposed to mitigate and manage impacts at the development footprint before, during and after construction are outlined in Table 35.

Table 35: Measures proposed to mitigate and manage impacts

Measure	Risk before mitigation	Risk after mitigation	Action	Measure	Timing	Responsibility
Timing works to avoid critical life cycle events such as breeding or nursing	High	Low	Tree felling of hollow bearing trees should be undertaken outside of spring and summer (main breeding season for native birds and microbats). If this is not possible, strict pre-clearing protocols must be observed when removing tree hollows.	Prevent disturbance to fauna during breeding.	During felling	Contractor, Project Ecologist
Instigating clearing protocols including pre-clearing surveys, daily surveys and staged clearing, the presence of a trained ecological or licensed wildlife handler during clearing events	High	Moderate	Hollow bearing trees were identified during the field survey and contains roosting habitat for birds, arboreal mammals, microbats, etc. A Pre-clearance survey of trees and buildings to be removed and identification/location of habitat trees (e.g. trees with nests or to identify trees with any new hollows) by a suitably qualified ecologist is required. Supervision by a qualified ecologist/licensed wildlife handler during tree and building removal in accordance with best practice methods. Should any additional larger hollow bearing trees be identified, these should be felled by an arborist in one to two metre sections, beginning at the top of the crown, roping, sectioning and	Any fauna utilising habitat within the subject land will be identified and managed to ensure clearing works minimise the likelihood of injuring resident fauna	Prior to and during clearing works	Project Manager / Ecologist

Measure	Risk before mitigation	Risk after mitigation	Action	Measure	Timing	Responsibility
			lowered the hollow sections to the ground for inspection by the ecologist.			
Installing artificial habitats for fauna in adjacent retained vegetation and habitat or human made structures to replace the habitat resources lost and encourage animals to move from the impacted site, e.g. nest boxes	Moderate	Minor	Should any trees removed that have hollows/hollow trunks/fissures, they should be retained as ground fauna habitat and/or used as replacement hollows and attached to trees within the within the development footprint. If it is impractical to use salvaged hollows as replacement tree hollows, compensatory nest boxes should be installed where practical at a ratio of 1 nest box installed per hollow removed. Approximately nine hollow-bearing trees were identified within the development footprint and three will be retained.	Replacement of habitat features removed	Prior to and during clearing works	Project Manager/ Ecologist
Artificial lighting can have a negative impact upon nocturnal and diurnal fauna species. Lighting needs to be designed to minimise impacts to nocturnal and diurnal fauna.	Moderate	Minor	Light pollution can be reduced by limiting the duration of spotlight illumination, reducing the brightness of lights where possible, installing shield fixtures to reduce light scattering, and using narrow-spectrum light sources to reduce the wavelengths likely to interfere with animal behaviour. High priority areas where the implementation of measures to reduce light pollution should be considered would be located adjacent to important habitat. Wildlife friendly lighting (i.e. filtered yellow-green and amber LEDs wavelength of 590 nm with	Lighting impacts on nocturnal and diurnal fauna is minimised	During clearing works and post construction (i.e. design).	Project Manager/ Landscape Designer/ Ecologist

Measure	Risk before mitigation	Risk after mitigation	Action	Measure	Timing	Responsibility
			light shield protection controlling light spill) should be considered adjacent to retained bushland areas.			
Clearing protocols that identify vegetation to be retained, prevent inadvertent damage and reduce soil disturbance; for example, removal of native vegetation by chain-saw, rather than heavy machinery, is preferable in situations where partial clearing is proposed	High	Low	Boundaries of the impact area to be clearly delineated with heavy duty fencing, retained areas marked with "No Go" signage. Measures will be detailed in a CEMP.	Protection of retained vegetation with heavy duty fencing.	Throughout the life of the project	Project Manager in consultation with the ecologist
Sediment barriers or sedimentation ponds to control the quality of water released from the site into the receiving environment	Minor	Negligible	Appropriate controls will be utilised and maintained to manage exposed soil surfaces and stockpiles to prevent sediment discharge into waterways. Soil and erosion measures such as sediment fencing, clean water diversion must be in place prior the commencement of the construction work. Measures will be detailed in a CEMP.	Erosion and sedimentation will be controlled	For the duration of construction works	Construction Manager

Measure	Risk before mitigation	Risk after mitigation	Action	Measure	Timing	Responsibility
Noise barriers or daily/seasonal timing of construction and operational activities to reduce impacts of noise	Minor	Negligible	Daily timing of construction activities is recommended in accordance with Table 1 of Interim Noise Guidelines (2009)	All noise limited to acceptable work hours	Minor	Negligible
Adaptive dust monitoring programs to control air quality	Minor	Negligible	Dust suppression measures will be implemented during construction works to limit dust on site	Mitigate dust created during construction activities	For the duration of construction works	Construction Manager
Temporary fencing to protect significant environmental features such as riparian zones	High	Low	Temporary fencing and signage to be installed at the edge of the subject land to prevent entry into the vegetation patch to be retained.	No unintended clearing or trampling of adjacent vegetation to be retained.	For the duration of construction works	Construction Manager
Hygiene protocols to prevent the spread of weeds or pathogens between infected areas and uninfected areas	Moderate	Minor	Vehicles, machinery and building refuse associated with the development construction should remain only within construction footprint areas, avoiding weed or pathogen related impacts to vegetation outside of the subject land	Prevent spread of weeds or pathogens	For the duration of construction works	Construction Manager
Rubbish dumping	Minor	Negligible	Waste bins to be present on site. Covers to be used to prevent blown litter and the entry of pest animals or rain. Removal and appropriate disposal of general waste generated during the works.	Dumping of rubbish during construction prevented	For the duration of construction works	Construction Manager
Staff training and site briefing to communicate	Minor	Negligible	All staff working on the development will undertake an environmental induction as	All staff entering the Subject land are fully aware of the presence	To occur for all staff entering/working at the subject land. Site	Site Manager

Measure	Risk before mitigation	Risk after mitigation	Action	Measure	Timing	Responsibility
environmental features to be protected and measures to be implemented			part of their site familiarisation. This induction will include items such as: • Site environmental procedures (vegetation management, sediment and erosion control, exclusion fencing and weeds) • What to do in case of environmental emergency (chemical spills, fire, injured fauna) • Key contacts in case of environmental emergency.	of native vegetation adjacent to the site what to do in case of any environmental emergencies	briefings should be updated based on phase of the work and when environmental issues become apparent.	
Making provision for the ecological restoration, rehabilitation and/or ongoing maintenance of retained native vegetation habitat on or adjacent to the subject land	Minor	Negligible	Retained vegetation should be managed as part of the ongoing maintenance. Weeds should be managed and controlled within the adjacent vegetation to be retained.	Retained vegetation to be managed and protected.	Following completion of construction activities.	Construction Manager

8. Impact summary

Following implementation of the BAM and the BAMC, the following impacts have been determined.

8.1. Serious and Irreversible Impacts (SAII)

The development footprint contains one SAII entity as outlined in Table 36:

- 1.35 ha of TEC *Cumberland Plain Woodland in the Sydney Basin Bioregion* (comprised of PCT 3320 in low condition).

Detailed consideration of whether impacts on candidate species are serious and irreversible is included in Table 37 and on TECs is included in Figure 23.

Table 36: SAII - TEC

Species / Community	Principle	Direct impact individuals / area (ha)	Threshold
Cumberland Plain Woodland in the Sydney Basin Bioregion	1 & 2	1.35	Not set.

Table 37: Evaluation of an impact on a TEC consistent with 9.1.1 of the BAM

Impact Assessment Provisions 10.2.2.1	Assessment
1. the action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII	The development footprint has been situated within a section of the subject land containing predominantly low biodiversity values. The majority of impacts (93%) will occur in areas of low biodiversity values such as exotic grassland (260 ha), exotic vegetation (7.17 ha) and cleared land (10.87 ha). Several small patches of PCT 3320 which represents part Cumberland Plain Woodlands will be impacted (1.35 ha). Consideration of retaining biodiversity values was conducted during the design phase, however, due to the low retention value and the undulating landscape, the vegetation could not be retained in the final design. The patches consist of highly fragmented stands of *Eucalyptus moluccana* and very occasional *E. tereticornis*. No other native flora species were recorded within the midstorey or ground cover during the collection of plot data. The trees were noted in poor health, a significant amount of dead foliage was noted during field surveys. The trees have been subject to compaction of soils and on-going grazing impacts. The project involves an extensive restoration project to reshape and revegetate the riparian corridor in accordance with the VMP (ELA 2025). The restoration works will include revegetation using key diagnostic species in the canopy, mid and ground layer for local PCTs including PCT 3320 and 4023.

Impact Assessment Provisions 10.2.2.1	Assessment
2a. evidence of reduction in geographic distribution (Principle 1, clause 6.7(2)(a) BC Regulation) as the current total geographic extent of the TEC in NSW AND the estimated reduction in geographic extent of the TEC since 1970 (not including impacts to the proposal)	Cumberland Plain Woodland has undergone a substantial reduction in the geographic distribution. The most recent information about the reduction of this TEC in NSW is contained in the Final Determination for Cumberland Plain Woodland, which includes the following: • The total extent of Cumberland Plain Woodland was estimated to be ~8.8% of the community's pre-European distribution by Tozer in 2003 based on aerial photography from 1998. • This estimate was updated in 2007, showing a decline of ~5.2% in 9 years. • There are currently no estimates of the decline in the TEC since 1970.
2b. extent of reduction in ecological function for the TEC using evidence that describes the degree of environmental degradation or disruption to biotic processes (Principle 2, clause 6.7(2)(b) BC Regulation) indicated by: - change in community structure - change in species composition - disruption of ecological processes - invasion and establishment of exotic species - degradation of habitat - fragmentation of habitat	The extent of reduction in ecological function for the TEC is also found in the Final Determination, as follows: • The community structure has changed such that almost all of the remaining Cumberland Plain Woodland is considered to be regrowth woodland from past clearing activities. • Species composition has changed such that remnants are largely degraded by weed invasion and regrowth stands with high densities of saplings or shrubs may supress ground flora. • Ecological processes have been disrupted by the chemical and structural modification associated with agricultural land uses and more recent expansion of urban land uses which the TEC has historically been subjected to. • The TEC has been identified as being severely fragmented.
2c. evidence of restricted geographic distribution (Principle 3, clause 6.7 (2) (c) BC Regulation), based on the TECs geographic range in NSW according to the: i. extent of occurrence ii. area of occupancy, and iii. number of threat-defined locations.	Cumberland Plain woodland is highly restricted to the Sydney Basin Bioregion. According to the Final Determination, it was estimated to occur within an extent of 2,810 km^2 and is known from the Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly LGAs. These locations are all subject to threats to the TEC, including weed invasion and clearing of native vegetation.
2d. evidence that the TEC is unlikely to respond to management (Principle 4, clause 6.7 (2) (d) BC Regulation).	The Final Determination states that invasion of exotic species are listed as Key Threatening Process, including invasion by exotic: • vines and scramblers • Lantana • Boneseed • Perennial grasses • Escaped garden plants. The Cumberland Plain Recovery Plan (NSW DCCW 2010) states that the main constraints for the TEC recovery include fragmentation or vegetation in poor condition, weed invasion and edge effects. The Recovery Plan states that priority for larger patches of remnant vegetation to be conserved rather than small, fragmented patches. The vegetation within the development footprint

Impact Assessment Provisions 10.2.2.1	Assessment
	is small, in poor condition and subject to fragmentation. The recovery plan indicates the TEC responds to active management.
3. Where the TBDC indicated that data is 'unknown' or 'data deficient' for a TEC for a criterion listed in subsection 9.1.1(2), the assessor must record this in the BDAR or BCAR.	N/A – all data is provided in the Final Determination as summarised above.
4a. the impact on the geographic extent of the TEC (Principles 1 and 3) by estimating the total area of the TEC to be impacted by the proposal: i. in hectares, and ii. as a percentage of the current geographic extent of the TEC in NSW.	The total area of the TEC to be affected by the proposal is 1.35 ha. Current vegetation mapping estimates 21,915 ha of Cumberland Plain Woodland (identified as PCT849 or 850 by previous vegetation mapping) is present in NSW. Therefore, the area of TEC to be affected represents an estimate of 0.01% of the current geographic extent of the TEC. It should be noted that the GIS analysis used existing vegetation mapping datasets and did not include ground truthing the extent of the mapped Cumberland Plain Woodland.
4b. the extent that the proposed impacts are likely to contribute to further environmental degradation or the disruption of biotic processes (Principle 2) of the TEC by: i. estimating the size of any remaining, but now isolated, areas of the TEC; including areas of the TEC within 500 m of the development footprint or equivalent area for other types of proposals ii. describing the impacts on connectivity and fragmentation of the remaining areas of TEC measured by: - distance between isolated areas of the TEC, presented as the average distance if the remnant is retained AND the average distance if the remnant is removed as proposed, and - estimated maximum dispersal distance for native flora species characteristic of the TEC, and - other information relevant to describing the impact on connectivity and	The vegetation within the development footprint is highly fragmented and is disconnected from other patches of vegetation via major arterial roads and agricultural lands. There are small patches of the TEC mapped in the adjacent fragmented agricultural lands to the west and south of the development footprint. The vegetation within the is disconnected with these patches due to > 100 m gaps between patches. The agricultural lands are subject to intensive grazing of livestock and nutrient enrichment from improved pastural grasses. Existing vegetation mapping (e.g., SVTM, DPE 2022) has mapped 31 ha of PCT 3320 within 500 m of the subject land. The TEC mapped within the development footprint is in poor condition. It is represented by remnant canopy trees with 90% cover of exotic pastural grass. The patches are represented as small patches of remnant trees interspersed with large areas of grazing lands. Patches of the TEC are between 300 – 800 m away from each other and may represent challenges for pollinators to exchange genetic material between patches. The absence of native species in the ground and midstorey and lack of species diversity indicates that these patches are currently fragmented from each other for pollinating insects. However, mobile species such as birds and bat species may traverse large open areas. The estimated maximum dispersal distance for Grey-headed Flying-fox would be their average nightly foraging range of 20 km. The proposed development aims to improve connectivity within the development footprint through revegetation works within the riparian corridor. These works include substantial planting of native vegetation which may include PCT 3320 vegetation. The riparian corridor will connect the vegetation to scattered patches of vegetation in the west and north-south direct.

Impact Assessment Provisions 10.2.2.1	Assessment
fragmentation, such as the area to perimeter ratio for remaining areas of the TEC as a result of the development. - describing the condition of the TEC according to the vegetation integrity score for the relevant vegetation zone(s) (Section 4.3). The assessor must also include the relevant composition, structure and function condition scores for each vegetation zone.	

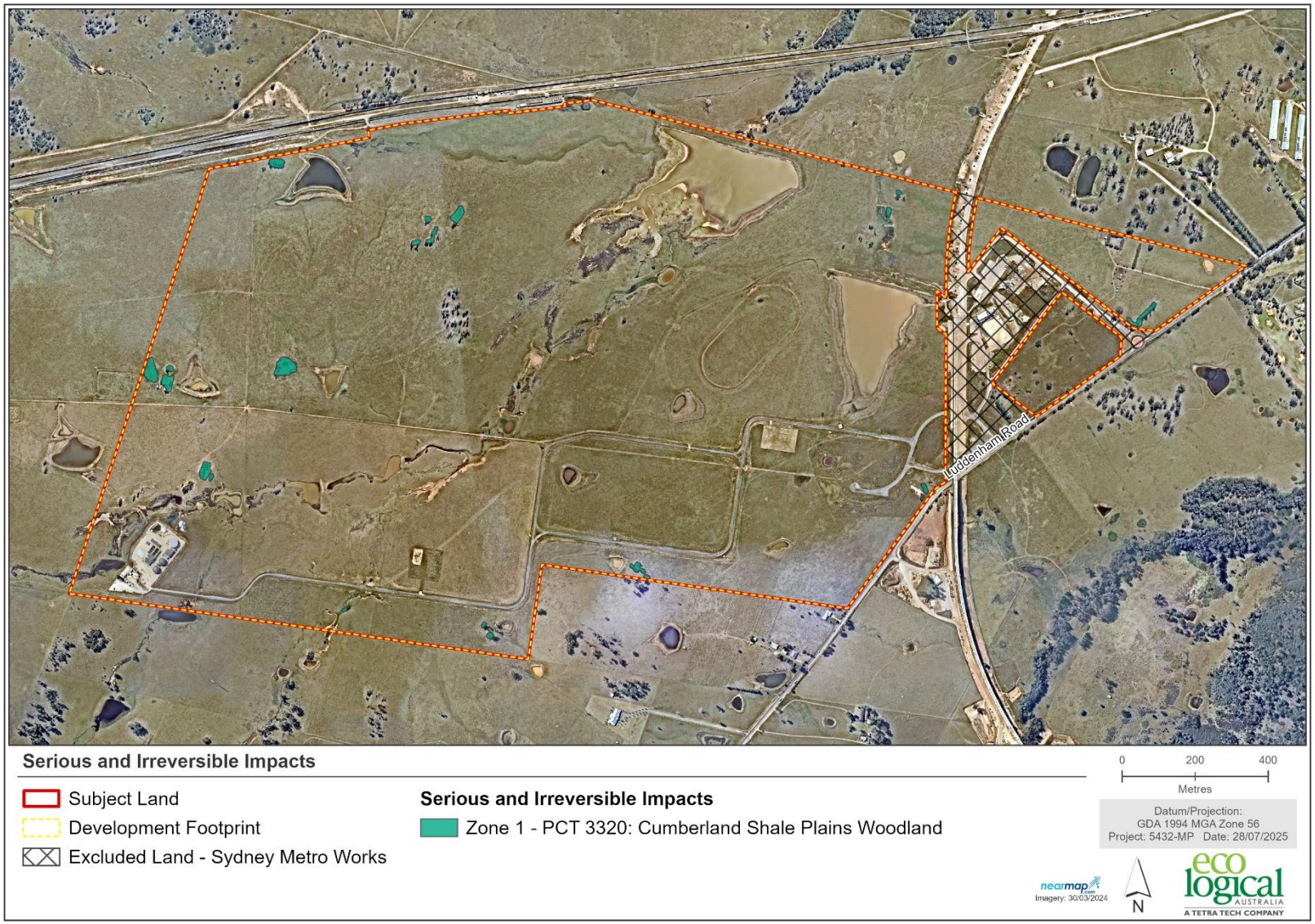

Figure 23: Serious and Irreversible Impacts

8.2. Impacts requiring offsets

The impacts of the development requiring offset for native vegetation are outlined in Table 38 and show on Figure 24. The impacts of the development requiring offset for species credit species and threatened species habitat are outlined in Table 39.

Table 38: Impacts to native vegetation requiring offsets

Veg Zone	PCT ID	PCT Name	Condition	Area (ha)
3	3975	Southern Lower Floodplain Freshwater Wetlands	Low	0.53

Table 39: Impacts on threatened species and threatened species habitat that require offsets

Species	Common Name	Direct impact number of individuals / habitat (ha)	NSW listing status	EPBC Listing status
Myotis macropus	Southern Myotis	2.19	Vulnerable	Not listed

8.3. Impacts not requiring offsets

The impacts of the development not requiring offset for native vegetation are outlined in Table 40 and shown on Figure 25. This includes impacts to native vegetation within the development footprint which had a low vegetation integrity score and did not require offsets. The vegetation integrity score for PCT 3320 and 4023 was 7.9 and 12.2, respectively. When the score is less than 15 for a TEC, the vegetation does not require offsets. The development also includes impacts to 0.46 ha of planted native vegetation which do not require offsets. Planted native vegetation do not have a vegetation integrity score.

Table 40: Impacts to native vegetation that do not require offsets

PCT ID	PCT Name	Vegetation Class	Vegetation Formation	Direct impact (ha)	Rationale
3320	Cumberland Shale Plains Woodland	Coastal Valley Grassy Woodlands	Grassy Woodlands	1.35	VI score 7.9 is less than 15.
4023	Coastal Valleys Riparian Forest	Coastal Floodplain Wetlands	Forested Wetlands	1.39	VI score 12.2 is less than 15.

8.4. Areas not requiring assessment

Cleared areas (i.e. 10.87 ha of gravel access tracks), exotic grazing land (260 ha) and exotic vegetation (7.17 ha) do not require assessment. Areas not requiring assessment are shown on Figure 26.

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8.5. Credit summary

Ecosystem credits are required for one PCT impacted by the development as outlined in Table 41.

The number of species credits required for the development are outlined in Table 42. A biodiversity credit report is included in Appendix H.

Table 41: Impacts to native vegetation that require offsets

Veg Zone	PCT ID	PCT Name	Vegetation class	Vegetation formation	Area (ha)	Credits required
3	3975	Southern Lower Floodplain Freshwater Wetlands	Coastal Freshwater Lagoons	Freshwater Wetlands	0.53	17

Table 42: Species credit summary

Species	Common Name	Direct impact habitat (ha)	Credits required
Myotis macropus	Southern Myotis	2.19	17

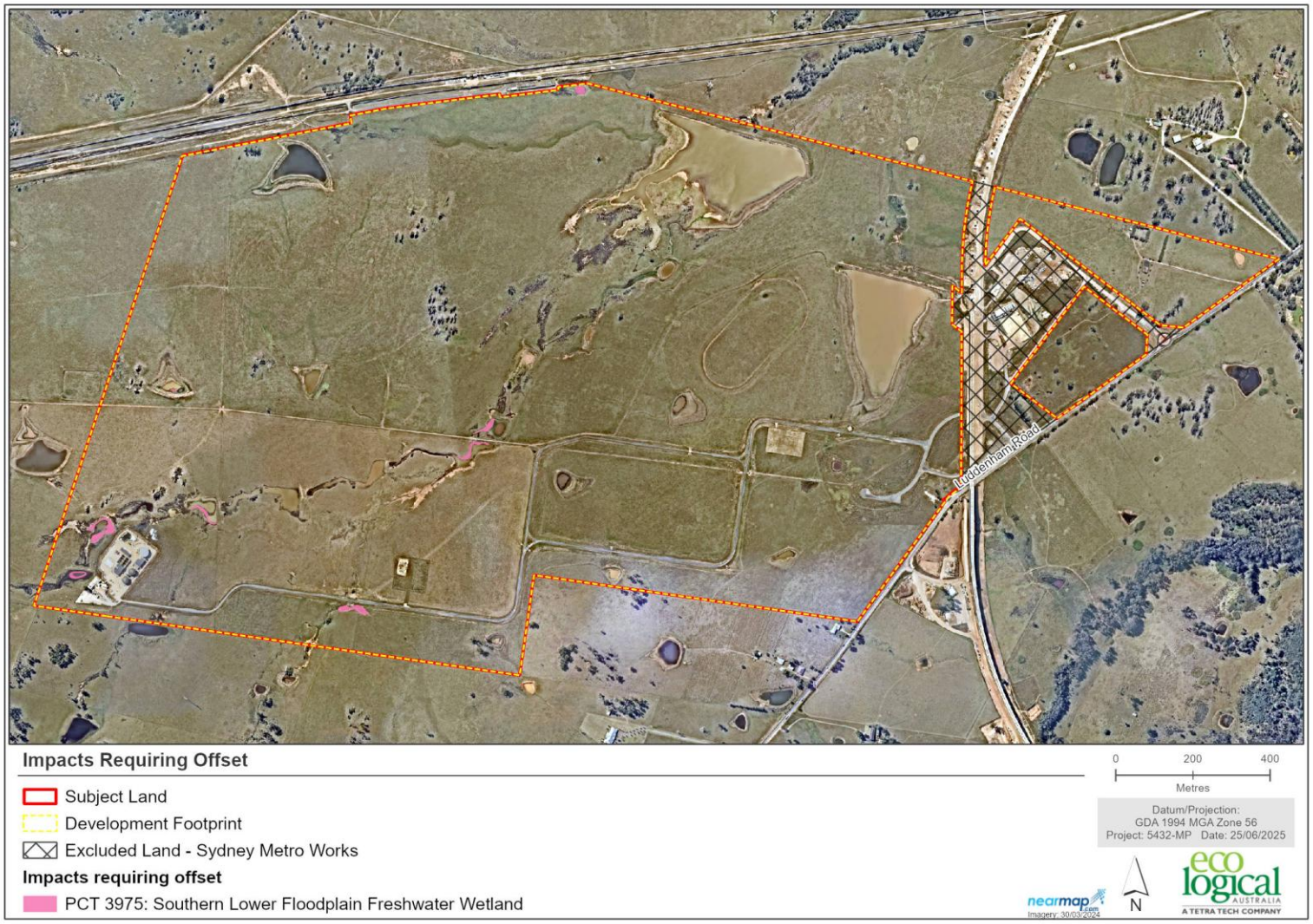

Figure 24: Impacts requiring offset

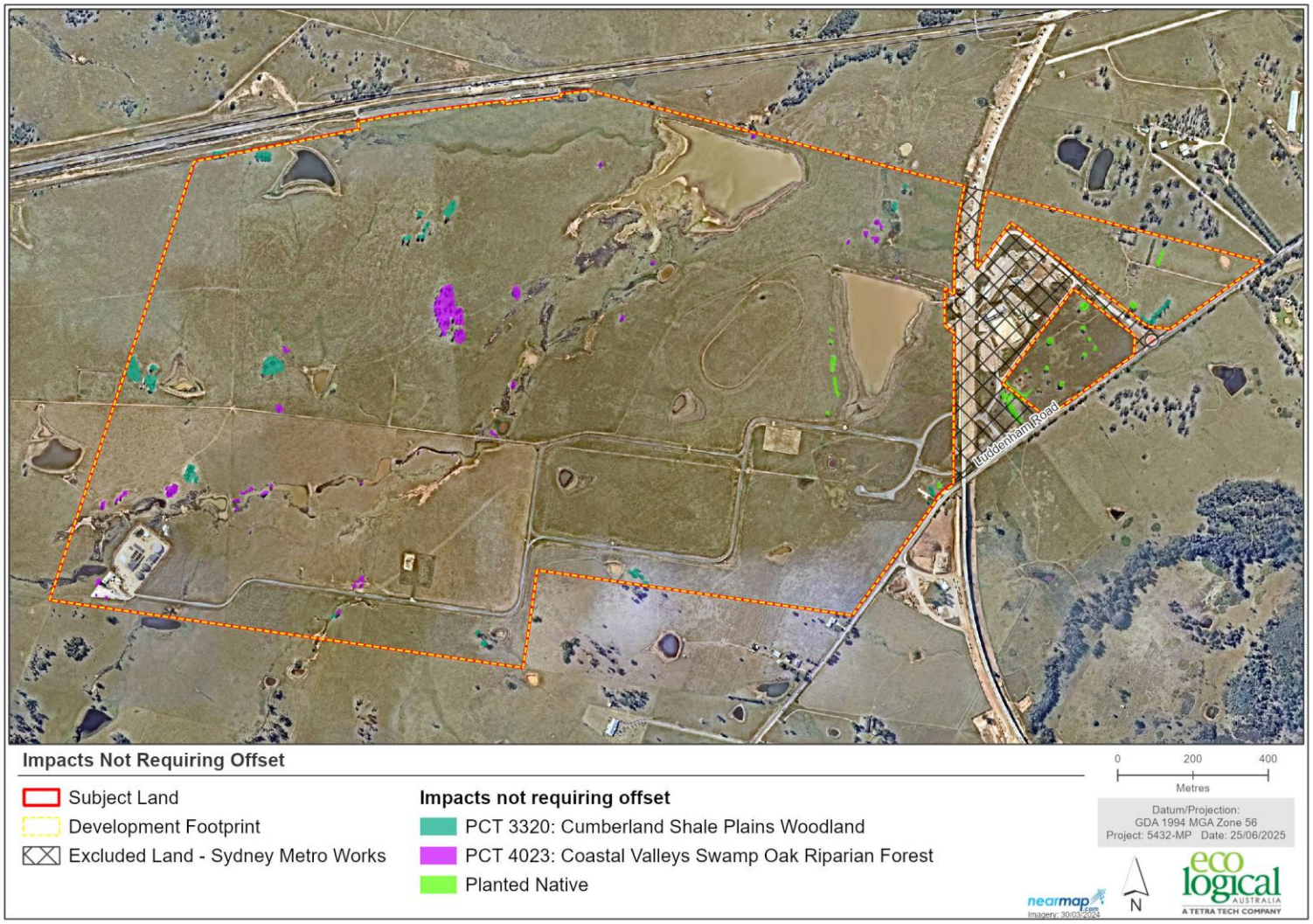

Figure 25: Impacts not requiring offset

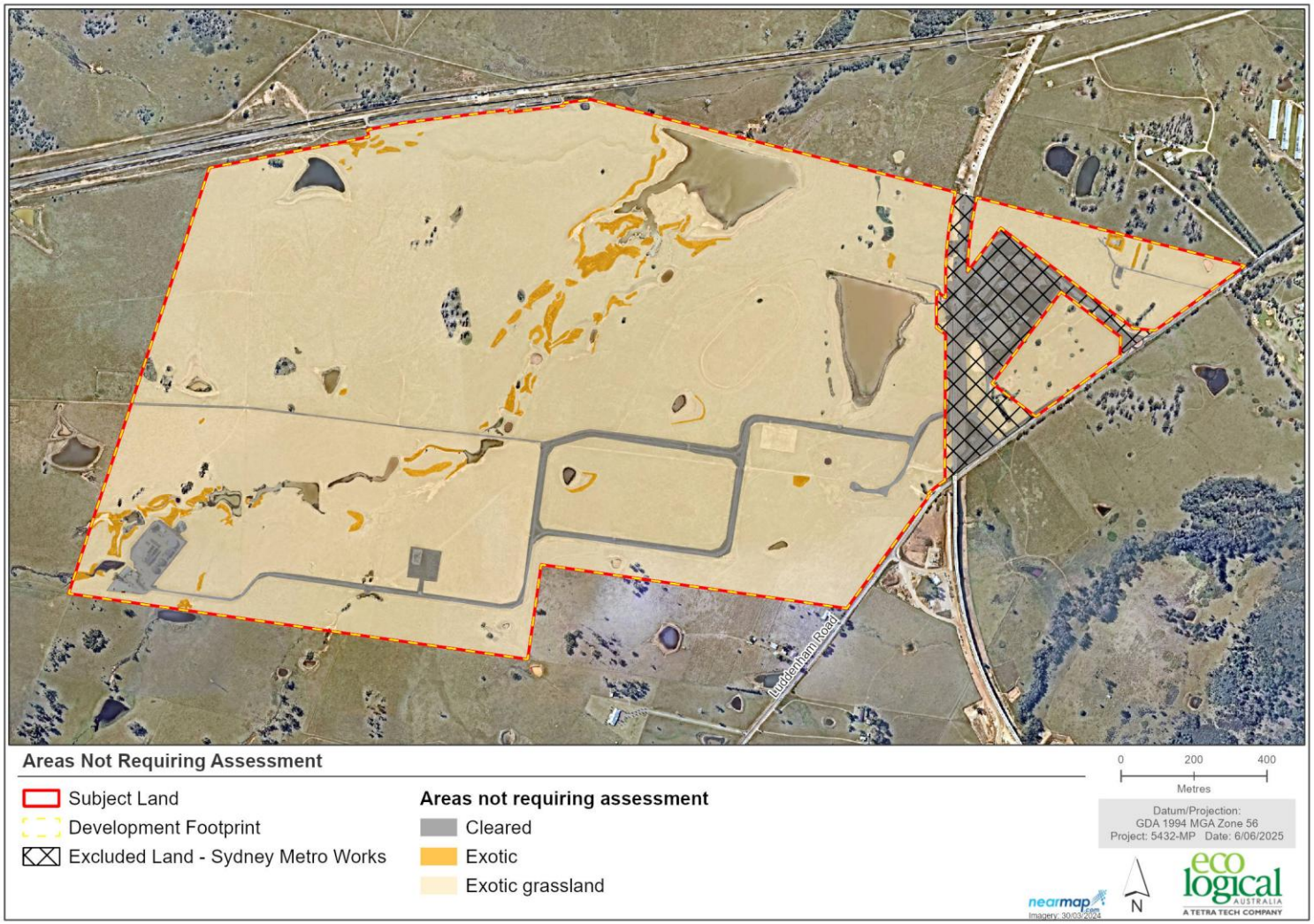

Figure 26: Areas not requiring assessment

9. Commonwealth EPBC Act

The EPBC Act establishes a process for assessing the environmental impact of activities and developments where MNES may be affected. Under the Act, any action which 'has, will have, or is likely to have a significant impact on a matter of MNES' is defined as a 'controlled action', and requires approval from the Commonwealth Department of Environment, Climate Change and Water (DECCW), which is responsible for administering the EPBC Act.

An assessment of the project was undertaken in accordance with the Significant Impact Guidelines 1.1 for the following MNES:

- *Gallinago hardwickii* (Latham's Snipe)
- *Calidris acuminata* (Sharp-tailed Sandpiper)
- *Tringa nebularia* (Common Greenshank)
- *Pteropus poliocephalus* (Grey-headed Flying-fox).

The project was referred to the Commonwealth DCCEEW (ref number 2025/10276) to determine whether the project is a Controlled Action. On the 18 November 2025 the Commonwealth concluded that the project is not a Controlled Action and therefore no further assessment or approval is required under the EPBC Act.

10. Conclusion

The proposed development involves direct and indirect impacts to the biodiversity values within the development footprint, through the clearing of native vegetation within the subject land. The vegetation within the subject land has been largely cleared and has an extensive history of use for cattle grazing of use for agricultural purposes, which has contributed to the overall poor ecological values present.

Three PCTs were recorded within the development footprint:

- 3320 *Cumberland Shale Plains Woodland*
- 4023 *Coastal Valley Riparian Forest*
- 3975 *Southern Lower Floodplain Freshwater Wetland.*

The occurrence of PCT 3320 within the subject land is consistent with the Threatened Ecological Community (TEC) *Cumberland Plain Woodland in the Sydney Basin Bioregion,* listed as critically endangered under the BC Act. It did not meet the criteria for listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The occurrence of PCT 4023 within the subject land is consistent with the TEC *Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregion,* listed as endangered under the BC Act. It did not meet the criteria for listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). PCT 3975 has one associated TEC listed in BioNet Vegetation Information System (VIS). However, the vegetation mapped as PCT 3975 within the subject land occurs within artificial environment (i.e. dams), so does not represent part of a TEC.

The proposed works directly impact of 1.35 ha of PCT 3320, 1.39 ha of PCT 4023 and 0.53 ha of PCT 3975. No Ecosystem Credits are required for PCT 3320 nor PCT 4023 because the Vegetation Integrity (VI) score is less than 15 for each of these PCTs. A total of 17 Ecosystem Credits are required for impacts to PCT 3975.

The development footprint will remove 0.46 ha of planted native vegetation which does not conform to a PCT, therefore the Streamlined Assessment Module – Planted Native Vegetation was applied in accordance with Appendix D of the Biodiversity Assessment Method 2020 (BAM). No ecosystem credits are required to offset impacts for planted native vegetation.

The subject land also contains cleared land, built environment and exotic vegetation which lack biodiversity values. Utilisation of these areas for the proposed development demonstrates attempts to avoid and minimise impacts to biodiversity values.

No threatened flora species were recorded on or within the subject land or are likely to persist in the soil profile. The vegetation within the subject land was deemed highly disturbed. No species credits are required for threatened flora.

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Myotis macropus (Southern Myotis) was recorded during the field survey in 2016 and 2024, and likely to utilise the dams within the development footprint as foraging habitat. The number of species credits required for the Southern Myotis is 17.

Haliaeetus leucogaster (White-bellied Sea Eagle) was observed utilising a large dam within the development footprint for foraging. As there were no stick nests observed during targeted survey, there is no breeding habitat within the development footprint. Therefore, no species credits are required for the White-bellied Sea Eagle.

Calidris acuminata (Sharp-tailed Sandpiper) and *Gallinago hardwickii* (Latham's Snipe) were recorded during the field surveys and are likely to utilise the dams within the development footprint as foraging habitat. The literature review identified one BioNet record for *Tringa nebularia* (Common Greenshank) from 2006 within the development footprint. As these are not BC Act listed species, they do not require Species Credits. No other threatened fauna species were recorded within the subject land. There is potential that highly mobile threatened species may utilise the vegetation for foraging resources on occasion.

The subject land contains one candidate for Serious and Irreversible Impact (SAII), *Cumberland Plain Woodland in the Sydney Basin Bioregion*. An assessment of this candidate SAII has been included in this report.

The following Matters of National Environmental Significance (MNES) were identified as having potential to be affected by the proposed subdivision:

- *Calidris acuminata* (Sharp-tailed Sandpiper) listed as vulnerable and migratory under the EPBC Act
- *Gallinago hardwickii* (Latham's Snipe) listed as vulnerable and migratory under the EPBC Act
- *Tringa nebularia* (Common Greenshank) listed as endangered and migratory under the EPBC Act
- *Pteropus poliocephalus* (Grey-headed Flying-fox) listed as vulnerable under the EPBC Act.

An assessment of the Commonwealth Significant Impact Criteria was undertaken for these MNES and included in a separate Referral under the EPBC Act. It concluded that the project would not have a significant impact on these threatened species.

Mitigation measures relating to direct, indirect and prescribed impacts are provided within this report to reduce and address any residual impacts from the development.

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Appendix A Definitions

Terminology	Definition
Biodiversity credit report	The report produced by the Credit Calculator that sets out the number and class of biodiversity credits required to offset the remaining adverse impacts on biodiversity values at a development footprint, or on land to be biodiversity certified, or that sets out the number and class of biodiversity credits that are created at a biodiversity stewardship site.
BioNet Atlas	The BioNet Atlas (formerly known as the NSW Wildlife Atlas) is the OEH database of flora and fauna records. The Atlas contains records of plants, mammals, birds, reptiles, amphibians, some fungi, some invertebrates (such as insects and snails) and some fish
Broad condition state:	Areas of the same PCT that are in relatively homogenous condition. Broad condition is used for stratifying areas of the same PCT into a vegetation zone for the purpose of determining the vegetation integrity score.
Connectivity	The measure of the degree to which an area(s) of native vegetation is linked with other areas of vegetation.
Credit Calculator	The computer program that provides decision support to assessors and proponents by applying the BAM, and which calculates the number and class of biodiversity credits required to offset the impacts of a development or created at a biodiversity stewardship site.
Development	Has the same meaning as development at section 4 of the EP&A Act, or an activity in Part 5 of the EP&A Act. It also includes development as defined in section 115T of the EP&A Act.
Development footprint	The area of land that is directly impacted on by a proposed development, including access roads, and areas used to store construction materials.
Development footprint	An area of land that is subject to a proposed development that is under the EP&A Act.
Ecosystem credits	A measurement of the value of EECs, CEECs and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a development footprint and the gain in biodiversity values at a biodiversity stewardship site.
High threat exotic plant cover	Plant cover composed of vascular plants not native to Australia that if not controlled will invade and outcompete native plant species.
Hollow bearing tree	A living or dead tree that has at least one hollow. A tree is considered to contain a hollow if: (a) the entrance can be seen; (b) the minimum entrance width is at least 5 cm; (c) the hollow appears to have depth (i.e. you cannot see solid wood beyond the entrance); (d) the hollow is at least 1 m above the ground. Trees must be examined from all angles.
Important wetland	A wetland that is listed in the Directory of Important Wetlands of Australia (DIWA) and SEPP 14 Coastal Wetlands
Linear shaped development	Development that is generally narrow in width and extends across the landscape for a distance greater than 3.5 kilometres in length
Local population	The population that occurs in the subject land. In cases where multiple populations occur in the subject land or a population occupies part of the subject land, impacts on each subpopulation must be assessed separately.
Local wetland	Any wetland that is not identified as an important wetland (refer to definition of Important wetland).

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Terminology	Definition
Mitchell landscape	Landscapes with relatively homogeneous geomorphology, soils and broad vegetation types, mapped at a scale of 1:250,000.
Multiple fragmentation impact development	Developments such as wind farms and coal seam gas extraction that require multiple extraction points (wells) or turbines and a network of associated development including roads, tracks, gathering systems/flow lines, transmission lines
Operational Manual	The Operational Manual published from time to time by OEH, which is a guide to assist assessors when using the BAM
Patch size	An area of intact native vegetation that: a) occurs on the development footprint or biodiversity stewardship site, and b) includes native vegetation that has a gap of less than 100 m from the next area of native vegetation (or ≤30 m for non-woody ecosystems). Patch size may extend onto adjoining land that is not part of the development footprint or stewardship site.
Proponent	A person who intends to apply for consent to carry out development or for approval for an activity.
Reference sites	The relatively unmodified sites that are assessed to obtain local benchmark information when benchmarks in the Vegetation Benchmarks Database are too broad or otherwise incorrect for the PCT and/or local situation. Benchmarks can also be obtained from published sources.
Regeneration	The proportion of over-storey species characteristic of the PCT that are naturally regenerating and have a diameter at breast height <5 cm within a vegetation zone.
Remaining impact	An impact on biodiversity values after all reasonable measures have been taken to avoid and minimise the impacts of development. Under the BAM, an offset requirement is calculated for the remaining impacts on biodiversity values.
Retirement of credits	The purchase and retirement of biodiversity credits from an already-established biobank site or a biodiversity stewardship site secured by a biodiversity stewardship agreement.
Riparian buffer	Riparian buffers applied to water bodies in accordance with the BAM
Sensitive biodiversity values land map	Development within an area identified on the map requires assessment using the BAM.
Site attributes	The matters assessed to determine vegetation integrity. They include: native plant species richness, native over-storey cover, native mid-storey cover, native ground cover (grasses), native ground cover (shrubs), native ground cover (other), exotic plant cover (as a percentage of total ground and mid-storey cover), number of trees with hollows, proportion of over-storey species occurring as regeneration, and total length of fallen logs.
Site-based development	a development other than a linear shaped development, or a multiple fragmentation impact development
Species credits	The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Biodiversity Data Collection.
Subject land	Is land to which the BAM is applied in Stage 1 to assess the biodiversity values of the land. It includes land that may be a development footprint, clearing site, proposed for biodiversity certification or land that is proposed for a biodiversity stewardship agreement.

Terminology	Definition
Threatened Biodiversity Data Collection	Part of the BioNet database, published by OEH and accessible from the BioNet website.
Threatened species	Critically Endangered, Endangered or Vulnerable threatened species as defined by Schedule 1 of the BC Act, or any additional threatened species listed under Part 13 of the EPBC Act as Critically Endangered, Endangered or Vulnerable.
Vegetation Benchmarks Database	A database of benchmarks for vegetation classes and some PCTs. The Vegetation Benchmarks Database is published by OEH and is part of the BioNet Vegetation Classification.
Vegetation zone	A relatively homogenous area of native vegetation on a development footprint, land to be biodiversity certified or a biodiversity stewardship site that is the same PCT and broad condition state.
Wetland	An area of land that is wet by surface water or ground water, or both, for long enough periods that the plants and animals in it are adapted to, and depend on, moist conditions for at least part of their life cycle. Wetlands may exhibit wet and dry phases and may be wet permanently, cyclically or intermittently with fresh, brackish or saline water
Woody native vegetation	Native vegetation that contains an over-storey and/or mid-storey that predominantly consists of trees and/or shrubs

Appendix B Vegetation plot data

Table 43: Vegetation integrity data (Composition, structure and function)

plot	pct	condition class	easting	northing
Plot 1	4023	low	288824	6252990
Plot 2	4023	low	289597	6253415
Plot 3	3320	low	289507	6253680
Plot 4	3975	low	288666	6252868

Composition (species)						
Plot no.	Tree	Shrub	Grass	Forb	Fern	Other
1	1	0	0	0	0	0
2	1	0	1	0	0	0
3	1	0	0	0	0	0
4	0	0	4	5	0	0

Structure (Total cover %)						
Plot no.	Tree	Shrub	Grass	Forb	Fern	Other
1	20.0	0.0	0.0	0.0	0.0	0.0
2	15.0	0.0	0.1	0.0	0.0	0.0
3	20.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	40.2	0.5	0.0	0.0

Function												
Plot no.	Large trees	Hollows	Litter cover (%)	Length fallen logs (m)	Tree stem 5-9 cm	Tree stem 10-19 cm	Tree stem 20-29 cm	Tree stem 30-49 cm	Tree stem 50-79 cm	Tree stem 80+ cm	Tree regen	HTW cover %
1	2	0	1.8	53	0	0	0	0	1	0	0	43.3
2	5	2	6.6	145	0	0	0	1	1	1	0	92.3
3	2	1	4.4	12	0	0	0	1	1	0	0	18.1
4	0	0	7.8	0	0	0	0	0	0	0	0	33.8

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Table 44: Species matrix (species recorded by plot)

Species	Common Name	Exotic	High Threat Weed	Growth Form Group	Plot 1			Plot 2			Plot 3			Plot 4		
					Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance
Acetosella vulgaris	Sheep Sorrel	*	1													
Aster spp.		*													0.2	50
Bromus catharticus	Praire Grass	*				0.1	10									
Casuarina glauca	Swamp Oak			Tree (TG)		20	6		15	4						
Cenchrus clandestinus	Kikuyu Grass	*	1			40	1000		90	1000		3	1000			
Chenopodium spp.	Goosefoot, Crumbweed			Shrub (SG)		0.1	20		0.1	1						
Chloris gayana	Rhodes Grass	*	1			2	100		2	50		15	1000		0.5	20
Cirsium vulgare	Spear thistle	*										0.1	5		0.2	10
Cynodon spp.	Common Couch			Grass & grasslike (GG)		1	100					60	1000			
Cynodon incompletus	Blue Couch	*													1	50
Cyperus eragrostis	Tall Flatsedge	*	1												0.1	3
Daucus carota	Wild Carrot	*				0.1	20									
Dichondra repens	Kidneyweed			Forb (FG)											0.1	20
Echinochloa crus-galli	Barnyard Grass	*													0.1	3
Eleusine indica	Crowsfoot Grass	*														

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Species	Common Name	Exotic	High Threat Weed	Growth Form Group	Plot 1			Plot 2			Plot 3			Plot 4		
					Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance
Eucalyptus moluccana	Grey Box			Tree (TG)								20	2			
Hypochaeris radicata	Cat's Ear	*													0.1	4
Juncus acutus subsp.acutus	Spiny Rush	*	1												30	500
Juncus usitatus				Grass & grasslike (GG)					0.1	1					5	50
Lachnagrostis filiformis	Common Blown-grass			Grass & grasslike (GG)											0.1	3
Lepidium africanum	Common Peppercress	*				0.1	100		0.1	10		0.1	10			
Lycium ferocissimum	African Boxthorn	*	1			1	5		0.2	1						
Marrubium spp.		*														
Marrubium spp.		*							0.1	1						
Modiola caroliniana	Red-flowered Mallow	*				0.2	100									
Onopordum spp.		*													0.1	2
Paspalum dilatatum	Paspalum	*	1			0.2	50								3	50
Paspalum distichum	Water Couch			Grass & grasslike (GG)											35	1000
Persicaria decipiens	Slender Knotweed			Forb (FB)											0.1	5
Plantago lanceolata	Lamb's Tongues	*							0.1	1					0.1	3

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Species	Common Name	Exotic	High Threat Weed	Growth Form Group	Plot 1			Plot 2			Plot 3			Plot 4		
					Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance	Stratum & Layer	Cover	Abundance
Plantago lanceolata	Lamb's Tongues	*				0.2	100					2	20			
Polygonum aviculare	Prostrate Knotweed	*													0.1	1
Portulaca oleracea	Purslane Weed			Forb (FB)											0.1	1
Rumex bidens				Forb (FB)											0.1	6
Rumex crispus	Curled Dock	*				0.2	100									
Senecio madagascariensis	Fireweed	*	1			0.1	10		0.1	10		0.1	3		0.2	20
Setaria spp.				Grass & grasslike (GG)		40	100		1	100						
Sida rhombifolia	Paddy's Lucerne	*				0.2	1000		0.1	20		0.1	3			
Solanum sisymbriifolium		*				0.1	20		0.1	5		0.1	2			
Sonchus asper	Rouch Sow-Thistle			Forb (FB)											0.1	10
Trifolium repens	White Clover	*				0.2	500		0.1	5					0.2	20
Typha orientalis				Grass & grasslike (GG)											0.1	3
Verbena bonariensis		*													0.1	1

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Table 45: Change in vegetation integrity scores for each management zone – future scores

Veg zone	PCT	Management zone	Area ha	Composition	Structure	Function	Veg integrity score	Change in score	Total change in score
1	3320	Direct	1.35	0	0	0	0	-7.9	-7.9
2a	4023	Direct	0.69	0	0	0	0	-12.2	-7.2
2b	4023	Canopy	0.71	1.7	16.1	37.2	10.1	-2.2	
3	3975	Direct	0.53	0	0	0	0	-51.7	-51.7

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Appendix C Description of habitat features during migratory bird surveys 2016 and 2023-2024

Table 46: Location, time, and habitat features of migratory bird surveys in the subject land

Date	Location	Start (am)	Finish (am)	Habitat Features
7 December 2016	1	5:45	6.50	fringing vegetation incl. *Juncus acutus* and *Eleocharis* sp. disturbed by cattle – pugging on edges
	2	7:00	8:00	minimal fringing vegetation incl. Juncus acutus and Eleocharis sp. disturbed by cattle – pugging on edges
21 December 2016	3	5:55	6:55	minimal fringing vegetation incl. Typha sp. and Eleocharis sp. disturbed by cattle – pugging on edges
	4	7:00	8:00	fringing vegetation of Typha sp. disturbed by cattle – pugging on edges
9 January 2017	5	5:40	7:00	fringing vegetation of Eleocharis sp. and Juncus acutus disturbed by cattle, foxes and fertilisers minimal water flow
	6	7:30	8:30	fringing vegetation of Eleocharis sp. and Typha sp. disturbed by cattle, foxes and fertilisers minimal water flow
23 January 2017	7	5:50	6:50	• disturbed by cattle, foxes and fertilisers surface flow impeded by roadway
	8	7:15	8:15	• disturbed by cattle, foxes and fertilisers • surface flow into dam emergent reeds (grazed) and weedy banks
2 February 2017	9	6:00	7:00	• disturbed by cattle • surface flow into dam • emergent Eleocharis sp. and weed grasses i.e. Cenchrus clandestinus on banks exposed mud on banks
	10	7:20	8:25	• disturbed by cattle • surface flow into dam • emergent Eleocharis sp. and weed grasses i.e. Cenchrus clandestinus on banks

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Date	Location	Start (am)	Finish (am)	Habitat Features
				exposed mud on banks
1 September 2023	11	8:30	9:00	Nest, no nest activity
8 September 2023	11	10:30	1:30	Nest, no nest activity
10 November 2023	12	6:02	7:05	as above
	13	7:20	8:20	as above
15 November 2023	14	6:06	6:26	• as above
	15	6:30	6:50	• as above
	16	7:10	7:30	• as above
21 December 2023	17	5:50	6:46	• as above
	18	6:48	7:28	as above
	19	7:34	8:03	• as above
18 December 2024	20	6:05	8:05	• as above
29 January 2024	21	7:26	7:46	• as above

Appendix D EPBC Act Likelihood of Occurrence

An assessment of likelihood of occurrence was made for threatened and migratory species identified from the Protected Matters Search Tool. Five terms for the likelihood of occurrence of species are used in this report. This assessment was based on database or other records, presence or absence of suitable habitat, features of the proposal site, results of the site inspection and professional judgement. Some Migratory or Marine species identified from the Commonwealth database search have been excluded from the assessment, due to lack of habitat. The terms for likelihood of occurrence are defined below:

- 'known' = the species was or has been observed on the site
- 'likely' = a medium to high probability that a species uses the site
- 'potential' = suitable habitat for a species occurs on the site, but there is insufficient information to categorise the species as likely to occur, or unlikely to occur
- 'unlikely' = a very low to low probability that a species uses the site
- 'no' = habitat within the development footprint and in the vicinity is unsuitable for the species.

A test of significance was conducted for threatened species or ecological communities that were recorded within the development footprint or had a higher likelihood of occurring and were not recorded during the site visit. It is noted that some threatened fauna species that are highly mobile, wide ranging and vagrant may use portions of the development footprint intermittently for foraging. For these fauna species, the habitat present and likely to be impacted is not considered to be important to the threatened species, particularly in relation to the amount of similar habitat remaining in the surrounding landscape. As such, a test of significance in reference to Commonwealth legislation was not considered necessary.

Information provided in the habitat associations' column has primarily been extracted (and modified) from the Commonwealth Species Profile and Threats Database and the NSW Threatened Species Data Collection.

Table 47: Likelihood of occurrence for threatened ecological communities listed under the EPBC Act.

Community Name	EPBC Act Status	Distribution	Habitat	Likelihood of Occurrence	Impact Assessment Required
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	E	Sydney Basin Bioregion, mostly in the Cumberland IBRA sub-region, with small occurrences in the Sydney Cataract, Wollemi and Burragorang sub-regions. It occurs primarily in the Castlereagh area in the north-west of the Cumberland Plain with other known occurrences near Holsworthy, Kemps Creek and Longneck Lagoon.	Occurs primarily on Tertiary sands and gravels of the Hawkesbury-Nepean river system. At Agnes Banks it primarily occurs on aeolian (wind-blown) sands overlying Tertiary alluvium. Found on flat or gently undulating terrain in rain shadow areas typically receiving 700–900 mm annual rainfall. The ecological community occurs primarily at low elevations up to 80 m above sea level (ASL), including old ridges, dunes and terraces.	No - this community was not identified during field survey.	No
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	E	The ecological community occurs in sub-tropical, sub-humid and temperate climatic zones from Curtis Island, north of Gladstone, in Queensland to Bermagui in southern New South Wales.	Typically found where groundwater is saline or brackish, but can occur in areas where groundwater is relatively fresh. It is typically found on coastal flats, floodplains, drainage lines, lake margins, wetlands and estuarine fringes where soils are at least occasionally saturated, water-logged or inundated.	No - this community was not identified during field survey.	No
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	CE	Occurs in western Sydney, with the most extensive stands occurring in the Castlereagh and Holsworthy areas. Smaller remnants occur in the Kemps Creek area and in the eastern section of the Cumberland Plain.	Mainly occurs on clay soils derived from the deposits of ancient river systems (alluvium), or on shale soils of the Wianamatta Shales.	No - this community was not identified during field survey.	No
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	Endemic to the shale hills and plains of the Sydney Basin Bioregion in NSW, occurring	Flat to undulating or hilly terrain, at elevations up to approximately 350 metres above sea level. Predominantly associated with clay soils, that are	No – PCT 3320 did not meet the	No

Community Name	EPBC Act Status	Distribution	Habitat	Likelihood of Occurrence	Impact Assessment Required
		primarily in, but not limited to, the Cumberland Sub-region.	derived from Wianamatta Shale geology. Minor occurrences may be present on other soil groups, notably Holocene Alluvium and soils derived from the Mittagong Formation.	EPBC Act listing criteria	
Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion	CE	Restricted to the Cumberland subregion of the Sydney Basin IBRA bioregion. It is only known from the Camden local government area (LGA) in proximity to the Nepean River.	Occurs on deep sandy substrates on high-level Tertiary alluvium, at low elevations, of around 60 to 100 m above sea level. The soil is likely to be low in nutrients and may be well- or poorly- drained.	No - this community was not identified during field survey.	No
River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria	CE	This encompasses the area from around Sale on the south-east coast of Victoria to around Raymond Terrace, just north of Newcastle on the New South Wales east coast.	Occurs on alluvial landforms related to coastal river floodplains and associated sites where transient water accumulates, including floodplains, river-banks, riparian zones, lake foreshores, creek lines (including the floors of tributary gullies), floodplain pockets, depressions, alluvial flats, fans, terraces, and localised colluvial fans.	No - this community was not identified during field survey.	No
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	CE	Occurs at the edges of the Cumberland Plain in western Sydney, most now occurs in the Hawkesbury, Baulkham Hills, Liverpool, Parramatta, Penrith, Campbelltown and Wollondilly local government areas.	Intergrade between clay soils from the shale rock and earthy and sandy soils from sandstone, or where shale caps overlay sandstone.	No - this community was not identified during field survey.	No
Western Sydney Dry Rainforest and Moist Woodland on Shale	CE	Cumberland Plain Sub-region of the Sydney Basin Bioregion.	It generally occurs in rugged terrain and other patches may occur on undulating terrain, with dry rainforest patches typically occupying steep lower slopes and gullies, and moist woodland patches typically occupying upper sections of the slope	No - this community was not identified during field survey.	No

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Community Name	EPBC Act Status	Distribution	Habitat	Likelihood of Occurrence	Impact Assessment Required
			Occurs almost exclusively on clay soils derived from Wianamatta Group shales.		

E = Endangered Ecological Community, CE = Critically Endangered Ecological Community, V = Vulnerable Ecological Community

Table 48: Likelihood of occurrence for threatened fauna listed under the EPBC Act.

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
Actitis hypoleucos	Common Sandpiper	M	Summer migrant. In NSW, widespread along coastline and also occurs in many areas inland.	Coastal wetlands and some inland wetlands, especially muddy margins or rocky shores. Also estuaries and deltas, lakes, pools, billabongs, reservoirs, dams and claypans, mangroves.	-	Unlikely – habitat marginal (dams and streams), but no records of species within 5 km	No	No
Anthochaera phrygia	Regent Honeyeater	CE	Inland slopes of south-east Australia, and less frequently in coastal areas. In NSW, most records are from the North-West Plains, North-West and South-West Slopes, Northern Tablelands, Central Tablelands and Southern Tablelands regions; also recorded in the Central Coast and Hunter Valley regions.	Eucalypt woodland and open forest, wooded farmland and urban areas with mature eucalypts, and riparian forests of Casuarina cunninghamiana (River Oak).	-	Unlikely – habitat marginal (low condition Eucalypt woodland), but no records of species within 5 km	No	No
Aphelocephala leucopsis	Southern Whiteface	V	Occur across most of mainland Australia	Open woodlands and shrublands where there is an	-	Unlikely – habitat marginal (low condition Eucalypt	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			south of the tropics, from the north-eastern edge of the Western Australian wheatbelt, east to the Great Dividing Range.	understorey of grasses or shrubs, or both		woodland), but no records of species within 5 km		
Aprasia parapulchella	Pink-tailed Legless Lizard	V	In NSW, only known from the Central and Southern Tablelands, and the South Western Slopes.	Sloping, open woodland areas with predominantly native grassy groundlayers, rocky outcrops or scattered, partially-buried rocks.	-	Unlikely – habitat marginal (low condition Eucalypt woodland), but no records of species within 5 km	No	No
Apus pacificus	Fork-tailed Swift	M	Recorded in all regions of NSW.	Riparian woodland., swamps, low scrub, heathland, saltmarsh, grassland, Spinifex sandplains, open farmland and inland and coastal sand-dunes.	-	Unlikely – habitat marginal (low condition riparian woodland), but no records of species within 5 km	No	No
Botaurus poiciloptilus	Australasian Bittern	E	Found over most of NSW except for the far north-west.	Permanent freshwater wetlands with tall, dense vegetation, particularly Typha spp. (bullrushes) and	-	Unlikely – habitat marginal some fringing wetland vegetation around dams and creeks),	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
				Eleocharis spp. (spikerushes).		but no records of species within 5 km		
Calidris acuminata	**Sharp-tailed Sandpiper**	**M**	**Summer migrant. Widespread in most regions of NSW, especially in coastal areas, but sparse in the south-central Western Plain and east Lower Western Regions.**	**Shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation.**	**1**	**Known – species found on site**	**Yes**	**Yes**
Calidris ferruginea	Curlew Sandpiper	CE, M	Occurs along the entire coast of NSW, and sometimes in freshwater wetlands in the Murray-Darling Basin.	Littoral and estuarine habitats, including intertidal mudflats, non-tidal swamps, lakes and lagoons on the coast and sometimes inland.	-	Unlikely – habitat marginal (some fringing wetland vegetation around dams and creeks), but no records of species within 5 km	No	No
Calidris melanotos	Pectoral Sandpiper	M	Summer migrant to Australia. Widespread but scattered in NSW. East of the Great Divide, recorded from Casino and Ballina, south to Ulladulla. West of the Great Divide, widespread in	Shallow fresh to saline wetlands, including coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	-	Unlikely – habitat marginal (some fringing wetland vegetation around dams and creeks), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			the Riverina and Lower Western regions.					
Callocephalon fimbriatum	Gang-gang Cockatoo	E	In New South Wales, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes.	In spring and summer, generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In autumn and winter, the species often moves to lower altitudes in drier more open eucalypt forests and woodlands, particularly box-gum and box-ironbark assemblages, or in dry forest in coastal areas and often found in urban areas.	-	Unlikely – habitat marginal (low condition riparian woodland), but no records of species within 5 km	No	No
Calyptorhynchus lathami lathami	South-eastern Glossy Black-Cockatoo	V	They can be found from Mitchell, Queensland, through eastern New South Wales to East Gippsland, Victoria	Feed almost exclusively on the seeds of sheoaks (Allocasuarina spp. and Casuarina spp.), usually relying on one	-	Unlikely – habitat marginal (some Casuarina glauca), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
				or two species within a region				
Chalinolobus dwyeri	Large-eared Pied Bat	V	Recorded from Rockhampton in Qld south to Ulladulla in NSW. Largest concentrations of populations occur in the sandstone escarpments of the Sydney basin and the NSW north-west slopes.	Wet and dry sclerophyll forests, Cyprus Pine dominated forest, woodland, sub-alpine woodland, edges of rainforests and sandstone outcrop country.	-	Unlikely – habitat marginal (low condition woodland), but no records of species within 5 km	No	No
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern)	V	The eastern subspecies lives in eastern NSW in eucalypt woodlands through central NSW and in coastal areas with drier open woodlands such as the Snowy River Valley, Cumberland Plains, Hunter Valley and parts of the Richmond and Clarence Valleys.	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or	-	Unlikely – habitat marginal (low condition riparian woodland), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
				more shrub species; also found in mallee and River Red Gum (Eucalyptus camaldulensis) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer				
Dasyurus maculatus maculatus (SE mainland population)	Spotted-tailed Quoll	E	Found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Qld.	Rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.	-	Unlikely – habitat marginal (low condition woodland), but no records of species within 5 km	No	No
Delma impar	Striped Legless Lizard	V	In NSW, occurs in the Southern Tablelands, the South West Slopes and possibly on the Riverina.	Natural Temperate Grassland, secondary and modified grassland, open Box-Gum Woodland.	-	Unlikely – habitat marginal (low condition woodland), but no records of species within 5 km	No	No
Erythrotriorchis radiatus	Red Goshawk	V	In NSW, extends to ~30°S. Recent records confined to the	Open woodland and forest, often along or near watercourses or	-	Unlikely – habitat marginal (low condition	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			Northern Rivers region north of the Clarence River.	wetlands. In NSW, preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and coastal riparian Eucalyptus forest.		woodland), but no records of species within 5 km		
Falco hypoleucos	Grey Falcon	V	Sparsely distributed in NSW, chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range.	Usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast.	-	Unlikely – habitat marginal (low condition riparian woodland), but no records of species within 5 km	No	No
Gallinago hardwickii	**Latham's Snipe**	**M**	**Migrant to east coast of Australia, extending inland west of the Great Dividing Range in NSW.**	**Freshwater, saline or brackish wetlands up to 2000 m above sea-level; usually freshwater swamps, flooded grasslands or heathlands.**	**6**	**Known – species found on site**	**Yes**	**Yes**
Grantiella picta	Painted Honeyeater	V	Widely distributed in NSW, predominantly on the inland side of the Great Dividing	Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests.	-	Unlikely – habitat marginal (low condition woodland), but no	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			Range but avoiding arid areas.			records of species within 5 km		
Heleioporus australiacus	Giant Burrowing Frog	V	South eastern NSW and Victoria, in two distinct populations: a northern population in the sandstone geology of the Sydney Basin as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria.	Heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based.	-	Unlikely – habitat marginal (low condition woodland), but no records of species within 5 km	No	No
Hirundapus caudacutus	White-throated Needletail	M	All coastal regions of NSW, inland to the western slopes and inland plains of the Great Divide.	Occur most often over open forest and rainforest, as well as heathland, and remnant vegetation in farmland.	-	Unlikely – habitat marginal (low condition woodland), but no records of species within 5 km	No	No
Hirundo rustica	Barn Swallow	M	Non-breeding migrant from northern hemisphere. Vagrant to eastern NSW.	Open country, agricultural land, railways, towns.	1	Unlikely – habitat marginal (open agricultural land), but minimal records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
Hoplocephalus bungaroides	Broad-headed Snake	E	Largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney.	Shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in crevieces or hollows in large trees within 500m of escarpments in summer.	-	Unlikely – habitat marginal (low condition riparian woodland), but no records of species within 5 km	No	No
Lathamus discolor	Swift Parrot	CE	Migrates from Tasmania to mainland in Autumn-Winter. In NSW, the species mostly occurs on the coast and south west slopes.	Box-ironbark forests and woodlands.	7	Unlikely– habitat is marginal (low condition woodland/forest) and low number of species records within 5 km.	No	No
Litoria aurea	Green and Golden Bell Frog	V	Since 1990, recorded from ~50 scattered sites within its former range in NSW, from the north coast near Brunswick Heads, south along the coast to Victoria. Records exist west to Bathurst,	Marshes, dams and stream-sides, particularly those containing Typha spp. (bullrushes) or Eleocharis spp. (spikerushes). Some populations occur in highly disturbed areas.	1	An Expert report has been prepared for this species including targeted surveys. No individuals have been identified. No habitat present.	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			Tumut and the ACT region.					
Melanodryas cucullata cucullata	South-eastern Hooded Robin	E	Widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast.	Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses	-	Unlikely – habitat marginal (low condition riparian woodland), but no records of species within 5 km	No	No
Monarcha melanopsis	Black-faced Monarch	M	In NSW, occurs around the eastern slopes and tablelands of the Great Divide, inland to Coutts Crossing, Armidale, Widden Valley, Wollemi National Park and Wombeyan Caves. It is rarely recorded farther inland.	Rainforest, open eucalypt forests, dry sclerophyll forests and woodlands, gullies in mountain areas or coastal foothills, Brigalow scrub, coastal scrub, mangroves, parks and gardens.	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
Motacilla flava	Yellow Wagtail	M	Regular summer migrant to mostly coastal Australia. In NSW recorded Sydney to Newcastle, the Hawkesbury and inland in the Bogan LGA.	Swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land, lawns.	-	Unlikely – habitat marginal (some wetland areas and fields), but no records of species within 5 km	No	No
Myiagra cyanoleuca	Satin Flycatcher	M	In NSW, widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains.	Eucalypt-dominated forests, especially near wetlands, watercourses, and heavily-vegetated gullies.	-	Unlikely – habitat marginal (low condition forest near watercourses), but no records of species within 5 km	No	No
Neophema chrysostoma	Blue-winged Parrot	V, Mar	Breed on mainland Australia south of the Great Dividing Range in southern Victoria from Port Albert in Gippsland west to Nelson, and sometimes in the far south-east of South Australia, and the north-western, central and eastern parts of	Inhabit a range of habitats from coastal, sub-coastal and inland areas, through to semi-arid zones.	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			Tasmania. Migrate across Bass Strait in winter.					
Numenius madagascariensis	Eastern Curlew	CE, Mig	The Eastern Curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. Eastern Curlews are rarely recorded inland. In NSW the species occurs across the entire coast but is mainly found in estuaries such as the Hunter River, Port Stephens, Clarence River, Richmond River and ICOLLs of the south coast.	Generally occupies coastal lakes, inlets, bays and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats and sometimes saltmarsh of sheltered coasts.		Unlikely – habitat marginal (some fringing wetland vegetation around dams and creeks), but no records of species within 5 km	No	No
Pandion haliaetus	Osprey	Mar, M	Breeding range of the Eastern Osprey extends around the northern coast of Australia (including	Occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate	-	Unlikely – habitat marginal (some wetland), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			many offshore islands) from Albany in Western Australia to Lake Macquarie in NSW	Australia and offshore islands.				
Petauroides volans	Greater Glider population in the Eurobodalla local government area	V	This population on the south coast of NSW is bounded by the Moruya River to the north, Coila Lake to the south and the Princes Highway and cleared land exceeding 700 m in width to the west.	Eucalypt forests and woodlands.	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No
Petaurus australis australis	Yellow-bellied Glider (south-eastern)	V	It predominantly occurs in forests along the eastern coast, from the NSW-Qld border to the NSW-Vic border.	Occurs in eucalypt-dominated woodlands and forests, including both wet and dry sclerophyll forests	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No
Petrogale penicillata	Brush-tailed Rock-wallaby	V	In NSW they occur from the Qld border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges	Rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges.	-	No – no records of species within 5 km and unsuitable habitat (no rocky escarpment)	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			being the western limit.					
Phascolarctos cinereus	Koala	E	In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. There are sparse and possibly disjunct populations in the Bega District, and at several sites on the southern tablelands.	Eucalypt woodlands and forests.	2	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No
Pluvialis squatarola	Grey Plover	M	Regular summer migrant to coastal Australia, including NSW. Rarely inland, on passage.	Mudflats, saltmarsh, tidal reefs and estuaries.	1	No –record of species within 5 km but habitat unsuitable (no mudflat or tidal reef).	No	No
Pommerhelix duralensis	Dural Land Snail	E	The species is a shale-influenced-habitat specialist, which occurs in low densities along the western and northwest fringes of the Cumberland IBRA subregion on shale-	Favours sheltering under rocks or inside curled-up bark. It does not burrow nor climb. The species has also been observed resting in exposed areas, such as on exposed rock or leaf litter, however it		Unlikely – habitat marginal (some fringing wetland vegetation around dams and creeks), but no records of species within 5 km	No	No

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Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			sandstone transitional landscapes.	will also shelter beneath leaves, rocks and light woody debris.				
Pseudomys novaehollandiae	New Holland Mouse	V	Fragmented distribution across eastern NSW.	Open heathlands, woodlands and forests with a heathland understorey, vegetated sand dunes.	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No
Pteropus poliocephalus	**Grey-headed Flying-fox**	**V**	**Along the eastern coast of Australia, from Bundaberg in Qld to Melbourne in Victoria.**	**Subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops.**	**54**	**Likely – foraging habitat suitable (eucalypt species) and species known to occur within 5 km, but no camps within the development footprint**	**Yes**	**Yes**
Pycnoptilus floccosus	Pilotbird	V	Upland Pilotbirds occur above 600 m in the Brindabella Ranges in the Australian Capital Territory, and in the Snowy Mountains in New South Wales and	strictly terrestrial, living on the ground in dense forests with heavy undergrowth	-	No – no records of species within 5 km and unsuitable habitat (no dense undergrowth)	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			north-east Victoria. Lowland Pilotbirds occur in forests from the Blue Mountains west of Newcastle, around the wetter forests of eastern Australia, to Dandenong near Melbourne					
Rhipidura rufifrons	Rufous Fantail	M	Coastal and near coastal districts of northern and eastern Australia, including on and east of the Great Divide in NSW.	Wet sclerophyll forests, subtropical and temperate rainforests. Sometimes drier sclerophyll forests and woodlands.	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No
Rostratula australis	Australian Painted Snipe	E	In NSW most records are from the Murray-Darling Basin. Other recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys.	Swamps, dams and nearby marshy areas.	1	Unlikely – habitat marginal (dams), but minimal records of species within 5 km	No	No
Stagonopleura guttata	Diamond Firetail	V	Endemic to south-eastern Australia, extending from central	Found in grassy eucalypt woodlands, including Box-Gum		Unlikely – habitat marginal (some fringing wetland	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			Queensland to the Eyre Peninsula in South Australia. It is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Cental and South Western Slopes and the North West Plains and Riverina.	Woodlands and Snow Gum Eucalyptus pauciflora Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.		vegetation around dams and creeks), but no records of species within 5 km		
Tringa nebularia	**Common Greenshank**	**M**	**Summer migrant to Australia. Recorded in most coastal regions of NSW; also widespread west of the Great Dividing Range, especially between the Lachlan and Murray Rivers and the Darling River drainage basin, including the Macquarie Marshes, and north-west regions.**	**Terrestrial wetlands (swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans, saltflats, sewage farms and saltworks dams, inundated rice crops and bores) and sheltered coastal habitats (mudflats, saltmarsh, mangroves,**	**1**	**Known – This species has previously been recorded within the development footprint from BioNet records from 2006. Marginal habitat present (dams and streams), and minimal records of species within 5 km**	**Yes**	**Yes**

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
				embayments, harbours, river estuaries, deltas, lagoons, tidal pools, rock-flats and rock platforms).				

EPBC Act: V= Vulnerable; E= Endangered, CE = Critically Endangered Act, M = Migratory.

Table 49: Likelihood of occurrence for threatened flora listed under the EPBC Act

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
Acacia bynoeana	Bynoe's Wattle	V	Found in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains.	Heath or dry sclerophyll forest on sandy soils.	-	No – no records of species within 5 km and unsuitable habitat (no sandy soil)	No	No
Acacia pubescens	Downy Wattle	V	Restricted to the Sydney region around the Bankstown-Fairfield-Rookwood and Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon.	Open woodland and forest, including Cooks River/Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland. Occurs on alluviums, shales and at the intergrade between shales and sandstones.	-	Unlikely – habitat marginal (low condition CPW), but no records of species within 5 km	No	No
Allocasuarina glareicola		E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool.	Castlereagh woodland on lateritic soil. Found in open woodland with Eucalyptus parramattensis,	-	No – no records of species within 5 km and unsuitable habitat (no Castlereagh woodland)	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
				Eucalyptus fibrosa, Angophora bakeri, Eucalyptus sclerophylla and Melaleuca decora.				
Cynanchum elegans	White-flowered Wax Plant	E	Restricted to eastern NSW, from Brunswick Heads on the north coast to Gerroa in the Illawarra region, and as far west as Merriwa in the upper Hunter River valley.	Dry rainforest; littoral rainforest; Leptospermum laevigatum-Banksia integrifolia subsp. integrifolia (Coastal Tea-tree– Coastal Banksia) coastal scrub; Eucalyptus tereticornis (Forest Red Gum) or Corymbia maculata (Spotted Gum) open forest and woodland; and Melaleuca armillaris (Bracelet Honeymyrtle) scrub.	-	Unlikely – habitat marginal (low condition CPW), but no records of species within 5 km	No	No
Eucalyptus aggregata	Eucalyptus aggregata H.Deane & Maiden	V	Population located in the Wingecarribee local government area, at	Alluvial soils, on cold, poorly-drained flats and hollows adjacent to creeks	-	Unlikely – habitat marginal (some creeks throughout site), but no	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
	population in the Wingecarribee local government area		Berrima, Medway and Sutton Forest.	and small rivers. Usually occurs in open woodland with a grassy groundlayer.		records of species within 5 km		
Eucalyptus aggregata	Black Gum	V	In NSW, found in the Central and Southern Tablelands, in the South Eastern Highlands Bioregion and on the western fringe of the Sydney Basin Bioregion.	Alluvial soils, on cold, poorly-drained flats and hollows adjacent to creeks and small rivers. Usually occurs in open woodland with a grassy groundlayer.	-	Unlikely – habitat marginal (some creeks throughout site), but no records of species within 5 km	No	No
Eucalyptus benthamii	Camden White Gum	V	Alluvial flats of the Nepean River and its tributaries. Mainly Kedumba Valley of the Blue Mountains National Park and Bents Basin State Recreation Area. Also along the Nepean River around Camden and Cobbitty, at Werriberri (Monkey) Creek in The Oaks, and on the Nattai	Occurs in open forest. Requires a combination of deep alluvial sands and a flooding regime.	-	Unlikely – habitat marginal (low condition PCT 3320), but no records of species within 5 km	No	No

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Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			River in Nattai National Park.					
Genoplesium baueri	Bauer's Midge Orchid	E	Has been recorded from locations between Nowra and Pittwater and may occur as far north as Port Stephens.	Dry sclerophyll forest and moss gardens over sandstone.	-	Unlikely – habitat marginal (low condition PCT 3320), but no records of species within 5 km	No	No
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	Sporadically distributed throughout the Sydney Basin and in the Hunter in the Cessnock - Kurri Kurri area. Also known from Putty to Wyong and Lake Macquarie on the Central Coast.	Heath and shrubby woodland to open forest on sandy or light clay soils usually over thin shales.	-	Unlikely – habitat marginal (low condition woodland/forest), but no records of species within 5 km	No	No
Haloragis exalata subsp. exalata	Square Raspwort	V	Disjunct distribution in the Central Coast, South Coast and North Western Slopes botanical subdivisions of NSW.	Protected and shaded damp situations in riparian habitats.	-	Unlikely – habitat marginal (some creeks in development footprint), but no records of species within 5 km	No	No
Macadamia integrifolia	Macadamia Nut	V	Not known to occur naturally in the wild in NSW; recorded from	Drier subtropical rainforest.	1	No – minimal records of species within 5 km and	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			Camden Haven but it is not known if the tree was cultivated or growing naturally.			unsuitable habitat (no rainforest)		
Melaleuca deanei	Deane's Paperbark	V	Ku-ring-gai/Berowra area, Holsworthy/Wedderburn area, Springwood (in the Blue Mountains), Wollemi National Park, Yalwal (west of Nowra) and Central Coast (Hawkesbury River) areas.	Heath on sandstone.	-	No – no records of species within 5 km and unsuitable habitat (no heath)	No	No
Persicaria elatior	Tall Knotweed	V	In south-eastern NSW recorded from Mt Dromedary, Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests).	Beside streams and lakes, swamp forest or disturbed areas.	-	No – habitat marginal (some creeks in development footprint), but no records of species within 5 km and not recorded during targeted survey	No	No

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Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
Persoonia nutans	Nodding Geebung	E	Restricted to the Cumberland Plain in western Sydney, between Richmond in the north and Macquarie Fields in the south.	Northern populations: sclerophyll forest and woodland (Agnes Banks Woodland, Castlereagh Scribbly Gum Woodland and Cooks River / Castlereagh Ironbark Forest) on aeolian and alluvial sediments. Southern populations: tertiary alluvium, shale sandstone transition communities and Cooks River / Castlereagh Ironbark Forest.	-	Unlikely – habitat marginal (low condition CPW), but no records of species within 5 km	No	No
Pimelea curviflora var. curviflora	-	V	Confined to the coastal area of the Sydney and Illawarra regions between northern Sydney and Maroota in the north-west	Woodland, mostly on shaley/lateritic soils over sandstone and shale/sandstone transition soils on	-	Unlikely – habitat marginal (low condition CPW), but no records of species within 5 km	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			and Croom Reserve near Albion Park in the south.	ridgetops and upper slopes.				
Pimelea spicata	Spiked Rice-flower	E	Two disjunct areas; the Cumberland Plain (Marayong and Prospect Reservoir south to Narellan and Douglas Park) and the Illawarra (Landsdowne to Shellharbour to northern Kiama).	Well-structured clay soils. Eucalyptus moluccana (Grey Box) communities and in areas of ironbark on the Cumberland Plain. Coast Banksia open woodland or coastal grassland in the Illawarra.	9	Unlikely – habitat is marginal (low condition PCT 4023 and PCT 3320) and species known to occur within 5 km, but unlikely due to due to high and consistent levels of degradation.	No	No
Pomaderris brunnea	Brown Pomaderris	V	In NSW, found around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden. It also occurs near Walcha on the New England tablelands.	Moist woodland or forest on clay and alluvial soils of flood plains and creek lines.	-	Unlikely – habitat marginal (low condition CPW), but no records of species within 5 km	No	No
Pterostylis saxicola	Sydney Plains Greenhood	E	Restricted to western Sydney between Freemans Reach in the north and Picton in the south.	Small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines, adjacent to sclerophyll forest or	-	Unlikely – habitat is marginal (low condition and PCT 3320) but species known to occur within 5 km.	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
				woodland on shale/sandstone transition soils or shale soils.				
Pultenaea parviflora		V	Endemic to the Cumberland Plain. Mainly from Windsor to Penrith and east to Dean Park, with outlier populations at Kemps Creek and Wilberforce.	Dry sclerophyll forest, especially Castlereagh Ironbark Forest, Shale Gravel Transition Forest and transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland.	2028	Unlikely – habitat is marginal (low condition PCT 3320), species known to occur within 5 km, but unlikely due to high and consistent degradation and disturbance.	No	No
Rhizanthella slateri	Eastern Australian Underground Orchid	E	In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra.	Sclerophyll forest in shallow to deep loams.	-	No – habitat not suitable (not associated with the PCTs within the development footprint), no records within 5 km, and not within Great Lakes LGA.	No	No
Rhodamnia rubescens	Scrub Turpentine	CE	Occur from coastal districts of NSW north from Batemans Bay	Occurs in all rain forest subforms	-	No – habitat not suitable (not associated with	No	No

Scientific Name	Common Name	EPBC Act Status	Distribution	Habitat	Number of records within 5 km	Likelihood of occurrence on site	Habitat on the site directly or indirectly impacted	Impact assessment required
			to Bundaberg in Queensland	except cool temperate rainforest.		the PCTs within the development footprint, and no rainforest), no records within 5 km.		
Syzygium paniculatum	Magenta Lilly Pilly	V	Only in NSW, in a narrow, linear coastal strip from Upper Lansdowne to Conjola State Forest.	Subtropical and littoral rainforest on gravels, sands, silts and clays.	-	No – habitat not suitable (no rainforest), no records within 5 km.	No	No
Thesium australe	Austral Toadflax	V	In eastern NSW it is found in very small populations scattered along the coast, and from the Northern to Southern Tablelands.	Grassland on coastal headlands or grassland and grassy woodland away from the coast.	-	No – habitat not suitable (not associated with PCTs within development footprint and degraded) and no records within 5 km	No	No

EPBC Act: V= Vulnerable; E= Endangered, CE = Critically Endangered Act, M = Migratory.

Appendix E Opportunistic fauna species list

Scientific name	Common name	Native / Exotic	Conservation status
Birds			-
Anas castanea	Chestnut Teal	Native	-
Anas superciliosa	Pacific Black Duck	Native	-
Anhinga novaehollandiae	Australiasian Darter	Native	-
Anthus novaeseelandiae	Australian Pipet	Native	-
Aythya australis	Hardhead	Native	-
Cacatua tenuirostris	Long-billed Corella	Native	-
Calidris acuminata	Sharptailed Sandpiper	Native	Migratory under EPBC Act
Chenonetta jubata	Australian Wood Duck	Native	-
Cisticola exilis	Golden-headed Cisticola	Native	-
Corvus coronoides	Australian Raven	Native	-
Cygnus atratus	Black Swan	Native	-
Egretta novaehollandiae	White-faced Heron	Native	-
Elseyornis melanops	Black-fronted Dotterel	Native	-
Falco cenchroides	Nankeen Kestrel	Native	-
Fulica atra	Eurasian Coot	Native	-
Gallinago hardwickii	Latham Snipe	Native	Vulnerable under BC Act and EPBC Act
Gallinula tenebrosa	Eurasian Moorhen	Native	-
Grallina cyanoleuca	Magpie lark	Native	-
Gymnorhina tibicen	Australian Magpie	Native	-
Haliaeetus leucogaster	White-bellied Sea-Eagle	Native	Vulnerable under BC Act
Himantopus himantopus	Black winged stilt	Native	-
Hirundo neoxena	Welcome Swallow	Native	-
Malurus cyaneus	Superb Fairywren	Native	-
Pelecanus conspicillatus	Australian Pelican	Native	-
Petrochelidon ariel	Fairy Martin	Native	-
Phalacrocorax sulcirostris	Little Black Cormorant	Native	-
Porphyrio porphyrio	Purple Swamphen	Native	-
Rhipidura leucophrys	Wille-Wagtail	Native	-
Tachybaptus novaehollandiae	Australasian Grebe	Native	-
Unknown	Quail	Native	-

Scientific name	Common name	Native / Exotic	Conservation status
Vanellus miles	Masked lapwing	Native	-
Reptile			
Pseudechis porphyriacus	Red belly black snake	Native	-
Mammal			
Vulpes vulpes	European red fox	Exotic	-

Appendix F Microbat Report

Provided as a separate document.

Ultrasonic bat call analysis report

Sydney Science Park BDAR, Luddenham

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1. Background

The purpose of this project was to undertake species surveys for insectivorous bats, to analyse ultrasonic bat call data to determine species presence and assemblage, and to identify species credit species and ecosystem credit species within the Sydney Science Park site in Luddenham, NSW (the study area).

The following insectivorous bats are species credit species (SCS) or ecosystem credit species (ECS) (target species) and require targeted surveys in accordance with the BAM 2020:

- *Miniopterus australis* (Little Bent-winged Bat) – ECS – foraging habitat only
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat) – ECS – foraging habitat only
- *Myotis macropus* (Southern Myotis) - SCS

This survey was undertaken to:

- Identify the species of insectivorous bat species present within the study area.
- Assess the presence of target species.

This report outlines the methods used to undertake ultrasonic recording of insectivorous bat calls and the results of the data analysis.

2. Methods

2.1. Ultrasonic data collected at the study area

Four sites were surveyed passively using Song Meter Mini Bats (Wildlife Acoustics) and Anabat Swifts (Titley Scientific) recording in wave sound (WAV) file type. Detectors were deployed for four nights each from 10 November 2023 to 15 November 2023 inclusive, equating to a total of sixteen (16) detector nights completed for this study (Table 1). The detectors were placed close to nearby waterbodies and drainage lines within the study area. The survey effort, detector types and a description of detector locations are summarised in Table 1. Settings for each of the detectors are in Table 2.

Table 1. Location of survey sites and information on data recorded at all sites.

Site ID	GPS location	Date start	Date end	No. detector nights	No. files	Habitat description
Swift SUT04	-33.834483, 150.720857	10/11/23	15/11/23	4	1,400	10-15m from water's edge. Small stand of *Eucalyptus* approx. 10m from device, including one large stag. Minimal riparian vegetation. Device attached to wooden stump.
Swift SUT05	-33.835755, 150.732795	10/11/23	15/11/23	4	1,282	Approx. 5-10m from large dam with moderate riparian vegetation. A handful of small *Melaleuca* nearby, no stags. Device attached to large *Juncus acutus.*
Mini SYD SM02	-33.840070, 150.732820	10/11/23	15/11/23	4	4,028	Approx. 5m from small dam with minimal fringing veg. No trees nearby.

Site ID	GPS location	Date start	Date end	No. detector nights	No. files	Habitat description
Mini SYD SM06	-33.839660, 150.736740	10/11/23	15/11/23	4	2,684	10-15m from a large dam. A row of half a dozen or so large stags with potential bat habitat. Very minimal fringing riparian veg.
TOTAL	-	-	-	16	9,394	

Table 2. Settings for the four (4) detectors deployed.

Site & Device ID	Make and model	Sensitivity / gain	Min. trigger freq. (kHz)	Min. event time (milliseconds)	Trigger window (seconds)	Max. file length (seconds)
Swift SUT04	Anabat Swift	16	8	2	2	10
Swift SUT05	Anabat Swift	16	10	2	2	10
Mini SYD SM02	Song Meter Mini Bat	6	10	1.5	2	10
Mini SYD SM06	Song Meter Mini Bat	6	10	1.5	2	10

2.2. Call analysis

Calls were analysed in Anabat Insight version 2.0.8-0-g4157d1f (Titley Scientific, 2023). Files were first run through the 'All Bats' filter to separate bat calls from noise files. Files that passed the 'All Bats' filter were processed through a region-specific decision tree which added a species label to files which passed specific parameters. Species were manually verified using the 'Bat calls of New South Wales' regional echolocation guide (Pennay et al., 2004) and the accompanying reference library of calls downloaded from the NSW Department of Environment and Planning website. Bat calls were analysed by Ecologist Kylie Lopes (Ecological Australia, ELA) with a subsample of calls reviewed by experienced call analyst Rodney Armistead (Rodney Armistead Environmental Consultants).

2.2.1. General rules for bat call identification

Bat call analysis uses species-specific call parameters including call shape, characteristic frequency, initial slope and time between pulses (Reinhold et al., 2001). To ensure reliable and accurate results, the following protocols (adapted from Lloyd et al., 2006) were followed:

- Call sequences not attributed to insectivorous bat calls (e.g. insect buzzes, wind, rain and anthropogenic noise) were dismissed from analysis,
- Recorded calls containing less than three pulses were not analysed and these sequences were labelled as unidentifiable, being too short to confidently determine the identity of the species producing the call (Law et al., 1999),
- Search phase calls were used in the analysis, rather than feeding buzzes or social calls (McKenzie et al., 2002). Feeding buzzes were only identified if there were sufficient search phase pulses

before or after. Social calls are not typical of species and provide poor descriptive power and cannot be used for identification purposes.

- For calls able to be used for species identification, two categories of confidence were used (Mills et al., 1996):
    - Present: the quality and structure of the call profile is such that the bat species may not be confused with other species,
    - Potentially present: the quality and structure of the call profile is such that the bat species may be confused with other species that produce similar call profiles.
- Call sequences of inferior quality and therefore not able to be identified to any bat species are labelled as unidentifiable but are included in quantification of overall bat activity.

2.2.2. Limitations of call analysis

Many insectivorous bat species produce calls that overlap in call profile parameters and depending on the call quality and type recorded (search phase, feeding buzz, social calls), cannot always be separated. Additionally, weather and climatic conditions affect the detectability of calls and the quality of those calls recorded. Calls were only positively identified to species when the defining characteristics were present and there was no chance of confusion between species with overlapping and / or similar calls. Calls that could not positively be identified to species level due to intermediate characteristics between multiple species were therefore given a species or genus complex.

2.3. Target Species

Files were analysed for the presence of insectivorous bat target species (BAM 2020) shown in Table 3. These species roost primarily in caves and similar habitat such as rocky overhangs and hollow bearing trees. However most have been known to utilise man-made structures including disused mineshafts, stormwater drains and culverts, bridges and buildings. These species forage in a variety of habitat types and have differing preferences (see Table 3); however, all generally forage close to roosting habitat. Myotis is reliant on the presence of water and waterways.

Table 3. Insectivorous bat species of interest, their conservation status and habitat.

Scientific name	Common name	BC Act status	EPBC Act status	Roost habitat	Foraging habitat
Myotis macropus	Southern Myotis	Vulnerable	Not listed	Close to water in caves, mine shafts, under bridges, culverts and water channels and hollow bearing trees.	Forages over streams, pools and other water bodies.
Miniopterus australis	Little Bent-winged Bat	Vulnerable	Not listed	Caves, tunnels, tree hollows, mines, culverts, stormwater drains, bridges and sometimes buildings.	Forages beneath the canopy of densely vegetated areas.
Miniopterus orianae oceanensis	Large Bent-winged Bat	Vulnerable	Not listed	Primarily caves, will also use mines, storm water tunnels and	Forages in forested areas generally above

Scientific name	Common name	BC Act status	EPBC Act status	Roost habitat	Foraging habitat
				culverts, buildings and other structures.	the canopy. Open and edge space aerial forager.

2.3.1. Target species limitations

Some of the target species can be difficult to distinguish definitively from other species by call alone. *Myotis macropus* is rarely able to be positively identified from *Nyctophilus* species. They are often recorded as a species complex due to the call similarity (in shape and frequency) and because they are known to inhabit similar foraging and roosting habitats. Sometimes they can be separated if call recordings are of a very high quality allowing for specific features within *Myotis macropus* calls to be seen (Pennay et al. 2004), otherwise these species generally require further targeted sampling (such as harp traps) to positively identify presence.

Miniopterus orianae oceanensis calls may overlap with *Vespadelus* species. *Miniopterus orianae oceanensis* can be distinguished if the calls have a down sweeping tail, long characteristic section and / or uneven consecutive pulses (Pennay et al. 2004).

Due to the location of the study site and its proximity to records, *Vespadelus regulus* has been included in this report due to potential for overlap at the extent of its range (Altas of Living Australia, 2023). *Vespadelus regulus* can often overlap with the target species *Miniopterus orianae oceanensis* as with other *Vespadelus* species but can be distinguished if calls are of high quality.

Vespadelus troughtoni is not a target species for this study area; however, does occur within the greater region so has been left within the list of potential species. This species' call is indistinguishable from the very common *Vespadelus vulturnus* and *Vespadelus pumilus* where their ranges overlap so has been considered as a complex.

Scotorepens orion, *Scoteanax rueppellii* and *Falsistrellus tasmaniensis* calls often overlap in call frequency, shape and metrics and can be difficult to separate with certainty, these species have been considered as a complex for the context of this report unless a very definite call was able to be identified.

In many cases *Chalinolobus morio* and the *Vespadelus* spp. calls are unable to be distinguished clearly and so have been considered as a complex. In both of these cases these species will be labelled as potential (P) unless a very clear call example was identified.

2.4. Reporting

This report adheres to the standards outlined by the Australasian Bat Society Inc. for insectivorous bat surveys using bat detectors (Australasian Bat Society, 2006). Species taxonomic list and nomenclature adhere to Armstrong *et al*. (2020) noting that the common name for *Miniopterus orianae oceanensis* is listed as 'Eastern Bent-winged Bat', whereas the New South Wales Department of Climate Change, Environment, Energy and Water (formerly Office of Environment and Heritage) uses the common name 'Large Bent-winged Bat'. This report uses 'Large Bent-winged Bat' as per the DCCEEW conventions.

3. Results

A total of 9,394 files were analysed from four (4) detectors recorded at The Sydney Science Park site, in Luddenham, NSW, between 10 November 2023 to 15 November 2023, inclusive. Detectors were deployed at an appropriate time of year to survey for these species (as outlined in 'Species credit threatened bats and their habitats: NSW survey guide for the Biodiversity Assessment Method' DPIE, 2021). Of the files recorded 7,146 were deemed to be 'noise' and did not pass the 'All Bats' and 'minimum 3 pulse' filters. A sample set of these 'noise' files were checked to ensure that the filter was operating correctly and to confirm that no bat calls were being incorrectly removed. These files were anthropogenic noise, insects and other non-identifiable sounds, no bat calls were found within the 'noise' files. A total of 2,248 files passed the 'All Bats' and 'minimum 3 pulse' filters and were then sorted by characteristic frequency and given species labels based on these metrics. Files were selectively manually checked, and species adjusted and/or removed.

3.1. Species occurrence

Bat species occurrence at all sites is shown in Table 4. Call recordings were overall of good quality and therefore many species were able to be identified with a high degree of certainty. Those species that were unable to be separated out of a complex or that had calls of lower quality are marked as potentially present. Representative calls for the species from this dataset are included in the Appendix.

Table 4. Occurrence of bat species at four (4) sites in the study area. ✓ = species present, P = species potentially present.

Scientific name	Swift SUT04	Swift SUT05	Mini SYD SM02	Mini SYD SM06
Austronomus australis	✓	✓	✓	✓
Chalinolobus gouldii	✓	✓	✓	
Chalinolobus morio	✓			P
Falsistrellus tasmaniensis		P		P
Micronomus norfolkensis	✓	✓	P	✓
Miniopterus orianae oceanensis				✓
Myotis macropus	✓	✓		
Myotis macropus / *Nyctophilus geoffroyi / Nyctophilus gouldi*	✓	✓	✓	
Ozimops ridei	✓	✓	✓	✓
Scoteanax rueppellii		P		P
Scotorepens orion		P		P
Vespadelus darlingtoni / Vespadelus regulus	P		P	P
Vespadelus pumilus / Vespadelus troughtoni / Vespadelus vulturnus	✓		✓	✓

3.2. Bat activity

Bat activity of target species and any other identified threatened species is shown in Table 5. Calls that were of 'low' quality or otherwise unidentifiable were not included in activity analysis. In the case of *Myotis macropus*, calls that were only able to be identified to the *Myotis / Nyctophilus* species complex are recorded as potential calls.

Table 5. Activity (number of calls) for target species over the site

Scientific name	Good Quality calls	Potential calls	Total
Miniopterus orianae oceanensis	1	6	7
Myotis macropus	4	14	18

4. Discussion and conclusion

The purpose of this project was to undertake targeted surveys for 'species credit' and 'ecosystem credit' (target species) insectivorous bats, and to analyse ultrasonic bat call data collected to understand overall species presence within the Sydney Science Park site in Luddenham, NSW (the study area).

Detectors were deployed at four sites for a total of 16 detector nights with comparable settings appropriate to the target species. Detectors all functioned correctly with appropriate numbers of calls recorded over the survey period. A total of 9,394 files were analysed for species presence with a focus on the target species *Miniopterus australis*, *Miniopterus orianae oceanensis* and *Myotis macropus*.

Many common species that are expected to occur within the region were identified across the study area. Species including *Austronomus australis, Chalinolobus gouldii, Ozimops ridei* and *Micronomus norfolkensis*, were identified or potentially identified on all detectors and were the most common species identified. Other more common species were identified or potentially identified on several detectors though were not as prevalent overall. These included the *Vespadelus* sp. and *Nyctophilus* sp. complexes which were identified as being present or potentially present at three out of the four sites.

Of the three target species *Miniopterus australis* was not identified within the site during this survey. *Miniopterus orianae oceanensis* was identified at one site (Mini SYD SM06), this call was of good quality and identified with a high degree of certainty. There is no suitable breeding or significant roost habitat for these species within the study area, however their presence suggests that they use the study area for foraging and may roost in nearby areas or within the marginal roosting habitat (stag trees) on occasion. This species is known to forage and move over large distances.

Myotis macropus was positively identified at two sites (Swift SUT04, Swift SUT05). These calls showed the required specific call metrics to distinguish them from those of the *Nyctophilus* spp. calls and detectors were placed close to water bodies in habitat suitable for foraging *Myotis macropus*. The *Myotis*/ *Nyctophilus* complex was also identified at three out of the four sites. Further physical surveys are not required for this species, calls identified were of high quality and were verified with a very high degree of certainty.

The threatened *Vespadelus troughtoni* (not a target species for this site) cannot be distinguished from the much more common *Vespadelus vulturnus* or *Vespadelus pumilus* by call. This species complex was identified at three of the four sites. Due to the lack of appropriate breeding and roosting habitat for *V. troughtoni* within or close to the study area these calls are much more likely to be those of *V. vulturnus*, however this species cannot be completely ruled out and may utilise the study area as very marginal foraging habitat on occasion.

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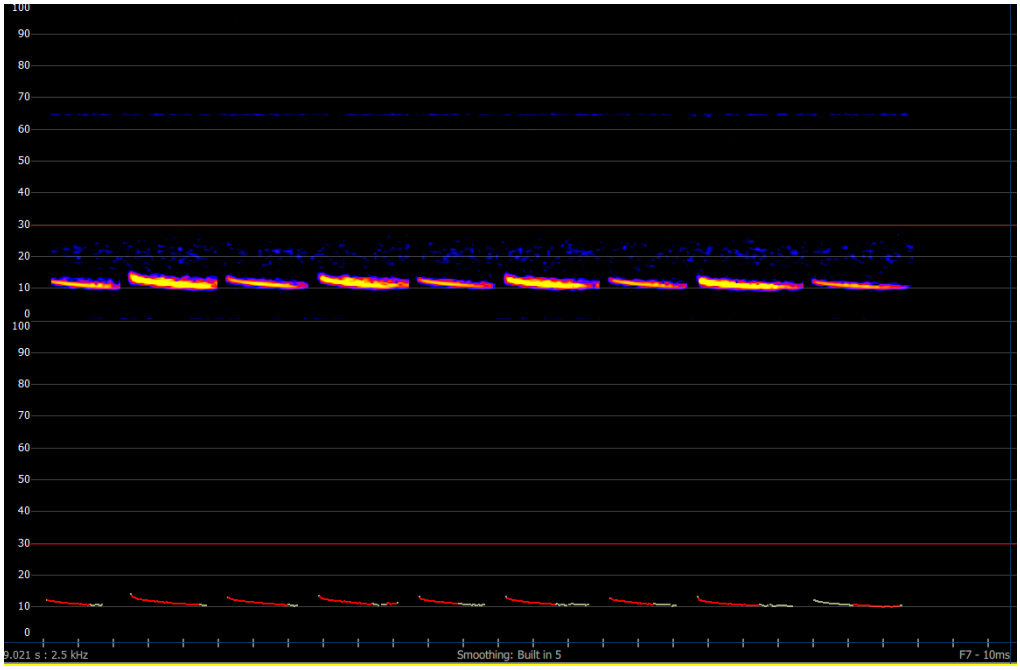
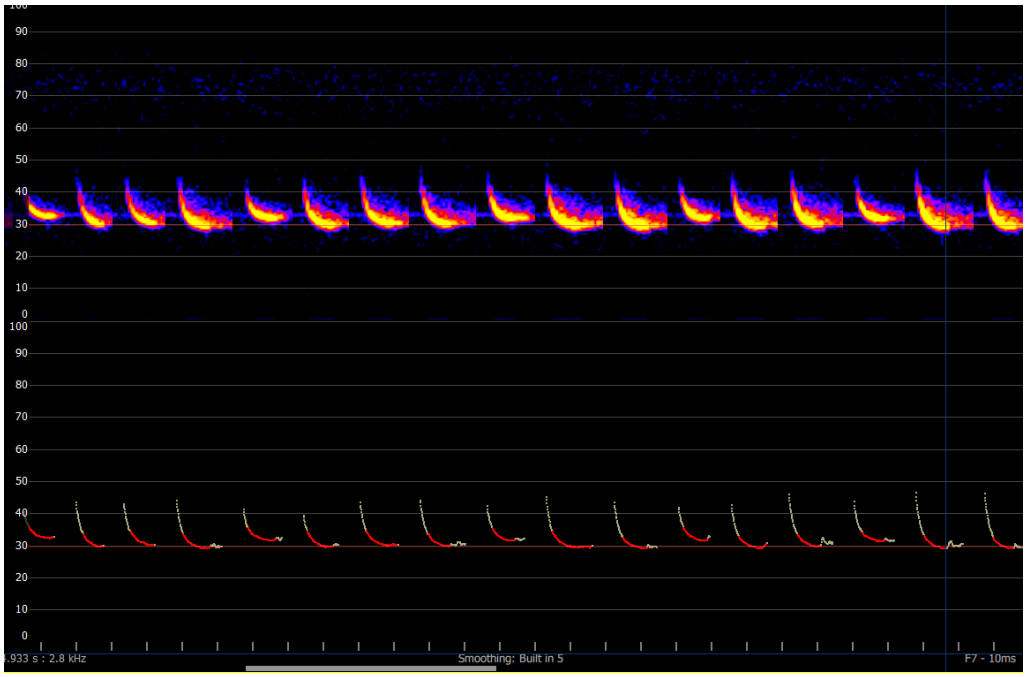
Titley Scientific. (2023). *Anabat Insight* (2.0.7-0-g3e26022).

6. Appendix: Example calls from this dataset

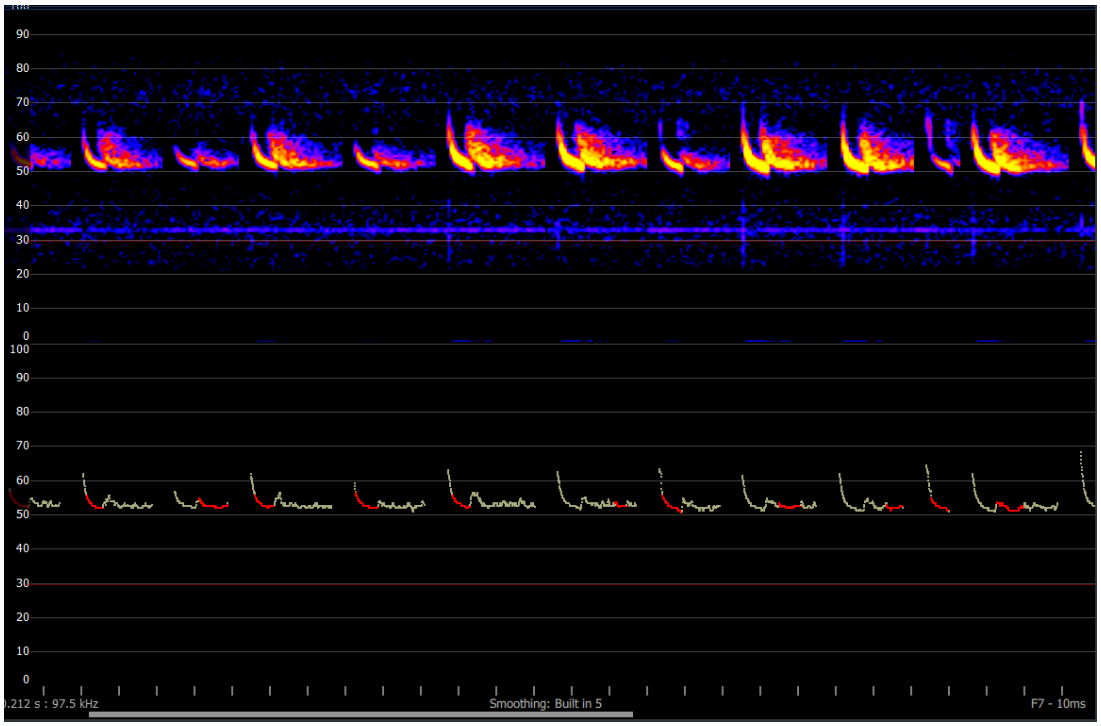
Appendix 1. Example call of *Austronomus australis* recorded at SM02. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



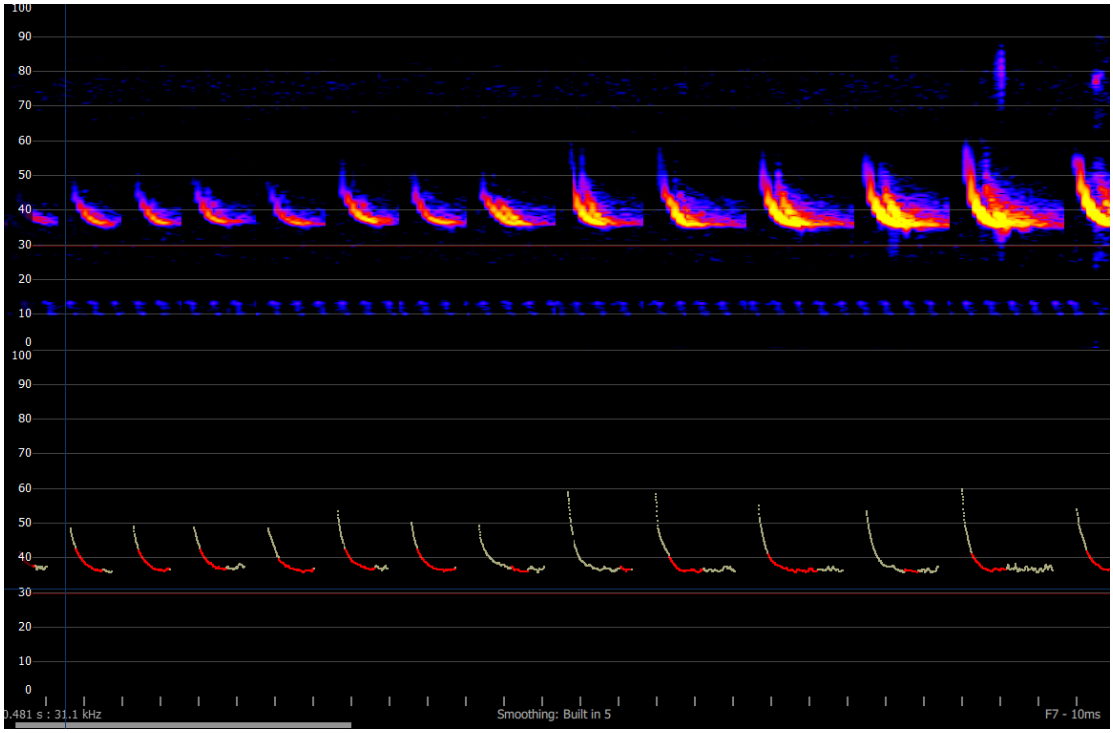
Appendix 2. Example call of *Chalinolobus gouldii* recorded at SUT05. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



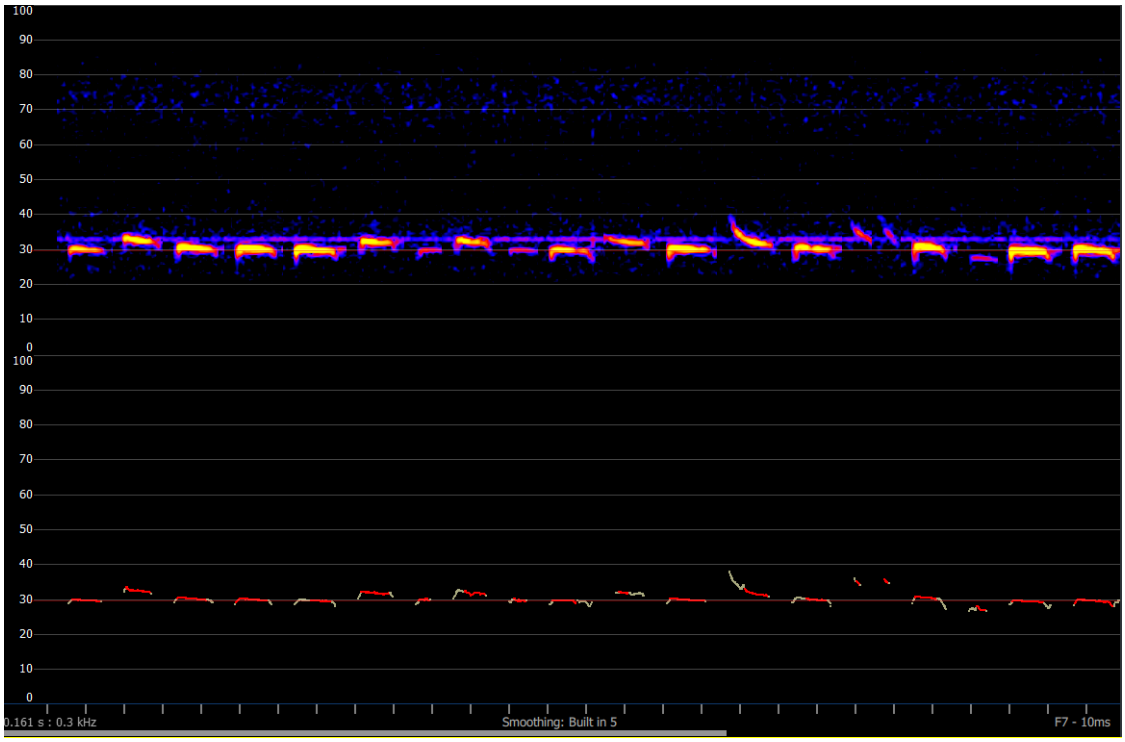
Appendix 3. Example call of *Chalinolobus morio* recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



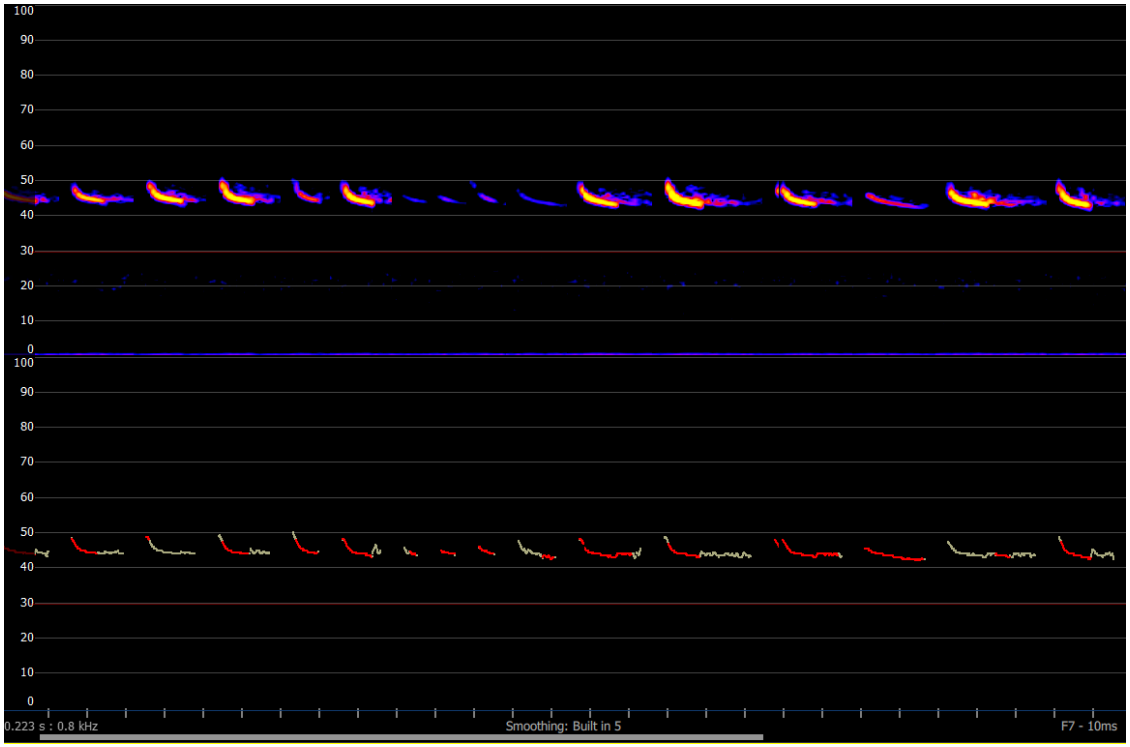
Appendix 4. Example call of species complex *Falsistrellus tasmaniensis / Scoteanax rueppellii / Scotorepens orion* recorded at SUT05. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



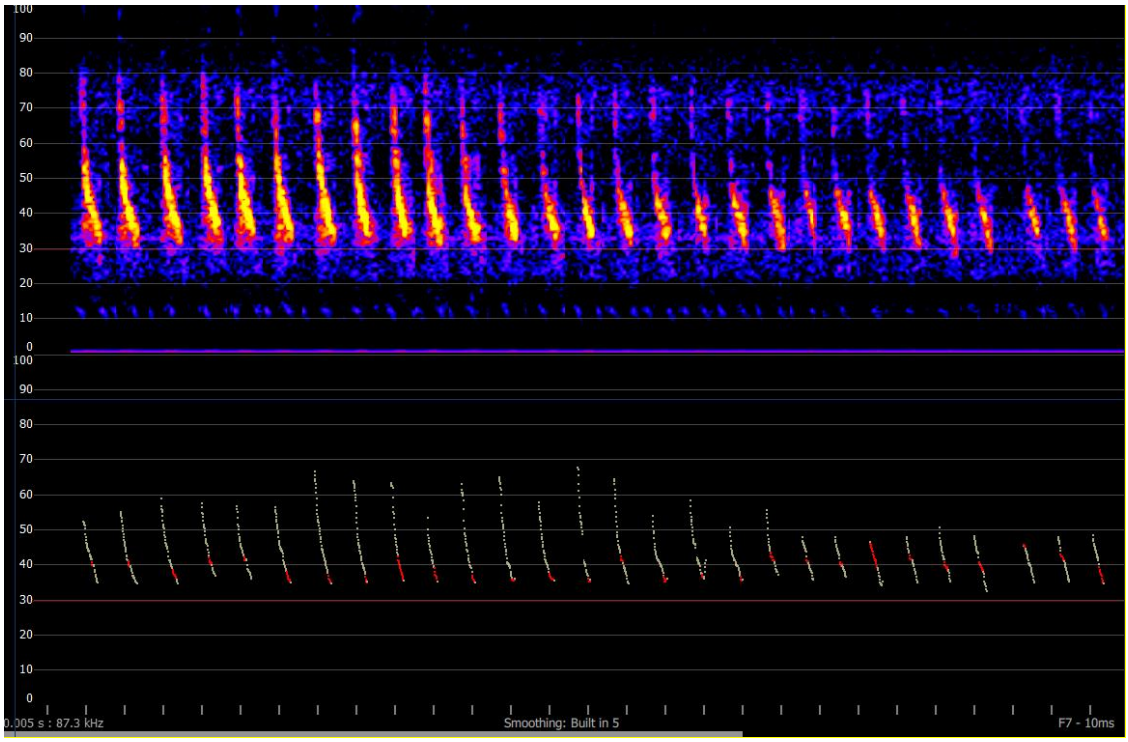
Appendix 5. Example call of *Micronomus norfolkensis* recorded at Sut04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



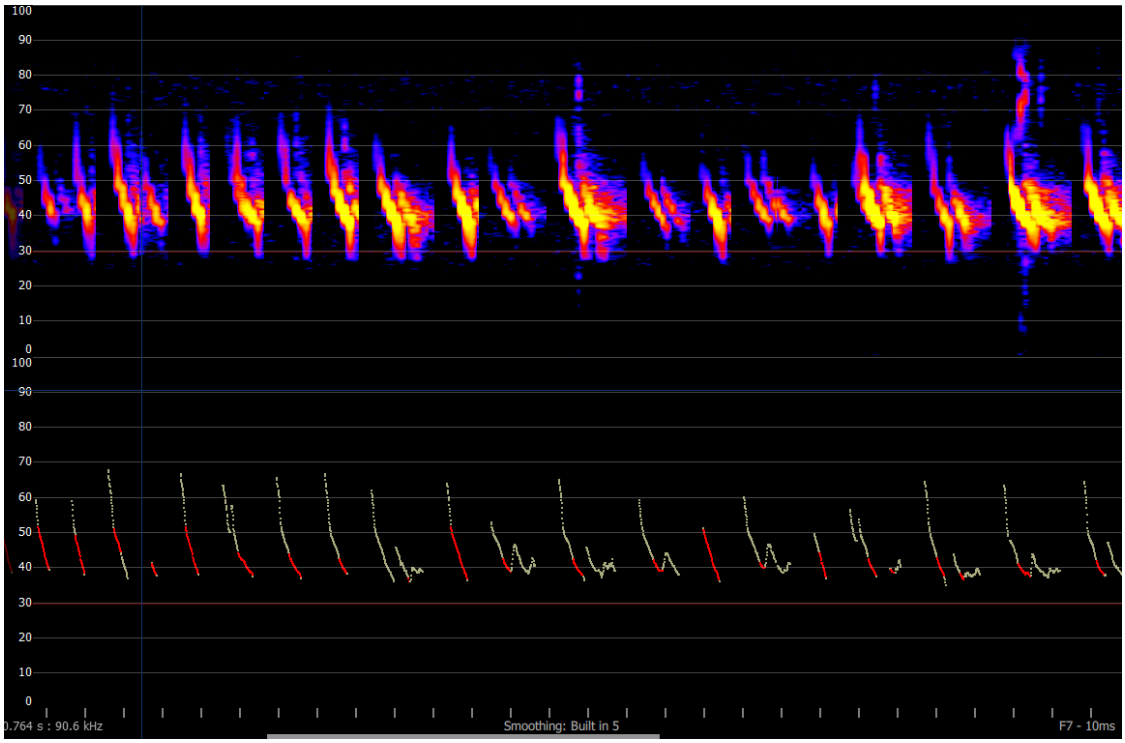
Appendix 6. Example call of *Miniopterus orianae oceanensis* recorded at SM06. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



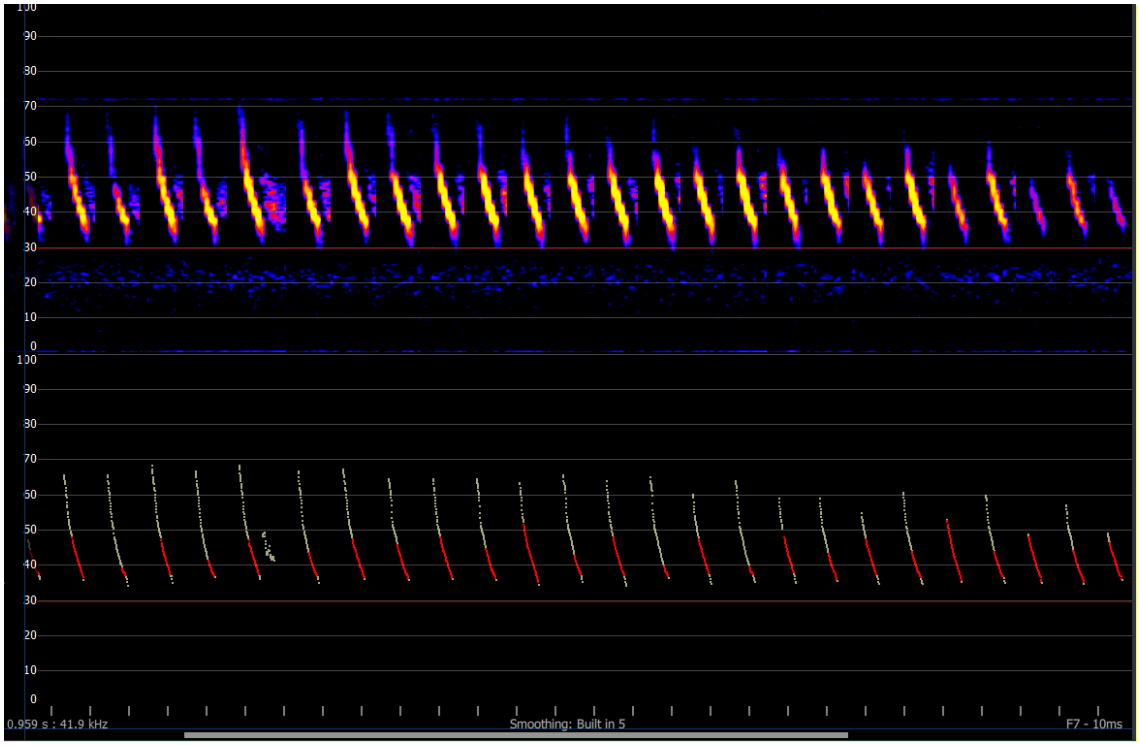
Appendix 7. Example call of *Myotis macropus* recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



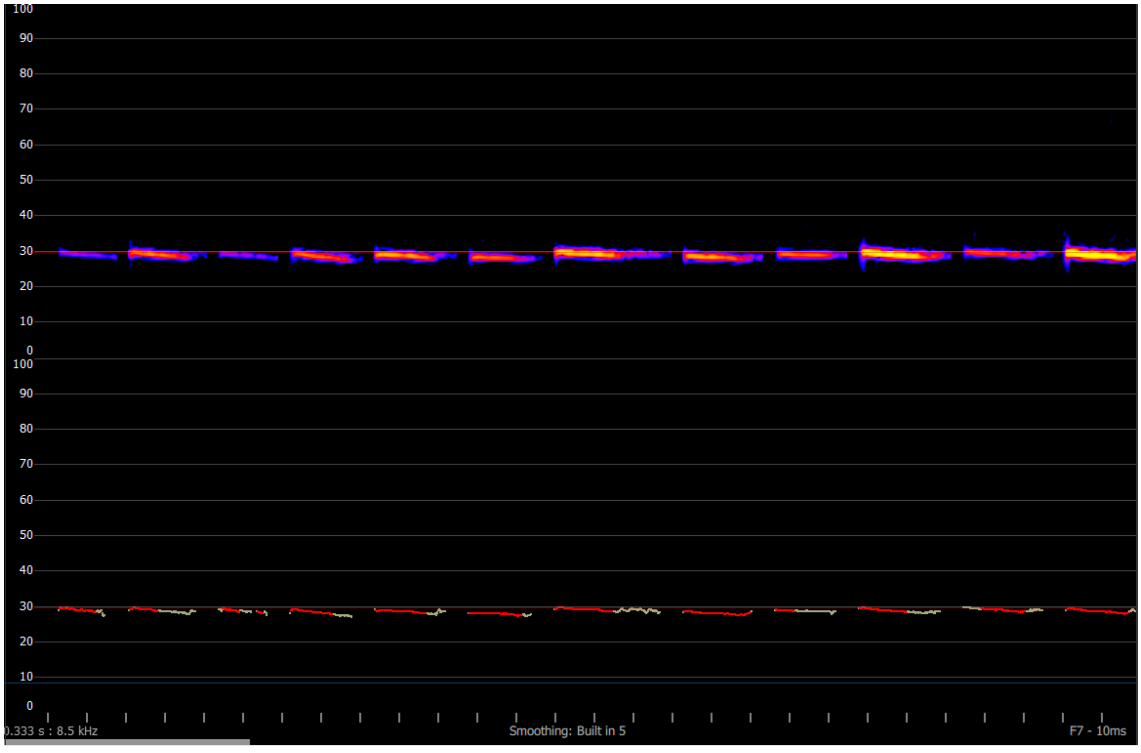
Appendix 7. Example call of *Myotis macropus* recorded at SUT05. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



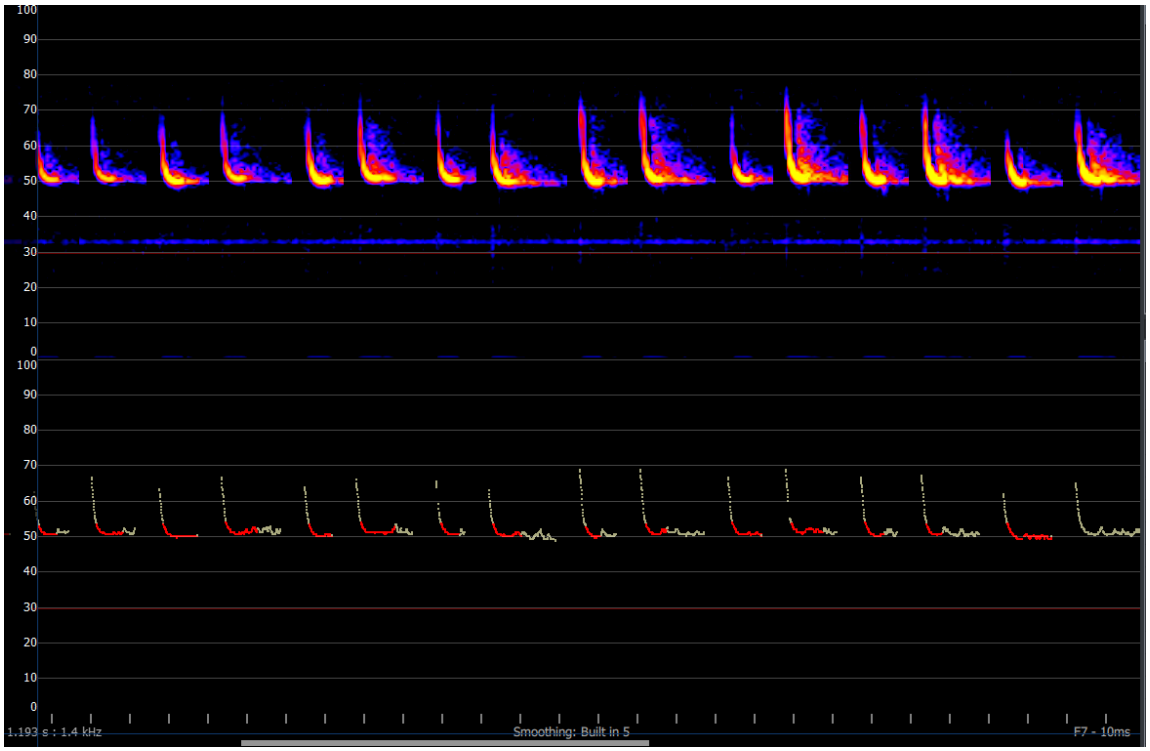
Appendix 8. Example call of the species complex *Myotis macropus* / *Nyctophilus geoffroyi*/ *Nyctophilus gouldi* recorded at Hunt03. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



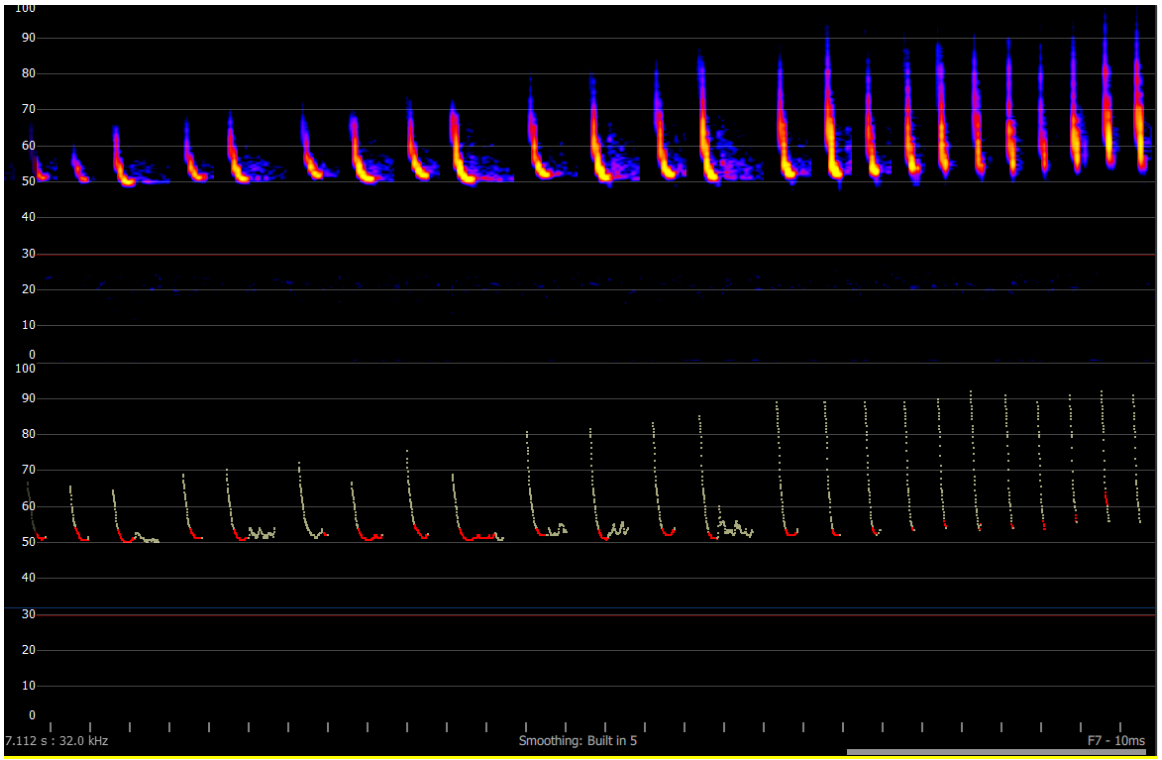
Appendix 9. Example call of *Ozimops ridei* recorded at SUT05. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



Appendix 10. Example call of *Vespadelus* sp. recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



Appendix 11. Example call of species complex *Vespadelus pumilus* / *Vespadelus troughtoni* / *Vespadelus vulturnus* recorded at SM06. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.0.8-0-g4157d1f. Settings are true time / time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.



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Appendix G Expert report – Green and Golden Bell Frog

Provided as a separate document

Sydney Science Park – Green and Golden Bell Frog Expert Report

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Template 2.8.1

Executive Summary

Introduction

Celestino Developments SSP Pty. Ltd. is planning to develop the Sydney Science Park on Luddenham Road at Luddenham, in southwestern Sydney. The proposed development of Sydney Science Park covers a range of building types including an education area and associated student accommodation, retail space, dwellings and a primary school. The works also include new roads and infrastructure, landscaping, open space, sporting fields and parks, wetlands and riparian works and community facilities.

One species potentially present within the subject land is *Litoria aurea*, the Green and Golden Bell Frog (GGBF). This frog is a species credit species historically recorded broadly across the Sydney Basin (Cogger 2014) and habitat the species is known to use is present within the subject land. Surveys for this species were conducted in April 2016 and March 2018 and did not detect the frog. Surveys were again completed over four nights between November 2023 and March 2024 and followed the methods required under the NSW Biodiversity Assessment Method (BAM) Survey Guidelines for Threatened Frogs (DPIE 2020). However, the rainfall through all of this period did not reach the preferred levels for surveys and so an expert report is being completed to provide an additional assessment for the species on the area of the proposed development.

There are no historic records from within the development site and the closest record is from approximately 3 km southwest of the development site and was recorded in 2019. The details available for the record were minimal and enquiries found the record to be erroneous. Survey work completed at various times by ELA to assess impacts of the proposed development did not locate any individuals. The closest identified important population is the St Mary's Population, which is located over 10 km to the north.

Species Biology

GGBF breed in a wide range of water bodies that includes human-created environments such as abandoned mines, quarries and artificial wetlands. GGBF prefer to breed in water bodies that are still, shallow, ephemeral, unshaded, with aquatic plants and free of the Plague Minnow (*Gambusia holbrooki*) and other predatory fish. The species may prefer to breed in ephemeral water bodies when available. Frogs generally migrate 100-300 m from the breeding site to settle into recognisably different complementary non-breeding habitat. The GGBF non-breeding habitat is another water body which they use rather than dispersing away into terrestrial environments. Movements into surrounding vegetation are usually only over a relatively small distance (< 50 m), for short times (days) as a means of finding food or temporary refuges. There is a preference for grassy areas and areas of open vegetation that provide open foraging habitats and/or that contain a range of diurnal shelter sites such as logs, rocks or dense vegetation. More regular terrestrial movements of the GGBF are primarily undertaken along either streams that contain water or between pools/ponds that provide stepping stones of shelter between start and end water bodies. GGBF individuals may occasionally move distances as far as 10 km, but the species does not generally persist at ponds isolated from other occupied water bodies by over 500 m.

GGBF are considered to follow a classical metapopulation structure with the "local" population consisting as a series of patchy populations within the larger single metapopulation that need to maintain connection for the overall metapopulation to survive. Core sites provide ongoing and regular reproductive success and maintain long-term populations, but a critical part of the population dynamics is driven by inter-year success of breeding at a range of available breeding sites leading to ongoing dispersal and colonisation of unoccupied breeding and non-breeding habitat. Movements can occur over long distances, but ponds become significantly less likely to be inhabited once they are more than 500 m from another inhabited pond, so distance to water bodies is important for their potential to be used. Additionally, the presence of the GGBF at sites may also be mediated by the presence of suitable vegetation, the presence/absence of introduced fish and the extent of land development, particularly the road network. Such factors lead to fragmentation of populations and barriers to critical movements between sites and GGBF are typically absent from ponds in areas with fewer and more isolated ponds and with higher densities of roads.

Habitat Present on the Development Site

The Sydney Science Park development site historically had 35 isolated water bodies present along with a range of drainage lines located within a generally cleared rural landscape. This environment provides potentially suitable habitat for the GGBF, but a number of the water bodies have been de-watered to aid in the development process. There are currently 28 mapped water bodies (dams) present that the frogs could use and these cover a range of sizes from < 10 m diameter to > 200 m diameter. These are generally located along drainage lines that flow intermittently and the available water bodies range from occasional shallow pools to permanent deep water bodies. The water bodies provide a mosaic of closely located ponds that are typical of areas with populations of GGBF as such an array of water bodies provides an environment where frogs can move between aquatic sites to maintain a metapopulation. These water bodies provide potentially suitable breeding habitat in that they all have some emergent/fringe vegetation, are unshaded and were found to have varying numbers of introduced predatory fish depending on the time of the inspection. They are also bordered by low grassy areas that the species is considered to prefer as foraging habitat and can move through easily to reach ponds through overland travel

However, only a few small water bodies (< 20 m diameter) in the central part of the site contain any significant areas of aquatic vegetation that the species prefers as this vegetation provides shelter and basking opportunities. And they are all located within cleared grazing lands with very little retained native vegetation present to provide shelter when frogs move between water bodies. Frogs present would typically have to travel over 500 m to reach any area of substantial vegetation that may provide protective habitat when not using a water body. There are no indications of any ephemeral water bodies forming anywhere on the development site.

Importance of the subject land to the Green and Golden Bell Frog

The available information indicates that the development site is not likely to have been used by a viable population of the GGBF in recent times and is unlikely to do so for the foreseeable future. This is because the species is no longer present in this part of the Sydney Basin as a result of multiple threats, most importantly the amphibian Chytrid fungus and the Plague Minnow, which was evident across the site at different times.

Given that there are no records of the GGBF within the subject land and there are also no records from adjacent lands and locality for over 20 years, the species has been determined to be absent from the study area and will not be impacted in any way by the proposed development. Hence there is no requirement to produce a species polygon to create an offset.

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1. Introduction

Celestino Developments SSP Pty Ltd is planning to develop the Sydney Science Park located on 565-601 and 601a Luddenham Road, Luddenham, in southwestern Sydney (referred to as 'subject land'). The subject land includes Lot 1 DP1276320, Lot 2 DP1276320, Lot 3 1276320 and Lot 206 DP 1280188 and is located approximately 55 km west of Sydney and 18 km south of Penrith.

The development footprint encompasses the area of land that will be directly impacted by the proposed works. For the purposes of this assessment, Lots 201, 203 and 205 DP1280188 are excluded from the development footprint. These lots are associated with the construction footprint for the Sydney Metro Western Airport link and are not proposed for development under the current SSDA (Figure 2).

The subject land is within the Penrith City Council Local Government are (LGA). The site is primarily zoned Mixed Use (MU), with portions of the site over the riparian corridors and recreational spaces zoned ENZ – Environmental Recreation. The western portion of the site is zoned Enterprise (ENT) with areas of ENZ along the riparian corridor. However, the land zoned ENT is not identified as Sydney Science Park (SSP) under Section 4.28A of the Western Parklands City SEPP.

The subject land comprises exotic grazing land (260 ha), cleared areas (10.87 ha of gravel access tracks), exotic vegetation (7.17 ha), planted native vegetation (0.46 ha) and fragmented remnant native vegetation in poor condition (3.27 ha). The subject land also contains numerous streams and human made dams. The majority of the vegetation is in poor condition. The subject land has an extensive history of use for agricultural purposes including ongoing cattle grazing and pasture improvement. This has contributed to the overall poor condition of the ecological values present.

TARGET SPECIES

Litoria aurea, the Green and Golden Bell Frog (GGBF), has been identified as needing impact assessment for the subject land. GGBF is a species credit species that is listed in the Endangered category of the NSW *Biodiversity Conservation Act 2016* (BC Act) as well as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This frog was historically recorded broadly across the Sydney Basin and was well known for inhabiting environments such as that present in the development site. This expert report has been included to inform the Biodiversity Development Assessment Report (ELA 2025) to adequately assess this species as the levels of rainfall during the assessment period were not sufficient to provide confidence in detecting the species during the surveys that were conducted across the site. The subject land for this assessment is defined as the area covered by the proposed development. The study area includes the subject land and a buffer of 200 m as well as any identified migratory and/or shelter habitat for GGBF that could interact with the study area (discussed in more detail in following sections), as detailed under the NSW Survey Guide for Threatened Frogs (DPIE 2020). The assessment also included coverage of the lands immediately to the west of, and contiguous with the subject land , which is partly included as part of the study area. This was done in consideration that this land may be subject to a subsequent development application.

1.1 Use of an expert report

Box 3 of the Biodiversity Assessment Method 2016 (BAM) notes the following for the use of an expert report*:*

"An expert report can be used instead of a species survey for all proposals to determine whether a species is present or not present on the subject land. Where an assessor assumes the species is present (except for a proposed biodiversity stewardship site), an expert report may be used to determine the location and area of fauna/flora habitat for the species polygon, and the estimated number of individuals of the flora species.

An expert report can only be prepared by a person who, in the opinion of the Secretary of the Department or anyone authorised by the Secretary, has specialised knowledge, which may be based on training, study or experience, to provide an expert opinion regarding the threatened species to which the report relates".

and

"An expert report can only be used instead of survey for species credit species. An expert report may be used to support the estimation of the area of suitable habitat or number of individual flora where the species is assumed to be present on a development site or in the biodiversity certification assessment area. The expert report must document the information that was considered, and/or rejected as unsuitable, to reach the determination made in the expert report. The BAR must include the expert report".

and

An expert report must set out whether:

a. the species is unlikely to be present on or use habitat on the subject land, in which case, no further assessment of the species is required, or

b. the species is likely to be present on or use habitat on the subject land.

If the species is likely to be present on or use the subject land, the expert report must:

a. identify the species or population

b. justify the use of an expert report

c. justify the likelihood of occurrence of the species or population and prepare a species polygon as per Subsection 5.2.5

d. estimate the area of habitat (if the species is assessed by area) or the maximum number of individuals (if the species is assessed by count of individuals) on the subject land. Evidence such as a population estimate from a reference site could be used to justify this estimation

e. include the information considered in making this determination

f. state the expert's credentials."

Dr Lemckert is a listed accredited expert for the GGBF under the Biodiversity Assessment Method and so has been approved to write an expert report pertaining to this species. His CV is provided in Appendix A.

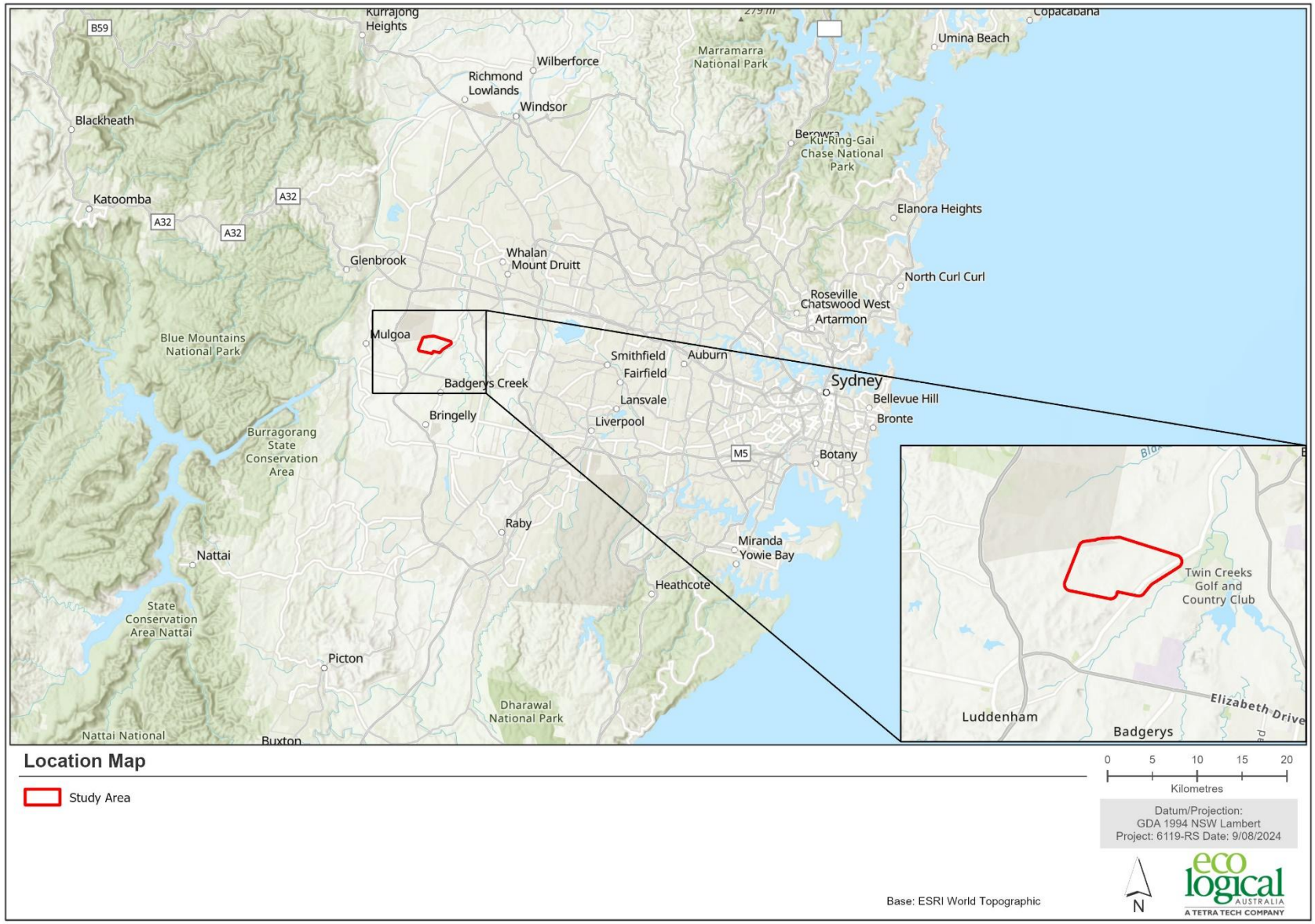

Figure 1: Location of Development Site in NSW

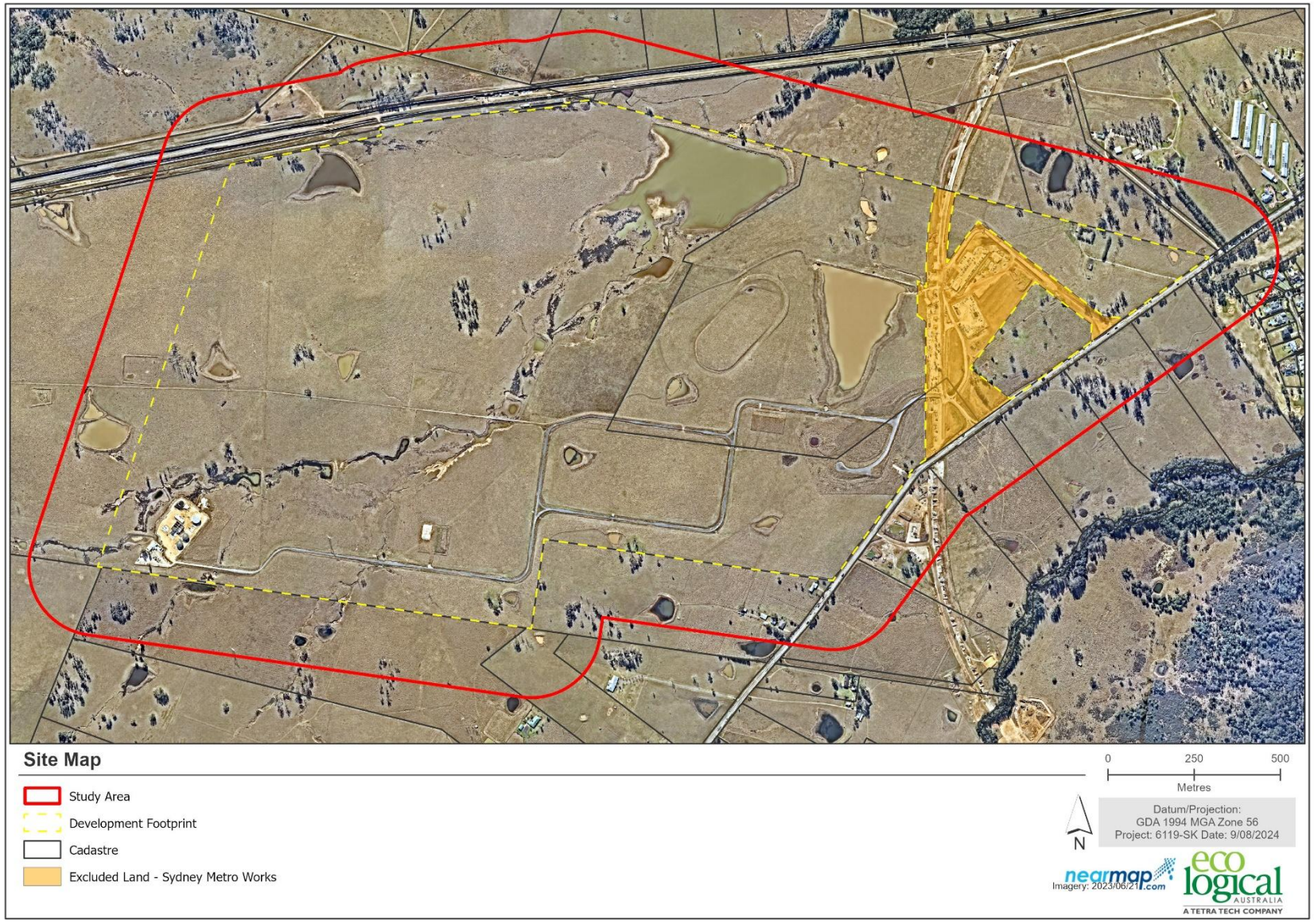

Figure 2: Study area and development footprint including 200 m buffer around boundary

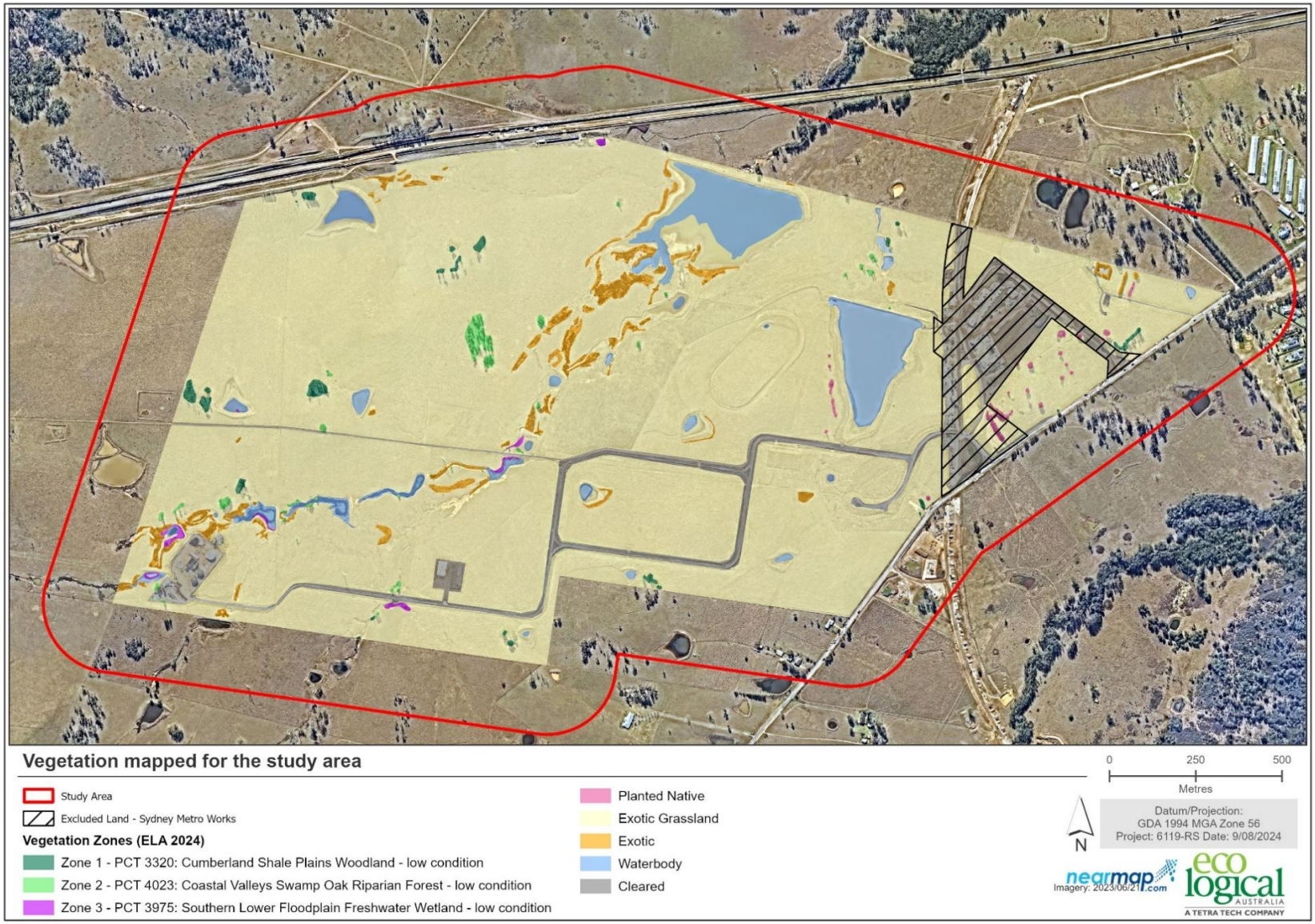

Figure 3: Plant Community Types mapped on the subject land

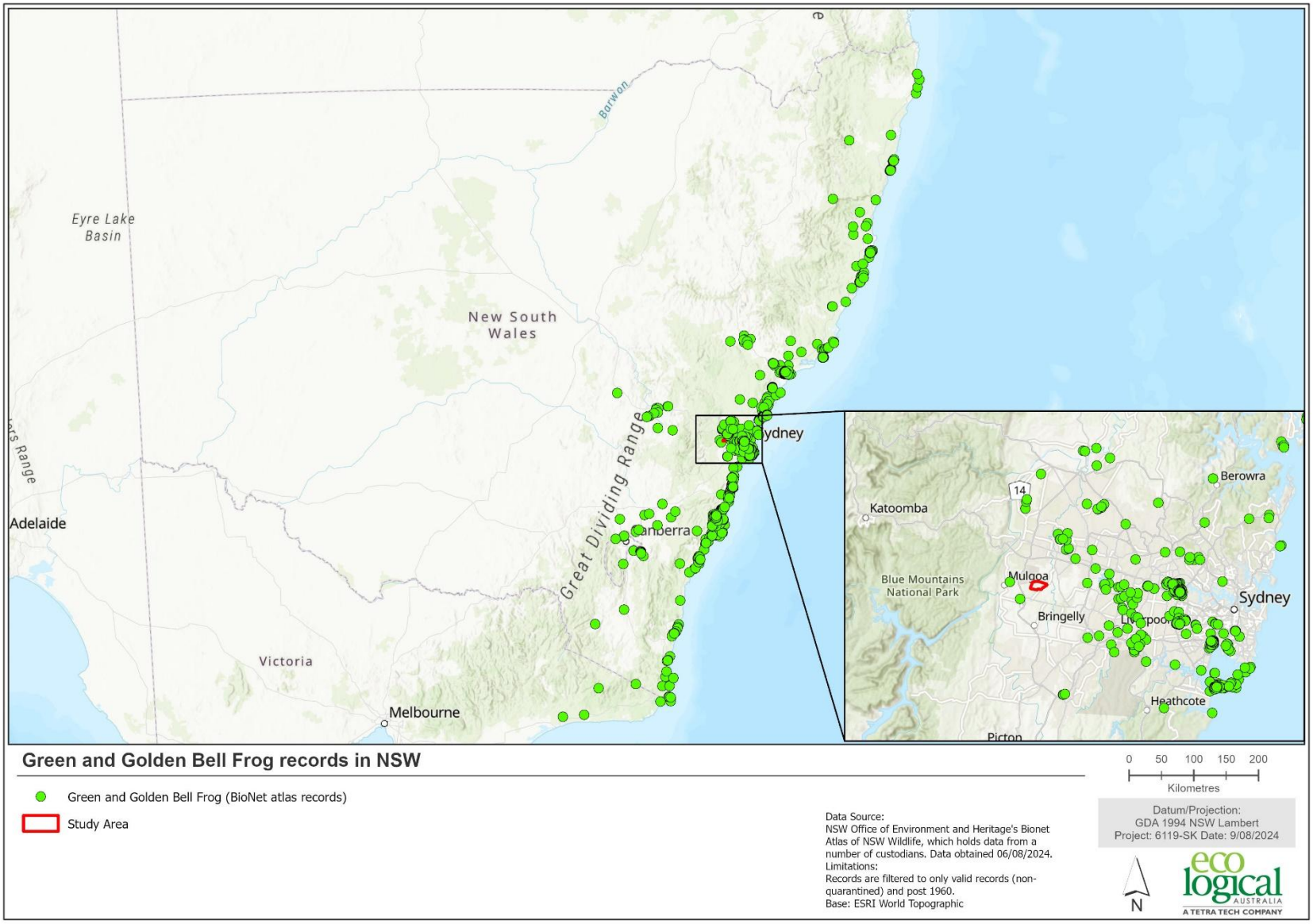

Figure 4: Records for the Green and Golden Bell Frog across NSW.

1.2 Project context

The proposed development is seeking approval for the development of the Sydney Science Park at Luddenham in southwestern Sydney (Figure 1). The subject land covers 565-601 and 601a Luddenham Road, Luddenham, which encompasses Lot 1 DP1276320 (100.6 ha), Lot 2 DP1276320 (187.5 ha), Lot 3 DP1276320 (2.40 ha) and Lot 206 DP1280188 (6.39 ha).

The SSDA 1 will seek Concept approval for the site-wide strategies and staged development of the subject land, as well as a detailed proposal for the first stage of development in accordance with Section 4.22 of the EP&A Act. The Concept Proposal and Stage 1 Development comprises the following:

Element	Area / legal description	Description	Stage
Concept Proposal			
Concept Plan	Entire site (Lots 1, 2 and 3 DP 1276320 Lots 206 DP 1280188)	The concept proposal comprises the following: Appendix A: A concept urban structure plan based on a site wide approach for the development of urban blocks/super lots, including site-wide open space and riparian corridors and key transport infrastructure links (sub-arterial, indicative collector and local roads, and associated intersections). Appendix B: Staging plan, setting out the development stages, and Appendix C: Guidelines for the future stages of development. The SSDA will seek approval for the following site-wide strategies: Appendix D: Connecting with Country Design Response Appendix E: Open Space Strategy that details that six (6) different categories of open space areas that are proposed throughout the site as per the below: E1: Key destinations E2: Local open spaces E3: Cultural spaces E4: Wetlands and riparian E5: Green loops E6: Streetscape Appendix F: Integrated Water Cycle Management (IWCM) and flooding Strategy Appendix G: Civil and Bulk Earthworks Strategy Appendix H: Biodiversity and Ecology Appendix I: Environmental Site Assessment (Contamination) Appendix J: Site Infrastructure and Servicing	All stages
Stage 1 Precinct	Lot 1 DP 1276320 (part lot) Lot 206 DP 1280188	The Stage 1 Precinct, which will primarily be located on the south-eastern portion of the site and will include the following: Appendix K: Clearing, tree removal, bulk and detailed earthworks, including cut/fill, grading, and benching. Appendix L: Construction of structural support, including retaining walls and batters. Appendix M: Staged construction of civil and infrastructure works, including temporary works associated with roadworks and IWCM. Appendix N: Landscaping and streetscape.	Stage 1

Element	Area / legal description	Description	Stage
		Appendix O: Provision and augmentation of services (potable water, sewer, recycled water, electricity, and telecommunications), and Appendix P: Associated environmental management works, including erosion and sediment control.	
Stage 1 Estate Works	Lots 1, 2 and 3 DP 1276320 Lot 206 DP 1280188	The Stage 1 Estate Works will primarily comprise the following and will be executed in a staged manner: Appendix Q: Clearing, tree removal and earthworks, including cut and fill, benching and stabilisation (batters and/or retaining walls) to achieve appropriate site levels across the site. Appendix R: Stormwater and other related civil work, including the provision of utility services. Appendix S: Public domain work such as the provision of footpaths from Stage Precinct 1 to the Metro Station and associated signage, and Appendix T: Internal reticulation of services and utilities, including connections to and from the existing Sydney Integrated Water Recycling Hub.	Stage 1
Stage 1 Subdivision	Lots 1, 2 and 3 DP 1276320 Lot 206 DP 1280188	Staged subdivision of Stage 1 Development area, creating a total of 18 lots, comprising: ▪ five (5) development lots and ▪ thirteen (13) residue lots.	Stage 1

The proposed development also seeks approval to remove native vegetation and to restore and rehabilitate areas within the subject land. A copy of the Landscape Plan is provided in Figure 5.

The proposal has considered options to retain existing native vegetation, however, the majority of the native vegetation within the subject land is in poor condition. Due to the proposed Stormwater Management Strategy the existing vegetation along the riparian corridors could not be retained. As such, one patch of native vegetation (0.71 ha), with some retention values (due to the presence of hollow-bearing trees) was identified to be retained within the subject land and subject to revegetation works in accordance with a Vegetation Management Plan (VMP) (ELA 2025).

The subject land boundary and development footprint are presented in Figure 2.

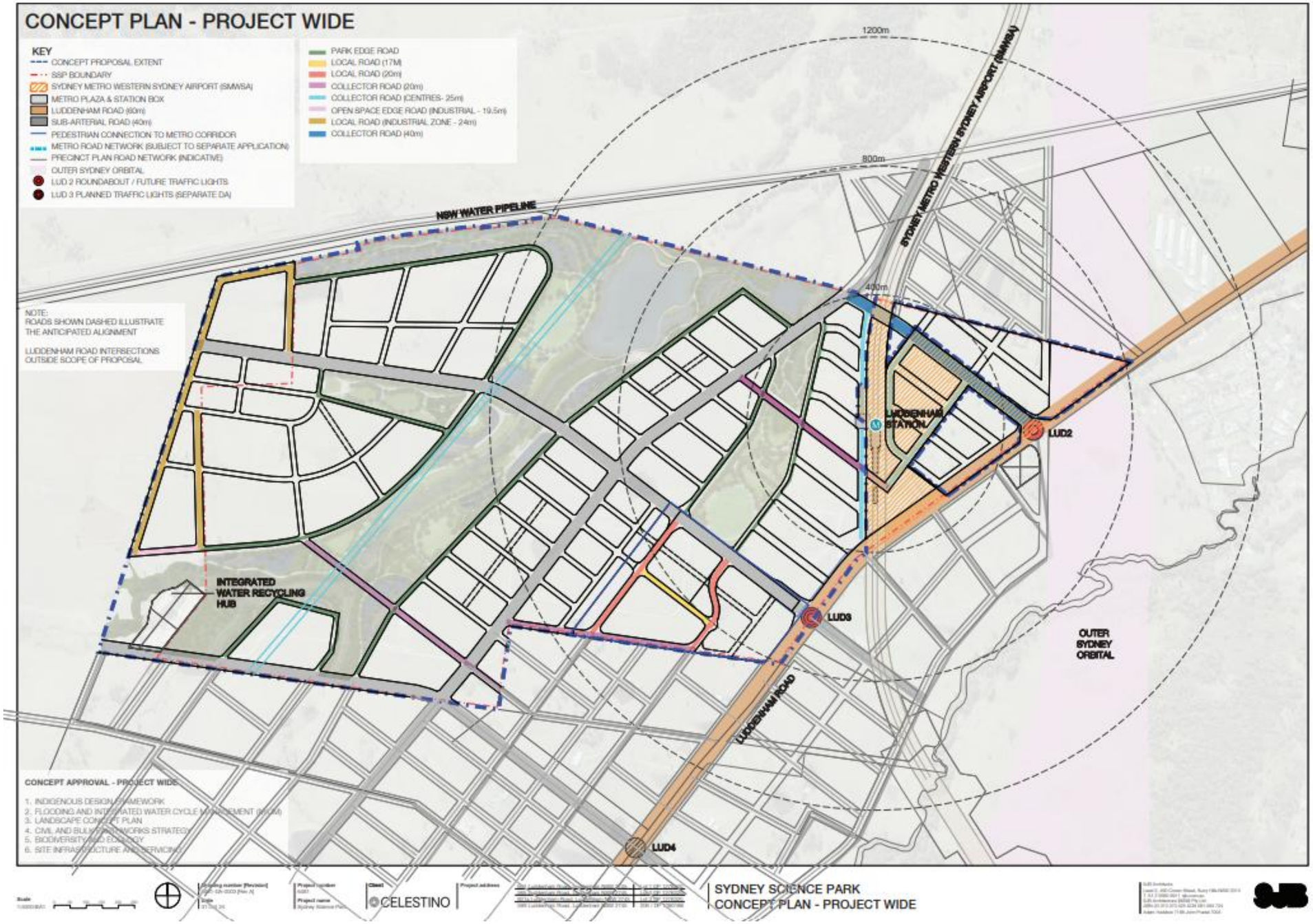

Figure 5: Masterplan provided by Celestino Developments SSP Pty Ltd

1.3 Assessment Area

The study area for this report comprises the subject land and a 200 m buffer around the boundary of the development extents. This area covers the distance of the buffer zone around breeding sites that is considered habitat for offsetting under the NSW Survey Guide for Threatened Frogs (DPIE 2020). This is the area that is generally used by frogs as complementary non-breeding habitat adjacent to breeding sites and is also essential for the survival of the local population. Land outside of this distance is typically used insufficiently frequently to be of importance to the population unless it is part of a movement corridor.

1.4 Reasons for use of an expert report

The Biodiversity Assessment Method places two specific requirements for where an expert report can be used instead of surveys:

- an expert report can only be used instead of a survey for species to which species credits apply
- an expert report may be obtained instead of undertaking a species survey at a development site, clearing site, land to be biodiversity certified or a biodiversity stewardship site.

The GGBF meets the first criteria, being listed as a species credit species under the BC Act.

The GGBF is known to be able to use the types of landscapes present within the study area (see Section 2.4) and there are records of the frogs present within the adjacent residential subdivision and two records in the broader BCAA from within the last five years (Figure 3). Field surveys were able to be completed to the intensity required under the BAM survey guidelines (DPIE 2020) with four surveys being carried out across this site between November 2024 and March 2024, including three by the author of the report. However, rainfall levels through this period did not meet the 75 mm over 24 hours or 150 mm over 72 hours as set under the EPBC survey guidelines for the species and so it was determined that an expert report should be completed for the species to provide added certainty in the assessment process for the subject land.

CREDENTIALS OF EXPERT

Dr Lemckert is an Ecologist that has been undertaking studies into the ecology and management of frogs since 1986 and has been a principal ecological consultant since 2011. His skills include survey design / implementation / targeted species surveys, data handling, analysis and interpretation and the production of high level reports including papers published in international peer-reviewed journals and technical reports and recovery plans for the Commonwealth and NSW Governments.

He has also been an expert witness for the assessment of the impacts of alleged illegal clearing for the Commonwealth, NSW and Local Governments and provided an expert review of the development assessment process for impacts on Matters of National Environmental Significance for two proposed Coal Seam Gas developments in Queensland. Dr Lemckert represented Forests NSW (now Forestry Corporation NSW) as a reptile and amphibian expert in the Comprehensive Regional Assessments and Regional Forest Agreement Process carried out between 2000 and 2002, as an expert in fauna management for negotiations over a new Threatened Species License for harvesting operations in 2014 and again as part of a team developing a historic assessment of forestry impacts and monitoring for the Integrated Forest Operations Agreement in 2022.

He has completed two rounds of expert review of the status of Australia's amphibians for the IUCN and lead a team reviewing prescriptions protecting threatened species for the NSW Private Native Forestry Codes of Practice (2022).

Dr Lemckert is an acknowledged expert on eastern Australian frogs having completed his MSc and PhD on the ecology and management of frogs in this region and has published over 70 papers (or book chapters) in Australian and International peer-reviewed journals. He has been used by both the NSW and Commonwealth Governments as an expert witness in court cases assessing the impacts of land clearing on threatened frogs.

He is a member of the Amphibian Specialist Group of the IUCN, secretary of the NSW Declining Frog Working Group of NSW and past president of the Australian Society of Herpetologists. He co-supervised two PhD students, a Master of Applied Science Student and three Bachelor of Science (Honours) students who completed theses addressing issues of frog biology and conservation. He is listed as an accredited expert by the NSW Department of Planning and Environment (DPE) to provide expert reports for multiple frog species under the Biodiversity Assessment Method (BAM), including the GGBF. He has produced expert reports for the GGBF for the Warragamba Dam raising project, for the Strategic Assessment for the Cumberland Plain Conservation Plan and the Advanced Water Recycling Centre in Western Sydney. He has recently written the survey guidelines for NSW threatened frog species to be used in assessments under the Biodiversity Assessment Method (BAM).

Dr Lemckert can demonstrate his expertise on the GGBF through the following publications and reports:

- Gillespie, G.R., Roberts, J.D., Hunter, D., Hoskin, C.J., Alford, R.A., Heard, G.W., Hines, H. **Lemckert, F.**, Newell, D. & Scheele, B.C. 2020. Status and Priority Conservation Actions for Australian Frog Species. Biological Conservation 247, 108543. https://doi.org/10.1016/j.biocon.2020.108543.
- **Lemckert, F.L.**, & Mahony, M.J. 2018. The status of Decline and Conservation of Frogs in Temperate Coastal South-eastern Australia. **Pp 59-72** In: *Amphibian Biology Volume 11 - Conservation and Decline of Amphibians: Eastern Hemisphere (Australia, New Zealand and Pacific Islands)*. H. Heatwole and J. Rowley (Eds.). CSIRO Publishing, Melbourne.
- **Lemckert, F.L.** 2017 and 2021. Surveys for the Green and Golden Bell Frog at Meroo for the Saving our Species Research Program. Report to NSW Office of Environment and Heritage.
- Mahony, M.J., Hamer, A.J., Pickett, E.J., McKenzie, D.J., Stockwell, M.P. Garnham, J.I., Keely, C.C., Deboo, M., O'Meara, J., Pollard, C.J., Clulow, S., **Lemckert, F.L.**, Bower, D.S., & Clulow, J. 2013. Identifying conservation and research priorities in the face of uncertainty: a review of the threatened bell frog complex in eastern Australia. *Herpetological Conservation and Biology* **8:**519-538.
- Penman, T.D. & **Lemckert F.L.** 2008. Monitoring the green and golden bell frog: current problems and an alternative approach. *Australian Zoologist* **34:**373-378.
- Hero, J-M., Gillespie, G., Cogger, H., **Lemckert, F.** & Roberston, P. 2008. *Litoria aurea*. Pp 256 In: *Threatened Amphibians of the World.* S.N. Stuart, M. Hoffman, J.S., Chanson, N.A. Cox, R.J. Berridge, P.J. Ramani & B.E. Young (Eds). Lynx Edicions, Barcelona, Spain.
- Hero, J-M., Gillespie, G., Cogger, H., **Lemckert, F.** & Robertson, P. 2004. *Litoria aurea*. The IUCN Red List of Threatened Species 2004: e.T12143A3325402. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T12143A3325402.en. Downloaded on 17 May 2018.
- **Lemckert, F.L.** 1998. Survey report for the green and golden bell frog at Badgerys Creek, NSW. Unpublished report for Biosis Pty. Ltd.

- **Lemckert, F.L.** 1996. Surveys for the green and golden bell frog, *Litoria aurea*, by the State Forests of New South Wales. *Australian Zoologist* **30:**208-213.

In addition, he is recognised as an expert in the species having been engaged by:

- Legacy Pty Ltd to provide an expert report on the presence of the GGBF for the re-development of the Corrimal Cokeworks (2023).
- Remara Property to provide an expert report on the presence of the GGBF at a development at Sussex Inlet (2023).
- Ford Civil to manage impacts of the development of the Barton Park Precinct development on the local population including survey and monitoring programs (2022-23).
- Sydney Olympic Park Authority as an invited speaker at the GGBF Management Workshop held at Sydney Olympic Park (2022).
- NSW Roads and Maritime Services to conduct expert surveys for this species for the Princes Highway-Jervis Bay Road Upgrade (2021-2022).
- Kooragang Island KIEP site (contaminated lands) pre-clearing management and relocation of the Green and Golden Bell Frog population on the development site during the vegetation clearance program prior to capping of the site (2021-2022).
- Expert assessment on the presence of the GGBF for the Kurri Smelter re-development project (2021).
- Kooragang Island KIWEF facility survey and relocation of Green and Golden Bell Frogs from five separate areas requiring the relocation of over 1000 juvenile Green and Golden Bell Frogs into selected translocation ponds (2020).
- Blacktown Council to complete surveys for the Green and Golden Bell Frog in around the old Riverstone Meat Works to determine potential presence of the species for future development of the site (2020).
- NSW Office of Environment and Heritage (now DPIE) to complete a baseline survey for the Meroo Lake population of the GGBF for the Saving Our Species (SOS) program (2016-2017 and 2021).
- NSW Office of Environment and Heritage to be part of the expert panel determining the categorisation of this species under the SOS program and in determining the populations requiring specific management to meet the SOS requirement to have a viable population maintained 100 years into the future.
- Daracon to provide expert advice and survey for this species at Kooragang Island for a soil emplacement facility (2019-2020).
- NSW Roads and Maritime Services to conduct expert surveys for this species for works at Sydney Airport, Shortland to Sandgate and Berry to Bomaderry (various since 2014).
- NSW Roads and Maritime Services to conduct expert surveys for this species in the area around South Nowra (2011-2016).
- Port Kembla Coal Terminal to conduct annual ongoing monitoring of this species as part of a Green and Golden Bell Frog Management Plan (2014-2017).
- John Holland Group and Daracon to provide expert advice and survey for this species at Kooragang Island for a rail and road corridor upgrade (2015-2016).
- EPBC surveys for the GGBF at Port Kembla to determine the presence/absence of this species in relation to a proposed development along Masters Road (2014).

- Wollongong Golf Club to complete repeat surveys at Wollongong Golf Course as part of pre- clearing of drainage culverts (2013).
- Provided expert opinion on the status of this species during assessments undertaken for the IUCN in 2001 and 2016.
- Provided expert opinion on the habitat requirements, sub-population status and reservation requirements for the Green and Golden Bell Frog during the NSW Government's Comprehensive Regional Assessment program (2000-2001).
- Distribution surveys through its historic range between Sydney, NSW, and the Gippsland area of eastern Victoria, as part of a project to look at overlap zones and pre-mating isolating mechanisms between the Green and Golden Bell Frog and Southern Bell Frog (*Litoria raniformis*) (1986-1987).

Dr Lemckert's full CV is provided as Appendix A of this report.

2. Species information

2.1 Species description

The GGBF is an endemic Australian tree frog that is a member of the Australian frog family Pelodryadidae (formerly Hylidae). It is one of the largest tree frog species in Australia, with adult males ranging in snout-urostyle length from 55-80 mm and females 65-100 mm snout to vent length (Tyler and Knight 2009; Clulow and Swan 2018). The species gets its name from the typical dorsal body colour seen for the species which a vivid green splotched with gold (Plate 1). However, in some individuals the back may be almost entirely green whereas other have dominant gold markings. There is a pale creamish-white stripe extending from the upper eyelids usually almost to the groin and a cream stripe along the top lip. The frog also characteristically has blue or bluish-green markings in the thighs and groin. The snout is relatively pointy and the belly granular. There is rarely a mid-dorsal stripe, which typically distinguishes this frog from *Litoria raniformis* (Southern Bell Frog).

Plate 1: Typical adult Green and Golden Bell Frogs (second frog is basking on emergent vegetation)

2.2 Life cycle

The GGBF is considered to have a calling season that extends from Spring to Autumn (Lemckert and Mahony 2008). Within that period of time calling is usually initiated by rainfall events. The males produce an advertisement call sounding like “whaaark whaark whark” along with a growling territorial call. Calling occurs mainly at night, but occasionally males will call during the day when conditions are favourable (DEC 2005). The males call in groups floating on the surface of the water usually holding on to emergent vegetation, with males synchronising their calls with a lead calling male so that they all call essentially at the same time (Barker et al. 1995; Pyke and White 2001). This may help to confuse predators by masking individual calls.

Male GGBF show signs of sexual maturity, in the form of nuptial pads and a darkened throat area, at around 45–50 mm snout-vent length (DEC 2005). These features become evident usually a year after metamorphosis. Females reach sexual maturity at a snout-vent length of around 65 mm, which typically takes to the second season after metamorphosis (DEC 2005).

Female GGBF produce a large number of eggs for an Australian species, with Pyke and White (2001) indicating an average clutch size is about 3,700 eggs, but with van de Mortel & Goldingay (1996) recording a maximum clutch of 11,682 eggs. Egg size is around 4 mm in diameter. Spawn is laid among aquatic vegetation, with it

initially floating on the water surface as a mass, but sinking within 24 hours of being laid. Eggs typically hatch 2–5 days after ovipositing/fertilisation (Anstis 2013) with water temperature playing a role in development time (eggs hatch faster in warmer water) and can hatch in less than one day.

Tadpoles grow at variable rates depending on conditions and availability of food. They can reach up to 80 mm in length before metamorphosis, although they will metamorphose at smaller body lengths. Time to metamorphosis is variable and dependent on conditions and time of year, taking between two and eleven months, but with a mean of three months (Anstis 2013). Tadpoles may overwinter if breeding occurs late in autumn. They should typically eat algae and other aquatic vegetation and can often be seen sucking at the surface of the water, presumably to take in organic material floating on the water surface. But their actual diet has not been studied. As for most species, it is likely that tadpoles will also eat dead animal material if it is available, including other tadpoles.

The tadpoles can tolerate salinity levels of six parts per thousand (ppt) without any apparent negative effects (Kearney et al. 2012), while salinity of 8 ppt or higher decreases growth rates and increases mortality rates (Christy and Dickman 2002), although adults can tolerate much higher salinity levels over short time periods. The pH of a pond does not appear to affect the likelihood of the eggs to hatch (Pyke and White 2001). These are important points regarding the observed impacts of the amphibian chytrid fungus (see Section 2.4).

2.3 Distribution and abundance

2.3.1 Broad distribution

The species has been recorded from Yuraygir National Park on the far North Coast of NSW to around Lakes Entrance in south-eastern Victoria (White and Pyke 2008), with there being suggestions that they may once have reached as far north as the NSW/Queensland border. Courtice and Grigg (1975) completed a detailed study of the distribution of the GGBF and in Gippsland and found it only as far west as Marlo, where it abutted and had a potential hybrid zone with *Litoria raniformis* (Growling Grass Frog). In the mid-1980s the species was recorded at least 60 km further west at Nowa Nowa and the Growling Grass Frog were no longer present in that location (F. Lemckert Pers. Obs.).

The range was extended 15 km further west at Lakes Entrance by White and Pyke (2008). By 2011 they had been recorded another 70 km to the west at Dutson Downs (Gippsland Water 2021). This may suggest a westward expansion of the species in Victoria since the 1970s. Historically the species was known from a number of sites at least 50 km inland into the NSW ranges including at Bathurst (White and Pyke 1999), Bungendore (Humphries 1979) and 30 km inland at Ulong on the NSW north coast (Moore 1961). The furthest and now only extant "inland" population is near Hoskinstown in the Southern Tablelands of NSW (Osborne et al. 2008). Natural GGBF populations are also known from three islands off the coast of NSW; Bowen Island, Kooragang Island and Broughton Island (DEC 2005). Extra-limital populations have been introduced to New Zealand (Pyke et al. 2002), and New Caledonia and Vanuatu (Pyke and White 2001) with the species occurring in high densities in some areas on these islands (M. Mahony Pers. Comm.).

The extent of occurrence of the species in Australia was estimated to be approximately 150,000 km² (Mahony 1999). The extent of occurrence has declined further since that time and is continuing to reduce as populations are also known to have continued to decline (Mahony et al. 2013). Using the Atlas of Living Australia data, the extent of occurrence using records obtained since 2000 is approximately 9,750 km^2.

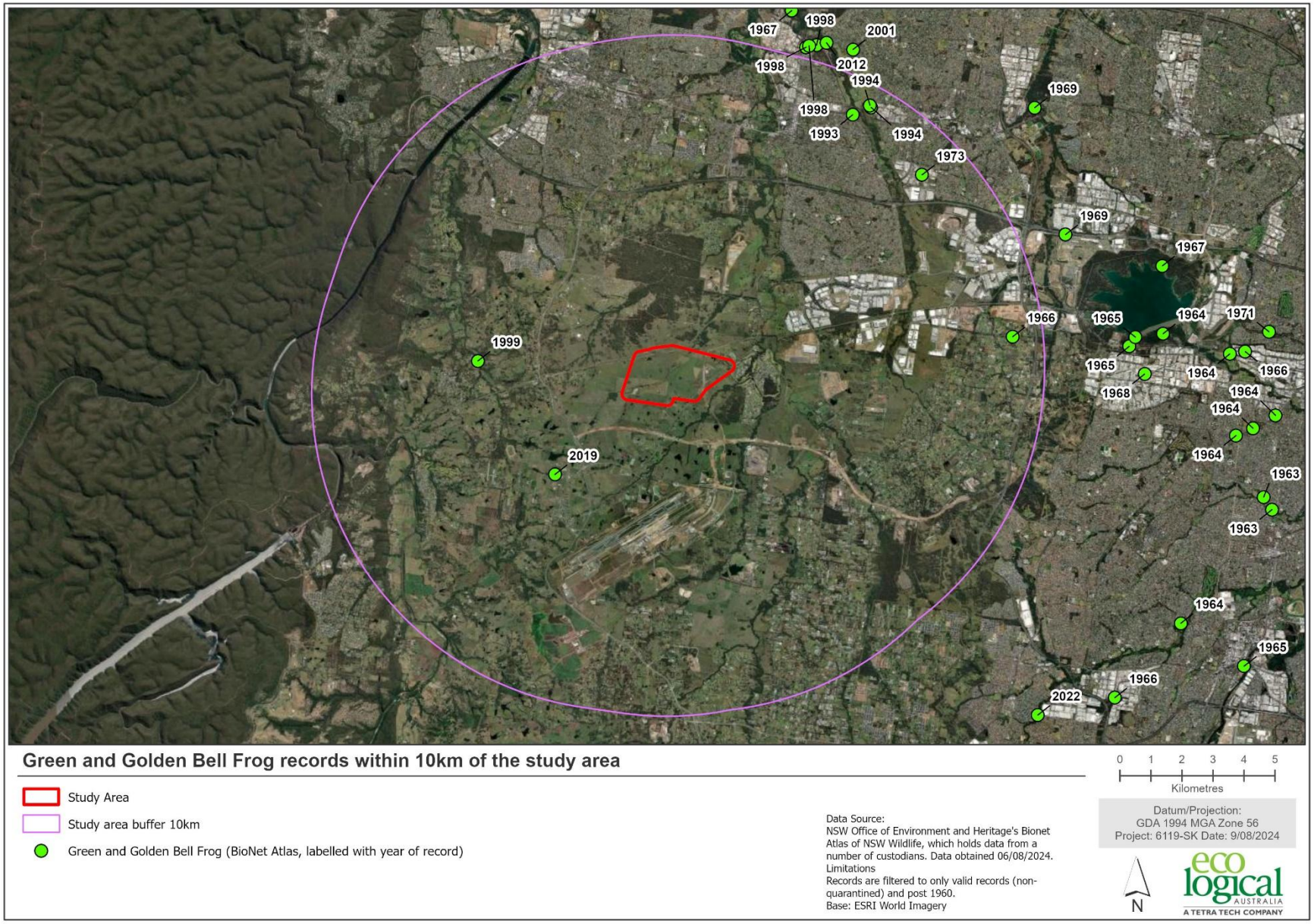

Figure 6: Location of Green and Golden Bell Frog records relative to the development site

2.3.2 Distribution in the Cumberland Subregion

The Draft Recovery Plan for the GGBF (DECC 2005) provides the following information on the GGBF in the Sydney Basin area.

The Sydney Region includes all of the LGAs of the greater metropolitan area north to the Hawkesbury, west to include Blue Mountains and south including Camden and Campbelltown. This region is known to have had major populations within its separate catchments. This included the wetlands around the margins of Botany Bay and including the Georges River and Cooks River sub-catchments; wetlands of the Parramatta River drainage and also associated with the Hawkesbury Nepean drainage to the west and south west. Pyke and White (1996) and White (1993b, 1996) document in some detail the declines in some of these populations and numerous other historical records of various herpetologists have assisted in piecing together the species former Sydney distribution (R. Wells pers. comm.; L. Tarvey pers. comm.; M. Mahony pers. comm.; R. Wellington unpublished).

Sydney still contains some of the largest but also most disturbed and isolated populations. Eight key populations exist within the greater Sydney Region along with a number of other transient sites that are believed to consist of small populations difficult to reliably locate or based on observations of migrating individuals. Some of these populations are considered to be operating more or less as metapopulations but their fragmented and isolated nature is the product of development and other human disturbances rather than a naturally patchy distribution. However preliminary genetic analysis of selected populations has demonstrated that differentiation between proximal populations does occur and warrants a conservative approach to conservation initiatives, management and environmental impact assessment decisions (see Colgan, 1996).

The study area is not included in any of the areas covered by one of the eight listed key populations. The closest is the St Mary's Population which is approximately 5 km to the northeast and for which the Draft Recovery Plan provides the following information:

St Marys population consisting of a number of sub-populations that are somewhat transient in the reliability with which their population can be detected at a given site. The included sub-populations may possibly be operating as a metapopulation and are located on RailCorp lands, TransGrid lands, Sydney Water lands and private lands at St Marys, Mt Druitt, Prospect and Riverstone. The distance between some of these sites and the barriers to connectivity may mean that some are operating as isolated entities.

A total of over 13,000 GGBF BioNet records are available on the Cumberland Subregion. However, this number is highly skewed by the records from Sydney Olympic Park and the majority (>95 %) come from the eastern half of the Cumberland Subregion. The very limited number of records in the western half of the Cumberland Subregion suggests that the GGBF may never have been common or widespread across this region, despite the apparently adaptable nature of this frog (see Section 2.4). Notably, most of these were obtained from before 1990.

Figure 6 indicates the BioNet records for the species from within the locality of the development site. It shows that there are no historic records from within the development site, two within 5 km and only seven within 10 km. The closest of these is a 2019 record of a single individual located approximately 3 km away to the southwest. This record was reviewed by DPE and found to be erroneous and is being removed (Enhua Lee Pers. Comm.). It is considered likely that the other record within 5 km is also erroneous. Survey work

completed for the GGBF by ELA as part of the biodiversity assessment for the proposed development (ELA 2018) did not locate any individuals, although surveys did not fully meet the current BAM requirements.

2.3.3 Abundance

The GGBF was recorded as once being a very abundant and widespread frog (Goldingay 1996). Fletcher (1889) stated that this species was commonly encountered in the Sydney area and Harrison (1922) noted that this species was "probably our best known frog" and was "known to me since childhood". Extensive surveys for the species by Courtice and Grigg (1975) in the early 1970s recorded it very regularly and abundantly across coastal NSW and into southeast Victoria. However, there was a serious decline of the species in the 1980s, with the timing being uncertain, but with frogs having disappeared from many historic sites by 1987 (F. Lemckert Pers. Obs.). By 1996 the GGBF was regarded as rare by White & Pyke (1996) and its recorded declines recognised to be of concern (White 1995).

The recovery plan written for the species (DEC 2005) found the GGBF to have declined to less than 50 populations in NSW and the declines have been continuing (Mahony et al. 2013) with accounts such as that by Daly (2014) noting that the population known from Nowra has apparently continued to contract from a previous expansion. Populations of over 1,000 frogs were (and likely still are) present at Kooragang Island, Broughton Island and perhaps Homebush (Hamer et al. 2002) and Meroo (F. Lemckert Pers. Obs.), but the other core populations known around the state are generally much smaller.

The amphibian chytrid fungus has been implicated as the main driver of these severe declines (Mahony et al. 2013), although habitat loss (Goldingay 1996) and introduced predatory fish (Pyke and White 1999, Goldingay 2008) have also been suggested to have played significant roles in population declines and losses. Current populations are almost exclusively found within 10 km of the coastline (Mahony et al. 2013) with the impacts of salinity attenuating the effects of the fungus. Similarly, there are indications that populations at Homebush and near Captains Flat (ACT) persisted because of chemical pollutants that inhibited the growth of the chytrid fungus, but were tolerable to the frogs and tadpoles (Threlfall et al 2008). Such conditions are likely less than optimal, but still represent the only areas where populations are able to persist because the fungus has minimal impact.

Over the short-term the GGBF can exhibit significant local population fluctuations when conditions result in high tadpole survivorship (e.g. Daly 2014). The GGBF has a life cycle that fits what is termed to be an R-selected species (Hamer and Mahony 2007), producing large numbers of offspring and adults have relatively shorter lifespans. Hence, there is a relatively rapid turnover of individuals and survival of the local population depends on occasional very successful seasons, when population size and area utilised rapidly increase, interspersed with years of low recruitment when numbers fall away and there are local extinctions in less favourable areas of habitat. This is considered a typical pattern for amphibians (Alford and Richards 1999). In fact, The GGBF has been suggested to be a colonising species with a series of its attributes that suit this lifestyle: habitat generalist, high fecundity, rapid growth, early sexual maturity, and relative high dispersal ability (Hamer & Mahony 2007). White and Pyke (1999) suggest that the GGBF rapidly move into areas of newly created breeding habitats that have little competition from tadpoles from other species, are open to sunlight to increase water temperatures to provide good thermal environments and lack or have minimal predators present such as dragonfly larvae or fish.

As noted above, only seven records are available in BioNet from within a 10 km radius and none within of those are within 1 km, which is well beyond the 500 m that the GGBF is considered able to typically travel

within the standard metapopulation structure. So the site would not be used or have been used by frogs from the nearest records, even when those populations were present. The subject lands could possibly eventually be "rescued" by recolonisation, as happens with metapopulations as they expand through multiple years of high recruitment, but the impacts of the chytrid fungus and the severe urbanisation of the surrounding area makes this now increasingly unlikely to happen once extinctions occurs (see Section 2.5).

2.4 Habitat requirements

2.4.1 Breeding Habitat

GGBF breed in a wide range of water bodies and the species has been recorded inhabiting all but fast flowing streams (Pyke & White 1996). It inhabits many human- created environments, including highly disturbed sites such as abandoned mines and quarries (Pyke et al. 2002), as well as artificial wetlands created for the GGBF at places such as Kooragang Island (Hamer et al. 2002) and Sydney Olympic Park (Darcovich and O'Meara 2008).

Pyke & White (1996) undertook a review of the known breeding habitat of the GGBF and found that they preferred to breed in water bodies that were still, shallow, ephemeral, unshaded, with aquatic plants and free of the Plague Minnow (*Gambusia holbrooki*) and other predatory fish. This study also found that breeding occurs in a significantly higher proportion of sites with ephemeral (temporary) ponds, rather than sites with fluctuating or permanent ponds. Hamer et al. (2002) found a similar result for the GGBF populations at Kooragang Island where larger males would move to ephemeral water bodies to breed, when they were available, although reproduction was also associated with permanent water bodies. The frogs in that study tended to remain relatively faithful to one water body. Ongoing monitoring of frogs in the area of Meroo Lake has provided similar results (F. Lemckert Pers. Obs.) with calling and breeding most typically being associated with flooded freshwater fringes of otherwise saline coastal lakes, but calling also being heard less frequently in permanent ponds.

The presence of the Plague Minnow does not exclude GGBF from breeding in a water body, but success is likely low and appears to be dependent on the presence of more complex aquatic vegetation, which allows the GGBF to breed successfully (Hamer et al. 2002). Hence the Plague Minnow is not a sole determinant of the likely presence of the GGBF in most situations.

Plate 2: Examples of permanent pond breeding habitat used by the Green and Golden Bell Frog (Western Sydney and Kioloa, NSW)

2.4.2 Non-breeding habitat

A review of movements of frogs indicates that the individuals in the majority of species that have been studied migrate an 100-300 m from the breeding site to settle into recognisably different complementary non-breeding habitat (Lemckert 2004). The GGBF is unusual for an Australian frog in that its non-breeding habitat is most usually another water body rather than an area of the terrestrial environment. When they do move out into surrounding vegetation it is usually only a relatively small distance (< 50 m) and for short times (days) and preferably into grassy areas and areas of open vegetation that contain a range of diurnal shelter sites such as logs, rocks or dense vegetation (Pyke and White 1996). There are observations though, of GGBF at least being willing and able to forage in taller forests with denser understorey (e.g. dry sclerophyll forest at Nowra; M. Greenlees Pers. Comm. and dense woodlands at Meroo; F. Lemckert Pers. Obs.) and even foraging in suburban backyards (DEC 2005). This again demonstrates the observed adaptability of the species to a range of environmental conditions and a lack of habitat specificity.

Adult frogs show a strong site fidelity, returning to the same ponds over time (Hamer et al. 2008), but their movements around those ponds and immediately adjacent areas appear to be relatively random for most individuals and especially juveniles (F. Lemckert Pers. Obs.). Females though, have been observed to congregate together into specific shelter and foraging sites in areas immediately adjacent to breeding sites (Hamer 1998, Pyke and White 2001).

Shelter sites are used when GGBFs are inactive and vulnerable and of most importance in providing secure over-wintering locations. Preferred locations include rock piles, logs or in the base of grass tussocks (Mahony et al. 2013). Studies at Kooragang Island have suggested that females may use slightly different non-breeding areas to males and may have very important and specific over-wintering areas located in dense vegetation (M. Mahony Pers. Comm.). Whether this is the same for other populations is unknown, but there is evidence from Sydney Olympic Park that females there also concentrate in specific locations (J. O'Meara Pers. Com.).

2.5 Habitat requirements Habitat requirements

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The presence of the Plague Minnow does not exclude GGBF from breeding in a water body, but success is likely low and appears to be dependent on the presence of more complex aquatic vegetation, which allows the GGBF to breed successfully (Hamer et al. 2002). Hence the Plague Minnow is not a sole determinant of the likely presence of the GGBF in most situations.), apparently to increase body temperatures (Pyke and White 2001). Basking in frogs is unusual, but such activities in ectotherms typically allow for periods of greater activity or faster digestion of food items. Whilst the importance of this activity for its physiological requirements is not known, individual GGBF appear to bask regularly and so it is likely an important activity. Basking on emergent aquatic vegetation likely allows individuals the option to make a rapid escape from diurnal predators by diving into the water. The presence of water bodies that contain emergent vegetation are known important determinants of the presence of GGBF (Pyke and White 1996; Hamer et al. 2002).

Whilst GGBF may retain a closer association with water bodies and appear to generally be faithful to a single water body for their general activities, they can move along and between different water bodies, particularly as part of migrations to and from breeding sites (Hamer et al. 2002). Hamer et al. (2008) noted that male GGBFs at Kooragang Island often moved > 200 metres to reach an ephemeral breeding site, crossing over extended grassland areas and other habitats including disturbed habitats. Studies have found that occasionally an individual may move longer distances over time including distances of more than 1 km (Hamer et al. 2008), up to 3 km (Pyke & White 2001) and even dispersals as far as 10 km (White & Pyke 2008). These longer distance movements may represent occasional dispersal events that provide for colonisations of new habitats, but are undertaken by few individuals and do not form part of regular movements that keep a local population connected. It is likely that most such movements end up with the death of the frog as it moves into areas without suitable resources.

2.5.2 Migratory habitat

Christy (2001) and Muir (2008) state that terrestrial movements of the GGBF are primarily undertaken through open environments such as grasslands and mown areas rather than adjacent areas with denser vegetation cover. These open habitats also preferably contain patches of shelter within them such as rocks, logs or ponds or areas of thick vegetation. Such habitats provide relatively little impediment to the movements of frogs but allow for individuals to seek shelter as required during the period of movement. Terrestrial movements are typically undertaken at night and are most likely associated with rainfall events (F. Lemckert Pers. Obs.) which would provide protection against desiccation when traversing the preferred open environments. As previously noted, the GGBF is strongly associated with water bodies through all parts of its life cycle and presumably the species is relatively less tolerant of desiccation than species that use terrestrial environments when not breeding. Thus, movements along corridors are strongly associated with either streams that contain water or along lines of pools/ponds that provide stepping stones of shelter between start and end water bodies (Muir 2008; DEWHA 2009). Hamer et al. (2002) found that water bodies on Kooragang Island where the GGBF did not persist were typically isolated from other occupied water bodies by a distance of over 500 m and it was concluded that movements of GGBF between ponds was most likely dependent on distance to the nearest suitable pond rather than physical barriers.

Mahony (1999) cautions that the studies that have been carried out since the declines of the GGBF do not necessarily identify the actual preferred requirements of the species. He notes that the changed environment and factors causing the declines may have “altered” the optimal habitats for the species in comparison to their habitat use patterns prior to the declines. This is based on the fact that the use of ephemeral breeding sites was not noted for the bell frog group in earlier habitat descriptions. Such altered habitat use has been noted for other species such as the Armoured Mist Frog (*Litoria lorica*) that now is only present in open rocky streams

whereas it was once known as a rainforest stream species (Puschendorf 2011). This change is attributed to the impacts of the chytrid fungus, with the frog only surviving in a relatively extreme environment where the fungus is affected by the hotter conditions. Given the chytrid fungus appears also to have been the major cause of the decline of the GGBF, there is a significant potential that the GGBF is now persisting in different environments to those it historically preferred. However, that is unlikely to ever be confirmed.

2.6 Metapopulation dynamics

A critical consideration in the likely presence/absence of the GGBF are metapopulation dynamics. The GGBF is considered to follow a classical metapopulation structure with the "local" population consisting as a series of patchy populations within the larger single metapopulation. Individuals move regularly between a mosaic of wetlands across a broad area throughout a single breeding season (Hamer et al. 2008; Hamer & Mahony 2010). There is high site-specific population turnover with local extinctions being balanced by colonisations of other ponds or parts of the local area by regularly dispersing individuals, but with the overall metapopulation remaining stable. There are core sites that provide ongoing and regular reproductive success and that maintain long-term populations, but the major part of the population dynamics is driven by inter-year success of breeding at a range of available breeding sites, with years of very good reproductive success leading to opportunities to expand ranges and colonise new sites. On Kooragang Island, GGBF typically reside in permanent waterbodies where they exhibit high site fidelity, but during periods of high rainfall disperse over several hundred metres to breed at ephemeral water bodies that have flooded (Hamer et al. 2008). Reproductive activity (e.g. calling) typically occurs over several nights at these ephemeral waterbodies, with individuals returning to core permanent waterbodies. In times of poor rainfall, the core sites become the refuges for the species and Valdez et al. (2015) found that probability of occupancy of a site increased at large and permanent wetlands.

Following on from this is the identified need for connected sites to allow this population interaction. Hamer (2016) found that the presence of the GGBF at sites at Nowra was dependent on accessibility of ponds, a factor mediated both by the presence of vegetation and the extent of roads in the area, with the presence of roads providing a likely serious barrier to pond use. The presence of vegetation directly around ponds correlated significantly with the potential for greater species diversity. The type of pond available also was important, with the species avoiding steep sided concrete ponds. The apparent negative impacts of roads were confirmed in follow up work (Hamer 2018) where it was again found that the extent of accessible habitat (habitat close to ponds and not isolated from the pond by a road) positively influenced the likelihood of pond occupancy. Extinctions of GGBF were significantly more likely to occur at ponds in areas with higher densities of roads. Similar findings have been obtained for pond occupancy by frogs in the United States (Marsh et al. 2017).

The spatial arrangement of wetlands and the extent of wetlands measured in a 1 km radius has been found to be an important predictor of pond occupancy by GGBF in studies by Hamer et al. (2002), Hamer and Mahony (2010) and Valdez et al. (2015) with more ponds, ponds in closer proximity and already occupied ponds increasing the potential for the GGBF to be present or occupy a previously unoccupied pond (Puschendorf et al. 2011).

The Sydney Science Park development site has permanent or near permanent water bodies present along drainage lines, often < 200 m apart, which provides for significant connectivity. The general locality within 10 km retains a significant portion of rural land, especially to the west and southwest where GGBF could broadly live in and move through, but expanding urbanisation to the east and north in particular (Figure 6) is continuing to shrink the habitat in these directions and now provides a major barrier to movements in these directions.

The presence of an extensive road network in these areas and to the south also creates very significant barriers to regular movements of frogs across the broader area. The absence of an established breeding population within 10 km of the subject land indicates that there is no real connectivity to any viable known population of GGBF.

2.7 Vegetation associations

The OEH profile records the GGBF to be associated with a broad range of vegetation formations and classes within the Sydney Basin Interim Biogeographic Region, the location of the development site and infrastructure (https://www.environment.nsw.gov.au/threatenedspeciesapp/profileData.aspx?id=10483&cmaName=Sydney+Basin). These are:

1. Dry sclerophyll forests (shrub/grass sub-formation)
    - Clarence Dry Sclerophyll Forests
    - Cumberland Dry Sclerophyll Forests
    - Hunter-Macleay Dry Sclerophyll Forests
    - North-west Slopes Dry Sclerophyll Forests.
2. Dry sclerophyll forests (shrubby sub-formation)
    - Coastal Dune Dry Sclerophyll Forests
    - South Coast Sands Dry Sclerophyll Forests
    - South East Dry Sclerophyll Forests
    - Southern Tablelands Dry Sclerophyll Forests
    - Sydney Coastal Dry Sclerophyll Forests
    - Sydney Hinterland Dry Sclerophyll Forests
    - Sydney Sand Flats Dry Sclerophyll Forests.
3. Forested wetlands
    - Coastal Floodplain Wetlands
    - Coastal Swamp Forests
    - Eastern Riverine Forests
    - Inland Riverine Forests.
4. Freshwater wetlands
    - Coastal Freshwater Lagoons
    - Coastal Heath Swamps
    - Montane Bogs and Fens.
5. Grasslands
    - Maritime Grasslands
    - Temperate Montane Grasslands.
6. Grassy woodlands
    - Coastal Valley Grassy Woodlands
    - Southern Tablelands Grassy Woodlands
    - Tableland Clay Grassy Woodlands
    - Western Slopes Grassy Woodlands.
7. Heathlands

- Coastal Headland Heaths
- Sydney Coastal Heaths
- Wallum Sand Heaths.

8. Miscellaneous ecosystems
    - Highly disturbed areas with no or limited native vegetation
    - Marine environments
    - Rocky islands
    - Water bodies, rivers, lakes, streams (not wetlands).
9. Rainforests
    - Dry Rainforests
    - Littoral Rainforests
    - Northern Warm Temperate Rainforests.
10. Saline wetlands
    - Mangrove Swamps
    - Saltmarshes.
11. Wet sclerophyll forests (grassy sub-formation)
    - Northern Hinterland Wet Sclerophyll Forests
    - Southern Lowland Wet Sclerophyll Forests
    - Southern Tableland Wet Sclerophyll Forests.
12. Wet sclerophyll forests (shrubby sub-formation)
    - North Coast Wet Sclerophyll Forests.

This vegetation list demonstrates the very broad variety of vegetation types the GGBF us associated with, ranging from rainforests to heathlands and swamps to dunes, along with various non-vegetation types. These vegetations types cover essentially all possible environments present within the Sydney Basin IBRA Region and all habitats present on the subject lands. The range reflects the understanding that the GGBF is a very adaptable species with little in the way of habitat limitations and the species is capable of using even highly disturbed environments.

2.7.1 Threats

The OEH profile for this species lists the following as threats to this species:

- Alteration of drainage patterns and stormwater runoff.
- Frog Chytrid Fungus, a fungal pathogen.
- Predation by feral animals such as foxes.
- Herbicides and other weed-control measures.
- Road mortality, where populations are already small due to other threats*.
- Predation by exotic fish such as Plague Minnow.
- Loss of suitable breeding habitat through alteration by infilling and destruction of wetlands.
- Current knowledge of the status of the population and threats to the population is poor*.
- Species occurs on private land where land management practices may not be suitable for the species, e.g. grazing and loss of breeding habitat*.
- Changes in salinity due to sea level rise. Frogs are unable to breed in waters with salt concentrations of greater than six parts per thousand.

- Overgrowth of pond vegetation leading to declining water temperature.
- Small population size*.
- Lack of information regarding habitat permanency.
- Drying of breeding habitat and refuge habitat as a result of increased temperatures and more frequent droughts, potentially leading to wetlands becoming hypersaline.
- Lack of landscape connectivity leading to isolation of small populations*.
- Heavy metal pollution.
- Four-wheel drives impacting habitat.
- The introduced frog species, Green Tree Frog, on Broughton Island potentially competing with the species and representing a reservoir for chytrid fungus.
- Invasion of habitat by Salvinia (*Salvinia molesta*)*.

The threats denoted with an * are those that are considered relevant to this study area and report.

The Australian Government's Species Profile and Threats Database (SPRAT) (https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1870) lists the following threats for GGBF:

- Habitat removal.
- Habitat degradation (which includes siltation, changes to aquatic vegetation diversity or structure reducing shelter, increased light and noise, grazing, mowing, fire).
- Habitat fragmentation.
- Reduction in water quality and hydrological changes (for example, pollution, siltation erosion and changes to timing, duration or frequency of flood events).
- Disease (for example, infection of the frog with chytrid fungus (*Batrachochytrium dendrobatidis*) resulting in chytridiomycosis).
- Predation (for example, by the introduced Mosquito Fish [NSW Plague Minnow, *Gambusia holbrooki*], Cats (*Felis catus*) or Foxes (*Vulpes vulpes*).
- Introduction or intensification of public access to GGBF habitats.

The IUCN Redlist profile for the GGBF (Hero et al. 2004) notes the following for the GGBF: *"The cause(s) of the apparent declines observed in populations of all taxa within the L. aurea complex are unclear (Gillespie et al. 1995). Investigations of disappearances among the group have primarily focused on L. aurea and L. castanea and two major directions in research have been pursued: the role of increased ultraviolet radiation; and the impact of the introduced fish, Gambusia (Mahony 1999). It is also possible that disease, such as a viral infection or chytrid fungus, might have contributed to the decline of this species (W. Osborne pers. comm.). Chytrid fungus was detected in this species in Hoskinstown and Homebush Bay in Sydney, New South Wales".* This information can be considered to be relatively dated.

In regard to the study area, many of these threats would already be in place and not significantly added to by the proposed development. The following are considered to be of relevance to the proposed development:

- habitat removal (through the construction of the Science Park)
- habitat fragmentation (through construction of the Science Park)
- spread of the amphibian chytrid fungus (construction works and vehicle movements)
- hydrological changes (through the loss of water bodies and changes in water flow patterns).

The likely small size of the local population is a consideration for the long-term management of the species.

2.7.2 Variables determining GGBF presence

This information provides the following important points when trying to assess the potential presence of the GGBF in any area:

- The GGBF is more likely to be present where multiple suitable breeding sites are within a close enough proximity for frogs to migrate between them with relative ease.
- The GGBF is more likely to be present where multiple non-breeding water bodies are present in close enough proximity to allow migration between them (and breeding sites) with relative ease.
- The GGBF is more likely to be present where the connectivity of breeding and non-breeding habitat contains a matrix (vegetation and shelter) that facilitates migration.
- The GGBF is more likely to be present when other GGBF occupied ponds are in close proximity.
- The GGBF is unlikely to be present within areas containing a large number of introduced fish.
- The GGBF is unlikely to be present in areas that are more than 10 km from the coast unless those areas have a history of human development that may have led to land contamination.

3. Description of the study area

3.1 Land use history

The following information has been derived from the Cumberland Plain Recovery Plan (DECCW 2010a). At the time of European settlement, the Cumberland Subregion would have consisted of extensive areas of grassy woodlands were present along with wooded areas including ironbark and turpentine forests, dry rainforests, and floodplain communities. Agricultural development commenced before 1800 and by the middle of the 19th century most of the region was either being grazed or was cultivated. Clearing for agriculture was later supplemented by clearing for residential, commercial and industrial purposes.

The subject land is currently comprised mainly of areas of exotic grass cover along with cleared areas (gravel access tracks) and remnant native vegetation in poor condition (**Error! Reference source not found.**). The subject land also contains a number of drainage lines and human made dams. The subject land has an extensive history of use for agricultural purposes including cattle grazing, which has contributed to the overall poor ecological values present. Cattle remain present grazing across the subject land.

3.2 Landscape features

The following landscape feature, as defined by the BAM, are relevant to the project.

3.2.1 Bioregions

The impact area and impact assessment area occur within the Sydney Basin IBRA bioregion and the Cumberland IBRA subregion.

The Sydney Basin Bioregion lies on the central east coast of NSW and covers an area of approximately 3,624,008 hectares. It occupies about 4.53% of NSW and is one of two bioregions contained wholly within the state. The bioregion extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee. The bioregion is bordered to the north by the North Coast and Brigalow Belt South bioregions, to the south by the South East Corner Bioregion and to the west by the South Eastern Highlands and South Western Slopes bioregions. The Sydney Basin Bioregion is one of the most species diverse in Australia. This is a result of the variety of rock types, topography and climates in the bioregion (OEH 2016).

The Cumberland IBRA subregion occurs on the coastal side of the Lapstone monocline and is characterised by low rolling hills and wide valleys in the rain shadow area of the Blue Mountains. Underlying geology is predominantly formed from Triassic Wianamatta group shales and sandstones with occasional volcanic intrusions, in addition to Tertiary river gravels, sands and Quaternary alluvium along ancient and current waterways. Vegetation of the Cumberland IBRA subregion consists of dry and wet sclerophyll forests on sandstone and transitional slopes and hills, dry sclerophyll woodlands on plains and shale hills, alluvial forests on riverflats and wetlands in lagoons, swamps and floodplains (OEH 2016).

3.2.2 NSW (Mitchell) Landscape

The development site falls within the Cumberland Plain Mitchell Landscape. This landscape is characterised by low rolling hills and valleys and underlying geology consists of Triassic shales and lithic sandstones interspersed with a small number of volcanic vents, Tertiary river gravels and sands and Quaternary alluvium along major streams. General elevation is between 30 and 120 m and local relief is 50 m. Soils consist of

uniform red to brown clays around volcanic hills and red and brown texture-contrasts soils on crests, grading to harsh yellow soils in valleys. Associated vegetation is influenced by location within the rain shadow of the Blue Mountains and consists of dry sclerophyll woodlands and pockets of dry sclerophyll forests throughout with forested wetlands occurring on poorly drained valley floors (Mitchell 2002).

3.2.3 Soil

The subject land occurs on the Luddenham Erosional Soil Landscape, based on the Soil Landscapes of the Penrith 1:100,000 Sheet map (Bannerman & Hazelton 1990). The Luddenham Erosional soil landscape is characterised by undulating to rolling low hills with narrow ridges, hillcrests and valleys (5 to 20%) over Wianamatta Group shales and Minchinbury Sandstone with local relief of 50 to 80 metres. Soils are shallow to moderately deep and comprise dark podzolic soils or massive earthy clays on crests, moderately deep red podzolic soils on upper slopes and moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines. Soils exhibit low to moderate fertility, have low permeability and are susceptible to minor gully and moderate sheet erosion. Vegetation within this soil landscape has been extensively cleared with pockets of dry sclerophyll woodlands and forests remaining.

3.2.4 Native vegetation

ELA (2023) identified the following plant communities present on the subject land (Table 1) with the mapped location being shown in Figure 3. Both PCTs fall within vegetation formations that are listed as being used by the GGBF (see Section 2.4.4).

Table 1: Plant Community Types (PCT) in the development footprint

	PCT ID	PCT Name	Condition	Area (ha)
1	3320	Cumberland Plain Woodland	Low	1.35
2	4023	Coastal Valley Riparian Forest	Low	1.39
3	3975	Southern Lower Floodplain Freshwater Wetland	Low	0.53
4	-	Planted native vegetation		0.46
5	-	Exotic grazing land	-	260
6		Exotic vegetation	-	7.17
7	-	Cleared land	-	10.87
8	-	Waterbodies	-	15.67
			Total	**297.44**

3.2.5 Rivers and streams

The study area contains one drainage catchment with a single stream with three main arms and ranges from first to fourth order streams (Figure 7).

The drainage lines themselves do not appear to hold water for more than short periods and likely do so only after periods of higher rainfall. They are not permanently flowing streams (e.g. see Figure 7). All or nearly all of these water bodies will be lost through the development and surrounding water bodies more isolated from each other by the development. The central drainage line area was identified to hold *Gambusia holbrooki* (Plague Minnow) during targeted GGBF surveys in 2018 (ELA 2018). None were seen in the field inspection in November 2023, but the species was again widespread and common across the water bodies in March 2024.

3.2.6 Wetlands

The study area includes farm dams that generally fall along defined drainage lines that represent unnamed first to fourth order streams (Figure 7). The dams range in size from relatively small (<10 m diameter; Plate 11) to very large at >200 m at the widest points (Plate 10). These dams were created presumably for stock watering and are permanent in most years, although surveys conducted in 2018/19 at the time of drought found some of them to have dried out.

As noted above, the proposed development will remove all or nearly all of the current drainage line system.

3.2.7 Connectivity features

The broader area around the study area has been cleared for rural activities and is mainly used for grazing. There is some retained vegetation to the south and to the north (Figure 7), but it is patchy and interspersed with rural lands, with larger patches being located 300 m to >1.2 km to the north and south. This habitat is potentially crossed by GGBF as they are known to travel such distances and grasslands are easily traversed and there are a range of stepping stone water bodies available. There is further vegetated land to the northwest and the Blue Mountains National Park is 10 km to the west through a matrix of mainly agricultural lands.

A pipeline to the north forms a partial boundary with the subject land (Plate 3), but does not appear to form any sort of barrier to movement as GGBF can pass underneath the pipeline.

The drainage line on site flows into South Creek as does Cosgrove's Creek to the south of the study area. These drainage lines contain patches of aquatic vegetation (Plate 3) and Cosgrove's Creek has significant riparian vegetation along much of its length, providing an available movement corridor. The rural lands present, along with the numerous ponds, should allow relatively easy movement between these streams and across the landscape broadly.

The road system within close proximity to the study area is relatively minimal, with most roads being small and unsealed. Luddenham Road is the obvious major exception that runs along the southeast boundary and is a single lane each way carriageway with moderate traffic flows. This would represent a barrier to movement towards Cosgrove's Creek, but not a major one at this time. The Twin Creeks Golf Club to the east is a highly urbanised area, but does not have an extensive road system. The impacts of roads on the GGBF can be severe and even the few roads present can be expected to have some effect on connectivity (see Section 2.5).

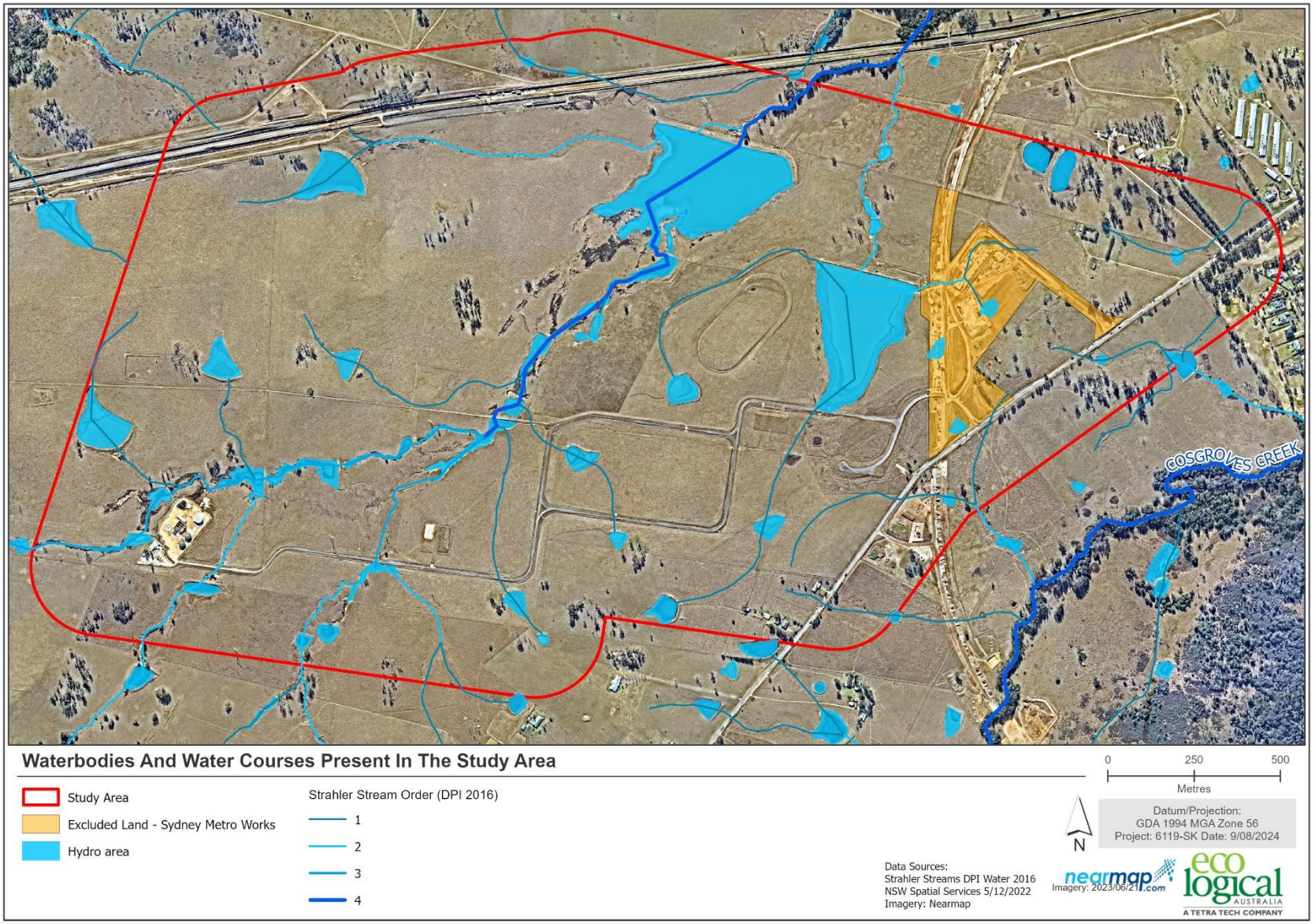

Figure 7: Waterbodies and watercourses present in and around the study area

3.2.8 Areas of geological significance

There are no recorded areas of geological significance within the study area and the area itself has little rock exposure.

3.2.9 Climate

Key climate statistics for weather stations located at three stations located on the southwestern Cumberland Plain are provided in Table 2. They indicate is that the site has a mild climate with moderate rainfall, as it typically found in the Sydney Basin.

Table 2*:* Key climatic statistics for stations on the southwestern Cumberland Plain (taken from en.climate-data.org)

Weather station	Mean total rainfall (mm)	Mean January maximum (°C)	Mean July minimum (°C)
Penrith Lakes AWS	718.6	31.0	5.3
Orchard Hills Treatment Works	832.7	28.5	5.3
Badgerys Creek	794.3	28.6	3.8

Plate 3: Second order drainage line towards northern end of subject land

Plate 4: Areas of sedge around drainage line leading into large dam in centre of study area

Plate 5: Isolated trees on low hill at western side of subject land. Note the lack of ground cover resulting from a long grazing history of the site

Plate 6: Edge of isolated dam showing relatively bare banks and limited area of emergent fringing vegetation

Plate 7: Evidence of poor water quality on site with film on top of water.

Plate 8: Scattered retained Casuarina trees and stumps along shallow drainage line

Plate 9: Dam with essentially no fringing or emergent vegetation present – highly impacted by stock grazing

Plate 10: Very large dam at northern end of subject land showing some fringing vegetation and a few patches of emergent vegetation

Plate 11: Small temporary pool immediately adjacent to the above large dam

4. Assessment of GGBF to be present on the Development Site

4.1 Green and Golden Bell Frogs in the region

The available records indicate that the GGBF has not been recorded within the development area. The nearest record from BioNet is approximately 3.3 km to the southwest (Figure 6), but this record has been confirmed to be erroneous. The only other record within 5 km is one approximately 4.25 km directly west from 1999, which has little information attached to the record except it is an individual and it seems highly likely to also be an error. There are only five other records with 10 km, all of which are to the northeast and are over 9 km distant and are over 10 years old. These records are more likely correct with the individuals having originated from the Riverstone population, but did not persist. Hence there is no indication of any significant extant population within the locality of 10 km and no indications of breeding.

4.2 Subject land as potential habitat

4.2.1 Breeding habitats

There are numerous water bodies present within the development site that form potential breeding habitat, although none that would be considered to be high quality habitat as very few ponds had significant emergent aquatic vegetation present. Aquatic vegetation provides protection from predators for both frogs and tadpoles and also provides a basking location for frogs. Most sites had some fringing sedges, but the surface area coverage was much less than 5% emergent vegetation and the narrow sedges did not represent good basking habitat. The sole exception were two dams in the centre of the development site that contained a moderate (30%) coverage of *Typha* spp. These provided the best habitat available. These ponds typically had shallow sections of water around the banks and were not shaded in any meaningful way due to the absence of tree cover across the subject land. This is a favourable aspect for the GGBF.

No temporary wetlands were evident, which is a habitat that GGBF will use in the correct conditions. The closest were areas of drainage lines that do not hold water much of the time but could flood after significant rainfall and hold water for some period of time. These locations lacked vegetation that could serve as better quality emergent aquatic vegetation, having only some sedges present (e.g.). The best temporary flooded habitat would be the overflow and fringes of the current dams. These sites typically have some sedges present that would become emergent vegetation and stay as emergent vegetation for days to weeks after flooding and so present better places for male frogs to call from and provide protection for eggs and tadpoles. Being shallow, they would also provide warmer waters that tadpoles appear to prefer for development. The main disadvantage of these sites is the lack of good basking vegetation and no debris is present on the ground for frogs to shelter under. Frogs would be almost entirely reliant on sedge clumps as a source of protection across the subject land.

The broad absence of the Plague Minnow as an exotic fish predator in inspections completed in 2023 was very noticeable and unexpected given they are relatively ubiquitous across the Sydney Basin. There was an indication of fish at one point in a pool in the centre of the subject lands (Points SSP 10 and SSP11 in Figure 8), which was the same area where the Plague Minnow was recorded by ELA in previous targeted GGBF surveys (ELA 2018). However, by the February surveys in 2024, all sites associated with the drainage lines or that could easily be flooded overland were seen to contain moderate to high densities of the Plague Minnow and only a few isolated ponds near the top of the ridgelines appeared to be Plague Minnow free. Carp were also observed in the larger dams and are likely also spread across the drainage lines. Hence the majority of

potential breeding habitat is subject to pressure from introduced predatory fish that would be expected to seriously impact any breeding efforts.

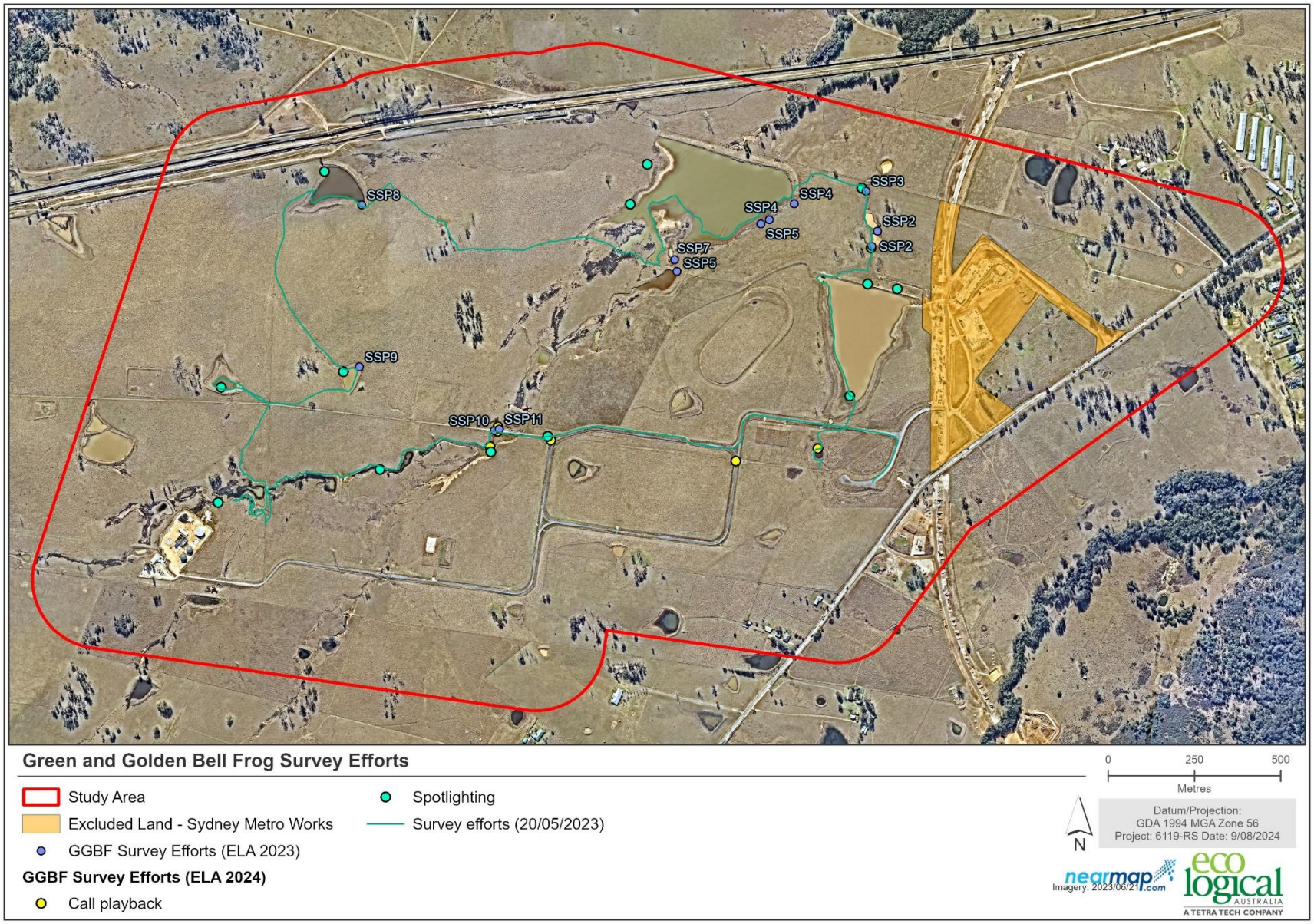

Figure 8. Locations of various points covered during the site inspection

4.2.2 Sheltering and foraging habitat

The subject land's water bodies and riparian areas form the most important shelter habitat for the GGBF given their preference to remain around water bodies for most of their activities and the noted absence of other sheltering habitat. The sedges on the edges of most dams and parts of the drainage lines does provide a thick and protective tussock that GGBF have been recorded using for shelter (Humphries 1977) and lines a large part of the drainage system, providing a corridor of protection. There is little emergent vegetation otherwise that GGBF could use for protection.

Sheltering habitat away from the water bodies is very poor with the site having occasional scattered tree limbs and branches or rocks in an otherwise uniform area of low grassy grazing lands. This provides very little in the way of shelter for frogs to use to protect them when moving overland between water bodies and so migratory movements outside of the drainage line may necessarily have to be done in one night to avoid desiccation and predation the following day. These low grassed areas are otherwise considered as favourable migratory pathways because they are easily traversed (Muir 2008).

These areas also then offer no options for over-wintering habitat and so would also require frogs to remain around water bodies to find shelter. This puts them at some risk in winter floods when they are relatively inactive and vulnerable to being washed out of shelter sites.

Grassy areas are considered to be preferable areas for foraging for the GGBF (Muir 2008) as they represent open environments where frogs can see prey and easily move to catch them. The very short cover present and very simple vegetation structure strongly suggests that invertebrate numbers and diversity is very low in this environment and food would be very limited.

It is likely the best foraging habitat remains around the water bodies where the tussocks provide better habitat for invertebrates and small vertebrates that the frog can eat. The water bodies have other species of frogs present and the GGBF is well known for eating other frogs (including cannibalising its own species). The presence of frogs combined with the tussocks provide favourable foraging along with the fringing vegetation.

4.2.3 Dispersal habitat

As noted, the species will move some distance overland from shelter sites to reach breeding sites and back to preferred non-breeding pools, but the species is noted to avoid ponds that are more than 500 m from another water body (Hamer et al. 2002). The species also prefers to disperse through areas with low or minimal ground cover that allows easier movements (Muir 2008). The subject land contains ponds that are close enough (< 200 m) to allow regular movements between them by GGBF. The drainage lines present also form highly suitable dispersal habitat, especially following rain events. The terrain between ponds, cleared grazing lands is easily traversable. Grazing lands dominate habitats present in the adjacent lands for a least 1 km in each direction and so the study area and its surrounds broadly provide good dispersal opportunities for the GGBF. The main exceptions to this appear to be Luddenham Road and the Twin Creeks Golf Course development that both may provide some barriers to dispersal but are unlikely to form significant blockages in their current state.

5. Assessment of species presence

5.1 Features determining Green and Golden Bell Frog presence

The first consideration at this time for the presence of the GGBF in any location is whether the area is greater than 10 km from coast. Studies have demonstrated that water bodies this close to the coast can have saline influences that inhibit the growth of the chytrid fungus (Mahony et al. 2013). Based on the few recent records of the GGBF further than 10 km from the coast, the GGBF is only likely to be present where a refuge is provided from the fungus. This can be because of human intervention to create ideal breeding conditions and temperatures that retard the effects of the fungus (e.g. habitats created at Riverstone by a backyard breeder) or where historic land use has provided an "anti-fungicidal" environment (i.e., have chemical properties that inhibit growth; e.g. Sydney Olympic Park and the Captains Flat Gold Mine) that supresses the growth of the fungus, but is not too toxic for the frogs and tadpoles themselves.

There is no indication that such an environment is present in the study area as the area has had a long rural use for stock rather than industrial use that might have provided contaminants for the site. If "anti-fungal" conditions do exist and a population could establish itself, it would seem very likely that the species would already have been recorded there and already identified the habitat as suitable. The best understanding of the suitability of sites is based on recent records of the GGBF and the absence of records indicates that there is no viable population using the subject land.

The above point about human created habitats at Riverstone has relevance to this project as any actual record of the GGBF within or close to the locality that are post 2010 are almost certainly individuals originating from the backyard of that house, that has been set up to allow for a semi-wild population to persist. Occasionally there is a good breeding event and individuals disperse over the following 12-18 months to create new records, but viable breeding populations do not ever appear to be established and the animals ultimately succumb to the chytrid fungus. If the record to the southwest is a genuine record of the GGBF it is highly likely that this is a long-range dispersal from Riverstone and, as evidenced by the lack of any further records, no permanent viable population was established.

Secondarily, studies have demonstrated a relationship to exist between the probability of occupancy of a pond by GGBF and both the presence of other GGBF nearby and the connectivity of wetland sites within the landscape. The spatial arrangement of permanent wetlands must provide a short enough distance and suitable matrix of intervening habitat for frogs to move between ponds as well as a large enough number and types of wetlands within a 1 km radius to provide multiple interactive breeding sites (Hamer et al. 2002; Hamer & Mahony 2010; Valdez et al. 2015; Hamer 2018). The maintenance of a viable GGBF population at a local scale is based on the presence of a high density of well-connected water bodies with suitable intervening habitat. This is the case in the study area (see Figure 7) and so it provides suitable habitat in that regard.

The matrix of roads present also has been found to have a major influence on whether GGBF can inhabit an area. A high density of roads and the presence of larger roads with high volumes of traffic provides a negative environment for the GGBF. Their habit of migrating between water bodies to maintain a metapopulation requires free movement to allow populations to remain connected, allow new breeding sites to be colonised and allow local extinctions to be repopulated by dispersing individuals. Large roads represent barriers in both distances that frogs must cover in exposed conditions and the typically heavier volumes of traffic prohibit the successful crossing by frogs. Numerous smaller roads provide the same effect. Rural areas generally have a

low density of roads and so provide a relatively suitable environment for the GGBF where there are water bodies present. The study area and surrounds has just one larger road present along one side and otherwise has scattered smaller roads within minimal traffic use. So roads are unlikely to result in the isolation or fragmentation of the site such that GGBF would not be able to use it.

5.2 Suitability of habitat on the subject land

The information in Section 2 demonstrates the ability of the GGBF to use a broad range of habitats and only urbanised areas really represent broadly unsuitable habitat. This is because of the absence of interconnected and spatially suitable breeding ponds and the high density of roads and buildings that form barriers to movements. The subject land itself represents suitable habitat for the species as there are suitable breeding ponds with open water and some, if often minimal, emergent vegetation and that broadly do not contain fish. These ponds and the available drainage lines provide additional water bodies in close enough proximity to allow for easy movement of frogs between sites as is considered necessary for this species to survive (Hamer et al. 2002).

There is also moderately suitable foraging habitat in the form of extensive grassy areas that a local population could use for foraging. These grassy areas do lack debris and denser vegetation that provide shelter for overland movements or remaining away from water bodies during the day, which is unfavourable, but the widespread connectivity of ponds and drainage lines minimises this effect. So the environment overall is at least reasonably favourable for use by the GGBF.

5.3 Importance of the subject land to the Green and Golden Bell Frog

The subject land is not within 10 km of the coast and so it is unlikely that a viable population of the GGBF exists and uses the subject land in any meaningful way. The species is not expected to frequent the site in any way for the foreseeable future as there is no indication of the species recovering from recent declines, but rather the opposite, with most populations likely still declining. Therefore, there is unlikely to be a recolonisation of western Sydney in the foreseeable future.

As a positive, the subject land contains a variety of closely located permanent water bodies suitable for breeding, but perhaps only one obvious ephemeral breeding site. The breeding sites also have direct connection to the areas of preferred foraging habitat and frogs can cross between water bodies with relative ease. However, predatory introduced fish are widespread across the subject land making the water bodies much less favourable for use as breeding habitat. There is also little in the way of debris and denser vegetation for use as shelter outside of the water bodies and drainage lines. The subject land lacks temporary pools and does not have good shelter habitat.

The lands immediately surrounding the development site provide no barrier to dispersal and so a population, if present, could move more broadly into and out of the study area to places like Cosgrove's Creek (Figure 6).

If a population was present, it would provide good, but not ideal habitat for the GGBF. However, any use of the site is likely to be minimal as there is not an established breeding population within the study areas or close by to the study area and chytrid fungus is very likely preventing and going to prevent the establishment of a population for the foreseeable future.

Based on the BAM guidelines (DPIE 2020) the following applies when assigning any species polygon for the GGBF:

The species polygon boundary should align with aquatic habitats linked directly to the record and a buffer, incorporating the PCTs with which the species is associated, of 200 m radius from the top of bank. The polygon should include minimum 50 m wide corridors of native and non-native vegetated areas linking the available water bodies, where relevant.

As there are no records for the subject land and as it is considered that there are no frogs currently using the subject land, the GGBF is considered absent from the study area. Furthermore, it is not realistic to expect a viable population to establish in or close to the subject land for the foreseeable future. Hence there is no reason to produce a polygon to protect PCTs within a 200 m radius of the available ponds.

6. Conclusion

The for the Green and Golden Bell Frog to be present on the lands to be developed for the Sydney Science Park found that habitat was present for the species, but that the species is considered extinct in the locality and so the species does not use the subject land. This was supported by the absence of records from the locality over the previous 20 years, known extinction of the species more broadly from areas further than 10 km from the coast and was supported by the surveys completed on the proposed development site. On that basis there is no need to develop a species polygon for consideration of any offset needs under the Biodiversity Assessment Method.

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8. Appendix A Dr Frank Lemckert CV

Frank Lemckert **PRINCIPAL SCIENTIFIC ECOLOGIST**

Frank has been a professional scientist since 1992, specialising in understanding and managing the ecology and management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland), establishing long-term research and monitoring programs into the management of fauna and developing strategies to mitigate the impacts of human disturbances. He has worked extensively with the NSW state and federal Governments on varying issues of fauna and flora management including the preparation of a draft NSW/National recovery plan for the Giant Burrowing Frog (Heleioporus australiacus) and recent expert review roles on fauna management plans and monitoring strategies for the NSW Natural Resources Commission. Frank is an accredited expert under the NSW Biodiversity Assessment Method (BAM) for a range of threatened frogs and is writing the BAM survey guidelines for NSW's threatened frogs. Frank has prepared reports on endemism and representation in reserves of flora and fauna for the Commonwealth, represented the NSW Forestry Commission in license negotiations for the Comprehensive Regional Assessment process (2000), been a member of a state regulators advisory group for the management of Cane Toads across Australia and the Taren Point Cane Toad Advisory Group, and provided expert ecological advice on illegal land clearing for the NSW and Commonwealth Governments. He has authored over 100 peer-reviewed publications. Frank is a research associate with the Australian Museum and University of Newcastle and convenor of the NSW Declining Frog Working Group. He is a recognised expert in frog ecology and management, but has completed management related projects and works on a range of terrestrial vertebrate fauna.

Frank's primary role as a consultant has been to use his expertise and experience in technical writing and threatened species legislation to develop and maintain quality assurance in projects including:

- >100 flora and fauna reports and assessments of significance using the EP&A Act and EPBC Act and two species impact statements.
- Roadside mapping, survey and management strategies for the Wallum Froglet and Mahony's Toadlet.
- Biodiversity Assessment Reports for Warragamba Dam Raising, Nowra Bridge, Golden Highway and Eurobodalla Dam.
- Manager for the Oxley Highway to Kempsey and Frederickton to Eungai ecological monitoring program.
- Construction and Environmental Management Plans, Monitoring Plans and Vegetation Management Plans for roads at Port Macquarie, Berry to Bomaderry and South Nowra.
- Nest Box, microbat and Green and Golden Bell Frog management plans for the Berry to Bomaderry and Oxley Highway to Kempsey Highway Upgrades.
- Review of Private Native Forestry prescriptions under the Code of Practices and assessment of habitat changes using BAM as a monitoring tool.
- Review of two proposed Coal Seam Gas Impact Assessment methods for Matters of National Environmental Significance (contracted by the Commonwealth Government).
- Provision of species credit species expert reports for the Warragamba Dam raising project and Western Sydney Growth Centres Biocertification and developments on the NSW Central and South Coasts.

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QUALIFICATIONS

- Bachelor of Science, University of Sydney, 1984 (Terrestrial Ecology and Marine Management)
- Master of Science, University of Sydney, 1991 (Population biology of the Common Froglet)
- PhD, University of Newcastle, 2009 (Management of forest frogs in timber production forests of NSW).

PROJECT EXPERIENCE

ECOLOGICAL IMPACT ASSES

- MONITORING OF BAT POPULATIONS AND ASSESSMENT OF POTENTIAL IMPACTS OF THE PROPOSED JEREMIAH WINDFARM AT ADJUNGBILLY, NSW (2019-PRESENT).
- MANAGEMENT OF IMPACTS ON GREEN AND GOLDEN BELL FROGS FOR THE KIWEF PROJECT AT KOORAGANG ISLAND, NSW FOR DARACON (2019-PRESENT).
- IMPACT ASSESSMENTS FOR HOUSING DEVELOPMENTS ON KOALAS IN THE CAMPBELLTOWN AREA (PRIVATE DEVELOPMENT AND CAMPBELLTOWN COUNCIL)
- EXPERT REPORT ON THE GREEN AND GOLDEN BELL FROG FOR TWO WESTERN SYDNEY GROWTH AREAS BIOCERTIFICATION PROJECT (2018-PRESENT)
- WARRAGAMBA DAM RAISING PROJECT TARGET SURVEYS, IMPACT ASSESSMENTS, EXPERT REPORTING (SIX SPECIES) AND Q/A FOR WATER NSW (2018-19)
- GRANITE HILLS WINDFARM BIRD AND BAT STRIKE MODELLING AND ECOLOGICAL IMPACT ASSESSMENT, NIMMITABEL, AKUO ENERGY (2018) AND ELYSIAN WINDFARM, NIMMITABEL, AKUO ENERGY (2018)
- VEGETATION REMOVAL AND THREATENED FROG MANAGEMENT STRATEGIES, NEW INTERCITY FLEET MANAGEMENT FACILITY, JOHN HOLLAND GROUP (2018-PRESENT)
- EUROBODALLA DAM BIODIVERSITY ASSESSMENT REPORT, EUROBODALLA SHIRE COUNCIL (2017-18)
- NOWRA BRIDGE EIS ECOLOGICAL ASSESSMENTS, NSW RMS (2018)
- HEATHCOTE ROAD UPGRADE IMPACT ASSESSMENT AND REVIEW OF MITIGATION MEASURES, NSW RMS (2018-2019)

GOVERNMENT REVIEWS/REPORTS

- BIODIVERSITY ASSESSMENT METHOD FROG SURVEY GUIDELINES FOR SPECIES CREDIT SPECIES (2020)
- EXPERT WORKSHOP TO DEVELOP A NSW-WIDE NIL-TENURE FAUNA MONITORING PROGRAM, NSW NATURAL RESOURCES COMMISSION (2020)
- REVIEW OF SPECIES MANAGEMENT PLANS FOR THE YELLOW-BELLIED GLIDER, GIANT BURROWING FROG, EASTERN BRISTLEBIRD AND SOUTHERN BROWN BANDICOOT PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- PROVISION OF INFORMATION AS THE BASIS FOR THE DEVELOPMENT OF SIX THREATENED FLORA SPECIES MANAGEMENT PLANS TO BE PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- EXPERT REVIEW OF BIODIVERSITY IMPACT ASSESSMENT REPORT FOR THE HORNSBY QUARRY REHABILITATION PROJECT (2019)
- HORNSBY COUNCIL EXPERT WITNESS FOR DEVELOPMENT IMPACTS AT DURAL, HORNSBY SHIRE COUNCIL (2016)
- EXPERT ADVICE ON IMPACTS OF ILLEGAL LAND CLEARING AT EVANS HEAD, NSW STATE GOVERNMENT (2016)
- EXPERT ADVICE ON IMPACTS OF ILLEGAL LAND CLEARING AT SOMERSBY, COMMONWEALTH GOVERNMENT (2015)

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- REVIEW OF MONITORING STRATEGIES FOR THE WOOLGOOLGA TO BALLINA AND WARRELL CREEK TO NAMBUCCA HEADS PROGRAMS FOR THE PACIFIC HIGHWAY UPGRADE, NSW RMS (2014)
- REVIEW OF IMPACT ASSESSMENT PATHWAYS FOR TWO LPNG PROJECTS, COMMONWEALTH GOVERNMENT (2013)
- REVIEW OF THREATENED SPECIES MODELLING IN FORESTRY AREAS, VIC FORESTS (2012)
- FLORA AND FAUNA REPRESENTATION IN THE AUSTRALIAN RESERVE SYSTEM, COMMONWEALTH GOVERNMENT (2010)
- FLORA AND FAUNA ENDEMISM PATTERNS ACROSS AUSTRALIA, COMMONWEALTH GOVERNMENT (2009)
- REVIEW IMPACTS TO THREATENED REPTILES AND AMPHIBIANS IN THE SOUTHERN BRIGALOW BELT, FOR WPS (2008)
- EXPERT REPRESENTING FORESTS NSW IN THE COMPREHENSIVE REGINAL ASSESSMENT PROGRAM FOR THE REGIONAL FOREST AGREEMENT PROGRAM (1999-2001)
- EXPERT REVIEW OF FAUNA AND FLORA IMPACTS FOR 13 NSW FORESTRY COMMISSION EIS REPORTS (1992-94).

EPBC REFERRALS

- GREEN AND GOLDEN BELL FROG (*LITORIA AUREA*) REFERRALS FOR THE PRINCES HIGHWAY UPGRADE AT SOUTH NOWRA, NSW RMS (2011-2012).
- AUSTEN QUARRY (*EUCALYPTUS PULVERULENTA*), HARTLEY, HY-TEC INDUSTRIES (2014-15)
- MARYS MOUNT KOALA (*PHASCOLARCTOS CINEREUS*) REFERRAL, GUNNEDAH QUARRY PRODUCTS (2015)

MONITORING PROGRAMS

- NIL-TENURE FERAL MANAGEMENT AND MONITORING STRATEGY FOR THE NARRABRI COAL SEAM GAS PROJECT, SANTOS (2019).
- THREATENED FAUNA MONITORING HUME HIGHWAY, KAPOOKA, NSW RMS (2018)
- GREEN AND GOLDEN BELL FROG BASELINE MONITORING PROGRAM AT MEROO LAKES, NSW OEH (2016-17)
- OXLEY HIGHWAY TO KEMPSEY THREATENED BIODIVERSITY MONITORING, NSW RMS (2013-2017)
- FCNSW STATE-WIDE ECOLOGICAL MONITORING PROGRAM, FORESTRY CORPORATION OF NSW (2009-10)

PLANS OF MANAGEMENT / STRATEGIES

- GREEN AND GOLDEN BELL FROG PRE-CLEARING WORKS KOORAGANG ISLAND (DARACON 2016 & CURRENT)
- REVIEW OF SPECIES MANAGEMENT PLANS FOR THE YELLOW-BELLIED GLIDER, GIANT BURROWING FROG, EASTERN BRISTLEBIRD AND SOUTHERN BROWN BANDICOOT PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- PROVISION OF INFORMATION AS THE BASIS FOR THE DEVELOPMENT OF SIX THREATENED FLORA SPECIES MANAGEMENT PLANS TO BE PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- NESTBOX, MICROBAT AND GREEN AND GOLDEN BELL FROG MANAGEMENT PLANS, BERRY TO BOMADERRY UPGRADE OF THE PRINCES HIGHWAY, NSW RMS (2017)
- GREEN AND GOLDEN BELL FROG SURVEYS AND MONITORING, PRINCES HIGHWAY UPGRADES AT SOUTH NOWRA AND BERRY TO BOMADERRY, NSW RMS (2012-2017)
- THREATENED FROG MODELLED HABITAT REQUIREMENTS, HORNSBY SHIRE COUNCIL (2016)
- MICROBAT MANAGEMENT PLAN FOR CLARENCETOWN BRIDGE, NSW RMS (2016)
- EASTERN BENTWING-BAT MANAGEMENT PLAN, GERRINGONG, NSW RMS (2014)
- GREEN AND GOLDEN BELL FROG MANAGEMENT STRATEGY, PRINCES HIGHWAY UPGRADE, NSW RMS (2012-2014)

- EXPERT REVIEW OF THREATENED FROG MANAGEMENT PLAN - WOOLGOOLGA TO BALLINA UPGRADE, NSW RMS (2014)
- THREATENED MICROBAT MANAGEMENT PLAN FOR WARRINGAH MALL, NORTHERN BEACHES COUNCIL (2014)
- COMMONWEALTH/NSW GIANT BURROWING FROG RECOVERY PLAN, DEWHA/DECC (2012)
- NSW DPI REPRESENTATIVE FOR THE NATIONAL ADVISORY GROUP ON CANE TOAD MANAGEMENT (2009-2011)
- TAREN POINT CANE TOAD MANAGEMENT ADVISORY GROUP (2007-2008).

TRAINING

- LEAD INSTRUCTOR > 50 WILDLIFE TRAINING SCHOOLS RUN IN NSW, ACT AND VICTORIA PROVIDING PRESENTATIONS ON THE SURVEY, IDENTIFICATION AND MANAGEMENT OF ALL FLORA AND FAUNA. THIS INCLUDED DETAILED INSTRUCTION ON THE MANAGEMENT OF THREATENED WADING AND AQUATIC BIRDS AND OTHER AQUATIC SPECIES PRESENTED TO QUEENSLAND, VICTORIAN, NSW AND COMMONWEALTH GOVERNMENT STAFF (1993-2017)
- PRIVATE FORESTRY SURVEY REQUIREMENTS, VICTORIAN TIMBER (2016).

PUBLICATIONS

Book Chapters

Hecnar S. J., & Lemckert, F.L. 2012. Habitat Protection: Refuges and Reserves. Pp 3636-3675 In Biology of the Amphibia Volume 10 - Conservation and Decline of Amphibians: Ecology, Effects of Humans, and Management. H. Heatwole (Ed.). Surrey-Beattey and Sons, Sydney.

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Appendix H Biodiversity credit report

NSW GOVERNMENT

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00047260/BAAS18159/24/00047261	Syd Science Park	05/08/2025
Assessor Name	Report Created	BAM Data version *
Belinda Jane Failes	21/11/2025	Current classification (live - default) (82)
Assessor Number	BAM Case Status	Date Finalised
BAAS18159	Finalised	21/11/2025
Assessment Revision	BOS entry trigger	Assessment Type
1		Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits

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BAM Credit Summary Report

Coastal Valleys Riparian Forest											
2	4023_low	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	12.2	7.2	1.4	Biodiversity Conservation Act listing status	High Sensitivity to Gain	Endangered Ecological Community	Not Listed	2.00		0
											Subtotal	**0**
Cumberland Shale Plains Woodland											
1	3320_low	Cumberland Plain Woodland in the Sydney Basin Bioregion	7.9	7.9	1.4	Biodiversity Conservation Act listing status	High Sensitivity to Gain	Critically Endangered Ecological Community	Not Listed	2.50	True	0
											Subtotal	**0**
Southern Lower Floodplain Freshwater Wetland											
3	3975_low	Not a TEC	51.7	51.7	0.53	PCT Cleared - 93%	High Sensitivity to Gain			2.50		17
											Subtotal	**17**
											Total	**17**

Species credits for threatened species

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BAM Credit Summary Report

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits
Myotis macropus / Southern Myotis (Fauna)									
3320_low	7.9	7.9	1.1	Biodiversity Conservation Act listing status	Species dependent on habitat attributes	Vulnerable	Not Listed	False	4
4023_low	7.2	7.2	0.75	Biodiversity Conservation Act listing status	Species dependent on habitat attributes	Vulnerable	Not Listed	False	3
3975_low	51.7	51.7	0.38	Biodiversity Conservation Act listing status	Species dependent on habitat attributes	Vulnerable	Not Listed	False	10
								Subtotal	**17**

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BAM Biodiversity Credit Report (Like for like)

Proposal Details

Assessment Id 00047260/BAAS18159/24/00047261	Proposal Name Syd Science Park	BAM data last updated * 05/08/2025
Assessor Name Belinda Jane Failes	Assessor Number BAAS18159	BAM Data version * Current classification (live - default) (82)
Proponent Names Jude Adikari	Report Created 21/11/2025	BAM Case Status Finalised
Assessment Revision 1	BOS entry trigger	Assessment Type Major Projects
Date Finalised 21/11/2025	* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.	

Potential Serious and Irreversible Impacts

Name of threatened ecological community	Listing status	Name of Plant Community Type/ID
Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered Ecological Community	3320-Cumberland Shale Plains Woodland
Species		
Nil		

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BAM Biodiversity Credit Report (Like for like)

Additional Information for Approval

PCT Outside Ibra Added

None added

PCTs With Customized Benchmarks

PCT
No Changes

Predicted Threatened Species Not On Site

Name
No Changes

Ecosystem Credit Summary (Number and class of biodiversity credits to be retired)

Name of Plant Community Type/ID	Name of threatened ecological community	Area of impact	HBT Cr	No HBT Cr	Total credits to be retired
3320-Cumberland Shale Plains Woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion	1.4	0	0	0
4023-Coastal Valleys Riparian Forest	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	1.4	0	0	0
3975-Southern Lower Floodplain Freshwater Wetland	Not a TEC	0.5	0	17	17

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BAM Biodiversity Credit Report (Like for like)

3320-Cumberland Shale Plains Woodland	**Like-for-like credit retirement options**					
	Name of offset trading group	Trading group	Zone	HBT	Credits	IBRA region
	Cumberland Plain Woodland in the Sydney Basin Bioregion This includes PCT's: 3319, 3320	-	3320_low	Yes	0	Cumberland, or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.
3975-Southern Lower Floodplain Freshwater Wetland	**Like-for-like credit retirement options**					
	Class	Trading group	Zone	HBT	Credits	IBRA region
	Coastal Freshwater Lagoons This includes PCT's: 3964, 3975	Coastal Freshwater Lagoons >=90%	3975_low	No	17	Cumberland, or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.
4023-Coastal Valleys Riparian Forest	**Like-for-like credit retirement options**					
	Name of offset trading group	Trading group	Zone	HBT	Credits	IBRA region

Assessment Id: 00047260/BAAS18159/24/00047261

Proposal Name: Syd Science Park

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BAM Biodiversity Credit Report (Like for like)

	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions This includes PCT's: 1731, 3962, 3963, 3985, 3987, 3993, 4016, 4023, 4026, 4027, 4028, 4030, 4035, 4038, 4040, 4048, 4049, 4050, 4056	-	4023_low	Yes	0	Cumberland, or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

Species Credit Summary

Species	Vegetation Zone/s	Area / Count	Credits
Myotis macropus / Southern Myotis	**3320_low, 4023_low, 3975_low**	2.2	17.00

Credit Retirement Options

Like-for-like credit retirement options

	Spp	IBRA subregion
Myotis macropus / Southern Myotis	**Myotis macropus /** Southern Myotis	Any in NSW

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