INLAND RAIL

Technical reports

INLAND RAIL—NARROMINE TO NARRABRI
ENVIRONMENTAL IMPACT STATEMENT

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

IR_1929

TECHNICAL REPORT 1

Biodiversity development assessment report

PART 1 OF 3

Main report

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

ARTC Inland Rail

Narromine to Narrabri Project

Biodiversity Development Assessment Report

Technical Report 1

2-0001-250-EAP-00-RP-0002

Certification under Section 6.15 of the *Biodiversity Conservation Act 2016*

We, Leigh Maloney (BAAS18086) and Kirsten Crosby (BAAS17011) certify that this Biodiversity Development Assessment Report and the accompanying finalised credit report dated 21 August 2020 has been prepared in accordance with the requirements of (and information provided under) the Biodiversity Assessment Method.

Leigh Maloney – BAAS18086

21 August 2020

Kirsten Crosby – BAAS17011

21 August 2020

Table of contents

Table index

Figure index

Appendices

Appendix A – Minimum information requirements for the Biodiversity Development Assessment Report
Appendix B – Detailed PCT profiles and fauna habitat descriptions
Appendix C – Likelihood of occurrence of threatened and migratory biota
Appendix D – Survey effort and timing
Appendix E – Flora survey results
Appendix F – Fauna survey results
Appendix G – Landscape features and vegetation zone maps by segment
Appendix H – PCT extent of impacts in investigation corridor
Appendix I – Threatened species information, species polygon maps and justification for species polygons
Appendix J – Fauna connectivity measures
Appendix K – Biodiversity credit calculations
Appendix L – Plot justifications and BAM input data
Appendix M – EPBC Act assessments of significance

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Executive summary

The proposal

The Australian Government has committed to delivering a significant piece of national transport infrastructure by constructing a high performance and direct interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland. Inland Rail is a major national program that will enhance Australia's existing national rail network and serve the interstate freight market.

The proposal consists of about 306 kilometres of new single-track standard gauge railway with crossing loops. The proposal also includes changes to some roads to facilitate construction and operation of the new section of railway, and ancillary infrastructure to support the proposal.

The proposal would link the Parkes to Narromine section of Inland Rail located in central western NSW, with the Narrabri to North Star section of Inland Rail located in north-west NSW.

Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Narromine to Narrabri section of Inland Rail ('the proposal').

The proposal is State significant infrastructure and is subject to approval by the NSW Minister for Planning and Public Spaces under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also determined to be a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and requires approval from the Australian Minister for the Environment.

This report

This Biodiversity Development Assessment Report (BDAR) has been prepared on behalf of the ARTC to assess the potential ecological impacts of the proposal in accordance with the NSW Biodiversity Offsets Scheme (BOS) and responds to the Secretary's environmental assessment requirements (SEARs) for biodiversity.

Extensive literature reviews, the identification of relevant landscape features and detailed flora and fauna field surveys undertaken between September 2018 and June 2020 of the proposal investigation corridor, in accordance with the Biodiversity Assessment Method (BAM) (Office of Environment and Heritage (OEH) 2017). A biodiversity survey investigation plan was developed in consultation with, and endorsed by the Department of Planning, Industry and Environment – Biodiversity Conservation Division (BCD). The Biodiversity Assessment Method Calculator (BAMC) was used following field surveys and desktop assessment to calculate the total number and types of ecosystem and species credits that need to be purchased and retired to offset impacts of the proposal. The report also provides a discussion of the likely requirement for offsets to comply with the EPBC Act environmental offsets policy (Department of Sustainability, Environment, Water, Heritage and the Arts 2012).

Existing landscape

Much of the southern and central portion of the proposal is located in land cleared for agriculture. This comprises a mix of cropped land and native grassland used for livestock. Areas of native woodland are also located in agricultural land. In the northern end of the proposal site, large sections are located in areas dominated by vegetation associated with state forests of the Pilliga.

Field surveys were conducted in September and November 2018, and March, August, September and October 2019. Much of NSW, including the proposal site, had been subject to ongoing drought during and prior to surveys being conducted.

Native vegetation in the proposal site generally comprise a woodland community, with the dominant canopy species including Pilliga Grey Box (*Eucalyptus pilligaensis*), Baradine Gum (*Eucalyptus chloroclada*), Poplar Box (*Eucalyptus populnea*) and White Cypress Pine (*Callitris glaucophylla*). Scattered areas of derived natural grasslands also occur. A total of 37 PCTs were identified in the proposal site. Some areas of derived native grassland have been assigned to the woodland PCTs that would have originally occurred. Five threatened ecological communities listed under the *Biodiversity Conservation Act 2016* (BC Act), and five listed under the EPBC Act were identified during field surveys.

One threatened flora species, Cobar Greenhood (*Pterostylis cobarensis*), was identified at one location in Pilliga East State Forest. Potential habitat for an additional eight threatened flora species listed under the BC Act and/or EPBC Act is also present in the proposal site. Eighteen threatened fauna species were recorded during surveys, and potential habitat for an additional 33 threatened fauna species listed under the BC Act and/or EPBC Act is also present in the proposal site.

Impacts from the proposal during construction

The proposal is located in agricultural and forested lands and would have the following impacts on biodiversity values:

- removal of 1,732 hectares of native vegetation, comprised of around 1,125 hectares of native woodland and forest vegetation in good condition, 600 hectares of derived native grassland (including about six hectares of derived Kurrajong grassy open woodland / isolated trees), and about seven hectares of wetland vegetation
- removal of 630 hectares of native vegeation from the Pilliga forests
- removal of an estimated 13,000-30,000 hollow-bearing trees
- potential impacts on threatened flora species
- injury and mortality of fauna during construction
- potential spread of weeds and diseases
- substantial direct impacts on species credit fauna species listed under the NSW BC Act including the Koala, Barking Owl, Masked Owl, Glossy Black-cockatoo, Squirrel Glider, Eastern Pygmy-possum, Bush Stone-curlew, Little Eagle, Square-tailed Kite, Rufous Bettong and Pale-headed Snake
- substantial direct impacts on ecosystem credit fauna species listed under the BC Act such as the Pilliga Mouse and Corben's Long-eared Bat
- significant impacts on threatened species listed under the EPBC Act, including the Koala, Corben's Long-eared Bat, Pilliga Mouse, Painted Honeyeater, Regent Honeyeater, Swift Parrot, *Tylophora linearis, Commersonia procumbens* and *Lepidium monoplocoides.*

Impacts from the proposal during operation

Operation of the proposal has the potential to result in the following impacts:

- injury and mortality of fauna attempting to cross the rail line and roads
- impacts on connectivity (and associated impacts on population viability and genetics), particularly for terrestrial fauna in the Pilliga area

- dust, noise and vibration
- spread of weeds and pests.

Avoidance and minimisation of impacts

During the development of the proposal, a number of alternate alignments and wider investigations corridors were investigated to assist with identification of the preferred alignment. These layouts were developed in response to ongoing environmental and engineering investigations and consultation with landowners (both on impacted properties or adjacent to the proposal site). Overall, the route through the Pilliga forest was selected as the preferred option due to a combination of lower construction cost, avoidance of prime farming land, and reduced transit time during operation. As such, a substantial impact on biodiversity values has not been able to be avoided.

The proposal was purposefully modified to avoid impacts to biodiversity values and especially threatened biota as follows:

- Locating of the proposal in predominantly cleared farmland rather than paper roads and other road reserves containing remnant native vegetation where practicable.
- Avoidance of areas of threatened ecological communities where practicable through selection of route options in some locations with no impacts on these communites.
- The proposal includes 73 bridges along the alignment, including at large rivers and many ephemeral creeks. The presence of bridges will allow retention of some riparian vegetation, providing connectivity for fauna and proposed design changes have been made to allow these structures to facilitate the movement of fauna. Many fauna use dry creek beds and riparian vegetation for movement through the landscape, and these bridges will allow continued fauna movement and gene flow.
- Inclusion of about 630 banks of drainage culverts would provide some connectivity for fauna species. Design modifications are being developed for additional dedicated fauna culverts in areas of Pilliga Mouse habitat where no drainage culverts are required.

Further targeted survey effort during more favourable survey conditions was planned for March 2020. However planned surveys were cancelled in late March 2020 due to the global coronavirus (Covid-19) pandemic. Some additional surveys were completetd in June 2020 and planning for further surveys in the second half of 2020 is currently underway to assist with minimising impact to biodiversity within the construction impact zone.

Recommeneded mitigation measures

Design phase

The following mitigation measures are proposed during the design phase:

- preparation of a fauna connectivity strategy, including detailed assessment and design of locations for fauna crossing structures, including glider poles and barrier poles, description of all crossing measures, fauna furniture and the need for fencing, a monitoring program and reporting requirements.
- preparation of a fauna management plan(s), including protocols for the removal of habitat features and rescue and relocation of fauna during vegetation clearing and construction.
- further surveys targeting threatened species, to minimise the offset liability for species assumed present through indientification of species occurrence rather than assumed presence and to determine specific mitigation measures required during construction.

Construction phase

The following mitigation measures are proposed during the construction phase:

- mapping and fencing of sensitive areas
- pre-clearing surveys for threatened species
- rehabilitation (including revegetation where required) of disturbed areas following construction
- management and control of pathogens, weeds, erosion and sedimentation
- management and control of other invasive species (eg invasive ants).

Operation phase

The following mitigation measures are proposed to be incorporated into an Operational Environmental Management Plan (OEMP) within the rail corridor during the operation phase:

- monitoring of fauna crossing structures, with adaptive management as required
- monitoring and control of feral pests, particularly the Red Fox and Feral Cat in the Pilliga forests
- management and control of weeds
- management and control of other invasive species along the rail corridor (eg invasive ants).

Offsets

The Australian Government formally endorsed the NSW Biodiversity Offsets Scheme (BOS) in March 2020. Offset requirements for species likely to be significantly impacted have been calculated in accordance with BAM, and will be delivered in accordance with the BOS and BC Act, pursuant to the assessment bilateral agreement. Species credits have been calculated in accordance with the BAM for the two flora species, and for important habitat for the Koala. Ecosystem credits have been calculated for the remaining threatened fauna species.

Following the application of appropriate avoidance and mitigation measures, the BDAR identified the following biodiversity features and subsequent credits required to offset the impacts of the proposal in accordance with the BAM:

- 34,820 ecosystem credits
- 160,421 species credits.

ARTC are proposing to complete additional targeted survey effort in the second half of 2020. The main aim of the surveys will be to gain a better understanding of proposal impacts to threatened flora and to complete vegetation integrity plots outside of drought conditions and in areas previously extrapolated due to access restrictions. Results of these surveys will be documented in an addendum biodiversity report following exhibition.

Glossary and abbreviations

Acronym/term	Definition
ARKS	Area of Regional Koala Significance
ARTC	Australian Rail Track Corporation
BAM	Biodiversity Assessment Methodology
BAMC	Biodiversity Assessment Method Calculator
BC Act	*Biodiversity Conservation Act 2016*
BCD	Biodiversity and Conservation Division (NSW)
BCF	Biodiversity Conservation Fund
BCT	Biodiversity Conservation Trust
BDAR	Biodiversity Development Assessment Report
Biodiversity offsets	Biodiversity offsets are measures that benefit biodiversity by compensating for the residual adverse impacts elsewhere of an action, such as clearing for development. Biodiversity offsets work by protecting and managing biodiversity values in one area to compensate for impacts on biodiversity values in another.
BOM	Bureau of Meteorology
BOS	Biodiversity Offset Scheme
CEEC	Critically endangered ecological community
CEMP	Construction environmental management plan
CMA	Catchment Management Authority
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DECC	Department of Environment and Climate Change (NSW) (former)
DECCW	Department of Environment, Climate Change and Water (NSW) (former)
DEE	Department of Environment and Energy (Commonwealth) (former)
DEWHA	Department of Environment, Water, Heritage and the Arts (Commonwealth) (former)
DIWA	Directory of Important Wetlands of Australia
DLWC	Department of Land and Water Conservation (NSW) (former)
DoE	Department of Environment (Commonwealth) (former)
Ecosystem credit	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 site and the gain in biodiversity values at a biodiversity stewardship site.
EEC	Endangered ecological community
EES	NSW Environment, Energy and Science Division of the Department of Planning, Industry and the Environment (formerly known as OEH)
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*

Acronym/term	Definition
FBA	Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major proposals
FMZ	Forestry Management Zone
GDE	groundwater dependent ecosystems
GIS	geographic information system
GPS	global positioning system
ha	hectare
HCV	high conservation value
IBA	Important Bird Area
IBRA	Interim Biogeographic Regionalisation for Australia
Inland Rail programme (Inland Rail)	The Inland Rail programme encompasses the design and construction of a new inland rail connection between Melbourne and Brisbane, via Wagga, Parkes, Moree, and Toowoomba. The route for Inland Rail is about 1,700 kilometres in length. Inland Rail will involve a combination of upgrades of existing rail track and the provision of new track.
KTP	key threatening process
LGA	local government area
MNES	Matters of National Environmental Significance
NPWS	National Parks and Wildlife Services
NSW	New South Wales
OEH	Office of Environment and Heritage (former)
PCT	plant community type
Proponent (designated)	Individual or organisation who is proposed to be designated as the proponent if the Minister decides that the action is a controlled action and further assessment and approval is required. The proponent is responsible for meeting the requirements of the EPBC Act during the assessment process. The proponent may or may not be the person proposing to take the action.
Ramsar wetland	Wetlands of International Significance especially as Waterfowl Habitat, identified by the Ramsar Convention.
RDPs	Rapid Data Points
The proposal	Defined as the construction and operation of the Narromine to Narrabri section of Inland Rail.
the proposal site	Defined as the area that would be directly affected by construction of the proposal (also known as the construction footprint). It includes the location of proposal infrastructure, the area that would be directly disturbed by the movement of construction plant and machinery, and the location of the compounds and laydown areas that would be used during construction.
Rail corridor	The corridor within which the rail tracks and associated infrastructure would be located.
SAII	Serious and irreversible impact
SEAR	Secretary Environmental Assessment Requirements
SEED	Sharing and Enabling Environmental Data

Acronym/term	Definition
Species credit	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 species profile database.
SPRAT	Species Profile and Threats Database
State significant infrastructure (SSI)	Major transport and services infrastructure which has been declared to be State significant infrastructure for the purposes of Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979*.
Study area	The 'study area' refers to the area that was assessed for direct or indirect impacts that may arise from the proposal, generally located within 50 metres of the proposal site or construction footprint (refer to Figure 1.2).
TEC	Threatened ecological community
VI	Vegetation integrity
VIS	vegetation information system
WSP	Water Sharing Plan

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1. Introduction

1.1 Overview

1.1.1 Inland Rail and the proposal

The Australian Government has committed to delivering a significant piece of national transport infrastructure by constructing a high performance and direct interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland. Inland Rail is a major national program that will enhance Australia's existing national rail network and serve the interstate freight market.

The Inland Rail route, which is about 1,700 kilometres long, involves:

- using the existing interstate rail line through Victoria and southern NSW
- upgrading about 400 kilometres of existing track, mainly in western NSW
- providing about 600 kilometres of new track in NSW and south-east Queensland.

The Inland Rail program has been divided into 13 sections, seven of which are located in NSW. Each of these projects can be delivered and operated independently with tie-in points on the existing railway.

Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Narromine to Narrabri section of Inland Rail ('the proposal').

1.1.2 Approval and assessment requirements

The proposal is State significant infrastructure and is subject to approval by the NSW Minister for Planning and Public Spaces under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The proposal is also determined to be a controlled action under the Commonwealth *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act), and requires approval from the Australian Minister for the Environment.

This report has been prepared by the JacobsGHD Joint Venture as part of the environmental impact statement (EIS) for the proposal. The EIS has been prepared to support the application for approval of the proposal, and address the environmental assessment requirements of the Secretary of the NSW Department of Planning, Industry and Environment (the SEARs), dated 9 September 2020.

1.2 The proposal

The proposal consists of about 306 kilometres of new single-track standard gauge railway with crossing loops. The proposal also includes changes to some roads to facilitate construction and operation of the new section of railway, and ancillary infrastructure to support the proposal.

The proposal would be constructed to accommodate double-stacked freight trains up to 1,800 metres long and 6.5 metres high. It would include infrastructure to accommodate possible future augmentation and upgrades of the track, including a possible future requirement for 3,600 metre long trains.

The land requirements for the proposal would include a new rail corridor with a minimum width of 40 metres, with some variation to accommodate particular infrastructure and to cater for local topography. The corridor would be of sufficient width to accommodate the infrastructure currently proposed for construction, as well as possible future expansion of crossing loops for 3,600 metre long trains. Clearing of the proposal site would occur to allow for construction and to maintain the safe operation of the railway.

1.2.1 Location

The proposal would be located between the towns of Narromine and Narrabri in NSW. The proposal would link the Parkes to Narromine section of Inland Rail located in central western NSW, with the Narrabri to North Star section of Inland Rail located in north-west NSW.

The location of the proposal is shown in Figure 1.1.

1.2.2 Key features

The key design features of the proposal include:

Rail infrastructure

- a new 306 kilometre long rail corridor between Narromine and Narrabri
- a single-track standard gauge railway and track formation within the new rail corridor
- seven crossing loops, at Burroway, Balladoran, Curban, Black Hollow/Quanda, Baradine, The Pilliga and Bohena Creek
- bridges over rivers and other watercourses (including the Macquarie River, Castlereagh River and the Namoi River/Narrabri Creek system), floodplains and roads
- level crossings
- new rail connections and possible future connections with existing ARTC and Country Regional Network rail lines, including a new 1.2 kilometre long rail junction between the Parkes to Narromine section of Inland Rail and the existing Narromine to Cobar Line (the Narromine West connection)

Road infrastructure

- road realignments at various locations, including realignment of the Pilliga Forest Way for a distance of 6.7 kilometres
- limited road closures.

The key features of the proposal are shown in Figure 1.2.

Ancillary infrastructure to support the proposal would include signalling and communications, drainage, signage and fencing, and services and utilities.

Further information on the proposal is provided in the EIS.

Figure 1.1 **Location of the proposal**

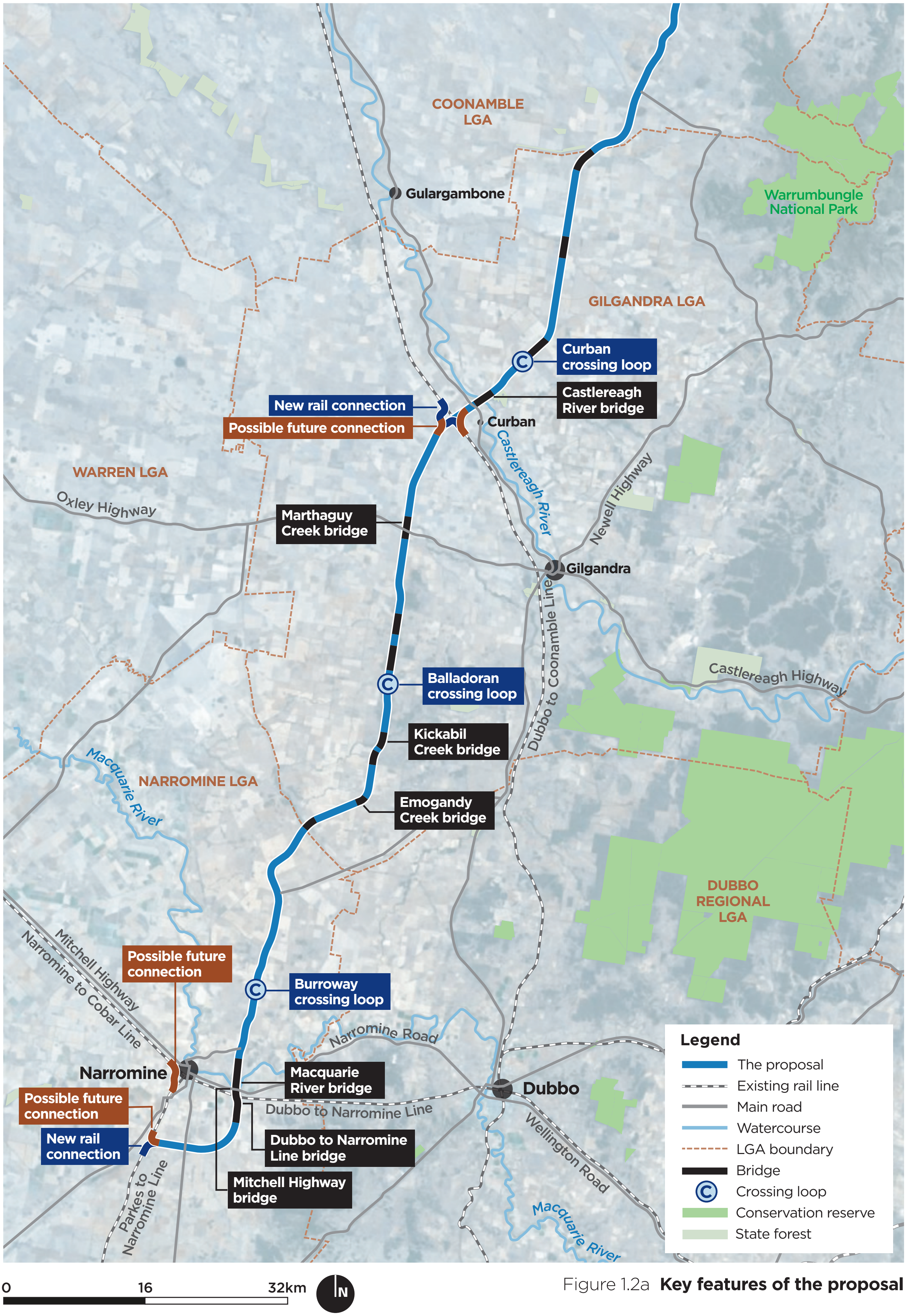

Figure 1.2a **Key features of the proposal**

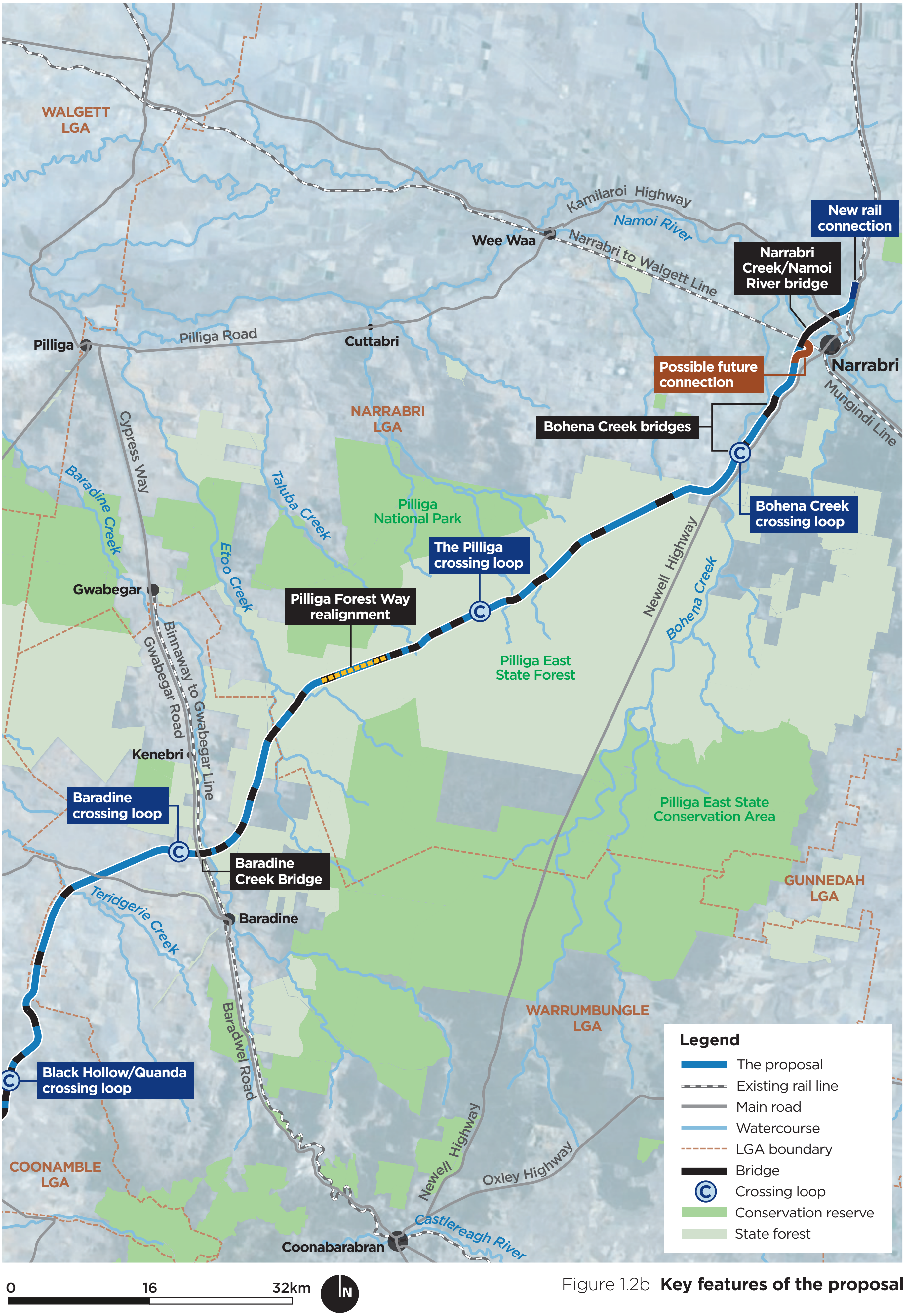

Figure 1.2b **Key features of the proposal**

1.2.3 Construction overview

An indicative construction strategy has been developed based on the current reference design to be used as a basis for the environmental assessment process. Detailed construction planning, including programming, work methodologies, staging and work sequencing would be undertaken once construction contractor(s) have been engaged and during detailed design.

Timing and work phases

Construction of the proposal would involve five main phases of work as outlined in Table 1.1. It is anticipated that the first phase would commence in late 2021, and construction would be completed in 2025.

Table 1.1 Main construction phases and indicative activities

Phase	Indicative construction activities
Pre-construction	• Establishment of areas to receive early material deliveries • Delivery of certain materials that need to be bought to site before the main construction work
Site establishment	• Establishment of key construction infrastructure, work areas and other construction facilities • Installing environmental controls, fencing and site services • Preliminary activities including clearing/trimming of vegetation
Main construction works	• Construction of the proposed rail and road infrastructure, including earthworks, track, bridge and road works
Testing and commissioning	• Testing and commissioning of the rail line and communications and signalling systems
Finishing and rehabilitation	• Demobilisation and decommissioning of construction compounds and other construction infrastructure • Restoration and rehabilitation of disturbed areas

Key construction infrastructure

The following key infrastructure is proposed to support construction of the proposal:

- borrow pits:
  - borrow pit A – Tantitha Road, Narromine
  - borrow pit B – Tomingley Road, Narromine
  - borrow pit C – Euromedah Road, Narromine
  - borrow pit D – Perimeter Road, Narrabri
- three main compounds, which would include a range of facilities to support construction (‘multi-function compounds’), located at:
  - Narromine South
  - Curban
  - Narrabri West
- temporary workforce accommodation for the construction workforce:
  - within the Narromine South multi-function compound
  - Narromine North
  - Gilgandra
  - Baradine
  - within the Narrabri West multi-function compound.

The key construction infrastructure are shown in Figure 1.3.

Other construction infrastructure would include a number of smaller compounds of various sizes located along the proposal site, concrete batching plants, laydown areas, welding yards, a concrete pre-cast facility and groundwater bores for construction water supply.

1.2.4 Operation

The proposal would form part of the rail network managed and maintained by ARTC. Train services would be provided by a variety of operators. Inland Rail as a whole would be operational once all 13 sections are complete, which is estimated to be in 2025.

It is estimated that Inland Rail would be trafficked by an average of 10 trains per day (both directions) in 2025, increasing to about 14 trains per day (both directions) in 2040. This rail traffic would be in addition to the existing rail traffic using other lines that the proposal interacts with.

The trains would be a mix of grain, bulk freight, and other general transport trains. Total annual freight tonnages would be about 10 million tonnes in 2025, increasing to about 17.5 million tonnes in 2040.

Train speeds would vary according to axle loads, and range from 80 to 115 kilometres per hour.

1.3 Purpose and scope of this report

The purpose of this report is to assess the potential terrestrial biodiversity impacts from constructing and operating the proposal. The report:

- addresses the relevant SEARs listed in
- describes the existing environment with respect to terrestrial biodiversity
- assesses the impacts of constructing and operating the proposal on terrestrial biodiversity
- recommends measures to mitigate and manage the impacts identified.

The methodology for the assessment is described in section 3.

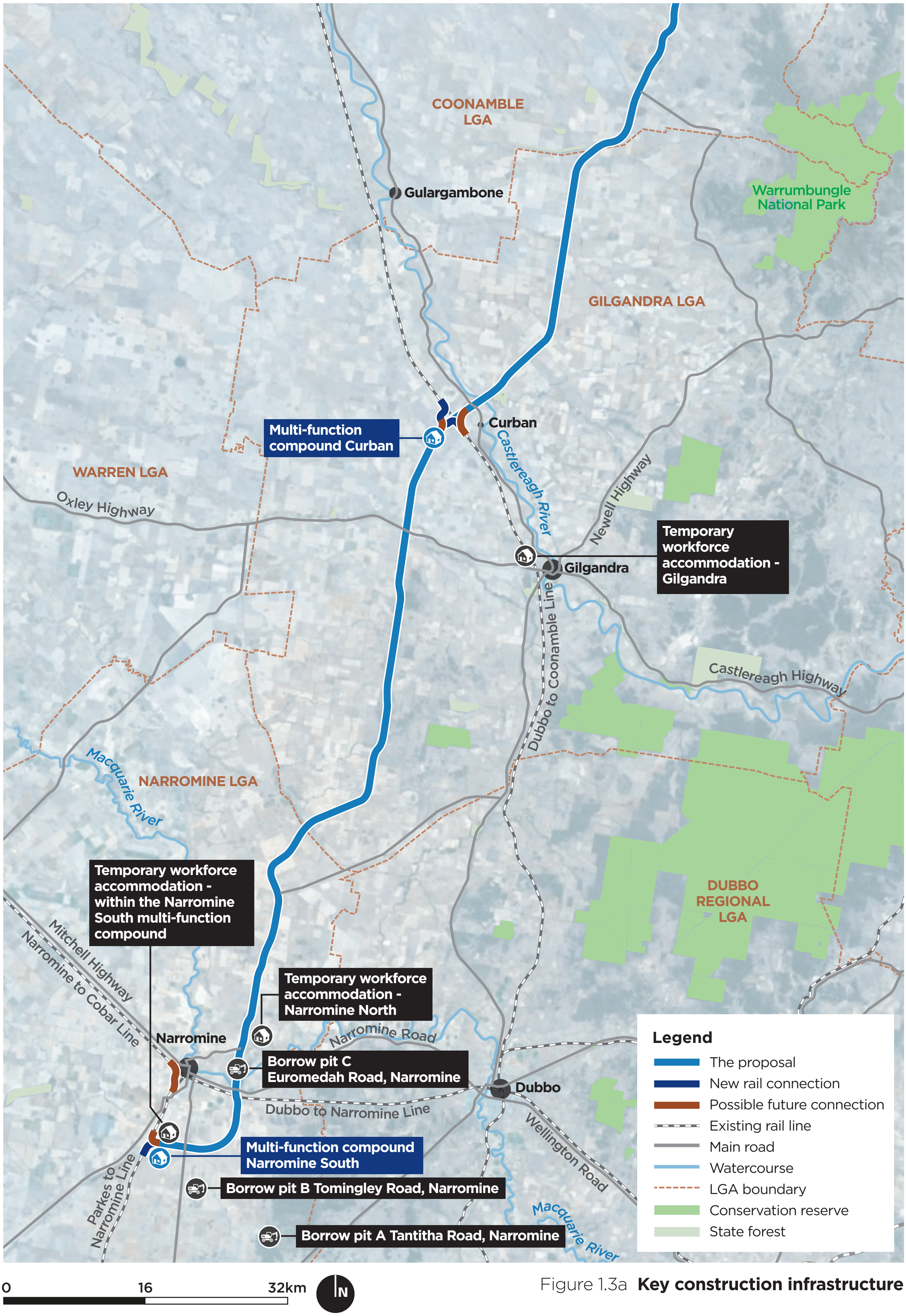

Figure 1.3a **Key construction infrastructure**

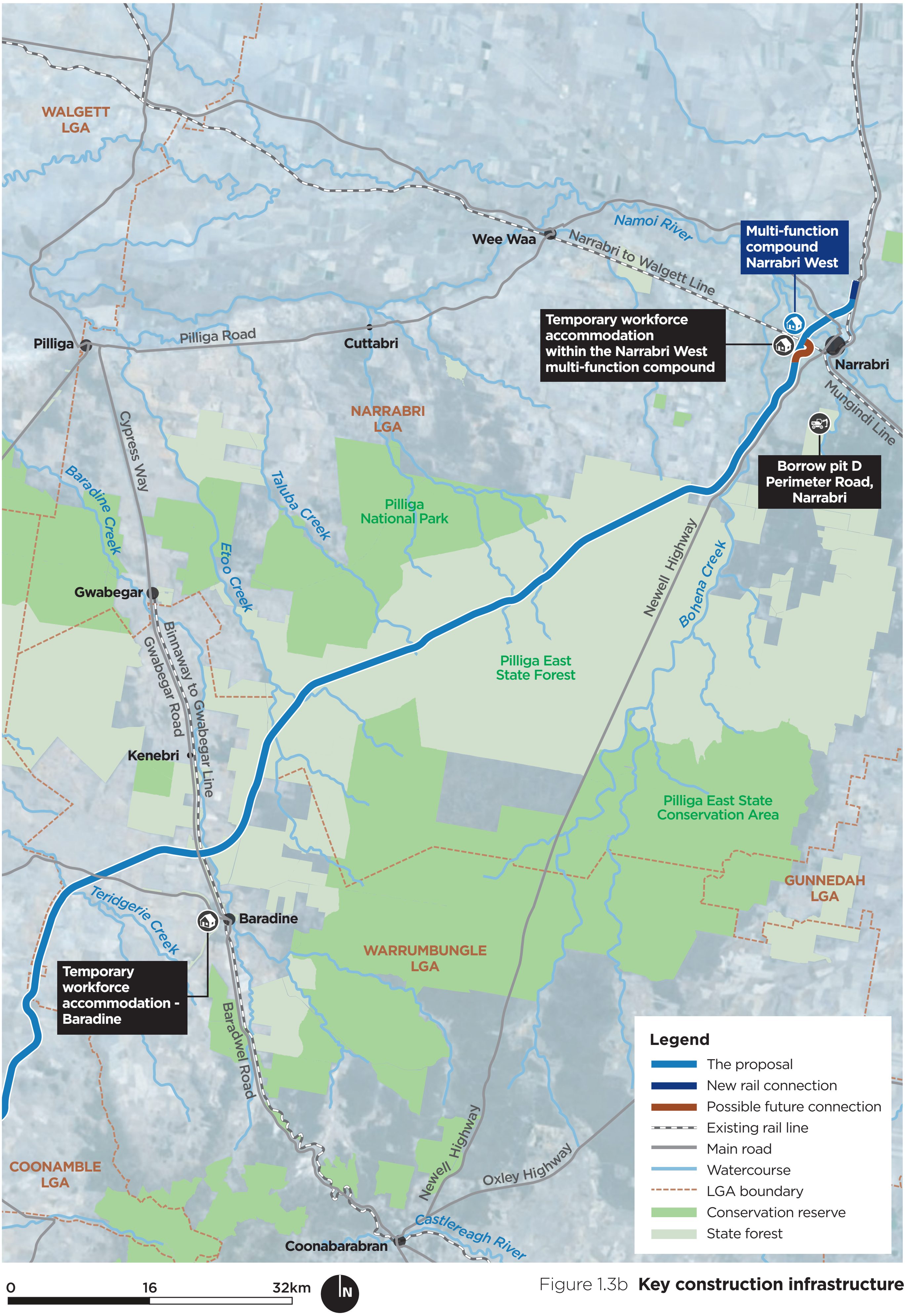

Figure 1.3b **Key construction infrastructure**

This Biodiversity Development Assessment Report (BDAR) addresses the relevant SEARs for the EIS, as outlined in Table 1.2, the requirements of the Department of Planning, Industry and Environment (DPIE) – Biodiversity and Conservation Division (BCD) (formerly NSW Office of Environment and Heritage (OEH)) as outlined in Appendix A, and relevant guidelines and policies.

Table 1.2 SEARs relevant to this assessment

SEAR number	Requirements	Where addressed in this report
5.6	The Proponent must assess biosecurity risks and identify management measures to minimise the spread of pests, diseases or weeds along the rail corridor (including residual lands), in accordance with the 'general biosecurity duty' under the *Biosecurity Act 2015*.	Weed species recorded in the proposal site are identified in section 5.5, vertebrate pests recorded are identified in Appendix F, and diseases with the potential to occur are identified in section 9.3. Recommended management measures are provided in section 11.1. Also refer to Agriculture and land use assessment.
6.1	The Proponent must assess biodiversity impacts in accordance with s7.9 of the *Biodiversity Conservation Act* 2016 (BC Act), the Biodiversity Assessment Method (BAM), and be documented in a Biodiversity Development Assessment Report (BDAR).	This report is the BDAR, prepared in accordance with the BAM as required under s7.9 of the BC Act.
6.2	The BDAR must include information in the form detailed in s6.12 of the BC Act, cl6.8 of the Biodiversity Conservation Regulation 2017 and the BAM.	This BDAR has been prepared in accordance with the BAM. Biodiversity values of the proposal site are described in section 4 (landscape context), section 5 (native vegetation) and section 6 (threatened species). Potential impacts are assessed in section 8.3 (construction), section 8.4 (operation), section 9.1 (serious and irreversible impacts) and section 9.2 (prescribed impacts). Section 8.1 details the measures taken to avoid or minimise impacts. Section 12.1.2 provides the number and type of ecosystem credits required and section 12.1.3 provides the number and type of species credits required to offset the residual impacts of the proposal. Section 12.1.1 details the proposed offset strategy. Section 2 and Appendix A Table A2.
6.3	The BDAR must be submitted with all digital spatial data associated with the survey and assessment as per Appendix 10 of the BAM.	Refer to GIS package.

SEAR number	Requirements	Where addressed in this report
6.4	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 s6.10 of the BC Act.	Table 3.13 provides the details of the accredited assessors who prepared this report.
6.5	The BDAR must include details of the measures proposed to address offset obligations.	Section 12.1.1 provides the measures proposed to address offset obligations.
6.6	The Proponent must assess any impacts on biodiversity values not covered by the BAM. This includes a threatened aquatic species assessment (Part *7A Fisheries Management Act 1994*) to address whether there are likely to be any significant impact on listed threatened species, populations or ecological communities listed under the *Fisheries Management Act 1994* (FM Act).	Refer to Aquatic Ecology Assessment.
6.7	The Proponent must identify whether the project, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the BC Act, FM Act and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).	Section 9.3 provides an assessment of key threatening processes.
7.1	The Proponent must assess the impacts of the project on environmentally sensitive land and processes (and the impact of processes on the project) including, but not limited to:	
	a. Protected areas (including land and water) managed by OEH and/or DPI Fisheries under the *National Parks and Wildlife Act 1974* (NPW Act) and the *Marine Estate Management Act 2014* b. Key Fish Habitat as mapped and defined in accordance with the FM Act	Refer to Aquatic Ecology Assessment and Agriculture and Land Use Assessment.
	c. Waterfront land as defined in the *Water Management Act 2000*	
	d. Land or waters identified as Critical Habitat under the BC Act, FM Act or EPBC Act e. Biobank sites, private conservation lands and other lands identified as offsets.	

The proposal has been declared a controlled action under the EPBC Act due to likely significant impacts to matters of national environmental significance (MNES). The relevant MNES and the corresponding EPBC Act controlling provisions for the proposed action are:

- listed threatened species and communities (sections 18 and 18A).

The Australian Department of Agriculture, Water and the Environment (DAWE) delegate for the Commonwealth Minister for the Environment considers that the proposed action is likely to significantly impact the following listed ecological communities:

- Coolibah - Black Box Woodland of the Darling Riverine Plains and the Brigalow Belt South Bioregions – endangered
- Brigalow (*Acacia harpophylla* dominant and co-dominant) – endangered
- Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (Grey Box Woodlands) – endangered
- Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern QLD – critically endangered
- Weeping Myall Woodlands – endangered
- White Box- Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box Gum Woodland) – critically endangered.

All listed threatened species that may occur in the proposal site are potentially relevant and require further assessment of significance. It is the responsibility of ARTC to ensure any protected matters under this controlling provision are assessed for the Commonwealth decision-maker's consideration.

The amended SEARs issued for the proposal on 9 September 2020 included the EPBC Act requirements (EPBC 2018/8259). The general assessment requirements issued by DAWE are provided in Table 1.3.

Table 1.3 EPBC Act general assessment requirements

SEAR number	Requirements	Where addressed in this report
Attachment A	The EIS must address the matters outlined in Schedule 4 of the EPBC Regulations and the matters outlined below in relation to the controlling provisions.	Section 1 Section 3 Section 8 Section 11
Attachment A 1	For each of the EPBC Act listed species predicted to occur in the project site, and each of the EPBC Act listed ecological communities likely to be significantly impacted, the EIS/BDAR must provide:	
	a. Survey results, including details of the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Commonwealth guidelines and policy statements and/or the NSW Biodiversity Assessment Method (BAM).	Section 3 Appendix I

SEAR number	Requirements	Where addressed in this report
	b. A description and quantification of habitat in the study area (including suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival), with consideration of, and reference to, any relevant Commonwealth guidelines and policy statements including listing advices, conservation advices and recovery plans, threat abatement plans and wildlife conservation plans; and	Section 5 Section 6 Section 7
	a. Maps displaying the above information (specific to each EPBC protected matter) overlaid with the proposed action.	Section 7
	Note - It is acceptable, where possible, to use the mapping and assessment of Plant Community Types (PCTs) and the species surveys prescribed by the BAM as the basis for identifying EPBC Act-listed species and communities. The EIS/BDAR must clearly identify which PCTs are considered to align with habitat for the relevant EPBC Act listed species or community and provided individual maps for each species or community.	Section 7
Attachment A 2	The EIS/BDAR must describe the nature, geographic extent, magnitude, timing and duration of any likely direct, indirect and consequential impacts on any relevant EPBC Act listed species and communities. It must clearly identify the location and quantify the extent of all impact areas to each relevant EPBC Act listed species or community.	Section 8 Section 9 Section 10
Attachment A 3	For each of the EPBC Act listed species and communities that are likely to be impacted by the development, the EIS/BDAR must provide information on proposed avoidance and mitigation measures to deal with the impacts of the action, and a description of the predicted effectiveness and outcomes that the avoidance and mitigation measures will achieve.	Section 8.1 Section 8.1.2 Section 11
Attachment A 4	The EIS/BDAR must identify each EPBC Act listed species and community likely to be significantly impacted by the proposed action. Where a significant impact is likely, the EIS must provide information on the proposed offset strategy, including discussion of the conservation benefit, how offsets will be secured, and timing of protection.	Section 10 Appendix M
Attachment A	Note - A number of offsets options under the NSW Biodiversity Conservation Act 2016 will be acceptable for EPBC Act approval purposes. It is a requirement that offsets directly contribute to the ongoing viability of the specific protected matter impacted by a proposed action ie ‘like for like’. Like-for-like includes protection of native vegetation that is the same EEC or habitat being impacted, or funding to provide a direct benefit to the matter being impacted ie threat abatement, breeding and propagation programs or other relevant conservation measures.	Section 12

1.4 Structure of this report

The structure of the report is outlined below.

- Section 1 – provides an introduction to the report
- Section 2 – describes the legislative context
- Section 3 – describes the methodology for the assessment
- Section 4 – describes the landscape context of the proposal
- Section 5 – describes the native vegetation
- Section 6 – describes the threatened species listed under the BC Act that require assessment
- Section 7 – describes the Matters of National Environmental Significance that occur or may be affected by the proposal
- Section 8 – discusses measures to avoid and minimise impacts and an assessment of construction, operation and cumulative impacts of the proposal on biodiversity values
- Section 9 – discusses serious and irreversible impacts, prescribed impacts and key threatening processes
- Section 10 – described impacts on Matters of National Environmental Significance
- Section 11 – describes the mitigation measures recommended to minimise impacts during construction and operation of the proposal
- Section 12 – describes the offset requirements
- Section 13 – provides a conclusion.

2. Legislation

2.1 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides legal status for biota of conservation significance in NSW. The BC Act aims to, amongst other things, 'maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development'. It provides for the listing of threatened species and communities, establishes a framework to avoid, minimise and offset the impacts of proposed development (the Biodiversity Offsets Scheme), and establishes a scientific method for assessing the likely impacts on biodiversity values and calculating measures to offset those impacts (the Biodiversity Assessment Method, BAM). These are discussed further below.

2.1.1 Biodiversity Offset Scheme and Biodiversity Assessment Methodology

The BC Act, together with the Biodiversity Conservation Regulation 2017, provides a mechanism to address impacts on biodiversity from land clearing associated with development. Under this legislation, there are provisions for a Biodiversity Offsets Scheme (BOS), which includes a framework to avoid, minimise and offset impacts of development on biodiversity.

The aim of the BOS is to provide a transparent, consistent and scientifically based approach to biodiversity assessment and offsetting. It also allows for the establishment of biodiversity stewardship agreements, which are in-perpetuity agreements entered into by landholders, to secure offset sites and generate biodiversity credits, which can be used to offset impacts of development. The aim of the BOS is to ensure that the impacts of development, clearing or biodiversity certification will result in no net loss of biodiversity.

The BAM was established by BCD as a standard method to implement the aims of the BOS and to address the loss of biodiversity and threatened species. The scheme creates a market framework for the conservation of biodiversity values and the offsetting of development impacts. It also provides the mechanisms to offset impacts of development, clearing or biodiversity certification such that there is no loss of biodiversity values.

The BAM sets out how biodiversity values will be assessed, prescribes requirements to avoid and minimise impacts, establishes rules for calculating the number and class of biodiversity credits required for unavoidable impacts, and determines the trading rules that will apply. The methodology includes a software package known as the Biodiversity Assessment Method Calculator (the credit calculator) which processes site survey and assessment data. The credit calculator specifies the type and extent of surveys required for a biodiversity assessment and then processes survey data to calculate the number and type of biodiversity credits that are either required at a development site or will be generated at a stewardship site. The BAM must be applied by a person accredited under the BC Act.

The Biodiversity Conservation Fund (BCF) ensures that landowners have the funds needed to carry out the management actions required each year and provides a financial incentive to landowners to carry out those actions. The scheme is administered by OEH and ensures accountability and compliance through legislation, regular reporting requirements and financial measures. Under certain circumstances a developer may make a payment directly into the BCF to offset the impacts of a proposed development in lieu of purchasing and retiring biodiversity credits. The Biodiversity Conservation Trust (BCT) must then use funds in the BCF to purchase and retire appropriate biodiversity credits.

The BOS and BAM have been addressed in accordance with the SEARs through the preparation of this BDAR by accredited assessors.

2.2 Biosecurity Act 2015

The *Biosecurity Act 2015* provides for risk-based management of biosecurity in NSW. It provides a statutory framework to protect the NSW economy, environment and community from the negative impact of pests, diseases and weeds.

The primary object of the Act is to provide a framework for the prevention, elimination and minimisation of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity matter, carriers or potential carriers.

In NSW, all plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

One priority weed was recorded in the study area. Legal requirements to minimise the potential for the introduction and/or spread of weeds as a result of the proposal are discussed in section 5.5.

2.3 Environment Protection and Biodiversity Conservation Act 1999

The objectives of the EPBC Act include providing for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance (MNES). The EPBC Act provides for the assessment and approval of actions which are likely to cause a significant impact on MNES. Under the EPBC Act, an action includes a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things. An action that ‘has, will have or is likely to have a significant impact on a matter of national environmental significance’ is deemed to be a ‘controlled action’ and may not be undertaken without prior approval from the Australian Minister for the Environment. MNES relevant to this report include threatened species and ecological communities and migratory species.

ARTC referred the proposal to the Australian Minister for the Environment in July 2018. The proposal was determined a controlled action regarding sections 18 and 18A of the EPBC Act (listed threatened species and communities) on 5 November 2018 (EPBC 2018/8259). The general assessment requirements for the proposal are detailed in Table 1.3.

The EPBC Act has been considered in this assessment through:

- desktop review to determine the listed biodiversity matters that are predicted to occur within the locality of the proposal and hence could occur, subject to the habitats present
- targeted field surveys for listed threatened biota and migratory species
- assessment of potential impacts on threatened and migratory biota, including assessments of significance in accordance with the *EPBC Act Significant Impact Guidelines 1.1* (DEE 2013)
- identification of suitable impact mitigation and environmental management measures for threatened and migratory biota, where required
- discussion of biodiversity offsets for impacts on listed biodiversity matters.

2.4 Assessment guidelines and information

This report has been prepared in accordance with the *Biodiversity Assessment Method* (OEH 2017a) and with reference to the following survey guidelines:

- *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Working Draft) (Department of Environment and Conservation 2004)
- *NSW Guide to Surveying Threatened Plants* (Office of Environment & Heritage 2016). Note that 2020 update was published after field surveys had been completed for the project
- '*Species Credit' threatened bats and their habitats. NSW survey guide for the Biodiversity Assessment Method* (OEH 2018)
- *Survey guidelines for Australia's threatened bats* (DEWHA 2010a)
- *Survey guidelines for Australia's threatened birds* (DEWHA 2010b)
- *Survey guidelines for Australia's threatened frogs* (DEWHA 2010c)
- *Survey guidelines for Australia's threatened mammals* (DEWHA 2010d)
- *Survey guidelines for Australia's threatened reptiles* (DEWHA 2010e)
- *Draft survey guidelines for Australia's threatened orchids* (DEWHA 2014).

Proposed threatened flora surveys would be completetd in accordance with the publication released in 2020:

- *Surveying threatened plants and their habitats. NSW survey guide for the Biodiversity Assessment Method* (DPIE 2020).

Other policies and guidelines of relevance include:

- *NSW State Groundwater Dependent Ecosystems Policy* (DLWC 2002)
- *Risk assessment guidelines for groundwater dependent ecosystems* (Serov et al 2012)
- *EPBC Act Condition-setting Policy* (DAWE 2020a)
- *EPBC Act environmental offsets policy* (DSEWPaC 2012).

A full list of references is provided in section 14.

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3. Methods

3.1 Definitions

The following terms are used in this report:

- The 'proposal' refers to the proposed works.
- The 'proposal site' refers to the area that would be directly impacted by the proposal.
- The 'study area' refers to the area that was assessed for direct or indirect impacts that may arise from the proposal, generally located within 50 metres of the proposal site or construction footprint.
- The 'investigation area' refers to wider study area assessed as part of the initial surveys and project narrowing studies. In some areas this was up to five kilometres wide.
- The 'locality' refers to the area within a 10 kilometre radius of the proposal site.

3.2 Desktop assessment

3.2.1 Database review

A desktop database review was undertaken to identify threatened flora and fauna species, populations and ecological communities (threatened biota) listed under the BC Act and EPBC Act, that could be expected to occur in the locality, based on previous records, known distribution ranges, and habitats present. These were also used to obtain the necessary site data to perform BAM calculations.

The threatened biota and migratory species identified in the desktop assessment are presented in Appendix B. Following collation of database records and threatened species and community profiles, a 'likelihood of occurrence' assessment was prepared for threatened biota and migratory species with reference to the broad vegetation types and habitats contained within the study area. This was further refined following field surveys and verification of vegetation types and identification and assessment of habitat present within the study area. A likelihood of occurrence ranking was attributed to these biota based on this information.

Information sources used in the preparation of this report include:

- DPIE – BCD NSW BioNet Atlas database for records of threatened species listed under the BC Act (OEH 2018a)
- Birdata records for threatened bird species for the stage 2 investigation area, provided under licence by Birdlife Australia (2020a)
- BCD Threatened biodiversity profile search online database for threatened ecological communities listed under the BC Act (OEH 2018b)
- Australian Department of Agriculture, Water and Environment (DAWE) Protected Matters Online Search Tool for MNES listed under the EPBC Act and predicted to occur in the locality (DEE 2018a)
- DAWE online Species profiles and threats database (SPRAT) (DEE 2018b)
- NSW BioNet Vegetation Classification (OEH 2018c) to identify matching plant community types (PCTs) in the study area
- Biodiversity Assessment Method Calculator (BAMC) outputs
- Biodiversity assessments prepared for other major projects in the locality.

3.2.2 Background research

Background research was conducted to identify:

- landscape-scale features of the study area in accordance with Section 4.2 of the BAM
- site context of the study area that includes assessing vegetation cover and patch size as required under Subsections 4.3.2 and 5.3.2 of the BAM
- the likely distribution of native vegetation and threatened ecological communities, based on previous mapping and aerial photograph interpretation, for targeted field verification as required under Section 5 of the BAM
- a list of predicted and candidate threatened species and populations of flora and fauna to assess the habitat suitability and threatened biodiversity data collection as required under Section 6 of the BAM (OEH 2017a).

Baseline information was evaluated to determine whether additional surveys, mapping and reporting was required to support proposal approval.

The background research included analysis of the following information sources:

- aerial photographic imagery
- NSW Mitchell Landscapes (DECC 2008a, 2008b)
- Interim Biogeographic Regionalisation of Australia (IBRA version 7.0)
- Atlas of Groundwater Dependent Ecosystems (GDE) (Australian Bureau of Meteorology 2018)
- Directory of Important Wetlands of Australia (DIWA – DOEE 2018a)
- threatened ecological community mapping prepared by Umwelt (2017) as part of the preliminary assessment for this proposal
- broad/regional vegetation types from existing mapping available from the SEED portal.

Research regarding threatened species habitat requirements and local populations included review of the following resources:

- Bionet records (licenced, data accessed in January 2020)
- Birdata records (licenced, data provided in March 2020)
- scientific journal articles and papers
- recovery plans and other agency publications
- local community wildlife group publications (such as birding groups)
- other biodiversity impact assessments for the locality
- soil mapping
- vegetation mapping.

3.3 Consultation with government agencies

3.3.1 Consultation with the BCD of DPIE

ARTC is committed to working with BCD to prepare a BDAR that fulfils regulatory requirements. A staged study approach was designed in consultation with BCD (see section 3.4) and ARTC has continued to seek detailed feedback from the BCD at appropriate times during the preparation of the BDAR to maintain transparency.

ARTC and JacobsGHD has consulted with the BCD throughout the preparation of the BDAR. In particular, this was to gain guidance on how to assess impacts in areas where access to private property was not possible, and how to account for the effect of ongoing drought conditions on the vegetation integrity and the detectability of threatened species. Consultation to agree on the staged approach to the BDAR was a key part of the consultation and included:

- Initial presentation of the proposed survey methodology in 3 December 2018. The outcome of this meeting was a requirement for the development of a staged methodology needed to be developed, with each stage to be approved by the BCD.
- Provision of the Stage 1 methodology to the BCD for approval on 18 October 2018.
- Provision of the Stage 2 methodology to the BCD for approval in March/April 2020.
- Submission of preliminary PCT mapping in September 2019.
- Meeting in Dubbo in October 2019 to discuss survey results, PCT mapping and Category 1/Category 2 land classification mapping.
- Teleconference in February 2020 with a number of BCD's threatened species accountable officers to discuss threatened species survey outcomes and assumptions and justification for species polygons.
- Request for staged approach to credit requirement on 20 March 2020. This request was approved on 29 April 2020.
- Provision of vegetation zone mapping, plot locations and species polygon justifications in April 2020.

The BCD has reviewed the Stage 1 methodology and provided guidance on matters to be addressed during the preparation of the BDAR. The Stage 2 methodology was reviewed by the BCD from April to July 2020. Stage 2 methodolgy review by BCD has been given in principal approval and will be further reviewed during adequacy.

Approach to BDAR

Section 7.14(4) of the BC Act requires the retirement of credits under a condition of approval to be completed before any development is carried out which would impact on biodiversity values. However, if the retirement of biodiversity credits applies to a stage of the development, compliance with the retirement requirement is postponed for that stage of the development, until prior to commencement of that stage. Given its scale and complexity, the proposal is intended to be carried out in stages. The retirement of biodiversity credits for a particular stage will be fulfilled prior to the commencement of construction of that stage which would impact on biodiversity values.

In consultation with the BCD, an approach was identified to mitigate the risk of delays to construction commencement and credit retirement through the preparation of a Segmented Biodiversity Development Assessment Report (Segmented BDAR). For this approach, an overall BDAR in accordance with the BC Act to present cumulative impacts still needs to be prepared, however it is proposed to also include delineation of the impacts into separate segments (ie construction segments or portions) and associated required offsets within the BDAR. This approach of presenting the construction segments in the BDAR will facilitate the orderly procurement and development of offsets within reasonable timeframes. There is a slight difference in the alignment of the segments in the BDAR and construction areas identified in EIS Chapter 8. Note that sequencing of the segments is variable and multiple segments can be delivered concurrently.

This segmented BDAR breaks down the biodiversity impacts and associated required biodiversity offset credit obligations for the proposal into smaller, delineated construction segments/portions (total of 11):

- Three major construction compounds – three segments
  - Segment 1 – Narromine South multi-function compound
  - Segment 2 – Curban multi-function compound
  - Segment 3 – Narrabri West multi-function compound
- Four borrow pits – four segments
  - Segment 4 – borrow pit A
  - Segment 5 – borrow pit B
  - Segment 6 – borrow pit C
  - Segment 7 – borrow pit D
- Alignment – four segments
  - Segment 8 – Narromine to Curban
  - Segment 9 – Curban to Pilliga
  - Segment 10 – Pilliga
  - Segment 11 – Pilliga to Narrabri.

The segmented BDAR contains only one credit calculator and credit assessment report (Appendix K). However, vegetation zone impacts and credit obligations for each segment are presented separately within the BDAR. Credit requirements would be prorated across the relevant vegetation zones for each segment. This includes for both ecosystem credits and species credits. Each segment has a separate set of maps for vegetation zones and species polygon maps.

This allows ARTC to retire credits for each segment at different times in accordance with the Principal Contractor's schedule rather than for the entire proposal at the same time. For example, efforts could be focussed on the compound credits first so that these construction activities can commence, and credits are then subsequently retired for the borrow pits and alignment. This would allow time for the orderly creation and procurement of the required offsets and reduce the risk of retirement of credits impacting construction commencement.

3.3.2 Consultation with DAWE

ARTC and JacobsGHD has also consulted with DAWE regarding the assessment process. As noted earlier, the proposal was referred to the Australian Minister for the Environment and determined to be a controlled action.

In February 2019, DAWE was briefed on the proposed Biodiversity Investigation Plan. On completion of the BDAR, ARTC will meet with DAWE to present the key findings and recommended mitigation and management measures, including offsetting requirements.

3.4 Terrestrial flora surveys

3.4.1 Stage 1 – mapping and identification of Plant Community Types (PCTs)

At commencement of the field program, the area that could be accessed for field surveys in November 2018 was about 30 per cent of the study area. State forest access was not finalised prior to the November 2018 surveys, and thus no vegetation integrity plots were undertaken in the Pilliga or other state forests and conservation areas during the initial 2018 surveys. Surveys were conducted in these areas in later surveys including March 2019 and September/October 2019. Note that initial surveys were conducted in a much wider investigation area (in some locations up to five kilometres across) to assist with constraints assessment and project narrowing.

Where property access was available, allocation of PCTs was conducted as per Section 5.2 of the BAM.

Where access to the study area and investigation corridor was not possible, a methodology was developed in consultation with the BCD to determine how PCTs would be identified in the absence of field data. The agreed stage 1 methodology is as follows:

- Review of previous vegetation mapping - Broad/regional vegetation types from existing mapping available from the SEED portal have been used to guide areas that potentially require plot and targeted surveys. These datasets have been selected based on these being the best current publicly available datasets that cover the investigation area and additional areas beyond the study area. Datasets accessed include:
  - Narromine HCV Vegetation Type
  - Lower Macquarie Existing VIS Map 816
  - Gilgandra80 Wheatbelt VIS Map 1604
  - Namoi CMA VIS 3851.
- In addition, previous ecological community mapping undertaken by Umwelt in 2016 and 2017 during phase 1 of the proposal was used to determine potential ecological communities that may occur. This mapping was based on desktop assessments and rapid inspections from publicly accessible areas.

Application of Category 1 and Category 2 land mapping to support areas where PCT classification would not be required, where Category 1 land is considered exempt land (see section 3.4.1 and Figure 3.1).

- Rapid ground-truthing of regional vegetation mapping - ecologists completed a five day rapid collection of dominant stratum species in September 2018:
  - rapid assessments were conducted on both private and public land along the investigation corridor
  - the three dominant canopy, shrub and groundcover species were recorded at each location
  - any relevant topographical characteristics were noted eg permanent and ephemeral water, slope, rocky outcrops and broad soil types
  - areas of grassland that were not accessible but that were not cropland (determined by viewing over the fence from public roads or from aerial imagery analysis), were classified as derived native grassland.

- Flora survey information contained in BioNet was reviewed to assist with refining potential PCTs prior to commencing rapid plot data collection and after rapid plot data collection. The resulting potential PCT list would include classifications of known, probable, possible and unlikely to occur.
- PCT classification mapping from other nearby projects was reviewed where relevant. This included:
  - projects GHD is currently working on near the proposal (eg other major projects near Narrabri and Gilgandra)
  - completed projects listed on the NSW DPIE major projects website for the Narromine, Gilgandra, Coonamble, Warrumbungle and Narrabri local government areas
  - other unpublished vegetation mapping reports sourced from local councils, NPWS, Forests NSW and other private developments wherever possible.
- Sampling of flora plots in nearby native vegetation:
  - where there was no access to native vegetation on private property but adjacent vegetation on public land was part of the same patch (as defined in the BAM), PCTs were allocated as per the plot completed from the same patch in the publicly accessible land
  - for any other patches of native vegetation on private property where access was not possible a PCT was allocated based on the above regional vegetation mapping and viewing of nearby vegetation from as close as possible to the patch. An explanation for each patch of extrapolated PCT allocation is provided in the PCT justification in stage 2 vegetation zone identification.
- Analysis of soil type, landscape position and landuse maps in conjunction with existing regional vegetation mapping was used to determine potential PCT classification in areas where no access at all was possible. This included use of at least the following:
  - use of the OEH soil types layer from SEED to compare known regional vegetation types/PCTs where access was available to areas with the same soil types
  - review of the NSW Landuse Map (2013) to identify areas of similar historical land use
  - review of above mentioned existing VIS regional vegetation mapping.
- Throughout the PCT classification process, aerial photography and other relevant imagery was reviewed to compare known PCTs in the investigation area from the rapid plot data collection stage with other vegetation patches where PCT classification is unknown.

Non-native vegetation identification

Non-native vegetation was identified using a combination of aerial imagery, field survey verification and the land use categorisiation process (see below). Wherever access was possible, field verification was used to identify areas of non-native vegetation by rapid site walk overs and visual confirmation of cropped/cultivated areas. Where grasslands occurred that were not pasture improved, vegetation integrity plots and site walkovers were used to confirm if each patch was a native grassland.

Where no access was possible, areas were assigned to non-native vegetation (Category 1) according to the land categorisation process outlined below. A conservative approach was adopted and areas that appeared to be mapped incorrectly or where uncertainty over native grasslands arose, were assigned to category 2 and considered to be native vegetation.

Land use categorisation

Land in NSW is categorised into various categories under the *Local Land Services Act 2016* (LLS Act):

- Category 1 (Exempt land) – land that allows native vegetation clearing without approval from Local Land Services.
- Category 2 (Regulated land) – which is any Category 2 land that is not Vulnerable or Sensitive regulated land. Authorisation for native vegetation clearing may be required from Local Land Services.
- Category 2 (Vulnerable regulated land) – is land where clearing of native vegetation may not be permitted under the Land Management (Native Vegetation) Code 2018, and a limited suite of allowable activities apply.
- Category 2 (Sensitive regulated land) – where clearing is not permitted.
- Excluded land – refers to land outside of the land management framework.

Categorisation of land provides certainty to landholders and defines options available for each category for native vegetation management. The impacts from clearing native vegetation and loss of habitat on Category 1 exempt land is excluded from assessment under the BAM, and therefore no biodiversity credit obligation is created.

During proposal discussions, BCD identified that the use of Category 1 land mapping would be a useful way for JacobsGHD to gain certainty around the requirement to apply the BAM where access was not available (ie in areas not mapped as Category 1 land). Given the access constraints of the proposal, JacobsGHD used Category 1 exempt land to locate cleared land that would not require vegetation integrity plot surveys and threatened species surveys in accordance with the BAM (see Figure 3.1).

The BCD provided ARTC and JacobsGHD with specific spatial datasets to assist with the categorisation of land, including:

- 2017 landuse map
- 2017 woody extent map
- Category 2 - sensitive regulated and Category 2 – vulnerable regulated land from the Native Vegetation Regulatory Map.

An initial map layer was generated for further categorisation by overlaying the BCD provided layers. A single GIS layer with attributes that identifies land according to the classifications in Figure 3.1 was produced.

3.4.2 Stage 2 – identifying vegetation zones and a method to meet the minimum plot requirements

Following the Stage 1 PCT allocation, PCTs were further split into vegetation zones in consultation with BCD to ensure the minimum number of plots for each zone was collected and for subsequent entry into the BAM calculator. This method was developed on the basis of the initial collection of plot data and PCT verification conducted in November 2018.

The allocation of vegetation zones included:

- analysis of aerial photography for the alignment and adjacent vegetation that form part of the same patch
- review of GIS output layer from land categorisation process as described in section 3.4.1
- review of NSW Landuse Map (2013) and anecdotal information collected from landholders during field surveys

- review of vegetation integrity plot data collected during field surveys (refer to section 3.6.1)
- review of rapid vegetation survey data collected during field surveys
- justification for use of plots outside the construction impact zone (see Appendix L)
- use of benchmark plots where minimum plot requirements for vegetation zones could not be met due to access restrictions.

The Stage 2 methodology was reviewed by the BCD during April to July 2020. The Stage 2 methodology review by BCD has been given in principal approval and minor revision were made to provide additional clarity following the adequacy review.

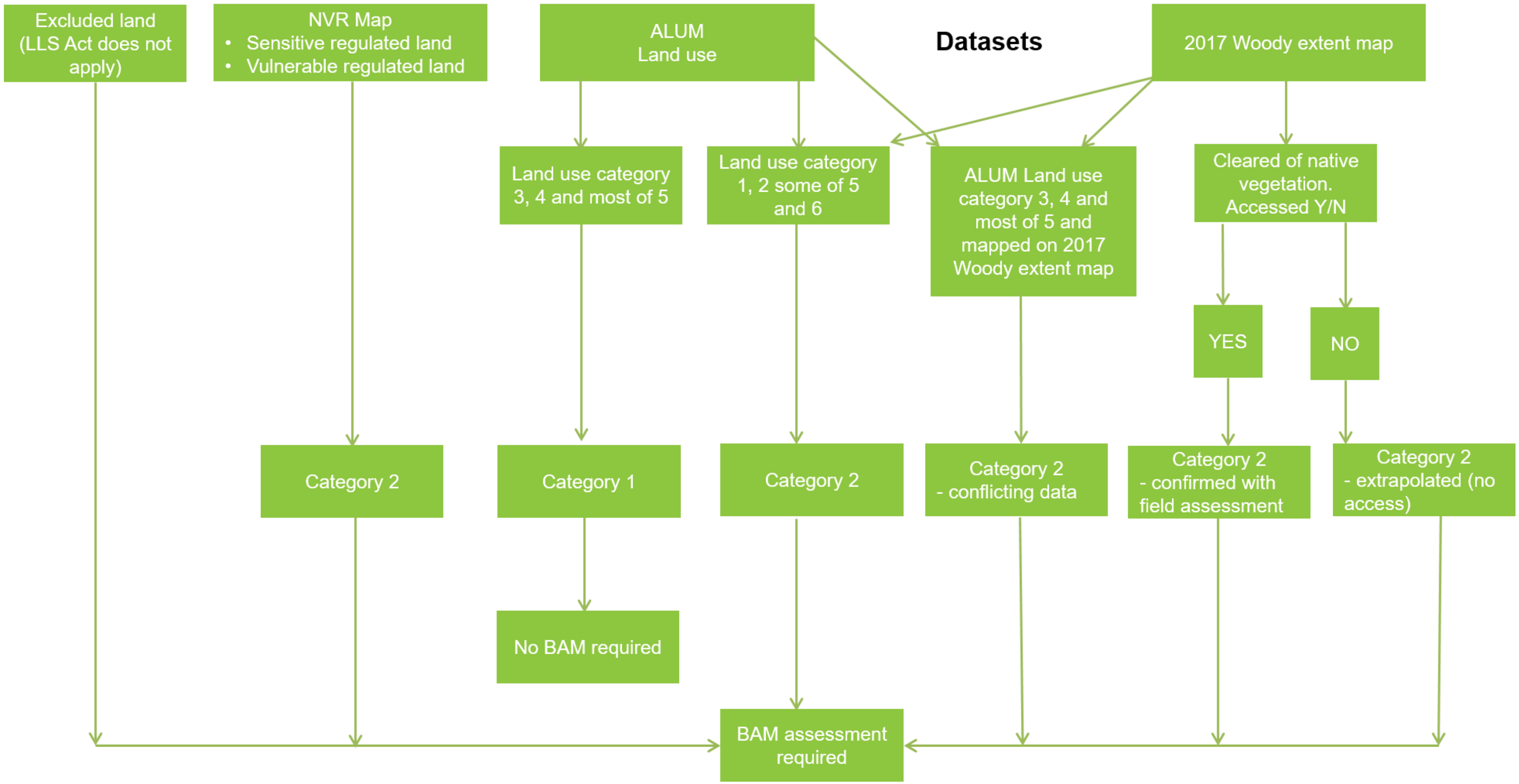


Figure 3.1 Flowchart overview of land categorisation process

3.4.3 Vegetation integrity plots

The site value was determined by assessing ten attributes used to assess function, composition and structure of vegetation within a 50 metre by 20 metre plot. These attributes were then assessed against benchmark values. Benchmarks are quantitative measures of the range of variability in condition in vegetation with relatively little evidence of alteration, disturbance or modification by humans since European settlement (DECC 2009). Attributes assessed within each plot are listed in Table 3.1. All flora species within a 20 metre by 20 metre plot nested within the 50 metre by 20 metre plot were identified according to the nomenclature of the RBGT (2017). Each species identified was allocated a growth form group and designated as either native, exotic or high threat exotic in accordance to the lists provided in the BAM calculator.

Table 3.1 Site data collected within each plot

Attribute	Area assessed
Native plant species richness	20 x 20 metre plot
Percentage foliage cover for each species	20 x 20 metre plot
Estimated number of individuals for each species	20 x 20 metre plot
Number of large trees	50 x 20 metre plot
Tree regeneration (presence/absence)	50 x 20 metre plot
Tree stem size class	50 x 20 metre plot
Total length of fallen logs	50 x 20 metre plot
Litter cover	5 times 1 x 1 metre plot
High threat exotic vegetation cover	50 x 20 metre plot
Hollow bearing trees	50 x 20 metre plot

Plot surveys were conducted in accordance with Section 5.3.3 and Section 5.3.4 the BAM (OEH 2017a) to obtain vegetation integrity data for the calculation of biodiversity credits. BAM plot data sheets are provided in Appendix L.

Wherever possible, within land access restrictions, plots were located to comply with the minimum number of plots required by Table 4 in the BAM (OEH 2017a). Due to refinements of the preferred corridor, borrow pits and ancillary facilities as part of efforts to reduce impacts on native vegetation, some plots used in the BAM calculations are located outside the final proposal site boundary.

Each vegetation zone represents a PCT and its condition. Hence, one PCT can have more than one vegetation zone accounting for the variance in vegetation condition across the PCT.

Each vegetation zone then has a minimum number of plots that are required to be surveyed depending on the area of the vegetation zone (see Table 3.2).

Table 3.2 Minimum number of plot requirements per vegetation zone

Vegetation zone (ha)	Minimum number of plots
<2	1 plot
>2-5	2 plots
>5-20	3 plots
>20-50	4 plots
>50-100	5 plots
>100-250	6 plots

Vegetation zone (ha)	Minimum number of plots
>250-100	7 plots; more plots may be needed if the condition of the vegetation varies across the zone
>1000	8 plots; more plots may be needed if the condition of the vegetation varies across the zone

A total of 160 plots were completed over the four survey periods. Of these, 137 have been used in subsequent credit calculations, while the remaining 23 were not used as they occurred in alternative alignments or potential borrow pit sites that were discarded as part of proposal refinement.

Thirty-nine PCTs were identified during field surveys. A total of 133 plots were required for entry of vegetation zones into the credit calculator. The minimum number of plots required for each vegetation zone and the number surveyed is provided in Table 3.3. In accordance with the BCD approved approach for the proposal (see section 3.3.1), for those zones where the minimum number of plots could not be surveyed due to access restrictions, relevant PCT benchmark data was used to reach the minimum plot number. A total of 24 benchmark plots were used and 137 plots from field surveys. Where previously inaccessible properties are able to be accessed in the future, vegetation zones where benchmark data was used will be targeted for collection of BAM plot data. For those vegetation zones where more plots occurred within the construction footprint than was required, all plots were included in the vegetation zone.

ARTC are proposing to complete additional targeted survey effort in the second half of 2020. The main aim of the surveys will be to gain a better understanding of proposal impacts to threatened flora and to complete vegetation integrity plots outside of drought conditions and in areas previously extrapolated due to access restrictions. These surveys are likely to include:

- vegetation integrity plots and plant community type mapping in previously extrapolated areas (where possible)
- targeted surveys for threatened flora (mostly in the Pilliga) where drought conditions previously limited detection
- vegetation integrity plots in PCTs sverly impacted by drought in previous surveys (ie vegetation integrity scores <17).

Results of these surveys will be included in an addendum biodiversity report following exhibition.

3.4.4 Rapid surveys

Rapid Data Points (RDPs) were collected during random meanders through PCTs. RDPs are essentially summaries of dominant floristic composition and structure taken at random points over a large spatial scale, and are used as a fast and reliable way of describing vegetation patterns. RDPs are not a standard size; they simply document the vegetation within view (approximate 50 metre radius), aiming to describe the vegetation type present at any given point. During field surveys, vegetation boundaries (ecotones) were also marked with waypoints or their boundaries walked. A total of 1,067 RDPs were collected during field surveys. All field data was captured using the ArcGIS Collector application on a standard mobile device.

Table 3.3 Vegetation zones, patch size and minimum plot survey requirements

PCT ID	Vegetation zone	Area impacted (ha)	Patch size category	Minimum plot number required	Plot ID
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion - good	3.05	101	2	T2SP2, 27-BenchA
35	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – good	0.61	101	1	T2P5
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – good	5.08	101	3	T2P30, T1P32, T1P25
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion - derived	176.1	101	6	T1MP38, T2MP24, T2P18, P11, P14, P20, WP1, WP2, WP3
55	Belah woodland on alluvial plain and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions - good	0.21	101	1	WP5
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW - good	19.5	25-100	3	T1P13, T2P21, Singles2, WP5
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion - good	26.23	101	4	T1P8, T2P1, T2P15, T2P14, T1P9
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion - good	276.14	101	7	T1MP4, T1MP24, T1MP13, T2P16, T1P12, T1P11, T1P10, T1P16, T2P25, T1P17, T2P31, T1P22, T1P20
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – degraded understorey	1.65	101	1	T2P34
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion - good	29.47	101	4	T1MP11, T1MP13, T1MP14, T1MP19

PCT ID	Vegetation zone	Area impacted (ha)	Patch size category	Minimum plot number required	Plot ID
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion - good	53.99	101	5	T1SP1, T2SP4, T1SP2, T1BP5, Singles1
148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion - good	45.04	101	4	T2P6, T2P13, 148-BenchA, 148-BenchB
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain - derived	8.56	<5	3	T1-P1, 168-BenchA, 168-BenchB
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland - good	1.37	5-25	1	T2BP3, T2BP3-2
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) - good	3.59	101	2	202-BenchA, 202-BenchB
206	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion - good	12.66	101	3	WP7, WP8, 206-BenchA
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) - good	31.84	25-100	4	T2P19, T2MP25, T2MP26, T2P24
247	Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion - good	6.91	25-100	3	T1P21, 247-BenchA, 247-BenchB
248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW - good	14.71	101	3	T1P24, T2,P37, 248-BenchA
250	Derived tussock grassland of the central western plains and lower slopes of NSW- derived	82.84	101	5	250_BenchA, 250_BenchB, 250_BenchC, 250_BenchD, 250_BenchE
255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion - good	11.77	101	3	T2BP2, T2BP5, T2BP5-2

PCT ID	Vegetation zone	Area impacted (ha)	Patch size category	Minimum plot number required	Plot ID
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion - good	0.27	101	1	T1MP25
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions - good	58.79	101	5	T2MP18, T1MP30, T1MP31, T1MP34, T1MP42, T2P23, T1P14, T1P15
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions - fire derived	10.87	101	3	T1MP22, T1MP23, T2MP8,
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion - good	15.78	101	3	T2MP17, T2MP11, T2MP18, T2MP12, T1MP33, T1MP39
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion - good	361.28	101	7	T1MP6, T1MP3, T1MP7, T1MP9, T1MP10, T2MP2, T2MP1, T2MP5, T1MP20, T2MP14, T2MP20, T1MP35, T1MP36, T2MP15, T2MP19, T1MP40
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion –derived (shrubs removed)	8.5	101	3	T1MP40, T1MP41 (x2)
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion - good	53.71	101	5	T2P11, T2MP3, T1MP17, T1MP21, T1MP29, T1MP32, T2MP16
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests - good	23.05	101	4	T2MP6, T2MP7, T2MP10, 404_BenchA,
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests - good	2.3	101	2	T1MP16, T1MP15

PCT ID	Vegetation zone	Area impacted (ha)	Patch size category	Minimum plot number required	Plot ID
409	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion - good	0.82	101	1	T1MP28
411	Buloke - White Cypress Pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, Brigalow Belt South Bioregion - good	8.76	101	3	411_BenchA, 411_BenchB, 411_BenchC
414	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion - good	7.32	101	3	T1MP26, T1MP27, 414_BenchA
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion - good	6.11	101	3	435_BenchA, 435_BenchB, 435_BenchC
436	Derived Kurrajong grassy open woodland / isolated trees in the Brigalow Belt South and Nandewar bioregions – degraded understorey	5.98	101	3	T2P28, T2P29, T2SP1
444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion - good	1.11	25-100	1	T2P20
473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion - good	15.26	101	3	T2P7, T2P8, T2P9
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion - good	1.23	101	1	T1MP37
599	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions - good	2.21	25-100	2	T2P35, T2P36
619	Derived Wiregrass grassland of the NSW Brigalow Belt South and Nandewar bioregions - derived	326.26	101	7	T2P10, T1P4, T1P6, T2P3, T2P2, T2P22, 619-BenchA

PCT ID	Vegetation zone	Area impacted (ha)	Patch size category	Minimum plot number required	Plot ID
746	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion - good	2.12	101	2	T1BP1, T2BP2
1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion - good	8.77	101	3	T1MP12, 1384_BenchA, 1384_BenchB,
	Total – native vegetation	**1731.82**		133	
-	Non-native vegetation	1584.69	-	-	None required
	TOTAL – construction impact zone	3316.51			

3.4.5 Threatened flora

Potential candidate species credit entities for the proposal site were identified and assessed in accordance with Section 6.3 and steps 1 to 4 of Section 6.4 of the BAM (OEH 2017a). All threatened plants are classified under the BAM as species credit entities as their occurrence cannot be reliably predicted based on vegetation type.

The suite of threatened plants with potential to occur in the study area was identified based on the desktop assessment results and the species credit entities identified by preliminary BAM credit calculations. Habitat for these species was identified and assessed based on OEH threatened species profiles, experience and judgement of JacobsGHD ecologists and through ongoing consultation with BCD accountable officers for each species credit species.

The method for identification of threatened flora species included:

- detailed desktop assessment and habitat assessment
- targeted surveys within accessible portions of the study area, with a particular focus on the Pilliga, where extensive native vegetation and habitats are present
- where no access was possible, targeted surveys within areas in close proximity to the study area (eg nearby road reserves, travelling stock reserves etc)
- assumed presence of species credit species where suitable habitat exists and no surveys have been conducted (with some use of local information to refine the species polygons where possible).

Threatened flora species that may occur in the study area and for which targeted surveys are required given the presence of suitable habitat are detailed in Table 3.4. It also identifies the survey months identified in the BioNet threatened species database (OEH 2018b), species profiles (DEE 2018b) or threatened orchid survey guidelines (DotE 2013).

Targeted threatened flora surveys were completed in conjunction with vegetation integrity plot surveys in the following survey periods:

- September 2018: five days, two ecologists – rapid reconnaissance survey. Threatened flora searches at limited locations due to access limitations and time constraints with regards to private property visits.
- November 2018: 10 days, four botanists – threatened flora searches in accessible properties and public land of the study corridor excluding the Pilliga where survey permission had not yet been granted.
- March 2019: four botanists over 10 days – threatened flora searches in the Pilliga and any limited private properties not previously accessed.
- September 2019: three botanists over 10 days – targeted flora searches in the Pilliga and other suitable habitats on private land where access was permitted.
- June 2020: two botanists over three days – vegetation integrity plots and threatened flora potential habitats on private property not previously accessed.

Surveys for threatened flora species identified in Table 3.4 were conducted on private and publically accessible properties during field surveys. This included surveys within plots and surveys using random meander transects in areas of suitable potential habitat where possible.

Results of targeted surveys for threatened flora species were impacted by the prolonged drought conditions being experienced in the region over the entire survey period (see section 3.6.3). In addition, access to all potential habitat areas for targeted threatened flora surveys was restricted due to a lack of access agreements with private landholders (see section 3.6.3).

Due to increased rainfall in the Narrabri region and favourable growing conditions in March/April 2020, additional targeted flora survey were planned gain a better understanding the potential habitat of the following species:

- Winged Peppercress (*Lepidium monoplocoides*)
- Spiny Peppercress (*Lepidium aschersonii*)
- *Commersonia procumbens*
- *Tylophora linearis*.

However, planned surveys were cancelled in late March 2020 due to the global coronavirus (Covid-19) pandemic. Immediately prior to the proposed surveys the NSW government released the *Public Health (COVID-19 Restrictions on Gathering and Movement) Order 2020* which restricted non-essential travel (and in particular travel to regional areas) and put limits on gatherings.

As a result of the limitations regarding access, prolonged drought and Covid-19 travel restrictions, these and other species are assumed present in the proposal site (see section 6.1).

Additional targeted seasonal surveys are proposed to be undertaken in Spring 2020, to gain a better understanding of impacts to biodiversity within the construction impact zone and to assist in further refining the extrapolation of plant community types due to survey limitations documented in this report. Additional surveys are likely to include vegetation integrity plots in previously extrapolated areas and targeted species credit surveys for:

- *Commersonia procumbens*
- *Tylophora linearis*
- *Lepidium monoplocoides*
- *Pterostylis cobarensis*
- *Lepidium aschersonii*
- *Diuris tricolor*
- *Bertya opponens*

The results of these findings would be documented in an addendum biodiversity report following public exhibition.

Table 3.4 Candidate threatened flora species and survey season

Scientific name and Common name	Status BC Act	EPBC Act	Species credit	Survey timing
Bertya opponens Narrow-leaved Bertya	E	E	Count	No months identified
Commersonia procumbens	V	V	Area	Aug-May
Diuris tricolor Pine Donkey Orchid	V		Area	Sep-Oct
Lepidium aschersonii Spiny Peppercress	V	V	Area	Nov-Apr
Lepidium monoplocoides Winged Peppercress	E	E	Area	Nov-Feb
Pterostylis cobarensis Greenhood Orchid	V	-	Area	Sep-Nov

Scientific name and Common name	Status BC Act	EPBC Act	Species credit	Survey timing
Swainsona murrayana Slender Darling Pea	V	V	Area	Sep
Tylophora linearis	V	E	Area	Oct-May

Key: CE – critically endangered species; E – Endangered species; V- vulnerable species

3.4.6 Groundwater dependent ecosystems

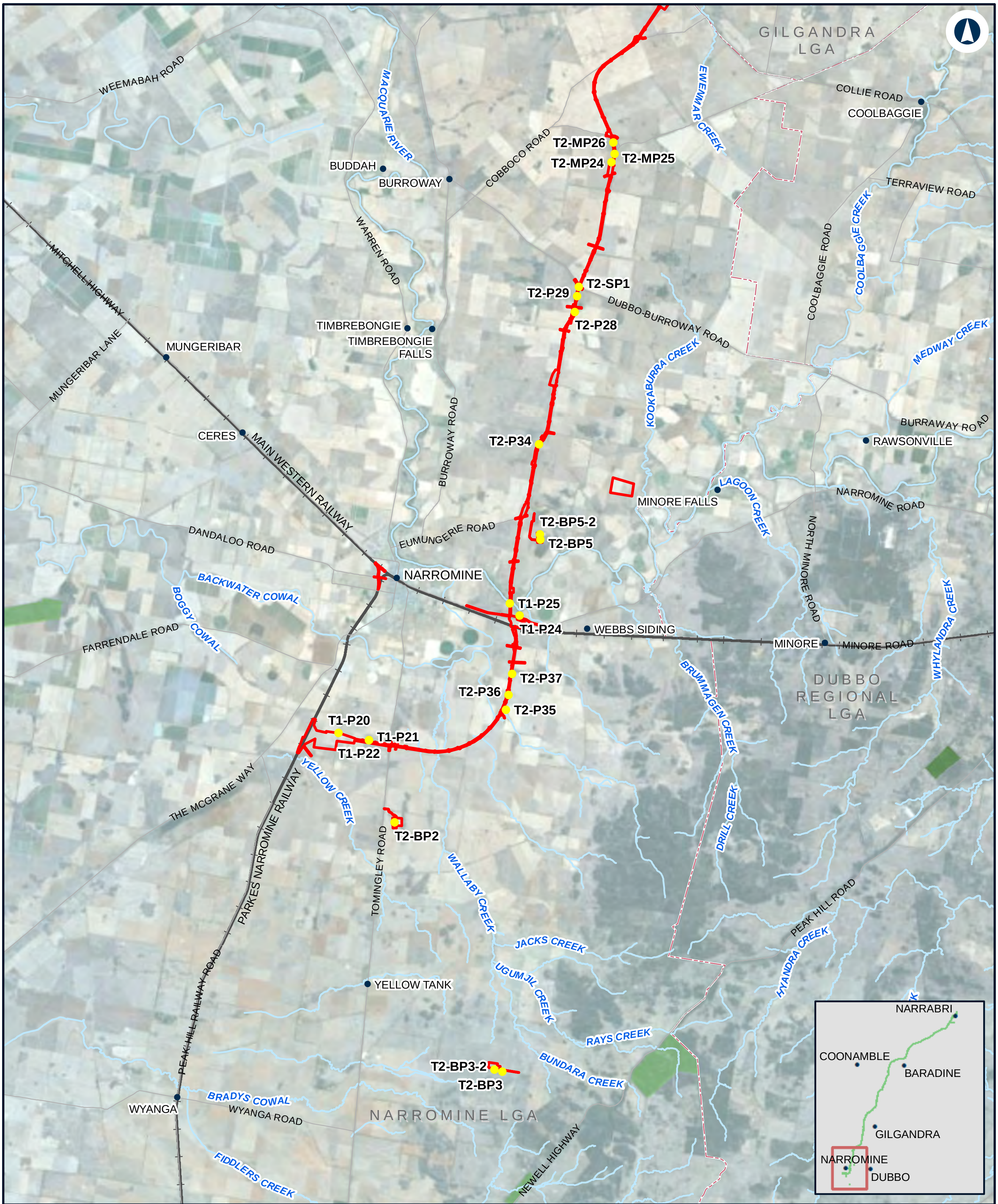
The *NSW State Groundwater Dependent Ecosystems Policy* defines groundwater dependent ecosystems (GDEs) as ecosystems which have their species composition, and their natural ecological processes determined by groundwater (DLWC 2002). The Policy defines groundwater as the water beneath the earth's surface that has filtered down to the zone where the earth or rocks are fully saturated (DLWC 2002). Ecosystems vary dramatically in the degree of dependency on groundwater, from having no apparent dependence through to being entirely dependent on it (DLWC 2002). Seven broad GDEs are identified in the NSW Office of Water risk assessment guidelines (Serov et al 2012), including three types of subsurface ecosystems and four types of above-ground ecosystems. Groundwater dependency can be inferred for many parts of the landscape as there is a strong association between floristic composition, topography and groundwater (Kuginis 2012).

A number of GDEs, particularly above-ground ecosystems, are likely to occur in the proposal site or near the proposal site. Surface activities can have an impact on groundwater quality, levels and pressure. These, in turn, can impact surface environments down slope/stream, ie in the discharge areas. Construction of the proposal may therefore impact GDEs to various degrees.

Due to its length, the proposal covers numerous water sharing plans (WSPs) and groundwater sources. To determine WSPs/groundwater sources applicable to the proposal, the WSPs/groundwater sources were visualised using the NSW Government SEED Web Map Service, viewed within geographical information system software. For the majority of the proposal the upper most WSP is the NSW Great Artesian Basin Groundwater Sources 2020 and the groundwater source is the Southern Recharge Groundwater Source. Further information on WSPs can be found in the *ARTC Inland Rail Narromine to Narrabri Groundwater Assessment* (JacobsGHD 2020b).

The Australian Government *Atlas of Groundwater Dependent Ecosystems* (BOM 2019) was used to identify any previously mapped GDEs that occur in or near the study area. This atlas identifies GDEs reliant on surface groundwater (rivers, springs and wetlands) and subsurface groundwater (vegetation). The Atlas was reviewed to ascertain whether any GDEs are likely to occur in the study area.

The risk assessment guidelines were also used to identify the likelihood of impacts on GDEs (such as through changes to water quality and biological integrity) and the possible magnitude of impacts (Serov et al 2012).



NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2a

0 3.5 7 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 14/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:248,130
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Vegetation plot

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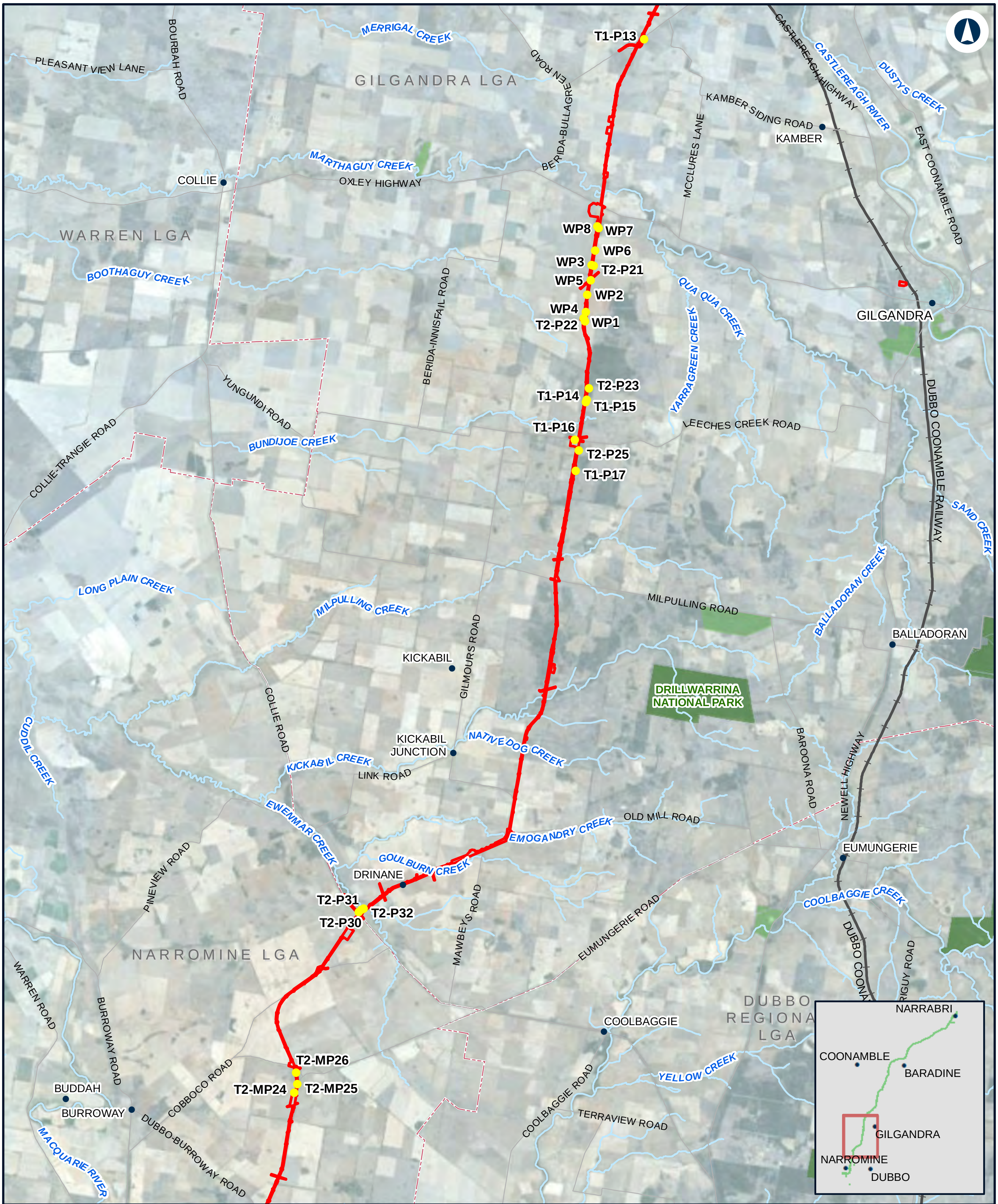

NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2b

0 3.5 7 Km

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NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2c

0 3.5 7 Km

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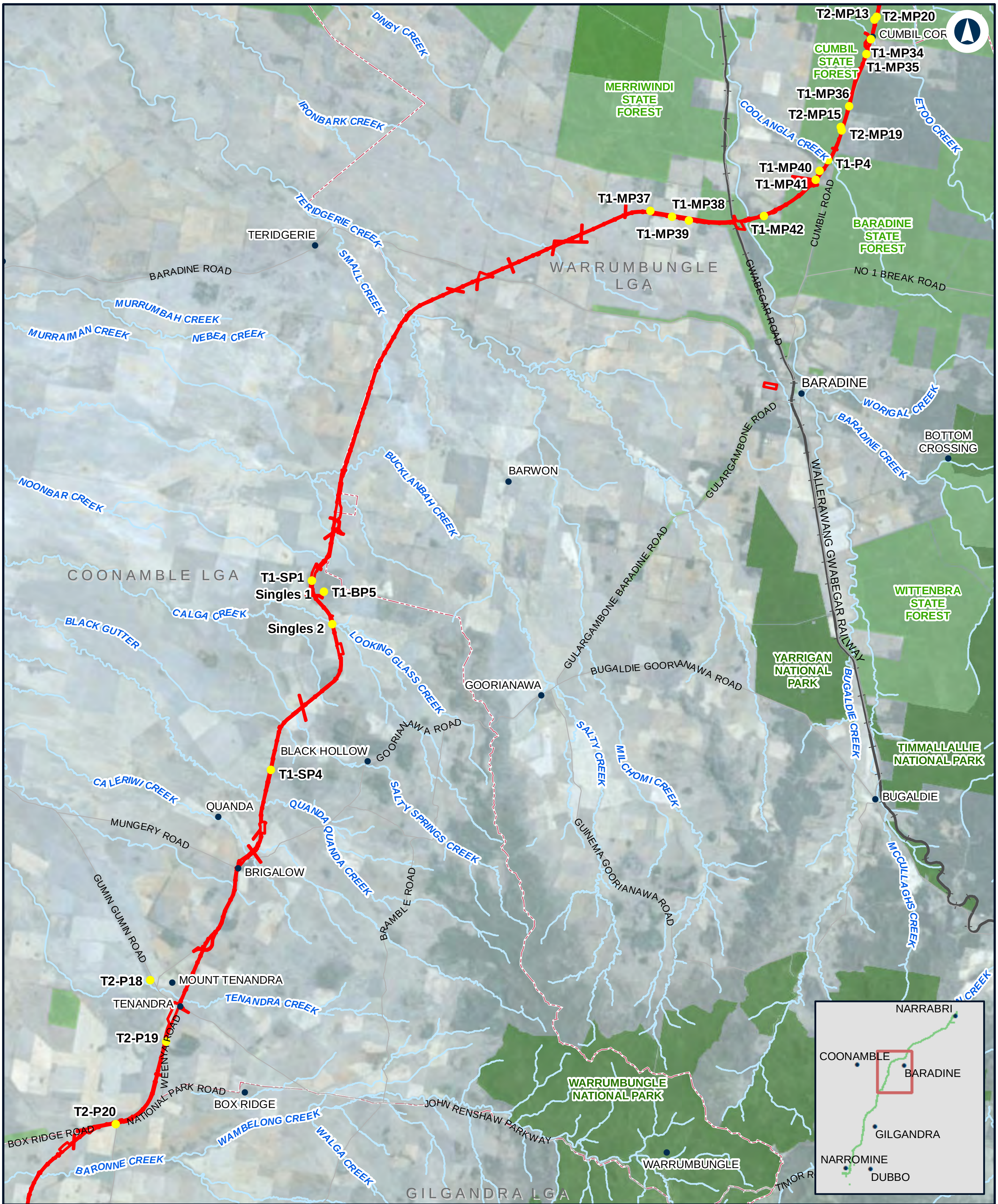

NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2d

0 3.5 7
Km

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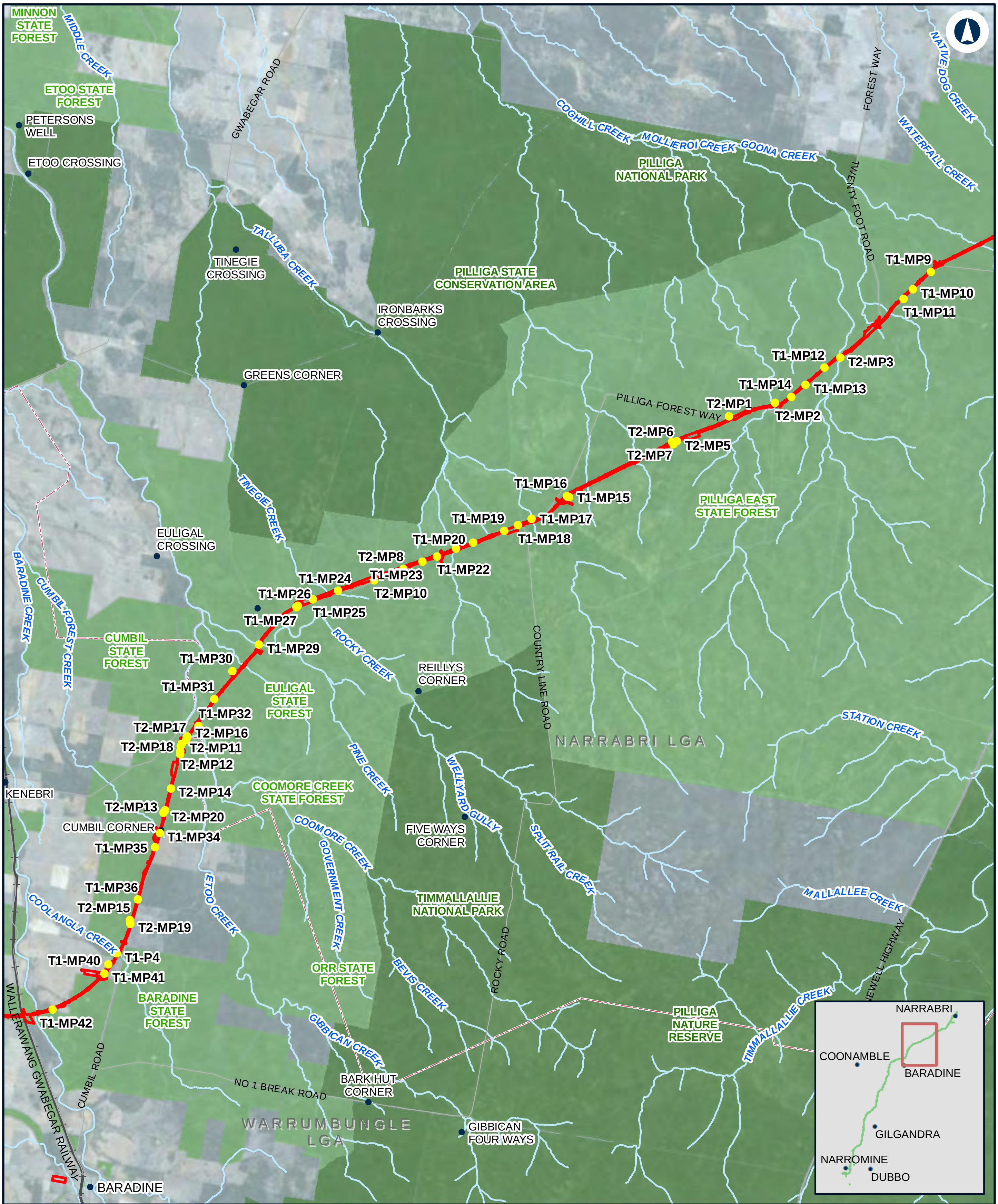

NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2e

0 3.5 7 Km

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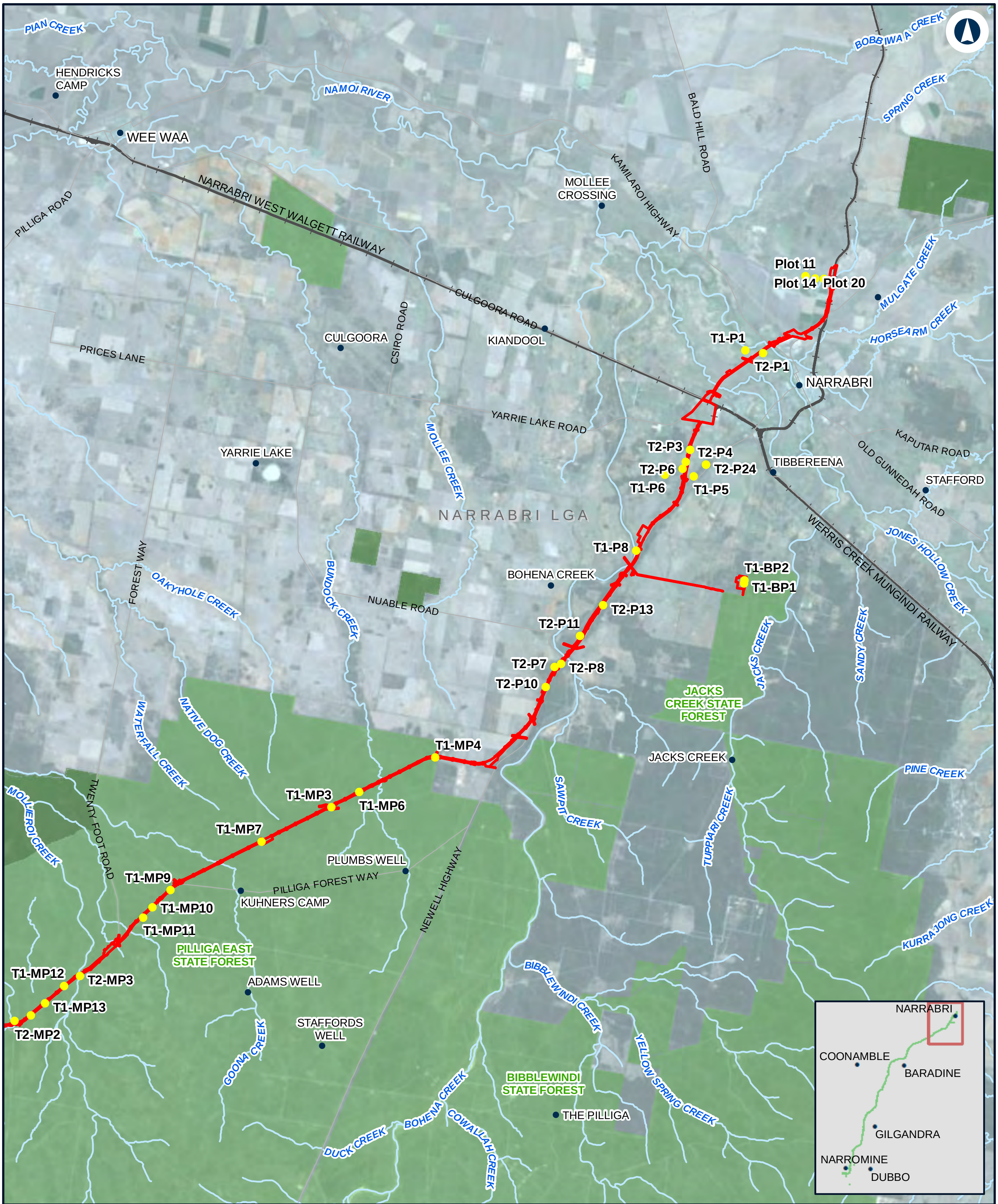

NARROMINE TO NARRABRI Vegetation integrity plot locations

Figure 3.2f

0 3.5 7 Km

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3.5 Terrestrial fauna surveys

3.5.1 Overview

The BAM identifies two classes of threatened fauna species:

- predicted, or ecosystem credit species that can be reliably predicted to occur within the subject site based on the site location, PCT(s) present, patch size and other habitat criteria specified in the BAM and the threatened species data administered by OEH
- species credit entities, comprising threatened fauna species or specific habitat resources such as occupied breeding habitat that cannot be reliably predicted.

Under the BAM, targeted surveys are not required for ecosystem credit species. These species are assumed to be present within certain PCTs, given a certain patch size and condition.

Targeted surveys are required for 'candidate threatened species', comprising those species credit entities that could occur at a proposal site based on known species distributions and the habitat resources present. Section 6.4 of the BAM notes that a candidate species credit species will be considered unlikely to occur on the subject land if after carrying out a field assessment of the habitat constraints or microhabitats on the subject land, the assessor determines that the habitat is substantially degraded such that the species is unlikely to utilise the subject land (or specific vegetation zones).

Staged surveys of the investigation area were conducted between September 2018 and October 2019 to inform the BDAR, and focussed on potential candidate threatened species listed under the BC Act and threatened and migratory species listed under the EPBC Act. These surveys are detailed below and in summary included:

- rapid assessments along accessible portions of the alignment, focussing on habitat assessments and identification of suitable habitat for threatened species of relevance, as well as conducting general fauna surveys (September 2018)
- targeted fauna surveys in some accessible portions of the alignment, particularly focusing on habitat assessments and nocturnal surveys for threatened species of relevance (November 2018)
- detailed fauna surveys, including trapping for threatened species of relevance, particularly focusing on the Pilliga area, and other vegetated areas (March 2019)
- winter surveys along the alignment, including owl surveys (August 2019)
- spring surveys, focussing on borrow pits and areas between Gilgandra and Baradine previously not surveyed, as well as surveys in the Pilliga (September/October 2019).

Fauna survey sites are mapped on Figure 3.3.

3.5.2 Fauna habitat assessment

Literature review

A literature review was conducted for the threatened species of concern (such as species credit species and species listed under the EPBC Act) to identify specific PCTs or microhabitats that are important for these species. This included a review of relevant reports and articles, OEH records, soil maps, vegetation mapping and spatial datasets (such as the Areas of Regional Koala Significance OEH 2019). This was used to refine survey locations as well as to assist with mapping species polygons.

Habitat assessment in the field

Fauna habitat assessments were undertaken in accessible portions of the proposal site, focussing on areas of suitable habitat for threatened species. This included active searches for potential shelter, basking, roosting, nesting and/or foraging sites. Specific habitat features and resources such as water bodies, food trees, the density of understorey vegetation, the composition of ground cover, the soil type, presence of hollow-bearing trees, leaf litter and ground debris were noted.

Habitat assessments included identification and assessment of:

- vegetation patch size, connectivity, age, disturbance and floristic and structural diversity as described in the vegetation integrity plots (important for determining habitat suitability for many threatened birds and mammals)
- presence of winter-flowering eucalypts (important for the Swift Parrot (*Lathamus discolor*), Squirrel Glider (*Petaurus norfolcensis*), Grey-headed Flying-fox (*Pteropus poliocephalus*) and Regent Honeyeater (*Anthochaera phrygia*)
- presence of specific food trees of the Koala (*Phascolarctos cinereus*) as identified in the Koala SEPP 2019 and OEH (2018b) (see Appendix I for a list of relevant species)
- presence of *Allocasuarina* species which is the sole foraging resource for the Glossy Black-cockatoo (*Calyptorhynchus lathami*)
- hollow-bearing trees and logs which provide refuge, nest and den sites for a range of threatened fauna species
- stags and other roost sites for raptors and owls
- rocky outcrops, caves, crevices and overhangs
- wetlands, water courses and moist grassland and other foraging or breeding habitat for waterbirds (including migratory birds), frogs, reptiles and mammals.

Evidence of animal presence was noted during the time spent on site, including specific searches for:

- mammal scats at the base of trees or along tracks and runways
- tracks in soft substrate
- nest/den sites within logs, tree bases or tree trunks
- guano or moth remains at the base of hollow-bearing trees (diagnostic of the presence of tree-roosting bats)
- scratches on tree trunks (potential evidence of Koalas, gliders or goannas) and worn bark around tree hollows (diagnostic of active use of hollows)
- owl pellets, whitewash or animal remains beneath trees (diagnostic of owl or raptor roosts).

Locations of important habitat features were captured with a global positioning system (GPS) unit.

3.5.3 Detailed surveys

Detailed fauna surveys focused on identifying habitat for species credit species identified by the BAM and threatened fauna listed under the EPBC Act. Surveys were conducted in:

- September 2018
- November 2018
- March 2019
- August 2019
- September 2019
- October 2019
- June 2020.

Where possible, surveys were conducted in the survey season identified by BCD, however access constraints meant that not all locations along the alignment could be surveyed in detail for all target species. The habitat assessment was used to identify target areas for the detailed surveys. Further discussion of survey limitations is provided in section 3.6.3. Survey methods are described below. Survey types and locations are mapped on Figure 3.3, and summarised in Table 3.5. Further details on targeted surveys for species credit species and EPBC Act listed threatened species are provided in the species profiles (Appendix I).

Additional targeted seasonal surveys are proposed to be undertaken in Spring 2020, to gain a better understanding of impacts to biodiversity within the construction impact zone and to assist in further refining the extrapolation of species polygons due to survey limitations documented in this report. The results of these findings would be documented in an addendum biodiversity report and included in an addendum biodiversity report following public exhibition.

General fauna surveys

Habitat area searches targeting all fauna species were performed at various locations and times of the day throughout the study area, depending on access constraints and timing of property visits (see section 3.6). Species were identified by sight and call. Incidental observations of species were also recorded throughout the day during general surveys.

Active searches

Ground debris searches were undertaken at various sites across the study area (see Figure 3.3). These included active searches for reptiles (turning logs, fallen branches and bark, rocks and scraping leaf litter), opportunistic observation of scats, tracks, burrows or other traces, searches for chewed *Allocasuarina* cones (signs of foraging by Glossy Black-cockatoos), and searches for owl pellets and feathers. Dedicated active searches were undertaken at 28 sites across the investigation area, with surveys lasting at least 30 minutes each (0.5 person hours). Incidental searches of shorter time periods were also undertaken while undertaking other surveys.

Table 3.5 Summary of survey methods, locations and timing

Survey method	Fauna groups	Species targeted	Survey locations	Survey timing
Diurnal surveys				
Habitat assessment	All	Incidental fauna	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov
Diurnal bird surveys	Birds	Birds, incidental fauna	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov, Jun
Active searches	Reptiles	Five-clawed Worm-skink	Narrabri area	Nov, Sep
		All reptiles	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov
	Mammals	Koala (scats)	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov
	Birds	Glossy Black-cockatoo (chewed cones), Owls (pellets, feathers etc)	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov
Scat searches	Mammals	Koala	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov
Nocturnal surveys				
Spotlighting	Mammals	Koala, Squirrel Glider	Various locations along the entire alignment during each survey month	Mar, Aug, Sep, Oct, Nov
	Birds	Owls, Bush Stone-curlew	Focus on Pilliga area	Mar, Aug, Sep, Oct
	Birds	Owls, Bush Stone-curlew	Various locations along the entire alignment during each survey month	Mar, Aug, Oct, Nov, Jun
	Reptiles	Pale-headed Snake	Focus on Pilliga area	Mar
	Reptiles	Pale-headed Snake	Narrabri area	Mar, Nov

Survey method	Fauna groups	Species targeted	Survey locations	Survey timing
	Mammals	Koala, Squirrel Glider, Eastern Pygmy-possum, Black-striped Wallaby, Rufous Bettong	Focus on Pilliga area	Mar, Aug, Oct
Anabat	Bats		Focus on Pilliga area	Mar
	Bats		Various locations along the entire alignment during each survey month	Mar, Sep, Nov
Call playback	Birds	Owls, Bush Stone-curlew	Focus on Pilliga area	Mar, Aug, Sep, Oct
	Birds	Owls, Bush Stone-curlew	Various locations along the entire alignment during each survey month	Mar, Aug, Oct, Nov, Jun
	Mammals	Koala	Focus on Pilliga area	Mar, Aug, Oct
Frog call recording (FrogID)	Frogs		Various locations along the entire alignment during each survey month	Aug, Nov
	Frogs		Focus on Pilliga area	Mar, Sep
Trapping				
Harp nets	Bats		Narrabri, Curban, Burroway	Nov
Harp nets	Bats		Pilliga, Gilgandra	Mar
Elliott - arboreal	Mammals	Squirrel Glider	Focus on Pilliga area	Mar
Elliott - terrestrial	Mammals	Pilliga Mouse, Eastern Pygmy-possum	Focus on Pilliga area	Mar
Pitfalls	Reptiles, mammals	Pilliga Mouse, Eastern Pygmy-possum	Focus on Pilliga area	Mar
Pitfalls	Reptiles, mammals		Gilgandra, Narrabri	Mar
Funnels	Reptiles	Pale-headed Snake	Pilliga, Narrabri	Mar
Funnels	Reptiles	Pale-headed Snake	Gilgandra, Narrabri	Mar

Survey method	Fauna groups	Species targeted	Survey locations	Survey timing
Remote surveys				
Camera (universal bait)	Mammals	Black-striped Wallaby, Rufous Bettong	Focus on Pilliga area	Mar
Camera (universal bait)	Mammals	Black-striped Wallaby, Rufous Bettong	Narrabri	Nov
Camera (universal bait)	Mammals, birds		Gilgandra, Narrabri	Nov, Mar
Camera (meat and molasses)	Mammals	Spotted-tailed Quoll, Black-striped Wallaby, Rufous Bettong	Focus on Pilliga area	Sep
Camera (water source)	Mammals, birds		Focus on Pilliga area	Mar, Sep

Koala searches

Targeted Koala scat searches (see Figure 3.3) were conducted with reference to the SPOT assessment method in areas identified as preferred habitat for the species, such as Red Gum woodland along creek lines. This comprised searching leaf litter at the base of 30 trees in areas of potential Koala habitat at twenty locations across the study area. Two minutes of searching was conducted per tree unless a scat was found prior to this time.

Scat searches were also done in conjunction with active searches discussed above (see Figure 3.3), targeting leaf litter under potential food trees. Searches were conducted for between half an hour to an hour in woodland patches, depending on the size of the patch and access limitations.

Trees along creek lines were scanned during diurnal surveys for Koalas. A parallel transect survey was conducted by four zoologists at Etoo Creek (near the Aloes picnic area in the Pilliga), which had been identified as a key site for observing Koalas in the ‘Bird routes of the Pilliga’ brochure (Johnston, undated). Numerous records of Koalas are mapped along this creek in EES (2019a). This survey involved four zoologists walking abreast in riparian vegetation from the Aloes picnic area to the eastern end of the alignment study area on Etoo Creek, and returning on the opposite bank. About four kilometres of linear habitat was covered by this survey. Searches for scats were conducted under Blakely’s Red Gums, Pilliga Box, and other eucalypts during the transect survey.

Possible Koala scats collected during surveys were sent to Georgeanna Story of ‘Scats About’ for verification.

Spotlighting and call playback was also used to target the Koala (see below).

Bird surveys

Dedicated bird surveys were conducted at 34 locations across the study area in all months of surveys. Where possible, targeted surveys were undertaken in the early morning or late afternoon when activity was likely to be highest. Bird surveys were also conducted in the middle of the day if private property access was arranged for that time, or if particularly habitats were visited at that time of day. Birds were identified by sight and call. Surveys generally consisted of area searches of 30 minutes to one hour by two ecologists, depending on patch size and habitat values present. Area searches were generally conducted over two hectares in woodland patches, or along transects in road reserves or creeklines. Birds were also surveyed for as part of general fauna surveys (85 locations), observed incidentally during all surveys, and while driving between sites. This latter method is particularly suitable for raptors and rarer species.

Nest tree surveys

Vegetation and paddock trees were scanned during all surveys for large raptor nests. This included scanning of vegetation while driving along the alignment to and from sites and accommodation and targeted searches in riparian areas. Land-owners also identified raptor nests on their land in some instances.

Large hollow-bearing trees along creek lines and rivers in the study area were searched for signs of occupation by owls and cockatoos, particularly white-wash, feathers, and owl pellets. Call playback (outside the main nesting period) and spotlighting (discussed in more detail below) were also conducted at these locations.

Forestry Corp provided the GPS locations for three Barking Owl nest trees near the alignment in the Pilliga (Baradine Creek, Etoo Creek and Rocky Creek). Hollow-bearing trees in these areas were surveyed during the day, with searches for signs of occupation (owl pellets, whitewash etc), and followed up with nocturnal spotlighting and call playback.

Microbat surveys

Microbat ultrasonic echolocation call recordings (Anabat surveys) were undertaken in September and November 2018 and March 2019 using either Anabat express units or Anabat zcaim units. In most locations, Anabat units were left to record for multiple nights. In some instances, access or timing constraints meant that Anabat units were left at a location for only one night or evening (see section 3.6.3 for more discussion on survey limitations). In spring 2018, nine sites were surveyed for 19 nights, and in autumn 2019, three sites in the Pilliga were surveyed for 12 survey nights (see Table 3.6). Sites included possible flyways along creeklines, dams and near rivers.

Table 3.6 Anabat survey effort

Timing	General location	Site	Habitat	Effort (detector nights)
September 2018	Narromine	Travelling Stock Reserve	River	1 night
November 2018	Narrabri	Narrabri Creek	River	1 night
	Narrabri	Private property	Dam	1 night
	Bohena	Bohena Creek (north)	Dry creek (narrow)	3 nights
	Bohena	Bohena Creek (south)	Dry creek (wide)	1 night
	Curban	Castlereagh River	River (dry)	7 nights
	Kickabil	Leeches Creek Road	Dam	1 night
	Kickabil	Kickabil Creek	Dry creek (narrow)	1 night
	Burroway	Ewenmar Creek	Dry creek (narrow)	3 nights
	Narromine	Travelling Stock Reserve	River	1 night
March 2019	Pilliga	Woodland	Clearing	4 nights
	Pilliga	Rocky Creek	Dry creek (narrow)	4 nights
	Pilliga	Coolangala Creek	Dry creek (wide)	4 nights

Calls were identified using zero-crossing analysis and AnalookW software (version 4.1t, Chris Corben 2015) by visually comparing the time-frequency graph and call characteristics (eg characteristic frequency and call shape) with reference calls and/or species call descriptions from published guidelines. The *bat calls of NSW: Region based guide to the echolocation calls of microchiropteran bats* (Pennay et al 2004) was used to assist call analysis. Call identification was also assisted by consulting distribution information for possible species (Pennay et al 2011; Churchill 2008; van Dyck and Strahan 2008) and records from the Atlas of NSW Wildlife (OEH 2015a). No reference calls were collected during the survey.

A call (pass) was defined as a sequence of four or more consecutive pulses of similar frequency. Calls with less than four defined pulses were excluded from the analysis. Due to variability in the quality of calls and the difficulty in distinguishing some species, the identification of each call was assigned a confidence rating (see Mills et al 1996 and Duffy et al 2000) as summarised in Table 3.7. Due to the absence of reference calls from the study area, high level of variability within a bat call and overlap in call characteristics between some species, a conservative approach was taken when analysing calls.

Table 3.7 Confidence ratings applied to bat calls

Species Identification	Description
D - Definite	Species identification not in doubt.
P - Probable	Call most likely to represent a particular species, but there exists a low probability of confusion with species of similar call type or call lacks sufficient detail.
Po – Possible (Species Group)	Call made by one of two or more species. Call characteristics overlap making it too difficult to distinguish between species eg *Chalinolobus gouldii / Mormopterus* spp. *Nyctophilus* spp. The calls of *Nyctophilus corbeni, N. geoffroyi* and *N. gouldi* cannot be distinguished during the analysis process and are therefore lumped together. *Scotorepens orion/Scoteanax rueppellii/Falsistrellus tasmaniensis*.

Harp netting

Harp nets were set along potential microbat flyways or near watercourses on six evenings during the November surveys. These included locations near Narrabri, Curban and Kickabil. Harp nets were set in the afternoon and taken down around 10pm due to access and work hour constraints.

Harp nets were also set near combined trapping sites during the March surveys. Harp nets were set at two dry creek sites (flyways) in the Pilliga (eight trap nights) and on a track at the site south-west of Gilgandra (three trap nights). Traps were checked prior to sunrise to allow bats to be released while it was still dark. These were set in the late afternoon and checked at dawn. Bats that required identification were taken back to the accommodation and released the following evening after sunset at the capture location.

Table 3.8 Harp net survey effort

Timing	General location	Site	Habitat	Effort
November 2018	Narrabri	Narrabri Creek	River	1 evening, 2 nets on edge of river
	West Narrabri	Small creek	Dry creek (narrow)	1 evening, 1 net
	West Narrabri	Farm dam	Dam	1 evening, 1 net
	Bohena	Bohena Creek (north)	Dry creek (narrow)	1 evening, 2 nets
	Curban	Castlereagh River	River	1 evening, 2 nets in woodland on edge of river
	Kickabil	Ewenmar Creek	Dry creek (narrow)	1 evening, 2 nets
March 2019	Pilliga	Rocky Creek	Dry creek (narrow)	4 evenings, 2 nets
	Pilliga	Coolangala Creek	Dry creek (wide)	4 evenings, 2 nets
	Gilgandra	Private property	Track in woodland	3 evenings, 2 nets

Spotlighting and call playback

Spotlighting targeting nocturnal animals was conducted over 8 nights in rural areas in November 2019, four nights in the Pilliga in March 2019, 6 nights across the alignment in August 2019 (including one night in the Pilliga), and two nights in early October 2019. Spotlighting was undertaken by two ecologists using 210 lumens P14 Led Lenser torches or similar. Each survey lasted 3 to 4 hours. Surveys were carried out within road reserves, travelling stock reserves, in larger woodland patches on private properties, Pilliga forests, at watercourses and dams.

Spotlighting comprised a combination of surveys on foot (about 0.5 kilometres per hour) and slow driving surveys (5 kilometres per hour) along roads and tracks, depending on access and the habitat values of each location surveyed. Surveys in the Pilliga included slow driving transects along Pilliga Forest Way and Cumbil Road. All driving surveys included regular stops for walking spotlighting transects along creek lines where hollow-bearing trees occurs in higher densities, along roads and tracks, and in areas of flowering shrubs.

Driving surveys are a recognised method for species such as the Pale-headed Snake (*Hoplocephalus bitorquatus*). Snakes can often be recorded on roads on warm nights, particularly after rain (DSEWPaC 2011).

Frogs were identified by sight and call when encountered opportunistically during surveys. Frog calls were recorded and verified using the Australian Museum's Frog ID app.

Call playback was undertaken on a total of 20 nights across the study area. Calls of the Barking Owl (*Ninox connivens*), Masked Owl (*Tyto novaehollandiae*) and Bush Stone-curlew (*Burhinus grallarius*) were broadcast in woodland areas. Calls of the Koala (*Phascolarctos cinereus*) were also broadcast in the Pilliga area. Calls were broadcast through a 15 watt megaphone for a minute each with gaps of about a minute between the call of each species. Calls were then repeated. A quiet listening period of ten minutes was held prior to and following call playback. Potential roost sites were scanned with a spotlight. Call playback surveys for owls were limited in winter to the end of August, with calls only broadcast for a brief period (less than 1 minute), to avoid disturbance of nesting owls.

Table 3.9 Nocturnal survey effort (call playback and spotlighting)

Timing	General location	Site	Habitat
12 Nov 2018	Narrabri	Narrabri Creek	River, riparian vegetation Farm dam, woodland
13 Nov 2018	Narrabri	Namoi River Private property	River, riparian vegetation Farm dam, woodland
14 Nov 2018	Bohena	Bohena Creek	Dry creek, woodland
15 Nov 2018	Gilgandra	Castlereagh River Road reserves north of Gilgandra	Dry river, riparian vegetation Linear roadside vegetation
19 Nov 2018	Narromine	Narromine Travelling Stock Reserve Road reserves south of Narromine	Riparian vegetation Woodland Farm dams Linear roadside vegetation
20 Nov 2018	Narromine	Road reserves north of Narromine (heavy rain event)	Linear roadside vegetation, roadside ditches, farm dams
21 Nov 2018	Burroway - Kickabil	Road reserves	Dry creek, woodland Linear roadside vegetation
22 Nov 2018	Gilgandra	Private property	Woodland, creek, dams
18 March 2019	Pilliga	Pilliga Forest Way	Forest
19 March 2019	Pilliga	Pilliga Forest Way	Forest
20 March 2019	Pilliga	Pilliga Forest Way	Forest
21 March 2019	Pilliga	Pilliga Forest Way	Forest
23 March 2019	Pilliga	Etoo Creek	Dry creek, woodland

Timing	General location	Site	Habitat
26 August 2019	Narromine	Pinedean Road, Narromine Travelling stock reserve	River Riparian vegetation Woodland Farm dams Linear roadside vegetation
27 August 2019	Burroway	Travelling stock reserve, roadsides	Dry creek (some pools), woodland Linear roadside vegetation
28 August 2019	Narrabri	Narrabri Creek, Bohena Creek	Riparian vegetation Woodland
29 August 2019	Pilliga	Pilliga East State Forest Euligal State Forest Cumbil State Forest	Riparian vegetation Woodland
30 August 2019	Curban	Castlereagh River, Curban Tonderburine	Riparian vegetation
30 September 2019	Pilliga	Cumbil State Forest Baradine State Forest	Riparian vegetation Woodland
1 October 2019	Pilliga	Cumbil State Forest Baradine State Forest	Riparian vegetation Woodland
23-24 June 2020	Gilgandra	Private	Woodland

Elliott and pitfall trapping

Twelve combined trapping sites were surveyed in March 2019. These consisted of six sites in the Pilliga in the first week of survey, and one site in the Pilliga, two sites at Bohena Creek near Narrabri and two sites near Gilgandra in the second week of survey. Each site was surveyed for four consecutive nights and targeted small mammals, arboreal mammals, reptiles and frogs. The following methods were employed:

- One pitfall trap-line was established at each combined fauna survey site. A trap line consisted of five 20 litre buckets buried with the lip flush with ground-level and placed at five metre intervals along a 30 metre long and 35 centimetre high drift fence to direct animals into pits. Funnel traps were placed at the ends of each trap-line. The bucket contained approximately 1-2 centimetres of soil, small drainage holes in its base and a damp sponge reflective shade cloth to protect animals while in the trap. Traps were checked once in the early morning and once in the mid-late afternoon.
- 10 Elliott A traps were placed on the ground and 10 Elliott B traps were attached to trees at the combined fauna trapping sites. Traps were spaced about 20-30 metres apart along two transects about 30-50 metres apart, with Elliott As and Elliott Bs placed near each other. Trees were sprayed with a diluted honey and water mixture. At the sites near Gilgandra, 20 Elliott A traps were set at each site to increase trap success, given the low capture rates during the first week of trapping. Traps were checked at dawn, with animals released within two hours of first light. Coconut fibre and bait (oats, peanut butter and honey) were placed in each trap.

Cameras traps

Camera traps were installed at various locations in the Pilliga forests and Bohena area to capture images of cryptic fauna that may be present, and as an adjunct survey method to general fauna surveys. A bait tube containing a mixture of chicken wings, tinned sardines and/or oats and honey was placed in front of the camera. In some locations no bait was used as cameras were set near dams, as water is the attractant. Cameras were set to take three pictures over one minute when triggered by movement, with at least five minutes between each set of photographs. One camera was set per location. Cameras in the November 2018 and March 2019 survey period were set for 3-4 nights. Cameras were set in late August 2019 in the Pilliga and collected in late September 2019 (see Table 3.10).

Table 3.10 Camera trap effort

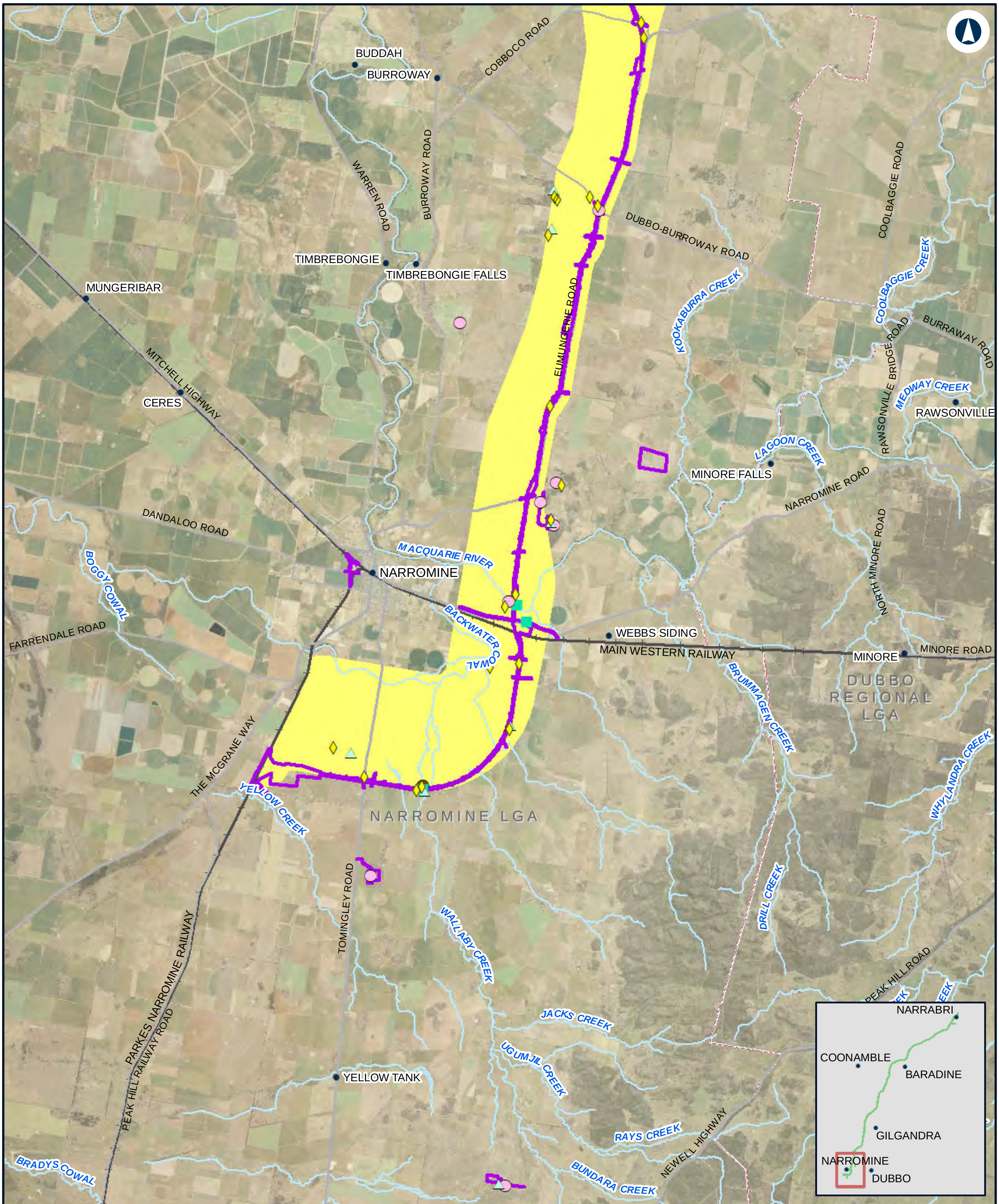
Timing	General location	Site	Habitat	Effort
November 2018	Bohena	Bohena Creek (north)	Dry creek (narrow)	3 nights
	Bohena	Bohena rest area	Forest clearing	3 nights
	Bohena	Bohena Creek (south)	Dry creek (wide)	3 nights
March 2019	Pilliga	Coolangala Creek	Dry creek (wide)	4 nights
	Pilliga	Etoo Creek	Dry creek (wide)	4 nights
	Pilliga	Coxes Road dam	Two dams (two units)	4 nights
	Pilliga	Trap site 5	Forest clearing	4 nights
	Pilliga	Trap site 4	Forest clearing with timber	4 nights
	Pilliga	Curbo Creek	Dry creek (narrow)	4 nights
	Pilliga	Emu Dam	Dam (dry)	4 nights
	Kickabil	Leeches Creek Road	Two dams (two units)	4 nights
September 2019	Pilliga	Kuhner's Bore	Forest clearing near dam	4 weeks
	Pilliga	Clay Foot Dam	Dam	4 weeks
	Pilliga	Pilliga Forest Way	Heath in flower	4 weeks
	Pilliga	Talluba Creek	Dry creek (narrow)	4 weeks
	Pilliga	Cumbil Forest Creek	Dry creek with rock outcrops (narrow)	4 weeks

Opportunistic observations

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. This included a conscious focus on suitable areas of habitat during surveys.

Hollow-bearing tree transects

Hollow-bearing tree transects were undertaken in various locations to get an indication of hollow density and sizes present in dominant PCTs in the proposal site.



NARROMINE TO NARRABRI

Fauna survey locations (diurnal)

Figure 3.3a

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction footprint
- Phase 2 - Investigation Corridor
- Active search
- Bird survey
- General fauna survey
- Hollow-bearing tree transect
- Scat search

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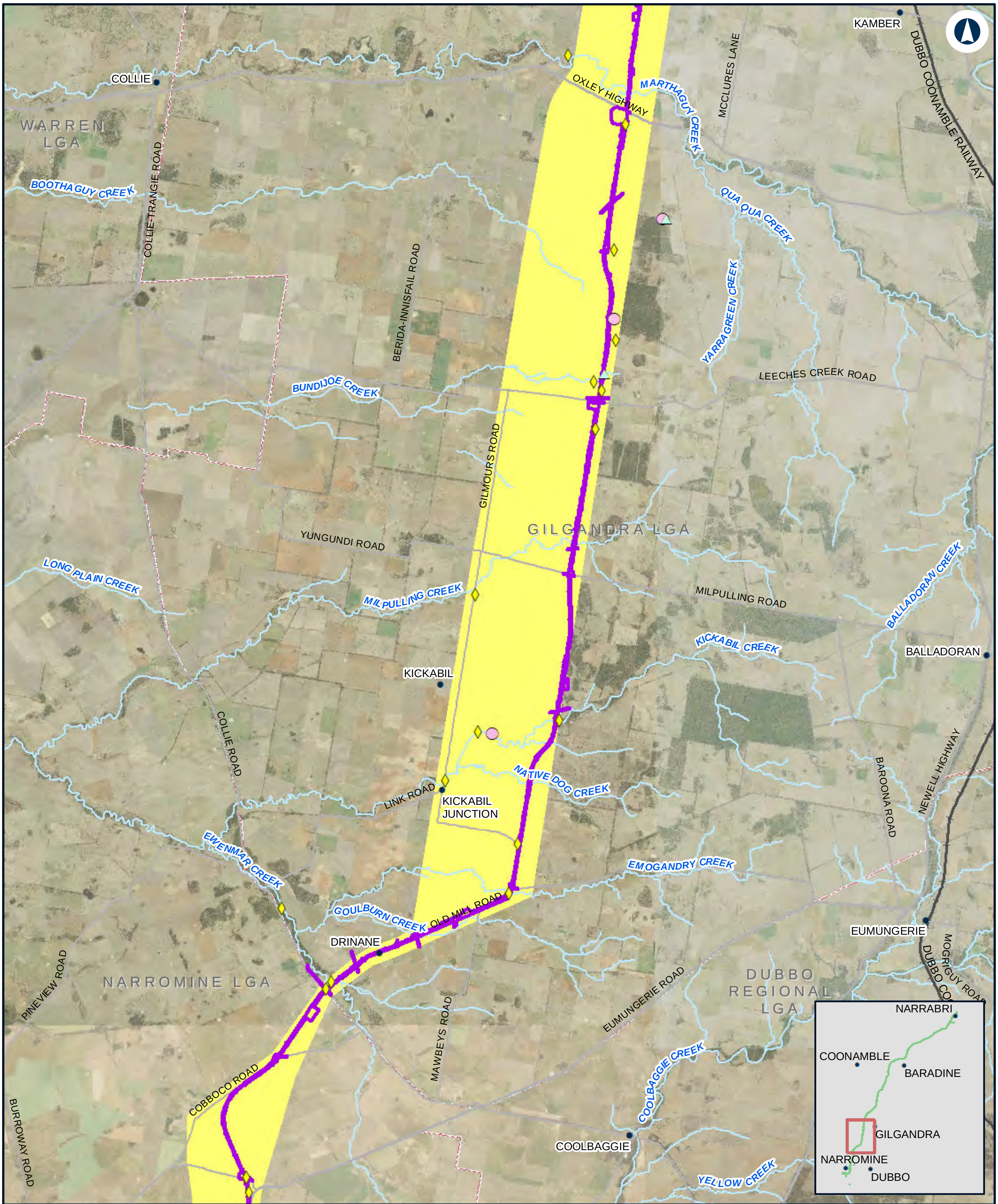

NARROMINE TO NARRABRI

Fauna survey locations (diurnal)

Figure 3.3b

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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LEGEND

- Construction footprint
- Phase 2 - Investigation Corridor
- Active search
- Bird survey
- General fauna survey

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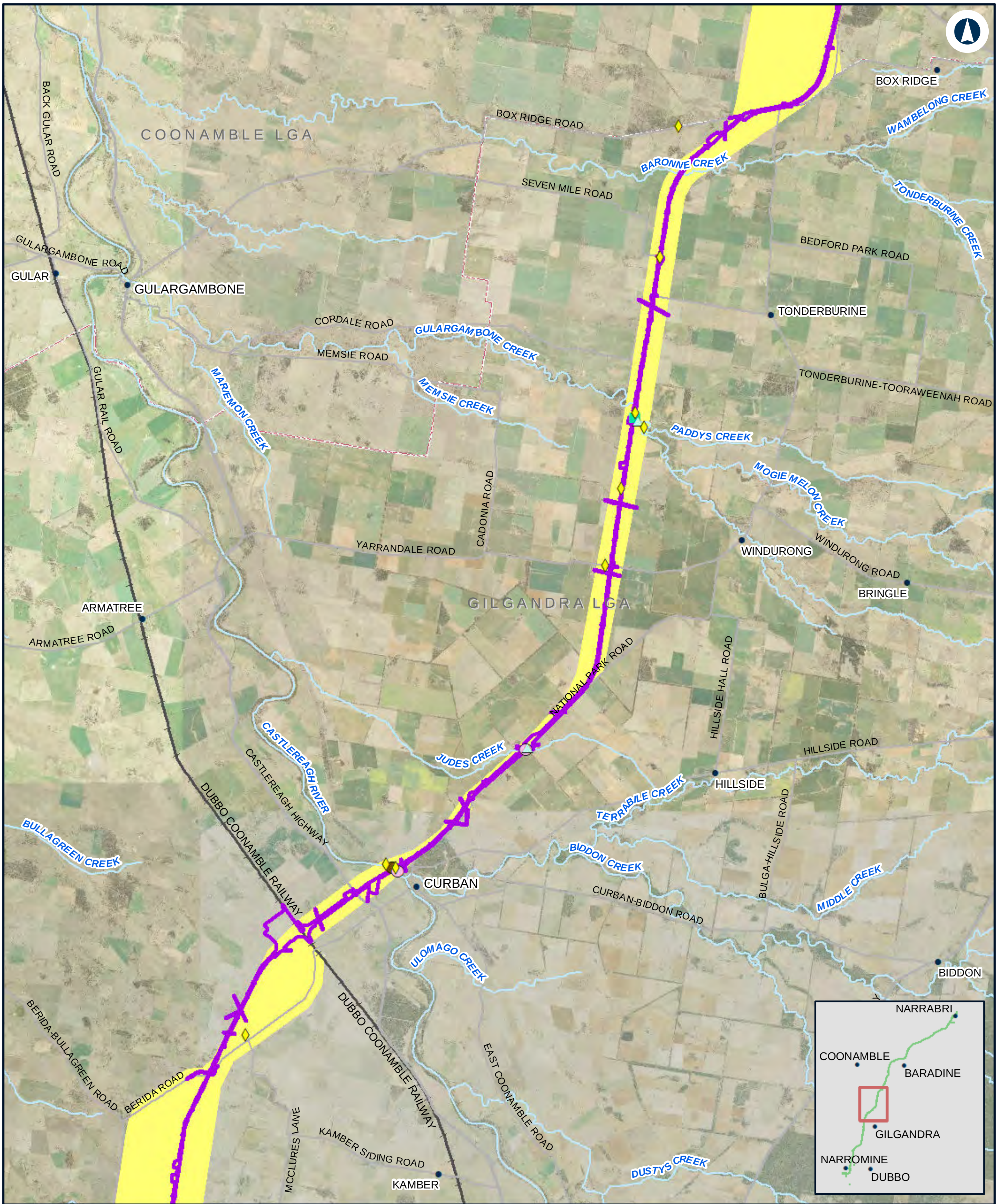

NARROMINE TO NARRABRI Fauna survey locations (diurnal) Figure 3.3c

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction footprint
- Phase 2 - Investigation Corridor
- Active search
- Bird survey
- General fauna survey
- Hollow-bearing tree transect
- Scat search

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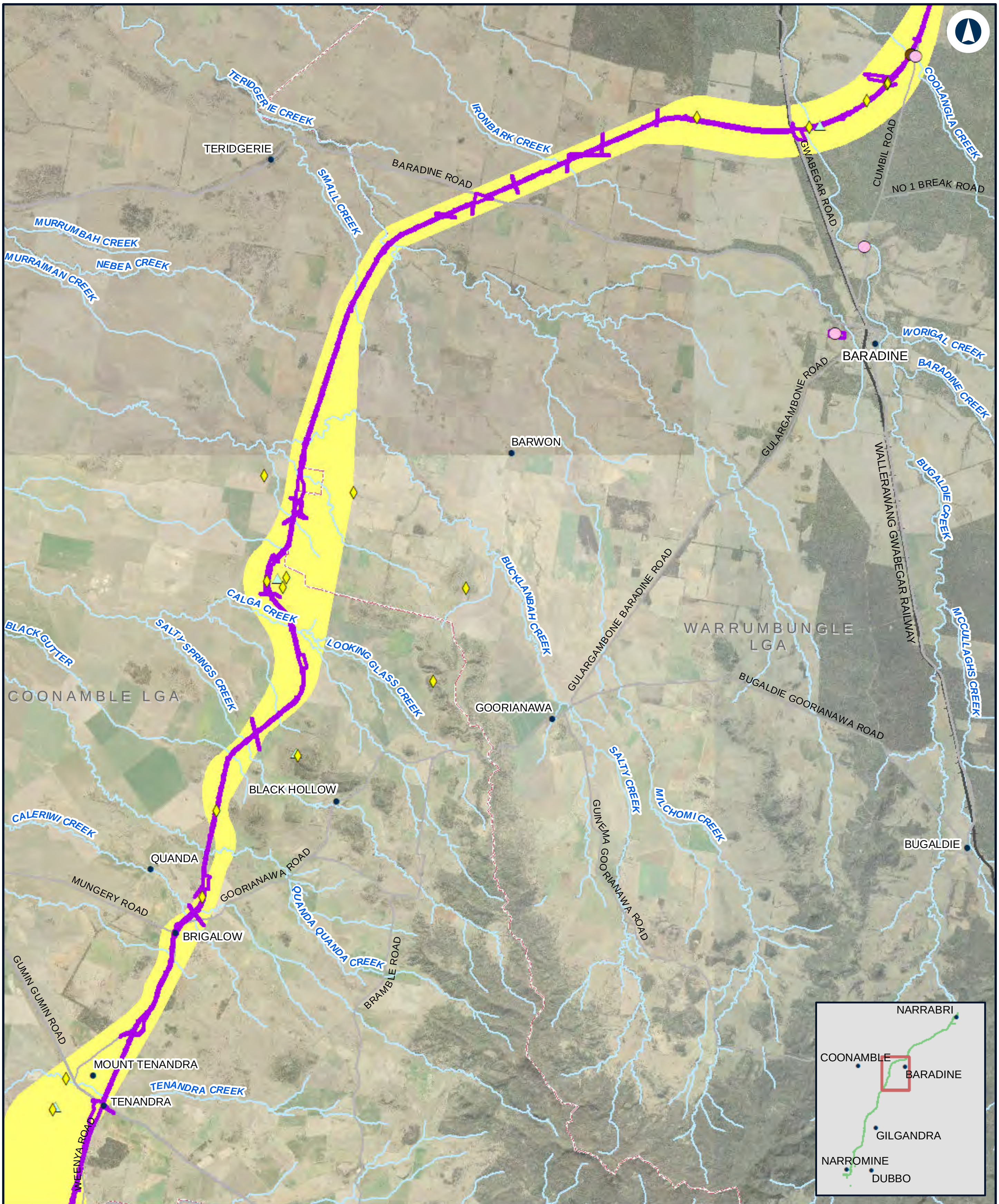

NARROMINE TO NARRABRI Fauna survey locations (diurnal) Figure 3.3d

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND
- Construction footprint
- Phase 2 - Investigation Corridor
- Active search
- Bird survey
- General fauna survey
- Scat search

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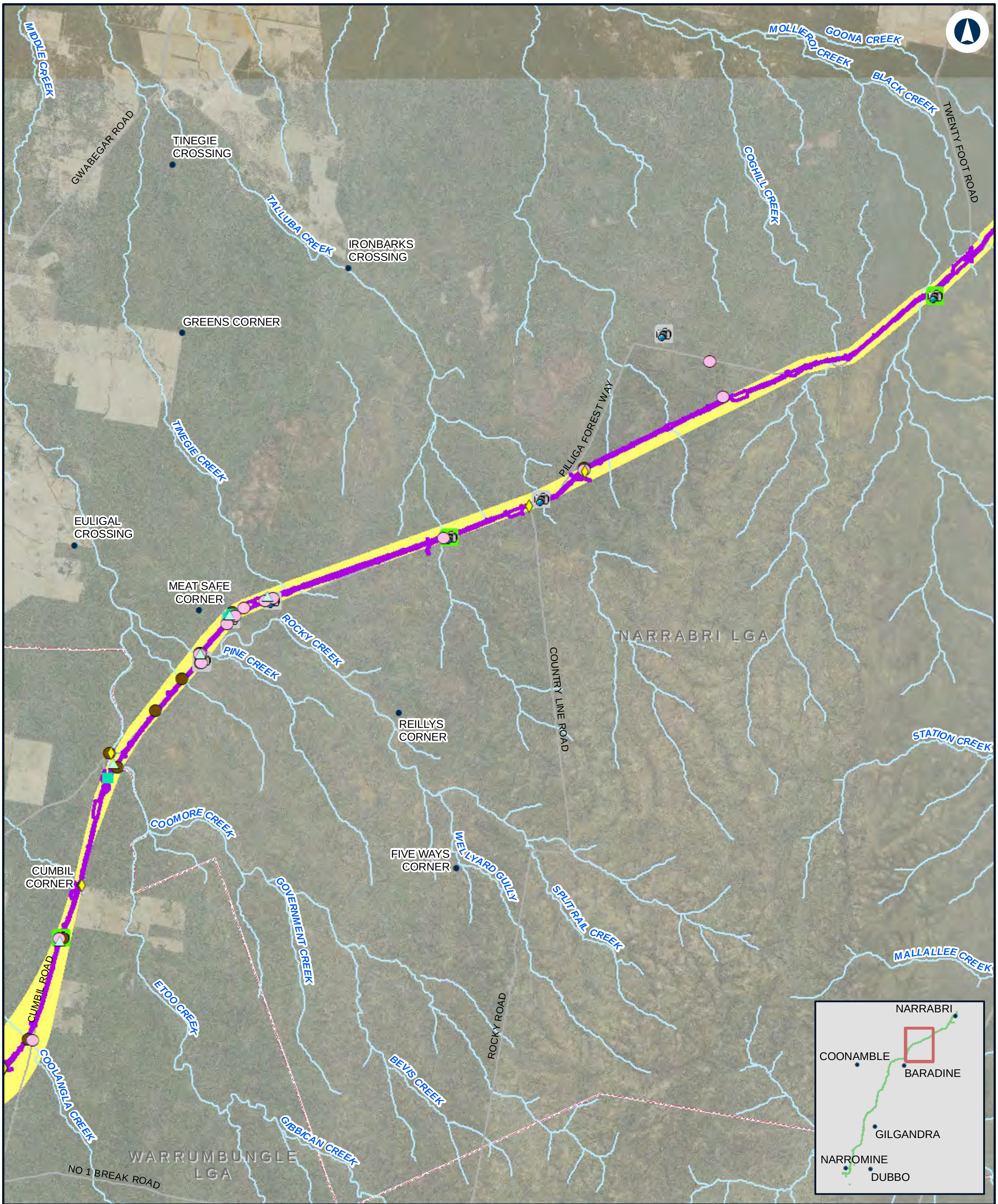

NARROMINE TO NARRABRI Fauna survey locations (diurnal) Figure 3.3e

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Author: JacobsGHD
Data Sources: Basemap layers: NSWSS;
Paper: A4
Scale: 1:200,000

LEGEND

- Construction footprint
- Phase 2 - Investigation Corridor
- Active search
- Bird survey
- General fauna survey
- Hollow-bearing tree transect
- Scat search
- Camera
- Camera (4 weeks)

INLAND RAIL ARTC

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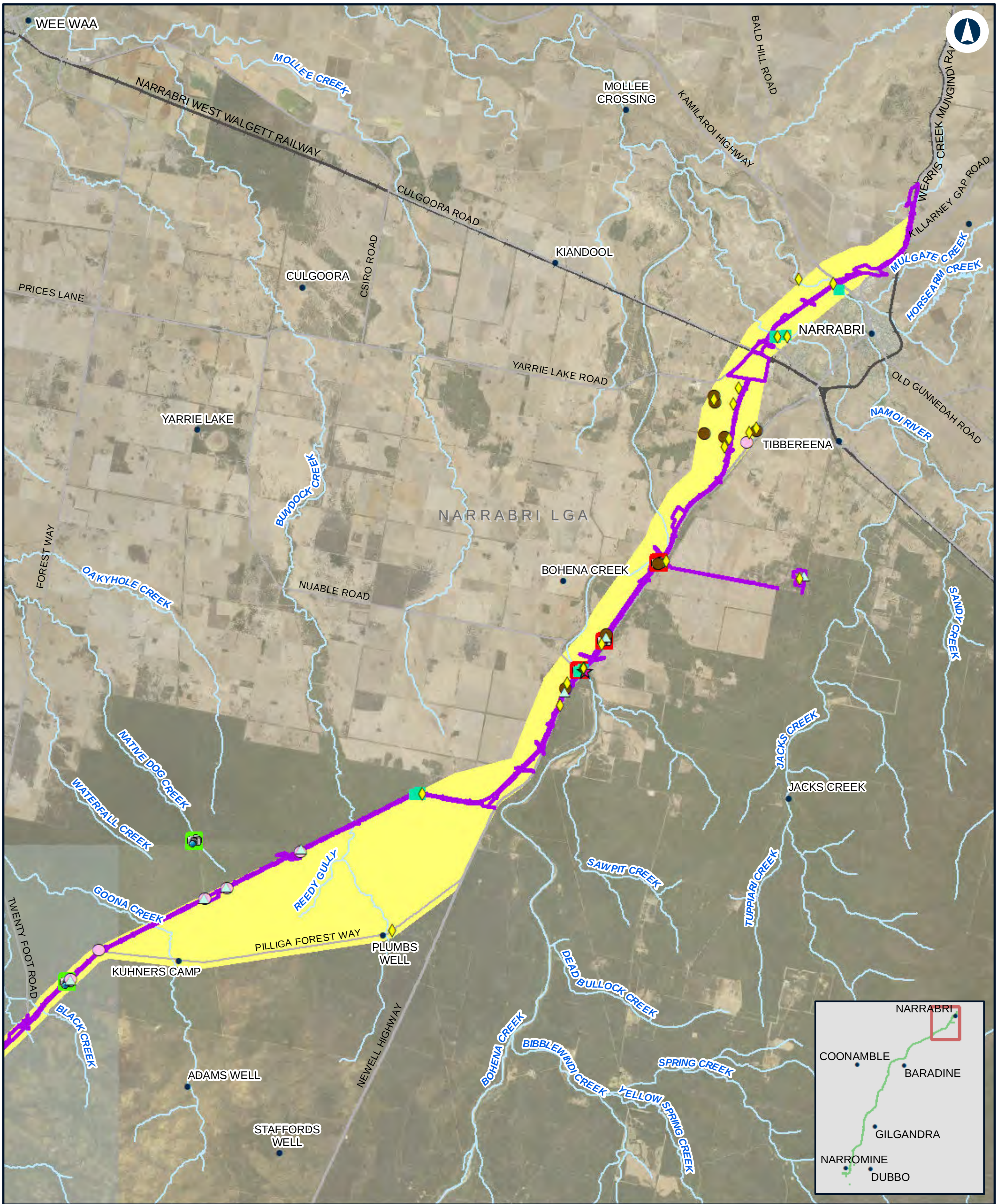

NARROMINE TO NARRABRI Fauna survey locations (diurnal) Figure 3.3f

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction footprint
- Phase 2 - Investigation Corridor
- Active search
- Bird survey
- Bridge search for roosting bats
- General fauna survey
- Hollow-bearing tree transect
- Scat search
- Camera (3 days)
- Camera (4 weeks)

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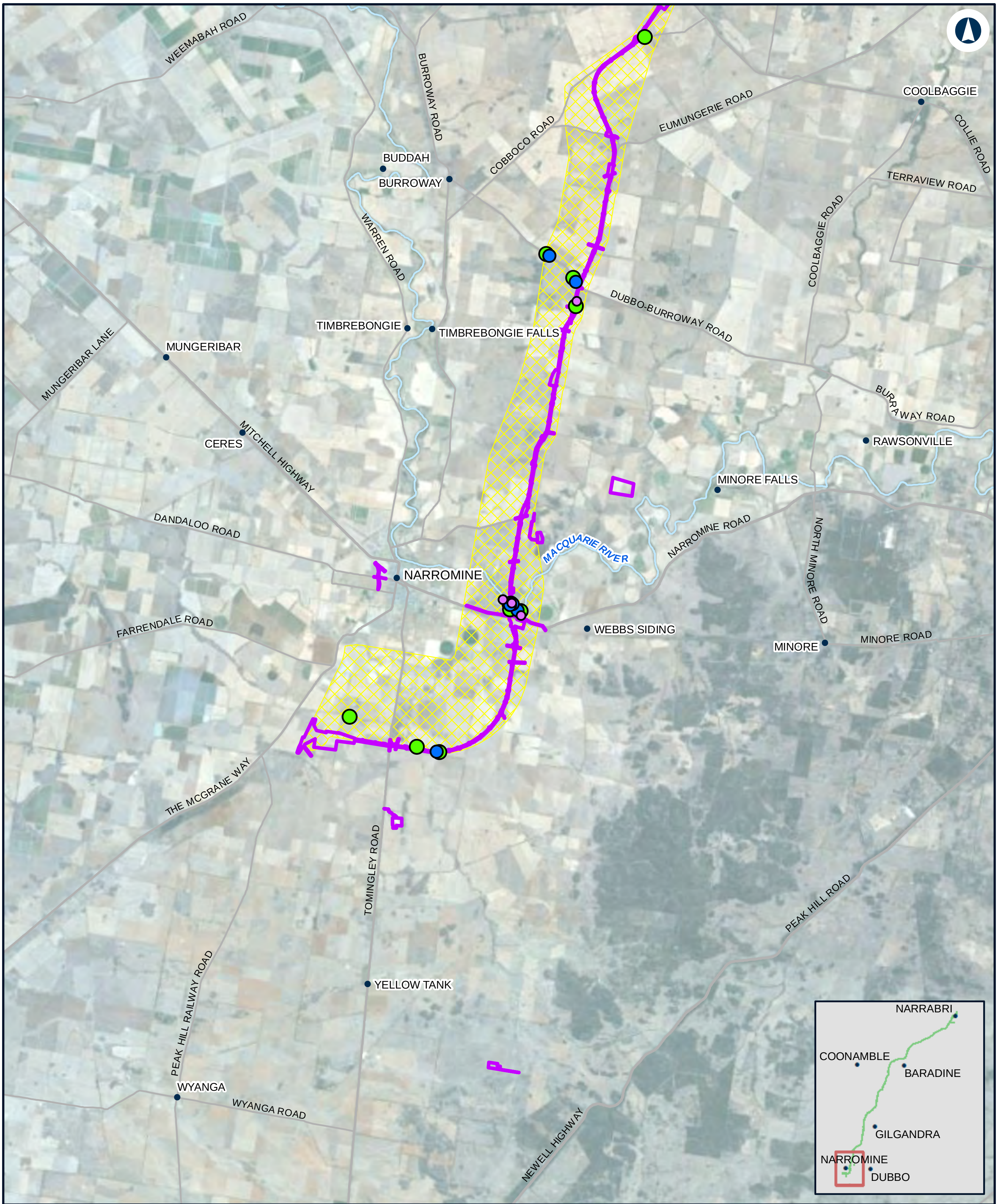

NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4a

0 3.5 7 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:248,130
Data Sources: Basemap layers: NSWSS;

LEGEND

Construction footprint
Investigation Corridor

Survey Type

Anabat
Call playback
Spotlighting

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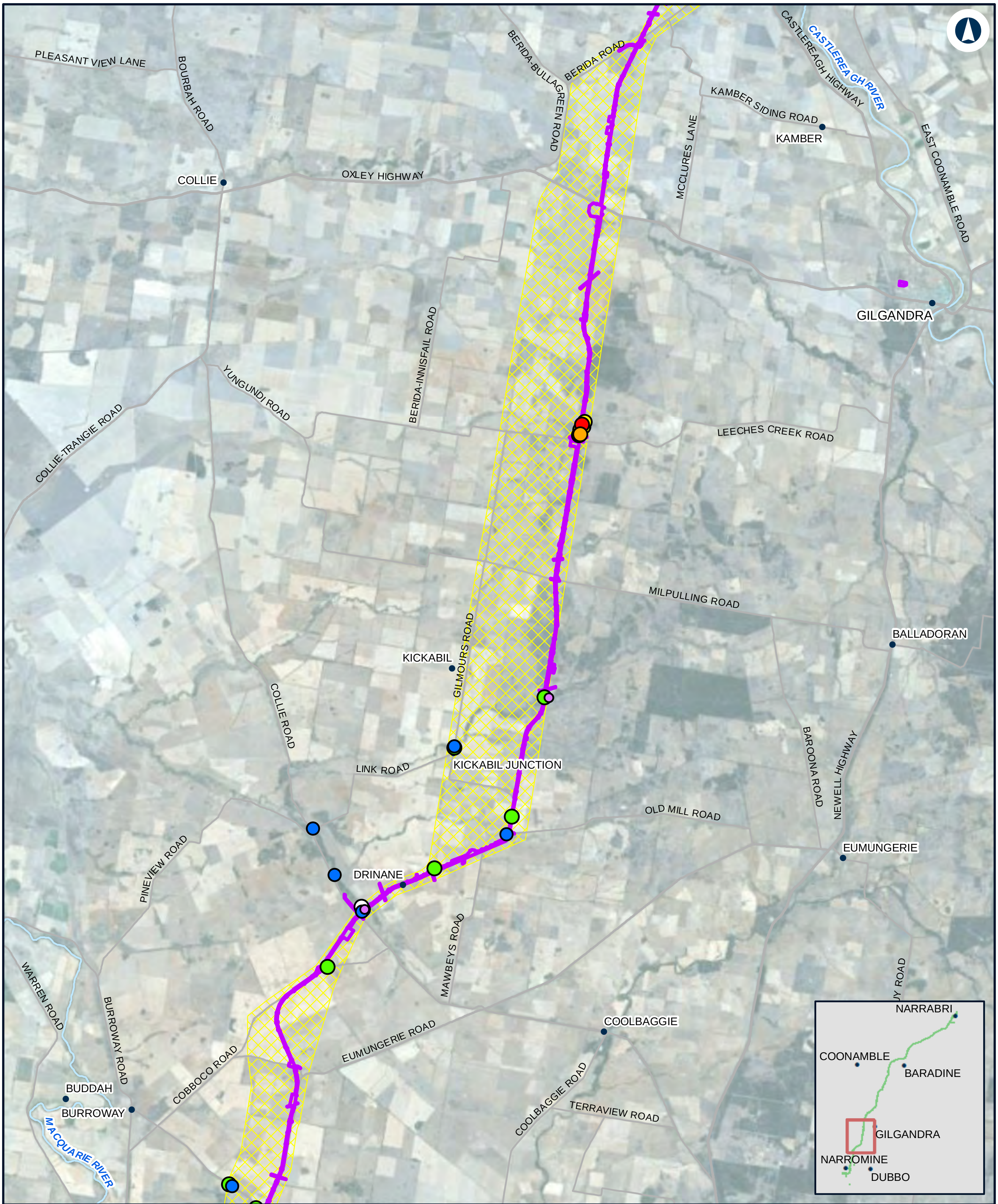

NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4b

0 3.5 7
Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:248,130
Data Sources: Basemap layers: NSWSS;

LEGEND

Construction footprint
Investigation Corridor

Survey Type

- Anabat
- Call playback
- Harp Net (4 nights)
- Harp Net (evening)
- Pitfall
- Spotlighting
- Trapping

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NARROMINE TO NARRABRI

Fauna survey locations (nocturnal)

Figure 3.4c

0 3.5 7 Km

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Author: JacobsGHD Scale: 1:248,130
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction footprint
- Investigation Corridor

Survey Type

- Anabat
- Call playback
- Harp Net (evening)
- Spotlighting

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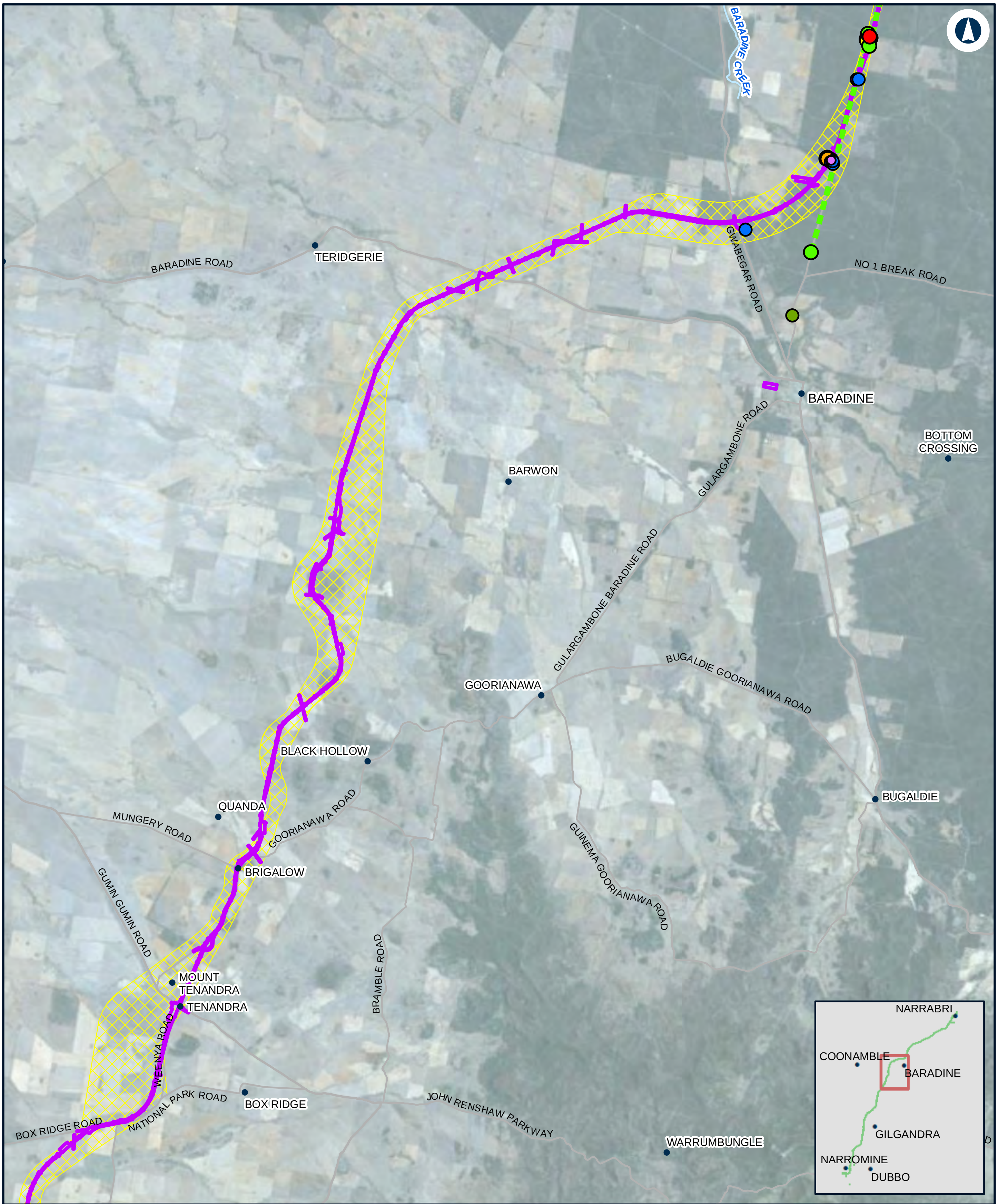

NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4d

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LEGEND

- Construction footprint
- Investigation Corridor

Survey Type

- Anabat
- Call playback
- Camera
- Frog survey
- Harp Net (4 nights)
- Pitfall
- Spotlighting
- Trapping
- Spotlighting
- Trapline

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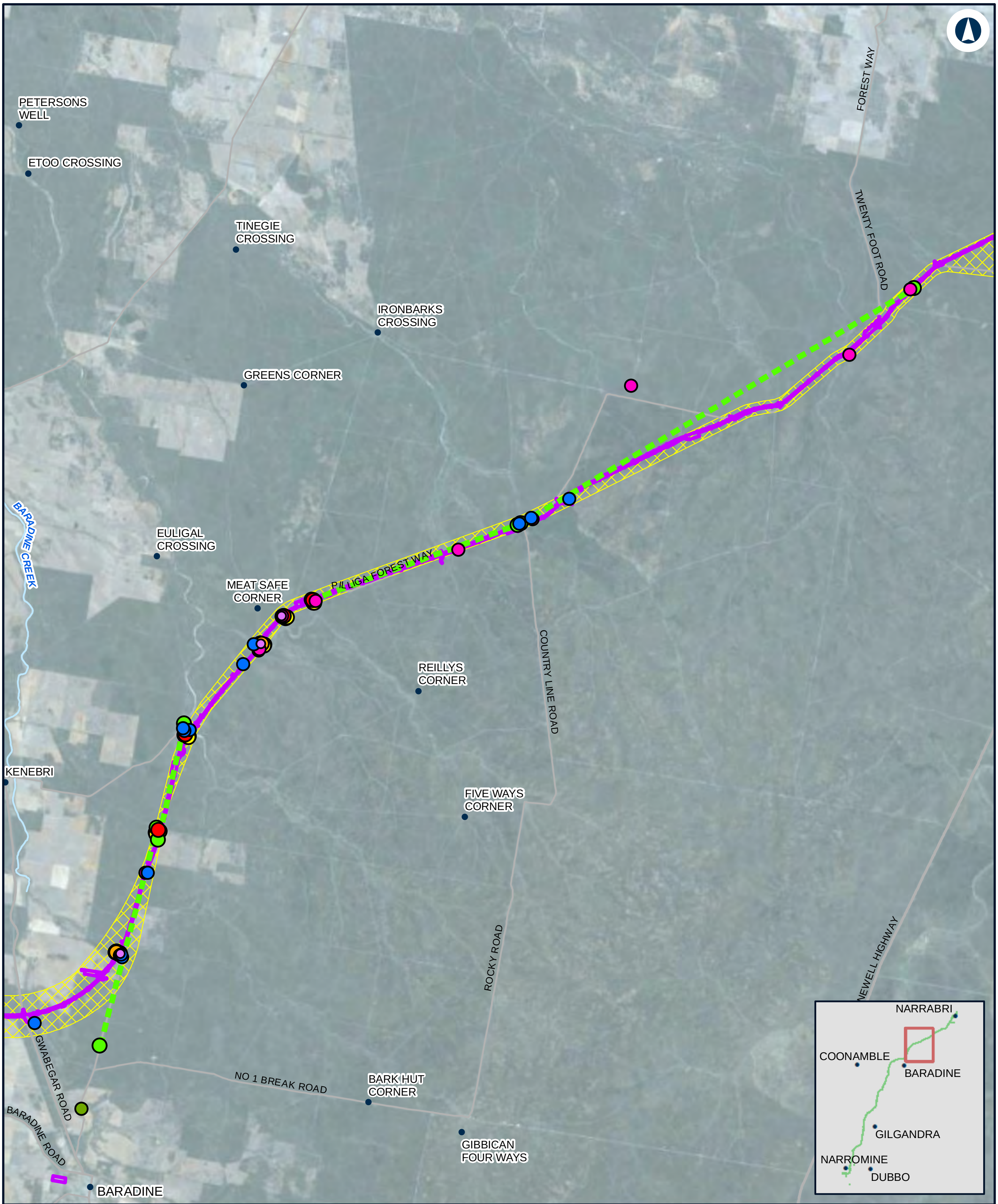

NARROMINE TO NARRABRI

Fauna survey locations (nocturnal)

Figure 3.4e

0 3.5 7 Km

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LEGEND

- Construction footprint
- Investigation Corridor

Survey Type

- Anabat
- Call playback
- Camera
- Frog survey
- Harp Net (4 nights)
- Pitfall
- Spotlighting
- Trapping
- Spotlighting
- Trapline

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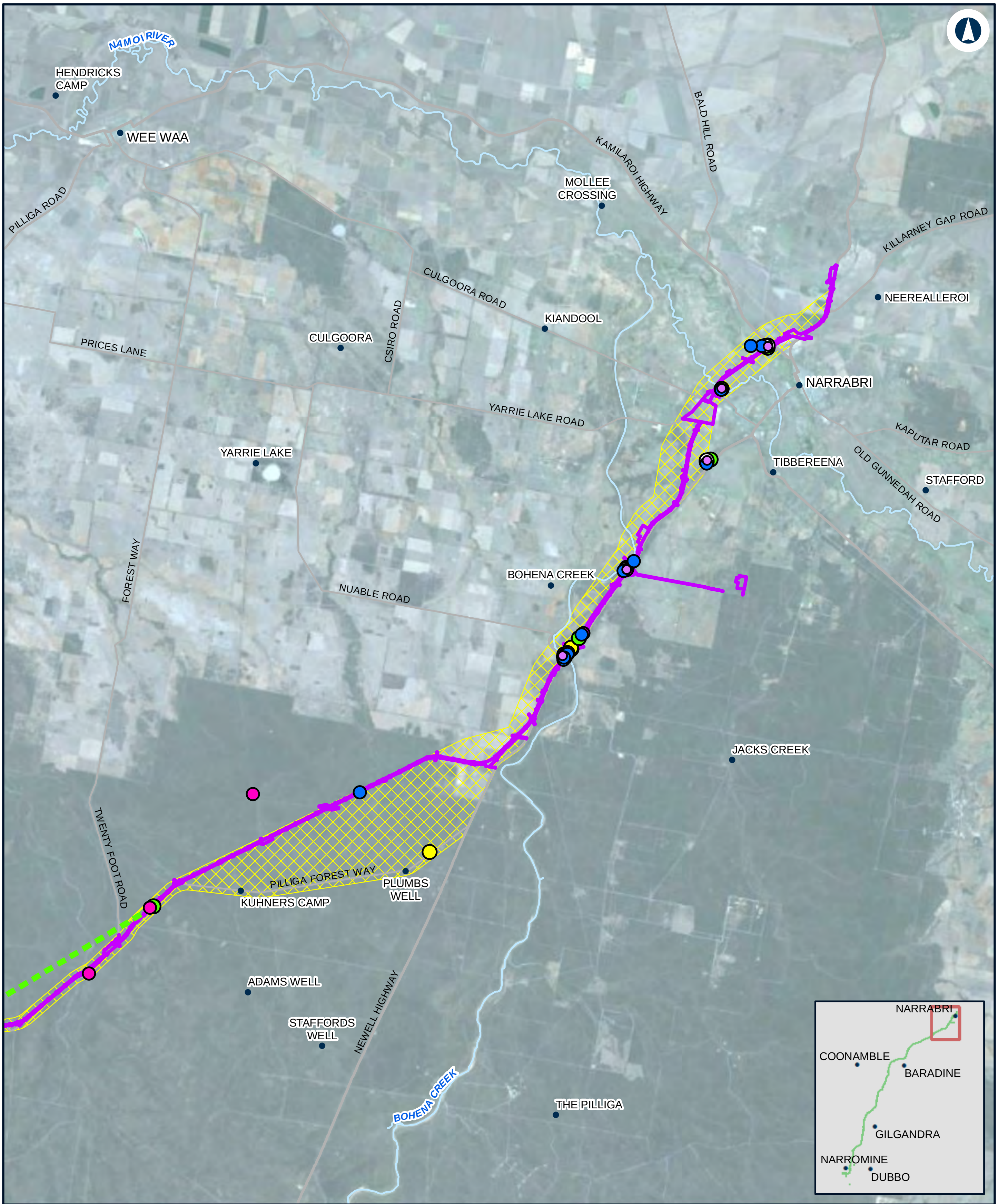

NARROMINE TO NARRABRI

Fauna survey locations (nocturnal)

Figure 3.4f

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LEGEND

- Construction footprint
- Investigation Corridor

Survey Type

- Anabat
- Call playback
- Camera
- Harp Net (evening)
- Spotlighting
- Trapping
- Spotlighting
- Trapline

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3.6 Survey effort, weather and limitations

3.6.1 Survey effort and timing

A summary of field survey timing and effort is provided in Appendix D. Flora survey results are provided in Appendix E and fauna survey results are provided in Appendix F.

3.6.2 Weather

The field surveys were undertaken between September 2018 and October 2019. Bureau of Meteorology (BOM) records for the survey date are outlined in Table 3.11. These records were taken at Dubbo weather station and Narrabri weather station (BOM 2018b). Much of NSW, including the proposal site, has been subject to ongoing drought during and prior to surveys being conducted (see section 3.6.3) and there was little rain. Weather during most surveys was warm to hot. Night-time temperatures were cold during the August 2019 nocturnal surveys.

Despite predominantly dry conditions, surveys coincided with a number of rain events. A storm event occurred on the evening of 21 November 2019 in Narromine, with local roads in town flooded. Wet weather provided good conditions for detecting frogs, with many species recorded that evening. A storm event occurred in the Baradine area immediately prior to the March 2019 Pilliga surveys. Baradine Creek was flowing at the beginning of surveys in the Pilliga, and weather was humid and warm. The Pale-headed Snake was recorded on the first evening of surveys. Substantial rain fell in the Gilgandra area on 25 March 2019, immediately prior to trapping surveys in this area. Bird diversity recorded during morning surveys was markedly higher immediately following this survey. Further discussion of weather is provided in section 3.6.3).

3.6.3 Limitations

Prolonged drought conditions

Flora and fauna field surveys conducted for the proposal would not be expected to detect all of the species present, however given the many days and various seasons over which surveys have been conducted, a large proportion of species that would occur across the proposal site are likely to have been recorded. Given the short period of time some locations were visited, a smaller proportion of the total expected would have been recorded, and some threatened species that may occur on occasion or flower at different times of the year may not have been recorded.

The year to date and previous two years (2018 and 2019) has been exceptionally dry in NSW and particularly in inland NSW, and also very warm. November rainfall in 2018 was above average across large areas of NSW which eased short to medium term rainfall deficiencies, but at the longer 20-month timescale, rainfall deficiencies remain largely unchanged (BOM 2018b). Annual rainfall from north to south along the proposal alignment was less than half at all locations in most years (see Table 3.12).

Table 3.11 Daily weather observations during the survey period

Date	Min temp (Deg Celsius)	Max temp (Deg Celsius)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
September 2018							
24/09/2018	11.7	22.9	0	Narromine	Dubbo	PCT mapping	General surveys, anabats
25/09/2018	9.6	22.9	0	Narromine	Dubbo	PCT mapping	General surveys, anabats
26/09/2018	8.9	22.6	0	Gilgandra	Dubbo	PCT mapping	General surveys, anabats
27/09/2018	8.7	24.4	0	Narrabri	Narrabri	PCT mapping	General surveys, anabats
28/09/2018	8.6	30.5	0	Gilgandra	Dubbo	PCT mapping	General surveys, anabats
November 2018							
12/11/2018	16.0	32.2	0	Narrabri	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
13/11/2018	14.2	32.6	0	Narrabri	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
14/11/2018	14.7	27.2	0	Narrabri	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
15/11/2018	13.9	32.2	1.6	Gilgandra	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
16/11/2018	14.6	30.1	0	Gilgandra	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys
17/11/2018	13.1	30.9	0	Narromine	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Incidental surveys during flora surveys
18/11/2018	14.5	30.3	0	Narromine	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Incidental surveys during flora surveys

Date	Min temp (Deg Celsius)	Max temp (Deg Celsius)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
19/11/2018	13.6	29.2	2.8	Narromine	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
20/11/2018	17.1	32.4	0.2	Narromine	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
21/11/2018	18.5	24.4	7.2	Narromine	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
22/11/2018	15.5	22.7	0	Gilgandra	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys, nocturnal
23/11/2018	10.9	22.7	0	Gilgandra	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Targeted surveys
March 2019							
18/03/2019	15.6	30.7	15.2	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, nocturnal, general
19/03/2019	18.0	32.7	0	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, nocturnal, general
20/03/2019	18.9	32.3	0	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, nocturnal, general
21/03/2019	19.4	34.0	0	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, nocturnal, general
22/03/2019	19.5	35.8	0	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general

Date	Min temp (Deg Celsius)	Max temp (Deg Celsius)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
23/09/2019	19.9	37.4	0	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general
24/09/2019	24.3	38.4	0	Pilliga	Narrabri	PCT mapping, vegetation integrity plots, threatened flora searches	Incidental surveys during flora surveys
25/09/2019	23.8	28.1	0.6/8.2	Narrabri/ Gilgandra	Narrabri/ Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general
26/09/2019	21.1	29.4	0/13.0	Narrabri/ Gilgandra	Narrabri/ Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general
27/09/2019	17.6	27.0	0.2/0	Narrabri/ Gilgandra	Narrabri/ Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general
28/09/2019	15.8	31.5	0.4/0	Narrabri/ Gilgandra	Narrabri/ Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general
29/03/2019	19.6	33.0	0/0	Narrabri/ Gilgandra	Narrabri/ Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Trapping, general
August 2019							
26/08/2019	4.3	19.9	0	Narromine	Dubbo	None	Nocturnal surveys, general
27/08/2019	-0.9	20.3	0	Narromine	Dubbo	None	Nocturnal surveys, general
28/08/2019	5.7	23.4	0	Narrabri	Narrabri	None	Nocturnal surveys, general
29/08/2019	1.1	20.9	0	Pilliga	Narrabri	None	Nocturnal surveys, general
30/08/2019	4.2	18.0	0	Gilgandra	Dubbo	None	Nocturnal surveys, general

Date	Min temp (Deg Celsius)	Max temp (Deg Celsius)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
September 2019							
27/09/2019	3.0	25.7	0	Narromine	Dubbo	Vegetation integrity plots, threatened flora searches	Incidental surveys during flora surveys
28/09/2019	14.1	23.8	0	Black Hollow	Coonabarabran	Vegetation integrity plots, threatened flora searches	General surveys
29/09/2019	9.8	22.3	0	Black Hollow	Coonabarabran	Vegetation integrity plots, threatened flora searches	General surveys
30/09/2019	9.1	22.5	0	Black Hollow	Coonabarabran	Vegetation integrity plots, threatened flora searches	General surveys, nocturnal surveys
October 2019							
1/10/2019	13.5	27.8	0	Pilliga	Narrabri	Vegetation integrity plots, threatened flora searches	General surveys, nocturnal surveys
2/10/2019	10.3	28.3	0	Pilliga	Narrabri	Threatened flora searches	General surveys
3/10/2019	10.8	29.6	0	Pilliga	Narrabri	Threatened flora searches	General surveys
4/10/2019	10.2	32.8	0	Pilliga	Narrabri	Threatened flora searches	Incidental surveys during flora surveys
5/10/2019	12.2	31.4	0	Pilliga	Narrabri	Threatened flora searches	Incidental surveys during flora surveys
6/10/2019	14.3	35.7	0	Pilliga	Narrabri	Threatened flora searches	Incidental surveys during flora surveys

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Table 3.12 Average annual rainfall and total rainfall for survey period along the alignment

Location	Average annual rainfall (mm)	Total 2018 annual rainfall (mm)	Total 2019 annual rainfall (mm)
Narromine (Dubbo station)	529.8	311.6	154.0
Gilgandra (Curban station)	554.2	286.4	188.9
Narrabri (Narrabri station)	540.5	376.4	206.2

Given these prevailing drought conditions, lower plant species diversity was likely to be present during the surveys. This in turn can affect identification of PCTs, distribution of vegetation zones and the likelihood of detecting threatened flora species. While the BCD are currently preparing drought condition benchmarks, these were not yet available and based on consultation with the Dubbo office of BCD, these drought condition benchmarks are not likely to be suitable to be used for this proposal due to a lack of benchmarks collected in the local region.

Weather also affects detectability of fauna species. Fauna surveys in the Pilliga occurred during March 2019, which was hot and predominantly dry. Hot days meant that most birds stopped calling early in the morning, although reptiles were observed basking. Few mammals were trapped during these surveys. No Elliott traps required closing over night due to inclement weather. Vegetation was very dry, with many dead shrubs observed. This lack of forage and shelter habitat is likely to have affected mammal abundance. Species such as the Pilliga Mouse, for example, have a dynamic population ecology, with higher numbers present when food is available after rain or fire (Paull et al 2014, Tokushima et al 2008). There was no evidence of recent fire in trapping locations, although wildfires have occurred in the Pilliga in 2006 and 1997. Drought conditions and lack of recent fires is likely to have affected detectability of the Pilliga Mouse and Eastern Pygmy-possum. Note that placement of trap sites were limited by access restrictions, with some preferred trap site locations not able to be accessed due to hunting (see below).

Substantial rain had fallen in the Baradine area immediately prior to these surveys, although standing water was limited to Baradine Creek and two small dams near Coxes Road. Humid weather in mid-March provided good opportunities for nocturnal reptile and amphibian surveys in the Pilliga. Wet weather prior to trapping at Gilgandra in March resulted in many birds calling on the first two mornings. As the area dried out and mornings were hotter later in the week, fewer birds were heard in the mornings. A rain event in Narromine in the November 2018 surveys led to increased frog activity on one evening. Limited success with frogs was recorded on other, dry, evenings of the same period.

Some species that may occur in the locality or region on a seasonal basis use habitats periodically (as part of a wider home range) or become active at different times of the year may not have been recorded. These species may include flora species that are difficult or impossible to locate or identify at certain times of year due to a lack of reproductive material and/or their seasonal nature (in particular, native orchids and forbs). Field surveys aimed to identify areas of suitable habitat for cryptic species and where necessary to assess the likelihood of occurrence at the proposal site.

Access restrictions

The study area was occupied by multiple landowners and featured a variety of land uses at the time of the field surveys. Access was not able to be obtained for the entire study area. Figure 3.5 shows the 'survey area' that was the subject of targeted biodiversity surveys and direct observations. Properties that are mapped as 'access not obtained' were not accessed on foot because of access restrictions or because they contained land uses such as intensive agriculture and could be reliability discounted as containing biodiversity values based on a desktop assessment or visual inspection during field surveys. As described above, these properties were assessed based on a combination of air photo assessment, direct observations from adjoining properties or public land and extrapolation of results from the survey area.

Timing of surveys on different properties was constrained by their location, meeting times with landowners, access issues, size of properties, and how many properties were accessed during the day. As such, not all surveys were necessarily conducted an optimal time of day for all target fauna species. Habitat assessments, results of surveys in nearby areas and local records were used to assess the likelihood of fauna occurrence in areas with access restrictions and associated survey limitations.

Surveys in the Pilliga forests were limited on some occasions by hunting in the area. Where a hunting permit was active, no or limited surveys were conducted. For example, for the first survey week in March 2019, no traps were able to be set in Pilliga East State Forest. This restricted which locations were able to be trapped, with all trap lines set in Cumbil State Forest and Euligal State Forest that week.

For the above reasons, the impact assessment and conclusions of this report draw upon information obtained from a variety of sources in addition to the field survey data. Where it is considered that the likelihood of observing a particular threatened species was diminished due to the extent of survey effort or seasonal or climatic factors, then this has been indicated. An assessment of the likelihood of occurrence of threatened species has been provided, on the basis of known distributional ranges, previous records in the locality, and habitat and resource availability at the proposal site. The assessment of impacts includes those threatened species recorded in the study area during the field surveys as well as those species not detected but considered likely to occur or to be impacted by the proposal.

A detailed assessment of threatened species habitat requirements, habitat values present, survey requirements and effort, and justification for species polygons is provided in Appendix I.

Covid-19 pandemic

Due to increased rainfall in the Narrabri region and favourable growing conditions in March\April 2020, additional targeted flora survey were planned for the following species that flower in summer and/or autumn (note that advice from BCD and other botanists in the region was finding species flowering outside their usual season):

- Winged Peppercress (*Lepidium monoplocoides*)
- Spiny Peppercress (*Lepidium aschersonii*)
- *Commersonia procumbens*
- *Tylophora linearis*.

However, planned surveys were cancelled in late March 2020 due to the global coronavirus (Covid-19) pandemic and associated travel restrictions. Further surveys are proposed in spring 2020, and will target the latter two species if conditions are appropriate.

3.7 Likelihood of occurrence of threatened and migratory biota

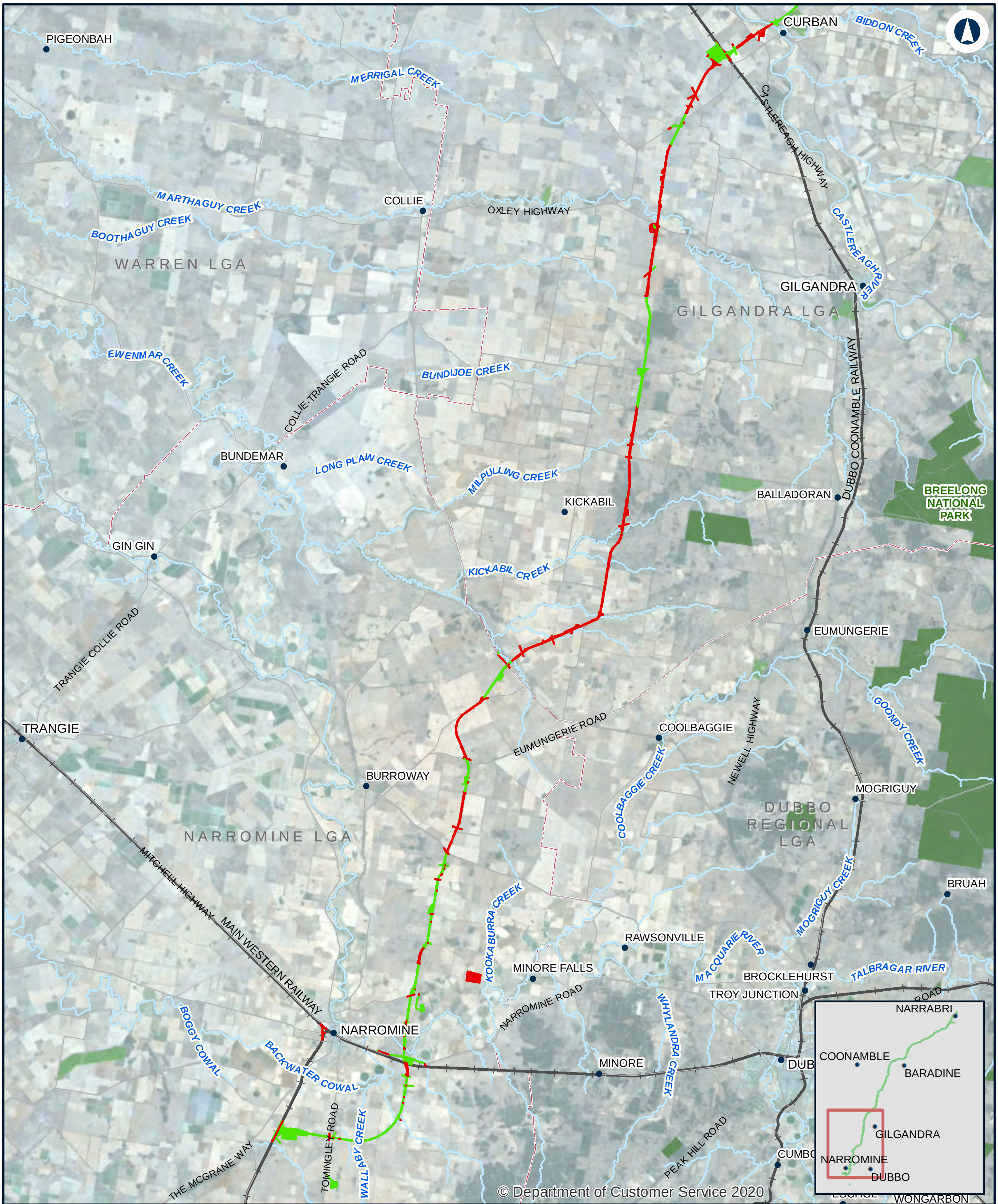
Following collation of BAMC outputs, database records and species and community profiles, a 'likelihood of occurrence' assessment was prepared with reference to the broad habitats contained within the study area. Identification of potential habitat for threatened and migratory species was based on presence of records from a 20 kilometre radius of the proposal site since 1998, species distribution and habitat preferences, IBRA subregion occurrence, information provided in the species profiles (DEE 2018b, OEH 2018b), recovery plans, journal articles, and the field staffs' knowledge of species habitat requirements. The likelihood of occurrence assessment was further refined following field surveys. The results of this assessment are provided in Appendix B.

3.8 Geographical Information System (GIS) analysis

GIS software (Collector for ArcGIS and ArcGIS) was used to collect survey information and map all figures. GIS was used to:

- plot the subject site on a high resolution aerial photo base and to map vegetation zones, survey effort, habitat resources and biodiversity values across the site
- calculate the extent of native vegetation to be impacted
- confirm the relevant IBRA bioregion, IBRA subregion and Mitchell Landscape for the site
- map rivers and streams and their buffer areas within the study area.

Additional GIS analysis was used to plot a 500 metre buffer area surrounding the site in which site context components were calculated. Native vegetation cover, extent and connectivity were assessed using aerial photography. Air photo interpretation was used to identify and record distinct vegetation patches, determine the broad condition state of vegetation types and the location and extent of vegetated habitat corridors. The buffer area and GIS area calculations were used to enter information about landscape value and to determine the change in Landscape Value score by assessing the impact of the proposal on native vegetation cover and connectivity as well as the patch size.



NARROMINE TO NARRABRI Access across the proposal Figure 3.5a

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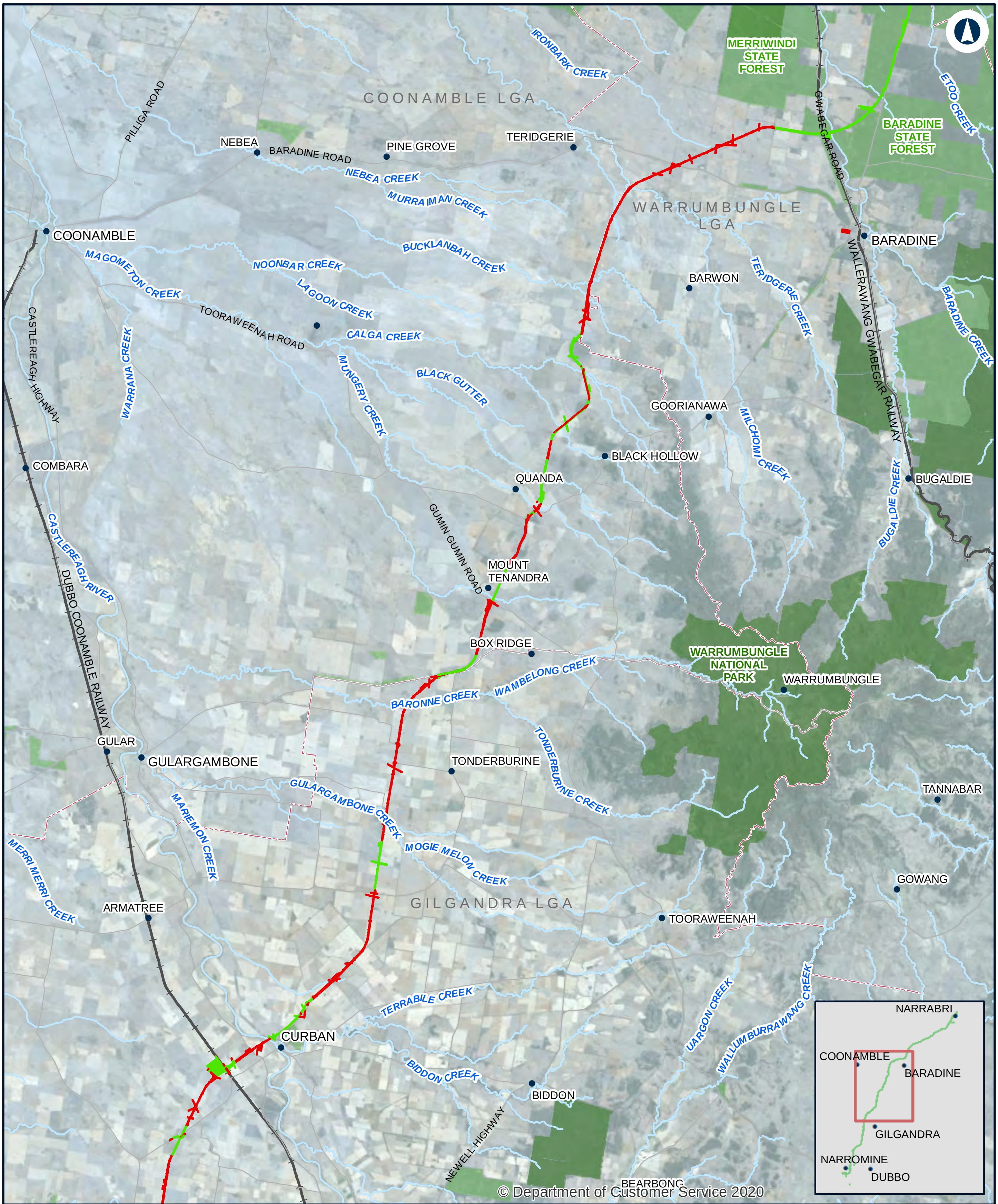

NARROMINE TO NARRABRI Access across the proposal Figure 3.5b

0 5.5 11 Km

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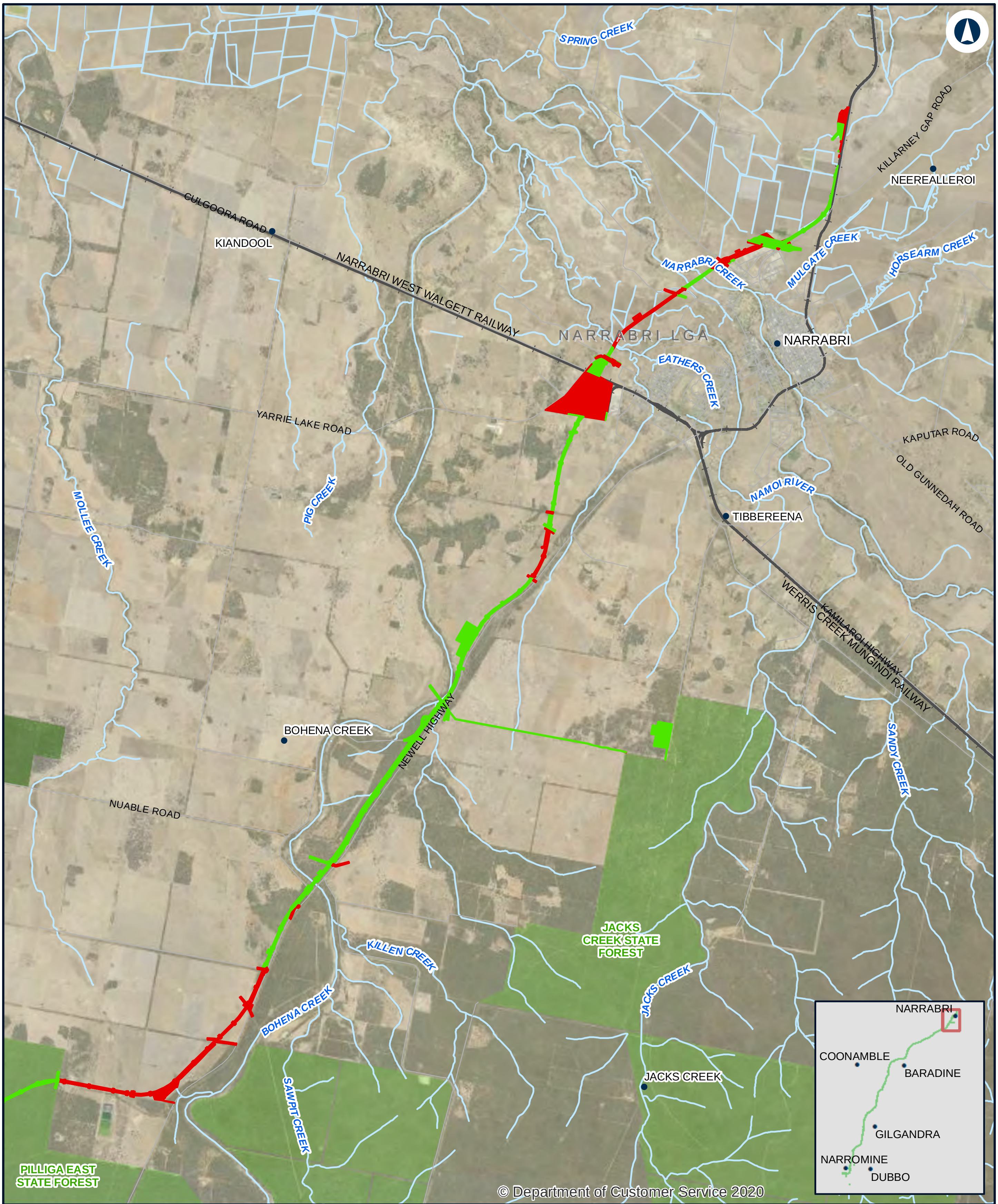

NARROMINE TO NARRABRI Access across the proposal Figure 3.5c

0 1.5 3 Km

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Author: JacobsGHD Scale: 1:125,000
Data Sources: Basemap layers: NSWSS;

LEGEND

Land access status

- Access
- No Access

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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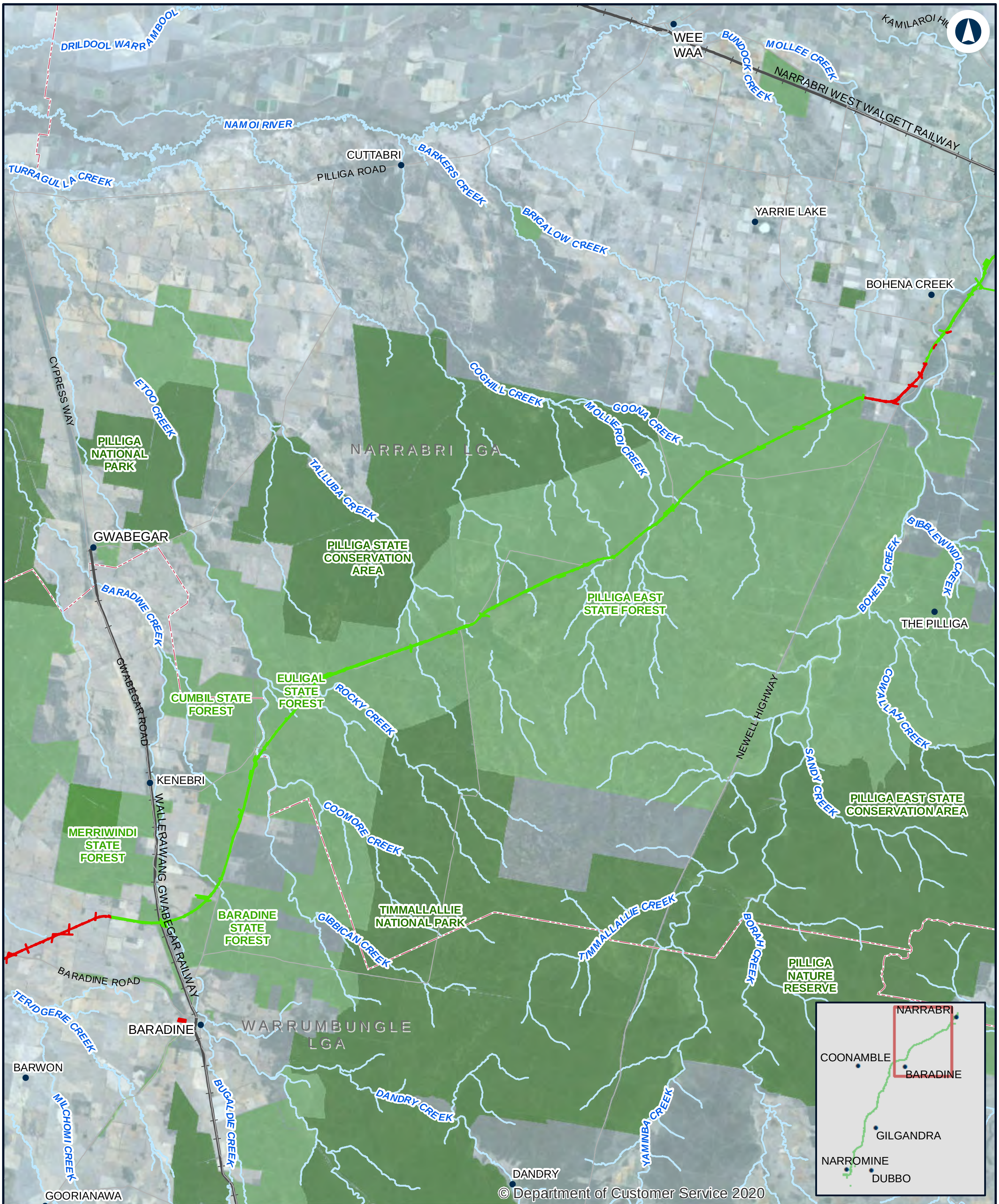

NARROMINE TO NARRABRI Access across the proposal Figure 3.5d

0 5.5 11 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:415,000
Data Sources: Basemap layers: NSWSS;

LEGEND

Land access status

- Access
- No Access

INLAND RAIL ARTC

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3.9 BAM calculations

The proposal was assessed according to the methodology presented in the BAM (OEH 2017a), and the *Biodiversity Assessment Methods Calculator Users Guide* (OEH 2017b). The credit calculator is a software application that is used to apply the BAM. Data is entered into the credit calculator based on information collected in the desktop assessment, site surveys and from using GIS mapping software. Credit calculator data is included in Appendix I.

The BAM credit calculations were performed by Leigh Maloney and Kirsten Crosby using credit calculator version 1.2.1. The biodiversity credit report is included in Appendix K. The data and assumptions used to perform the BAM credit calculations are summarised in section 9.

3.9.1 Segmented BDAR

Under the BC Act, the proposal must retire all biodiversity offset credits applicable to the proposal prior to the commencement of construction. Given the scale and complexity of Inland Rail projects and the estimated large quantity of credits required, there is a risk that the time taken to retire credits for the entire proposal as required by the BC Act could delay commencement of construction.

JacobsGHD and ARTC identified an approach to mitigate the risk of delays to construction commencement and delaying cost to ARTC of credit retirement through the preparation of a Segmented Biodiversity Development Assessment Report (Segmented BDAR), as required as part of the EIS. In this approach, an overall BDAR in accordance with the BC Act to present cumulative impacts still needs to be presented, however it also includes delineation of the impacts into separate segments (ie construction segments or portions) and associated required offsets within the BDAR. This approach of presenting the construction segments in the BDAR will provide valuable flexibility to the Principal Contractor during execution. The 11 segments comprise:

- Three major construction compounds – Three segments
  - Segment 1 – Narromine South multi-function compound
  - Segment 2 – Curban multi-function compound
  - Segment 3 – Narrabri West multi-function compound
- Four borrow pits – four segments
  - Segment 4 – borrow pit A
  - Segment 5 – borrow pit B
  - Segment 6 – borrow pit C
  - Segment 7 – borrow pit D
- Alignment – four segments
  - Segment 8 – Narromine to Curban
  - Segment 9 – Curban to Pilliga
  - Segment 10 – Pilliga
  - Segment 11 – Pilliga to Narrabri.

This BDAR contains one credit calculator and credit assessment report (see Appendix K). Despite calculations being prepared in one credit calculator, vegetation zone impacts and credit obligations for each segment are presented separately. Credit requirements would be prorated across the relevant vegetation zones for each segment. This includes for both ecosystem credits and species credits. Separate sets of maps for vegetation zones and species polygons are provided Appendix G and Appendix I.

It is important to note that delineation of the entire proposal into smaller segments can only be achieved prior to planning approval. This approach was confirmed by the BCD of DPIE at a meeting in October 2019.

The proposal will likely have the largest offset requirement of all Inland Rail NSW proposals given it has the largest footprint impacting native vegetation. Furthermore, assumed presence for some species credit species will be required due to drought conditions during the survey period and limited access to some locations. While the total cost of biodiversity offsets will be dependent on several factors. The segmented BDAR approach using one credit calculator to facilitate the staged retirement of credits over the length of the proposal has been developed to reflect the proposed construction programming, and to allow further time for the orderly creation and procurement of the required offsets

3.9.2 Predicted threatened species (ecosystem credit entities)

Based on the bioregional context for the assessment and the PCTs, patch size, vegetation cover and habitat resources present at the proposal site, the BAM calculator generates a list of threatened fauna species that are predicted to utilise the proposal site (ie potential 'predicted threatened species', or potential 'ecosystem credit entities'). The potential for these predicted threatened species to occur within the site were further refined based on the desktop assessment, habitat resources observed during field surveys, records during the surveys, and the knowledge and experience of the assessor. Targeted surveys are not required under the BAM for these species as they are assumed to be present. Targeted surveys may, however, be required if the predicted species are also listed under the EPBC Act, in order to assess the significance of impacts.

3.9.3 Candidate threatened species (species credit entities)

Threatened species that cannot reliably be predicted to occur on a development site based on PCT, distribution and habitat criteria are identified by the Threatened Biodiversity Data Collection as 'species credit' entities. In some circumstances, the particular habitat components of species assessed for ecosystem credit species, such as the breeding habitat of a cave roosting bat or forest owls, are also assessed for species credits. The credit calculator references geographic, vegetation and habitat data for the proposal site to generate a list of the species credit entities that are predicted to occur (ie the 'potential candidate threatened species').

Searches of threatened species databases were also completed to identify any additional potential candidate threatened species (to those generated by the credit calculator) that are known or predicted to occur in the locality (refer to likelihood of occurrence tables in Appendix B). The likelihood of occurrence of these additional potential candidate threatened species were reviewed, giving consideration to the habitats available in the study area. In accordance with section 6.4.1.7 of the BAM, the likelihood of occurrence has also taken into account different subregions that the proposal crosses, with separate assessments of likelihood conducted for subregions and the different segments of the proposal. These are also provided in Appendix B.

Given the scale of the proposal, detailed surveys could not be conducted in each vegetation zone across all subregions for each of the potential candidate threatened species (see section 3.6.3 and 3.10). Surveys were conducted in suitable habitat where possible with regards to access, time and seasonal constraints. In most cases, some assumption of presence has been required, based on known records, results of surveys, and habitat values present. This process has also been undertaken for breeding habitat for dual credit species. This approach was discussed with Accountable Officers at BCD in early 2020. These are BCD staff that are responsible for particular threatened species. Justification for species inclusion and exclusion are provided in Appendix I.

3.9.4 Minimum information requirements

Minimum information requirements for this BDAR are tabulated in Appendix A.

3.10 Assumptions

A 'proposal site' polygon (ie disturbance footprint) was prepared for the proposal. It is assumed that the description and spatial data accurately represent the extent of direct impacts arising from the proposal and so these data have been used to calculate the extent of removal of vegetation and habitat arising from the proposal using GIS. These calculations have in turn been relied upon in the BAM calculations and the determination of key thresholds such as whether the proposal would have a direct impact on a threatened species, whether biodiversity offsets are required for a particular impact and whether a particular impact is likely to be significant. The assessment conclusions may change as a result of the provision of an updated proposal design and/or spatial data.

Access was not possible across the entire proposal site, and surveys were also impacted by ongoing drought conditions. A survey methodology was submitted to BCD detailing the proposed approach to account for gaps in surveys. This is detailed in sections 3.3 and 3.4. A summary of survey methods and results, habitat descriptions and proposed species polygon assumptions were provided to BCD in early 2020 and discussions were held with BCD accountable officers for various species.

Justification for species polygons based on known habitat requirements, habitat values present in the study area and survey results are provided in Appendix I.

3.11 Personnel

This BDAR was prepared by Leigh Maloney (accredited assessor number 18086) and Kirsten Crosby (accredited assessor number BAAS17011) in accordance with the BAM. A technical review of the credit calculations was undertaken by Chris Thomson (accredited assessor number BAAS18058). Staff qualifications are presented in Table 3.13.

Table 3.13 Staff qualifications

Name	Position / Role	Qualifications	Relevant Experience
Leigh Maloney	Senior Ecologist (flora) Desktop assessment, field surveys, reporting	BEnvSc (Hons) Accredited BAM Assessor (BAAS18086)*	16+ years
Kirsten Crosby	Senior Ecologist (fauna) Desktop assessment, site surveys, reporting	BSc (Zoology), PhD Accredited BAM Assessor (BAAS17011)*	15+ years
Malith Weerakoon	Ecologist Desktop assessment, site surveys, reporting	BSc, MPhil. (Zoology)	5 years
Jayne Tipping	Technical Director Biodiversity Technical Review	BSc (Ecology), MEnvLaw	25+ years
Chris Thomson	Review of credit calculations	B.ASc (NatRescConsv) Accredited BAM Assessor (BAAS18058)*	19+ years

* Refer to BCT (2020) list of accredited assessors

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4. Landscape context

4.1 Introduction

The BAM requires the assessment of landscape features to help describe the biodiversity values of the subject site and assess the impacts of the proposal. Landscape features relevant to the BAM calculations are shown on Figure 4.1, discussed below and summarised in Table 4.5.

4.2 Location and land uses

The proposal would be located within a new section of proposed rail corridor between the towns of Narromine and Narrabri in western NSW. The proposal is for about 306 kilometre of single track rail line through private and public property in a ‘greenfield’ environment.

The proposal crosses five local government areas (LGAs) (Narromine Shire LGA, Gilgandra shire LGA, Coonamble Shire LGA, Warrumbungle Shire LGA and Narrabri Shire LGA).

Much of the southern and central portion of the proposal is located in land cleared for agriculture. This comprises a mix of cropped land and native grassland used for livestock. Areas of native woodland are also located in agricultural land. Where possible, the alignment has been designed to follow cadastral boundaries and road reserves to minimise impacts on properties.

In the northern end of the proposal site, large sections are located in areas dominated by vegetation associated with state forests of the Pilliga. In this area, the proposal passes through Baradine State Forest, Cumbil State Forest, Euligal State Forest and Pilliga East State Forest. The proposal also passes through heavily vegetated areas associated with travelling stock reserves, such as at Bohena Creek near Narrabri and the Macquarie River at Narromine.

4.3 Vegetation

Native vegetation generally comprise a woodland community, with the dominant canopy species including Pilliga Grey Box (*Eucalyptus pilligaensis*), Baradine Gum (*Eucalyptus chloroclada*), Poplar Box (*Eucalyptus populnea*) and White Cypress Pine (*Callitris glaucophylla*). Scattered areas of derived natural grasslands also occur. The most common PCT is Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion (PCT 88).

Five threatened ecological communities listed under the BC Act, and five listed under the EPBC Act were identified during field surveys:

- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (critically endangered - EPBC Act, critically endangered BC Act)
- Weeping Myall Woodland (endangered – EPBC Act, endangered - BC Act)
- Inland Grey Box in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South bioregions (endangered – EPBC Act, endangered - BC Act)
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverina Plains bioregions woodland (endangered – EPBC Act, endangered – BC Act)
- Fuzzy Box woodland on alluvial soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South bioregions (endangered – BC Act)
- Poplar Box grassy woodland on alluvial plains (endangered – EPBC Act).

4.3.1 Bioregion and IBRA subregion

The majority of the proposal site is located in the Brigalow Belt South Bioregion. The proposal site also approaches and crosses into the Darling Riverine Plains Bioregion at numerous points from Baradine to Narromine. Near Gilgandra and at the Narromine end, the proposal site is within the Darling Riverine Plains Bioregion.

The main IBRA subregions crossed by the proposal are the Pilliga Outwash and Pilliga, both in the Brigalow Belt South Bioregion. The proposal site also crosses the Castlereagh-Barwon and Bogan-Macquarie subregions of the Darling Riverine Plains Bioregion. These subregions are described in Table 4.1.

Table 4.1 Subregion description (Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Pilliga Outwash	Quaternary alluvial fans largely derived from Jurassic quartz sandstone.	Long slopes broken by sandy abandoned stream channels, patches of heavy grey clay and incised stream channels.	Deep texture contrast soils with harsh clay subsoils, grey clay with gilgai.	Poplar Box, Pilliga Box, Blakely's Red Gum, White Cypress Pine and Mugga on coarser soils. Belah, Brigalow, Yarran, Budda, Wilga Whitewood, Rosewood on heavier soils. River Red Gum in creek lines, occasional Silver-leaved Ironbark, White Box and Fuzzy Box in run-on sites.
Pilliga	Horizontal Jurassic quartz sandstones, limited shales, Tertiary basalt caps and plugs plus the sediments derived from these rocks.	Stepped sandstone ridges with low cliff faces and high proportion of rock outcrop. Long gentle outwash slopes intersected by sandy stream beds and prior stream channels. A few patches of heavy clay. Includes the spectacular mountain landscape of volcanic domes, plugs and dykes in the Warrumbungles.	Shallow black earths and red loams on basalts. Extensive harsh texture contrast soils, linear patterns of deep yellow sand, stony red brown earths.	White Box with White Cypress Pine and Kurrajong on the basalt hills. Blue-leaved Ironbark, White Gum, Black Cypress Pine, Whitewood, and Rough-barked Apple on stony sandstone plateau and streams. Narrow-leaved Ironbark, White Cypress Pine, Red Stringybark, patches of Green Mallee and Broomheath on gentler sandstone slopes. Pilliga Box with Grey Box, Bimble Box, Fuzzy Box, Bull Oak, Rosewood, Wilga and Budda on heavier soils in the west and north. River Red Gum lines all streams.
Castlereagh-Barwon	Extensive plains on overlapping low angle alluvial fans of several rivers. Sediment derived from Jurassic sandstones on the Castlereagh fan and from basalts on the Namoi fan. Same structure as Bogan-Macquarie.	Channels, floodplains, crevasse splays, levees, source bordering dunes and through flow swamps of past and present river systems.	Grey and brown clays on the plains and depressions. Brown loamy sands, pale yellow or red sands, and texture contrast soils on the low rises of former levees and channels.	River Red Gum on larger streams. Coolabah with occasional Weeping Myall, River Cooba, Whitewood, Belah and clumps of River Paperbark. Mitchell Grass with few trees on clay plains. Bimble Box with Wilga, Whitewood, Belah, White Cypress Pine, Silver-leaf Ironbark and occasional Brigalow on higher red soils.

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Bogan-Macquarie	Bogan and Macquarie River alluvial fans of Quaternary age. Western margin is bedrock of the Cobar bioregion. Alluvial sediments from mixed Palaeozoic bedrock bury basement rock to 100 metres. Underlying sediments of Cretaceous and Jurassic age form part of the Great Artesian Basin.	Channels, floodplains, and through flow swamps of past and present river systems.	Grey and brown clays on the plains and depressions with texture contrast soils on the low rises of former levees and channels.	River Red Gum and River Cooba on the channels. White Cypress Pine and Bimble Box on coarser levees. Black Box, Belah, Weeping Myall and Lignum on floodplains. Complex patterns of Common Reed, Cumbungi, and Water Couch depending on water levels in marshes. Bimble Box woodland with Wilga, Budda, White Cypress Pine, Grey Box, Yellow Box and Blakely's Red Gum on red soils on fan margins.

4.3.2 NSW landscape region (Mitchell Landscapes)

The proposal site crosses many NSW landscape regions. The main landscapes crossed by the proposal site are listed below (Table 4.2); descriptions provided are from DECC (2002).

Table 4.2 NSW landscape description (DECC 2002)

NSW soils landscape	General location	Description
Coghill Alluvial Plains	Bohena Creek district, Narrabri	Distal parts of the Quaternary alluvial fans largely derived from Jurassic quartz sandstone on streams draining from the Pilliga forests. Long gentle slopes broken by sandy abandoned stream channels (sand monkeys), patches of heavy grey clay, and contemporary incised stream channels. General elevation 200 to 280 metres, local relief 5 to 9 metres. Deep texture-contrast soils with harsh clay subsoils, grey clay with gilgai. Open forest of White Cypress Pine (*Callitris glaucophylla*), Bimble Box (*Eucalyptus populnea*), Pilliga Box (*Eucalyptus pilligaensis*), Blakely's Red Gum (*Eucalyptus blakelyi*), and Red Ironbark (*Eucalyptus sideroxylon*). Brown Bloodwood (*Corymbia trachyphloia*) and grass trees (*Xanthorrhoea* sp.) on sand monkeys. Patches of Bull Oak (*Allocasuarina luehmannii*) or Brigalow (*Acacia harpophylla*) on gilgai in heavy clay. Baradine Red Gum (*Eucalyptus dealbata*) and River Red Gum (*Eucalyptus camaldulensis*) in creek lines.
Baradine – Coghill Channels and Floodplains	Bohena Creek district, Narrabri Pilliga State Forest	Sandy incised channels and distributary streams on Quaternary alluvium in fans of Coghill and Baradine Creeks flowing from the sandstones of the Pilliga forest. General elevation 170 to 210 metres, local relief 10 metres. Deep texture-contrast soils with harsh clay subsoils, grey clay with gilgai and uniform deep yellow sands. Sediments and soils become finer down valley merging with the Coghill Alluvial Plains ecosystem. Gallery woodland dominated by River Red Gum (*Eucalyptus camaldulensis*) along the channels. Other species including; Bimble Box (*Eucalyptus populnea*), Pilliga Box (*Eucalyptus pilligaensis*), Blakely's Red Gum (*Eucalyptus blakelyi*), White Cypress Pine (*Callitris glaucophylla*) and Red Ironbark (*Eucalyptus sideroxylon*) and occasional Silver-leaved Ironbark (*Eucalyptus melanophloia*).
Cubbo Uplands	Pilliga State Forest	Pilliga horizontal Jurassic quartz sandstones, limited shales, Tertiary basalt caps and plugs plus the sediments derived from these rocks. Stepped sandstone ridges with low cliff faces and high proportion of rock outcrop. Long gentle outwash slopes intersected by sandy streambeds and prior stream channels. A few patches of heavy clay. General elevation 400 to 550 metres, local relief 50 metres. On sandstone, the ridge tops have thin discontinuous soils with stony, sandy profiles and low nutrients. Down slope texture-contrast soils are more common typically with harsh clay subsoils and in the valley floors sediments tend to be sorted into deep sands with yellow earthy profiles, harsh grey clays, or more texture-contrast soils with a greater concentration of soluble salts.

NSW soils landscape	General location	Description
		The sandstone outcrop areas support various forests and woodlands including; Blue-leaved Ironbark (*Eucalyptus fibrosa* ssp. *nubila*), Scribbly Gum (*Eucalyptus rossii*), Black Cypress Pine (*Callitris endlicheri*), Whitewood (*Atalaya hemiglauca*), and Rough-barked Apple (*Angophora floribunda*). Stony hills in the north of the region carry mallee patches with; Silver-leaved Ironbark (*Eucalyptus melanophloia*), Spotted Gum (*Corymbia maculata*), and Smooth-barked Apple (*Angophora costata*). Gentler sandstone slopes over most of the region carry; Narrow-leaved Ironbark (*Eucalyptus crebra*), White Cypress Pine (*Callitris glaucophylla*), Red Stringybark (*Eucalyptus macrorhyncha*), patches of Green Mallee (*Eucalyptus viridis*) and Broombush Heath (*Melaleuca uncinata*). In western and northern sections on texture-contrast or more uniform harsh clay soils forests of Pilliga Box (*Eucalyptus pilligaensis*), Grey Box (*Eucalyptus microcarpa*), Bimble Box (*Eucalyptus populnea*), and Fuzzy Box (*Eucalyptus conica*) are found with stands of Bull Oak (*Allocasuarina luehmannii*), Rosewood (*Alectryon oleifolium*), Whitewood (*Atalaya hemiglauca*), Wilga (*Geijera parviflora*), Belah (*Casuarina cristata*), Yarran (*Acacia homalophylla*), and Budda (*Eremophila mitchellii*).
Baradine Alluvial Plains	Baradine district	Similar to Baradine - Coghill Channels and Floodplains Ecosystem with slightly more western influence in the vegetation. Floors and channels on Quaternary alluvial fans derived from Jurassic quartz sandstone. Long shallow slopes of alluvial fans, broken by abandoned stream channels, patches of heavy grey clay and incised sandy bed streams. General elevation 280 to 160 metres, local relief 5 to 15 metres. Deep texture-contrast soils with harsh clay subsoils, grey clay with gilgai and linear strings of uniform deep yellow sands (sand monkeys). Limited areas of source bordering dune on the eastern side of the main streams. Sediments and soils become finer down fan merging with the Coghill Alluvial Plains ecosystem. Gallery woodland dominated by Baradine Red Gum (Eucalyptus dealbata) and River Red Gum (*Eucalyptus camaldulensis*) along the channels. Other species include; Bimble Box (*Eucalyptus populnea*), Pilliga Box (*Eucalyptus pilligaensis*), Blakely's Red Gum (*Eucalyptus blakelyi*), White Cypress Pine (*Callitris glaucophylla*), Red Ironbark (*Eucalyptus sideroxylon*) and Silver-leaved Ironbark (*Eucalyptus melanophloia*). Belah (*Casuarina cristata*), Yarran (*Acacia homalophylla*), Budda (*Eremophila mitchellii*), Wilga (*Geijera parviflora*), Whitewood (*Atalaya hemiglauca*), Warrior Bush (*Apophyllum anomalum*) and Rosewood (*Alectryon oleifolium*) on heavier soils.

NSW soils landscape	General location	Description
Teridgerie Alluvial Plains	Baradine district	Holocene fluvial sediments of backplain and channelised backplain facies on the Teridgerie Creek, relief to 10 metres. Brown silty clay with patches of sand and carbonate nodules deposited from suspended sediments in floodwater, often with gilgai in grey and brown clays. Elevated areas with red-brown texture-contrast soils. Sediment grain size increases toward the ranges. Open grasslands with scattered Coolibah (*Eucalyptus microtheca*), Black Box (*Eucalyptus largiflorens*), River Cooba (*Acacia stenophylla*), Bimble Box (*Eucalyptus populnea*), Belah (*Casuarina cristata*), Lignum (*Muehlenbeckia cunninghamii*), chenopods, Warrior Bush (*Apophyllum anomalum*) and Weeping Myall (*Acacia pendula*). Extensively cleared, cropped and grazed.
Castlereagh Alluvial Plains	Baradine to Gilgandra	Holocene fluvial sediments of backplain and channelised backplain facies of the Marra Creek Formation associated with the Castlereagh River main alluvial fan and distributary stream system, relief 1 to 3 metres. Dark yellow-brown silty clay with patches of sand and carbonate nodules deposited from suspended sediments in floodwater, often with gilgai. Slightly elevated areas with red-brown texture-contrast soils. Open grasslands with scattered Coolibah (*Eucalyptus microtheca*), Black Box (*Eucalyptus largiflorens*), River Cooba (*Acacia stenophylla*), Bimble Box (*Eucalyptus populnea*), Belah (*Casuarina cristata*), Lignum (*Muehlenbeckia cunninghamii*), saltbush (*Atriplex* sp.), Warrior Bush (*Apophyllum anomalum*) and Weeping Myall (*Acacia pendula*).
Goonoo Slopes	Gilgandra to Narromine	Extensive undulating to stepped low hills with long slopes on sub-horizontal Triassic/Jurassic quartz sandstone, conglomerates, siltstone, shale and some coal. General elevation 300 to 500 metres with overall westerly slope, poorly defined drainage network, local relief to 30 metres. Stony yellow earths with sandstone outcrop on ridgelines to yellow harsh texture-contrast soils in shallow valleys. Broad-leaved Ironbark (*Eucalyptus fibrosa* ssp. *fibrosa*) and Black Cypress Pine (*Callitris endlicheri*) on ridges. Broad-leaved Ironbark, Narrow-leaved Ironbark (*Eucalyptus crebra*), Red Ironbark (*Eucalyptus sideroxylon*), Fringe Myrtle (*Calytrix tetragona*), Spur-wing Wattle (*Acacia triptera*), Dainty Phebalium (*Phebalium obcordatum*), Daphne Heath (*Brachyloma daphnoides*) on slopes with patches of Green Mallee (*Eucalyptus viridis*), Dwyer's Mallee Gum (*Eucalyptus dwyeri*) and Broombush (*Melaleuca uncinata*). Grey Box (*Eucalyptus microcarpa*), Red Ironbark (*Eucalyptus sideroxylon*), Red Stringybark (*Eucalyptus macrorhyncha*), Fuzzy Box (*Eucalyptus conica*) and Blakely's Red Gum (*Eucalyptus blakelyi*) with Knob Sedge (*Carex inversa*), and Tall Sedge (*Carex appressa*) along streams.

NSW soils landscape	General location	Description
Boggy Cowal Alluvial Plains	Narromine	Pleistocene fluvial sediments of backplain facies of the Carrabear Formation associated with the Boggy Cowal distributary stream system. Medium to heavy grey cracking clays with extensive gilgai. Carbonate nodules common in the subsoil and worked to gilgai crests, local relief to 2 metres. Extensive grasslands with scattered stands of myall (*Acacia pendula*), Bimble Box (*Eucalyptus populnea*), Black Box (*Eucalyptus largiflorens*) and Belah (*Casuarina cristata*).

4.3.3 Soils and geology

Soil hazards

Hydrogeological landscape mapping exists for the western study area of the Central West Catchment Management Authority (Wooldridge *et al.* 2012), which covers the southern portion of the proposal site from Baradine to Narromine. The proposal site crosses many hydrogeological landscape regions. The main landscapes crossed by the proposal site are listed below (Table 4.3). There is no acid sulfate soil risk mapping data for the proposal site.

Table 4.3 Soil hazard features (Wooldridge *et al.* 2012)

Hydrogeological landscape	Overall sodicity hazard	Overall salinity hazard
Castlereagh Keelindi	Moderate	Low
Cobboco	Moderate	Moderate
Goorianawa	Moderate	High
Gular Outwash	Very high	High
Kickabil	Moderate	Low
Pine Clump	Moderate	Low
Teridgerie Outwash	High	High
Warrumbungles Outwash	Moderate	Moderate

Areas of geological significance

There are no karst, caves, crevices, cliffs or other areas of geological significance located within the subject site or buffer area surrounding the site.

4.3.4 Climate

The climate of the proposal site is warm and temperate. In the south at Narromine, the average rainfall is 579 millimetres, with the lowest rainfall in June and the highest in January, although there is little difference between the months. January is the hottest month, with the overall average of 25.5 °C and average maximum of 32.8 °C. July is the coldest month, with an overall average of 9.5 °C and average minimum of 3.6 °C.

In the north at Narrabri, about 658 mm of precipitation falls annually, with lowest rainfall in September and highest in January. January is also the warmest month in Narrabri with an average of 26.4 °C and maximum of 33.8 °C, while July is the coldest month of the year with an average of 10.6 °C and minimum of 3.8 °C.

4.3.5 Hydrology

Rivers and streams

The proposal is located within the major water catchments of the Macquarie Bogan River Basin, Castlereagh River Basin and the Namoi River Basin.

The proposal site crosses three rivers (Macquarie River, Castlereagh River and Namoi River) and up to 121 creeks and other intermittent unnamed watercourses and canals constructed to convey irrigation waters. Key waterways include Baradine Creek, Bohena Creek, Marthaguy Creek, Baronne Creek, Etoo Creek, Cubbo Creek, Teridgerie Creek, Bundijoe Creek, Milpulling Creek, Pint Pot Creek, Native Dog Creek, Goulburn Creek and Emogandy Creek.

During most field survey periods, water was present in the Macquarie River, Namoi River and Narrabri Creek only. After heavy rain during the November 2018 field surveys, some of the smaller creeks flowed for a short time, and pools of water were observed on roadsides. Heavy rain in March 2019 led to flows in Baradine Creek and the Castlereagh River, with some pools still present in these waterways in September 2019.

Important and local wetlands

The proposal site does not cross any important wetlands listed in the Directory of Important Wetlands in Australia (DIWA). The nearest important wetlands are Lake Goran, approximately 110 kilometres upstream to the east of Baradine; the Macquarie Marshes, approximately 80 kilometres downstream to the west of Gilgandra; and Gwydir Wetlands, approximately 105 kilometres downstream to the north of Narrabri. The proposal site does not cross any Ramsar wetlands, the nearest being the Macquarie Marshes Nature Reserve. Due to the significant distance from the study area it is unlikely the wetland will be affected by proposal activities. The Macquarie Marshes are the only wetland within the catchment area of the proposal.

Narrabri Lake is within the catchment area of the proposal and is located about 1.5 kilometres upstream to the east of the proposal site in Narrabri. It is an artificial lake that was created in 1991 by the damming of the ephemeral O'Briens Creek. When full it covers about 30 hectares, and also occasionally dries out during extended dry periods. The lake includes small areas of trees, as well as open grasslands, reed beds, mudflats and open water. The bird list for the lake produced by Narrabri Shire and the Local Land Services North West identifies that threatened species, including the Australian Painted Snipe (*Rostratula australis*), Magpie Goose (*Anseranas semipalmata*), Little Lorikeet (*Parvipsitta pusilla*), Square-tailed Kite (*Lophoictinia isura*) and Little Eagle (*Hieraaetus morphnoides*) have been recorded, as have the migratory Latham's Snipe (*Gallinago hardwickii*) and Sharp-tailed Sandpiper (*Calidris acuminata*) (Narrabri Shire and LLS 2013).

The Pilliga Outwash Ephemeral Wetlands in the Brigalow Belt South Bioregion are an endangered ecological community listed under the BC Act and are located about five kilometres downstream (north-west) of the alignment through the Pilliga forest at their closest point. These comprise either tank or shallow basin wetlands, and are generally under one hectare in size (EES 2019b). Bell et al (2012) mapped 340 of these wetlands in a restricted area of the Pilliga Outwash.

A small area of PCT 247 Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion is crossed by the proposal site south of Narromine. This wetland was dry during surveys, but is likely to contain water following heavy rain events.

4.3.6 Connectivity features

Wildlife corridors are vital for the maintenance of ecological processes, including the movement of animals and the continuation of viable populations. Corridors can consist of a sequence of stepping stones across the landscape (discontinuous areas of habitat such as paddock trees, wetlands and roadside vegetation), continuous lineal strips of vegetation and habitat (such as riparian strips, ridge lines etc.), or they may be parts of an extensive patch of vegetation (DEC 2004).

Connectivity is provided in the study area by:

- the Pilliga Forests
- large vegetated tracts associated with Crown Land/Travelling Stock Reserves (eg Bohena Creek and along the Newell Highway)
- vegetated riparian corridors (eg Narrabri Creek, Namoi River, Castlereagh River, Macquarie River, Kickabil Creek)
- vegetated road reserves and paper roads
- small isolated patches of woodland within farmland
- paddock trees.

The Pilliga Forests comprise about 3,000 square kilometres of semi-arid woodland and is the largest continuous woodland remnant in NSW. Extensive areas of connected vegetation such as the Pilliga provide habitat for large fauna and flora assemblages as they provide a mosaic of habitat types, and large areas of habitat for species that occur in low densities. Birdlife International (2019) has identified the Pilliga (also incorporating the Warrumbungles National Park) as an important bird area (IBA). IBAs are places of international significance for the conservation of birds and other biodiversity. The Pilliga forests provide important habitat and movement corridors for many species.

Areas of Crown land (including travelling stock reserves) occur throughout the proposal site and buffer. These often occur along road reserves, paper roads (eg ‘laneways’ along property boundaries) or in association with creeks and rivers, and provide continuous linear strips of vegetation. In some locations these connect to larger patches of vegetation elsewhere, providing increased connectivity in the landscape.

Stepping stone connectivity is provided by small patches of woodland vegetation retained in farmland, as well as isolated paddock trees. These areas are particularly important for mobile species such as birds and bats.

See section 9.2.1 for a detailed discussion of connectivity.

4.3.7 Areas of outstanding biodiversity value

Areas of Outstanding Biodiversity Value are special areas with irreplaceable biodiversity values that are important to the whole of NSW, Australia or globally. These are areas declared by the NSW Minister for the Environment. No declared Areas of Outstanding Biodiversity Value are intersected by the proposal site or are located near the proposal site.

4.4 Determining site context

To determine site context as required under Section 4.3 of the BAM, an assessment of native vegetation cover and patch size in accordance with Subsections 4.3.2 and 5.3.2 of the BAM have been undertaken and are outlined below.

4.4.1 Native vegetation cover

Native vegetation cover within the proposal site and a 500-metre buffer area along each side of the centre line of the proposal site was determined in accordance with Subsection 4.2.2 of the BAM. This is summarised in Table 4.4. This value is used by the BAM calculator as a filter to predict threatened species likely to occur in the proposal site.

Table 4.4 Native vegetation cover

Assessment area	Total assessment area (ha)	Area of native vegetation cover (ha)	Native vegetation percentage cover
500 metres along each side of the centre line of the proposal site	36,513	16,562	45.36%

4.4.2 Patch size

Patch size is defined under the BAM (OEH 2017) as an area of native vegetation that:

1 occurs on the development site or stewardship site, and
2 includes native vegetation that has a gap of less than 100 metres from the next area of moderate to good native vegetation (or ≤ 30 metres for non-woody ecosystems).

Patch size may extend onto adjoining land that is not part of the proposal site. Patch size area is assigned to each vegetation zone as a class, being < 5 hectares, 5-24 hectares, 25-100 hectares or ≥ 100 hectares, and is used by the BAM calculator as a filter to predict threatened species likely to occur in the proposal site.

In most cases patch size was greater than 100 hectares and therefore patch size for these zones was entered as 101. For discontinuous vegetation zones, patch size was assessed for each discontinuous polygon. Where different patch sizes were recorded, multiple patch sizes were entered. This occurred in only one vegetation zone. For discontinuous vegetation zones where the patch size was the same for discontinuous polygons, the same patch size was entered for the entire vegetation zone.

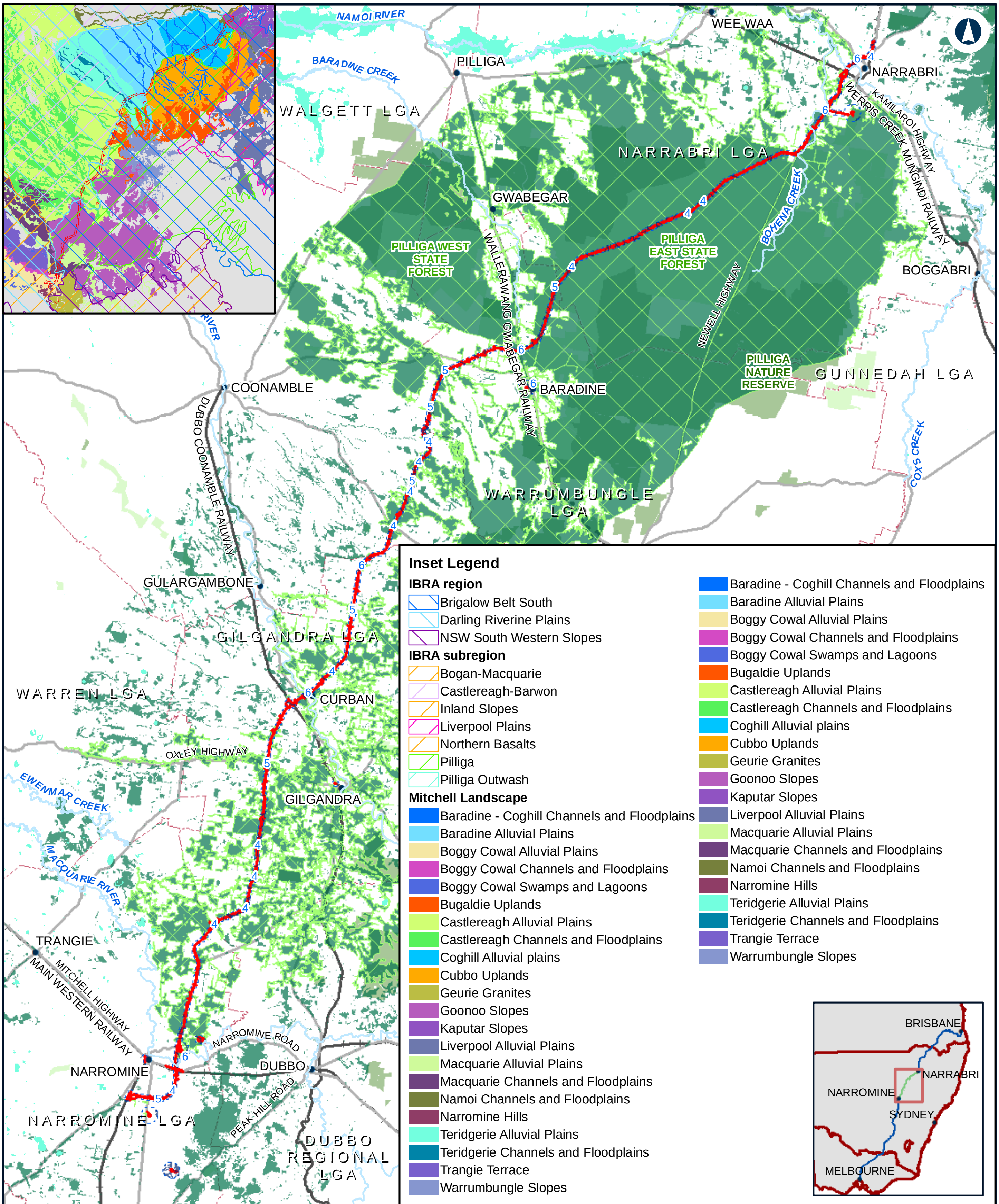
4.5 Summary of landscape features

A summary of landscape features relevant to the BAM is provided in Table 4.5 and relevant features are mapped on Figure 4.1.

Table 4.5 Landscape features

Landscape feature	Proposal site
Method applied for site context components	Linear-shaped development
Interim Biogeographic regionalisation of Australia (IBRA) bioregion	Brigalow Belt South Darling Riverine Plains
IBRA subregion	Pilliga Pilliga Outwash Castlereagh-Barwon Bogan-Macquarie

Landscape feature	Proposal site
Mitchell landscapes	Coghill Alluvial Plains Cubbo Uplands Baradine Alluvial Plains Teridgerie Alluvial Plains Goonoo Slopes Castlereagh Alluvial Plains
Native vegetation extent within buffer area	16,562 hectares
Rivers, streams and estuaries	• Macquarie River (9th order stream) • Castlereagh River (7th order stream) • Namoi River (9th order stream) Up to 121 creeks and other intermittent unnamed watercourses and canals constructed to convey irrigation waters. Includes 5^{th}, 6^{th} and 7^{th} order ephemeral creeks and streams.
Wetlands	There are no Important Wetlands as listed in the Directory of Important Wetlands of Australia in the proposal site.
Connectivity features	• The Pilliga Forests • Large vegetated tracts associated with Crown land/Travelling Stock Reserves (eg Bohena Creek and along the Newell Highway) • Vegetated riparian corridors (eg Narrabri Creek, Namoi River, Castlereagh River, Macquarie River, Kickabil Creek) • Vegetated road reserves and paper roads • Small isolated patches of woodland within farmland • Paddock trees
Areas of geological significance or soil hazard features	Goorianawa, Gular Outwash and Teridgerie Outwash hydrological landscapes have high salinity hazard ratings and moderate to very high sodicity hazard ratings.
Other landscape features	There are no areas of geological significance or outstanding biodiversity value identified within the proposal site.
Current per cent native vegetation cover in the buffer area	45.36 per cent
The future per cent native vegetation cover in the buffer area	40.54 per cent



NARROMINE TO NARRABRI

Landscape Features

Figure 4.1

0 10 20 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:1,100,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS;

LEGEND

- The proposal
- Buffer area
- Native vegetation
- Native vegetation patch size (>1000ha)
- Wetlands NSW
- Riparian buffer

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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5. Native vegetation

5.1 Overview

5.1.1 Native vegetation extent

With the exception of the Pilliga forests region, the majority of the study area has been cleared of large tracts of native vegetation and is used for agriculture, predominately grazing of livestock and dryland cropping. The dominant vegetation is represented by a mix of native and introduced pastures. A large proportion of the southern part of the study area has been cultivated and is comprised of improved pasture dominated by exotic species. The northern portion of the study area has been cleared but supports derived native grasslands dominated by a few native grass species.

The construction footprint including native and non-native vegetation is about 3316 hectares. The extent of native vegetation is about 1732 hectares and comprises remnant native woodland patches and derived native grassland. There is approximately 1584 hectares of non-native vegetation in the proposal site comprising cropping, horticulture, exotic pastures or exotic grassland, and planted windbreaks of non-native vegetation.

5.2 Plant community types

Thirty-nine PCTs have been identified in the construction footprint. While some of the native grasslands in the investigation corridor are naturally occurring, most occur as derived grasslands that are continuous with the understories of the remnant woodland patches in the study area and are considered to be derived from the clearing of the original woodland PCT. For this reason, some areas of derived native grassland have been assigned to the woodland PCTs that would have originally occurred. In determining the original woodland PCT that would have occurred at a location, consideration was given to nearby woodland patches (within and outside of the study area) and any scattered paddock trees present.

The vegetation types (including PCTs, derived grassland and non-native or non-indigenous vegetation) mapped within the proposal site are summarised in Table 5.1 and described in detail in Appendix B. PCTs are mapped in Appendix G.

Vegetation profiles for the 39 PCTs identified in the proposal site and justification for selection of these PCTs are in Appendix B.

5.2.1 Vegetation zones

Where appropriate, PCTs were allocated to vegatation zones according to different vegetation condition within PCTs. Where condition was different across a PCT, multiple condition zones were allocated to a PCT. The ongoing drought conditions, and management for agricultural practices meant that some PCTs were in a similar condition across the proposal site and across PCTs. Many areas of native vegatation within the proposal site retained a layer of native canopy and shrub vegatation with a mixed native and introduced understorey and were assigned to a 'good' condition despite the lack of groundcover species due to drought. Obvious changes to condition were separated into different zones including areas where communities were derived due to past fires, landholder management (eg manual removal of a stratum) and previous clearing of parts of the canopy. A total of 42 vegetation zones were identified in the proposal site. Vegetation zones are outlined in Table 5.2 and maps are in Appendix G. Finer scale maps showing greater detail are provided in Part E of the EIS in the Map Books.

Table 5.1 Plant Community Types in the proposal site

Plant Community Type	BC Act status	EPBC Act status	Extent in proposal site (ha)
PCT 27- Weeping Myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South Bioregion	Myall Woodland in the Darling Riverine Plains, Brigalow Bet South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	Weeping Myall Woodlands	3.05
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	Brigalow (*Acacia harpophylla* dominant and co-dominant)	0.61
PCT 36 River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Not listed	Not listed	5.08
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Not listed	Not listed	176.10
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	Not listed	Not listed	0.21
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	Not listed	* Occurrence of this PCT does not meet Poplar Box grassy woodlands on alluvial plains definition	19.5
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Not listed	Not listed	26.23
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Not listed	Not listed	277.79
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	Not listed	Not listed	29.47

Plant Community Type	BC Act status	EPBC Act status	Extent in proposal site (ha)
PCT145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion	Not listed	Not listed	53.99
PCT 148 Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	Not listed	Not listed	45.04
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	Not listed	Not listed	8.56
PCT 185 - Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland	Not listed	Not listed	1.37
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions	Not listed	3.59
PCT 206 Dirty Gum – Whit Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion	Not listed	Not listed	12.66
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	Not listed	Poplar Box grassy woodlands on alluvial plains	31.84
PCT 247 Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion	Not listed	Not listed	6.91
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	14.71

Plant Community Type	BC Act status	EPBC Act status	Extent in proposal site (ha)
PCT 250 Derived tussock grassland of the central western plains and lower slopes of NSW	Not listed	Not listed	82.84
PCT 255 - Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion	Not listed	Not listed	11.77
PCT 256 - Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	Not listed	Not listed	0.27
PCT 394 Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	Not listed	Not listed	69.66
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	Not listed	Not listed	15.78
PCT 398 Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Not listed	Not listed	369.78
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Not listed	Not listed	53.71
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Not listed	Not listed	23.05
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	Not listed	Not listed	2.30
PCT 409 Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	Not listed	Not listed	0.82

Plant Community Type	BC Act status	EPBC Act status	Extent in proposal site (ha)
PCT 411 - Buloke - White Cypress Pine woodland on outwash plains in the Piliga Scrub and Narrabri regions, Brigalow Belt South Bioregion	Not listed	Not listed	8.76
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion	Not listed	Not listed	7.32
PCT435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	White Box Yellow Box Blakely’s Red Gum Woodland	This patch does not meet EPBC definition	6.11
PCT 436 Derived Kurrajong grassy open woodland / isolated trees in the Brigalow Belt South Bioregion and Nandewar Bioregion	Not listed	Not listed	5.98
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	Not listed	Not listed	1.11
PCT 473 - Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	Not listed	Not listed	15.26
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	This patch does not meet community definition	This patch does not meet EPBC definition	1.23
PCT 599 Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	White Box Yellow Box Blakely’s Red Gum Woodland	White Box-Yellow Box-Blakely’s Red Gum Grassy Woodland and Derived Native Grassland	2.21
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	Not listed	Not listed	326.26

Plant Community Type	BC Act status	EPBC Act status	Extent in proposal site (ha)
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	Not listed	Not listed	2.12
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	Not listed	Not listed	8.77
			1731.82 ha

* Dominated by Belah and did not contain >50% Poplar Box to meet EPBC listing.

Table 5.2 PCTs and allocated vegetation zones in the proposal site

PCT ID	Veg zone #	Vegetation zone - condition	Area (ha)	Patch size category	Minimum plot number required
27	1	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion - good	3.05	101	2
35	2	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – good	0.61	101	1
36	3	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion - good	5.08	101	3
49	4	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – derived	176.1	101	6
55	5	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – good	0.21	101	1
56	6	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW - good	19.5	25-100	3
78	7	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion - good	26.23	101	4

PCT ID	Veg zone #	Vegetation zone - condition	Area (ha)	Patch size category	Minimum plot number required
88	8	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion - good	276.14	101	7
88	9	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – degraded	1.65	101	1
141	10	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion - good	29.47	101	4
145	11	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion - good	53.99	101	5
148	12	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion - good	45.04	101	4
168	13	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain - derived	8.56	<5	3
185	14	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – moderate	1.37	5-25	1
202	15	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) - good	3.59	2	2
206	16	Dirty Gum – Whit Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion - good	12.66	101	3
244	17	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) - good	31.84	25-100	4
247	18	Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion - good	6.91	25-100	3
248	19	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW - good	14.71	101	3
250	20	Derived tussock grassland of the central western plains and lower slopes of NSW - derived	82.84	101	5
255	21	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion - good	11.77	101	3

PCT ID	Veg zone #	Vegetation zone - condition	Area (ha)	Patch size category	Minimum plot number required
256	22	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion - good	0.27	101	1
394	23	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – fire derived	10.87	101	3
394	24	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions - good	58.79	101	5
397	25	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion - good	15.78	101	3
398	26	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion (derived, shrubs removed)	8.5	101	3
398	27	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion - good	361.28	101	7
399	28	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion - good	53.71	101	5
404	29	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests - good	23.05	101	4
406	30	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests - good	2.3	101	2
409	31	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion - good	0.82	101	1
411	32	Buloke - White Cypress Pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, Brigalow Belt South Bioregion - good	8.76	101	3
414	33	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion - good	7.32	101	3

PCT ID	Veg zone #	Vegetation zone - condition	Area (ha)	Patch size category	Minimum plot number required
435	34	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion - good	6.11	101	3
436	35	Derived Kurrajong grassy open woodland / isolated trees in the Brigalow Belt South and Nandewar bioregions – degraded	5.98	101	3
444	36	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion - good	1.11	25-100	1
473	37	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion - good	15.26	101	3
589	38	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion - good	1.23	101	1
599	39	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions - good	2.21	25-100	2
619	40	Derived Wiregrass grassland of the NSW Brigalow Belt South and Nandewar bioregions - derived	326.26	101	7
746	41	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion - good	2.12	101	2
1384	42	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion - good	8.77	101	3
-		Non-native vegetation	1498.63 ha	-	-

5.2.2 Threatened ecological communities (BC Act)

Of the seven potentially occurring NSW threatened ecological communities in the investigation corridor, five were recorded in the proposal site during field surveys (see Table 5.3). All five equivalent PCTs are more than 80 per cent cleared and are listed as endangered ecological communities. Threatened ecological communities listed under the BC Act are mapped on Figure 5.1. Threatened ecological communities listed under the EPBC Act are discussed in section 7.1.

Multiple PCTs can be part of a threatened ecological community. Condition of a PCT can also affect whether it fits the criteria of a threatened ecological community.

PCT 589 occurs in the proposal footprint and this PCT can form part of the Box-Gum Woodland endangered ecological community. However, the occurrence of this community was on private property and had been recently cleared with the groundcover and canopy almost completely removed. The PCT in this location could only be classified based on what remained connected outside the proposal site and evidence of felled canopy trees on the ground. The process of clearing had removed most groudcover species with remaining groundcover plants limited to scattered plants near the boundary of fences and remaining trees outside the proposal site in the wider study area. Only a few small scattered White Cypress Pine trees remained in the proposal site occurrence of this PCT. Therefore the occurrence of this PCT in the proposal site was not considered to form part of the BC Act listing of Box-Gum Woodland.

PCT 619 also occurs in the proposal footprint and this PCT can form part of the Box-Gum Woodland endangered ecological community. Occurrences of PCT 619 are not located near occurrences of Box Gum Woodland, and are thus not likely to be a derived form of this threatened ecological community.

Table 5.3 NSW threatened ecological communities in the proposal site

Community name	PCT in proposal site	BioNet database % cleared	Extent in proposal site (ha)
Myall Woodland in the Darling Riverine Plains, Brigalow Bet South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	27	86	3.05
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	35	90	0.61
Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions	202	75	3.59
Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	248	80	14.71
White Box Yellow Box Blakely's Red Gum Woodland	599 435	80 58	2.21 6.11

NARROMINE TO NARRABRI Threatened Ecological Communities Figure 5.1a

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 6/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

The proposal

Plant community type name

Inland Grey Box woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions

White Box - Yellow Box - Blakely's Red Gum Woodland (SAII entity)

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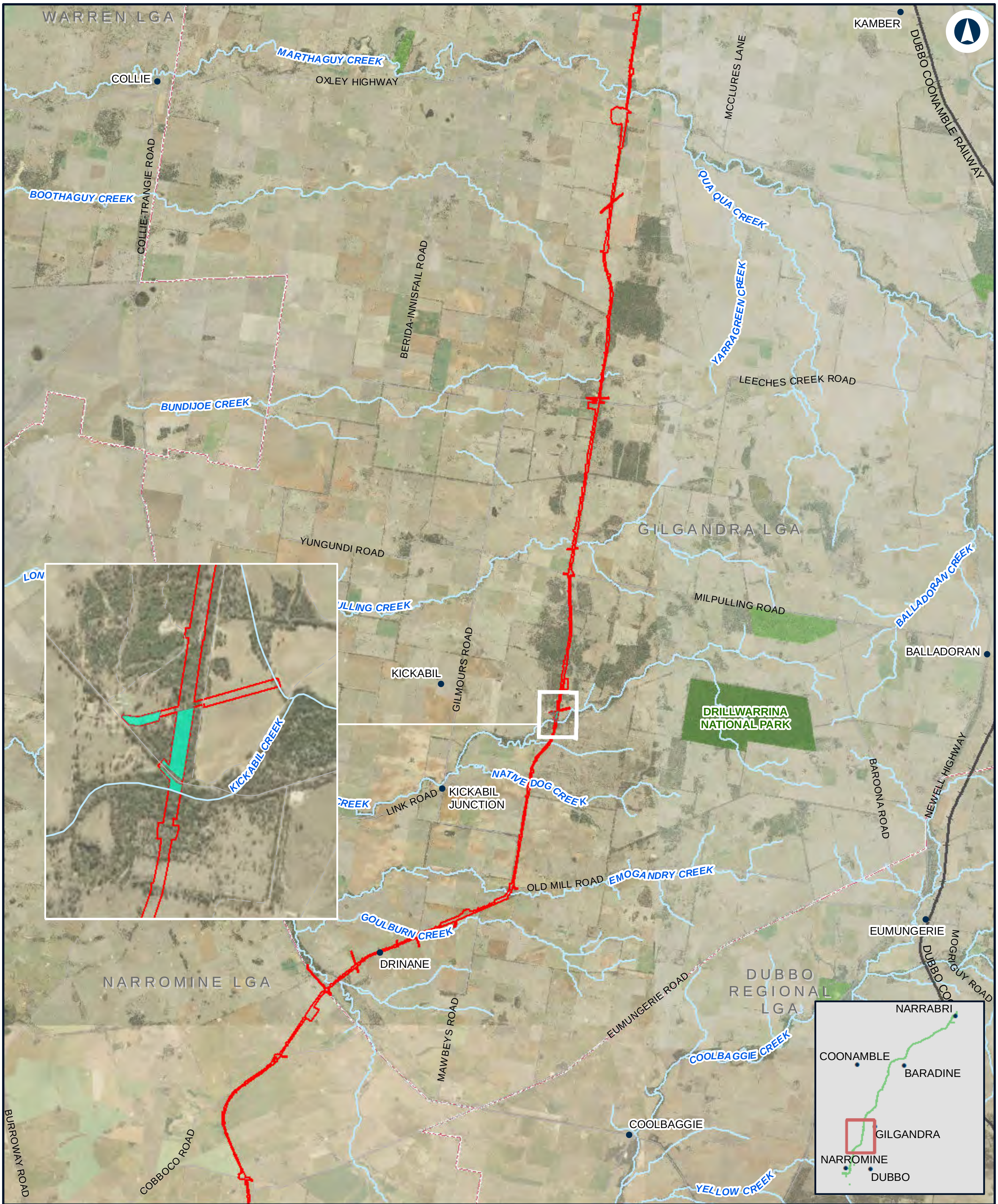

NARROMINE TO NARRABRI

Threatened Ecological Communities

Figure 5.1b

0 2.5 5 Km

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Date: 6/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

The proposal

Plant community type name

Fuzzy Box Woodland on alluvial soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions (SAII entity)

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NARROMINE TO NARRABRI Threatened Ecological Communities Figure 5.1c

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 6/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:24,000
Data Sources: Basemap layers: NSWSS;

LEGEND

The proposal

Plant community type name

Myall Woodland in the Darling Riverina Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes Bioregions

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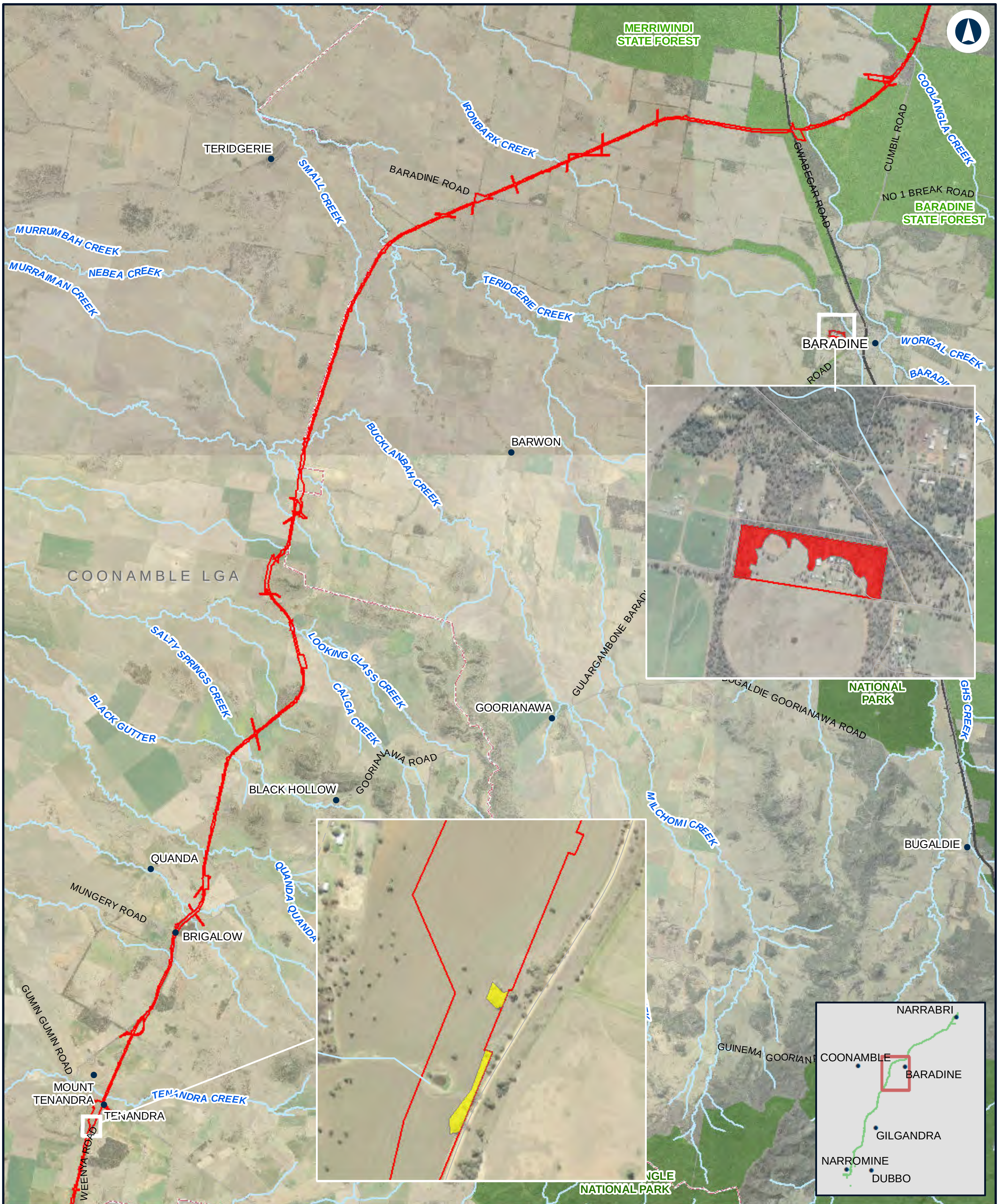

NARROMINE TO NARRABRI

Threatened Ecological Communities

Figure 5.1d

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 6/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

The proposal

Plant community type name

Myall Woodland in the Darling Riverina Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes Bioregions

White Box - Yellow Box - Blakely's Red Gum Woodland (SAII entity)

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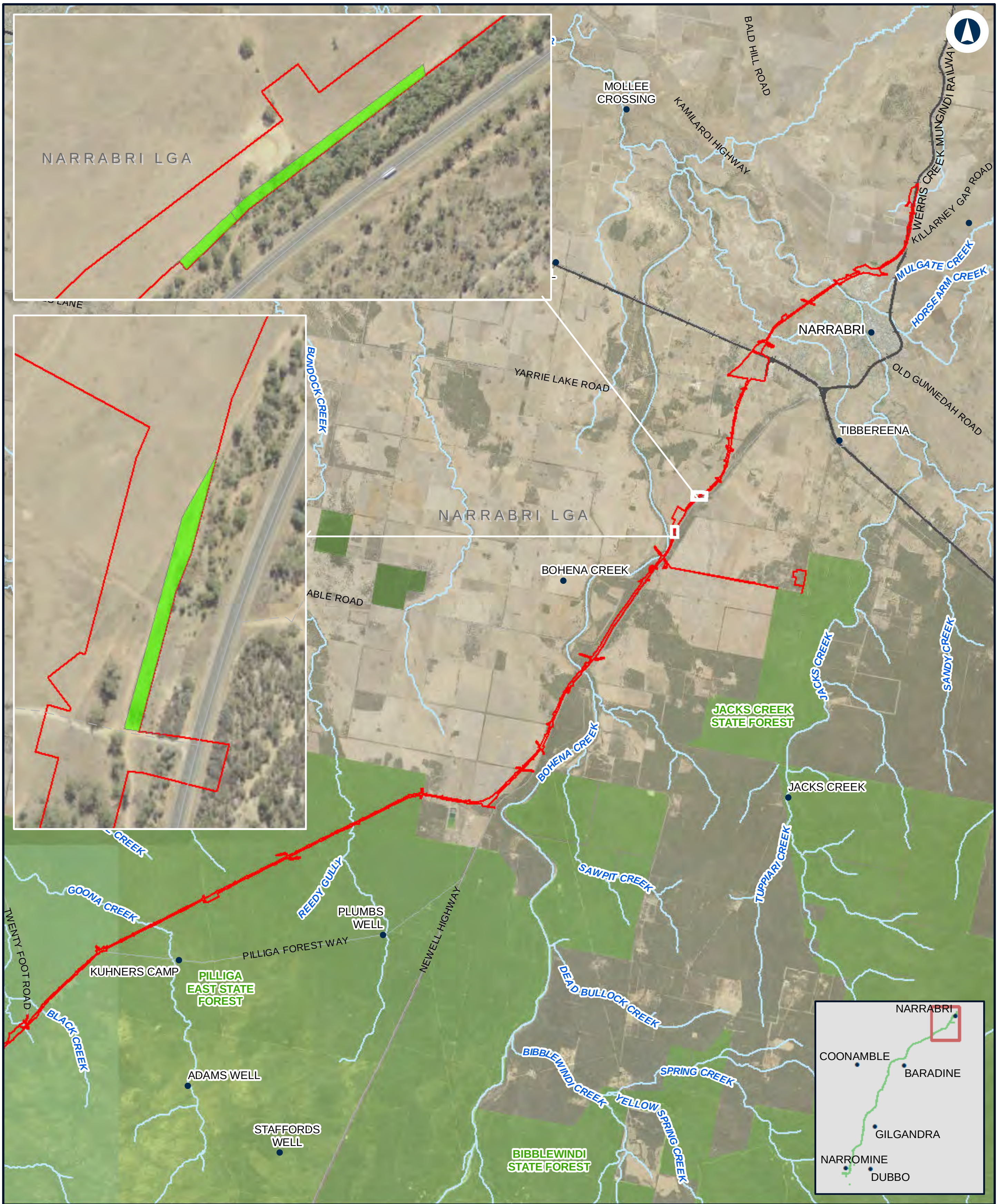

NARROMINE TO NARRABRI Threatened Ecological Communities Figure 5.1e

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 6/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:5,000
Data Sources: Basemap layers: NSWSS;

LEGEND

The proposal

Plant community type name

Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains bioregions (SAII entity)

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5.3 Flora species

A total of 462 species from 67 families were identified within the study area during field surveys, including 363 native species and 99 exotic species (Appendix E). The most species diverse families recorded were Poaceae (92 species), Fabacaea (50 species) and Asteraceae (39 species).

One threatened flora species was identified within the study area during the field survey (see section 6.1).

5.4 Non-native vegetation

Non-native vegetation in the study area is dominated by exotic grasslands comprising pastures or cropping for pasture, and roadside or trackside grassy swales. The dominant grass species recorded within exotic grassland was *Urochloa panicoides* (Urochloa Grass).

Other frequently recorded species within exotic grassland also comprised exotic plants and included Wireweed (*Polygonum aviculare)*, Flaxleaf Fleabane (*Conyza bonariensis)*, Paddy's Lucerne (*Sida rhombifolia*), St Barnaby's Thistle (*Centaurea solstitialis*) and Cat-head (*Tribulus terrestris)*.

5.5 Weeds

5.5.1 Priority weeds

The *Biosecurity Act* 2015 identifies priority weeds in NSW that have been assigned a biosecurity duty (such as prohibitions on sale and control measures). Sixteen priority weed species were recorded in plots in the study area. All of these species have a general biosecurity duty which requires any person who deals with the plant to ensure the biosecurity risk of the weed is prevented, eliminated or minimised, so far as is reasonably practicable. Regional measures for many species include the requirement that land managers should mitigate the risk of new weeds being introduced to their land. Species observed, plot locations and biosecurity duties are outlined in Appendix E.

5.5.2 Weeds of National Significance

Under the *Australian Weeds Strategy 2017 to 2027* (Invasive Plants and Animals Committee, 2016), 32 introduced plants have been identified as Weeds of National Significance (WONS). These weeds are regarded as the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts. Three WONS were recorded in the study area, and were also the weed species that occurred in the highest number of plots (see Appendix E):

- African Boxthorn (*Lycium ferocissimumi*)
- Prickly Pear (*Opuntia stricta*)
- Tiger Pear (*Opuntia aurantiaca*).

5.5.3 High threat weeds

A number of weeds are also identified as high threat weeds. These are plants not native to Australia that if not controlled will invade and outcompete native plant species. The cover of high threat weeds in a plot is entered into the BAM calculator and affects the vegetation integrity score of a vegetation zone. Eighteen high threat weeds were recorded in the study area. The full list of high threat weeds is provided in Appendix E.

5.6 Groundwater dependent ecosystems

5.6.1 Background

GDEs are ecosystems whose species or ecological processes rely on groundwater. Groundwater dependency can range from total reliance to a proportional, opportunistic use of groundwater (Serov et al 2012). Examples of GDEs include rivers, springs and swamps fed by groundwater, vegetation whose roots can access groundwater, and animals living in aquifers (stygofauna) and cave streams.

GDEs are classified into three broad types (IESC 2019):

- aquifer and cave ecosystems (subterranean GDEs)
- ecosystems dependent on the surface expression of groundwater (aquatic GDEs)
  - river baseflow systems—aquatic and riparian ecosystems that exist in or adjacent to streams (including the hyporheic zone) which are fed by groundwater
  - wetlands – aquatic communities and fringing vegetation dependent on groundwater-fed lakes and wetlands. These include wetlands that receive groundwater discharge, and can include spring and swamp ecosystems
- ecosystems dependent on the subsurface presence of groundwater (terrestrial GDEs).

5.6.2 High Priority GDEs (vegetation)

The proposal's relevant WSPs map areas of High Priority GDE vegetation within the groundwater study area. High Priority GDE vegetation as mapped by the WSPs is shown in Figure 5.2.

Mapped High Priority GDE vegetation areas are crossed by the proposal's alignment at the following locations:

- Macquarie River
- Castlereagh River
- Gulargambone Creek
- Baradine Creek
- Etoo Creek
- Rocky Creek
- Goona Creek
- Bohena Creek
- Small unnamed tributary of Bohena Creek, located close (less than 200 metres) to Bohena Creek
- Namoi River
- Narrabri Creek.

5.6.3 High Priority GDEs (springs)

Review of the proposals relevant WSPs indicates there are 10 mapped High Priority GDE springs within the groundwater study area. The closest is located about 10 kilometres from the alignment and all reside in the WSP for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020, Lachlan Fold Belt Murray Darling Basin Groundwater Source. For completeness, High Priority spring GDEs within the groundwater study area are shown in Figure 5.2 but are not discussed further as impacts due to the proposal are highly unlikely because of the large separation distance.

5.6.4 Bureau of Meteorology's GDE Atlas

The Bureau of Meteorology's GDE Atlas (BOM 2018a) was reviewed to investigate the potential for GDEs to exist within the broader region of the proposal.

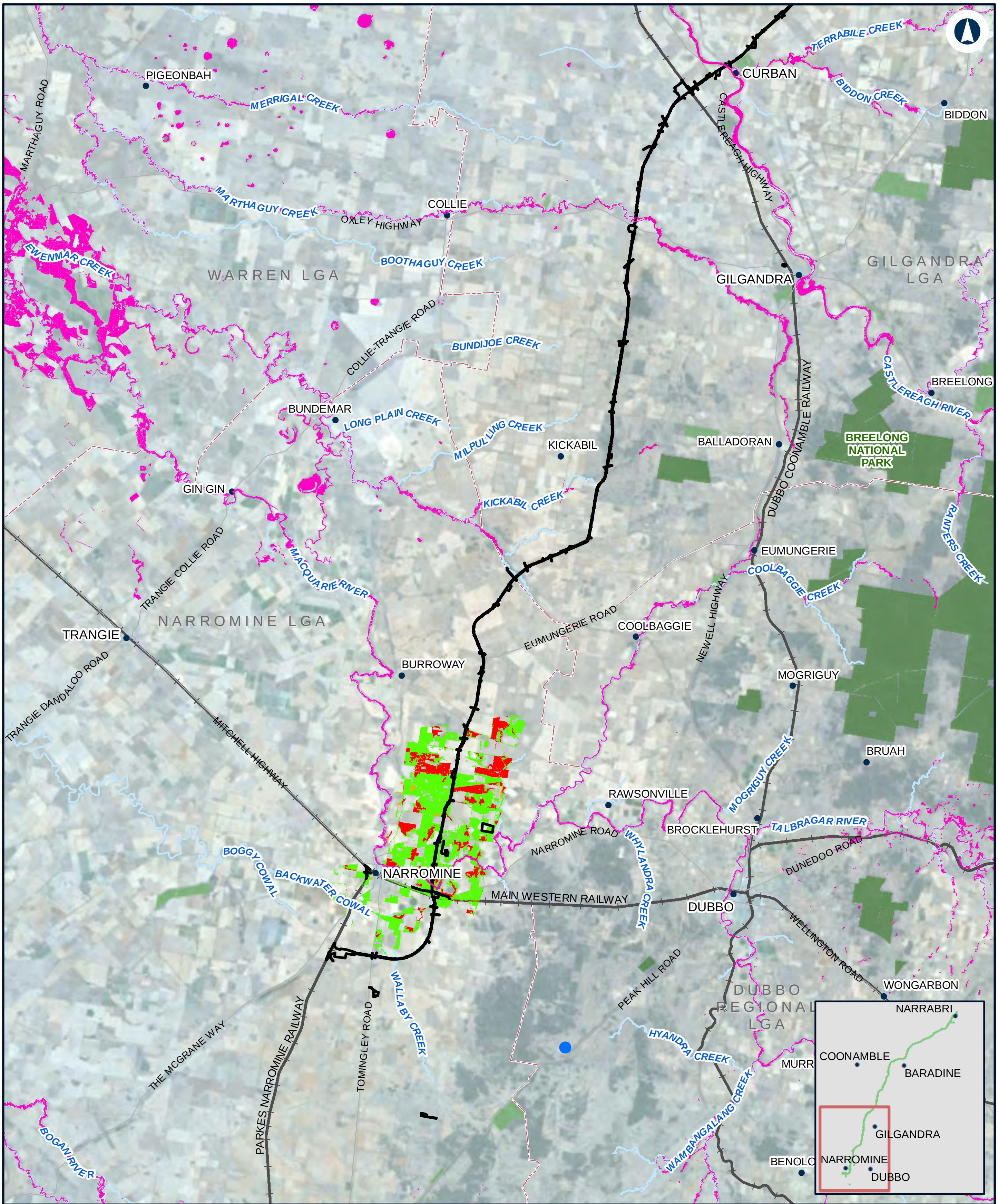
The Macquarie River, Castlereagh River and Namoi River are mapped as low potential aquatic GDEs. Larger creeks, including Bohena Creek, Mollieroi Creek, Etoo Creek, Baradine Creek, Teridgerie Creek, Marthaguy Creek, Kickabil Creek and Wallaby Creek are mapped as moderate potential aquatic GDEs.

Four main broad areas of mapped potential terrestrial GDEs are crossed by the proposal (see Figure 5.2):

- Narromine to Burroway area – low and high potential terrestrial GDEs including grassland and woodland areas
- Tonderburine to Kenebri area – low, medium and high potential terrestrial GDEs including woodland and forest
- Pilliga East State Forest – low potential terrestrial GDEs including woodland and forest
- Narrabri area – low and high potential terrestrial GDEs including grassland, woodland, forest and sedgeland.

In these areas, high potential GDEs comprise riparian vegetation such as River Red Gum communities.

The Pilliga Outwash Ephemeral Wetlands in the Brigalow Belt South Bioregion located about five kilometres downstream (north-west) of the alignment through the Pilliga forest at their closest point are not GDEs. These gilgai wetlands rely on rainfall events for their occasional inundation (Bell et al 2012).



NARROMINE TO NARRABRI | Terrestrial Groundwater Dependent Ecosystems | Figure 5.2a

0 7 14 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 22/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:500,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- High potential GDE - from regional studies
- Moderate potential GDE - from regional studies
- Low potential GDE - from regional studies
- High Priority GDE (spring) (WSP for the NSW MDB Fractured Rock Groundwater Sources 2020)
- High priority GDE vegetation (NSW Gov WSPs)

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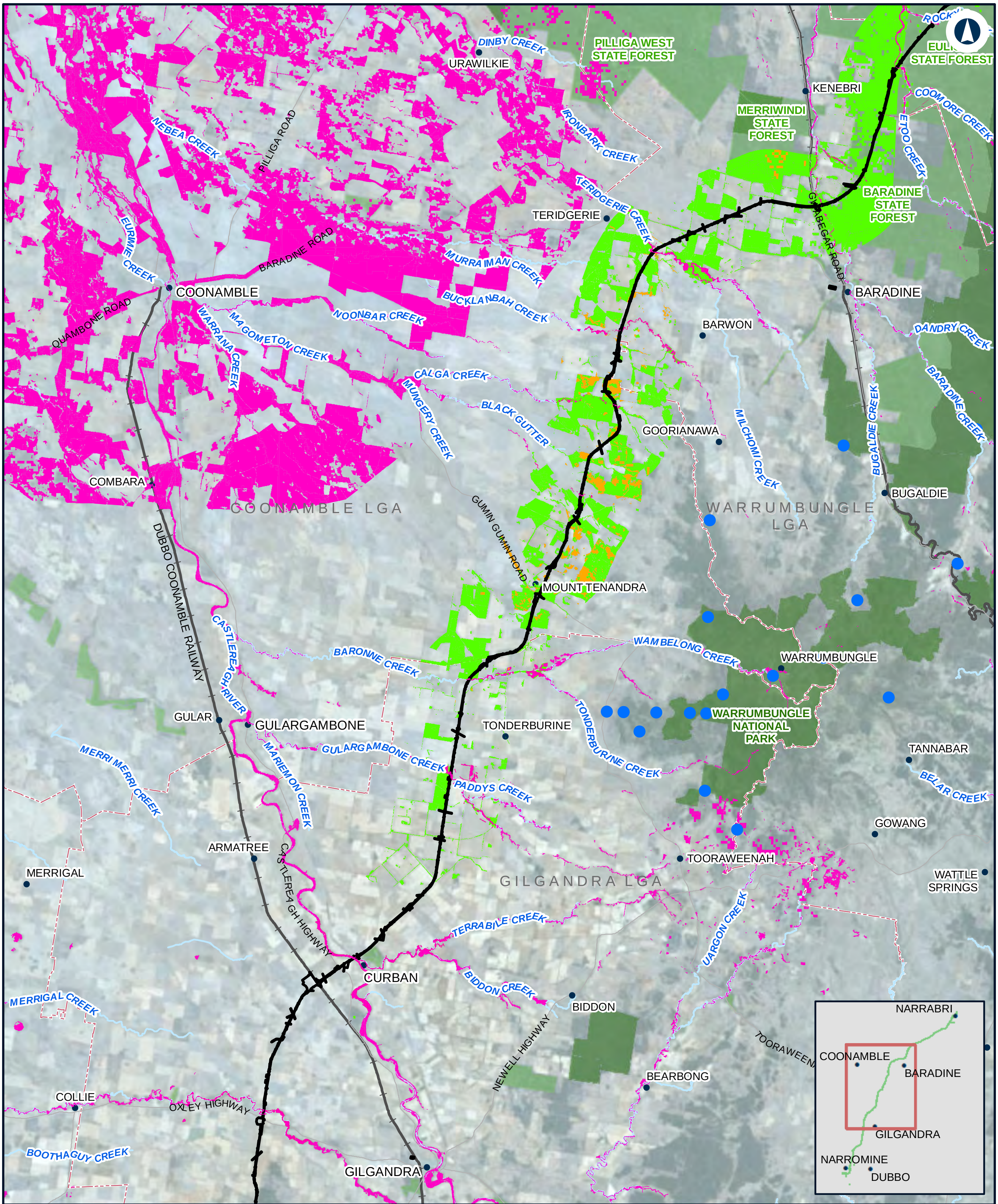

NARROMINE TO NARRABRI

Terrestrial Groundwater Dependent Ecosystems

Figure 5.2b

0 7 14 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 22/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:500,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- High potential GDE - from regional studies
- Moderate potential GDE - from regional studies
- Low potential GDE - from regional studies
- High Priority GDE (spring) (WSP for the NSW MDB Fractured Rock Groundwater Sources 2020)
- High priority GDE vegetation (NSW Gov WSPs)

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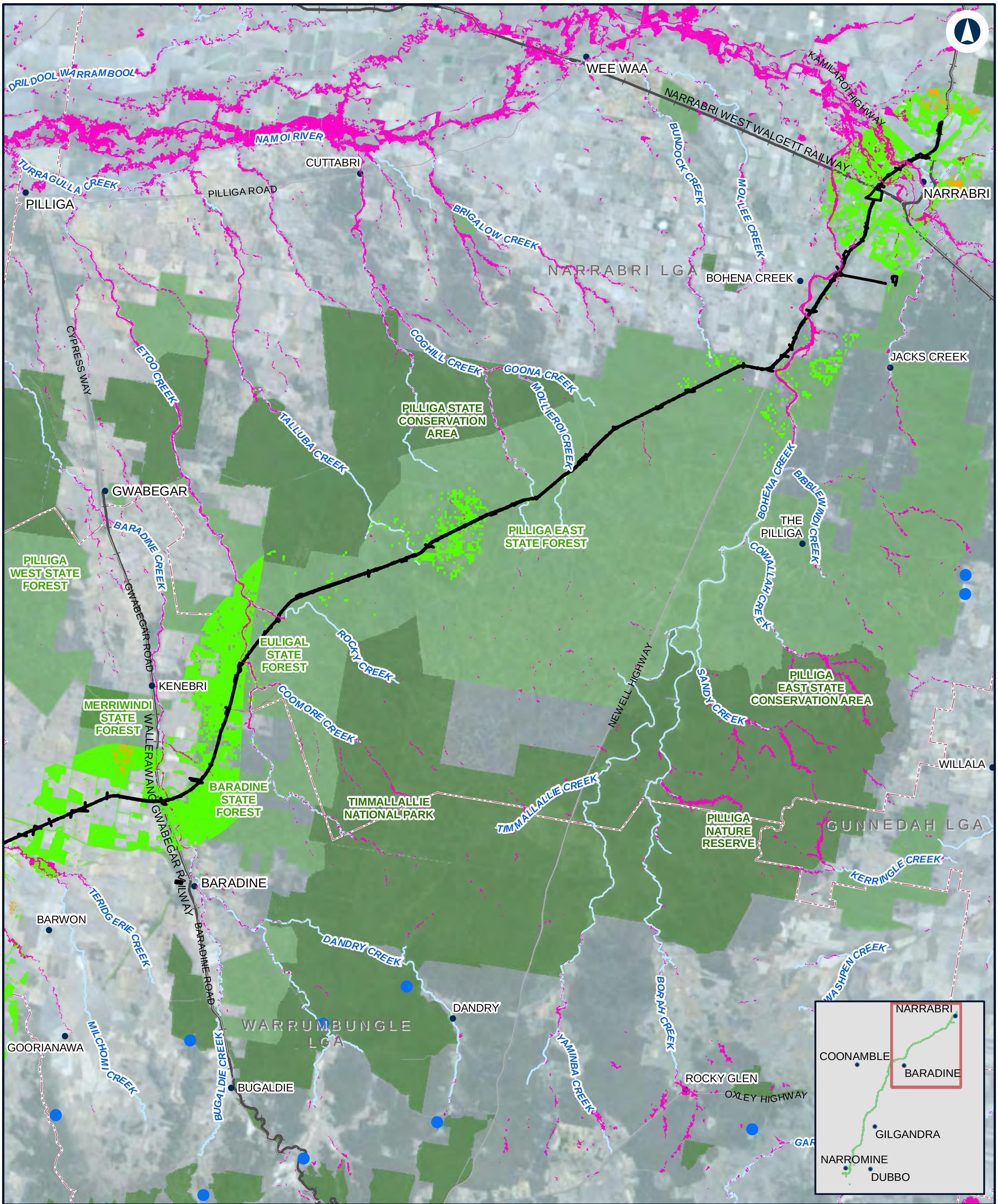

NARROMINE TO NARRABRI Terrestrial Groundwater Dependent Ecosystems Figure 5.2c

0 7 14 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 22/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:500,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- High potential GDE - from regional studies
- Moderate potential GDE - from regional studies
- Low potential GDE - from regional studies
- High Priority GDE (spring) (WSP for the NSW MDB Fractured Rock Groundwater Sources 2020)
- High priority GDE vegetation (NSW Gov WSPs)

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6. Threatened species

6.1 Threatened flora

6.1.1 Threatened flora recorded or predicted to occur

Threatened species that cannot reliably be predicted to occur on a development site based on PCT, distribution and habitat criteria are identified by the Threatened Biodiversity Data Collection as ‘species credit’ entities.

Searches of threatened species databases were completed to identify any additional potential candidate threatened species (to those generated by the credit calculator) that are known or predicted to occur in the locality (refer to likelihood of occurrence table in Appendix C). The likelihood of occurrence of these additional potential candidate threatened species were reviewed, giving consideration to the habitats available in the study area.

Potential candidate threatened species that could occur in the study area based on the habitat resources observed during field surveys were confirmed as candidate threatened species. ‘Confirmed’ candidate threatened species require targeted survey in accordance with Section 6.4.1.17 of the BAM (OEH, 2017a). The list of confirmed candidate threatened flora species is in Table 6.1. These species were subjected to targeted survey. Despite that fact that surveys were conducted in the appropriate season for all confirmed candidate threatened species, targeted survey results are not considered a reliable indicator of their presence or absence at the proposal site due to prolonged drought conditions and limited access to some suitable potential habitat areas (see Table 6.1). Therefore, a precautionary approach was adopted and where suitable potential habitat for threatened flora species was recorded in accordance with the TBDC and suitable PCTs identified, then the species were assumed to be present (see Appendix B and Appendix I).

Due to increased rainfall in the Narrabri region and favourable growing conditions in March/April 2020, additional targeted flora survey were planned gain a better understanding the potential habitat of the following species:

- Winged Peppercress (*Lepidium monoplocoides*)
- Spiny Peppercress (*Lepidium aschersonii*)
- *Commersonia procumbens*
- *Tylophora linearis*.

However, planned surveys were cancelled in late March 2020 due to the global coronavirus (Covid-19) pandemic. Immediately prior to the proposed surveys the NSW government released the *Public Health (COVID-19 Restrictions on Gathering and Movement) Order 2020* which restricted non-essential travel (and in particular travel to regional areas) and put limits on gatherings. As a result of the limitations regarding access, prolonged drought and Covid-19 travel restrictions, these and other species are assumed present in the proposal site.

ARTC are proposing to complete additional targeted survey effort in the second half of 2020. The main aim of the surveys will be to gain a better understanding of proposal impacts to threatened flora and to complete vegetation integrity plots outside of drought conditions and in some areas previously extrapolated due to access restrictions.

Table 6.1 Confirmed candidate flora species credit species for which surveys were conducted

Common name *Scientific name*	BioNet records in locality	Survey months	Presence	Justification
Coolabah Bertya *Bertya opponens*	Yes, one only near Bohena Creek	Jan-Dec	Yes – surveyed and assumed (due to drought conditions)	This species is known from adjacent to Bohena Creek Rest area on the Newell Highway within the proposal site (four individuals have been previously recorded). No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March, September, October and November. With the exception of Bohena Creek, the PCTs in the study area are not associated with stony or gravelly mallee ridges or sandy gully habitats; these latter habitats are typically associated with sandy outwash areas such as those found in the Pilliga Outwash sub-region to the south of Narrabri (where Jacks State Forest is located).
Cobar Greenhood *Pterostylis cobarensis*	Yes. Recorded at multiple locations in the Pilliga	Sep-Nov	Yes – surveyed and assumed (due to drought conditions)	This species was recorded at one location in Pilliga East State Forest. No evidence of the species was recorded in other suitable habitat areas surveyed in the proposal site in October, September and November. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Commersonia procumbens	Yes. Recorded at multiple locations in the Pilliga	Aug-May	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March, September, October and November. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Pine Donkey Orchid *Diuris tricolor*	Yes. Recorded at multiple locations in the Pilliga	Sep-Oct	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in September and October. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Slender Darling Pea *Swainsona murrayana*	Yes. Recorded from roadside reserves in the mid and southern segments	Sep-Oct	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in September and October. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.

Common name *Scientific name*	BioNet records in locality	Survey months	Presence	Justification
Spiny Peppercress *Lepidium aschersonii*	Yes. Multiple records from near Narrabri	Nov-Apr	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March, October, September and November. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Native Milkwort *Polygala linariifolia*	Yes. Recorded at multiple locations in the Pilliga	Oct-Feb	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March, October and November. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed presence based on previous records, suitable potential and discussions with BCD accountable officers.
Tylophora linearis	Yes. Recorded at multiple locations in the Pilliga	Oct-May	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March and October. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Winged Peppercress *Lepidium monoplocoides*	Yes. Known from near Narrabri	Nov-Feb	Yes – assumed (due to drought conditions)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March, October, September and November. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.

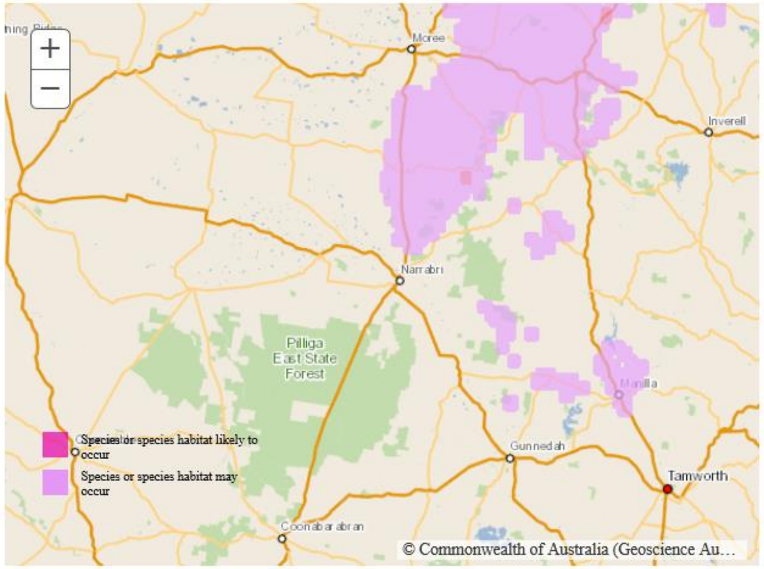
One threatened flora species was identified within the study area during field surveys conducted over multiple survey seasons (see section 3.4). Four individual Cobar Greenhood (*Pterostylis cobarensis*) were observed at one location in the Pilliga East state forest in early November 2018 (see Figure 6.1). Repeat surveys at this location in October 2019 did not relocate any individuals.

Where access was possible, all potential threatened plant habitat associated with native vegetation in the proposal site was traversed on foot. Field staff were able to traverse all areas of potential threatened flora habitat on foot, in a manner that reflected threatened species survey guidelines (OEH 2016; Cropper 1993). Although visibility was high during all survey periods, the lack of groundcover as a result of prolonged drought conditions also inhibited the potential presence of threatened flora species (see section 3.6.3). Due to the lack of access and drought conditions, multiple threatened flora species could not be excluded from occurring at the proposal site.

A number of species could be reliably discounted as occurring within the study area based on the habitat types present and/or the known distribution of the species. Detailed justification for the exclusion of candidate species is provided in Table 6.2 and/or the ‘habitat/constraints’ fields in the credit calculator.

Table 6.2 Excluded candidate threatened flora species for which a species polygon was not prepared

Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Bluegrass *Dichanthium setosum*	Yes. Near Narrabri	Associated with heavy basaltic black soils and red-brown loams with clay subsoil.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Lack of suitable microhabitats** These soil types occur mostly to the north within the volcanic basaltic soils north of Narrabri and Mount Kaputar. Soil mapping of the Moree Plain which covers the north of the study area does not identify any related soil types with these soils mainly mapped as stagnant alluvial poorly drained brown or yellow sodosols and grey vertosols. Field surveys in the northern section of the proposal site and near Narrabri within the proposal site confirmed a lack of suitable potential soil types and associated Plant Community Types. Field surveys used a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers. The vegetation integrity score of PCT 619 where species may occur near Narrabri was low at 33.9. Consultation with BCD accountable officer Terry Mazzer on 13 February 2019, confirmed the species is unlikely to occur due to lack of suitable soil types and associated habitat types in proposal site and therefore no species polygon has been prepared.

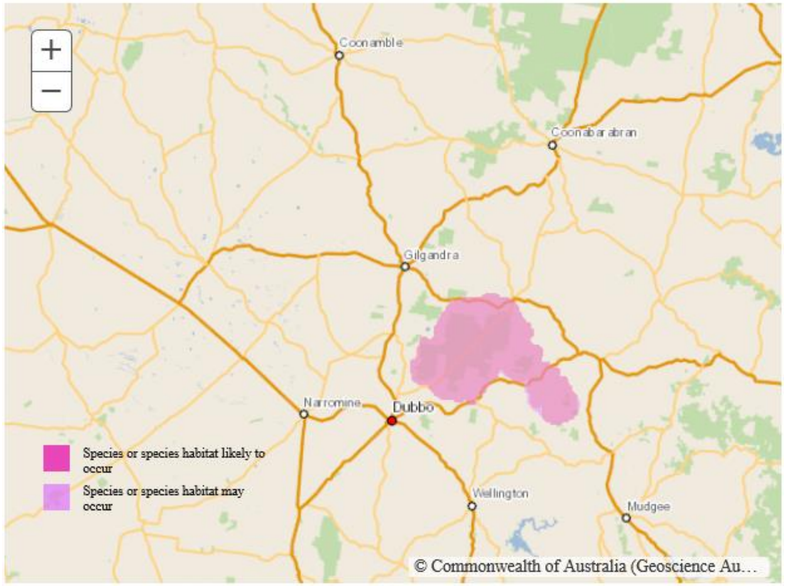
Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Belson's Panic *Homopholis belsonii*	No	Grows in dry woodland often on poor soils, north of proposal site on north west plains.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution** This species is known to occur on the north west slopes and plains of NSW between Wee Waa and Goondiwindi. The proposal site occurs to the south of the species known distribution and east of predicted distribution areas.  Consultation with BCD accountable officer Terry Mazzer on 13 February 2019, confirmed the species is unlikely to occur due to geographic limitations of the proposal site to the south, and therefore no species polygon has been prepared.

Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Finger Panic Grass *Digitaria porrecta*	No	Native grassland, woodlands or open forest with a grassy understorey, on richer soils where there is light grazing and occasional fire.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution and lack of microhabitats** In NSW this species is found on the North West Slopes and Plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran. The proposal occurs west of the Newell Highway and records of this species are restricted to east of the Newell Highway. Some suitable potential habitats, including Weeping Myall Woodland (PCT 27) and derived native grasslands occur to the north west of Gilgandra on richer soils. Field surveys used a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers. Threatened flora traverses did not identify this species within these PCTs, including roadsides and private properties where suitable potential habitat occurred. Suitable potential habitats in these areas are largely cleared and heavily cropped north west of Gilgandra. Limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded during survey, and therefore no species polygon has been prepared.
Homoranthus darwinioides	No	Occurs in thin sandy soils on sandstone outcrops and sloping ridges.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution and lack of microhabitats** Known from the Goonoo forest region outside proposal locality usually in gravelly and sandy soils. Suitable soil types derived from sandstone limited to one section of the proposal site about one kilometre in length in the Pilliga forest in PCT406 - White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests. Field surveys used a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers. The vegetation integrity score of PCT 406 where species may occur in the Pilliga was moderate at 49. In addition, the occurrence of this PCT had been burnt within the last five years. Threatened flora traverses did not identify this species within this PCT. No suitable soil types were observed outside the Pilliga during PCT mapping, vegetation integrity plots and threatened flora surveys. Limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded during survey, and therefore no species polygon has been prepared.

Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Leafless Indigo *Indigofera efoliata*	No	Previously known only from a few collections in the Dubbo area and possibly considered extinct.	**Surveys:** multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution** Previously known from near Dubbo and Goonoo forest region and now thought to be extinct from these regions. Previously known records in the Dubbo area are from slight rises amongst ironstone formation in stony red-brown sandy loam. Known distribution does not extend to the proposal site.  The proposal site is outside the known distribution of the spcies and there is limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded during survey, and therefore no species polygon has been prepared.

Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Large-leafed Monotaxis *Monotaxis macrophylla*	No	Requires fire for germination and grows on rocky ridges and hillsides.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution and lack of suitable microhabitats** Grows on rocky ridges and hillsides and requires fires for germination. Germination is stimulated by the passage of fire and populations do not persist in the absence of fire. The proposal site traverses mostly flat and gently undulating plains and does not traverse any rocky ridges or hillsides. While fire occurrence can occur anywhere, within the proposal site, it has been mostly restricted to the Pilliga and no suitable microhabitats were observed in the proposal site in the Pilliga or elsewhere within private and agricultural land. Limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded during survey, and therefore no species polygon has been prepared
Scant Pomaderris *Pomaderris queenslandica*	No	Found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution and lack of suitable microhabitats** While there are a number of suitable potential PCTs present for this species, particularly within the Pilliga (eg PCT 339, 404, 414), shrubby understories were uncommon. Where they did occur within the Pilliga and near Bohena Creek, field surveys were completed. Field surveys using a combination of vegetation integrity plots and threatened flora traverses with 10 metre increments between observers were used to survey for this species. Threatened flora traverses did not identify this species within any suitable potential habitats, therefore no species polygon has been prepared

Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Silky Swainson-pea *Swainsona sericea*	No	Sometimes found in association with cypress-pines *Callitris* spp but habitat on the plains is not well known.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Geographic distribution and lack of suitable microhabitats** In the region, this species is known from Box-Gum woodland and occasionally *Callitris* grassy habitats. These grassy woodlands are uncommon in the central and northern portion of the proposal site and the proposal site is on the northern edge of the species distribution at the southern end of the proposal site. While there are a small number of suitable potential PCTs present for this species at the southern end, including PCT 599 - Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion and PCT248 - Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW, they occur as small roadside remnant patches or in Crown Reserves with moderate vegetation integrity scores (58 and 64 respectively). All of these areas were accessed and surveyed. Field surveys using a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers were used to survey for this species. Threatened flora traverses did not identify this species within any suitable potential habitats, therefore no species polygon has been prepared.
Austral Toadflax *Thesium australe*	No	Known association with Kangaroo Grass (*Themeda australis*) and some other grass species in grassy woodlands often associated with basalt and alluvial plains.	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Lack of suitable microhabitats** Known association with Kangaroo Grass (*Themeda australis*) and some other grass species in grassy woodlands often associated with basalt and alluvial plains of which habitats on these soils in the proposal site are mostly degraded. Nearest records from grassy woodlands east of Mount Kaputar National Park (about 50 kilometres east). No suitable potential habitat that is not degraded is present in the proposal site. *Themeda australis* was identified only within two vegetation integrity plots at a cover of less 0.2% and was uncommon across the proposal site. There is only one PCT in the proposal site with which the species has a known association (PCT619 – Derived Wiregrass grassland). Field surveys used a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers. The vegetation integrity score of PCT 619 where species may occur was low at 33.9. Basalt soil types occur mostly to the north of the proposal site within the volcanic basaltic soils north of Narrabri and Mount Kaputar. Limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded during survey, and therefore no species polygon has been prepared.

Common name *Scientific name*	BioNet records in locality	Habitat constraint	Justification
Keiths Zieria *Zieria ingramii*	No	Known from light sandy soils in *Eucalyptus-Callitris* woodland or open forest with a shrubby to heathy understorey in Goonoo forest region and grows only in small localised populations within the north-east and central areas of Goonoo.	**Surveys**: multiple survey periods between September 2018 and October 2019(see section 3.6). No individuals recorded during surveys. **Geographic distribution and lack of suitable microhabitats** Usually occurs in shrubby ironbark communities and only known from Goonoo State Conservation Area.  While there are a number of suitable potential PCTs present for this species, particularly within the Pilliga (eg PCT 404, 414), they occurred on flat plains with no rocky surfaces which provide suitable microhabitats for this species. Limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded during survey, and therefore no species polygon has been prepared.

6.1.2 Potential habitat for threatened flora

One threatened flora species was recorded in the construction footprint (Figure 6.1). An additional eight species are assumed to be present despite not being recorded based on recent and known records in the study area and locality and potential habitats observed during targeted surveys (see Table 6.1).

Potential habitat for threatened flora is largely predicted by PCTs and smaller micro habitats within each PCT and vegetation zone. Within the study area, most of the PCTs known and likely to support threatened flora species occurs in the Pilliga forests and in derived grasslands areas north of the Pilliga.

Detailed descriptions of each PCT and threatened flora potentially associated with PCTs are provided in Appendix B. Specific habitats relating to species credit species are discussed in further detail in the assessment of each of these species (Appendix I).

6.2 Threatened fauna

6.2.1 Fauna species

A total of 232 fauna species were recorded during field surveys (Appendix F). This comprised 10 frog species, 37 reptile species, 141 bird species, and 44 mammal species (including 18 microbat species). Thirteen introduced species were recorded. Eighteen threatened fauna species and one migratory species were recorded (Table 6.3), and are mapped on Figure 6.1. The species' credit type and whether the species is subject to serious and irreversible impacts (SAII) are also included.

Table 6.3 Threatened and migratory fauna species recorded during surveys

Common name	Scientific name	BC Act	EPBC Act	Credit type	SAII
Black Falcon	*Falco subniger*	V	-	Ecosystem	No
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis gularis*	V	-	Ecosystem	No
Brown Treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	V	-	Ecosystem	No
Flame Robin	*Petroica phoenicea*	V	-	Ecosystem	No
Fork-tailed Swift	*Apus pacificus*		M	NA	NA
Glossy Black-cockatoo	*Calyptorhynchus lathami*	V	-	Species/Ecosystem	No
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	V	-	Ecosystem	No
Speckled Warbler	*Chthonicola sagittata*	V	-	Ecosystem	No
Spotted Harrier	*Circus assimilis*	V	-	Ecosystem	No
Superb Parrot	*Polytelis swainsonii*	V	V	Species/Ecosystem	No

Common name	Scientific name	BC Act	EPBC Act	Credit type	SAII
Varied Sittella	*Daphoenositta chrysoptera*	V	-	Ecosystem	No
Corben's Long-eared Bat	*Nyctophilus corbeni*	V	V	Ecosystem	No
Large Bent-winged Bat	*Miniopterus orianae oceanensis*	V	-	Species/Ecosystem	No
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	V	Species	Yes (breeding habitat only)
Little Pied Bat	*Chalinolobus picatus*	V		Ecosystem	No
Yellow-bellied Sheathtail-Bat	*Saccolaimus flaviventris*	V	-	Ecosystem	No
Koala	*Phascolarctos cinereus*	V	V	Species (important habitat)	No
Squirrel Glider	*Petaurus norfolcensis*	V	-	Species	No
Pale-headed Snake	*Hoplocephalus bitorquatus*	V	-	Species	No

Key: M – migratory, V - vulnerable

6.2.2 Fauna habitats

Fauna habitats have been categorised into broad groupings made up of various PCTs. Within each of these there are variations in specific canopy trees and other floristic diversity and structure. A summary of fauna habitat types present across the study area is provided in Table 6.4. Detailed descriptions of each PCT and fauna habitat type are provided in Appendix B. Threatened fauna species recorded or likely to occur in each of these habitat types are identified. Specific habitats relating to species credit species are discussed in further detail in the assessment of each of these species (Appendix I).

Table 6.4 Fauna habitats

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
Grassland with scattered paddock trees 	Dominated by exotic crop species (eg Oats) or derived native grassland. Occasional isolated paddock trees or small groups of paddock trees are present. Paddock tree species comprise Pilliga Box (*Eucalyptus pilligaensis*) and occasional White Cypress Pine (*Callitris glaucophylla*). Many paddock trees are hollow-bearing, and could provide roosting habitat for microbats and parrots. These trees would provide foraging habitat and 'stepping stone' connectivity for small birds, and may also provide connectivity for species such as the Koala and Squirrel Glider (where spacing is closer).	• Spotted Harrier – observed hunting over cleared agricultural land near Narromine, and in roadside vegetation in Gilgandra. • Yellow-bellied Sheathtail-bat – recorded at various locations via Anabat surveys. Could roost and breed in paddock trees. • Little Pied Bat – recorded north of Narrabri. • Eastern Freetail Bat – recorded north of Narrabri. • Koala – recorded in Pilliga. Could use this habitat elsewhere along the alignment. • Squirrel Glider – recorded in Pilliga. Could use these habitats in the Narrabri area. • Five-clawed Worm-skink – not recorded, but may occur in the Narrabri area.	• Little Eagle – not observed during surveys, but could forage over agricultural land. • Square-tailed Kite – not observed during surveys, but could forage over agricultural land.

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
Woodland patches in agricultural land 	Woodland vegetation is present as various-sized patches within agricultural land. This can comprise small patches within a larger paddock, riparian vegetation retained along creek lines, linear strips along roadsides and paper roads or 'laneways', and larger patches associated with travelling stock reserves. This vegetation comprises a canopy of eucalypts and Cypress Pine, often with a sparse understory and grassy ground layer. A high density of leaf litter and fallen timber is present, particularly along paper roads and in travelling stock reserves. Hollow-bearing trees and stags are present. Connectivity between patches varies. Some patches in agricultural land are isolated from other areas. Vegetation along creek lines and roads provides narrow strips of connectivity through the highly cleared agricultural landscape. This vegetation tends to be impacted by grazing, and clearing for firewood and fencing. In publicly accessible areas such as travelling stock reserves, vegetation and habitats are impacted by creation of tracks for dirt-bike riding, and rubbish dumping.	• Grey-crowned Babbler - the most frequently recorded threatened species observed during surveys, and often occurred in woodland patches in agricultural land. • Black Falcon – recorded in a small woodland patch with two Whistling Kite nests north of Narrabri, to the west of the study area. • Varied Sittella – occasional records in larger woodland patches. • Speckled Warbler – recorded in dense, shrubby roadside vegetation at Bohena Creek. • Black-chinned Honeyeater – recorded at Leeches Creek Road near Gilgandra. • Painted Honeyeater – may occur on occasion. • Swift Parrot – may occur on occasion. • Regent Honeyeater – may occur on occasion.	• Koala – there is an EES (2019a) record associated with roadside vegetation south of Narromine. No Koalas were recorded during surveys for the proposal other than in the Pilliga. • Squirrel Glider – there is potential for this species to occur in remnants, particularly where there is connectivity with the Pilliga Forests. • Little Eagle, Square-tailed Kite – potential for these species to nest in these area.

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
Forests of the Pilliga 	Much of the Pilliga is dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*) and White Cypress Pine (*Callitris glaucophylla*) with a sparse understory. Other trees present include Pilliga Box (*E. pilligaensis*), Poplar Box (*E. populnea*) and White Bloodwood (*Corymbia trachyphloia*) among others. It is believed that prior to 1830 the Pilliga was an open, grassy woodland with low incidences of large old eucalypts and cypress pines. With the increase in grazing, and exclusion of fire, and later the introduction of logging, perennial grasses declined and the incidence of old trees decreased. The forest is now dominated by a mostly young overstorey of eucalypts, cypress pines and Buloke, and a dense understorey of small eucalypts, cypress pines, Buloke and shrubs, but little grass (Date et al 2002). Remnant trees with hollows were observed within these forests, providing habitat for threatened species such as the Squirrel Glider, Glossy Black-cockatoo and microbats. Forests of the Pilliga are impacted by logging, fire and grazing. Logging in the Pilliga is associated with habitats which have high frequencies of Narrow-leaved Ironbark and/or White Cypress Pine. Fire is also excluded from commercially valuable stands, but is used for fuel reduction in non-commercial stands. Grazing is also used to thin cypress pine regeneration (Date et al 2002). Date et al. (2002) found that many bird species are declining in the Pilliga as a result of these disturbance regimes, and will continue to do so without adaptive management for maintaining and rehabilitating their habitats. Box-ironbark forests have a large number of logs, stumps and dead trees, due to experiencing intense logging but little fire (Date et al 2002).	• Grey-crowned Babbler – the most commonly recorded threatened species during surveys. • Varied Sittella – recorded on few occasions. • Brown Treecreeper – recorded on few occasions. • Speckled Warbler – recorded in shrubby forest at Bohena Creek rest area. • Inland Forest Bat – probable record at Trap site 5. • Yellow-bellied Sheathtail Bat – definite record at trap site 5. • Pilliga Mouse – not recorded during surveys, but known to occur. • Black-striped Wallaby – not recorded during surveys, but known to occur. • Painted Honeyeater – known to occur. • Swift Parrot – may occur on rare occasions. • Regent Honeyeater – may occur on rare occasions.	• Glossy Black-cockatoo – a few pairs were observed flying overhead during surveys in the Pilliga and Bohena area. A small family group was recorded at a dam in the Pilliga by a camera trap. No nest trees identified. • Squirrel Glider – a family group were observed at a hollow in a Narrow-leaved Ironbark adjacent to Pilliga Forest Way. • Eastern Pygmy-possum – not recorded during surveys, but known to occur. • Rufous Bettong – not recorded, but scattered records known from the Pilliga. • Large-eared Pied Bat – probable record at Trap site 5. No caves, scarps, cliffs, rock overhangs and disused mines located within 2 kilometres of the alignment in the Pilliga. • Bush Stone-curlew – occasional scattered records known from the Pilliga. • Barking Owl – the Pilliga contains the largest population of the species in NSW. No individuals were recorded during surveys. • Masked Owl – occasional scattered records known from the Pilliga.

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
			• Little Eagle – occasional scattered records known from the Pilliga. • Square-tailed Kite – occasional scattered records known from the Pilliga
Heath and shrublands of the Pilliga 	The proposal crosses comparatively small areas of heathy vegetation in the Pilliga, including dense heath, and a more open heath under woodland canopy. Shrub species include Broombush (*Melaleuca uncinata*), various wattles (*Acacia* spp.), *Darwinia* spp., Seven Dwarfs Grevillea (*Grevillea floribunda*), Urn-heath (*Melichrus urceolatus*), Silver Cassia (*Senna artemisioides)*, Drooping Cassinia (*Cassinia arcuata*), Rosy Paperbark (*Melaleuca erubescens*), Fringed Heath Myrtle (*Micromyrtus ciliata*) and Sticky Hop-bush (*Dodonaea viscosa*). Overstory species include Narrow-leaved Ironbark (*Eucalyptus crebra*), White Cypress Pine (*Callitris glaucophylla*), mallee form of Dwyers Gum (*Eucalyptus dwyeri*) and White Bloodwood (*Corymbia trachyphloia*). Occasional hollow-bearing trees occur in woodland areas. The ground cover is often very sparse with bare patches of soil prevalent.	• Pilliga Mouse – not recorded but known to occur. • Various microbats likely to occur.	• Eastern Pygmy-possum – not recorded but known to occur.

Creeks of the Pilliga  Etoo Creek	Creek lines of the Pilliga generally have a canopy of Blakely's Red Gum and the Rough-barked Apple. Cypress. Blakely's Red Gums often have hollows present, and hollows also occur in the Rough-barked Apple. These provide breeding habitat for threatened species such as the Barking Owl, Brown Treecreeper and microbats. The shrub layer is sparse overall and includes Tantoon (*Leptospermum polygalifolium*), Dean's Wattle (*Acacia deanei*), Narrow-leaved Bottlebrush (*Callistemon linearis*) and Drooping Cassinia (*Cassinia arcuata*). Watercourses are generally bare of vegetation with occasional patches of shrubs, sedges, water plants and rushes. Woodlands on creeks had fewer stumps, logs or dead trees than box-ironbark forests, due to the lack of logging in these areas (Date et al 2002). Creeks beds are usually sandy, and no water was observed during surveys. Some ponds were present in Baradine Creek outside the Pilliga as a result of rains immediately prior to the March survey. No emergent vegetation is present in the creeks, other than Baradine Creek outside the study area. Burrows of various sizes were observed in the sandy banks and soils of the creek beds. Cumbil Creek has low outcrops of sandstone present, with small crevices that would provide habitat for reptiles such as skinks and geckos. Blakely's Red Gum woodlands associated with creek lines in the Pilliga have been found to be characterized by 36 bird species that were virtually absent from the nearby box-ironbark forests away from the creeks, including 10 threatened and declining species (Date et al 2002). Many of these species are habitat specialists, and are dependent on mature trees for abundant nectar, insect prey or nesting, or are dependent on the grassy or grass/shrub mosaic understory to forage or nest. Creek line vegetation has been subject to less	• Brown Treecreeper – recorded on few occasions. • Corben's Long-eared Bat – trapped at Coolangala Creek in Baradine State Forest. • Little Pied Bat – recorded on anabats at Rocky Creek. • Eastern Bentwing Bat – definite Anabat record at Rocky Creek. • Yellow-bellied Sheathtail Bat – definite Anabat record at Rocky Creek. • Painted Honeyeater – known to occur. • Swift Parrot – may occur on rare occasions. • Regent Honeyeater – may occur on rare occasions.	• Barking Owl – No individuals recorded during surveys. Known nest trees occur near the alignment at Baradine Creek, Etoo Creek and Rocky Creek (records courtesy of Forestry Corporation), although a Barn Owl was observed at the likely nest tree at Rocky Creek, and this tree may not currently be in use by Barking Owls. The Pilliga forests support the largest Barking Owl population in NSW (EES 2019b). Stanton (2011) found that the species appeared to be associated with forests on the Pilliga Outwash rather than the less productive forests associated with the Pilliga sandstone. • Koala – scats were recorded at Coolangala Creek and Etoo Creek. No individuals were observed, despite the targeted transect survey along Etoo Creek (a previous stronghold for the species). Koalas are known to have declined substantially in numbers in the Pilliga in recent years (Lunney et al 2017). • Squirrel Glider – this species was recorded ironbark forest in the Pilliga, and could den in hollow-bearing trees along creeklines. • Large-eared Pied Bat – probable Anabat record at Coolangala Creek. No caves, scarps, cliffs, rock overhangs and disused mines located within 2 kilometres of the alignment in the Pilliga.

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
	logging and grazing, but moderate fire impacts (Date et al 2002).		• Pale-headed Snake – one individual recorded on Cumbil Forest Road on a warm evening after rain.
Rivers and associated riparian vegetation  Macquarie River, Narromine	The alignment crosses the Macquarie River, Castlereagh River, Namoi River and Narrabri Creek. Only the Macquarie River, Namoi River and Narrabri Creek had water present during surveys. Both the Namoi River and Narrabri Creek appeared to comprise large pools, while the Macquarie River was flowing at all times. The Castlereagh River flowed following a rain event immediately after surveys in March 2019, however was dry during all survey periods. Riparian vegetation comprises a canopy of large old River Red Gums, most with hollows of various sizes. These provide important denning and breeding habitat for a variety of species. In some locations, such as at the Castlereagh River, multiple hollows in individual trees were observed to be occupied by Common Brush-tailed Possums, showing the importance of the habitat in an otherwise predominantly cleared landscape. A range of shrubs occur under the canopy. Emergent vegetation is present in some locations, providing habitat for small birds and frogs. Exotic trees including Willows are present in some areas. Riparian vegetation provides an important corridor through the generally cleared agricultural landscape surrounding these rivers. Riparian vegetation is disturbed by access by stock, feral pigs and people. Rubbish dumping was evident at the travelling stock reserve on the Macquarie River at Narromine.	• Grey-crowned Babbler – recorded at the Castlereagh River. • Eastern Bentwing Bat – probable record at the Macquarie River and Castlereagh River. • Eastern Freetail Bat - probable record at Narrabri Creek. • Little Pied Bat – probable record at the Castlereagh River. • Yellow-bellied Sheath-tail Bat – definite record at Narrabri Creek. • Brown Treecreeper – likely to occur. • Painted Honeyeater – may occur.	• Barking Owl – occasional records are known from the Macquarie and Castlereagh Rivers. • Pale-headed Snake – known to occur along the Namoi River and Narrabri Creek. • Squirrel Glider – there is potential for this species to occur riparian vegetation, particularly where there is connectivity with the Pilliga Forests. • Koala – riparian vegetation is likely to provide habitat and dispersal corridors for this species.

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
Creeks and associated riparian vegetation in agricultural land  Ewenmar Creek	Many small creeks cross the proposal site within predominantly cleared agricultural land. Riparian vegetation is generally retained in these areas, and provides important linkages across the landscape for fauna movement. Riparian vegetation provides habitat for a range of bird species, including many small woodland birds such as White-plumed Honeyeaters, Western Gerygones and Superb Fairy-wrens. Galahs, Australian Ringnecks and Sulphur-crested Cockatoos were commonly observed. Dominant tree species comprise River Red Gums in the south, and Blakely's Red Gums in the north. Many hollow-bearing trees are present. These creeks remain dry for much of the year, with flows occurring on occasion after heavy rain. Occasional small pools remain for longer periods of time, and provide breeding habitat for frogs.	• Yellow-bellied Sheathtail Bat – definite record at Bohena Creek and Ewenmar Creek. • Little Pied Bat – probable record at Ewenmar Creek. • Painted Honeyeater – may occur. • Brown Treecreeper – likely to occur.	• Little Eagle – may provide nesting habitat. • Square-tailed Kite – may provide nesting habitat. • Squirrel Glider – there is potential for this species to occur riparian vegetation, particularly where there is connectivity with the Pilliga Forests. • Koala – riparian vegetation is likely to provide habitat and dispersal corridors for this species
Dams, roadside ditches and soaks 	Farm dams are present in agricultural land. These provide water for stock as well as native fauna including frogs, turtles, birds, macropods and bats. Few contain emergent aquatic vegetation, and little floating or submerged aquatic vegetation was observed, although this may be a result of ongoing drought conditions and heavy use by stock. Dams are present at various locations within the Pilliga forest. During surveys there was limited water present, with only some dams containing low levels of water. These dams provide important water sources for native fauna in the forest, as generally there is no water in the ephemeral creeklines. Roadside ditches contain pools of water after heavy rain. These are often vegetated with grasses and sometimes sedges. Frogs were often heard calling from these areas.	• Eastern Bentwing Bat – probable record at a farm dam near Gilgandra. • Little Pied Bat – definite record at a farm dam near Narrabri. • Yellow-bellied Sheathtail Bat – recorded at farm dams near Narrabri. • Australian Painted Snipe – may occur at dams with emergent vegetation on occasion. • Australasian Bittern – may occur at dams with emergent vegetation on occasion.	• Glossy Black-cockatoo - Dams in the Pilliga are known to be an important water source for Glossy Black Cockatoos. A family group were recorded at Clay Foot Dam in the Pilliga on a remote camera.

Habitat type	Description	Predicted threatened species recorded and EPBC Act listed species that may occur	Candidate threatened species and EPBC Act threatened species recorded or likely to occur
Rocky areas 	Rocky hillsides occur in the Black Hollow area north-east of Gilgandra near the Warrumbungle Range. In these areas, the proposal is located in cleared agricultural land, with rocky areas occurring upslope of the proposal site. Rocks occur as loose and embedded surface rock on steep slopes. Rock does not occur on gentle slopes at the base of these hills, and may have been 'tidied up' historically buy landowners. Rocky area of low topographic relief occur at Borrow Pit A. No caves or crevices were recorded in these areas.	• Yellow-bellied Sheath-tail Bat – likely to occur.	• Little Eagle – may provide nesting habitat. • Square-tailed Kite – may provide nesting habitat.

6.2.3 Threatened fauna species predicted to occur under the BAM

The suite of 'confirmed' predicted threatened species associated with ecosystem credits required for the proposal site, and with relevant habitat resources present on the site, are listed in Table 6.5. For each confirmed predicted threatened species, the vegetation zone association is provided in Appendix I. Five species are not confirmed predicted species (Table 6.6). The site is considered to be outside the usual distribution of four of these species, and one species in considered extinct in the area.

Table 6.5 Threatened fauna species reliably predicted to utilise the proposal site

Common name	Scientific name	Sensitivity to gain	Recorded on site during surveys?
Australasian Bittern	*Botaurus poiciloptilus*	Moderate	
Australian Painted Snipe	*Rostratula australis*	Moderate	
Barking Owl	*Ninox connivens*	High	
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis gularis*	Moderate	Yes
Black-necked Stork	*Ephippiorhynchus asiaticus*	Moderate	
Black-striped Wallaby	*Macropus dorsalis*	High	
Blue-billed Duck	*Oxyura australis*	Moderate	
Brolga	*Grus rubicunda*	Moderate	
Brown Treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	High	Yes
Corben's Long-eared Bat	*Nyctophilus corbeni*	High	Yes
Diamond Firetail	*Stagonopluera guttata*	Moderate	
Dusky Woodswallow	*Artamus cyanopterus cyanopterus*	Moderate	
Flame Robin	*Petroica phoenicea*	Moderate	Yes
Freckled Duck	*Stictonetta naevosa*	Moderate	
Gilbert's Whistler	*Pachycephala inornata*	Moderate	
Glossy Black-cockatoo	*Calyptorhynchus lathami*	High	Yes
Greater Broad-nosed Bat	*Scoteanax rueppellii*	High	
Grey Falcon	*Falco hypoleucos*	Moderate	
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	Moderate	Yes
Hooded Robin (south-eastern form)	*Melanodryas cucullata cucullata*	Moderate	
Koala	*Phascolarctos cinereus*	High	Yes
Large Bent-winged Bat	*Miniopterus orianae oceanensis*	High	Yes
Little Eagle	*Hieraaetus morphnoides*	Moderate	
Little Lorikeet	*Glossopsitta pusilla*	High	
Little Pied Bat	*Chalinolobus picatus*	High	Yes

Common name	Scientific name	Sensitivity to gain	Recorded on site during surveys?
Magpie Goose	*Anseranas semipalmata*	Moderate	
Masked Owl	*Tyto novaehollandiae*	High	
Painted Honeyeater	*Grantiella picta*	Moderate	
Pilliga Mouse	*Pseudomys pilligaensis*	High	
Regent Honeyeater	*Anthochaera phrygia*	High	
Scarlet Robin	*Petroica boodang*	Moderate	
Speckled Warbler	*Chthonicola sagittata*	High	Yes
Spotted Harrier	*Circus assimilis*	Moderate	Yes
Spotted-tailed Quoll	*Dasyurus maculatus*	High	
Square-tailed Kite	*Lophoictinia isura*	Moderate	
Stripe-faced Dunnart	*Sminthopsis macroura*	High	
Superb Parrot	*Polytelis swainsonii*	Moderate	Yes
Swift Parrot	*Lathamus discolor*	Moderate	
Turquoise Parrot	*Neophema pulchella*	High	
Varied Sittella	*Daphoenositta chrysoptera*	Moderate	Yes
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	High	
White-fronted Chat	*Epthianura albifrons*	Moderate	
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	High	Yes

Table 6.6 Predicted threatened fauna species not considered to be present in the proposal site

Common name	Scientific name	Comment
Black-breasted Buzzard	*Hamirostra melanosternon*	Outside usual range
Grey-headed Flying-fox	*Pteropus poliocephalus*	Outside usual range
Malleefowl	*Leipoa ocellata*	Considered extinct in the Pilliga
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*	Outside usual range
Powerful Owl	*Ninox strenua*	Outside usual range

6.2.4 Candidate threatened fauna species (species credit entities)

Potential candidate threatened species that could occur in the study area based on the habitat resources observed during field surveys were confirmed as candidate threatened species. ‘Confirmed’ candidate threatened species require targeted survey in accordance with Section 6.4.1.17 of the BAM (OEH, 2017a). The list of confirmed candidate threatened species is presented in Table 6.7; these species were subjected to targeted survey. Threatened species recorded in the study area are mapped in Figure 6.1. Detailed discussion of the habitat requirements of these species, the habitat values in the study area, survey methods and effort, results and justification for the species polygon is provided in Appendix I.

A number of species could be reliably discounted as occurring within the study area based on the habitat types present, known distribution of the species and/or vagrant nature of the species. Detailed justification for the exclusion of these species is provided in Table 6.8 and the 'habitat/constraints' fields in the credit calculator.

Table 6.7 Confirmed candidate fauna species credit species for which surveys were conducted

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Bush Stone-curlew *Burhinus grallarius*	Yes. 11 records in the locality, mainly in the Pilliga-Narrabri area.	All year (**Mar, Jun, Aug, Sep, Oct, Nov**)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site. However, the species is likely to occur and drought conditions and low densities are likely to have been a large contributing factor to species absence. This species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Pale-headed Snake *Hoplocephalus bitorquatus*	Yes. Eight records in the Pilliga-Narrabri area.	November – March (**Mar, Nov**)	Yes – surveyed	This species was recorded during surveys in close proximity to the proposal site and potential habitat occur in the Pilliga and Narrabri areas. This species is assumed present at various locations based on previous records, suitable potential and discussions with BCD accountable officers.
Square-tailed Kite *Lophoictinia isura*	Yes. 11 records in the locality, mainly in the Pilliga-Narrabri area.	September – January (Mar, Aug, **Sep, Oct, Nov**)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site. However, the species is likely to occur and drought conditions and low densities are likely to have been a large contributing factor to species absence. Nest trees are assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Barking Owl *Ninox connivens*	Yes. 333 records in the locality, mainly in the Pilliga.	May – December (Mar, **Aug, Sep, Oct, Nov**)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. Nest trees are assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Masked Owl *Tyto novaehollandiae*	Yes. 4 records in the Pilliga area.	May – August (Mar, **Aug**, Sep, Oct, Nov)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site. However, the species is likely to occur and drought conditions and low densities are likely to have been a large contributing factor to species absence. Nest trees are assumed present based on previous records, suitable potential and discussions with BCD accountable officers.

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Little Eagle *Hieraaetus morphnoides*	Yes. 18 records in the locality, scattered along the alignment.	August – October (Mar, **Aug, Sep, Oct**, Nov)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site. However, the species is likely to occur and drought conditions and low densities are likely to have been a large contributing factor to species absence. Nest trees are assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
White-bellied Sea-Eagle *Haliaeetus leucogaster*	Yes. 5 records in the locality.	Jul – Dec (Mar, **Aug, Sep, Oct**, **Nov**)	No - surveyed	No evidence of the species was recorded during surveys. No large waterbodies other than the Macquarie River and Narrabri Creek are present (note that the Castlereagh River and Namoi River were mostly dry during the surveys. No large stick nests were observed near any large waterbodies. No breeding habitat is considered to be present.
Rufous Bettong *Aepyprymnus rufescens*	Yes. Two records in the Pilliga.	All year (**Mar**, **Aug, Sep, Oct**, **Nov**)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site via remote cameras and spotlighting. However, the species is likely to occur and its low densities of occurrence and cryptic nature (small nocturnal species) are likely to have been a large contributing factor to lack of evidence during surveys. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Glossy Black-Cockatoo *Calyptorhynchus lathami*	Yes. 107 records in the locality, mainly in the Pilliga-Narrabri area.	March – August (**Mar**, **Aug,** Sep, Oct, Nov)	Yes – surveyed	This species was recorded during surveys, although no nest trees were recorded. Nest trees are assumed present based on previous records, suitable potential and discussions with BCD accountable officers.
Eastern Pygmy-possum *Cercartetus nanus*	Yes. 7 records in the locality, predominantly from the Pilliga-Narrabri area.	Oct – Mar (**Mar,** Aug, Sep, **Oct, Nov**)	Yes – assumed present	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March, or during spotlighting at other times of the year. However, the species is likely to occur and drought conditions are likely to have been a large contributing factor to species absence. The species is assumed present based on previous records, suitable potential and discussions with BCD accountable officers.

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Squirrel Glider *Petaurus norfolcensis*	Yes. 14 records in the locality, predominantly from the Pilliga-Narrabri area.	All year (**Mar, Aug, Sep, Oct, Nov**)	Yes - surveyed	This species was recorded in one location in the Pilliga during the March surveys, and habitat is present throughout much of the Pilliga. The species is assumed present throughout the Pilliga, and within roadside remnants, riparian vegetation and patches in agricultural land with connectivity to the Pilliga, based on previous records, suitable potential and discussions with BCD accountable officers.
Koala *Phascolarctos cinereus*	Yes. 523 records in the locality, predominantly from the Pilliga-Narrabri area.	All year (**Mar, Aug, Sep, Oct, Nov**)	Yes - surveyed	This species was recorded at two locations in the Pilliga (via scats), and habitat is present throughout much of the Pilliga. The species is assumed present in much of the Pilliga based on previous records, suitable potential and discussions with BCD accountable officers. One record is also located near Narromine in roadside vegetation, and some other records are located elsewhere within 10 kilometres of the alignment.
Pink-tailed Legless Lizard *Aprasia parapulchella*	None	Sep-Nov (**Sep)**	No -surveyed	Rocky habitat occurs at Borrow Pit A, which is located within an IBRA subregion where this species is known to occur, however there are no local records, topographic relief is low, rocky habitat is restricted in area, and there is limited connectivity to better quality potential habitat located to the east.

Table 6.8 Excluded species credit fauna species for which targeted surveys were not conducted or the species and/or breeding habitat are not considered to occur on site

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Swift Parrot *Lathamus discolor*	Yes. One only	Species/Ecosystem (Important habitat)	Other (as per mapped areas)	**No important habitat present** No important habitat for the species overlaps with the study area (BCD advice, January 2019; DPIE 2020b).
Regent Honeyeater *Anthochaera phrygia*	Yes. One only	Species/Ecosystem (Important habitat)	Other (as per mapped areas)	**No important habitat present** No important habitat for the species overlaps with the study area (BCD advice, January 2019; DPIE 2020b).
Large-eared Pied Bat *Chalinolobus dwyeri*	Yes. Three records in the Pilliga	Species	Cliffs (within 2 km of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two kilometres of old mines or tunnels) Species polygon guidance: All habitat on the subject land where the subject land is within 2 km of caves, scarps, cliffs, rock overhangs and disused mines. Note: any breeding habitat identified for this species is a potential serious and irreversible impact.	**Surveys**: Microbat ultrasonic echolocation call recordings (Anabat surveys) were undertaken in September and November 2018 and March 2019, and harp netting in November 2018 and March 2019 (see section 3.6). A possible call of the species was recorded at Trap Site 1 (Coolangala Creek) in the Pilliga in March. No calls were recorded in the Narrabri area in November. No individuals were trapped in harp nets. Limited harp netting in the breeding season (November – January) was conducted given the lack of suitable breeding habitat near the proposal site. **No caves etc present**. No rocky outcrops with caves or crevices are located within 2 kilometres of the alignment in the Pilliga. As such, no targeted surveys were conducted in the breeding season for this species and no species polygon has been mapped for this area. Rocky hillsides occur in the Mount Tenandra and Black Hollow area. This area is located west of the mapped distribution of the species (EES 2019b), and there are no records of the species in this area in the last 20 years (EES 2019a). This species is known to occur in the Warrumbungles, and is more likely to occur where large tracts of woodland vegetation occur within the Warrumbungle National Park area. Scattered patches of vegetation in predominantly cleared agricultural land in the proposal site are unlikely to support this species. No species polygon has been mapped for this area.
Large Bent-winged Bat	Yes	Species/Ecosystem (Breeding habitat)	Caves (cave, tunnel, mine, culvert or other structure)	**Surveys**: Microbat ultrasonic echolocation call recordings (Anabat surveys) were undertaken in September and November 2018 and March 2019, and

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Miniopterus orianae oceanensis			Species polygon: All breeding habitat including the cave, or other features, used for breeding and the area immediately surrounding this feature (100 m buffer).	harp netting in November 2018 and March 2019 (see section 3.6). Multiple records of this specie identified via Anabat analysis along the alignment. **No caves etc present**. The Large Bent-winged Bat forms discrete populations centred on a maternity cave that is used annually in spring and summer. Maternity caves have very specific temperature and humidity regimes. At other times of the year, populations disperse within about 300 kilometre range of maternity caves (EES 2020b). No breeding habitat (limestone caves, mines etc) is present in or near the proposal site. As such, no species polygon is required. Foraging habitat is an ecosystem credit for this species.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Eastern Cave Bat *Vespadelus troughtoni*	Yes. Eight records in the locality, mainly in the Pilliga	Species	Caves (within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, crevices or boulder piles, or within two kilometres of old mines, tunnels, old buildings or sheds)	**Surveys**: Microbat ultrasonic echolocation call recordings (Anabat surveys) were undertaken in September and November 2018 and March 2019, and harp netting in November 2018 and March 2019 (see section 3.6). No individuals were recorded on Anabat or were trapped in harp nets. Limited harp netting in the breeding season (November – January) was conducted given the lack of suitable breeding habitat near the proposal site. **No caves etc present, outside known distribution**. No rocky outcrops with caves or crevices are located within two kilometres of the alignment in the Pilliga. As such, no targeted surveys were conducted in the breeding season for this species and no species polygon has been mapped for this area. Rocky hillsides occur in the Mount Tenandra and Black Hollow area. This area is located west of the mapped distribution of the species (EES 2020b), and there are no records of the species in this area in the last 20 years (EES 2020a). This species is known to occur in the Warrumbungles and is more likely to occur where large tracts of woodland vegetation occur within the Warrumbungle National Park area. Scattered patches of vegetation in predominantly cleared agricultural land in the proposal site are unlikely to support this species. No species polygon has been mapped for this area.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Brush-tailed Rock-wallaby *Petrogale penicillata*	Yes. One only	Species	Other (land within 1 km of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or clifflines)	**Surveys**: survey of rocky areas in the Mount Tenandra and Black Hollow areas were conducted in September and October 2019 (see section 3.6). No individuals were recorded. **No rocky escarpment etc present**. This species is known to occur in the Warrumbungles and Mt Kaputar, well to the east of the proposal site (EES 2020a). There are no escarpment habitats in the proposal site. Rocky hillsides occur in the Mount Tenandra and Black Hollow area, adjacent to the proposal site. This area is located west of the mapped distribution of the species in the Warrumbungles (EES 2020b) and separated from this area by cleared agricultural land. Historically the species occurred in central NSW, however these popualtions are extinct and the Warrumbungles population is now the most westerly population still extant (DECC 2008, Short and Milkovits 1990). The proposal site is outside the current range of this species, and given the lack of appropriate habitat, no species polygon has been prepared.
Australian Bustard *Ardeotis australis*	None	Species	None	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). Not recorded during surveys. **Vagrant species.** Australian Bustards are nomadic, and numbers may sometimes irrupt (build up rapidly) and then disperse again in response to availability of food (for example after rains or grasshopper plagues) (Ziembicki 2009). The Australian Bustard has undergone large historic population declines in the south and south-east of Australia and are now largely absent from areas where they were formerly found (Garnett and Crowley 2000, Marchant and Higgins 1993). In NSW, they are now mainly found in the north-west corner and less often recorded in the lower western and central west plains regions. Occasional vagrants are still seen as far east as the western slopes and Riverine plain (EES 2019b). A survey of landowners found that in NSW, Australian Bustards were usually short-term visitors, whereas the species was considered resident on properties in Queensland (Ziembicki 2009). The species is considered to be extinct in the Pilliga area (Date et al 2002). There were no local records prior to the main surveys being undertaken (EES 2020a/ Birdlife Australia 2020a), however three birds (two males and

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
				a female) were observed near Narrabri by locals in early 2020 (Birdlife Australia 2020b, Narrabri Courier 2020). Local birdwatchers noted that Australian Bustards are not common in the area and had not been observed for many years (about 30 years according to one article). Records on Birdata for the region surrounding the study area include six individuals at Burren Junction in 2020 and one individual at Pilliga Bore Baths in 2016 (both locations about 80 km west of the study area), and one individual at Eulah Creek in 2006 (about 15 km east of Narrabri) (Birdlife Australia 2020). Best quality habitat for the Australian Bustard is the margin between tussock grass plains and desert scrub, and ecotones between open plains and open woodlands are regarded as preferred nesting areas (Downes 1982, Marcharnt and Higgins 1993). The Australian Bustard is considered a vagrant in the study area, given the low number of observations in the Narrabri region in the last twenty years, and that the core area in NSW is the north-west corner of the state.
Black-breasted Buzzard *Hamirostra melanosternon*	None	Species/Ecosystem (Nest trees)	Waterbodies (land within 40 m of riparian woodland on inland watercourses/ waterholes containing dead or dying eucalypts)	**Surveys**: multiple survey periods between September 2018 and October 2019, including multiple surveys during the breeding season (see section 3.6). No individuals recorded during surveys. No suitable large nests observed. **Vagrant species.** Any individuals that may occur on occasion are unlikely to breed in the proposal site. The main range of this species occurs well to the west of the proposal. BCD Accountable Officers noted that individuals may occur on occasion but would be vagrant and non-breeding (teleconference with BCD, February 2020). The compiled distribution map provided by BirdLife International species range maps (as published on the Atlas of Living Australia 2020a) is shown below, and shows the main distirbution of the species to the west of the study area.

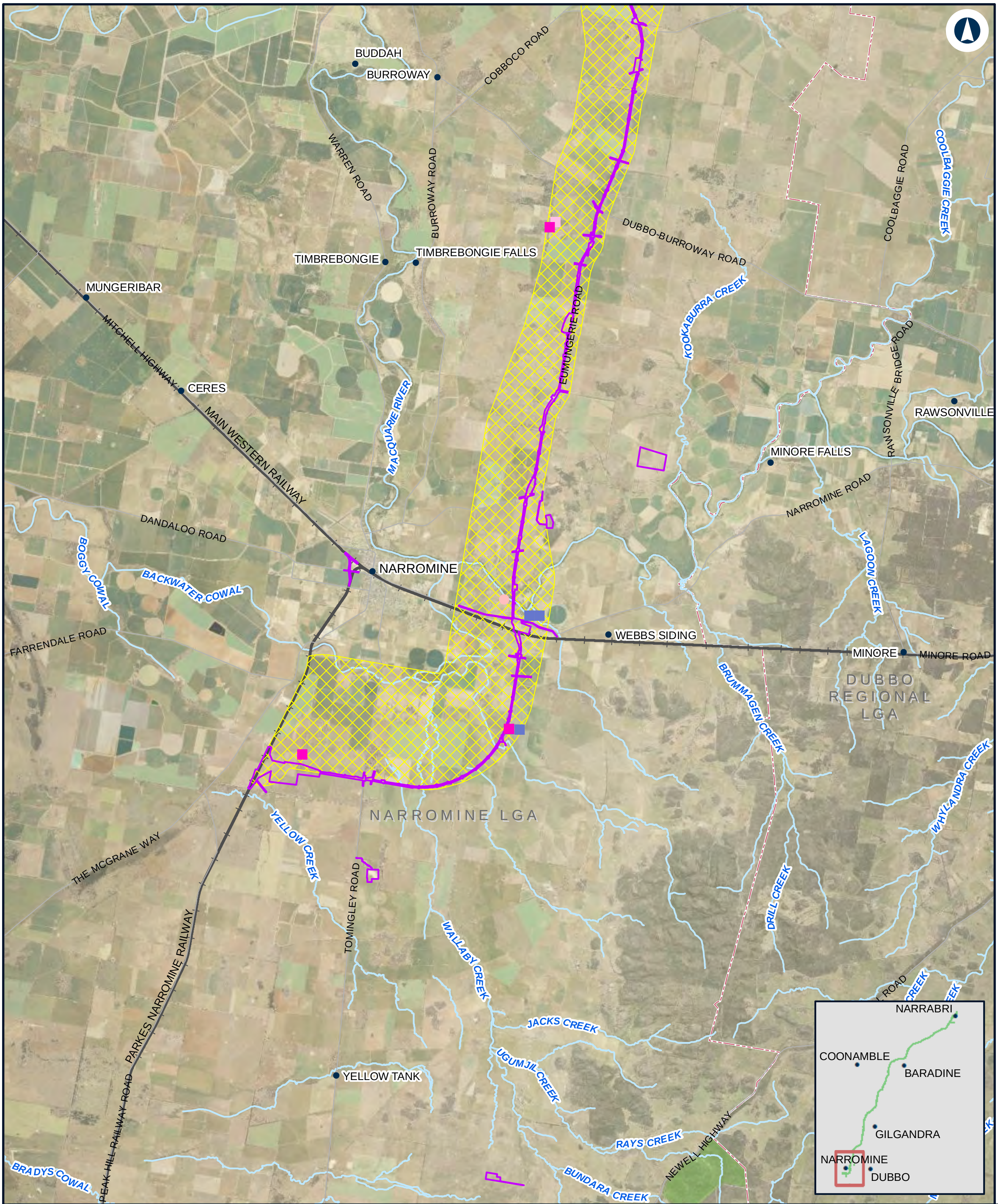
Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
				 Given the location of the proposal site outside the breeding distribution of the species, a species polygon has not been prepared for this species. Foraging habitat is an ecosystem credit for this species.
Major Mitchells Cockatoo *Lophochroa leadbeateri*	None	Species/Ecosystem (Nest trees)	Hollow-bearing trees	**Surveys**: multiple survey periods between September 2018 and October 2019, including multiple surveys during the breeding season (see section 3.6). No individuals recorded during surveys. **Vagrant species**. Most records of the species in NSW are located west of Walgett, Trangie and Parkes, although the species is occasionally recorded further east (Birdlife Australia 2020). A species polygon is only required for impacts on breeding habitat. Any individuals that may occur on occasion are unlikely to breed in the proposal site. The main range of this species occurs to the west of the proposal. The compiled distribution map provided by BirdLife International species range maps (as published on the Atlas of Living Australia 2020b) is shown below, and shows the main distirbution of the species to the west of the study area.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
				 BCD accountable officers noted that individuals may occur on occasion but would be vagrant and non-breeding (teleconference with BCD, February 2020). Given the location of the proposal site outside the breeding distribution of the species, a species polygon has not been prepared for this species. Foraging habitat is an ecosystem credit for this species.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Superb Parrot *Polytelis swainsonii*	Yes. 49 Records	Species/Ecosystem (Nest trees)	Hollow-bearing trees	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). Four individuals were recorded on site, near a narrow roadside remnant north-east of Gilgandra. **Foraging habitat only, no breeding habitat present**. A species polygon is only required for impacts on breeding habitat. The breeding range of the Superb Parrot is divided into three main areas: the first, along the Murray and Edward Rivers; the second, along the Murrumbidgee River; and the third, in the South-west Slopes, in a triangle bounded by Molong, Yass and Young (DEE 2020a). Birds breeding in the South-west slopes are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers (DEE 2020a). Superb Parrots have been observed near Collie (west of Gilgandra) just before or during the breeding season, and there is a possibility that breeding occurs this far north. Further north at sites such as Narrabri, birds were absent during the breeding season, supporting the proposition that birds do not breed in these areas (Christie 2004). BCD accountable officers noted that individuals may occur on occasion but are unlikely to breed in the proposal site, given its location outside the breeding areas for this species (teleconference with BCD, February 2020). Given the location of the proposal site outside the breeding distribution of the species, a species polygon has not been prepared for this species. Foraging habitat is an ecosystem credit for this species.
Powerful Owl *Ninox strenua*	None	Species/Ecosystem (Nest trees)	Hollow-bearing trees	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **Vagrant, outside usual range** Proposal outside usual range of this species. The Powerful Owl mainly occurs along the coast of NSW and the Great Dividing Range, with only sparse records further west (Birdlife Australia 2020, Debus and Chafer 1994). The recovery plan does not map the Powerful Owl as occurring as far west as the proposal site (DEC 2006) (see map below).

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
				 The compiled distribution map provided by BirdLife International species range maps (as published on the Atlas of Living Australia 2020c) similarly shows the main distirbution of the species to the east of the study area.
Grey-headed Flying-fox *Pteropus poliocephalus*	Yes. Five records	Species/Ecosystem (Breeding habitat)	Other (breeding camps)	**Surveys**: multiple survey periods between September 2018 and October 2019 (see section 3.6). No individuals recorded during surveys. **No roost camps present**. Grey-headed Flying-foxes are generally found within 200 km of the eastern coast of Australia, but in times of natural food shortages, individuals may be found further west (EES 202a). Occupancy at the edges of their range is ephemeral in most areas, and vagrants are occasionally sighted several hundred kilometres beyond expected bounds (Eby and Law 2008). No Grey-headed Flying-fox breeding camps are mapped in the area by the National Flying-fox Web Viewer (DAWE 2020). No camps were observed in the proposal site during surveys. Given the location of the proposal outside the usual range of the species, lack of evidence of the species during survyes, and lack of evidence of any roost camps, no species polygon has been prepared. Foraging habitat is an ecosystem credit for this species.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Sloane's Froglet *Crinia sloanei*	None	Species	Semi-permanent/ephemeral wet areas Swamps Waterbodies	**Surveys:** surveys for this species were conducted as part of the winter surveys in August 2019. Surveys were also conducted in September 2018 and 2019, although these are outside the usual calling period for this species (see section 3.6). No individuals were recorded. **Vagrant/outside usual distribution.** Recent research has found many existing records of the species in the north of its range are likely to be misidentification of other, morphologically similar, species in the same genus (Spark 2015). Records for Sloane's Froglet north of Dubbo are likely to be misidentification of other *Crinia* species (Spark 2015). Sloane's Froglet has disappeared from much of its former range and now appears to be restricted to a very small area of NSW near Albury and Corowa, as well as the Wahgunyah and Rutherglen regions in Victoria (Knight 2015). Given the location of the proposal well to the north of the current range of this species, no species polygon has been prepared.



NARROMINE TO NARRABRI

Threatened flora and fauna species recorded during surveys

Figure 6.1 MAP 1 OF 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 7/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction Footprint
- Investigation Corridor

Threatened Species

- Large Bentwing Bat
- Grey-crowned Babbler
- Spotted Harrier
- Varied Sittella

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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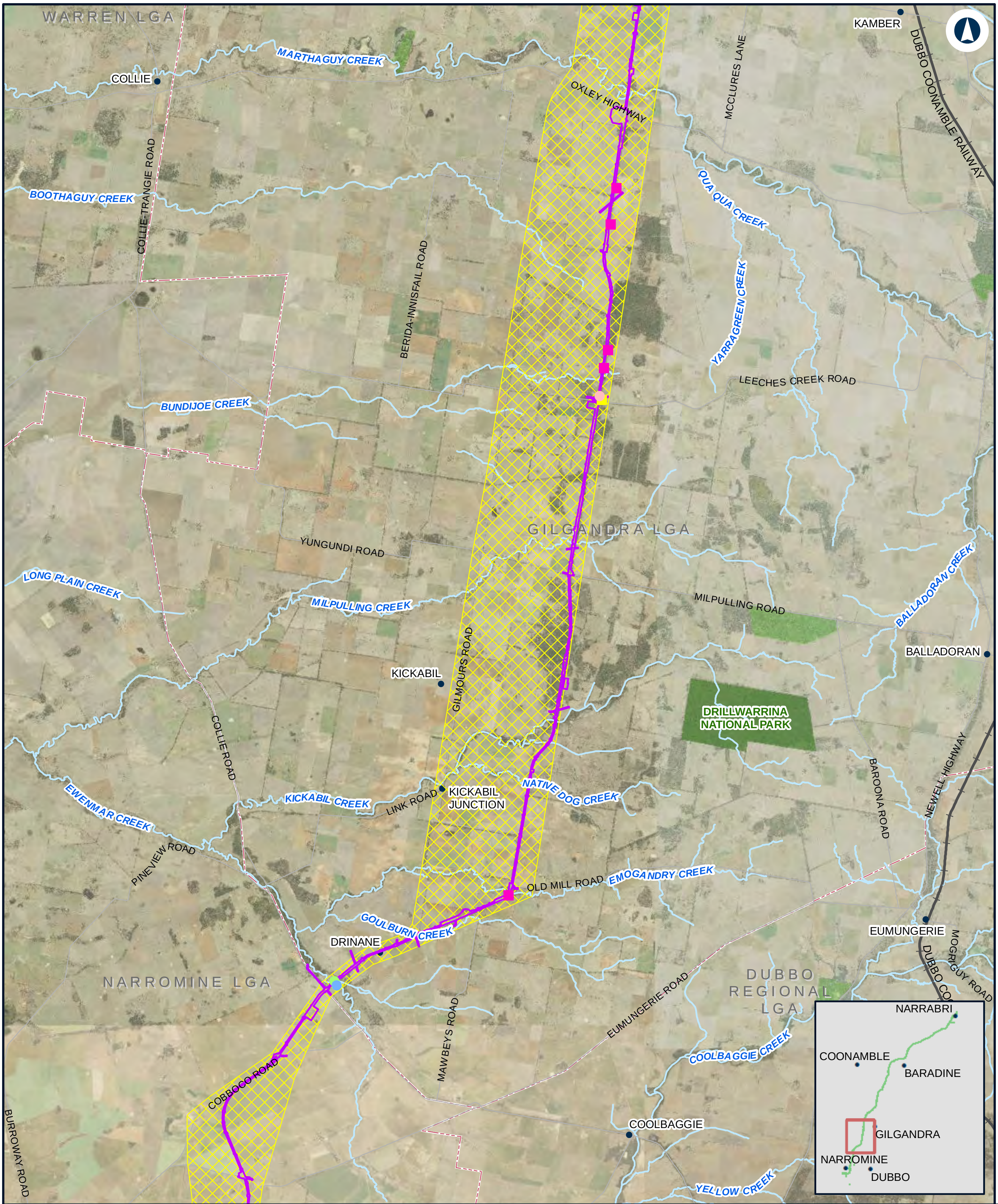

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys Figure 6.1 MAP 2 OF 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 7/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction Footprint
- Investigation Corridor

Threatened Species

- Black-chinned Honeyeater
- Large Bentwing Bat
- Grey-crowned Babbler
- Little Pied Bat
- Yellow-bellied Sheath-tail Bat

INLAND RAIL ARTC

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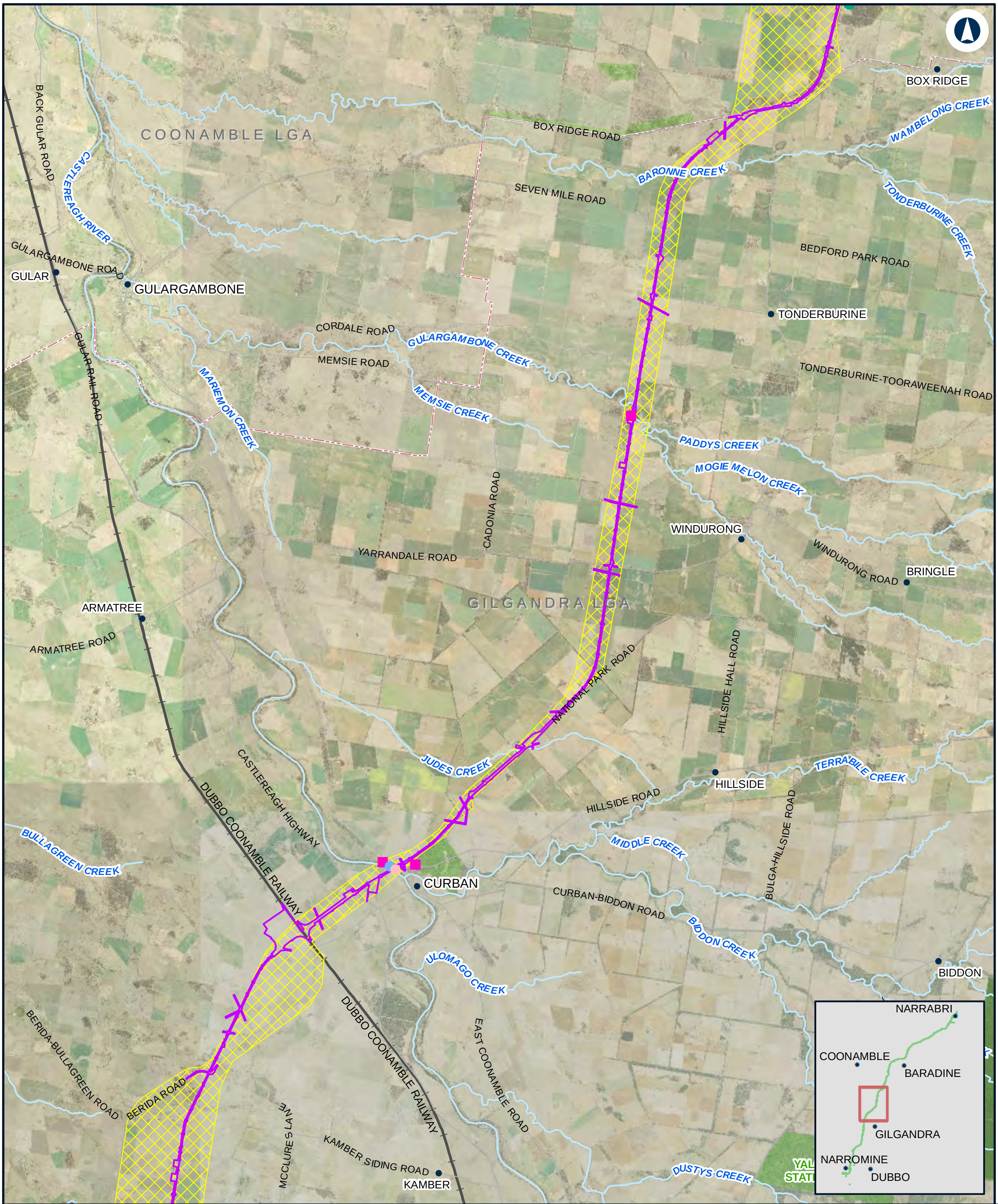

NARROMINE TO NARRABRI

Threatened flora and fauna species recorded during surveys

Figure 6.1 MAP 3 OF 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 7/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction Footprint
- Investigation Corridor

Threatened Species

- Large Bentwing Bat
- Grey-crowned Babbler
- Little Pied Bat
- Superb Parrot

INLAND RAIL ARTC

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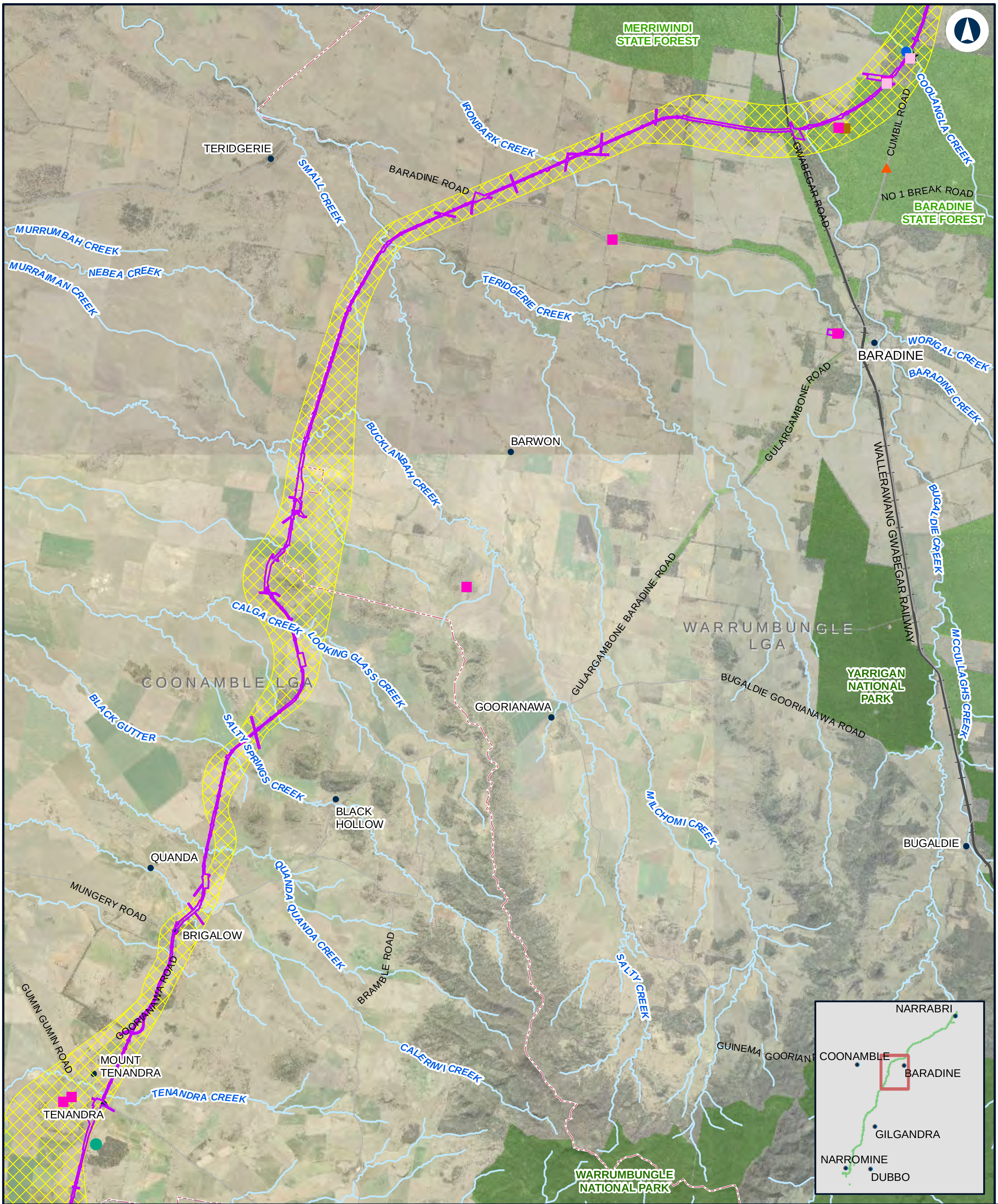

NARROMINE TO NARRABRI

Threatened flora and fauna species recorded during surveys

Figure 6.1 MAP 4 OF 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 7/08/2020
Paper: A4
Author: JacobsGHD
Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction Footprint
- Investigation Corridor

Threatened Species

- Brown Treecreeper
- Large Bentwing Bat
- Grey-crowned Babbler
- Corben's Long Eared Bat
- Koala (scats/scratches)
- Large-eared Pied Bat (probable)
- Little Pied Bat
- Pale-headed Snake
- Superb Parrot
- Varied Sittella
- Yellow-bellied Sheath-tail Bat

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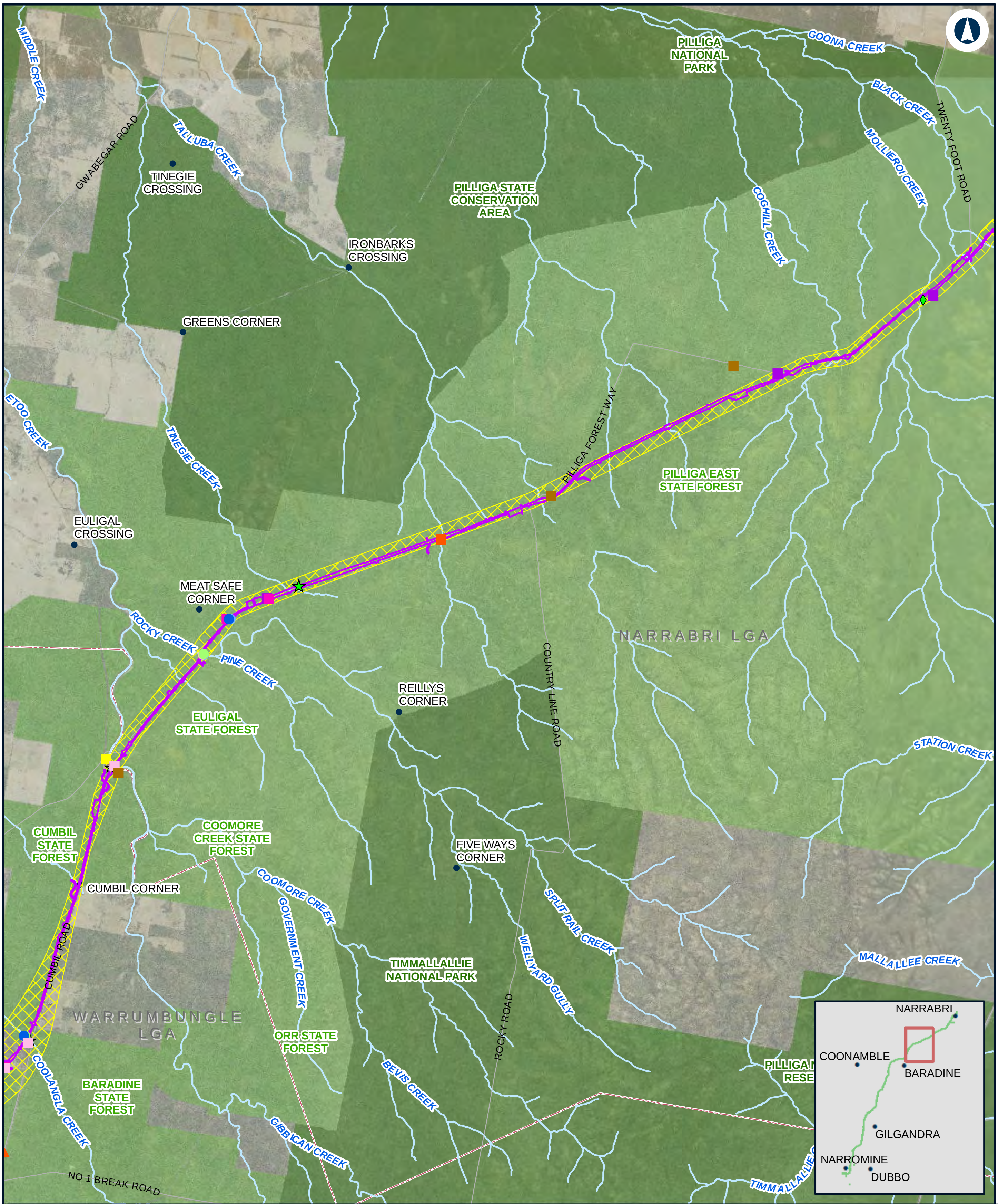

NARROMINE TO NARRABRI

Threatened flora and fauna species recorded during surveys

Figure 6.1 MAP 5 OF 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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LEGEND

- Construction Footprint
- Investigation Corridor

Threatened Species

- Black-chinned Honeyeater
- Brown Treecreeper
- Large Bentwing Bat
- Flame Robin
- Glossy Black Cockatoo
- Grey-crowned Babbler
- Corben's Long Eared Bat
- Koala (scats/scratches)
- Large-eared Pied Bat (probable)
- Little Pied Bat
- Pale-headed Snake
- Pterostylis cobarensis
- Squirrel glider
- Varied Sittella
- Yellow-bellied Sheath-tail Bat

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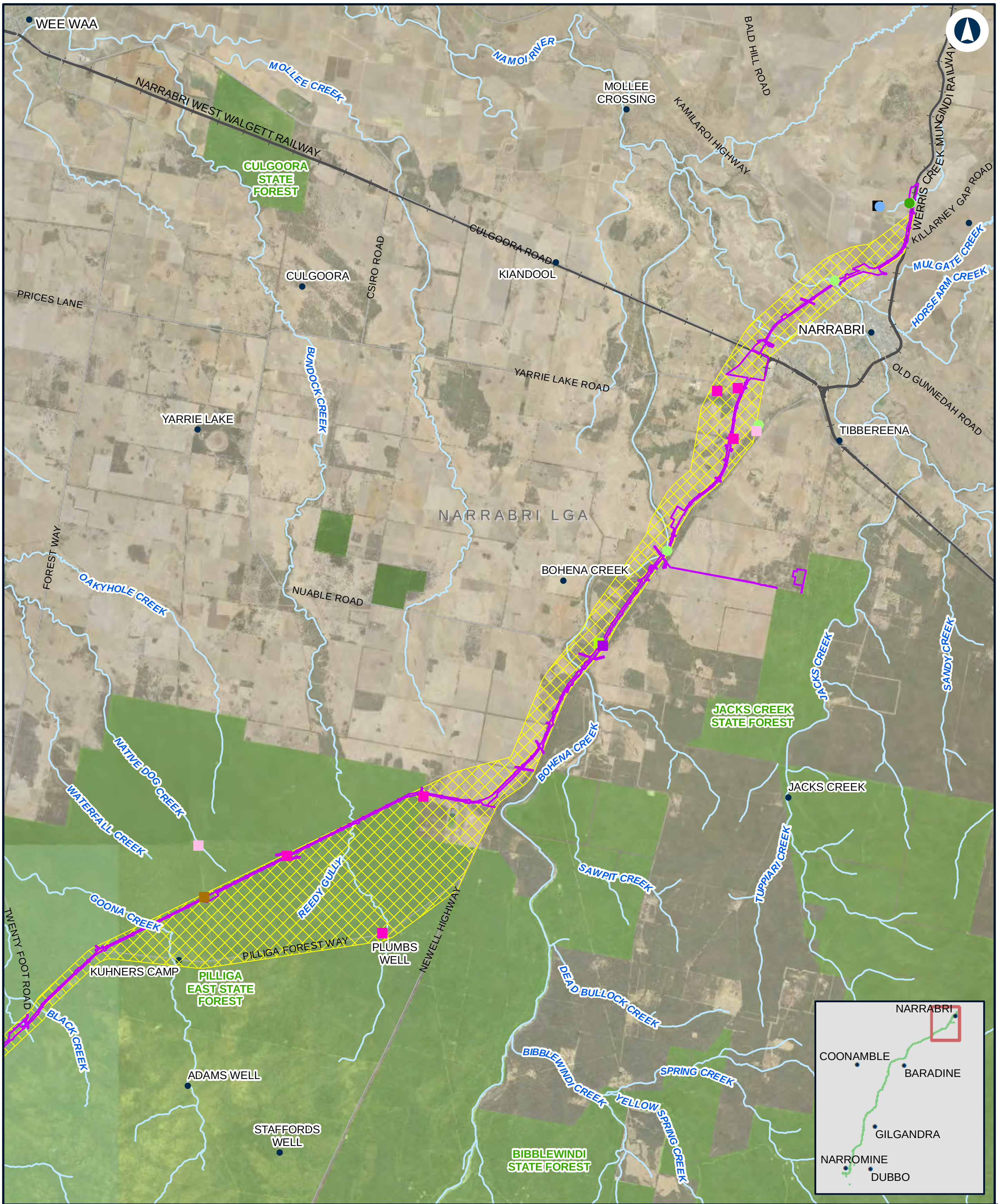

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys Figure 6.1 MAP 6 OF 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 7/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- Construction Footprint
- Investigation Corridor

Threatened Species

- Black Falcon
- Brown Treecreeper
- Eastern Freetail Bat
- Glossy Black Cockatoo
- Grey-crowned Babbler
- Little Pied Bat
- Speckled Warbler
- Varied Sittella
- Yellow-bellied Sheath-tail Bat

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7. Matters of national environmental significance

7.1 Threatened ecological communities

Five threatened ecological communities listed under the EPBC Act would be impacted by the proposal (see Table 7.1). The locations of these communities are mapped on Figure 7.1.

Table 7.1 EPBC threatened ecological communities in the proposal site

Community name	PCT ID	EPBC status	Extent in proposal site (ha)
Weeping Myall Woodlands	27	E	3.05
Brigalow (*Acacia harpophylla* dominant and co-dominant)	35	E	0.61
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia	248	E	14.71
Poplar Box grassy woodland on alluvial plains	244	E	31.84
White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grassland	599	CE	2.21
		Total	**52.42 ha**

Key: CE – critically endangered, E – endangered

Weeping Myall woodland occurred as only one patch on one private property in the Curban to Pilliga segment of the alignment. Brigalow is restricted to the edge of a linear roadside strip in the Pilliga to Narrabri segment of the alignment, while similarly White Box – Yellow Box - Blakey's Red Gum Woodland occurred in one roadside patch which extended into private property in the Narromine to Curban segment of the alignment. Poplar Box grassy woodland was listed under the EPBC Act in mid-2019. This community occurs as scattered patches mostly throughout the Curban to Pilliga segment of the alignment.

While PCT 56 can be part of the Poplar Box grassy woodland TEC, its occurrence within the proposal is dominated by dominated by Belah and did not contain >50 per cent Poplar Box to meet EPBC listing guidelines.

7.2 Threatened species

Three threatened fauna species were positively identified during surveys, and one was potentially identified based on Anabat analysis. A number of additional fauna species and flora species have the potential to occur in the proposal site. These are summarised in Table 7.2. A number of other species have been assessed to have a low potential to occur given lack of suitable habitat and few local records (Appendix C).

Table 7.2 EPBC threatened flora and fauna species recorded during surveys or likely to occur

Common name	Scientific name	EPBC Act	Record
Fauna			
Koala	*Phascolarctos cinereus*	V	Scats recorded in Pilliga area during surveys. Scattered records occur elsewhere in the region (EES 2019a).
Corben's Long-eared Bat	*Nyctophilus corbeni*	V	Trapped at Coolangala Creek (Trap site 1) in the Pilliga. Calls of *Nyctophilus* species were also recorded at Rocky Creek (Trap site 6) and Trap Site 5 in the Pilliga, and sites near Narromine, although the precise species cannot be determined by Anabat analysis as calls overlap. The stronghold for this species is the Pilliga, and it could occur elsewhere in the study area.
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	Probable calls of this species were recorded at Coolangala Creek in the Pilliga.
Pilliga Mouse	*Pseudomys pilligaensis*	V	Not recorded during surveys. Known to occur in the Pilliga.
Superb Parrot	*Polytelis swainsonii*	V	Four individuals were observed flying into roadside Box – Callitris woodland north-east of Gilgandra. Likely to occur as non-breeding visitors in the study area.
Australasian Bittern	*Botaurus poiciloptilus*	E	Not recorded during surveys. May forage at farm dams and other aquatic habitat in the proposal site.
Australian Painted Snipe	*Rostratula australis*	E	Not recorded during surveys. May forage at farm dams and other aquatic habitat in the proposal site.
Painted Honeyeater	*Grantiella picta*	V	Not recorded during surveys. May forage and breed in the proposal site.
Regent Honeyeater	*Anthochaera phrygia*	CE	Not recorded during surveys. No breeding habitat present. May forage on occasion in the proposal site.
Swift Parrot	*Lathamus discolor*	CE	Not recorded during surveys. No breeding habitat present. May forage on occasion in the proposal site.
White-throated Needletail	*Hirundapus caudacutus*	V	Not recorded during surveys. Likely to occur throughout the study area.
Five-clawed Worm-skink	*Anomalopus mackayi*	V	Not recorded during surveys. Occurs north from Narrabri and Wee Waa area. Potential to occur in the Narrabri area.
Flora			
Coolabah Bertya	*Bertya opponens*	V	Not recorded during surveys. Known from one location in alignment near Bohena Creek. Known to occur in the wider region from near Jacks Creek State Forest.

Common name	Scientific name	EPBC Act	Record
Slender Darling Pea	*Swainsona murrayana*	V	Not recorded during surveys. Known to occur in the wider locality along length of proposal.
	Commersonia procumbens	V	Not recorded during surveys. Known to occur within Pilliga forest in study area.
Spiny Peppercress	*Lepidium aschersonii*	V	Not recorded during surveys. Known to occur in study area between the northern end of the Pilliga and Narrabri.
	Tylophora linearis	E	Not recorded during surveys. Known to occur within Pilliga forest in study area.
Winged Peppercress	*Lepidium monoplocoides*	E	Not recorded during surveys. Known to occur east of study area near Narrabri.

Key: E – endangered, V – vulnerable, CE – critically endangered

7.2.1 Assessment of habitat value for the Koala

Koala habitat has been assessed with regards to the EPBC Act referral guidelines for the Koala (DoE 2014) to determine if the proposal will impact habitat critical to the survival of the species. The Koala population in the Pilliga is considered an 'important population' for the purposes of the assessment of significance for this species (refer to Appendix M). The Koala habitat assessment tool in DoE (2014) assists in determining the sensitivity, value and quality of the impact area and, therefore, whether it contains habitat critical to the survival of the Koala. From a national recovery perspective, this is Koala habitat that is considered to be important for the long-term survival and recovery of the Koala. Impact areas that score five or more using the habitat assessment tool contain habitat critical to the survival of the Koala (DoE 2014).

A detailed description of Koala habitat requirements and habitat values present in the proposal site is provided in Appendix I. Based on the assessment of habitat values provided in Table 7.3, Koala habitat in the proposal site scores 10, and is thus habitat critical to the survival of the species.

Table 7.3 EPBC Act Koala habitat assessment tool

Attribute	Description	Score
Koala occurrence	Evidence of one or more Koalas within the last five years: Koala scats were recorded during surveys for the proposal in the Pilliga	2 (high)
Vegetation composition	Has forest, woodland or shrubland with emerging trees with two or more known Koala food tree species: Feed trees with documented high use (OEH 2018b) that are present in the proposal site include *Eucalyptus chloroclada* (Dirty Gum), *Eucalyptus blakelyi* (Blakely's Red Gum), *Eucalyptus populnea* (Poplar Box) and *Eucalyptus camaldulensis* (River Red Gum). Feed trees with documented high use in the Pilliga (OEH 2018b) that are present in the proposal site include *Eucalyptus pilligaensis* (Pilliga Box) and *Callitris glaucophylla* (White Cypress Pine). Feed trees with documented significant use in the Pilliga (OEH 2018b) comprises *Eucalyptus crebra* (Narrow-leaved Ironbark).	2 (high)

Attribute	Description	Score
Habitat connectivity	Area is part of a contiguous landscape ≥ 1,000 hectares: the Pilliga forest contains about 3,000 square kilometres of forested vegetation.	2 (high)
Key existing threats	Little or no evidence of Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence	2 (high)
Recovery value	Habitat is likely to be important for achieving the interim recovery objectives: • Protect and conserve the quality and extent of habitat refuges for the persistence of the species during droughts and periods of extreme heat, especially in riparian environments and other areas with reliable soil moisture and fertility • Maintain the quality, extent and connectivity of large areas of koala habitat surrounding habitat refuges.	2 (high)
Total score		**10**

Note that the assessment of habitat critical to the survival of the Koala provided here is different to the assessment of important habitat undertaken to determine the species credit area for credit calculations. As noted in Appendix I, the area defined as the species polygon for the Koala included the Pilliga Area of Regional Koala Significance and vegetation within 10 kilometres of a recent record elsewhere along the alignment.

7.3 Migratory species

7.3.1 Migratory wetland species

A critical consideration in assessing the significance of potential impacts on listed migratory shorebird species is whether or not a proposed action is likely to affect 'important habitat' (DEE 2017a). Important habitat is defined separately for 36 of the listed migratory shorebird species and Latham's Snipe (*Gallinago hardwickii*).

An area of 'important habitat' for the 36 migratory shorebird species identified in DEE (2017a) is defined as either:

- a site that is identified as internationally important; or
- a site that supports either:
  a) at least 0.1 per cent of the flyway population of a single species; or
  b) at least 2000 migratory shorebirds; or
  c) at least 15 shorebird species (DEE 2017a).

No mapped important habitat for the 36 migratory waders is located in or near the proposal site (EES 2020).

Some Australian inland wetlands and grasslands are also important habitat for migratory shorebirds. Many of these inland areas are ephemeral due to variability in Australia's climate and rainfall. For this reason, many inland areas may not be used for several years. However, when these areas receive rain they can provide extremely productive and important food sources for migratory shorebirds (DoE 2017). There are records of the Marsh Sandpiper (*Tringa stagnatilis*) and Sharp-tailed Sandpiper (*Calidris acuminata*) at Narrabri Lake (EES 2019a).

Important habitat for Latham's Snipe is treated differently due to its cryptic lifestyle. Important habitat for this species occurs at sites that have previously been identified as internationally important for the species, or sites that:

- support at least 18 individuals of the species
- are naturally occurring open freshwater wetlands with vegetation cover nearby (for example, tussock grasslands, sedges, lignum or reeds within 100 metres of the wetland) (DEE 2017a).

There are records of the Latham's Snipe at Narrabri Lake and in the Pilliga (EES 2019a). This species has the potential to occur in an areas of Lignum Shrubland Wetland that is located in the proposal site near Narromine when conditions are suitable. Narrabri Lake has the potential to support 18 individuals of the species, however it is unlikely that this many individuals would occur at any dams in the Pilliga given the small size and limited vegetation cover. Similarly, the Lignum Shrubland Wetland is likely to provide habitat for occasional individuals, and not 18 or more individuals. No important habitat for this species would occur in the proposal site.

7.3.2 Other migratory species

A number of other migratory species could occur in the proposal site. These include migratory flycatchers that breed in eastern Australian forests and non-breeding migratory birds from Asia (DoE 2015a). One migratory species, the Fork-tailed Swift (*Apus pacificus*), was recorded during surveys. The proposal site intersects with core range of two other species (Table 7.4). Habitat for these species is discussed with reference to the Referral guideline for 14 birds listed as migratory species under the EPBC Act (DoE 2015a).

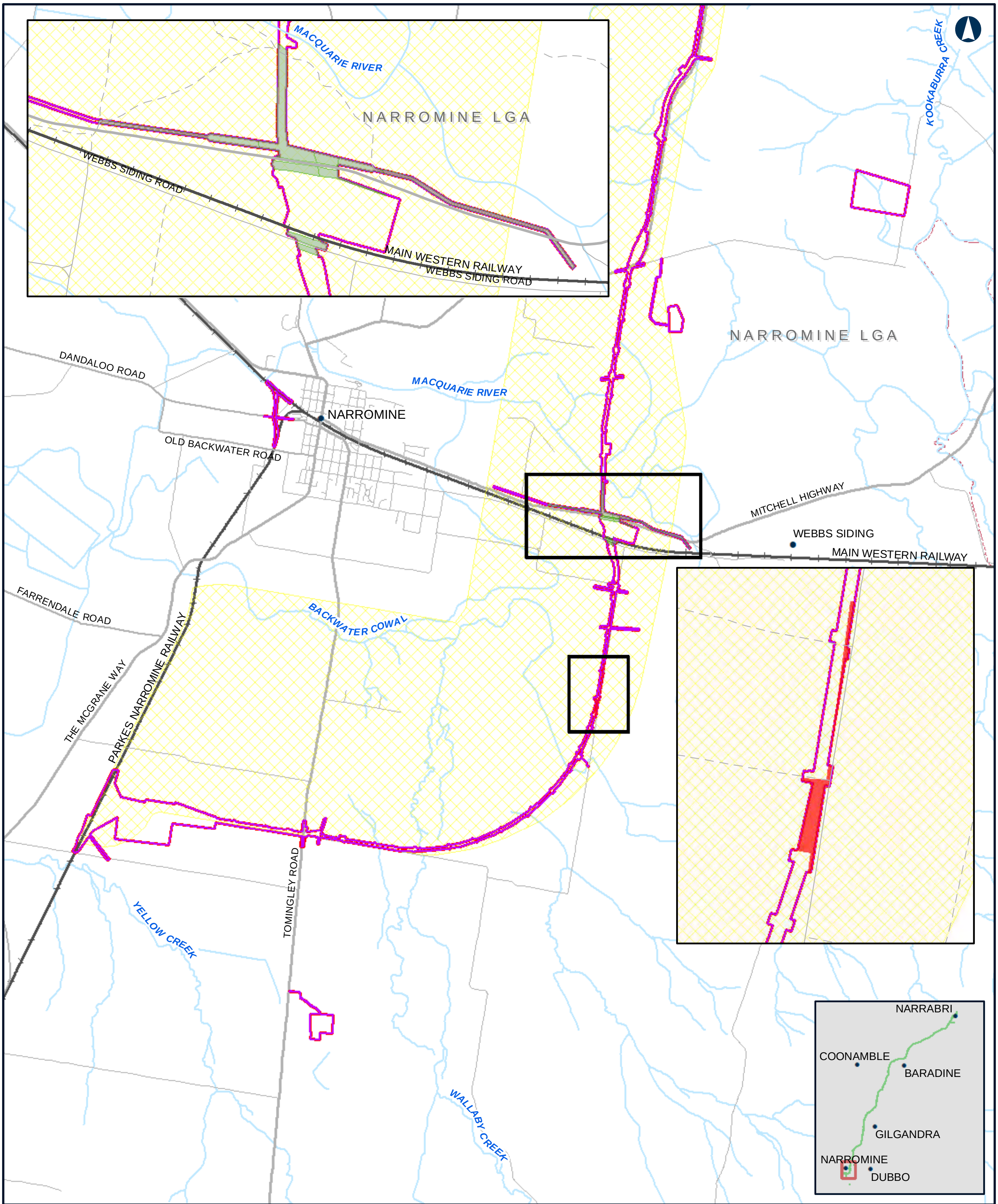
Table 7.4 EPBC Act migratory species recorded during surveys or with important habitat present

Common name	Scientific name	Important habitat (DoE 2015)	Record
Fork-tailed Swift	*Apus pacificus*	Non-breeding visitor only: Found across a range of habitats, from inland open plains to wooded areas, where it is exclusively aerial.	A large flock (~100 individuals) was observed flying over Leeches Creek Road near Gilgandra on one occasion during surveys. This would equate to an ecologically significant proportion of a population of this species (0.1 per cent) (DoE 2015). The proposal site is located within the core non-breeding range (DoE 2015).
White-throated Needletail	*Hirundapus caudacutus*	Non-breeding visitor only: Found across a range of habitats, more often over wooded areas, where it is almost exclusively aerial. Large tracts of native vegetation, particularly forest, may be a key habitat requirement for species.	Not recorded during surveys. The proposal site is located within the core non-breeding range (DoE 2015).

Common name	Scientific name	Important habitat (DoE 2015)	Record
Rufous Fantail	*Rhipidura rufifrons*	Moist, dense habitats, including mangroves, rainforest, riparian forests and thickets, and wet eucalypt forests with a dense understorey. When on passage a wider range of habitats are used including dry eucalypt forests and woodlands and Brigalow shrublands.	Not recorded during surveys. The proposal site is located within the core non-breeding range, but not the core breeding range (DoE 2015).

7.4 Wetlands of International Importance (Ramsar wetlands)

Four wetlands of international importance are identified by DAWE (2020b) as occurring downstream of the proposal site. Of these, the Macquarie Marshes are closest, located about 80 kilometres downstream from the proposal site.



NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1a

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Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:100,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Construction Footprint
- Grey Box grassy woodland and derived native grasslands of south-eastern Australia
- White Box Yellow Box Blakelys Red Gum grassy woodland and derived native grassland.

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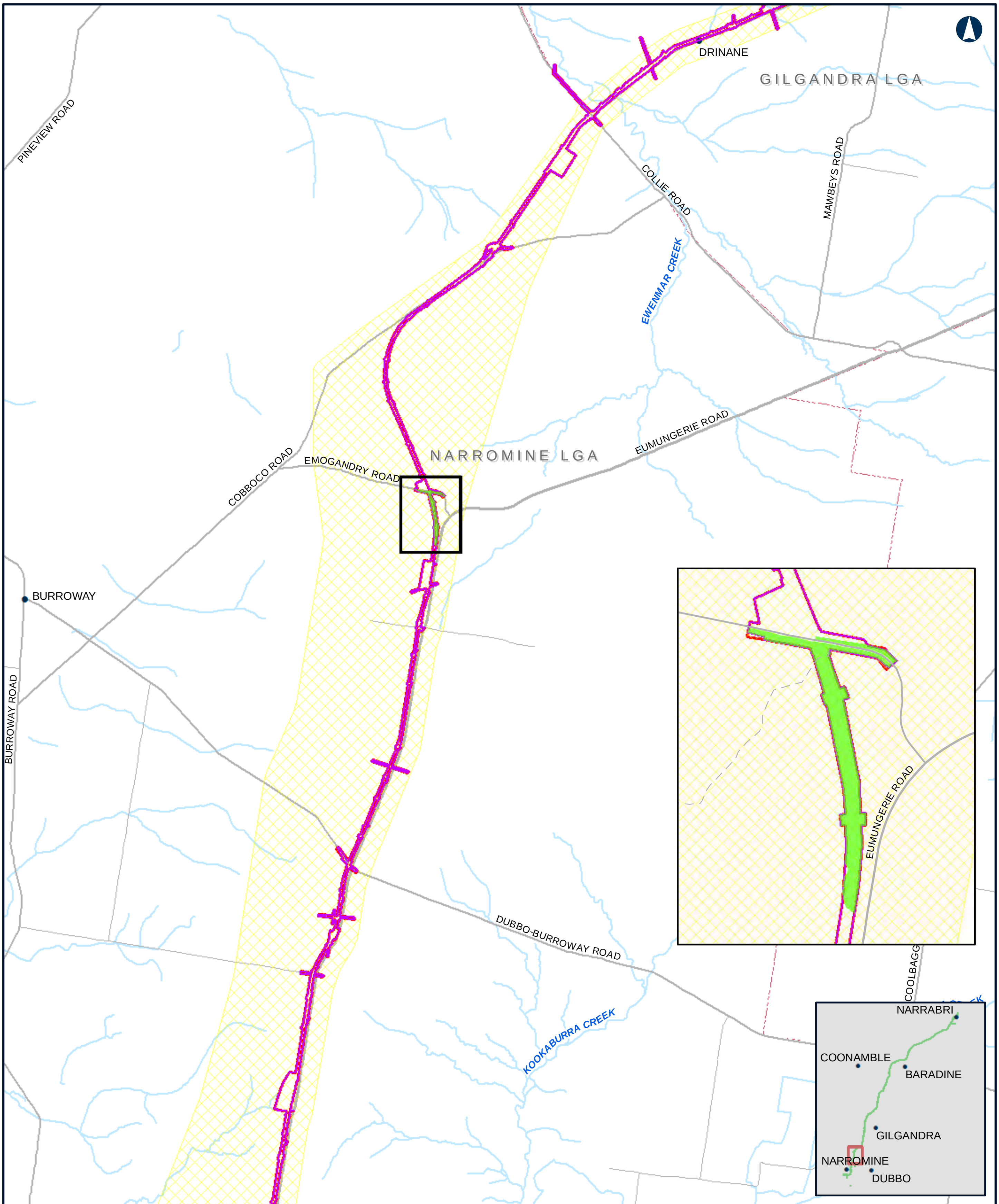

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1b

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Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:20,000
Data Sources: Basemap layers: NSWSS;

LEGEND
- The proposal
- Construction Footprint
- Poplar Box grassy woodland on alluvial plains

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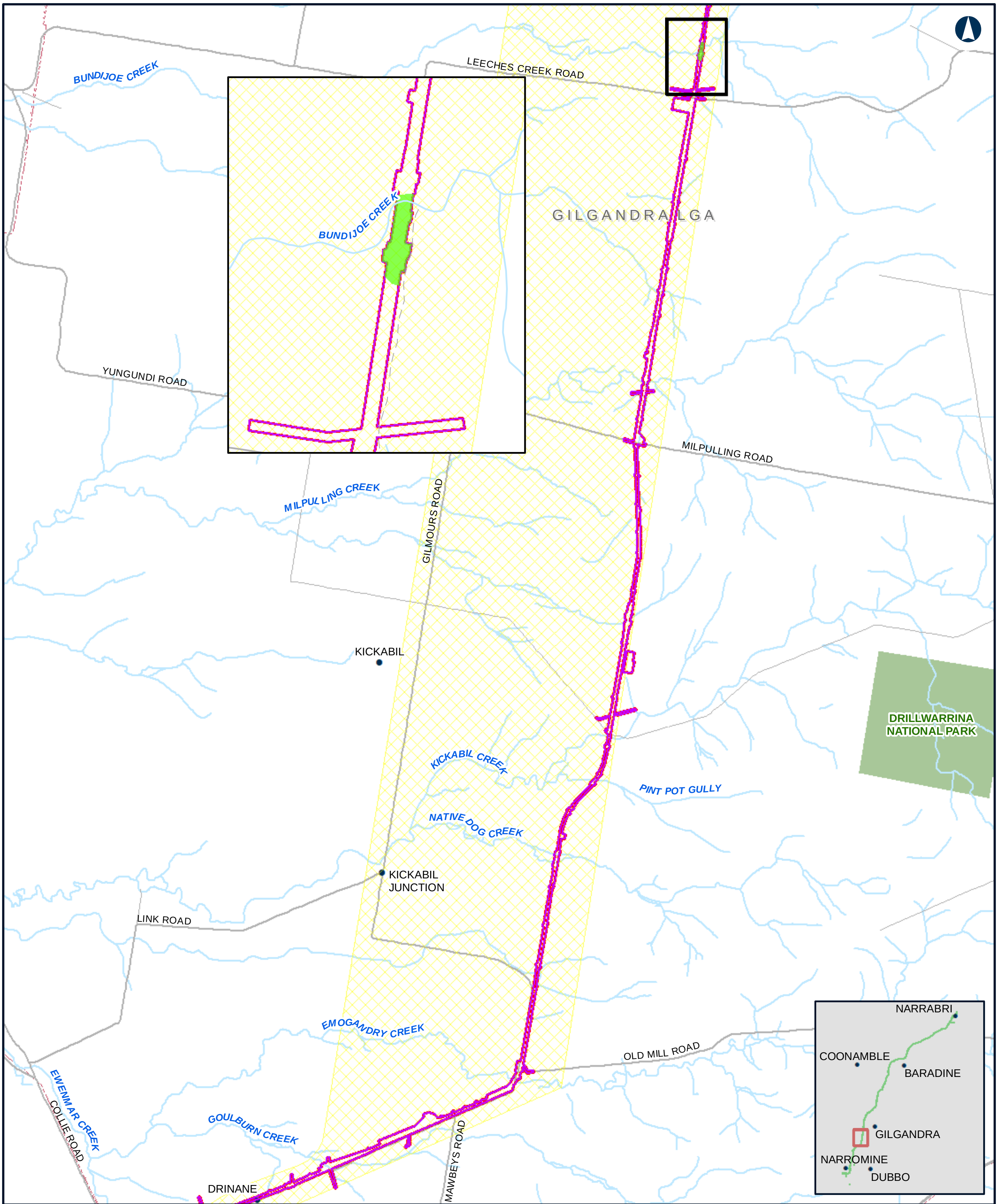

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1c

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LEGEND

- The proposal
- Construction Footprint
- Poplar Box grassy woodland on alluvial plains

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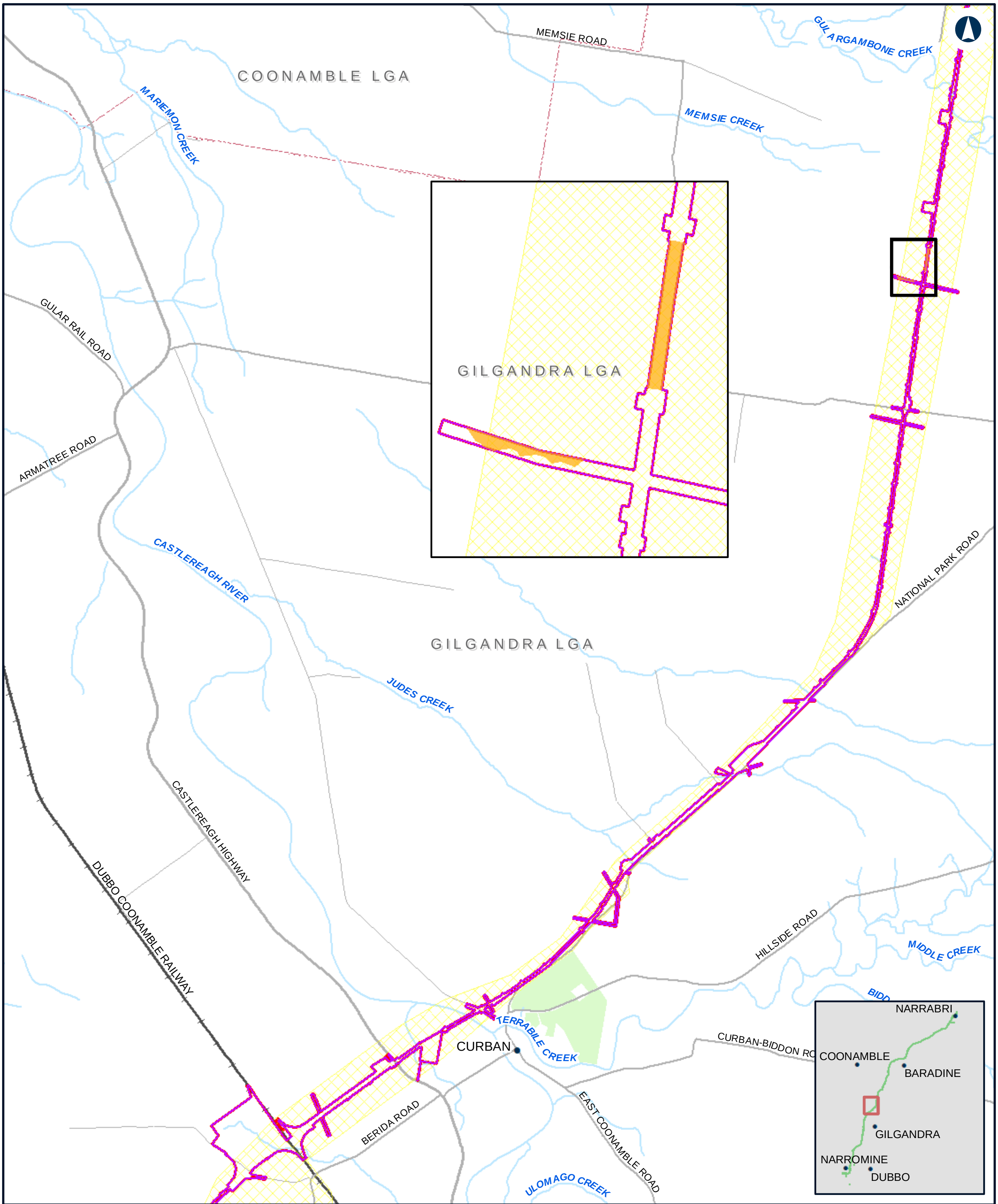

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1d

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Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Construction Footprint
- Weeping Myall woodlands

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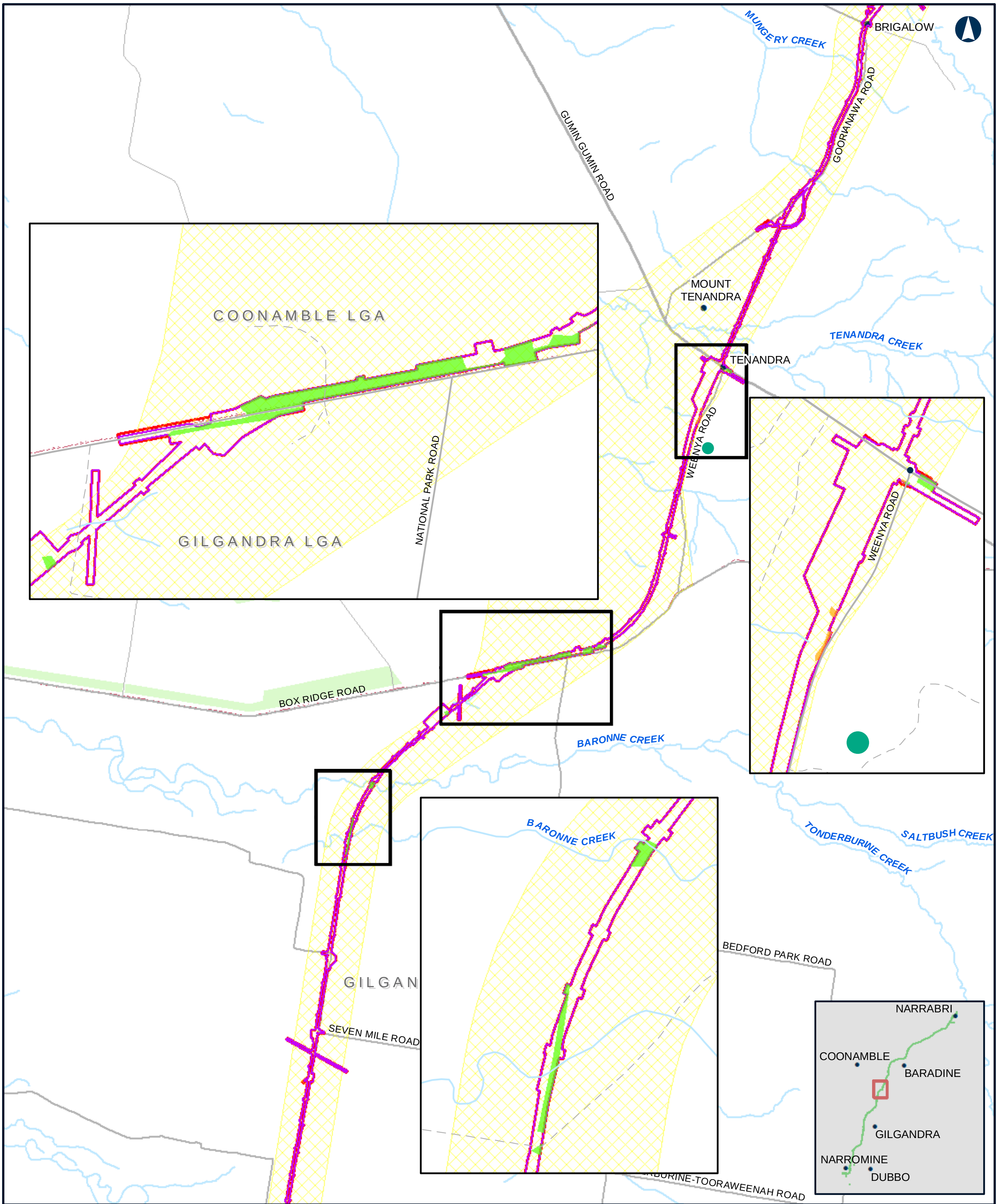

NARROMINE TO NARRABRI

Matters of National Environmental Significance

Figure 7.1e

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Date: 7/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:100,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Construction Footprint

Threatened Species

- Superb Parrot
- Poplar Box grassy woodland on alluvial plains
- Weeping Myall woodlands

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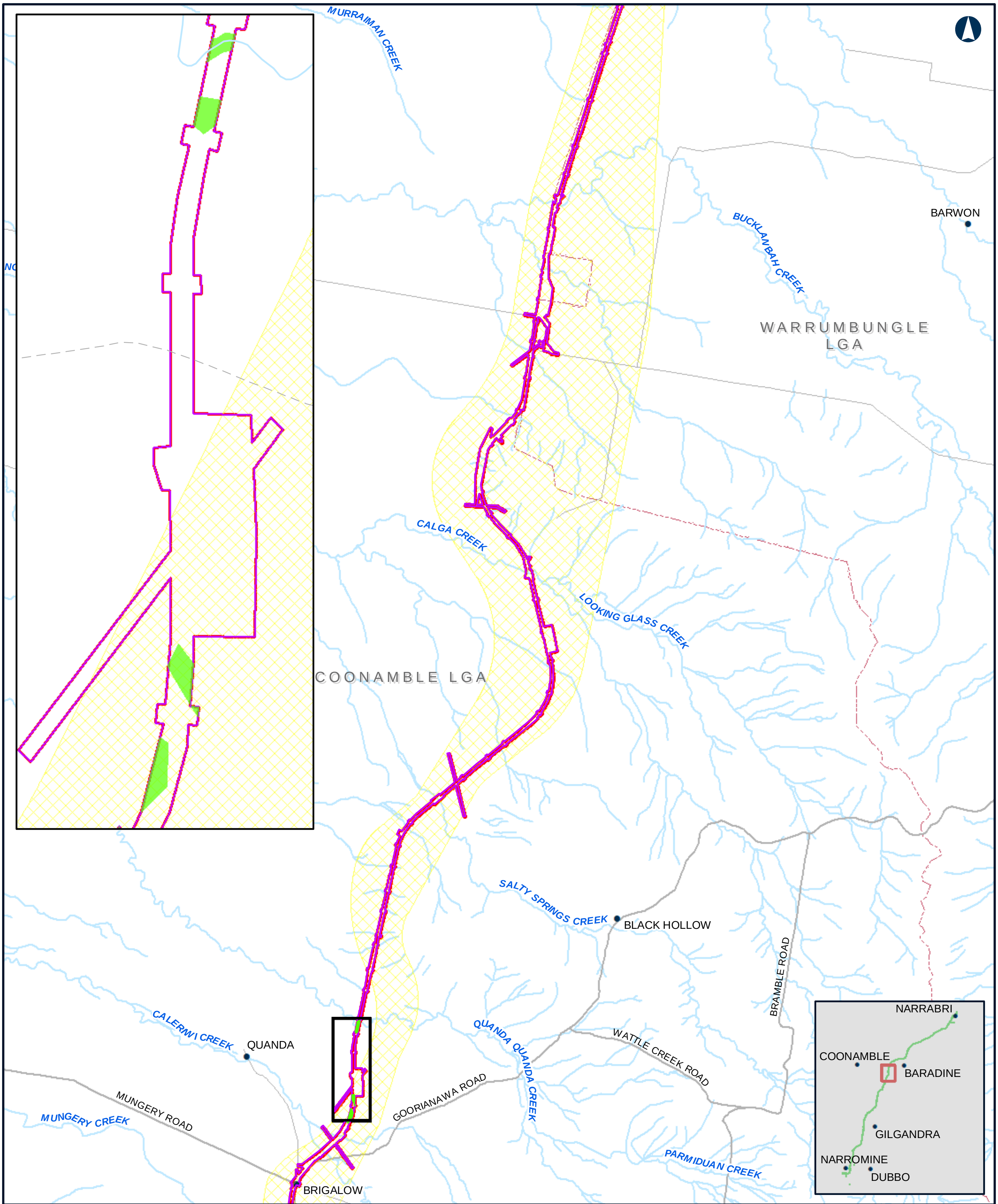

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1f

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Date: 18/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:100,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Construction Footprint
- Poplar Box grassy woodland on alluvial plains

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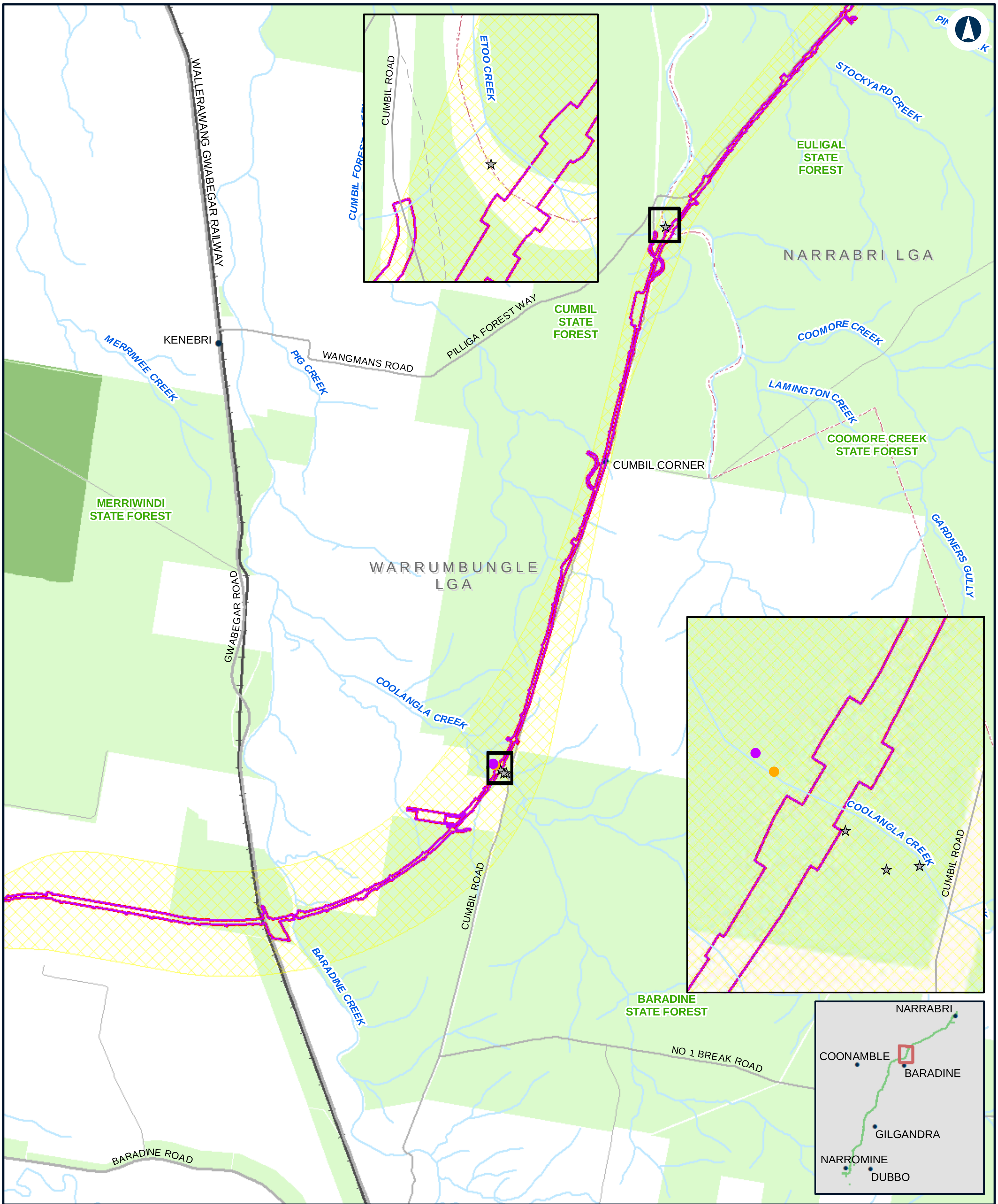

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1g

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Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:12,500
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Construction Footprint

Threatened Species

- Corben's Long Eared Bat
- Koala (scats/scratches)
- Large-eared Pied Bat (probable)

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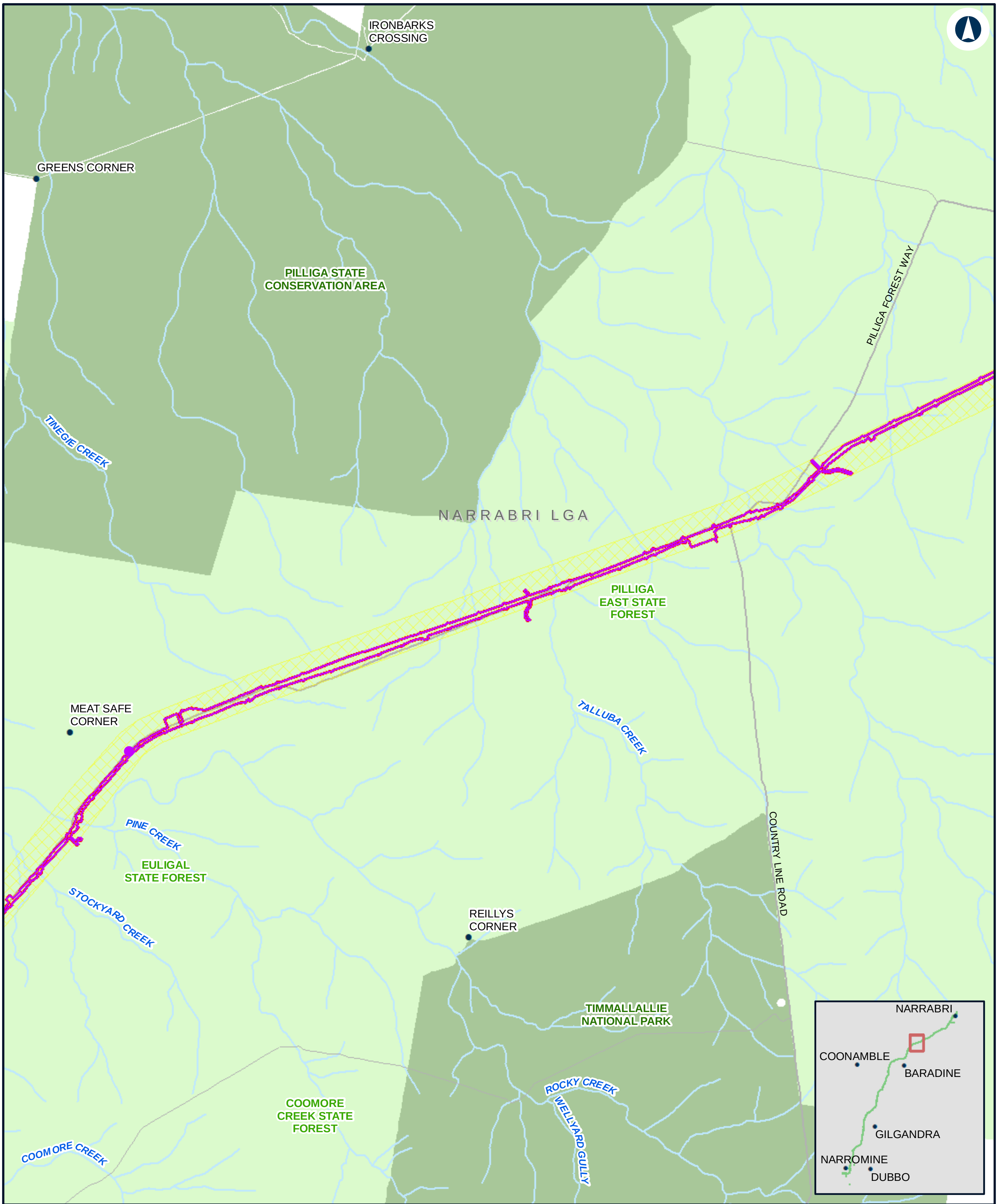

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1h

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Date: 3/08/2020 Paper: A4
Author: JacobsGHD Scale: 1:25,000
Data Sources: Basemap layers: NSWSS;

LEGEND

The proposal
Construction Footprint

Threatened Species

Corben's Long Eared Bat

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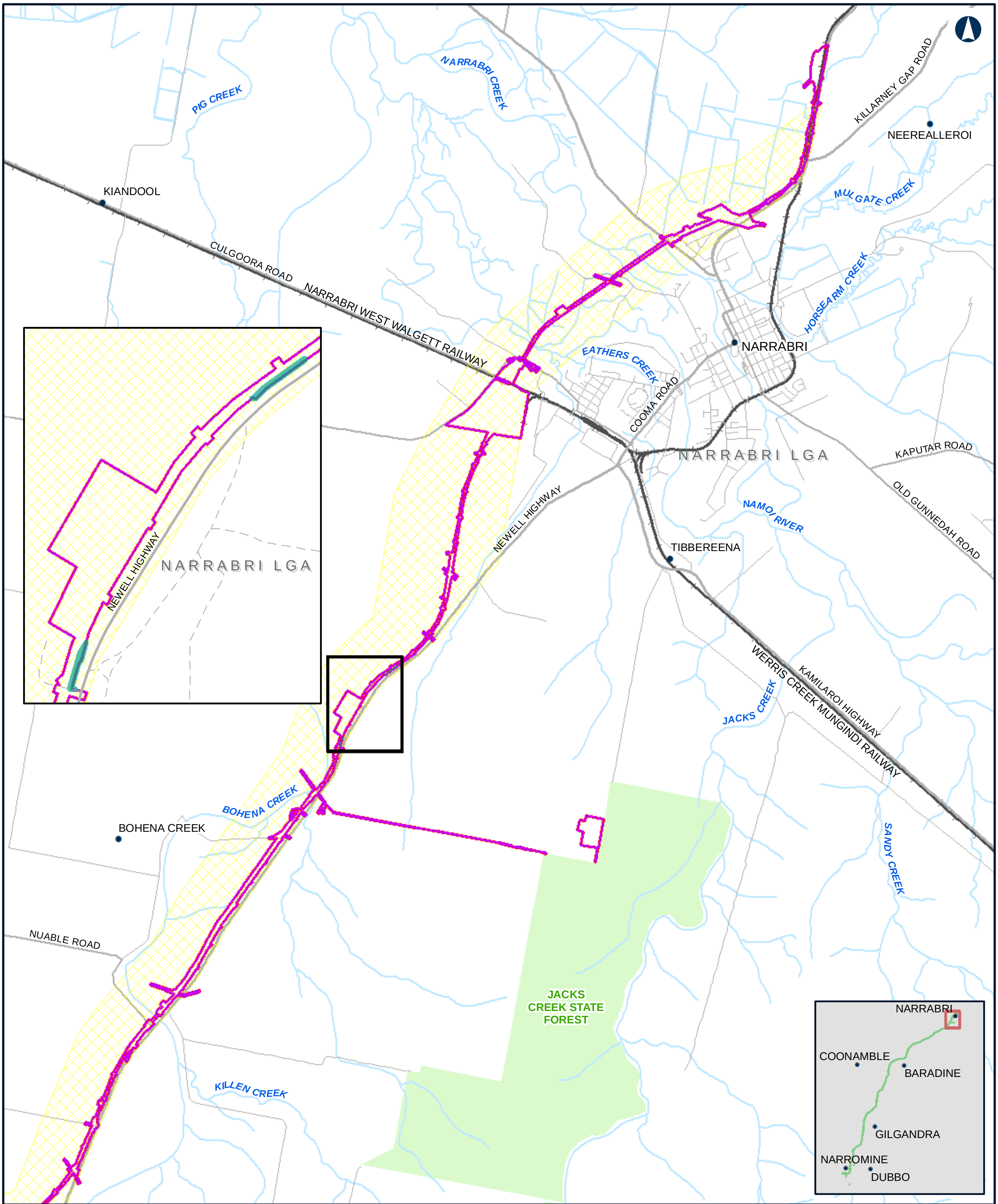

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1i

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Date: 31/07/2020 Paper: A4
Author: JacobsGHD Scale: 1:25,000
Data Sources: Basemap layers: NSWSS;

LEGEND

- The proposal
- Construction Footprint
- Brigalow (Acacia harpophylla dominant and co-dominant)

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8. Impact assessment

8.1 Avoid and minimse impacts

8.1.1 Measures to avoid impacts

The approach to design development has included a focus on avoiding and/or minimising the potential for impacts during all key phases of the design process. Various options assessments have been undertaken, and the preferred option chosen based on the outcome of the assessments. The options assessment process also included assessment of opportunities and risks. Multi-criteria assessments (MCA) were undertaken to assist in identifying the final alignment. In some parts of the study area there were no feasible route alternatives. The MCA workshops took into account a range of issues, including impacts on biodiversity, heritage, flooding and property, geotechnical conditions, constructability, cost and speed of rail among others.

During the phase 1 concept design process, about 50 route options were considered for the Narromine to Narrabri section of Inland Rail. This included routes via Dubbo and Coonamble and others that avoided the Pilliga. The routes through the Pilliga forest were identified as preferable due to a combination of lower construction cost, avoidance of prime farming land, and reduced transit time during operation. As such, impacts on biodiversity values in the Pilliga forests have not been able to be avoided.

Detailed environmental investigations have been conducted for the proposal. These investigations included an initial broader study area to identify key constraints early in the design process and assist with avoiding and minimising impacts where possible. ARTC has, where possible, altered the proposal route to avoid and minimise ecological impacts in the proposal planning stage.

At the end of phase 1, while a preferred option had been selected in some parts, a wide study area was defined to allow for a further phase of investigations to occur prior to finalising a preferred route. The phase 2 study area varied in width, from about five kilometres wide south and east of Narromine, to about 500 metres in other sections. The alignment layouts were developed in response to ongoing environmental and engineering investigations and consultation with landowners of impacted properties and those adjacent to the proposal site. The results of early biodiversity surveys (for example the September and November 2018 surveys) fed into the narrowing of the project investigation corridor, as did reviews of regional vegetation mapping.

The proposal was purposefully modified to avoid impacts to biodiversity values in particular locations and especially threatened biota as follows:

- Areas of existing wooded vegetation outside the Pilliga were avoided so far as practicable. Where the proposed rail alignment was aligned with a paper road (a Crown road reserve with no formed road) the alignment was preferentially located in native grassland in private land adjacent to the paper road where possible to retain the wooded vegetation with higher threatened species habitat value in the road reserve.
- So far as practicable, route options were selected to avoid or minimise impacts to threatened ecological communities. Reviews of regional vegetation mapping and results of field surveys were used to identify route options that had less of an impact or no impact on threatened ecological communities.
- Compounds and borrow pits were located in areas predominantly cleared of woodland vegetation.

8.1.2 Design measures to minimise impacts

Design features that minimise direct impacts on biodiversity values include:

- The need for many bridges along the alignment allows opportunities for retention of connectivity and have been designed to minimise impacts so far as practicable. Many fauna use dry creek beds and riparian vegetation for movement through the landscape. The retention of these areas will minimise impacts on fauna movement and gene flow. Long bridges over floodplains (for example the Narrabri Bridge, which is about four kilometres long and between 5-12 metres above ground level) would allow some retention of groundcover and riparian vegetation, and allow fauna to move under the rail line.
- The retention of some groundcover and riparian vegetation may also present an opportunity for minimising impacts through the retention of structural layers.
- Inclusion of about 630 banks of drainage culverts would provide some connectivity for fauna species. Additional dedicated fauna culverts have been proposed in areas of Pilliga Mouse habitat where no drainage culverts are required.

Further refinement would be made during detailed design, where practicable, to minimise the potential for biodiversity impacts as far as possible. The following tasks are likely to be undertaken prior to project approval:

- surveys of previously unassessed properties where possible to better quantify impacts and identify site-specific mitigation measures
- spring surveys to target threatened flora species and better identify direct impacts and the potential for local avoidance or minimisation of impacts
- narrowing of the construction impact zone where feasible in areas of higher biodiversity value.

8.2 Proposed measures to mitigate impacts

A range of mitigation measures are proposed in section 11 to minimise impacts on biodiversity and will be included in the project Construction Environment Management Plan (CEMP). Specific measures include:

- Preparation of a fauna connectivity strategy, including detailed assessment and design of locations for fauna crossing structures, including Pilliga Mouse culverts, glider poles and barrier poles, description of all crossing measures (including bridges and drainage culverts), a monitoring program and reporting requirements. Further detail on fauna connectivity measures is provided in section 11.1.2.
- Preparation of a fauna management plan(s), including protocols for the removal of habitat features and rescue and relocation of fauna from areas of disturbance.
- Further surveys targeting threatened species, to determine specific mitigation measures required during construction.
- Mapping and fencing of sensitive areas to minimise additional vegetation clearing.
- Staged rehabilitation (including revegetation where required) of disturbed areas following construction.
- Erosion and sediment control during construction and operation.
- Management and control of weeds during construction and operation.

- Management and control of other invasive species (eg invasive ants) during construction and operation.
- Monitoring and control of feral pests during operation, particularly the Red Fox and Feral Cat in the Pilliga forests.

8.3 Construction impacts

Construction of the proposal would result in direct impacts within a 3,258 hectare disturbance footprint, including 1,732 hectares of native vegetation as shown in Appendix G. The proposal includes impacts on around 1,125 hectares of native woodland and forest vegetation in good condition, 600 hectares of derived native grassland (including about six hectares of derived Kurrajong grassy open woodland / isolated trees), and about seven hectares of wetland vegetation. The proposal would impact 630 hectares of native vegetation within the Pilliga forests.

8.3.1 Construction direct impacts

Rail infrastructure

Direct impacts on native vegetation

The proposal would remove up to 1,732 hectares of native vegetation which equates to about 24 per cent of native vegetation in the investigation corridor used for Stage 1 Plant community type mapping.

Land clearance is listed as a Key Threatening Process (KTP) under the BC Act and EPBC Act. Land clearance consists of the destruction of the above ground biomass of native vegetation and its substantial replacement by non-local species or by human artefacts. The removal of 1,732 hectares of native vegetation would constitute a notable increase in the operation of this KTP in the locality, particularly within the Pilliga forests. The removal of native vegetation for construction of the proposal would predominantly be permanent and irreversible. Some rehabilitation of non-operational land (eg portions of the rail corridor not required for the rail line or access) would occur following construction (see section 11.1.3). The impact to each PCT as an area and percentage in the study area is outlined in Appendix H.

Close to half of the proposal site is disturbed and consists of cleared land containing introduced pasture species or environmental weeds. These areas contain little native vegetation cover and have limited habitat value for native plants. Vegetation clearing required in these areas would remove non-threatened native plants and introduced plant species including priority and high threat weeds.

The clearing of around 1,732 hectares of native vegetation would involve the removal of a large number of individuals and a moderately diverse range of non-threatened native plants. The proposal includes around 1,125 hectares of native woodland and forest vegetation in good condition that contains an over storey of mature trees. Mature trees have particular value within plant populations because they take longer to replace and often provide profuse sources of pollen and seed.

This reduction in the extent of native vegetation is less significant at the regional scale and is unlikely to threaten the persistence of any populations of native plants and vegetation communities. It is unlikely that an ecologically significant proportion of any regional plant populations would be located entirely within the proposal site. At the regional scale, flora populations would persist in habitat that is conserved in the Pilliga National Park and Nature Reserve, Timmallallie National Park and to a lesser extent regional state forests such as Cumbil, Baradine, Euligal and Pilliga East state forests.

Plant species with a limited distribution in the locality would be most affected by vegetation clearing for the proposal including the threatened *Tylophora linearis* and *Commersonia procumbens* (if they occur) and *Pterostylis cobarensis*.

A summary of direct impacts on flora and fauna habitat values is provided in Table 8.1.

Direct impacts on fauna and habitat values

The proposal would result in the removal of 1,584 hectares of exotic grassland or cropland and 600 hectares of derived native grassland and shrubland (including about six hectares of derived Kurrajong grassy open woodland / isolated trees) which provides only limited habitat values for fauna in isolation, but is valuable as it is part of the mosaic of habitat over a large area. The loss of these areas would mainly remove foraging, breeding and shelter habitat for small grassland animals such as reptiles and would remove foraging habitat for species including macropods, open-country microchiropteran bats, and bird species.

Construction would require the permanent removal of a maximum area of 1,125 hectares of woodland and forest habitat, including large areas containing mature trees, hollow-bearing trees (see Table 8.2) and trees with mistletoe and other foraging resouces. Clearing of this forest and woodland vegetation would permanently remove foraging and breeding resources for native fauna. Eucalyptus and other native canopy species provide nectar resources as well as foraging substrate for a diverse range of arboreal species, such as birds and arboreal mammals, as well as bats (see Appendix F). Shrub layers and leaf litter would also be removed as a result of construction. This would result in the loss of habitat for small woodland birds that rely on these resources for foraging and breeding. In addition, loss of leaf litter would remove habitat for small reptiles and gastropods that rely on this feature for shelter, breeding and foraging.

The proposal would have substantial impacts on fauna habitats within the Pilliga forests. A clearing of generally 50 metres wide and 73 kilometres long would create a new gap in the forest, result in the loss of numerous hollow-bearing trees and other habitat features such as heathy areas, and is likely to encourage the spread of weeds and pests (including feral predators) through the forest.

The proposal impacts a number of forestry management zones, set aside for the protection of specific flora and fauna habitats. These include a number of Zone 3: Harvesting Exclusions and Special Prescriptions areas. The purpose of Zone 3 is for management for conservation of identified values and/or forest ecosystems and their natural processes, while also facilitating other management and production activities. Examples of forestry management zones crossed by the proposal include:

- FMZ 1 – flora reserve broomplain. Management of the reserve is aimed at preserving the flora and fauna in a natural and undisturbed condition.
- FMZ 3A – special value fauna broom/bloodwood. Management of this zone is to protect habitat for the Pilliga Mouse.
- FMZ 3A – special value fauna wattle. Management of this zone provides areas of structural diversity (midstorey).
- FMZ 3B – grassy box woodland. This zone is managed to encourage the same species that are often associated with Inland Grey Box and Box Gum Woodland threatened ecological communities.
- FMZ 3B – general habitat mosaic. Management of this zone protects large-crowned trees which provide areas of structural diversity (overstorey).

A summary of direct impacts on flora and fauna habitat values is provided in Table 8.1.

Removal of hollow-bearing trees

The loss of over 1,125 hectares of native forest and woodland will result in the removal of a substantial number of hollow-bearing trees. Numbers of hollow-bearing trees were recorded for each vegetation integrity plot. Total numbers of hollow-bearing trees to be removed have been estimated by multiplying the average number of hollow-bearing trees per vegetation integrity plot for each vegetation zone by the total area, and also by multiplying the highest number of hollow-bearing trees recorded in a vegetation plot per vegetation zone by area. The latter gives a possible ‘worst case’ estimate. The proposal may remove between 13,079 and 29,930 hollow-bearing trees based on these estimates (see Table 8.2), with most to be lost as a result of construction of the rail infrastructure. Note that small hollows in ironbark species are very difficult to observe from the ground, and the ‘worst case’ estimate may be an underestimate for a number of PCTs, particularly a number of ironbark communities in the Pilliga. The totals calculated above have been adjusted to account for missed hollows. For vegetation zones where ironbarks are a subdominant, the total has been multiplied by 1.1 (ie 10 per cent of hollow-bearing trees not accounted for), while for those dominated by ironbark species the total has been multiplied by 1.3 (ie 30 per cent of hollow-bearing trees not accounted for). This increased the number of hollow-bearing trees that may be lost to between 15,028 and 29,930 respectively.

The loss of such a large number of hollow-bearing trees will have a substantial impact on local populations of threatened fauna reliant on these habitat features, such as the Glossy Black-cockatoo, Barking Owl, Squirrel Glider, Corben’s Long-eared Bat and other microbat species, as well as many more common species. Hollow-bearing trees often have multiple hollows, and thus one tree can provide denning and breeding habitat for multiple species, or multiple individuals of a species (as seen at the Castlereagh River where a number of Common Brushtailed Possums were observed occupying large River Red Gums with several hollows).

Table 8.1 Direct impacts on flora and fauna and habitat values in the proposal site

Impact	Description	Further detail
Removal of threatened flora	Construction is likely to result in the removal of known habitat for threatened flora species including Coolabah Bertya, Cobar Greenhood and Spiny Peppercress which all have known records in the proposal site. Construction is likely to result in the direct removal of individual plants as well as potential habitat.	Refer to Appendix I for details on threatened flora to be impacted.
Injury and mortality	Construction is likely to result in the injury or mortality of individuals of less mobile fauna species and other small terrestrial fauna that may be sheltering in vegetation within the proposal site during clearing activities and unable to move out of the area. This could include nesting birds, small terrestrial mammals, lizards and frogs, nocturnal fauna sheltering in hollows, and less mobile species such as Koalas. More mobile native fauna such as adult birds, and larger terrestrial mammals and reptiles that may be sheltering in vegetation in the proposal site are more likely to evade injury during construction activities. Increased movement of vehicles in the area during construction increases the risk of vehicle strike for terrestrial fauna. Terrestrial fauna are already at risk from vehicle movements on roads and on private property. Mitigation measures are proposed to minimise the risk of injury and mortality (see section 11.1.1).	Impacts of vehicle strike (including train strike) are discussed in detail in section 9.2.3. Fauna connectivity measures and fencing are discussed in more detail in section 1.1.1.
Fragmentation and isolation of habitat.	The proposal will create a new linear gap through the Pilliga forests, exacerbating the existing impacts on connectivity created by Pilliga Forest Way and the Newell Highway. In other locations, the rail line will fragment smaller patches of vegetation, including linear riparian and roadside remnants. Habitat loss and fragmentation strongly influence animal movement patterns, which are intrinsically related to population dynamics (Neibuhr et al 2015). Habitat fragmentation can result in reduced dispersal and reproductive success of biota within the fragment, a decline in populations resulting from increased predation by introduced species or native species that do not normally occur in the community, and an increased probability that stochastic events (eg fire) may reduce population numbers below critical levels required for their survival (Andrew 1990). Some species are at greater risk in fragmented landscapes than others as a result of their ecological requirements. Species of animals most at risk of population fragmentation due to linear infrastructure include species that are unwilling or unable to travel across cleared areas (Forman et al. 2002) or have poor dispersal ability (Neibuhr et al 2015).This would include species such as the Squirrel Glider, which is limited by its glide distance, and also potentially the Pilliga mouse. The threat posed by fragmentation is increased for species with large home ranges, which migrate or disperse over long distances, or for those that have specialised dietary or habitat requirements (Jackson 2000). In general, larger fragments are less susceptible to adverse impacts than are smaller fragments.	Impacts on connectivity are discussed in detail in section 9.2.1 Impacts on life-cycle movements of fauna are discussed in detail in section 9.2.2.

Impact	Description	Further detail
	The proposal would be located in a highly fragmented, rural landscape for much of the alignment. Fragmentation of native vegetation and associated fauna habitats in the locality has previously occurred through clearing for agriculture, residences and farm buildings and construction of linear infrastructure (such as transmission lines and roads). These land uses have created barriers to movement for some fauna species, particularly those that are limited by dispersal abilities and habitat preferences. More mobile species such as birds and bats can readily traverse this landscape. The proposal would exacerbate fragmentation in these areas. The Pilliga forests provide a large area of connected habitat. These forests are fragmented by a range of roads and tracks. The proposal will be located alongside Pilliga Forest Way and Cumbil Road within the Pilliga forest for about 51 kilometres, further widening the gap in the forest. At the northern end of the alignment in Pilliga East State Forest, the proposal will create a new gap in the forest, further fragmenting habitats in this area. A section of the alignment near Cumbil Road has been moved about 80 metres from the road to avoid impacts on Aboriginal heritage and thus there would be additional forest fragments created at these locations. Additionally, Pilliga Forest Way will be realigned in some areas and the forest gaps at these locations would be wider.	
Impact on aquatic habitat	The proposal crosses three major rivers (the Macquarie River, Castlereagh River and the Namoi River/Narrabri Creek) as well as many other creeks. A detailed assessment of impacts on aquatic habitats is provided in *ARTC Inland Rail Narromine to Narrabri Aquatic Ecology Assessment* (JacobsGHD, 2020a). The proposal includes construction of bridges across the major river and larger creeks, and many culverts along minor drainage lines. Direct impacts would comprise removal of riparian vegetation under these bridges, although some would be retained, particularly under longer and taller bridges. This vegetation provides connectivity for terrestrial fauna and birds.	Impacts on hydrology are discussed in detail in section 9.2.8 Impacts on fish habitat are discussed in the aquatic ecology assessment.
Removal of hollow-bearing trees	The proposal will potentially remove between 13,079 and 29,930 hollow-bearing trees in the proposal, including paddock trees in agricultural land, large remnant red gums in riparian areas, and many in the Pilliga and other forested areas (see Table 8.2). Hollow-bearing trees are critical habitat components for many tree-dwelling fauna species, including arboreal mammals, microchiropteran bats and woodland birds that rely on hollows for shelter and breeding habitat. Due to the long timeframe it takes for hollows to form in eucalypts (usually greater than 150 years) (Gibbons et al 2000), the loss of these hollows represents a long-term reduction in habitat resources for fauna. The loss of such a large number of hollow-bearing trees will have a substantial impact on fauna such as the Glossy Black-cockatoo, Barking Owl, Brown Treecreeper, Squirrel Glider, Corben's Long-eared Bat and other microbat species.	See Table 8.2 for calculations of loss of hollow-bearing trees

Table 8.2 Loss of hollow-bearing trees

Veg Zone ID	PCT ID	PCT	Area (ha)	Average number of HBTs per veg zone	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone
Zone 0	0	Crop and/or introduced grassland	1584	0	0	0	0	0	0
Zone 1	27	Weeping Myall open woodland	3.05	0	0	0	0	0	0
Zone 2	35	Brigalow - Belah open forests / woodland	0.61	1	1	10	10	6	6
Zone 3	36	River Red Gum tall to very tall open forest/woodland wetland	5.08	1.67	3	16.7	30	85	152
Zone 4	49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland	176.10	0	0	0	0	0	0
Zone 5	55	Belah woodland on alluvial plains and low rises	0.21	1	1	10	10	2	2
Zone 6	56	Poplar Box-Belah woodland	19.5	1.5	4	15	40	344	918
Zone 7	78	River Red Gum riparian tall woodland / open forest wetland	26.23	1.2	3	12	30	315	787
Zone 8	88	Pilliga Box - White Cypress Pine- Buloke shrubby woodland	1.65	0.71	3	7.1	30	12	50
Zone 9	88	Pilliga Box - White Cypress Pine- Buloke shrubby woodland	276.10	1	1	10	10	2761	2761
Zone 10	141	Broombush - wattle very tall shrubland	29.47	0	0	0	0	0	0
Zone 11	145	Western Rosewood - Wilga - Wild Orange - Belah low woodland	53.99	1.4	3	14	30	756	1620
Zone 12	148	Dirty Gum - Buloke - White Cypress Pine - Ironbark shrubby woodland	45.04	0.5	1	5	10	225 (248)	450 (495)
Zone 13	168	Derived Copperburr shrubland	8.56	0	0	0	0	0	0
Zone 14	185	Dwyer's Red Gum - Black Cypress Pine - Currawang shrubby low woodland	1.37	0	0	0	0	0	0
Zone 15	202	Fuzzy Box woodland	3.59	2	3	20	30	72	108

Veg Zone ID	PCT ID	PCT	Area (ha)	Average number of HBTs per veg zone	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone
Zone 16	206	Dirty Gum White Cypress Pine tall woodland of alluvial sand (sand monkeys)	12.66	0.5	1	5	10	63	127
Zone 17	244	Poplar Box grassy woodland	31.84	0.75	2	7.5	20	239	637
Zone 18	247	Lignum shrubland wetland	6.91	1	3	10	30	69	207
Zone 19	248	Mixed box eucalypt woodland	14.71	1.67	3	16.7	30	246	441
Zone 20	250	Derived tussock grassland	82.84	0	0	0	0	0	0
Zone 21	255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland	11.77	1	1	10	10	118 (153)	118 (153)
Zone 22	256	Green Mallee tall mallee woodland	0.27	0	0	0	0	0	0
Zone 23	394	Narrow-leaved Ironbark, White Cypress Pine woodland on slopes and flats	10.87	0.25	1	2.5	10	27 (35)	109 (142)
Zone 24	394	Narrow-leaved Ironbark, White Cypress Pine woodland	58.79	0	0	0	0	0	0
Zone 25	397	Poplar Box- White Cypress Pine shrub grass tall woodland	15.78	1.5	6	15	60	237	947
Zone 26	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest	8.5	0.67	4	6.7	40	57 (74)	340 (442)
Zone 27	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest	361.3	1.5	3	15	30	5419 (7045)	10838 (14089)
Zone 28	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland)	53.71	2.14	7	21.4	70	1149	3760
Zone 29	404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland	23.05	1.25	3	12.5	30	288 (374)	692 (900)
Zone 30	406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest	2.3	1	2	10	20	23 (25)	46 (51)
Zone 31	409	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland	0.82	1	1	10	10	8	8

Veg Zone ID	PCT ID	PCT	Area (ha)	Average number of HBTs per veg zone	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone
Zone 32	411	Buloke - White Cypress Pine woodland	8.76	1	1	10	10	88	88
Zone 33	414	White Mallee - Dwyer's Red Gum mallee heath	7.32	0.33	1	3.3	10	24	73
Zone 34	435	White Box – White Cypress Pine shrub grass hills woodland	6.11	1	1	10	10	61	61
Zone 35	436	Derived Kurrajong grassy open woodland / isolated trees	5.98	0	0	0	0	0	0
Zone 36	444	Silver-leaved Ironbark grassy tall woodland	1.11	1	1	10	10	11 (14)	11 (14)
Zone 37	473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest	15.26	1.67	2	16.7	20	255 (281)	305 (336)
Zone 38	589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland	1.23	1	1	10	10	12 (13)	12 (13)
Zone 39	599	Blakely's Red Gum - Yellow Box grassy tall woodland	2.21	4.5	7	45	70	99	155
Zone 40	619	Derived Wiregrass grassland	326.3	0	0	0	0	0	0
Zone 41	746	Brown Bloodwood - cypress - ironbark heathy woodland	2.12	0	0	0	0	0	0
Zone 42	1384	White Cypress Pine - Bulloak - ironbark woodland	8.77	0.67	1	6.7	10	59 (65)	88 (97)
Total								**13,079**	**25,778**
Adjusted total to account for small hollows in ironbarks								**15,028**	**29,930**

Road infrastructure

The proposal requires a number of changes to road infrastructure, and would include road closures and road realignments:

- Where the proposal crosses existing public and private roads either a new bridge structure would be constructed to take the road under the proposed rail line or a level crossing would be constructed.
- An operational access road would be provided within the rail corridor for maintenance purposes. The access road would provide for railway maintenance, access to crew change and train stowage locations, access for emergency recovery, maintenance access (as relevant), and access from public roads to the rail corridor.

Road closures are required where it is not feasible to provide a new level crossing. Access would be provided via a road realignment to a new level crossing or around the proposal via an existing road.

Construction of road infrastructure would impact areas of native vegetation, including forest and woodland, and derived native grassland. This would include removal of fauna habitats, including hollow-bearing trees as included in above hollow-bearing tree removal estimates.

Key construction infrastructure

Multi-function compounds

Three major construction sites would be established for the proposal, located at Narromine, Curban and Narrabri. Impacts associated with these sites are summarised in Table 8.3 and are included in the total impacts of the project.

All disturbed areas not required for ongoing operations would be rehabilitated. Finishing and rehabilitation would be undertaken progressively. Site rehabilitation would be carried out in accordance with the rehabilitation strategy; the requirements of which would be incorporated into the CEMP. Restoration of disturbed areas would be undertaken, including revegetation where required.

Table 8.3 Direct impacts on vegetation and habitats at compound sites

Segment number and name	Vegetation removal	Threatened species impacts
Segment 1 - Narromine multi-function compound	The majority of this compound would be located in existing cleared and disturbed land dominated by cropping. A 2.17 hectare linear strip of PCT 88 (Pilliga Box - White Cypress Pine - Buloke shrubby woodland) would be removed, 1.74 hectares of PCT 49 (Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland) and 1.24 hectares of PCT 247 (Lignum shrubland wetland) would be removed.	No habitat for threatened flora species would be removed. Roadside vegetation and small patches of woodland vegetation in predominantly cleared agricultural land provide habitat for the threatened Grey-crowned Babbler, recorded at this location. Clearing of this habitat removes foraging and breeding habitat for this species, and impacts connectivity for this species, which tends not to cross large gaps. A previous record of the Koala exists in this area. Removal of vegetation further reduces habitat for this species, and similarly affects connectivity across the landscape.

Segment number and name	Vegetation removal	Threatened species impacts
Segment 2 – Curban multi-function compound	This entire compound would be located in existing cleared and disturbed land dominated by cropping and introduced grassland. There would be no impacts on native vegetation.	No habitat for threatened flora species would be removed. Removal of cropping and introduced grassland would have negligible impact on threatened fauna species. Broad-ranging threatened species such as the Little Eagle and Spotted Harrier may forage over the site on occasion.
Segment 3 – Narrabri multi-function compound	The establishment of this compound would require the removal of 86.68 hectares of PCT 619 (Derived Wire Grass grassland) and 5.01 hectares of PCT 148 (Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland).	Assumed habitat for the threatened flora species *Lepidum monoplocoides* would be removed. Removal of grassland would have limited impact on threatened fauna species. Broad-ranging threatened species such as the Little Eagle and Spotted Harrier may forage over the site on occasion. Woodland may provide habitat for the Grey-crowned Babbler.

Borrow pits

Four borrow pits are required to construct the proposal. All borrow pits require a new section of haul road to be constructed within the property to provide access to the public road network. Clearing of vegetation would be required at all sites. Haulage to the proposal would then be via the public road network with no works / improvements proposed. Crushing would be required at all sites, with blasting also proposed at borrow pit C and borrow pit D. Potential impacts associated with the four borrow pits are summarised in Table 8.4.

Following extraction of all required material from the borrow pits, all facilities would be removed and they would be stabilised to be a free draining landform and rehabilitated. It is proposed that excess material (that does not meet design specifications or cannot be feasibly used within the rail formation) from the main construction works would be used to assist with the reshaping of the borrow pits.

Table 8.4 Direct impacts on vegetation and habitats in borrow pits and associated haul roads

Borrow Pit and segment	Location	Vegetation removal	Threatened species impacts
Segment 4 – Borrow Pit A	Borrow pit A is located in largely agricultural land south of Narromine.	This site is vegetated predominantly with PCT 619 (Derived Wire Grass grassland) with a small area of PCT 185 (Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland) in the south-west corner. Woodland vegetation that would be removed is part of a small patch of woodland with limited connectivity to other patches of better quality native vegetation. A total of 11.77 hectares of native vegetation would be removed.	No threatened flora are known or assumed to be present in borrow pit A. Construction will remove small patches of woodland provide habitat for threatened species such as the Grey-crowned Babbler, which occurs in many small remnants, and microbats, which may roost in hollow-bearing trees. Loose surface rock is present at this site, which may be habitat for the Pink-tailed Legless Lizard. This borrow pit is on the western edge of the known distribution of this species, there are no local records, and preferred habitat characteristics are not present (sloping, well-drained hillsides), and this species is unlikely to occur as a result.
Segment 5 - Borrow Pit B	BP-B is located in largely cleared agricultural land south of Narromine. The site has previously been used as a quarry.	Construction of this borrow pit would remove 3.60 hectares of PCT 255 (Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland), located adjacent to the existing quarry. Areas of cropping would also be removed. There is some connectivity with other patches of woodland located to the east of the borrow pit, however these areas have limited connectivity other than via narrow vegetated 'paper roads'. Vegetation to be removed occurs on the edge and no areas would become fragmented as a result of clearing of this vegetation. 4.49 hectares of cropped land would be removed.	No threatened flora are known or assumed to be present in borrow pit B. Previous clearing has already impacted threatened species habitats at this site. Additional clearing would be required around the edges of the quarry, and may impact habitat for fauna such as the Grey-crowned Babbler and microbats.

Borrow Pit and segment	Location	Vegetation removal	Threatened species impacts
Segment 6 - Borrow Pit C	Borrow Pit C is located north of Narromine.	Construction of this borrow pit would remove 0.41 hectares of PCT 88 (Pilliga Box - White Cypress Pine - Buloke shrubby woodland) and 6.71 hectares of PCT 255 (Mugga Ironbark – Buloke – Pilliga Box – White Cypress Pine shrubby woodland). This vegetation is part of a larger patch of woodland. Clearing would occur on the edge of this patch, and no areas would become isolated as a result of the proposal. 4.05 hectares of cropped land would be removed.	Assumed habitat for the threatened flora species *Diuris tricolor* would be removed. Construction will remove small patches of woodland provide habitat for threatened species such as the Grey-crowned Babbler, which occurs in many small remnants, and microbats, which may roost in hollow-bearing trees.
Segment 7 – Borrow Pit D	Borrow Pit D is located south-east of Narrabri	Construction of this borrow pit would remove 20.90 hectares of cleared land. Despite its appearance an aerial imagery, much of this site had been cleared during field surveys by the landholder. A narrow strip of PCT 746 (Brown Bloodwood - cypress - ironbark heathy woodland) to be removed on the western edge of the Borrow Pit (1.7 hectares). The haul road would impact 2.40 hectares of PCT 398 (Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest). A larger area of native vegetation occurred previously at the borrow pit site, and had been recently cleared prior to the biodiversity site survey.	Assumed habitat for the threatened flora species *Pterostylis cobarensis*, *Polygala linariifolia* and *Tylophora linearis* would be removed. A narrow strip of vegetation would be removed from the eastern edge of the borrow pit. This has limited connectivity to Jacks Creek State Forest given the presence of various tracks along the fence line, although some more mobile threatened fauna may occur on occasion. The loss of this habitat would have limited impacts on these fauna given its small size and limited connectivity.

Temporary workforce accommodation

Outside the three multi-function compound sites, temporary workforce accommodation may be required at North Narromine, Gilgandra, and near Baradine at an existing campground known as Camp Cypress.

There is no native vegetation at North Narromine and vegetation at Gilgandra is non-native vegetation with scattered small regrowth of White Cypress Pine that do not constitute any PCT.

While the groundcover layer at Camp Cypress near Baradine is already heavily modified and removed due to the existing camp facilities, it retains an overstorey of native trees of PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion. This occurrence of this PCT is part of the BC Act listed Box-Gum Woodland. Further removal of native vegetation may be required at this site to expand the existing accommodation infrastructure. This vegetation provides known habitat for the threatened Grey-crowned Babbler, observed at the site, and is potential habitat for the Koala, other threatened birds and threatened microbats.

All disturbed areas not required for ongoing operations would be rehabilitated. Finishing and rehabilitation would be undertaken progressively. Site rehabilitation would be carried out in accordance with the rehabilitation strategy; the requirements of which would be incorporated into the CEMP. Restoration of disturbed areas would be undertaken, including revegetation where required.

8.3.2 Indirect impacts on native vegetation and habitat

A summary of indirect impacts associated with the proposal is provided in Table 8.5.

Table 8.5 Indirect impacts on biodiversity values

Impact	Description
Weed invasion and edge effects	'Edge effects' refer to increased noise and light or erosion and sedimentation at the interface of intact vegetation and cleared areas. Edge effects may result in impacts such as changes to vegetation type and structure, increased growth of exotic plants, increased predation of native fauna or avoidance of habitat by native fauna. Altered environmental conditions along new edges can allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge effects would result from construction activities and then continue to affect vegetation and habitats adjoining the proposal site. The proposal site and adjoining land has been extensively cleared for agriculture, although large areas of native vegetation are present, particularly in the Pilliga area and at river and creek crossings. Small patches of vegetation occur elsewhere along the alignment. Smaller patches of native vegetation are already severely affected by edge effects and associated negative impacts such as weed infestation. The proposal would create few novel edge effects in these locations and is unlikely to result in a significant increase in the impact of existing edge effects. Much of the alignment through the Pilliga and Bohena Creek area follow the alignment of Pilliga Forest Way or the Newell Highway. These areas may be subject to some edge effects from these roads, however construction and operation of the railway will create a new edge and extend the edge effects in these areas. Construction activities, in general, have the potential to introduce or spread weeds through transport on vehicles and machinery. Hygiene protocols are recommended to minimise the spread of weeds.

Impact	Description
Pests and pathogens	Construction activities, in general, have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*) and Myrtle Rust (*Uredo rangelii*) into native vegetation. These diseases may also be spread during rehabilitation works post construction, including through the transport of mulch and seedlings. Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and degrade fauna habitats. No evidence of these pathogens was observed during surveys and they are unlikely to occur in the area given the arid nature of the region. As such, the risk of spread is low, however suitable hygiene protocols are recommended to prevent introduction. There are large numbers of priority weeds, high threat weeds and WONS present across the proposal site. The proposal has the potential to result in further spread of these weed species into native vegetation where they are not yet established or where they occur at low densities. Construction activities, in general, have the potential to introduce or spread Chytrid fungus (*Batrachochytrium dendrobatidis*), which affects both tadpoles and adult frogs and can cause 100 per cent mortality in some populations once introduced into an area. Given the generally dry nature of the proposal site, the risk of spread of Chytrid fungus is low, however suitable hygiene protocols are recommended.
Noise, light and vibration	Construction of the proposal would require the use of vehicles and plant in the proposal site. Pile driving or other piling methods are also a source of noise. Noise has been shown to have a variety of impacts on fauna, including changing foraging behaviour, impacting breeding success and changing species occurrences (Barber et al 2009). Construction work would be undertaken during the following primary proposal construction hours, between 6am to 6pm seven days a week. Specific noise generating activities such as blasting would be further assessed in accordance with appropriate guidelines and adjacency of sensitive receivers to minimise impacts where possible, and these activities would be separately listed and addressed in the CEMP. Fauna are currently subject to varying levels of disturbance from noise, light and vibration. Parts of the proposal site are located alongside existing roads and rail lines, and thus there would be some habituation of fauna to traffic noise in these areas. In the Pilliga, noise levels from road traffic would be low, with only occasional vehicular movements along Pilliga Forest Way and other tracks. Increased noise and vibration would occur during forestry operations, however these impacts would tend to be localised. Vibration and noise may deter native fauna from using the area surrounding the source of disturbance. This may potentially interrupt dispersal at a location if an individual is unwilling to travel through an area where vibration or noise is detectable (for example less mobile fauna or those that prefer not to cross clearings). There is the potential for individuals that nest or den in trees that are close to the proposal abandoning their nests and dens as a result of noise and vibration during construction.
Sedimentation and erosion	Construction of the proposal has the potential to result in sedimentation and erosion within the construction corridor and adjoining native vegetation and aquatic habitats, through soil disturbance and construction activities. Sediment laden runoff to waterways can alter water quality and adversely affect aquatic life.

Impact	Description
Dust	Construction of the proposal would result in generation of dust emissions. High dust levels could reduce habitat quality for flora and fauna species by reducing plant and animal health in adjacent areas of vegetation. Dust may affect photosynthesis, respiration and transpiration in plants and allow the penetration of gaseous pollutants. This then leads to decreased productivity, and in the long-term can alter community structure (Farmer 1993). Dust would also impact health of fauna, such as through respiratory disease, and the reduction in health of animals would be exacerbated by changes to plant health and community structure. During construction, water for earthworks and dust suppression comprise the bulk of the water requirements for the proposal. Based on existing climate conditions and the availability of water it is proposed that the primary source of water would be groundwater extraction from deep groundwater systems. The proposal allows for 12 bore fields from which groundwater would be extracted for construction use to minimise the generation of dust. Drought conditions in the region in recent years have resulted in regular dust storms in the area. Vegetation in close proximity to Pilliga Forest Way and other rural dirt roads are regularly subject to generation of dust as a result of vehicle movements. As such, dust generation is not a novel impact in the area, however impacts would be exacerbated by the proposal.
Fire	Construction of the proposal presents a potential risk of fire, for example from storage of combustible fuels or ignition from works areas. In drought conditions, this risk would be increased due to the dry nature of the vegetation. Much of Australia's biodiversity is adapted to and relies upon bushfire as a natural ecosystem process. However, fires can lead to mortality of fauna, and destruction of habitat resources, especially if too regular or intense. Small fires can spread very quickly in unfavourable conditions to become large wildfires. For example, in November 2006 a severe and extensive wildfire occurred in the Pilliga forests, burning more than 120 000 hectares (Law et al 2018). Bushfires of high to extreme intensity can result in significant modification of vegetation structure and composition such that the original vegetation type and condition is no longer identifiable (EES 2020). The risk of fires spreading to adjacent areas would be minimised through a fire hazard management plan and other measures to contain and control the outbreak of fire.
Aquatic disturbance and pollution	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments into waterways, or chemical spills from vehicles or plant. The introduction of pollutants from the proposal into the surrounding environment, if uncontrolled, could potentially impact on water quality further downstream. Refer to section 9.2.8 for a discussion of prescribed impacts associated with hydrology.

8.4 Operation impacts

8.4.1 Rail infrastructure

The proposal would form part of the rail network managed and maintained by ARTC. Train services would be provided by a variety of operators. Inland Rail as a whole would be operational once all 13 sections are complete. The Inland Rail trains within the proposal extent would be a mix of grain, bulk freight, and other general transport trains.

Potential impacts of operation of the rail line are discussed in Table 8.6.

Table 8.6 Operational impacts of the rail line

Impact	Description	Further detail
Injury and mortality	Operation of the rail line will create a novel strike risk in the area via the movement of trains along the alignment. This would include impacts on terrestrial fauna that may cross the tracks, as well as the Squirrel Glider, birds and bats that may collide with trains while gliding or flying above the rail line.	Impacts of vehicle strike (including train strike) are discussed in detail in section 9.2.3
	The rail line will be fenced (as required) where it is located in agricultural land to prevent mortality of stock. This may minimise mortality of fauna species such as kangaroos and emus, however these animals can cross stock fences and may still be subject to injury and mortality through train strike. Fences would create additional barriers to fauna movements but these already exist on agricultural lands.	Fauna connectivity measures and fencing are discussed in more detail in section 1.1.1.
	Limited fauna fencing is proposed for the Pilliga. This is due mainly to the low train traffic rate, which is proposed to be an average of 8.5 trains per day (both directions) in 2025, increasing to about 15 trains per day (both directions) in 2040. Fauna fencing would-be provided at bridges and large sets of culverts.	
	A number of fauna connectivity measures are proposed to minimise mortality through train strike (11.1.2). These include bridges, underpasses and glider poles.	
Connectivity	The proposal will clear a gap of about 300 kilometres by at least 40 metres wide, with 73 kilometres of this through the Pilliga. For much of this latter length it will increase the existing gap associated with Pilliga Forest Way. The proposal will compound fragmentation caused by Pilliga Forest Way and other cleared tracks, as well as other roads elsewhere in the alignment.	Fauna connectivity measures are discussed in more detail in section 1.1.1
	Linear infrastructure is a threat to biodiversity worldwide. Rail lines can be physical barriers, where a species cannot pass across the railway or behavioural, when the species may be physically able to cross the barrier but does not do so because of unfavourable ambient conditions or perceived risk. The barrier effect of the rail line will reduce or prevent genetic exchange for some species, while having little impact on others.	
	A number of fauna connectivity measures are proposed to minimise the impact on connectivity (11.1.2). These include bridges, underpasses and glider poles.	

Impact	Description	Further detail
Noise	Operation of the rail line would introduce regular noise and vibration into the proposal site, through the movement of trains. Noise has been shown to have a variety of impacts on fauna, including changing foraging behaviour, impacting breeding success and changing species occurrences (Barber et al 2009). Studies on bats have found that some species avoid foraging in noisy areas such as near highways (noise levels between 68-80 dBA) as the noise may interfere with listening for prey (Schaub et al 2008). Similarly, highways have also been shown to have an impact on woodland birds, resulting in lower incidence of bird occurrence near noise (Reijnen et al 1995). Traffic noise has also been shown to interfere with frogs, resulting in decreases in calling activity, and preventing females from easily locating the source of male calls, both of which could reduce reproductive success (Bee and Swanson 2007, Lengagne 2008). Species less tolerant to disturbance may be displaced from adjacent vegetation. Other more resilient fauna species typical of disturbed areas are likely to become accustomed to the noise.	
Light	Trains lights will create a novel light impact, particularly in the Pilliga area. The lights may result in the displacement of less-tolerant species in vegetation adjacent to the rail corridor, but could also attract some birds and bats that forage on insects attracted to light. These species may then be susceptible to train strike in the absence of mitigation.	
Fire	Operation and maintenance of the rail line will create a risk of fire from sparks. The risk of fires spreading to adjacent areas would be expected to be minimal given the presence of a cleared rail corridor, however given the dry nature of the forests, there is some potential for wildfires starting from sparks. These fires have the potential to impact large areas of the forest particularly in the Pilliga.	

Impact	Description	Further detail
Biosecurity	Operation of the proposal has the potential to spread weeds and pests. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Introduction and spread of weeds can impact agricultural land and native vegetation. A summary of weeds recorded during surveys is provided in section 5.5, and detailed in Appendix E. Introduction of weeds is of particular concern in the Pilliga Forests, which is identified as an Important Bird and Biodiversity Area. As described in section 8.3.2, weeds can reduce quality of vegetation and thus impact fauna and flora habitats. Mitigation measures to minimise the risk of weed introduction and spread are provided in section 11.1.2. A few records of animal species being transported as stowaways in trains can also be found in the scientific literature and the media. Perhaps the most recurrent cases refer to urban pest species, such as rats and mice (Li et al. 2007), but there are also references to ants (Elton 1958), beetles (White 1973), spiders (Nentwig and Kobelt 2010) and even armadillos (Hofmann 2009). Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017).	

8.4.2 Road infrastructure

To facilitate operation of the proposal, changes to the local public road network would also be required to suit new level crossings.

There would be limited additional impacts from operation of new road infrastructure near the rail line. There are already many roads in the locality, and the operation of the rail would not substantially increase road traffic in the area. Terrestrial fauna are at risk of vehicle strike, however no material change above current levels is anticipated.

Movement of traffic has the potential to lead to introduction and spread of weeds, as discussed elsewhere. This is an ongoing risk for all roads in the locality, and the operation of these realigned roads would be unlikely to substantially increase the risk of weed spread in the locality.

Roads would also be closed where the impact of diversions or consolidations is considered acceptable, or the existing location is not considered safe and cannot be reasonably made safe. A number of tracks in the Pilliga would be closed, and it is likely that vegetation would regrow over time in these areas.

8.5 Impacts on groundwater dependent ecosystems

Impacts on aquatic GDEs such as the rivers and larger creeks crossed by the proposal are assessed in *ARTC Inland Rail Narromine to Narrabri Aquatic Ecology Assessment* (JacobsGHD, 2020a). Further detail on groundwater impacts is provided in *ARTC Inland Rail Narromine to Narrabri Groundwater Assessment* (JacobsGHD, 2020b).

Most native vegetation in the proposal site is considered to have low to moderate potential to be groundwater dependent. PCT 36 River Red Gum tall to very tall open forest/woodland wetland has high potential to be groundwater dependent. The proposal would cross riparian vegetation at major rivers and creeks. Generally, at these locations the proposal is perpendicular to the riparian vegetation, and a narrow corridor would be impacted. A total of 73 rail bridges are proposed for the proposal to cross the major rivers and many major and minor creeks. Many of the bridges cross the associated floodplains. Large trees would be removed in these areas, however some of the lower riparian vegetation would be retained. Shading would alter the condition of the vegetation. The proposal would require construction of piers in riparian and other vegetation to support the bridges. The footprint of these would be comparatively small, and there would be limited interaction with groundwater. The regional water table occurs at a typical depth of about 20-30 metres below ground level. However, near major rivers and in low lying areas this regional water table comes closer to the ground surface (see *ARTC Inland Rail Narromine to Narrabri Groundwater Assessment* (JacobsGHD, 2020b)).

Given the comparatively small area of high potential groundwater dependent (riparian) vegetation to be impacted, small footprint of piers required for construction of bridges, and retention of riparian vegetation under bridges, there is likely to be only limited impact on groundwater dependent terrestrial ecosystems.

8.6 Cumulative impact

8.6.1 Overview

For an EIS, cumulative impacts can be defined as the successive, incremental, and combined effect of multiple impacts, which may in themselves be minor, but could become significant when considered together. The methodology and projects considered for the cumulative impact assessment are provided in detail in the EIS (Part D chapter D1). The study area for the cumulative biodiversity assessment comprises the surrounding LGAs. Six major projects were identified as having a cumulative impact and sufficient information to undertake a cumulative impact assessment. These include:

- Inland Rail – Narrabri to North Star
- Inland Rail – Parkes to Narromine
- Narrabri Gas Project
- Silverleaf Solar Farm, Narrabri
- Gilgandra Solar Farm
- Narromine Solar Farm.

There was insufficient information available for the Western Slopes Pipeline for inclusion in the cumulative assessment.

8.6.2 Construction

The above identified projects involve some clearing of vegetation, with some projects comprising clearing of large areas of native vegetation and threatened species habitats. Potential areas of impacts to native vegetation and threatened species habitat of these projects are summarised in Table 8.7 and shown in Figure 8.1. Clearing of native vegetation from these projects is more than 1,700 hectares with some impacts of projects not yet quantified.

In summary, there would be cumulative impacts on the following five threatened ecological communities:

- Box Gum Woodland (BC Act) – 33.3 hectares (8.3 hectares for the proposal / 25 hectares from other projects).
- Brigalow (BC Act) – 24.61 hectares (0.61 hectares for the proposal / 24 hectares from other projects).
- Fuzzy Box Woodland (BC Act) – 11.59 hectares (3.59 hectares for the proposal / 8 hectares from other projects).
- Myall Woodland (BC Act) – 13.05 hectares (3.05 hectares for the proposal / 10 hectares from other projects).
- Inland Grey Box Woodland (BC Act) – 53.79 (14.71 hectares for the proposal / 39 hectares from other projects).

In addition to the clearing of the five threatened ecological communities, the cumulative loss and fragmentation of native vegetation and associated habitats identified above would adversely affect native flora and fauna species, including a large number of threatened species.

8.6.3 Operation

Operation of the proposal would impact connectivity and increase the risk of fauna mortality through wildlife-train collisions. Other existing linear infrastructure have similar operational impacts, particularly where they pass through patches of native vegetation.

Table 8.7 Other project impacts in the region

Project	Description	Impacts on native vegetation	Impacts on threatened ecological communities	Impacts on threatened species
Inland Rail – Narrabri to North Star (Umwelt 2017a)	Construction of approximately 183 kilometres of upgraded track between Narrabri and North Star	Removal of 410.62 hectares of native vegetation	**BC Act** Brigalow • 4.75 hectares (comprising 3.54 hectares permanent disturbance and 1.21 hectares temporary disturbance) Myall Woodland • 6.95 hectares (comprising 5.05 hectares permanent disturbance and 1.90 hectares temporary disturbance) **EPBC Act** Weeping Myall Woodland • 2.61 hectares (comprising 1.99 hectares permanent disturbance and 0.62 hectares temporary disturbance) Natural grassland on basalt and Fine-textured Alluvial Plains • 268.64 hectares (comprising 237.41 hectares permanent disturbance and 31.23 hectares temporary disturbance)	**Species credit impacts** • Removal of 28 individuals of *Digitaria porrecta* (Finger Panic Grass) • Removal of 73 individuals of *Homopholis belsonii* (Belson’s Panic) • Removal of 237.41 hectares of habitat for *Desmodium campylocaulon* (Creeping Tick-trefoil) • Removal of 62.77 hectares of Koala habitat **Ecosystem credit impacts** ▪ Removal of up to 410.62 hectares of habitat for a range of ecosystem species

Project	Description	Impacts on native vegetation	Impacts on threatened ecological communities	Impacts on threatened species
Inland Rail – Parkes to Narromine (Umwelt 2017b)	Upgrade of the rail line between Parkes and Narromine and a new rail connection to the Broken Hill Line	Removal of 66.72 hectares of native vegetation	**BC Act** Fuzzy Box Woodland (BC Act) • 1.88 hectares (1.50 hectares permanent disturbance and 0.38 hectares temporary disturbance) to be directly impacted by the proposal. Box Gum Woodland (BC Act) • 24.93 hectares (17.28 hectares permanent disturbance and 7.63 hectares temporary disturbance) Myall Woodland (BC Act) • 3.47 hectares (3.16 hectares permanent disturbance and 0.31 hectares temporary disturbance) Inland Grey Box Woodland (BC Act) • 39.39 hectares (30.29 hectares permanent disturbance and 9.1 hectares temporary disturbance) **EPBC Act** Box Gum Woodland (EPBC Act) • 22.79 hectares (15.11 hectares permanent disturbance and 7.63 hectares temporary disturbance) Weeping Myall Woodland (EPBC Act) • 0.99 hectares (all to be permanently disturbed) Grey Box Grassy Woodlands and Derived Native Grassland (EPBC Act) • 41.51 (31.37 hectares permanent disturbance and 10.14 hectares temporary disturbance)	**Species credit impacts** • Removal of 18.88 hectares of Koala habitat requiring calculation of credits **Ecosystem credit impacts** • Removal of up to 66.72 hectares of habitat for a range of ecosystem credit fauna species

Project	Description	Impacts on native vegetation	Impacts on threatened ecological communities	Impacts on threatened species
Narrabri Gas Project	Extraction of natural gas from the Gunnedah Basin, south-west of Narrabri.	Removal of up to 988.8 hectares of native vegetation and indirect impacts on 181.1 hectares of native vegetation	**BC Act** Brigalow • 19.3 hectares Fuzzy Box Woodland • 5.90 hectares Weeping Myall Woodland • 0.10 hectares **EPBC Act** Weeping Myall Woodland • 0.10 hectares	Direct and indirect impacts on up to 1082 hectares of habitat for ten threatened flora species. Removal of up to 1169.1 hectares of habitat for threatened fauna, including an estimated 10,143 hollow-bearing trees.
Narromine Solar Farm	Construction and operation of a solar farm to the north-east of Narromine	No clearing of native vegetation	No impact on threatened ecological communities.	No threatened species likely to be impacted.
Gilgandra Solar Farm	Construction and operation and eventually decommission of a 40 megawatt (MW) solar farm about 23 kilometres south of Gilgandra.	Removal of 0.6 hectares of paddock trees Removal of 68.94 hectares of derived grassland Removal of 103.16 hectares of low condition grassland	No impact on threatened ecological communities.	No species credit species identified on site or requiring credits. Potential impacts on habitat for Grey-crowned Babbler and microbats.
Western Slopes Pipeline	Construction and operation of a high pressure gas pipeline connecting the Narrabri Gas Project to the Moomba-Sydney gas pipeline.	Impacts not yet quantified	Impacts not yet quantified.	Impacts not yet quantified.

Project	Description	Impacts on native vegetation	Impacts on threatened ecological communities	Impacts on threatened species
Silverleaf Solar Farm	Construction and operation and eventually decommission or recondition a 120 megawatt (MW) AC solar farm to the north of Narrabri	Removal of up to 183 hectares of native vegetation including 1.84 hectares of woodland and 181.46 hectares of derived native grassland remnant woodland and derived grassland	Impacts not yet quantified.	Impacts not yet quantified.

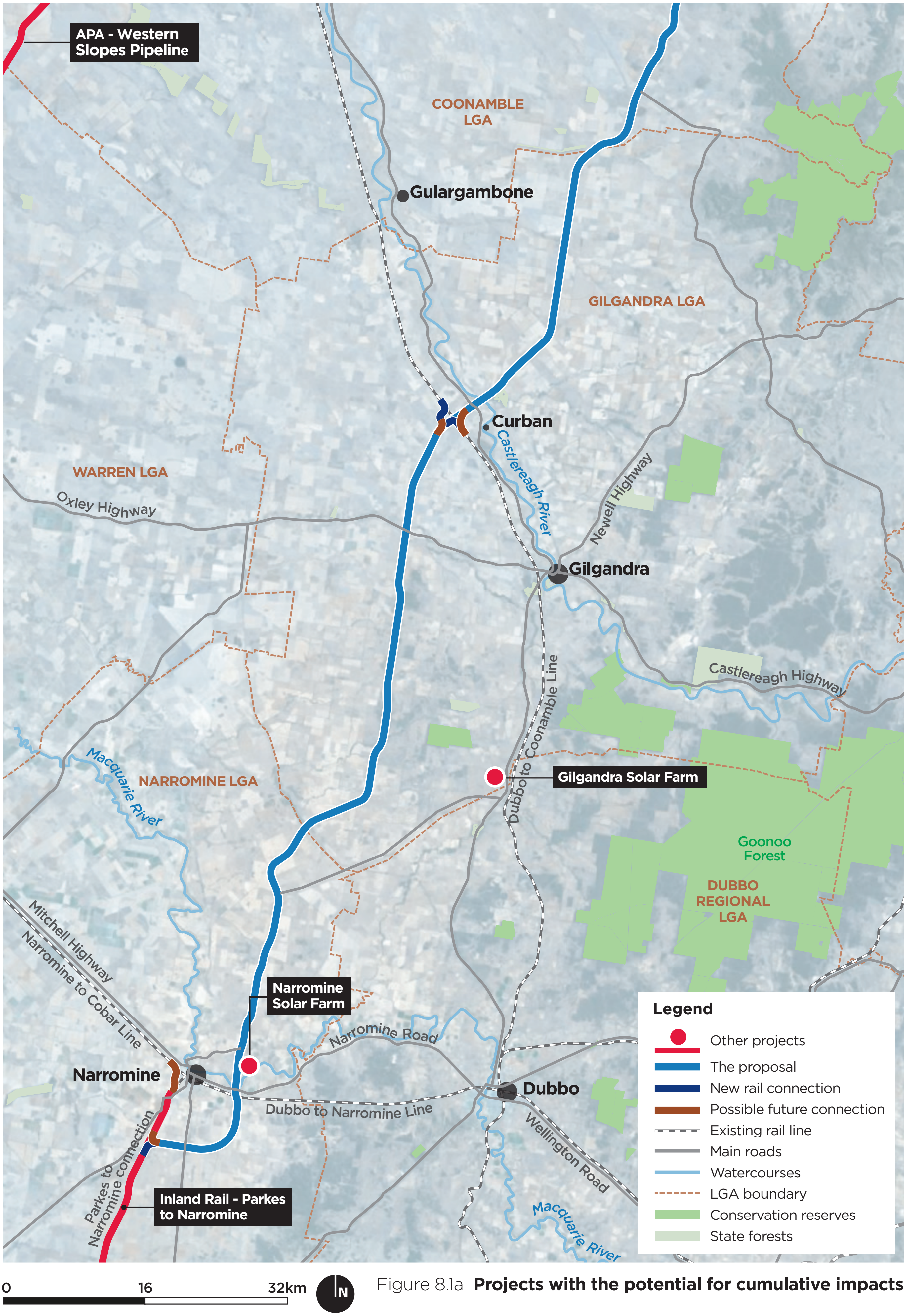

Figure 8.1a **Projects with the potential for cumulative impacts**

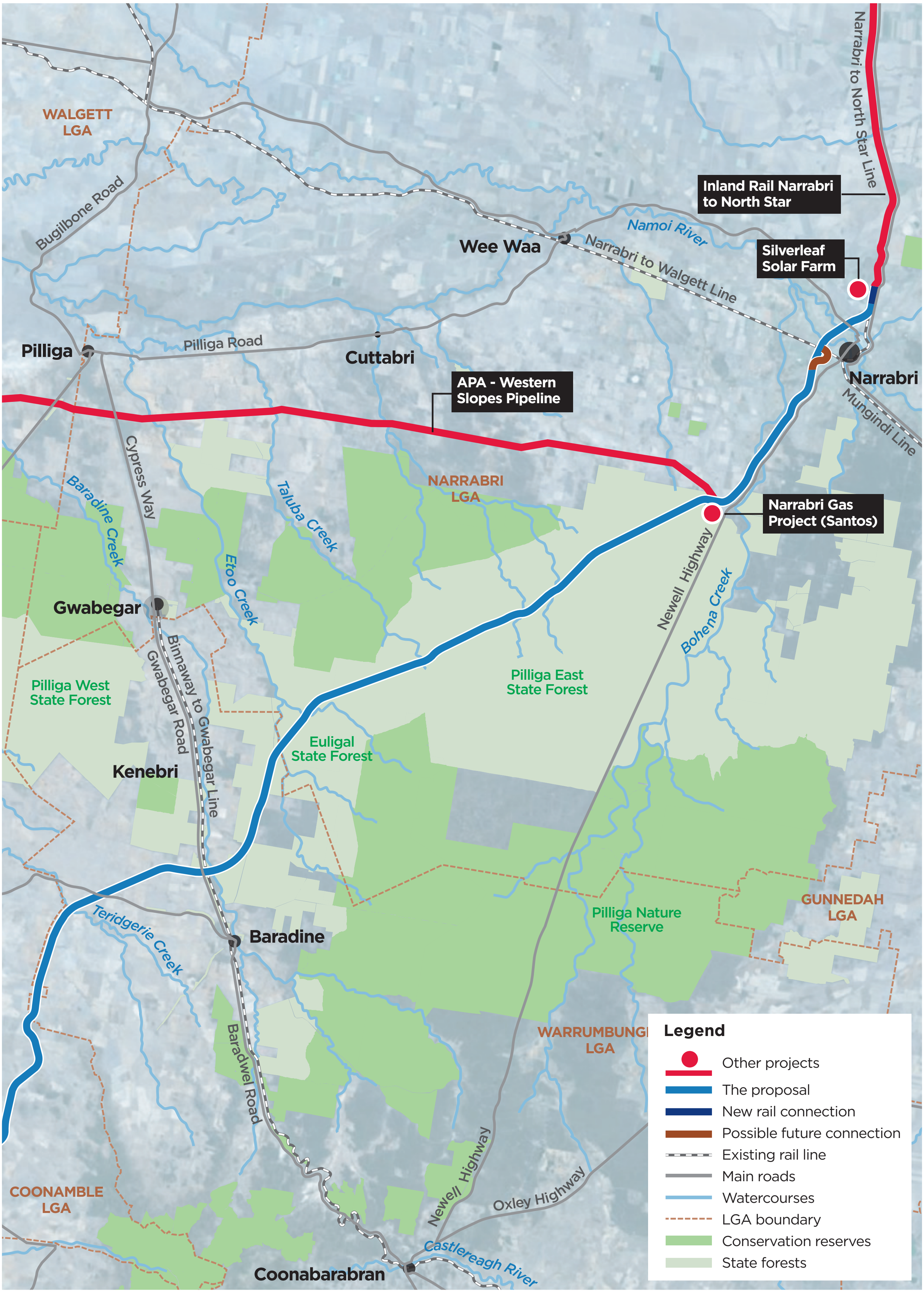

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Figure 8.1b **Projects with the potential for cumulative impacts**

9. Assessment of impacts required by the BAM

9.1 Serious and irreversible impacts

The concept of serious and irreversible impacts is fundamentally about protecting threatened entities that are most at risk of extinction from potential development. The Biodiversity Offsets Scheme recognises that there are some types of serious and irreversible impacts that the community expects will not occur except where the consent authority considers that this type of impact is outweighed by the social and economic benefits that the development will deliver to the State (EES, 2020).

Under the BC Act, a determination of whether an impact is serious and irreversible must be made in accordance with the principles set up in Section 6.7 of the BC Regulation.

The principles are aimed at capturing impacts which are likely to contribute significantly to the risk of extinction of a threatened species or ecological community in NSW.

The decision-maker must determine whether or not an impact on biodiversity values is likely to be a serious and irreversible impact (SAII). The framework allows for decision-makers to take into account the scale of an impact and the potential for avoidance and mitigation. These factors are weighed against the status and vulnerabilities of the potential SAII entity to ultimately determine if a proposal will indeed have a serious and irreversible impact (OEH 2017c).

9.1.1 Threatened species

One threatened fauna species that has the potential for serious and irreversible impacts was recorded during surveys, the Large-eared Pied Bat. The threatened species profile database identifies impacts on breeding habitat as identified during survey as the threshold for this species (EES 2019c). All habitat on the subject land where the subject land is within two kilometres of caves, scarps, cliffs, rock overhangs and disused mines is to be mapped as the species polygon for this species (OEH 2018a). No such habitat has been identified within two kilometres of the proposal site, and as such no species polygon has been prepared. Given the lack of potential breeding habitat, no assessment of serious and irreversible impacts is required for this species.

9.1.2 Threatened ecological communities

Three threatened ecological communities identified as SAII entities have been recorded in the proposal site, Box-Gum Woodland, Fuzzy Box Woodland and Brigalow Woodland. A detailed assessment of impacts is provided in Table 9.1, Table 9.2 and Table 9.3 in accordance with section 10.2 of the BAM. A threshold of impacts has not been identified for these communities and any impact to these SAII entities is the discretion of the accredited assessor. Based on the assessment for each of the SAII in Table 9.1, Table 9.2 and Table 9.3, the small areas to be impacted and their extent in the wider locality and region, the impacts to these SAII entities is not likely to be significant.

Table 9.1 Assessment of serious and irreversible impacts for Box-Gum Woodland

Criteria	Discussion
(a) the action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII	The proposal involves construction of a 306 kilometre section of new single track railway between the towns of Narromine and Narrabri in western NSW, as part of the Inland Rail program. The proposal requires the clearing of native vegetation to accommodate the rail corridor and allow for safe operation. Plant community type mapping of the vegetation across the potential locations for the proposal was conducted to inform the design and potential locations of borrow pits in order to minimise and avoid potential impacts on the threatened community. Areas of the community were avoided where practicable.
(b) the area (hectares) and condition of the threatened ecological community (TEC) to be impacted directly and indirectly by the proposed development. The condition of the TEC is to be represented by the vegetation integrity score for each vegetation zone	The proposal would result in an impact on a SAII entity through the proposed removal of 8.32 hectares of Box-Gum Woodland. The ecological community is associated with Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregion (PCT 599) in moderate condition with a vegetation integrity score (VI) of 58. Vegetation in the study area adjoining the development area is in a comparable condition and would have a similar vegetation integrity score due to clearing occurring on the edge of the patch of the community. The remaining vegetation in the connected patch is about 2.98 hectares in size, which would be left as an isolated patch of Box-Gum Woodland, separated by over 90 metres to roadside vegetation. This remaining patch of woodland is likely to be subject to indirect impacts from the proposal and increased edge effects due to its isolation. White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion (PCT 435) in moderate condition was recorded at a potential camp site. This PCT is also commensurate with Box Gum Woodland SAII. No plots were collected within this PCT vegetation zone as the site was not identified as a potential camp site until after surveys were completed. Benchmark values were entered for this PCT and VI score is very high at 100. Further BAM vegetation integrity plots will be completed in 2020 to determine the VI score of this vegetation zone and patch. Development impacts are likely to be restricted to the proposal site. Given the mitigation measures specified in section 11, existing and adjoining land uses, and the extent of existing weed infestation and disturbance in the study area, the development is unlikely to significantly increase indirect impacts.

Criteria	Discussion
(c) a description of the extent to which the impact exceeds the threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact	Thresholds for SAII entities are designed to assist in determining whether an impact will be a potential SAII. Any impact below the threshold is unlikely to be a SAII. To date, thresholds for threatened flora and ecological communities are incomplete, and as such, no threshold has been published for Box-Gum Woodland.
(d) the extent and overall condition of the potential TEC within an area of 1000ha, and then 10,000ha, surrounding the proposed development footprint	Existing broad vegetation mapping for the 1000 hectares and 10,000 hectares area estimates for Box-Gum Woodland are: • 1,000 hectares buffer – 704.75 hectares • 10,000 hectares buffer – 3,658.68 hectares. Box-Gum woodland to be impacted represents about 1.18 per cent of the Box-Gum woodland in the 1,000 hectares buffer area and 0.23 per cent of Box-Gum Woodland in the 10,000 hectares buffer area.
(e) an estimate of the extant area and overall condition of the potential TEC remaining in the IBRA subregion before and after the impact of the proposed development has been taken into consideration	According to the national recovery plan for the community (DECCW 2011), the occurrence of the community on predominantly privately owned land means the spatial distribution and quality of remnants remains largely unknown. Problems due to access for identifying the remaining occurrence of the community and ongoing clearing and modification make it difficult to correctly determine the communities' current extent. The community has been drastically reduced in area and highly fragmented due to clearance for cropping and pasture improvement. Broad vegetation type mapping may also overestimate the remaining extent of the community. The area of the community to be impacted by the proposal occurs in the Bogan-Macquarie subregion of the Darling Riverine Plains bioregion. There is an estimated 2,605.6 hectares of the community remaining in this subregion. The removal of about 8.32 hectares of the community by the proposal represents about 0.3 per cent of the community within the subregion.
(f) an estimate of the area of the potential TEC that is in the reserve system within the IBRA region and the IBRA subregion	Within the Brigalow Belt South IBRA region, where the majority of the proposal occurs, the TEC is protected in the following reserve systems (Benson *et.al*. 2010): • Towarri National Park • Pilliga Nature Reserve • Dapper Nature Reserve • Coolah Tops National Park • Mount Kaputar National Park. The total protected area of the TEC in the region is about 3,217 hectares. The area of the TEC within the proposal site occurs in the Bogan-Macquarie subregion of the Darling Riverine Plains bioregion. Within this subregion protected areas are limited to the Macquarie Marshes Nature Reserve system. The TEC is not protected within this reserve system.

Criteria	Discussion
(g) the development, clearing or biodiversity certification proposal's impact on: (i) abiotic factors critical to the long-term survival of the potential TEC; for example, how much the impact will lead to a reduction of groundwater levels or the substantial alteration of surface water patterns	The proposal would modify surface water flows and other abiotic factors within the proposal site by removing native vegetation, modifying the natural landform, and constructing the railway. The proposal would cause soil disturbance due to the earthworks required for the construction of the railway and associated infrastructure such as culverts. The earthworks have the potential to cause soil erosion in the proposal site and lead to sedimentation of the drainage lines in the study area, and the potential to impact on surface water quality throughout the area of the TEC. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. A CEMP (or equivalent) would be required for the construction phase of the proposal. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants, as well as site-specific measures, including the procedures outlined in section 11. The proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community, given the proposed impact mitigation and environmental management measures for the proposal.
(ii) characteristic and functionally important species through impacts such as, but not limited to, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants	Construction of the proposal has a risk of fire from activities such as the storage of combustible fuels or ignition from works areas. In drought conditions this would be increased due to the dry nature of the vegetation. Bushfires of high to extreme intensity can result in significant modification of vegetation structure and composition. Risk of fires from the proposal would be minimised through a fire hazard management plan. The proposal is unlikely to alter flooding regimes in the area of the TEC, given there are no creeks or drainage lines within 500 metres of the occurrence of the community, and the installation of drainage structures as part of the proposal to appropriately manage water flows. The proposal would involve the clearing of the community along the edges of an existing patch. This small area would not contain an ecologically significant proportion of any of the species that characterise the community. Populations of the species that characterise the community would be maintained in the local and regional occurrence of the community outside the proposal site. As such, the proposal is unlikely to significantly impact on characteristic and functionally important species within the TEC outside the proposal site.

Criteria	Discussion
(iii) the quality and integrity of an occurrence of the potential TEC through threats and indirect impacts including, but not limited to, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the potential TEC	Within the proposal site, PCT 599 occurs as a stand of canopy species over a predominantly native understorey. The proposal would result in the complete removal of all vegetation (native and exotic) from within the proposal site. Vegetation outside of the proposal site that would not be directly impacted by the proposal is at some risk of indirect impacts resulting from the proposal, if appropriate mitigation measures are not adopted and implemented. The remaining patch of the TEC would become isolated from the remnant roadside vegetation that occurs in the study area, leaving it more vulnerable to edge effects and weed invasion. Within the proposal site PCT 435 occurs at an existing accommodation site on the outskirts of Baradine. This community occurs mostly as canopy species only due to continued use of the site for camping and caravans. This PCT extends off the proposed camp site into surrounding roadsides and private land. A number of mitigation measures are recommended in section 11 to limit the potential for indirect impacts that may affect vegetation and habitats outside of the proposal site.
(h) direct or indirect fragmentation and isolation of an important area of the potential TEC	The proposal will result in further fragmentation of the vegetation in the locality including the local occurrence of Box-Gum Woodland (from PCT 599), which would likely comprise an important area of the community due to the limited area remaining across the landscape. Vegetation from the community to be removed includes 2.2 hectares from the edge of an existing patch connected to remnant roadside vegetation. The remaining woodland would be a 2.98 hectare isolated patch, separated by over 90 metres to similar roadside vegetation. This remaining patch of woodland is likely to be subject to indirect impacts from the proposal and increased edge effects due to its isolation. PCT 435 would remain connected to other occurrences of the community that occur outside the proposal site. This includes areas that are part of the same patch to the north and south.
(i) the measures proposed to contribute to the recovery of the potential TEC in the IBRA subregion.	A Biodiversity Offset Strategy for the proposal would be finalised in accordance with the requirements of the Biodiversity Offsets Scheme and the BAM (OEH 2017). The strategy would be approved by DPIE prior to the commencement of construction work that would result in the disturbance of relevant ecological communities, threatened species, or their habitat, unless otherwise agreed. The strategy would secure and conserve areas of the TEC in perpetuity.

Table 9.2 Assessment of serious and irreversible impacts for Fuzzy Box Woodland

Criteria	Discussion
(a) the action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII	Plant community type mapping of the vegetation across the potential locations for the proposal was conducted to inform the design and potential locations of borrow pits in order to minimise and avoid potential impacts on the threatened community. Areas of the community were avoided where practicable.
(b) the area (hectares) and condition of the TEC to be impacted directly and indirectly by the proposed development. The condition of the TEC is to be represented by the vegetation integrity score for each vegetation zone	The proposal would result in an impact on a SAII entity through the proposed removal of 3.59 hectares of Fuzzy Box Woodland. The ecological community is associated with Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (PCT 202) in good condition with a vegetation integrity score (VI) of 90.7. The high VI score for the community is attributed to the use of benchmark conditions for plots to achieve the required plot number for the zone area. This was due to the lack of access to the majority of the patch. The plots conducted in this community were within the road reserve and likely in lower condition than those within the broader patch, however the patch is unlikely to achieve benchmark values in its current condition and a VI score as high as 90.7. The remaining vegetation in the connected patch of Fuzzy Box Woodland is about 5.31 hectares in size, which would be fragmented into two separate patches due to an almost 80 metre construction corridor dividing the patch. The remaining patches of woodland are likely to be subject to indirect impacts from the proposal and increased edge effects due their fragmentation. Development impacts are likely to be restricted to the proposal site. Given the mitigation measures specified section 11, existing and adjoining land uses, and the extent of existing weed infestation and disturbance in the study area, the development is unlikely to significantly increase indirect impacts.
(c) a description of the extent to which the impact exceeds the threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact	Thresholds for SAII entities are designed to assist in determining whether an impact will be a potential SAII. Any impact below the threshold is unlikely to be a SAII. To date, thresholds for threatened flora and ecological communities are incomplete, and as such, no threshold has been published for Fuzzy Box Woodland.
(d) the extent and overall condition of the potential TEC within an area of 1000ha, and then 10,000ha, surrounding the proposed development footprint	There is no existing broad vegetation mapping for the 1,000 hectare and 10,000 hectare area estimates for Fuzzy Box Woodland. However, about 8.2 hectares of this community was mapped in the investigation corridor during the field surveys.

Criteria	Discussion
(e) an estimate of the extant area and overall condition of the potential TEC remaining in the IBRA subregion before and after the impact of the proposed development has been taken into consideration	Less than five per cent of the TEC in the Brigalow Belt South, South Western Slopes and Darling Riverine Plains bioregions is estimated to remain compared to pre-European time due to past clearing (Austin et al. 2000, Seddon et al. 2002). The area of the community to be impacted by the proposal occurs in the Pilliga subregion. About 3.59 hectares of the community would be impacted by the proposal. Broad vegetation type mapping within the Pilliga subregion includes about 308.8 hectares of the TEC. Vegetation to be removed therefore is about 1.16 per cent of the mapped community within the Pilliga subregion.
(f) an estimate of the area of the potential TEC that is in the reserve system within the IBRA region and the IBRA subregion	There is currently only one stand of the TEC protected in NSW, which is within Weddin Mountains National Park. The size of this stand is not documented. The TEC is not protected in the Brigalow Belt South region and therefore the Pilliga subregion.
(g) the development, clearing or biodiversity certification proposal's impact on: (i) abiotic factors critical to the long-term survival of the potential TEC; for example, how much the impact will lead to a reduction of groundwater levels or the substantial alteration of surface water patterns	The proposal would modify surface water flows and other abiotic factors within the proposal site by removing native vegetation, modifying the natural landform, and constructing the railway. The proposal would cause soil disturbance due to the earthworks required for the construction of the railway and associated infrastructure such as culverts. The earthworks have the potential to cause soil erosion in the proposal site and lead to sedimentation of the drainage lines in the study area, and the potential to impact on surface water quality throughout the area of the TEC. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. A CEMP (or equivalent) would be required for the construction phase of the proposal. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants, as well as site-specific measures, including the procedures outlined in section 11. The proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community, given the proposed impact mitigation and environmental management measures for the proposal.

Criteria	Discussion
(ii) characteristic and functionally important species through impacts such as, but not limited to, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants	Construction of the proposal has a risk of fire from activities such as the storage of combustible fuels or ignition from works areas. In drought conditions this would be increased due to the dry nature of the vegetation. Bushfires of high to extreme intensity can result in significant modification of vegetation structure and composition. Risk of fires from the proposal would be minimised through a fire hazard management plan. The proposal is unlikely to alter flooding regimes in the area of the TEC due to the installation of drainage structures as part of the proposal to appropriately manage water flows. The proposal would not substantially alter the flow of water through the study area. The proposal would involve the clearing of the community along the edges of an existing patch. This small area would not contain an ecologically significant proportion of any of the species that characterise the community. Populations of the species that characterise the community would be maintained in the local and regional occurrence of the community outside the proposal site. As such, the proposal is unlikely to significantly impact on characteristic and functionally important species within the TEC outside the proposal site.
(iii) the quality and integrity of an occurrence of the potential TEC through threats and indirect impacts including, but not limited to, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the potential TEC	Within the proposal site, PCT 202 occurs as a stand of canopy species over a predominantly native understorey. The proposal would result in the complete removal of all vegetation (native and exotic) from within the proposal site. Vegetation outside of the proposal site that would not be directly impacted by the proposal is at some risk of indirect impacts resulting from the proposal, if appropriate mitigation measures are not adopted and implemented. The remaining patch of the TEC would become fragmented into two separate patches due to an almost 80 metre wide construction corridor dividing the patch, leaving it more vulnerable to edge effects and weed invasion. A number of mitigation measures are recommended in section 11 to limit the potential for indirect impacts that may affect vegetation and habitats outside of the proposal site.
(h) direct or indirect fragmentation and isolation of an important area of the potential TEC	The proposal will result in further fragmentation of the vegetation in the locality including the local occurrence of Fuzzy Box Woodland, which would likely comprise an important area of the community due to the limited area remaining across the landscape. Vegetation from the community to be removed includes 3.59 hectares that would fragment the existing patch due to an almost 80 metre wide construction corridor dividing the patch. The remaining woodland patch is about 5.31 hectares, which would likely be subject to indirect impacts from the proposal and increased edge effects due to its fragmentation.

Criteria	Discussion
(i) the measures proposed to contribute to the recovery of the potential TEC in the IBRA subregion.	A Biodiversity Offset Strategy for the proposal would be finalised in accordance with the requirements of the Biodiversity Offsets Scheme and the BAM (OEH 2017). The strategy would be approved by DPIE prior to the commencement of construction work that would result in the disturbance of relevant ecological communities, threatened species, or their habitat, unless otherwise agreed. The strategy would secure and conserve areas of the TEC in perpetuity.

Table 9.3 Assessment of serious and irreversible impacts for Brigalow Woodland

Criteria	Discussion
(a) the action and measures taken to avoid the direct and indirect impact on the potential entity for an SAII	Plant community type mapping of the vegetation across the potential locations for the proposal was conducted to inform the design and potential locations of borrow pits in order to minimise and avoid potential impacts on the threatened community. Areas of the community were avoided where practicable. Mapped areas of Brigalow woodland were used to help identify alignment selection and compound site location at Narrabri where the community occurs.
(b) the area (hectares) and condition of the TEC to be impacted directly and indirectly by the proposed development. The condition of the TEC is to be represented by the vegetation integrity score for each vegetation zone	The proposal would result in an impact on a SAII entity through the proposed removal of 0.61 hectares of Brigalow Woodland. The ecological community is associated with Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (PCT 35) in moderate condition with a vegetation integrity score (VI) of 61.1. Vegetation in the study area adjoining the development area is in a comparable condition and would have a similar vegetation integrity score due to clearing occurring on the edge of the patch of the community. The remaining vegetation in the connected patch is about 10.5 hectares in size, which would remain as a patch similar to its existing state due to clearing being limited to the northern and southern edges of the patch. This remaining patch of woodland is likely to be subject to indirect impacts from the proposal; however this is not expected to be to any greater extent than is already occurring due to its isolated location adjacent to a road and grassland area. Development impacts are likely to be restricted to the proposal site. Given the mitigation measures specified in section 11, existing and adjoining land uses, and the extent of existing weed infestation and disturbance in the study area, the development is unlikely to significantly increase indirect impacts.

Criteria	Discussion
(c) a description of the extent to which the impact exceeds the threshold for the potential entity that is specified in the Guidance to assist a decision-maker to determine a serious and irreversible impact	Thresholds for SAII entities are designed to assist in determining whether an impact will be a potential SAII. Any impact below the threshold is unlikely to be a SAII. To date, thresholds for threatened flora and ecological communities are incomplete, and as such, no threshold has been published for Brigalow Woodland
(d) the extent and overall condition of the potential TEC within an area of 1000ha, and then 10,000ha, surrounding the proposed development footprint	Existing broad vegetation mapping for the 1000 hectares and 10,000 hectares area estimates for Brigalow Woodland are: • 1,000 hectares buffer – 26.14 hectares • 10,000 hectares buffer – 180.17 hectares. Brigalow woodland to be impacted represents about 2.3 per cent of the Brigalow Woodland in the 1,000 hectares buffer area and 0.34 per cent of Brigalow Woodland in the 10,000 hectares buffer area. The overall condition of the TEC in these areas is unknown, however the community is known to be severely fragmented and often thinned and modified where it occurs.
(e) an estimate of the extant area and overall condition of the potential TEC remaining in the IBRA subregion before and after the impact of the proposed development has been taken into consideration	Brigalow in NSW has been extensively cleared for agricultural purposes and remnants have often been thinned and modified. Recent vegetation mapping of the northern wheatbelt has found that only about 13,000 hectares remains of this community and that it is severely fragmented (D. Sivertsen & L. Metcalf, pers comm.). The area of the community to be impacted by the proposal occurs in the Pilliga Outwash subregion. About 0.61 hectares of the community would be impacted by the proposal. Broad vegetation type mapping within the Pilliga Outwash subregion includes about 10,268.76 hectares of the TEC. Vegetation to be removed therefore is about 0.006 per cent of the mapped community within the Pilliga Outwash subregion.
(f) an estimate of the area of the potential TEC that is in the reserve system within the IBRA region and the IBRA subregion	There is currently only one stand of the TEC protected in NSW, within Brigalow Park Nature Reserve, which occurs within the Pilliga Outwash subregion of the Brigalow Belt South region. There are about 202 hectares of the TEC protected within this reserve.

Criteria	Discussion
(g) the development, clearing or biodiversity certification proposal's impact on: (i) abiotic factors critical to the long-term survival of the potential TEC; for example, how much the impact will lead to a reduction of groundwater levels or the substantial alteration of surface water patterns	The proposal would modify surface water flows and other abiotic factors within the proposal site by removing native vegetation, modifying the natural landform, and constructing the railway. The proposal would cause soil disturbance due to the earthworks required for the construction of the railway and associated infrastructure such as culverts. The earthworks have the potential to cause soil erosion in the proposal site and lead to sedimentation of the drainage lines in the study area, and the potential to impact on surface water quality throughout the area of the TEC. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. A CEMP (or equivalent) would be required for the construction phase of the proposal. The CEMP would include, as a minimum, industry-standard measures for the management of soil, surface water, weeds and pollutants, as well as site-specific measures, including the procedures outlined in section 11. The proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community, given the proposed impact mitigation and environmental management measures for the proposal.
(ii) characteristic and functionally important species through impacts such as, but not limited to, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants	Construction of the proposal has a risk of fire from activities such as the storage of combustible fuels or ignition from works areas. In drought conditions this would be increased due to the dry nature of the vegetation. Bushfires of high to extreme intensity can result in significant modification of vegetation structure and composition. Risk of fires from the proposal would be minimised through a fire hazard management plan. The proposal is unlikely to alter flooding regimes in the area of the TEC due to the installation of drainage structures as part of the proposal to appropriately manage water flows. The proposal would not substantially alter the flow of water through the study area. The proposal would involve the clearing of the community along the northern and southern edges of an existing patch. This small area would not contain an ecologically significant proportion of any of the species that characterise the community. Populations of the species that characterise the community would be maintained in the local and regional occurrence of the community outside the proposal site. As such, the proposal is unlikely to significantly impact on characteristic and functionally important species within the TEC outside the proposal site.

Criteria	Discussion
(iii) the quality and integrity of an occurrence of the potential TEC through threats and indirect impacts including, but not limited to, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the potential TEC	Within the proposal site, PCT 35 occurs as a stand of canopy species over a predominantly native understorey. The proposal would result in the complete removal of all vegetation (native and exotic) from within the proposal site. Vegetation outside of the proposal site that would not be directly impacted by the proposal is at some risk of indirect impacts resulting from the proposal, if appropriate mitigation measures are not adopted and implemented. The remaining patch of the TEC is likely to be subject to indirect impacts from the proposal; however this is not expected to be to any greater extent than is already occurring due to its isolated location adjacent to a road and grassland area. A number of mitigation measures are recommended in section 11 to limit the potential for indirect impacts that may affect vegetation and habitats outside of the proposal site.
(h) direct or indirect fragmentation and isolation of an important area of the potential TEC	The proposal would result in further fragmentation of the vegetation in the locality, however is unlikely to further fragment the local occurrence of Brigalow due to the removal of vegetation limited to the northern and southern edges of the existing patch. The patch of the community is likely to comprise an important area of the community due to the limited area remaining across the landscape; however unlikely to be further fragmented or isolated. Vegetation from the community to be removed includes 0.61 hectares from the northern and southern edges of an existing patch. The remaining vegetation in the connected patch is about 10.5 hectares in size, which would remain as a patch similar to its existing state due to clearing being limited to the edges of the patch. This remaining patch of woodland is likely to be subject to indirect impacts from the proposal; however this is not expected to be to any greater extent than is already occurring due to its isolated location adjacent to a road and grassland area.
(i) the measures proposed to contribute to the recovery of the potential TEC in the IBRA subregion.	A Biodiversity Offset Strategy for the proposal would be finalised in accordance with the requirements of the Biodiversity Offsets Scheme and the BAM (OEH 2017). The strategy would be approved by DPIE prior to the commencement of construction work that would result in the disturbance of relevant ecological communities, threatened species, or their habitat, unless otherwise agreed. The strategy would secure and conserve areas of the TEC in perpetuity.

9.2 Prescribed biodiversity impacts

9.2.1 Connectivity

Impacts of the proposal on the connectivity of different areas of habitat of threatened species that facilitates the movement of those species across their range must be assessed for prescribed impacts.

Habitat fragmentation can result in reduced dispersal and reproductive success of biota within the fragment, a decline in populations resulting from increased predation by introduced species or native species that do not normally occur in the community, and an increased probability that stochastic events (eg fire) may reduce population numbers below critical levels required for their survival (Andrew 1990). Some species are at greater risk in fragmented landscapes than others as a result of their ecological requirements. The threat posed by fragmentation is increased for species with large home ranges, which migrate or disperse over long distances, those that have specialised dietary or habitat requirements (Jackson 2000) and those with poor dispersal ability (Forman et al 2003, Neibuhr et al 2015). In general, larger fragments are less susceptible to adverse impacts than are smaller fragments.

Much of the research quantifying the effects of linear infrastructure on the environment has been conducted in North America and Europe, and has mainly focussed on arterial roads that carry large volumes of traffic (van der Ree et al 2008). Much less research has been conducted on the impact of rail on connectivity (Borda-de-Agua et al 2017). Increasing numbers of studies have assessed the impacts of roads on Australian Wildlife, however very few assess the impact of rail. A review of literature relating to rail impacts was undertaken by Borda-de-Agua et al (2017) and provides much information on potential impacts and mitigation measures relevant to this assessment.

Connectivity is provided in the study area by:

- the Pilliga forests
- large vegetated tracts associated with Crown Land/Travelling Stock Reserves (eg Bohena Creek and along the Newell Highway)
- vegetated riparian corridors (eg Narrabri Creek, Namoi River, Castlereagh River, Macquarie River, Kickabil Creek)
- vegetated road reserves and paper roads
- small isolated patches of woodland within farmland
- paddock trees.

The Pilliga forests comprise about 3,000 square kilometres of semi-arid woodland and is the largest continuous woodland remnant in NSW. Birdlife International (2019) has identified the Pilliga (also incorporating the Warrumbungle's National Park) as an important bird area (IBA). The IBA supports the largest population of Barking Owls (*Ninox connivens*) in NSW. Other threatened species such as the Glossy Black-Cockatoo (*Calyptorhynchus lathami*), Grey-crowned Babbler (*Pomatostomus temporalis*), Speckled Warbler (*Pyrrholaemus sagittatus*), Brown Treecreeper (*Climacteris picumnus*), Hooded Robin (*Melanodryas cucullata*) and Turquoise Parrot (*Neophema pulchella*) are common residents. There are irregular records of the Swift Parrot (*Lathamus discolor*), Flame Robin (*Petroica phoenicea*), Bush-stone Curlew (*Burhinus grallarius*), Malleefowl (*Leipoa ocellata*) and Regent Honeyeater (*Anthochaera phrygia*). In total, over 200 bird species have been recorded for the Pilliga. In addition, at least 36 native mammal species (including 16 bat species), 50 reptile species and at least 15 amphibian species have been recorded in the Nature Reserve, including at least 21 species listed as threatened in NSW, including the Pilliga Mouse (*Pseudomys pilligaensis*) and

Squirrel Glider (*Petaurus norfolcensis*) (Birdlife International 2019). These forests provide important habitat and movement corridors for these species.

Areas of Crown Land (including Travelling Stock Reserves) occur throughout the proposal site and surrounds. These often occur along road reserves, paper roads (eg ‘laneways’ along property boundaries) or in association with creeks and rivers, and provide continuous linear strips of vegetation. In some locations these connect to larger patches of vegetation elsewhere, providing increased connectivity in the landscape. Vegetated riparian corridors (not within Crown Land) extend these linear strips across the landscape. These areas provide habitat for a range of fauna groups, including birds, possums, bats, reptiles and frogs.

Stepping stone connectivity is provided by small patches of woodland vegetation retained in farmland, as well as isolated paddock trees. This areas are particularly important for mobile species such as birds and bats.

A detailed assessment of impacts on connectivity is provided in Table 9.4.

Table 9.4 Impacts on connectivity for threatened species

Criteria	Connectivity feature	Discussion
(a) identify the area/s of connectivity joining different areas of habitat that intersect with the subject land and the areas of habitat that are connected according to Paragraph 4.2.1.3	The following features are identified as the main connectivity features intersected by the proposal: • Pilliga forests • Riparian areas (eg Macquarie River, Castlereagh River, Narrabri Creek, and other wooded watercourses) • Vegetated road reserves and paper roads • Paddock trees and small isolated patches of vegetation ('stepping stones').	
(b) identify the species and ecological communities likely to benefit from the connectivity	Pilliga forests	The Pilliga forests provide an important area of habitat for a wide range of fauna and flora species. In particular, the area supports the largest population of Barking Owls (*Ninox connivens*) in NSW (Birdlife International 2019). A number of other threatened bird species occur in these forests. Surveys of the Pilliga forests in the 1990s suggested that the forests were carrying the largest population of Koalas west of the Great Dividing Range in NSW (Kavanagh and Barrott, 2001), however more recent repeat surveys for Koalas within the Pilliga forests showed a decline of over 80 per cent in both the distribution and activity of Koalas within the forests (Lunney et al. 2017). The forests provide habitat for a number of other threatened mammal species, including the Squirrel Glider, Eastern Pygmy Possum, Black-striped Wallaby and Pilliga Mouse, as well as a number of microbat species. In addition, the threatened Pale-headed Snake occurs. The Pilliga forests provide habitat for threatened flora species such as *Pterostylis cobarensis*. The large expanses of connected vegetation provide a significant area of habitat for these species, where much of the surrounding country has been cleared for agriculture.
	Riparian areas	Many fauna species use riparian vegetation to move through predominantly cleared agricultural land. Other fauna species rely on these habitats for their survival, because it is often the only remaining area of native vegetation. Large, hollow-bearing trees occur in these areas, and provide important denning and roosting habitat for hollow-dependant fauna, such as the Barking Owl, and nest sites for the Square-tailed Kite. Riparian areas also provide connectivity for species such as the Koala, and potentially also the Squirrel Glider.

Criteria	Connectivity feature	Discussion
	Vegetated road reserves and 'paper roads'	Many fauna species would rely on vegetated roadsides and 'paper roads' for movement given that much of the region has been cleared for agriculture. These areas would be used in conjunction with riparian areas to move across the landscape. Woodland remnants in travelling stock reserves support more species of birds and arboreal mammals than those on private land (Davidson et al 2005). Species such as the Koala and Squirrel Glider would rely on these areas for foraging and dispersal. The mature, hollow-bearing trees found along the travelling stock reserves provide vital habitat, nesting sites and protection for a range of birds, arboreal mammals and bats (Gibbons et al 2000). Threatened species recorded during surveys that may roost in these remnants include the Yellow-bellied Sheathtail bat and Little Pied Bat. The woodlands contained in travelling stock reserves provide habitat for a broad range of woodland birds in the sheep and wheat farming belt of NSW. Many of these species are sedentary passerine (songbird) species with a previously wide distribution range that are now undergoing a decline in their distribution (Smiles et al 2011). Threatened woodland birds such as the Grey-crowned Babbler, Speckled Warbler, Varied Sittella and Black-chinned Honeyeater were recorded in travelling stock reserves and other roadside remnants.
	Stepping stones	Many fauna species use stepping stone vegetation and isolated paddock trees to move through predominantly cleared agricultural land. These would include birds, bats, Koalas and the Squirrel Glider (depending on distance between trees). Large, hollow-bearing trees occur in these areas, and provide important roosting habitat for hollow-dependant fauna such as microbats.
(c) describe the nature, extent and duration of short and long-term impacts	Pilliga forests	The proposal would clear a gap of about 73 kilometres by 50 metres through the Pilliga, and for much of this length increase the existing gap associated with Pilliga Forest Way. The proposal will compound fragmentation caused by Pilliga Forest Way and other cleared tracks. Linear infrastructure is one of the largest threats to biodiversity worldwide, including habitat loss and fragmentation (Forman et al. 2003; Benítez-López et al. 2010; van der Ree et al. 2015). Rail lines create a number of different types of barriers to fauna as discussed below. **Physical and behavioural barrier** Rail lines can be physical barriers, where a species cannot pass across the railway or behavioural, when the species may be physically able to cross the barrier but does not do so because of unfavourable ambient conditions or perceived risk (Barrientos and Borda-de-Agua 2017). Physical barrier constraints mainly affect species of small size with reduced mobility, such as reptiles and frogs. Some fauna species will not cross open spaces, for example certain insects will turn back at the edge of a patch (Bhattacharya et al. 2003) (which can have flow-on effects for flora if they are pollinators). Some bat species have been found to only cross a parallel rail/road where a vegetation underpass or overpass is present (Kammonen 2015).

Criteria	Connectivity feature	Discussion
		Disturbance Traffic noise, vibrations, chemical pollution, and human presence can impact animal populations living close to railways, contributing to the barrier effects. Among the long-term disturbances related to barrier effects, one of the most significant seems to be the noise produced by trains, however the impacts are species-specific, and in some cases some species will take up residence in the rail corridor (Barrientos and Borda-de-Agua 2017). **Mortality** Train-related mortality can directly prevent connectivity among sub-populations, or reduce their reproductive success, if individuals seeking mates die or if their offspring are railway-killed (Barrientos and Borda-de-Agua 2017). Species at high risk include the Koala, Black-striped Wallaby and Squirrel Glider. Traffic flow is the most important factor, with the highest mortality occurring, in fact, in lines with moderate traffic flow because higher traffic volume deters animals from attempting to cross (Dorsey et al. 2015). Further discussion of mortality from train strike is provided in section 9.2.3. Inland Rail may be at the lower end of traffic volume, which may allow more animals to cross safely, although the novel risk created by the trains, and the height of trains, will result in mortality of fauna, including species such as terrestrial fauna, birds, bats and the Squirrel Glider. **Habitat loss and fragmentation** Habitat loss and fragmentation takes place when railway construction leads to the reduction of the available habitat, since the transformed railway bed and corridor is unsuitable for several species. Habitat changes also take place in railway corridors, as their verges commonly differ from the surrounding landscape, but are homogeneous along the railway network. These changes can be exploited by generalist species or by opportunistic individuals, using them as shelters or corridors (Barrientos and Borda-de-Agua 2017). The barrier effect of the rail line will reduce or prevent genetic exchange for some species, while having little impact on others. In some cases, railways have been found to have had little influence on genetic differentiation compared to roads, probably because of a combination of their low traffic flow, the presence of wildlife passes, and lack of fencing (Borda-de-Agua et al 2017). Railways have been shown to be more permeable to forest song bird movements than were roads, likely due to their narrower width and lower traffic, with the gap size in the vegetation was the most important factor constraining forest bird movement, especially when the gap was larger than 30 metres (Tremblay and St. Clair 2009). Moderate to low crossing rates may not necessarily imply functional connectivity (Riley et al. 2006). In addition, barrier effects on genetics of species may not be able to be detected for many years.

Criteria	Connectivity feature	Discussion
	Riparian areas	All major rivers and many creeks in the proposal site will be crossed by bridges. A total of 73 rail bridges are proposed for the proposal. Larger bridges are located over the major rivers, and are very long (Macquarie River: >1 kilometres long, Castlereagh River > 600 metres long, Namoi River/Narrabri Creek > 3 kilometres long). Many other bridges have expanses of over 100 metres. These bridges will allow some connectivity of vegetation, and given the generally dry nature of many will provide substantial areas of dry passage for fauna to pass underneath for much of the time.
	Vegetated road reserves and paper roads	Clearing for the proposal will include removal of vegetation from road reserves and paper roads. In some locations, the removal occurs parallel to the road, and would increase the gap created by the road, and also increase gasp between areas of vegetation.
	Stepping stones	Clearing for the proposal will include removal of isolated paddock trees and small patches of vegetation, further increasing the gaps between other remnant trees.
(d) describe, with reference to relevant literature and other reliable published sources of information, the importance of the area of connectivity within the bioregion	Pilliga forests	The Pilliga forests comprise about 3000 km^2 of semi-arid woodland and is the largest continuous woodland remnant in NSW. Birdlife International (2019) has identified the Pilliga (also incorporating the Warrumbungles National Park) as an important bird and biodiversity area (IBA). IBAs are places of international significance for the conservation of birds and other biodiversity.
	Riparian areas	In extensively cleared areas, where riparian vegetation may form the majority of the remnant native vegetation, it may be considered a critical landscape component (Fisher and Goldney 1997). Riparian corridors often form important links with larger tracts of vegetation, such as national parks and forests. Riparian vegetation provides important movement corridors for many species. Riparian vegetation has been shown to be a key element for avian diversity, even in massively altered landscapes (Johnson et al 2007). These areas are particularly important as drought refuges (Morton 1990 in Macleod 2002a).

Criteria	Connectivity feature	Discussion
	Vegetated road reserves and paper roads	The importance of travelling stock reserves as refugia for remnant vegetation and biodiversity conservation was identified in the 1970s (McKnight 1977; Hibberd & Soutberg 1991). Grazing pressure at many travelling stock reserves has reduced in recent decades, and biodiversity values have increased (McKnight 1977), due to a more diverse vegetation structure and floristics. A large proportion of travelling stock reserves are in bioregions or subregions (IBRA) which are less than five per cent reserved and, in some cases, travelling stock reserves provide the best, or only, opportunity for conservation of threatened species or communities. The linear network of travelling stock reserves forms a fundamental system of landscape corridors, particularly in the sheep–wheat belt and tablelands (DECCW 2009). Travelling stock reserves often represent the best examples of high quality grasslands and woodlands in NSW, and form an important stronghold for conservation of the once widespread but now endangered Box-Gum Woodland critically endangered ecological community and its component (often threatened) fauna species (Davidson et al 2005). The importance of the woodlands remaining in the travelling stock reserve network cannot be overstated. Most areas reserved as national parks and nature reserves in NSW are on land that was not suitable for clearing for agricultural uses, such as rocky outcrops and ridgelines. These areas generally have poorer soils and do not support the vegetation types and habitats that occur on the fertile valley floors with creek lines, rivers and rich alluvial soils. The travelling stock reserves network, however, mostly occurs on the fertile valley floors because it was developed following water sources. Therefore, the vegetation and habitats contained in travelling stock reserves are, in many cases, the best remnants of woodland ecosystems that are adapted to fertile soil conditions (Spooner and Lunt 2004, Smiles et al 2011). The travelling stock reserve networks in NSW and Queensland also extend across climatic gradients in eastern Australia. Temperatures in eastern Australia generally increase from south to north, whilst moisture increases from west to east. These conditions have a major influence on habitat. As the travelling stock reserve networks span these gradients, they allow species to move across the landscape in response to changes in rainfall and temperature. This enables the seasonal movement of species, particularly in response to extreme seasonal conditions such as drought. Perhaps more crucially, the network may also help plant and animal species to survive climate change by allowing them to move to new areas, as habitats and food sources shift with changing weather patterns (Sutherst et al 2008, Smiles et al 2011).

Criteria	Connectivity feature	Discussion
	Stepping stones	Stepping stones are isolated patches of vegetation, single trees, or wetlands or farm dams. The patches become a corridor when the distance between them is small enough for some species to be able to move from one patch to the next. Even single paddock trees are valuable and can act as stepping stones or provide habitat for some species (OEH undated). Small patches have been found to support high species richness. These patches are used on a daily basis by many species, and could be part of a larger habitat mosaic, providing complementary habitat to larger habitat areas in a landscape (Fischer and Lindenmayer 2002). Paddock trees are particularly important for mobile species such as birds and bats. Surveys at a site in northern NSW recorded 35 diurnal bird species foraging in paddock trees (predominantly generalist species), and 21 species of bat (seven threatened species) flying in close proximity to paddock trees. Relatively high levels of activity were recorded at one study location for the threatened Yellow-Bellied Sheathtail Bat, a species rarely recorded in forests (Law and Turner 2000).
e) predict the consequences of the impacts for the bioregional persistence of the suite of threatened species and communities currently benefitting from the connectivity with reference to relevant literature and other published sources of information and taking into consideration mobility, abundance, range and other relevant life history factors.		An assessment of potential impacts on connectivity for key threatened species is provided below. **Large terrestrial fauna: Koala, Black-striped Wallaby, Rufous Bettong** Operation of the rail line would affect movement of Koalas and the Black Striped Wallaby and create a risk of injury and mortality from train strike. The disruption of home-ranging patterns as a result of habitat fragmentation and degradation, the loss of home-range trees and creation of barriers to movement may result in the disintegration of social structure, potentially contributing to the decline of the population (Phillips 2000). Genetic research has identified major roads as a barrier to gene flow for Koalas (Lee et al 2009; 2010). A new rail line through the Pilliga Forest would create a barrier to movement, affecting home ranges of individual Koalas, and impacting movement corridors along better quality riparian habitat. Elsewhere along the alignment, the proposal would fragment habitat links for Koalas seeking to access habitats either side of the rail line. Impacts on gene flow may be mitigated by the presence of a variety of underpasses. Many of the creeks would be crossed by bridges, and Koalas, Rufous Bettongs and Black-striped Wallabies would be able to pass safely under the rail line for the majority of the time (given the ephemeral nature of most of the waterways). In total, 23 bridges creating 2.4 kilometres of underpasses would be constructed in the Pilliga. The average bridge length is 104 metres, with bridges ranging from 30 metres in length to 345 metres in length (Etoo Creek). In addition, minor drainage lines would be crossed by mostly multicell culverts. Many of these are of a suitable size for Koalas, Rufous Bettongs and Black-striped Wallabies to utilise to cross under the rail line. Flooding issues may preclude use of fauna furniture (eg wooden poles within culverts), which may reduce the effectiveness of culverts for Koala passage. Further discussion of bridges and culverts are provided in Table 11.4. Koalas, Black-striped Wallabies and Rufous Bettongs may also attempt to cross the rail tracks, and are at risk of rail strike, although rail traffic initially will be low, and this risk is also relatively low.

Criteria	Connectivity feature	Discussion
		Squirrel Glider Operation of the rail line would affect movement of Squirrel Gliders. Family groups may have their habitat bisected, or different family groups may become isolated. This species has an average glide distance of 21.5 metres (range 9–47 metres) in a horizontal plane and mean glide angle of 28.5° (Goldingay and Taylor 2009). Based on the glide angle and glide distance, a tree-gap of 20 metres (ie a two-lane road) or 43 metres (ie a four-lane road) will need to have trees a least 13 metres and 25 metres tall, respectively, to enable animals to safely glide across the gap (Taylor and Goldingay 2009). Where taller trees are present along the rail line gliders would be able to cross the gap, although the gap created may be at or near the limit of the species gliding distance. This would be exacerbated by the height of trains, which may carry stacked containers, and could result in mortality of individuals through train strike. Given the low number of trains proposed, the risk of mortality from wildlife-train collision is relatively low. Impacts would be reduced by locating glider poles at regular intervals through the Pilliga. These are proposed to be included in the design every 5-10 kilometres, and their position would be determined during detailed design to ensure locations are appropriate. **Pilliga Mouse** Operation of the rail line may affect movement of the Pilliga Mouse. Paull et al (2014) mapped areas of important habitat for the species. The majority of important habitat occurs south-east of the proposal site and east of the Newell Highway, however areas do occur to the north-west of the rail line. The Newell Highway is a major barrier between the eastern and western portions of the areas of important habitat. The proposal would create another major barrier for areas to the north-west and could fragment the important population into two or more populations. Impacts on gene flow may be mitigated by the presence of a variety of underpasses. Drainage lines would be crossed either by bridges or culverts. In total, 23 bridges creating about 2.4 kilometres of underpasses would be constructed in the Pilliga. Over 130 culverts are included in the design totalling over 1.7 kilometres of underpasses. Many of these are multicell culverts and have an average width of about 13 metres. These will be dry for the majority of the time. Seven culverts are located within PCT 141 (Broombrush - wattle very tall shrubland), totalling 61 metres in length. Ten culverts totalling 122 metres are located within 200 metres of this vegetation type. Many other culverts are located in other PCTs in which this species has been associated with (EES 2019c). Further discussion of bridges and culverts are provided in Table 11.4. Tokushima and Jarman (2008) measured average movement distances of 40 metres (range 0–181 metres) for recaptured individuals, however, larger movement patterns cannot be disregarded. Most culverts in the Pilliga will be 7.3 metres wide (perpendicular to the rail). One crossing loop is located in the Pilliga and culverts in this location will be 18.3 metres wide. Based on the average moving distances, this species is likely to be able to cross the rail line using culverts, although this depends on behaviour of the species (willingness to use culverts)

Criteria	Connectivity feature	Discussion
		and potentially treatment of culverts (eg revegetation near culverts). Monitoring of culvert use is recommended as little information on culvert use exists for this genus (see section 11.2). There is potential for the Pilliga Mouse to attempt to cross the rail tracks, although its small size may make this difficult. Given the low numbers of trains that would travel through the Pilliga at night, the large areas of available habitat, and the small size of the Pilliga Mouse the risk of train strike is considered to be relatively low. **Eastern Pygmy-possum** Across its range, the Eastern Pygmy-possum is a midstorey specialist inhabiting shrubby components of a variety of habitats, and is patchily distributed and generally occurs in low abundance (Harris 2008). The species is likely to have a strategy of high mobility in order to track floral foraging resources (Harris et al 2014). It is known to travel arboreally through the canopies of low vegetation, but also moves primarily on the ground in burnt heathland where trees are sparse or absent (Tulloch and Dickman 2006). Spool line studies of Eastern Pygmy-possums found individuals frequently traversed areas that were regenerating from logging and were not restricted to patches of unlogged habitat. Typically, individuals moved at ground level when understorey cover was low or when litter cover was high, suggesting that they avoid moving along the ground where cover is minimal (Law et al 2018). Distances recorded for overnight movements ranges between 72 to 450 metres and males tend to travel further than females. Note that animals were tracked hourly and these values may be underestimates (Bladon et al. 2002). The spool line study found Eastern Pygmy-possums crossed narrow logging tracks (Law et al 2018). The Eastern Pygmy-possum has been recorded using culverts under a freeway (RTA 2009). The Eastern Pygmy-possum would be impacted by the construction of the rail line, which would create a barrier to movement. Impacts on gene flow may be mitigated by the presence of a variety of underpasses. Drainage lines would be crossed either by bridges or culverts. In total, 23 bridges creating about 2.4 kilometres of underpasses would be constructed in the Pilliga. Over 130 culverts are included in the design totalling over 1.7 kilometres of underpasses. Many of these are multicell culverts and have an average width of about 13 metres. These will be dry for the majority of the time and would maintain some connectivity for this species. Seven culverts are located within PCT 141 (Broombrush - wattle very tall shrubland), totalling 61 metres in length. Ten culverts totalling 122 metres are located within 200 metres of this vegetation type. Many other culverts are located in other PCTs in which this species has been associated with (EES 2019c). Most culverts in the Pilliga will be 7.3 metres wide (perpendicular to the rail). Further discussion of bridges and culverts are provided in Table 11.4. There is potential for the Eastern Pygmy-possum to attempt to cross the rail tracks. Given the low numbers of trains that would travel through the Pilliga at night and the large areas of available habitat the risk of train strike is considered to be relatively low.

Criteria	Connectivity feature	Discussion
		Bats A number of threatened bat species were recorded in the Pilliga, including slow-flying species such as the Large eared Bat and Corben’s Long-eared Bat. These species are at risk of injury and mortality from train strike during operation of the rail line. Given the low numbers of trains that would travel through the Pilliga at night, and the large areas of available habitat, this risk is considered to be relatively low. Given the mobility of the species. Linear nature of clearing, and large area of available habitat, the proposal is unlikely to fragment habitat to such a degree that these mobile species could not move across the landscape.

9.2.2 Movement of threatened species

Impacts of the proposal on movement of threatened species that maintains their life cycle must be assessed for prescribed impacts. Threatened species with particular movement patterns include the Superb Parrot, Regent Honeyeater, Swift Parrot and Large Bent-winged Bat, as these species move large distances between specific breeding areas and foraging areas outside the breeding season. These species are discussed in Table 9.5.

Table 9.5 Impacts on movement of threatened species

Criteria	Species of relevance
(a) identify movement patterns key to the life cycle of relevant threatened species that intersect with the subject land	Most threatened fauna species that have been identified as relevant to the proposal are resident in the area. Species that move for particular parts of their life cycle include: • **Superb Parrot**. At least part of the population of this species undertakes regular seasonal movements, vacating the breeding area after the conclusion of the breeding season, and then returning in spring (Baker-Gabb 2011). Most of the breeding population from the inland slopes appears to move to the eucalypt-pine woodlands on the plains of west-central and north-central NSW (Webster 1988). In central NSW, movements are said to occur when eucalypts flower, and when food becomes scarce due to drought and birds seek alternative sources of food (Higgins 1999). • **Large Bent-winged Bat**. This species breeds in specific maternity caves over summer, and disperse outside of this period over a distance of about 300 kilometres to other roosting habitat. • **Regent Honeyeater**. The Regent Honeyeater breeds at four main locations in NSW and disperses outside the breeding season to foraging habitat. Habitat loss would decrease availability of winter forage for individuals that may occur, but would not affect the ability of this species to move between foraging and breeding areas. No important foraging habitat for the species would be removed by the proposal. • **Swift Parrot**. The Swift Parrot breeds in Tasmania and migrates to the mainland outside the breeding season. Habitat loss would decrease availability of winter forage for individuals that may occur, but would not affect the ability of this species to move between foraging and breeding areas. No important foraging habitat for this species would be removed by the proposal.
(b) describe the nature, extent and duration of short and long-term impacts	The construction and operation of the proposal is unlikely to impact the movement patterns of these species. While habitat will be removed along the alignment, alternate foraging (and/or breeding) habitat will remain in adjacent areas. Construction of the proposal would not affect movement of these species, given their high mobility and ability to traverse large areas of cleared land.

Criteria	Species of relevance
(c) describe, with reference to relevant literature and other reliable published sources of information, the importance of the movement of the threatened species to their life cycle	Movement of Large Bent-winged Bats is essential for their survival, as they rely on specific maternity caves for breeding, but forage and roost in a range of locations for the remainder of the year. Movement of the Superb Parrot is important for much of the population. This species relies on specific roost habitats for breeding, but disperses large distances outside the breeding season in search of seasonal foraging resources. Movement of the Regent Honeyeater and Swift Parrot are essential for their survival, as they are migratory/nomadic species and breeding and foraging habitat are located in different regions/areas and they rely on seasonal foraging resources.
(d) predict the consequences of the impacts for the bioregional persistence of the threatened species, with reference to relevant literature and other published sources of information	The ability of these species to move between their breeding and foraging areas will not be impacted by the rail line. As such, the proposal is unlikely to affect the bioregional persistence of species with reference to their movement patterns.

9.2.3 Vehicle strike

Construction

Terrestrial fauna are already at risk from vehicle movements on roads and on private property in the proposal site. Increased movement of vehicles in the area during construction increases the risk of vehicle strike for terrestrial fauna. An assessment of the risk of vehicle strike during construction is provided in Table 9.6.

Table 9.6 Impacts of vehicle strike during construction

Criteria	Discussion
(a) identify the range of threatened animal species or animals that are part of a TEC at risk of vehicle (or other transport mode) strike	A range of fauna species are at risk of vehicle strike during construction. These include macropods (mainly in the early morning and evening), reptiles basking on roads (such as the Bearded Dragon, goannas and snakes), and birds, including species such as Ravens and raptors that may be feeding on roadkill. In wet weather, road traffic can result in many deaths of frogs which emerge in warm weather after rainfall.
(b) predict the likelihood of vehicle strike to each relevant species, taking into consideration mobility, abundance, range and other relevant life history factors	Few threatened fauna species are at particular risk of road kill, however construction traffic has the potential to injure or kill terrestrial species such as the Black-striped Wallaby, Koala, and Pale-headed Snake. Given the low densities at which these species occur, the risk of vehicle strike is likely to be low. Vehicle strike during construction of species such as the Pilliga Mouse, Eastern Pygmy-possum, and Squirrel Glider are unlikely given their nocturnal habits. Similar, few threatened birds are at risk, given their preference for foraging in the canopy. Raptors that feed on road kill may have a higher risk of injury or mortality from roadkill. Microbats are similarly highly unlikely to be at risk of vehicle strike during construction.

Criteria	Discussion
	Movement of vehicles will mainly occur during daylight hours, which minimises the risk of vehicle strike impacting mammals such as kangaroos and Koalas. Risk of vehicle strike is increased around dawn and dusk, when workers are travelling to and from the construction site.
(c) estimate vehicle strike rates where supporting data or literature is available	Currently, road traffic along the alignment varies considerably. Much of the alignment is located in private land, with low levels of vehicle movements. Some of the alignment follows existing roads, with more frequent traffic, and some is adjacent to highways (eg the Newell Highway near Narrabri), with high levels of road traffic. Increased movements of vehicles associated with construction is likely to increase the rate of vehicle strike, particularly in areas that currently have low traffic volumes.
(d) predict the consequences of the impacts for the local and bioregional persistence of the suite of relevant species, with reference to relevant literature and other published sources of information.	Impacts of vehicle strike during construction are unlikely to substantially impact threatened species in the local areas and region as a whole. Most threatened species occur in low densities, and have a low risk of vehicle strike. Species that occur in higher densities (eg Grey-crowned Babbler) were often recorded foraging next to roads, and may be at a higher risk of vehicle strike.

Operation

Mortality of fauna can occur as a result of direct mortality from collisions with trains, as well as electrocution and wire strikes, and rail entrapment (some species of small body size can become trapped between the rails and die from dehydration or hunger) (Santos et al 2017). Besides possible population decreases, railway kills may cause shifts in the age structure of populations. In general, most reported victims are common species, which suggests that the effects on population levels should be small for species with large and widespread populations (van der Grift and Kuijsters 1998). However, the death of a few individuals of a rare or endangered species may further increase species extinction risk (van der Grift 1999).

Train mortality can have large impacts on mammal populations, particularly for species that are already endangered, species with large home ranges and low density populations, and species with low reproductive rate (van der Grift and Kuijsters 1998; van der Grift 1999). The highest mortality numbers are usually found at sections where rail lines intersect important mammal habitats or migration routes (Child 1983; Gundersen and Andreassen 1998; van der Grift 1999). In multispecies surveys in the northern hemisphere (Heske 2015; SCV 1996; van der Grift 1999) of all vertebrate recorded, the approximate proportion of mammals found dead on rail tracks ranges from 26 per cent (Netherlands), to 36 per cent (USA) and 38 per cent (Spain). The body size of the mammal species that are killed varies greatly, ranging from small insectivores and small carnivores, to large carnivores and ungulates.

Bats may be also killed by trains but no data are available to document this for railways (SCV 1996). Information for roads indicates that bats are very difficult to detect (Santos et al. 2011). Thus, bat mortality on railways can be high but have been ignored.

Some behaviours can contribute to the high mortality rate of mammals on railways. Animals may use the railway as a movement route (Kaczensky et al. 2003), or may be attracted by food resources (such as spilled grain) in railway verges (Gibeau and Herrero 1998; Waller and Servheen 2005).

Mortalities of amphibians were particularly high after rain events, when these species are most active and are also frequently found dead on the roads (Heske 2015). Railway mortality of amphibians and reptiles seems to depend on animals' physical features (such as body size and limb length) and is likely to be associated with the agility of the species (Budzic and Budzic 2014). Some species of small size may be less vulnerable because they cannot cross the rail track (Heske 2015). However, they may be affected by railways at the level of gene flow due to barrier effects (Holderegger and Di Giulio 2010) (see discussion in section 9.2.1). The railway bed may be lethal itself for smaller animals that can become trapped between the rails, where they may be susceptible to predation or physiological stress. This is the case of railway-induced mortality of Eastern box turtles (*Terrapene carolina*), in the USA, that often cannot escape when trapped between railway tracks. This has also been observed in Australia, with dead Eastern Long-necked Turtles (*Chelodina longicollis*) recorded in tracks during surveys conducted by the author of this report (K. Crosby).

Train strike has different impacts compared to vehicle strike on roads. Freight trains can sometimes reach speeds close to 200 kilometres/hour and cannot stop quickly when encountering animals on the rails, given their speed, mass and braking power. This obviously leads to high mortality numbers on railways that could be avoided more easily on roads (Dorsey et al. 2015; Heske 2015). Note that train speeds for Inland Rail are unlikely to exceed 120 kilometres per hour. The height of trains (for example those carrying double-stacked containers) also increases the risk of injury and mortality of fauna that may fly or glide into the side of the train.

For other species the railways may lead to lower mortality. For instance, the vibrations of approaching trains can be felt along the rails and this may give warning to some terrestrial vertebrates. This seems to be the case of snakes that may be warned of approaching trains by vibrations transmitted through the rails or the ballast (Heske 2015). In addition, while the traffic on roads can be simultaneously two-way, trains tend to approach from one direction at a time, and the width of a road is greater than the width of a railway, decreasing the vulnerability of vertebrates that cross railways (Heske 2015). In a study that compared mortality rates between roads and railways, it was found that railways had notably lower mortalities of songbirds, small mammals, and turtles when compared to those of roads (Heske 2015), suggesting that diurnal and vagile species may be more efficient at avoiding trains than avoiding cars and trucks on busy two-way roads (Heske 2015).

Frequently, roads and railways are co-aligned along the same corridor (eg Proctor et al. 2005; Li et al. 2010). As such, the co-occurrence of roads and railways is an important aspect to have in consideration, as wildlife response to one infrastructure can condition the response to the other. Impacts of train strike during operation are outlined in Table 9.7.

Table 9.7 Impacts of train strike during operation

Criteria	Discussion
(a) identify the range of threatened animal species or animals that are part of a TEC at risk of vehicle (or other transport mode) strike	Fauna are at risk of train strike during operation of the rail line. Most impacts are likely to be centred in the Pilliga, given the extensive area of native vegetation along the proposed route. These include species such as the Black-striped Wallaby, Koala, Squirrel Glider, Barking Owl, Glossy Black-cockatoo and Pale-headed Snake. There is also potential for train strike of threatened fauna such as microbats and birds at locations such as river and creek crossings and in patches of woodland if individuals are flying across the gap when the train is passing. Threatened raptors are at risk of train strike in open agricultural land, and some smaller threatened birds (such as the Grey-Crowned Babbler) may also be at risk in these areas if flying between habitat areas.
(b) predict the likelihood of vehicle strike to each relevant species, taking into consideration mobility, abundance, range and other relevant life history factors	**Koala** Habitat in the study area lies primarily within the Pilliga forests, although individuals may also utilise roadside remnants and other woodland patches elsewhere in the study area. Primary habitat areas are associated with riparian areas, particularly Etoo Creek. Koalas spend most of their time in trees, but come to the ground to move between foraging locations and during dispersal (Dique et al 2003). Dispersal distances in a population in Queensland were recorded as averaging 3.5 kilometres, but can be over 10 kilometres for their natal range (Dique et al 2003). In northern NSW, long-distance dispersal of up to 16.6 kilometres was recorded in around 20 per cent of the population, and the average dispersal distance was found to be 5.6 kilometres (Norman et al 2019). Koalas in an urban area in north-east NSW have been recorded crossing roads within their home ranges at least 5–53 times; one crossed the Bruxner Highway near a roundabout at least 32 times over his 2-year tracking period (Goldingay and Dobner 2014). Koalas are at risk of train strike while moving between forage trees. Given the low densities at which they occur in the study area, risk is likely to be low. Koalas are more likely to occur in vegetation associated with creeklines in the Pilliga. Most creeks would be crossed by bridges, and Koalas would be able to pass under the rail line at these locations. Additional mitigation such as fauna furniture and fencing may encourage usage of bridges for passage and could reduce the risk of train strike. **Black-striped Wallaby** The Black-striped Wallaby occurs in the Pilliga forests and is generally a nocturnal species that rests during the day. Groups tend to use well-established pathways access foraging areas (which area generally in more open areas with grassy understory) (EES 2019b). Black-striped Wallaby numbers are likely to be relatively low in the Pilliga, with individuals occurring as scattered groups in areas of appropriate microhabitat.

Criteria	Discussion
	Based on the habitat requirements of this species, train strike risk would be highest in areas where shrubby forest (shelter habitat) occurs near grassy areas (foraging habitat). This habitat type is likely to be restricted to small areas within the Pilliga, and potentially be focussed at the interface between the Pilliga forests and adjacent agricultural land. Risk of train strike would be highest at night time, however the risk may be reduced (in the long-term) by the species' preference for using established pathways. If any of these pathways are bisected by the rail line, risk of train strike would be high in the short-term. Groups may alter their movement patterns in the medium term to avoid travel across train tracks. **Rufous Bettong** The Rufous Bettong is likely to occur in low numbers in the Pilliga in woodland with a grassy understory, with populations unevenly located depending on availability of suitable habitat. As such, risk of train strike is low, but could occur on occasion. Train strike risk would be highest at night, with negligible risk during the day given the nocturnal habits of this species. **Squirrel Glider** Squirrel Gliders have the potential for injury or mortality from train strike when gliding across the rail corridor. This species is known to be able to glide up to 47 metres, however the average glide distance is around 22 metres. Based on the average glide distance and angle, trees need to be 25 metres tall for animals to safely glide across a road gap of about 40 metres (Goldingay and Taylor 2009). This is likely to be similar for the rail corridor for single-stacked containers, however for double-stacked containers Squirrel Gliders would not be able to cross safely above trains. Squirrel Gliders are likely be unevenly located in the Pilliga depending on availability of suitable foraging habitat and hollow-bearing trees. As such, risk of train strike is low, but could occur on occasion. Train strike risk would be highest at night, with negligible risk during the day given the nocturnal habits of this species. **Birds** Birds such as the Barking Owl are likely to use gaps in vegetation such as roads, creeklines and the rail corridor for movement. These species are at risk of train strike as a result of travelling across or along the rail corridor, particularly in forested areas such as the Pilliga. Train lights are likely responsible for the majority of owl kills, causing individuals to become disoriented with the approaching train, hence increasing the likelihood of being killed (Peña and Llama 1997; SCV 1996). Birds of prey were frequently registered as train casualties in Spanish railways, being 19.2 per cent of all birds killed (SCV 1996). One possible explanation is the attractiveness of perches along the trails and of railway verges as a hunting ground for birds of prey and owls (SCV 1996; van der Grift and Kuijsters 1998). Moreover, some species scavenge regularly along the rail corridor for food carcasses, increasing their vulnerability to collisions (SCV 1996). Mortality of species such as the Wedge-tailed Eagle may occur as this

Criteria	Discussion
	species is a scavenger, but it less likely for threatened species such as the Little Eagle and Square-tailed Kite, which hunt live prey. **Bats** Microbats are likely to use gaps in vegetation such as roads, creeklines and the rail corridor for movement. These species are at risk of train strike as a result of travelling across or along the rail corridor, particularly in forested areas such as the Pilliga. Train strike risk would be highest at night, with negligible risk during the day given the nocturnal habits of these species.
(c) estimate vehicle strike rates where supporting data or literature is available	The proposal estimates the train traffic rate to be an average of 8.5 trains per day (both directions) in 2025, increasing to about 15 trains per day (both directions) in 2040. Given this relatively low traffic, the risk of wildlife-train collisions are likely to be relatively low (as compared to roads).
(d) predict the consequences of the impacts for the local and bioregional persistence of the suite of relevant species, with reference to relevant literature and other published sources of information.	Mortality from train strike is a risk for most threatened fauna species that may occur in the proposal site. Species at most risk at a bioregional perspective are those with limited distribution such as the Rufous Bettong and Black-striped Wallaby. Given the low number of train movements proposed, risk of wildlife-train collisions are likely to be relatively low, although would occur on occasion. A range of mitigation measures to minimise injury and mortality from train strike are recommended in section 11.

9.2.4 Areas of geological significance

No areas of karst, caves, crevices or cliffs are present in the proposal site.

No karst, caves, crevices or cliffs are present within two kilometres of the proposal in the Pilliga that would provide suitable breeding habitat for cave-breeding bat species such as the Eastern Cave Bat or Large-eared Pied Bat. The nearest habitat suitable for breeding for these species would be the Sandstone Caves in Pilliga Nature Reserve, located about 35 kilometres to the east of the proposal, and Dandry Gorge, located about 20 kilometres south-east of the proposal in Timmallallie National Park.

Volcanism during the Tertiary resulted in the formation of a series of basaltic shield volcanoes which form the present day Warrumbungles, as well as Mount Kaputar north of Narrabri. Some of these basalts can be observed within close-proximity to the alignment in the vicinity of the Warrumbungles, forming the more elevated and pronounced hillsides in this area. A number of these hillsides were investigated during the assessment of potential borrow pit sites, with fauna surveys including bird surveys and active searches undertaken. No caves were observed in any of these hills. Basalt outcrops as small to large weathered rocks, with crevices present between rocks. These would provide shelter habitat for reptiles and small mammals such as the Yellow-footed Antechinus (*Antechinus flavipes*), but would be unlikely to provide roosting or breeding habitat for bats. Note that caves in the Warrumbungles occur in sandstone outcrops rather than basalt (eg Tara Cave). No escarpment habitat suitable for the Brush-tailed Rock-wallaby is present.

9.2.5 Rocks

Limited areas of scattered rocks are present in the study area. The lower slopes of the outlier hills associated with the Warrumbungle Range contain surface rock. In these areas, the proposal is located in cleared agricultural land, with rocky areas occurring upslope of the proposal site. Rocks occur as loose and embedded surface rock on steep slopes. Rock does not occur on gentle slopes at the base of these hills, and may have been 'tidied up' historically buy landowners. No crevices or caves suitable for roosting bats is present in these areas.

Loose surface rock is present at Borrow Pit A, south of Narromine. A small area of this habitat would be removed at this location. Surface rock can provide habitat for the threatened Pink-tailed Worm-lizard (*Aprasia parapulchella*), which uses ant nests under rocks for shelter, foraging and breeding. Borrow Pit A is on the western edge of the known distribution of this species and there are no local records. This species prefers habitat on well-drained hillsides, which do not occur at this site. Rocky habitat in the area is patchy, with limited connectivity to better quality potential habitat to the east. As such, this species is considered unlikely to occur.

9.2.6 Human made structures

The proposal is located predominantly in agricultural or forested land, and few human-made structures of relevance to threatened fauna will be removed by the proposal.

Structures that may be of relevance include any old buildings or wooden telegraph poles that may be removed. Threatened microbats such as the Yellow-bellied Sheath-tail Bat and Little Pied Bat are known to roost in old buildings, as well as hollow-bearing trees and caves (EES 2019b). These species were recorded at various locations along the alignment. One landowner along the alignment also noted that microbats had previously been recorded under the capping of an old telegraph pole on their property. A number of microbat species are known to roost in telegraph poles, including threatened species (Churchill, 2008).

Removal of old buildings and telegraph poles have the potential to disturb roosting microbats, and could potentially result in mortality of individuals. These species may also roost in paddock trees and other hollow-bearing trees along the alignment, and may not rely on human-made structures.

Mitigation measures are recommended to minimise the risk of mortality of bats during the removal of structures.

9.2.7 Non-native vegetation

A large proportion of the proposal site comprises cleared or cropped land (about 1,584 hectares). Small areas of planted trees (eg windbreaks) also occur. These provide habitat for common fauna species. Mobile threatened species may occur on occasion, but are unlikely to rely on these areas for their survival in the locality. Terrestrial species such as kangaroos and Emus would forage in and move through cropped land. A discussion of impacts on connectivity and movement is provided in sections 9.2.1 and 9.2.2.

The threatened Five-clawed Worm-skink occurs in grassy woodland and grassland with scattered trees in the Narrabri region. This species is also known to occur in open grassy paddocks with scattered eucalypts and moist black soil, but usually occurs in associated with fallen timber and logs (NPWS 1999). There is potential for this species to occur in adjacent cropped land, however given the lack of trees and timber cropped paddocks would provide only marginal habitat. The proposal would remove small linear fragments of this marginal habitat in the Narrabri area.

All construction sites, compounds and access routes would be rehabilitated following construction. Site reinstatement and rehabilitation would be undertaken progressively within each construction works area during the works, and would include revegetation where required.

9.2.8 Hydrological processes

Impacts of proposal on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities are assessed as a prescribed impact.

The proposal crosses three major waterways, the Macquarie River, Castlereagh River, and Narrabri Creek / Namoi River. In addition, the proposal crosses 12 non-perennial major creeks and 26 non-perennial minor creeks.

No terrestrial threatened ecological communities that are associated with riparian or swamp habitats are present in the proposal site. Impacts on aquatic threatened ecological communities are assessed in *ARTC Inland Rail Narromine to Narrabri Aquatic Ecology Assessment* (JacobsGHD, 2020a).

Riparian vegetation associated with these rivers and creeks provides habitat for a range of threatened fauna species. Species such as the Koala utilise riparian habitat within the Pilliga region, and the Pale-headed Snake relies on riparian habitat of the Namoi River and Pilliga area. Farm dams and small areas of wetland vegetation may provide habitat for transient threatened or migratory waterbirds. The proposal site is outside the usual distribution of threatened frog species, and thus none are likely to occur.

A total of 73 rail bridges are proposed for the proposal. Many of the bridges cross the associated floodplains and would provide substantial areas of dry passage for fauna to pass underneath for much of the time. Connectivity would be limited to varying degrees during rain or flood events. Water crossings have been designed to ensure retention of existing flows as much as practicable. Scour protection has also been incorporated into the design.

A total of about 630 banks of drainage culverts are proposed under the rail line for the proposal. Of these, 135 are located in the Pilliga area (between Gwabegar Road and Dog Fence Road). In the Pilliga culverts range from 0.6 metres in height to 3.0 metres in height. All culverts are 2.4 metres in width, however most comprise multiple cells (up to 32 cells, at an average of 5.4 cells per location). Combined culverts would be dry most of the time as most drainage lines are subject to ephemeral flows only.

The addition of water crossing structures results in an increase in the number of impervious surfaces than was previously present in the greenfield landscape. This would cause an increase in the volume of runoff that is able to mobilise to the waterway, which can lead to increased erosion and sedimentation downstream.

Further, the increase in runoff may contain sediments and gross pollutant from the rail formation, cuttings and from trackside drainage systems. This runoff could be high in heavy metals (from brake pads and track wear and points use) or organics due to minor oil, grease and diesel spills from locomotives operating along the track.

Given the generally ephemeral nature of the waterways in the proposal site and proposed mitigation measures, changes to hydrology are likely to be minimal in the context of impacts on riparian habitat relevant to threatened species.

9.3 Key threatening processes

A KTP is as an action, activity or project that:

- adversely affects two or more threatened species, populations or ecological communities
- could cause species, populations or ecological communities that are not currently threatened to become threatened.

KTPs listed under the BC Act, FM Act and EPBC Act relevant to this proposal are listed in Table 8.4 below. The proposal is not a KTP in itself, but would exacerbate KTPs during construction and operation as detailed in Table 9.8. Mitigation measures to limit the impacts of these KTPs (where possible) are discussed in section 11.

Table 9.8 Key threatening processes

KTP	Listing	Discussion
Clearing of native vegetation	BC Act EPBC Act	The proposal includes the clearing of about 1,125 hectares of native woodland and about 600 hectares of native grassland. Given the extent of vegetation removal and habitat fragmentation this would comprise a substantial contribution to the operation of this KTP. Mitigation measures are proposed in section 11 to minimise the impact of the proposal on native vegetation in adjacent areas as far as possible.
Removal of hollows	BC Act	A substantial number of hollows would be removed for the proposal. This includes hollows in forested areas such as the Pilliga, as well as those in travelling stock reserves, paddock trees, small patches of vegetation in rural lands and riparian vegetation elsewhere in the proposal site. Given the area of vegetation to be cleared, a large number of hollows would be lost, reducing breeding habitat for many threatened species. Habitat management procedures are recommended to limit impacts on fauna and their habitats (see section 11).
Removal of dead wood and dead trees	BC Act	The proposal would remove areas of dead wood and dead trees, particularly within the Pilliga area. This would reduce breeding habitat for many threatened species and remove foraging and refuge habitat for many ground-dwelling fauna. Habitat management procedures are recommended to limit impacts on fauna and their habitats (see section 11).
Ecological consequences of high frequency fires	BC Act	No burning is proposed as part of the proposal, however construction and operation have the potential to cause sparks that could start fires. Wildfire in the Pilliga area has the potential to result in the loss and damage of large areas of habitat for threatened species.

KTP	Listing	Discussion
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala*	BC Act EPBC Act	The Noisy Miner was recorded in small woodland patches throughout the alignment. There were few records in the larger expanse of woodland and forest through the Pilliga. The fragmentation of smaller woodland patches in agricultural land and roadsides is likely to encourage the occupation by the Noisy Miner, and could lead to further impacts on small woodland birds, including threatened species.
Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species	BC Act	The proposal is unlikely to introduce Psittacine circoviral (beak and feather) disease. Susceptibility to the infection may be influenced by environmental factors, such as climate, nutrition, habitat quality and social factors (DEH 2005). Cumulative impacts of further land clearing and impacts on habitat has the potential to increase susceptibility of Superb Parrots and Glossy Black-cockatoos in the region.
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	BC Act EPBC Act	Chytrid fungus is a water borne pathogen and could be spread through water or mud on vehicles, machinery, footwear and other equipment. Chytrid invades the skin of frogs causing skin legions, which can kill them or make them susceptible to other threats (eg predators, climate change). This highly virulent fungal pathogen of amphibians is capable at a minimum of causing sporadic deaths in some populations, and 100 per cent mortality in other populations. Construction activities have the potential to introduce or spread chytrid fungus in adjacent areas. Risk would be higher at permanent rivers and during wet periods. Mitigation measures to minimise the risk of introduction or spread of Chytrid fungus are proposed in section 11.
Infection of native plants by *Phytophthora cinnamomi*	BC Act EPBC Act	Construction activities, in general, have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*) and Myrtle Rust (*Uredo rangelii*) into native vegetation. Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and damage to fauna habitats. No evidence of these pathogens was observed during surveys and they are unlikely to occur in the area give the arid nature of the region. As such, the risk of spread is low, however suitable hygiene protocols are recommended in section 11.
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	BC Act	
Invasion of native plant communities by exotic perennial grasses	BC Act	The study area features large areas of exotic grassland. There is the potential for perennial exotic grasses to invade adjacent native vegetation through disturbance during construction of the proposal. The CEMP would include weed management measures and specific consideration of potential impacts on soil, water and native vegetation (see section 11).

<table>
<tr><th>KTP</th><th>Listing</th><th>Discussion</th></tr>
<tr><td>Competition from feral honeybees</td><td>BC Act</td><td>Breeding colonies of honeybees occupy large hollows in trees. These hollows are completely taken over by honeybees, and are removed from the pool of hollows available to native species. The proposal is unlikely to spread feral honeybees, but will remove a substantial number of hollow-bearing trees, further increasing competition for remaining hollows in areas adjacent to the rail corridor.</td></tr>
<tr><td>Competition and grazing by the feral European rabbit</td><td>BC Act
EPBC Act</td><td>Rabbits were recorded throughout agricultural land in the study area. Further fragmentation of native vegetation may encourage movement of this species into smaller remnant woodland patches.</td></tr>
<tr><td>Competition and habitat degradation by Feral Goats, Capra hircus Linnaeus 1758</td><td>BC Act</td><td rowspan="2">Goats and pigs were recorded in agricultural land and in the Pilliga area. Creation of new linear gaps in the Pilliga may encourage their movement through the forest. Smaller patches of remnant vegetation may be at a higher risk of impact through habitat degradation by these species.</td></tr>
<tr><td>Predation, habitat degradation, competition and disease transmission by Feral Pigs (Sus scrofa)</td><td>BC Act</td></tr>
<tr><td>Predation by feral cats</td><td>BC Act
EPBC Act</td><td rowspan="2">The European Red Fox (Vulpes vulpes) was recorded throughout the study area during field surveys, and the Feral Cat was recorded in the Pilliga. Predation by these species has the potential to affect various threatened species. Creation of new linear gaps in the Pilliga Forest can encourage the movement of this species and potentially increase predation risk for threatened species. Mitigation measures including monitoring and control of exotic species are proposed in section 11.</td></tr>
<tr><td>Predation by the European Red Fox</td><td>BC Act
EPBC Act</td></tr>
<tr><td>Importation of Red Imported Fire Ants into NSW</td><td>BC Act</td><td rowspan="3">Red Fire Ants were first detected at the Port of Brisbane and have since been recorded at ports elsewhere around Australia. Yellow Crazy Ants were also introduced to Australia via ports. In high numbers these species can have a devastating impact on native wildlife and plants, upsetting entire ecosystems.

Invasive ants can be spread with the movement of plants and soil. Trains create a biosecurity risk by providing a means for novel biota to enter an area. Given the distance from known infestations of these species, the proposal is unlikely to introduce the species during construction, however there is a risk of spread during operation.

Mitigation measures including monitoring and control are proposed in section 11.</td></tr>
<tr><td>Invasion of the Yellow Crazy Ant (Anoplolepis gracilipes) into NSW</td><td>BC Act</td></tr>
<tr><td>Novel biota and their impact on biodiversity</td><td>EPBC Act</td></tr>
</table>

KTP	Listing	Discussion
The degradation of native riparian vegetation along NSW water courses	FM Act	The proposal would remove areas of native vegetation from watercourses along the alignment. Some riparian vegetation will be retained under the bridges. Mitigation measures are recommended to limit the potential for adverse impacts on riparian vegetation during construction (see section 11).
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	BC Act FM Act	The proposal would alter the natural landform through placement of fill, increasing the proportion of hardstand surfaces and modifying surface water flows. 73 bridges and about 630 banks of culverts are included in the design to minimise impacts to flows and flooding.
Human-caused climate change	BC Act EPBC Act	Deforestation associated with construction of the proposal and combustion of fuels associated with construction and operation would contribute to anthropogenic emissions of greenhouse gases. The proposal would remove about 1732 hectares of native vegetation. Construction and operation of the proposal would lead to considerable fuel combustion. However, operation of the Inland Rail Program of which the proposal is an essential part, would result in the removal over 200,000 trucks from roads, thereby reducing greenhouse gas emissions from this source. Hence, the proposal would exacerbate this KTP during construction but would reduce it during operation.

10. Potential impacts on Matters of National Environmental Significance

10.1 Threatened ecological communities

Five threatened ecological communities were recorded in the proposal site. Assessments of significance have been prepared (Appendix M). A summary of impacts is provided in Table 10.1.

Table 10.1 EPBC threatened ecological communities in the proposal site.

Threatened ecological community	EPBC Act Status	Potential impacts	Significant impact likely
Weeping Myall Woodlands	E	3.05 hectares to be removed. Patch to be fragmented with two smaller patches retained each side of alignment.	No
Brigalow (*Acacia harpophylla* dominant and co-dominant)	E	0.61 hectares to be removed. Remaining patch about 10 hectares would be retained.	No
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia	E	14.71 hectares to be removed. Remaining patch along linear corridor of Mitchell Highway to be retained.	No
Poplar Box grassy woodland on alluvial plains	E	29.95 hectares to be removed from scattered and isolated smaller patches across the mid sections of the alignment.	No
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE	2.21 hectares to be removed. Remainder of patch is already isolated and proposal will decrease patch size further.	No
	Total	**52.42 hectares**	

10.2 Threatened species

Impacts on threatened species have been assessed in sections 8 and 9 of this report. Assessments of significance have been prepared and are provided in Appendix M. A summary of potential impacts and likely significance of impacts is provided in Table 10.2.

Table 10.2 Significance of impacts on EPBC Act listed threatened flora and fauna species

Name	EPBC Act	Potential impacts	Significant impact likely?
Fauna			
Koala	V	1,125 hectares of woodland and forest to be removed along a 300 kilometre linear alignment generally about 50 metres wide. Of this, 595 hectares of habitat would be removed in the Pilliga forests. Impacts on connectivity, however drainage crossings (73 bridges and about 630 banks of culverts) designed to maintain connectivity.	Yes
Corben's Long-eared Bat	V	1,125 hectares of woodland and forest to be removed along a 300 kilometre linear alignment. Of this, 624 hectares would be removed in the Pilliga forests. 13,000-30,000 hollow-bearing trees estimated to be removed.	Yes
Large-eared Pied Bat	V	624 hectares of woodland and forest of the Pilliga forests to be removed along a 73 kilometres linear alignment generally about 50 metres wide. No foraging habitat in close proximity to breeding and roosting habitat to be removed. No impact on breeding or roosting habitat.	No
Pilliga Mouse	V	624 hectares of woodland and forest of the Pilliga forests to be removed along a 73 kilometres linear alignment generally about 50 metres wide. This includes 29 hectares of PCT 141 which is preferred breeding habitat, and 457 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*, also identified as habitat for this species. Impacts on connectivity, however drainage crossings (73 bridges and about 630 banks of culverts) designed to maintain connectivity, and additional dedicated crossings included in potential breeding habitat.	Yes
Painted Honeyeater	V	1,125 hectares of woodland and forest to be removed along a 300 kilometres linear alignment generally about 50 metres wide. Of this, 624 hectares would be removed in the Pilliga forests. Removal of a large number of mistletoe (key foraging and breeding habitat).	Yes

Name	EPBC Act	Potential impacts	Significant impact likely?
Superb Parrot	V	1,125 hectares of woodland and forest to be removed along a 300 kilometres linear alignment generally about 50 metres wide from non-breeding area. Of this, 624 hectares would be removed in the Pilliga forests. No impact on breeding habitat.	No
Five-clawed Worm-skink	V	Up to 16.66 hectares of potential habitat to be removed along a 6.7 kilometres section for the alignment, generally about 50 metres wide. Retention of large area of potential habitat under Narrabri Bridge within this area. Habitat connectivity retained under Narrabri Bridge.	No
Pink-tailed Worm-lizard	V	13.5 hectares of low quality potential habitat to be removed. No connectivity with known populations.	No
Regent Honeyeater	CE	1,125 hectares of woodland and forest habitat to be removed along a 300 kilometres linear alignment. Of this, 479 hectares of forest containing preferred feed trees would be removed in the Pilliga forests. No impact on breeding habitat. No impact on important foraging areas identified by Birdlife Australia in the south of the Pilliga. Removal of 479 hectares of habitat containing preferred foraging species in the Pilliga (critical foraging habitat).	Yes
Swift Parrot	CE	1,125 hectares of woodland and forest to be removed along a 300 kilometres linear alignment. No impact on important foraging areas identified in the east of the Pilliga. No impact on breeding habitat. Removal of 717 hectares of potential foraging habitat containing preferred feed species for this species, of which 511 hectares is in the Pilliga.	Possible
White-throated Needletail	V	1,125 of hectares woodland and forest to be removed along a 300 kilometres linear alignment that may be used for foraging and roosting. No impact on breeding habitat.	No

Name	EPBC Act	Potential impacts	Significant impact likely?
Flora			
Coolabah Bertya *Bertya opponens*	V	Four individuals to be removed from a known previous location and 13.85 hectares of potential habitat to be removed.	No
Commersonia procumbens	V	565.14 hectares of potential habitat to be removed.	Yes
Lepidium aschersonii Spiny Peppercress	V	10.27 hectares of potential habitat to be removed.	No
Swainsona murrayana Slender Darling Pea	V	43.57 hectares of potential habitat to be removed.	No
Tylophora linearis	E	582.52 hectares of potential habitat to be removed.	Yes
Lepidium monoplocoides Winged Peppercress	E	194.29 hectares of potential habitat to be removed	Yes

Key: CE – critically endangered, E – endangered, V – vulnerable

10.3 Migratory species

No important habitat for any migratory wetland species would be impacted by the proposal. Any migratory species that may occur would be transient individuals and would not rely on the limited wetland habitat present in the proposal site. As discussed below, impacts on the Macquarie Marshes, which are important habitats for wetlands birds, are highly unlikely.

Three migratory species of forest and woodland habitats have potentially important habitat in the proposal site. Impacts on these species are outlined in Table 10.3.

Table 10.3 Potential impacts on important habitat of migratory species

Common name	Potential impacts	Significant impact likely?
Fork-tailed Swift	This species is entirely aerial within Australia. No area of habitat would be directly removed by the proposal. A total of 1,732 hectares of native vegetation would be removed which provides an insect community on which this species forages. While an ecologically significant proportion of the population was recorded during surveys, these individuals would be transient over the proposal site and would forage over a very wide area. The linear nature of the proposal minimises the potential impact on this highly mobile species.	No

Common name	Potential impacts	Significant impact likely?
White-throated Needletail	Large tracts of native vegetation, particularly forest, may be a key habitat requirement for species. The proposal will remove 1,125 hectares of woodland and forest habitat within the Pilliga that may be used on occasion for roosting. Large areas of roosting habitat are present in the Pilliga, and the species would not rely wholly on the linear proposal site for roosting. Native vegetation provides an insect community on which this species forages aerially. Individuals would be transient over the proposal site and would forage over a very wide area. The linear nature of the proposal minimises the potential impact on foraging habitat for this highly mobile species.	No
Rufous Fantail	No breeding habitat is located in the region. Individuals may occur transiently during their migration. Potential foraging habitat to be removed is not likely to be important habitat, and the proposal is unlikely to affect an ecologically significant proportion of the population.	No

10.4 Wetlands of international significance

The nearest Ramsar wetland is the Macquarie Marshes, located about 80 kilometres downstream of the proposal. The proposal includes 73 bridges that span the major rivers and drainage lines. Engineering features of the proposal that would impact the hydrology and hydraulics would primarily be the construction of the rail embankment across a number of floodplains. The embankment and associated structures would be required to permit an appropriate flow. A total of 630 banks of drainage culverts are included in the design.

Flows of major rivers and creeks are unlikely to be impacted by the proposal given the inclusion of many bridges and culverts, and generally ephemeral nature of the waterways. As such, the proposal is unlikely to impact the Macquarie Marshes, which are located about 80 kilometres from the proposal.

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11. Recommended mitigation measures

11.1 Environmental safeguards

11.1.1 Detailed design and pre-construction

Measures proposed for detailed design and pre-construction to mitigate the risk of biodiversity impacts are provided in Table 11.1.

11.1.2 Fauna connectivity

Fauna connectivity structures and mitigation devices

Animals use both non-wildlife passes (ie those placed and designed for purposes other than to allow wildlife crossing, like drainage culverts), or wildlife passes specifically designed on the basis of the target species traits (small tunnels for amphibians or small mammals; underpasses, overpasses, ecoducts or green bridges for large mammals) (Smith et al. 2015).

Large passes (such as extended bridge structures) mimicking natural habitat are more expensive, but they are also the most effective technique for reducing barrier effects, commonly suitable for most species.

A number of fauna connectivity measures have been incorporated into the design of the proposal (see Table 11.4). These tend to be drainage structures that would also be used by fauna, such as bridges and culverts. A number of dedicated fauna structures are also proposed, including dedicated culverts, glider poles and barrier poles. A full list of connectivity structures is provided in Appendix J. A fauna connectivity strategy that details the various measures, and outlines the monitoring and reporting requirements would need to be prepared as part of detailed design. This would include monitoring the incidence of train strike, and implementing additional mitigation measures (eg additional fencing) if required.

Table 11.1 Biodiversity mitigation measures for detailed design and pre-construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
Removal of vegetation	Direct impacts on biodiversity	Detailed design and construction planning would minimise the construction footprint and avoid impacts on native vegetation and hollow-bearing trees as far as reasonably practicable.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Pre-construction
		Vegetation clearing would be limited to the minimum necessary to construct the proposal and allow for its effective operation. Where appropriate, facilities within the multi-function compounds and temporary workforce accommodation would be located to further minimise or avoid impacts on native vegetation where practicable.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Pre-construction
	Rehabilitation strategy	A rehabilitation strategy would be prepared to guide the approach to rehabilitation of temporarily disturbed areas following the completion of construction. The strategy would include: • clear objectives and timeframes for rehabilitation works (including the biodiversity outcomes to be achieved) • details of the actions and responsibilities to progressively rehabilitate, regenerate, and/or revegetate areas temporarily disturbed areas, consistent with the agreed objectives • identification of appropriate flora species for planting and sources of plants • procedures for monitoring the success of rehabilitation • corrective actions should the outcomes of rehabilitation not conform to the objectives adopted.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Post-construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
Removal of fauna habitats		Measures for the management of impacts on fauna habitats during clearing activities should be developed and incorporated into the CEMP, including the following measures: • preparation of a hollow-bearing tree management strategy to minimise clearing of hollow-bearing trees where possible • preparation of a nest box strategy, including (at a minimum) reuse of hollows, identification of target species that best benefit from installation of nest boxes, nest box sizes and numbers, location of nest box installation and use of nest boxes as an immediate mitigation measure (ie for rescue and relocation of fauna during clearing). Any reused hollows or nest boxes installed would require monitoring. • pre-clearing surveys undertaken by a suitably qualified ecologist to mark and map hollow-bearing trees and logs that would require fauna management during removal • establishing protocols for the staged clearing of vegetation and safe tree felling and log removal to reduce the risk of fauna mortality.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Pre-construction
Threatened species	Threatened flora pre clearance survey	Additional threatened flora surveys should be completed where suitable climatic conditions occur prior to clearing for the species likely to be impacted by the proposal including: • *Lepidium monoplocoides* • *Tylophora linearis* • *Commersonia procumbens* • *Bertya opponens*.	Likely to be effective	Measures meet best practice management of flora and fauna on construction projects.	Pre-construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
	Translocation of threatened flora	The need for translocation options would be discussed with BCD accountable species officers and species experts, should these be required.	Potentially effective.	May not provide assurance of survival and so the impact assessment and offset calculations assume the removal of all individuals in the construction impact zone.	Pre-construction
Biodiversity Offset Strategy	Impacts on native PCTs and threatened species	Biodiversity offsets would be finalised in accordance with the requirements of the *Biodiversity Assessment Method* (OEH 2017). This includes retirement of like for like offsets for impacts on matters of national environmental significance.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Pre-construction
Train strike	Fauna mortality	Investigate options to provide stock fencing in agricultural areas to minimise the risk of stock-train collisions. Fencing is proposed either side of bridges and culverts in the Pilliga and major waterways to direct fauna to these crossing locations. Installation of wooden poles on larger bridges in the Pilliga to encourage birds and bats to fly over the trains or under the bridge. Before-after-control impact monitoring design recommended to assess the efficacy of this measure (see section 11.1.2). Glider poles and underpasses provided by bridges and culverts would also assist fauna to cross the rail corridor with reduced risk of train strike (see section 11.1.2)	Potentially effective.	Fencing minimises entry of fauna into the rail corridor but does not entirely prevent it. Barrier poles have not been tested in Australia but have been found to be effective in some situations in other studies.	Pre-construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
Connectivity	Population fragmentation	A fauna connectivity strategy would be prepared to guide detailed design. It would include detailed assessment and design of: • locations for fauna crossing structures in the Pilliga East State Forest, including bridges and culverts for threatened fauna, including the Koala and Pilliga Mouse in areas of preferred habitat, glider poles located at regular intervals and wooden crossing poles • the provision of localised fencing to direct fauna to crossing structures • fauna furniture to be included in the design of bridges and culverts where appropriate to encourage crossings by Koalas and other native fauna. The connectivity strategy would include monitoring and reporting requirements in relation to the operational performance of the final measures. Where impact thresholds are exceeded, additional mitigation measures would need to be investigated.	Potentially effective	Measures meet best practice management of flora and fauna on construction projects. Bridges, culverts and glider poles provide some crossing options, however will not entirely mitigate the presence of the rail line. The ability of some fauna to cross the rail line may be limited by their behavioural attributes (eg willingness to cross, glide distance) and the location of the structures in relation to preferred habitat.	Pre-construction

11.1.3 Construction

Measures proposed for construction to mitigate the risk of biodiversity impacts are provided in Table 11.2.

Table 11.2 Biodiversity mitigation measures for construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
Clearing of vegetation	General biodiversity impacts	A biodiversity management sub-plan would be prepared and implemented as part of the CEMP. It would include measures, processes and responsibilities to minimise the potential for biodiversity impacts during construction.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Construction
	Unexpected finds	An unexpected finds protocol should be prepared to detail measures to be undertaken if threatened flora and fauna not previously recorded on site are detected during clearing or construction activities, or if additional occurrences of threatened species previously recorded in the broader area, but not previously recorded at a specific location, are recorded during clearing or construction activities. Any unexpected finds would need to be included in the offset strategy as required.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Construction
	Mortality or injury to fauna	Pre-clearing surveys would be undertaken prior to construction. The surveys and inspections, and any subsequent relocation of species, would be undertaken and in accordance with the biodiversity management sub-plan in the CEMP. Specific surveys include: • surveys for roosting microbats and birds in wooden telegraph poles and old buildings to be removed • searches for nest trees • identification of hollow-bearing trees and logs requiring fauna management during removal • surveys for Koalas which may include trained detection dogs or other appropriate survey technique.	Likely to be effective	Measures meet best practice management of threatened species on construction projects.	Construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
	Avoidance of impacts – terrestrial and aquatic biodiversity	Exclusion areas would be established and maintained around native vegetation to be retained, particularly areas of biodiversity value adjoining the proposal site that are located in close proximity to work areas.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Construction
	Riparian vegetation	Compounds and stockpile sites would be located an appropriate distance from riparian vegetation where practicable to avoid indirect impacts on aquatic habitat. Direct impacts on in-stream vegetation and native vegetation on the banks of watercourses would be avoided as far as practicable.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Construction
Rehabilitation	Rehabilitation of vegetation subject to temporary disturbance	A rehabilitation strategy would be prepared to guide rehabilitation planning, implementation, monitoring and maintenance of disturbed areas outside of the operational footprint (such as compounds and temporary workforce accommodation). It would include clear objectives for rehabilitation of native vegetation in temporary disturbances areas.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Construction
Weed management	Introduction or spread of weeds	Priority weeds would be managed in accordance with the *Biosecurity Act 2015*. Weeds of national significance would be managed in accordance with the Weeds of National Significance: weed management guides. Any herbicides would be applied such that impacts on surrounding agricultural properties and native vegetation are avoided.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Construction
Invasive ants	Impacts on habitat	The biodiversity management plan would include measures to prevent the introduction and spread of invasive ants during construction.	Potentially effective	Measures meet best practice management of flora and fauna on construction projects. Risk of introduction and spread is low.	Construction

11.1.4 Operation

The main risks that are likely to impact biodiversity during operation of the proposal and the proposed mitigation measures are provided in Table 11.3.

Table 11.3 Biodiversity mitigation measures for operation

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
Weed management	Introduction or spread of weeds	Annual inspections would be undertaken for weed infestations and to assess the need for control measures. Any outbreak of priority weeds and/or weeds of national environmental significance would be managed in accordance with the *Biosecurity Act 2015*, the Weeds of National Significance: weed management guides, and the requirements of relevant authorities.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Operation
Connectivity	Population fragmentation	The operational performance of fauna connectivity measures would be monitored in accordance with the fauna connectivity strategy. This would include monitoring of use of crossing structures by feral predators in accordance with principles of the strategy. The need for additional measures or modifications to existing measures would be identified to respond to any issues identified.	Potentially effective	Measures meet best practice management of flora and fauna on construction projects. Measures will provide some mitigation of the impacts on connectivity, but the project is still likely to result in fragmentation of populations of some species with lower dispersal abilities.	Operation
Train strike	Fauna mortality	Monitoring of wildlife-train collisions is recommended as part of the monitoring of fauna connectivity, and fencing may be required if high concentrations of wildlife-train collisions are recorded	Potentially effective	Measures meet best practice management of flora and fauna on construction projects. Adaptive design is recommended to allow for improvements.	Operation

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
Feral animals	Predation	The connectivity strategy would include: • Monitoring of the use of the rail corridor and crossing structures by feral predators in the Pilliga. • Control of feral predators along the proposal site and adjacent to temporary camps in the Pilliga area.	Potentially effective	Measures meet best practice management of flora and fauna on construction projects. Adaptive design is recommended to allow for improvements.	Operation
Invasive ants	Impacts on habitat	The biodiversity management plan would include measures to prevent the introduction and spread of invasive ants during operation.	Potentially effective	Measures meet best practice management of flora and fauna on construction projects. Risk of introduction and spread is low.	Operation

Table 11.4 Fauna connectivity structures and mitigation devices

Structure type	Description and effectiveness	Locations
Bridges	Bridges typically traverse watercourses and are the preference for fauna connectivity when passing through flood-prone areas (VicRoads 2012). Bridges have the least impact on aquatic and riparian fauna habitat as they usually involve minimal disturbance to water flow and aquatic habitat, and allow some retention of riparian habitat. Bridges can also incorporate dry areas along banks to provide dry passage for terrestrial fauna species (TRM 2010). A total of 73 rail bridges are included in the proposal. Many of the bridges cross the associated floodplains and would provide substantial areas of dry passage for fauna to pass underneath for much of the time. Connectivity would be limited to varying degrees during rain or flood events. Bridges with dry passage have been shown to provide connectivity for a range of fauna species. Extensive revegetation works was carried out under a raised bridge structure over Slaty Creek on the Calder Freeway at Macedon in Victoria. Surveys showed that the vegetation under the bridge was capable of supporting a comparable number of species of mammal, bird, reptile and amphibian as the forest immediately adjacent to the freeway (Abson 2004). Fauna monitoring for the Bonville Pacific Highway Upgrade identified many species utilising bridge underpasses including species of wallabies, possums, Koala, echidna, bandicoots, rats, antechinus, bats, foxes, cats, and a variety of birds, lizards and snakes (RTA 2009). A study at Brunswick Heads recorded a greater number of complete passages made through bridge underpasses than box culverts (AMBS 2002a). Fauna furniture (horizontal wooden poles attached to the outer piers) is recommended particularly for bridges in the Pilliga area to encourage movement of Koalas and other scansorial fauna. Revegetation under bridges and at the approaches to the bridges would also assist with increasing the efficacy of these structures for connectivity. Fencing is recommended at least 200 metres either side of bridges in the Pilliga forests to direct fauna to the crossing location.	Examples of crossings and lengths are provided below: Major crossings: • Macquarie River (over 1 kilometres long), providing clearance over river of 19.6 metres and over Mitchell Highway of 7.7 metres. Crosses above the Narromine travelling stock reserve, retaining connectivity within this patch. • Castlereagh River (over 600 metres long). Provides clearance of 10.9 metres over river • Namoi River & Narrabri Creek (about 4 kilometres long). Provides clearance of 12.7 metres over Narrabri Creek and 12 metres over Namoi River creek. Has a clearance of over 5 metres over various roads and large areas of agricultural land. Pilliga Forest • Baradine Creek (over 200 metres long) • Etoo Creek (over 300 metres long) • Stockyard Creek (over 50 metres long) • Rocky Creek (over 100 metres long) • Talluba Creek (over 50 metres long) • Rocky Creek (over 50 metres long) • Coghill Creek (over 150 metres long) • Mollieroi Creek (over 50 metres long) • Goona Creek (over 50 metres long) • Bundock Creek (over 100 metres long) Drainage lines in agricultural land: • Ewenmar Creek (over 300 metres long) • Emogandy Creek (over 300 metres long) • Pint Pot Creek (over 100 metres long) • Kickabil Creek (over 200 metres long) • Bundijoe Creek (over 150 metres long)

Structure type	Description and effectiveness	Locations
		• Gulargambone Creek (over 400 metres long) • Baronne Creek (about 100m long) • Bucklanbah Creek (over 100 metres long) • Teridgerie Creek (over 100 metres long) • Bohena Creek (over 300 metres long)
Pole barriers	Bridges can represent a risk for flying species as they tend to cross above them. Bridges can be flanked by pole barriers to ensure safe passage for aerial species well above moving rail traffic (Zuberogoitia et al. 2015). These have been successful in reducing bird mortality in Florida (Bard et al 2002). Pole barriers are recommended for the larger creek crossings in the Pilliga, however additional bridges may need to be fitted with poles as a result of ongoing monitoring of wildlife-train collisions. Poles would be higher than maximum train height, and would be set at regular intervals along either side of the bridge where the main gap in vegetation (ie the flyway) is located. The effectiveness of this measure should be monitored by comparing mortality at bridges with no pole barriers. Poles at either end should be taller and be fitted with launch platforms to provide crossing opportunities for gliders.	Poles barriers are recommended at the following locations: • Baradine Creek (over 200 metres long) • Coolangala Creek (over 60 metres long) • Etoo Creek (over 300 metres long) • Rocky Creek (over 100 metres long) • Mollieroi Creek (over 90 metres long) • Goona Creek (over 50 metres long)
Combined drainage/fauna passage culverts	Combined culverts are constructed to maintain water flow, encourage the movement of aquatic animals and allow terrestrial fauna movement (VicRoads 2012). A dry ledge or similar structure can provide safe passage for terrestrial fauna species (VicRoads 2012). A total of 630 banks of culverts are proposed under the rail line. Of these, 135 are located in the Pilliga area (between Gwabegar Road and Dog Fence Road). In the Pilliga culverts range from 0.6 metres in height to 3 metres in height. All culverts are 2.4 metres in width, however most comprise multiple cells (up to 32 cells, at an average of 5.4 cells per location). Combined culverts would be dry most of the time as most drainage lines are subject to ephemeral flows only. Culverts for the proposal typically match the width of the top of formation (not the entire earthworks width). Most culverts will be 7.3 metres wide	Examples of combined drainage/fauna culverts in the Pilliga Forest • Cumbil Forest Creek (2.4 w x 3 h x 4 cells) • Tinegie Creek (2.4 w x 2.4 h x 6 cells) • Black Creek (2.4 w x 2.1 h x 10 cells) • Unnamed creek at chainage 817.150 (2.4 w x 3 h x 32 cells) • Unnamed creek at chainage 778.028 (2.4 w x 3 h x 8 cells) • Chainage 809.062 (2.4 w x 2.4 h x 12 cells) • Chainage 800.873 (2.4 w x 2.1 h x 15 cells)

Structure type	Description and effectiveness	Locations
	(perpendicular to the rail), but culverts beneath crossing loops will be 18.3 metres wide. This distance is well within the distance fauna will travel through culverts (which are often used successfully under multi-lane highways). Culverts have been shown to be used by a wide variety of fauna groups. At Compton Road, Brisbane, 16 species were found to use underpasses. The most abundant tracks were from small mammals (probably rodents), followed by lizards. About a third of tracks recorded were along shelves installed in the underpasses to provide raised passage (Bond and Jones 2008). During large monitoring projects for Brunswick Heads to Yelgun Pacific Highway Upgrade and Bulahdelah to Coolongolook upgrade many species were recorded using box culverts including a variety of mammals (wallabies, kangaroos, bandicoots, possums, antechinuses, cats, dogs, foxes, echidnas, bats, and rodents), reptiles (skinks, goannas, dragons and snakes), many bird species and the Cane Toad (AMBS 2001, AMBS 2002, RTA 2014). Bettongs have been clearly identified using culverts during surveys for the Glenugie upgrade (RMS 2014). Fauna underpass monitoring for the Bulahdelah to Coolongolook project identified a Tiger Quoll using a box culvert (AMBS 2001). Fauna furniture (such as horizontal wooden poles) is recommended at some culverts in the Pilliga area to encourage movement of Koalas and other climbing fauna. This would mainly be culverts near larger waterways, as well as to provide connectivity elsewhere in the Pilliga where fewer bridges are included in the design. Fauna furniture is also recommended elsewhere in the alignment where larger patches of native vegetation is present either side of the culvert. Dry ledges are proposed for the outside cells of multicell culverts throughout the Pilliga and Bohena areas, as well as other locations where better quality habitat is present either side of the culvert. Revegetation at the approaches to the culverts would also assist with increasing the efficacy of these structures for connectivity. Fencing is recommended at least 200 metres either side of culverts in the Pilliga forests to direct fauna to the crossing location.	

Structure type	Description and effectiveness	Locations
Dedicated underpasses	Dedicated culverts are positioned to directly benefit fauna rather than to channel water. These dedicated underpasses are used where connectivity is required in dry woodland with few creek crossings. Dedicated culverts have been shown to be used by a wide variety of fauna groups. A study of dedicated underpasses along the Brunswick Heads Bypass identified arboreal mammals, macropods, introduced carnivores, frogs, reptiles, birds, small mammals, rodents and echidnas using these underpasses. This study recommended increasing habitat cover surrounding culverts to facilitate movement by particular species such as potoroos (Taylor and Goldingay 2003). Koalas have been shown to use structures as small as 2.4 metres by 1.2 metres near Brunswick Heads (Taylor and Goldingay, 2003), and up to 100 metres long (SKM 2013b). Dedicated culverts under the M1 (Sydney to Newcastle freeway) were found to be used by the Spotted-tailed Quoll, Koala and Eastern Pygmy-possum (RTA 2009). A study of box culvert usage by Koalas for the Bonville Koala study identified 20 records of Koalas using a dedicated underpass; comprising four complete passages (equates to eight records), two probable complete passages, seven unlikely passages and three non-passages (AMBS 2009). Dedicated culverts are proposed in areas of PCT 141 broombush – wattle very tall shrubland in the Pilliga. This PCT is preferred breeding habitat for the Pilliga Mouse. Where larger patches occur on both sides of the alignment a series of culverts have been included in the design. Few culverts had originally been located in this PCT due to its position away from drainage lines. Small logs placed on the floor of the culvert or attached to the base of the culvert walls are recommended to encourage movement of Pilliga Mouse and other small terrestrial fauna. Revegetation at the approaches to the culverts would also assist with increasing the efficacy of these structures for connectivity. Fencing is recommended at least 200 metres either side of culverts in the Pilliga forests to direct fauna to the crossing location.	Dedicated culverts are proposed in areas of PCT 141 broombush – wattle very tall shrubland in the Pilliga to provide connectivity for the Pilliga Mouse in potential breeding habitat.

Structure type	Description and effectiveness	Locations
Glider poles	Vertical glider poles have been used to provide connectivity for gliders across roads and cleared areas by enabling gliders to cross large roads which create forest canopy gaps that are beyond their glide capacity (Sandpiper Ecological Surveys 2014). In road situations these have been placed in the centre median, on the road verge or on overpasses provide gliders with intermediate landing points and/or multiple launch opportunities (TMR 2010). In the rail situation, these would be placed in the rail verge or on bridges (potentially as part of the pole barriers for aerial species). Squirrel Gliders were frequently recorded utilising glider poles at Compton Road, Brisbane, within a year of construction. This species was recorded at sites at this location where they had not previously occurred, likely as a result of the glider poles providing connectivity (Robinson-Wolrath 2007, in TMR 2010). Squirrel Gliders were shown to use poles within a 70 metre clearing to traverse agricultural land between two forest patches (Ball and Goldingay 2008). Monitoring of wildlife road crossing structures by Soanes et al. (2013) found the rate of glider crossing increased over several years as animals habituated to the structure. Glider poles are recommended at a number of locations through the Pilliga. The precise locations would be determined during detailed design as part of the fauna connectivity strategy. Height of glider poles would need to take into account the height of stacked containers on the trains. Horizontal cross bars are required to provide launch pads. Revegetation near glider poles and under bridges is recommended to improve efficacy of these features for this species.	Pilliga Forest, Bohena Creek

Structure type	Description and effectiveness	Locations
Rope bridges	Rope bridges provide for genetic connectivity, dispersal movements and home range movements of arboreal species such as possums and gliders (VicRoads 2012). One advantage of rope bridges is that they can be used by non-gliding arboreal fauna, such as the Brush-tailed Phascogale, Antechinus species, possums and small gliders, such as the Feathertail Glider (Sandpiper Ecological Surveys 2013). As such, rope bridges are preferred to glider poles as they provide crossing opportunity for a greater range of species and use by several glider species has been confirmed in a highway setting (Goldingay et al. 2013). Rope bridges also provide greater flexibility as they can be designed to fit the forest gap (Sandpiper Ecological Surveys 2014). Rope bridges are generally attached to recycled electricity poles and have cables in the adjacent vegetation to provide tension and access (VicRoads 2012). The Common Brushtail Possum, Squirrel Glider, Sugar Glider, Feathertail Glider, Common Ringtail Possum, a species of Antechinus, frog species (*Litoria*), and introduced Black Rat and Feral Cat were recorded utilising rope bridges at the Karuah bypass (RTA 2009). Monitoring for the Bonville Pacific Highway Upgrade also identified Sugar Gliders and Feathertail Gliders utilising rope crossings (RTA 2009). Ringtail Possums have been recorded using rope bridges in Victoria (VicRoads 2012), and Brush-tailed Phascogales have also been recorded using a rope bridge on the Hume Highway (Soanes and Van der Ree 2009). Rope bridges should be used to complement glider poles in the Pilliga. Rope bridges are recommended under bridges throughout the Pilliga, major river crossings, and other large creek crossings. Rope bridges may also be used elsewhere in the Pilliga. The precise locations would be determined during detailed design as part of the fauna connectivity strategy.	Pilliga Forest, Macquarie River, Castlereagh River, Bohena Creek, Namoi river, Narrabri Creek

Structure type	Description and effectiveness	Locations
Fencing	Several studies have tested fencing to prevent animal crossings of railways. These can reduce wildlife-train collisions but, on the other hand, they can increase barrier effects (eg, Ito et al. 2005, 2008, 2013). Thus, they should only be implemented in areas of high concentration of wildlife-train collisions, and combined with wildlife passes to maintain railway permeability (van der Grift 1999). The rail line will be fenced where it is located in agricultural land to prevent mortality of stock. This may minimise mortality of fauna species such as kangaroos and emus, however these animals can cross stock fences and may still be subject to injury and mortality through train strike. Fauna fencing is proposed at bridges and culverts in the Pilliga to direct fauna to these crossing locations. Fencing would extend at least 200 metres either side of bridges and outer culvert cells. Complete fencing of the rail line in the Pilliga is not recommended. This is due mainly to the low train traffic rate, which is proposed to be an average of 8.5 trains per day (both directions) in 2025, increasing to about 15 trains per day (both directions) in 2040. The increased negative barrier effect that would be caused by fencing would outweigh the potential reduction in train strike mortality. Monitoring of wildlife-train collisions is recommended as part of the monitoring of fauna connectivity, and fencing may be required if high concentrations of wildlife-train collisions are recorded, including as train volumes increase.	Pilliga Forest, Bohena Creek

Structure type	Description and effectiveness	Locations
Alarm calls	Interesting alternatives to traditional connectivity measures are those devices that aim to reduce wildlife-train collisions without having barrier effects. For example, trains equipped with ultrasonic warning devices killed fewer moose in Canada than those without (Muzzi and Bisset 1990). More recently, Babińska-Werka et al. (2015) reported the development of a device in Poland that uses alarm calls from several wild animals in advance (30 seconds to 3 minutes) of an oncoming train that allows animals near the railway to react and escape in a natural way. The proportion of wildlife escaping from the tracks was higher, and individuals reacted faster, when the device was switched on and, importantly, animals did not show evidence of habituation to the warning signals (Babińska-Werka et al. 2015). Fox et al (2018) have tested the use of virtual fences in Tasmania at reducing road kill. These virtual fences consisted of an electronic system that generates sound and light stimuli when activated by the headlights of approaching vehicles. This study found the total roadkill rate reduced, and there was a reduction in roadkill of 50 per cent for the most common species. The use of train warning devices in the Pilliga may be considered as an adaptive management action where higher incidences of train-wildlife collisions occur. Alternatively, the use of these devices could be part of a study into their effectiveness.	Pilliga
Removal of ballast	Removing the gravel below pairs of sleepers to create a gap has been used to allow small vertebrates, like spotted turtles (*Clemmys guttata*) in the USA, to cross under the sleepers (Pelletier et al. 2006). In the Pilliga, this option could be considered for sections where there are larger distances between culverts. This measure may be considered during detailed design as part of the fauna connectivity strategy, and would be recommended where there are large distances between culverts.	Pilliga

Monitoring of fauna connectivity structures and mitigation devices

Linear infrastructures are one of the largest threats to biodiversity worldwide, including habitat loss and fragmentation and associated barrier effects (Forman et al. 2003; Benítez-López et al. 2010; van der Ree et al. 2015). It is thus important to assess the impacts of the rail line and the effectiveness of proposed crossing structures or mitigation devices at reducing barrier effects.

Methods of assessing barrier effects include:

- collection of wildlife-train collisions data
- surveillance of fauna crossings structures by remote cameras or other methods
- radio-tracking of fauna movements
- genetic assessments for population fragmentation
- computer simulations, such as population viability analysis (PVA).

A fauna connectivity strategy will be prepared for the proposal. This should include:

- discussion of the relevant species biology and distribution with respect to the rail line
- discussion of the various types of connectivity structures to be used
- locations of connectivity structures and other details (eg installation of fauna furniture)
- monitoring methods and frequency for fauna crossings
- monitoring of structural soundness of crossing structures
- monitoring of wildlife-train collisions
- reporting frequency
- adaptive management.

11.2 Adaptive management for uncertain impacts

As noted earlier in this BDAR, the impacts of rail infrastructure on Australian fauna has had limited study. Similarly, there has been limited research regarding the efficacy of fauna crossing structures on rail lines. Monitoring of fauna connectivity structures and relevant threatened species for this proposal will enable assessment of the value of the structures for minimising the impacts of habitat fragmentation, and allow for improvements for both this proposal and other rail proposals in Australia.

12. Offsetting

12.1 BC Act - Offset for affected threatened biota

Impacts associated with the proposal that require offsetting include the removal of 1732 hectares of native vegetation, and associated habitat for threatened biota.

12.1.1 Offsetting strategy

In accordance with the offset rules established by the Biodiversity Conservation Regulation 2017 there are various means by which offset obligations can be met. These include:

- retiring like for like credits from an established Biodiversity Stewardship Site
- retiring biodiversity credits in accordance with the 'variation rules' in clause 6.4 of the BC Regulation
- monetary payment directly into the Biodiversity Conservation Fund (BCF) or
- funding an approved biodiversity action.

ARTC is managing the offset strategy for the entire Inland Rail program, and have invited landowners within 100 kilometres of the route in NSW to contact them regarding establishing a Biodiversity Stewardship Site so that ARTC can purchase the appropriate credits. Where credits are not available for purchase or cannot be obtained in other ways (such as generation from an ARTC site), another option would be for ARTC to make a payment into the BCF.

Where ARTC is unable to source suitable offsets for the proposal, they may seek to apply the variation rules for retirement of some ecosystem and species credits, particularly those credits associated with native grasslands which may be difficult to source. Variation trading rules for ecosystem and species credits for the proposal are documented in Appendix K.

To be eligible to apply for offset trading rules, ARTC must document in the BDAR the reasonable steps that they have taken to source like for like offsets as well as, the credit class and number of credits proposed to be offset under the variation rule.

If the variation rules are proposed to be applied after consent has been granted, a section 4.55 modification under the EP&A Act (*Environmental Planning & Assessment Act 1979*) will be required.

The number and types of credits where application of trading rules are required is not yet known. Any application of offset trading rules would be documented in an addendum report.

ARTC are proposing to complete additional targeted survey effort in the second half of 2020. The main aim of the surveys will be to gain a better understanding of proposal impacts to threatened flora and to complete vegetation integrity plots outside of drought conditions and in areas previously extrapolated due to access restrictions. These surveys are likely to include:

- vegetation integrity plots and plant community type mapping in previously extrapolated areas (where possible)
- targeted surveys for threatened flora (mostly in the Pilliga) where drought conditions previously limited detection
- some additional fauna surveys in the Pilliga
- vegetation integrity plots in PCTs sverly impacted by drought in previous surveys (ie vegetation integrity scores <17).

Results of these surveys will be included in an addendum biodiversity report following exhibition.

Given the scale and complexity of Inland Rail projects and the estimated large quantity of credits required, there is a risk that the time taken to retire credits for the entire proposal as required by the BC Act could delay commencement of construction. In order to mitigate this, the proposal has been segmented into 11 separate construction segments, with the ecosystem and species credits prorated across each of the segments. This approach of presenting the construction segments in the BDAR will provide valuable flexibility to the Principal Contractor during execution. The 11 segments comprise:

- Three major construction compounds – three segments
  - Segment 1 – Narromine South multi-function compound
  - Segment 2 – Curban multi-function compound
  - Segment 3 – Narrabri West multi-function compound
- Four borrow pits – four segments
  - Segment 4 – borrow pit A
  - Segment 5 – borrow pit B
  - Segment 6 – borrow pit C
  - Segment 7 – borrow pit D
- Alignment – four segments
  - Segment 8 – Narromine to Curban
  - Segment 9 – Curban to Pilliga
  - Segment 10 – Pilliga
  - Segment 11 – Pilliga to Narrabri.

12.1.2 Ecosystem credits

The data from the fieldwork and mapping was entered into version 1.2.7.4 of the BAM credit calculator (version 29) as a ‘Development Assessment’ to determine the number and type of biodiversity credits that would be required to offset impacts of the proposal. The Biodiversity credit report is included in Appendix K and summarised below.

There is 1,732 hectares of native vegetation (remnant woodland and derived grassland) at the proposal site that would be impacted by construction and operations of the proposal. It is assumed that the construction and operation of the rail line will necessitate the removal of all vegetation layers and so the ‘future vegetation integrity score’ for the various vegetation zones was entered as 0.

Where the minimum number of plots was not able to be obtained for a vegetation zone (due to access constraints), benchmark data was used. The vegetation integrity score was significantly higher at these sites than those with actual plot data (see Table 12.2).

A total of 34,820 ecosystem credits are required for the proposal. Ecosystem credits that would be required to offset the impacts of the proposal are shown in Table 12.2. All credit calculations were conducted in one assessment for the 11 segments. Ecosystem credit requirements by segment (see Table 12.2) have been prorated based on the total number of credits required for each vegetation zone and the area of each vegetation zone within each segment.

Table 12.1 Ecosystem credits and impact area by PCT

Plant Community Type	Impact area (ha)	Ecosystem credits required
PCT 27 Weeping Myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South Bioregion	3.05	127
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	0.61	19
PCT 36 River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	5.08	115
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	176.1	2843
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	0.21	5
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	19.50	564
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	26.23	585
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	277.79	5166
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	29.47	425
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion	53.99	645
PCT 148 Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	45.04	1697
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	8.56	286
PCT 185 Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland mainly in the NSW South Western Slopes Bioregion	1.37	0
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	3.59	179
PCT 206 Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	12.66	376
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	31.84	677
PCT 247 Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion	6.91	234
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	14.71	470
PCT 250 Derived tussock grassland of the central western plains and lower slopes of NSW	82.84	2845
PCT 255 Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion	11.77	190

Plant Community Type	Impact area (ha)	Ecosystem credits required
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	0.27	4
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	69.66	1159
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	15.78	303
PCT 398 Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	369.78	8444
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	53.71	1105
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	23.05	544
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	2.30	49
PCT 409 Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	0.82	15
PCT 411 Buloke - White Cypress Pine woodland on outwash plains in the Piliga Scrub and Narrabri region, Brigalow Belt South Bioregion	8.76	327
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion	7.32	153
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	6.11	305
PCT 436 Derived Kurrajong grassy open woodland / isolated trees in the Brigalow Belt South Bioregion and Nandewar Bioregion	5.98	0
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	1.11	37
PCT 473 Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	15.26	318
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	1.23	27
PCT 599 Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	2.21	64
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	326.26	4067
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	2.12	36
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	8.77	415
Total	**1731.82**	**34820**

Table 12.2 Ecosystem credits required to offset impacts of the proposal by segment

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
SEGMENT 1 - Narromine multi-function compound					
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	1.74	36.9	0	Not listed	28
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	2.17	49.3	0	Not listed	40
PCT 247 Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion	1.24	77.3*	0	Not listed	42
SEGMENT 1 - TOTAL area impacted and ecosystem credits required	**5.15**				**110**
SEGMENT 2 – Curban multi-function compound					
No native vegetation to be removed	0	-	-	-	0
SEGMENT 3 – Narrabri multi-function compound					
PCT 148 Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	5.11	86.1*	0	Not listed	193
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	87.04	33.2	0	Not listed	1085
SEGMENT 3 - TOTAL area impacted and ecosystem credits required	**92.15**				**1278**
SEGMENT 4 – Borrow pit A and haul road					
PCT 185 - Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland mainly in the NSW South Western Slopes Bioregion	1.37	10.7	0	Not listed	0
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	12.09	33.2	0	Not listed	151
SEGMENT 4 – TOTAL area impacted and ecosystem credits required	**13.46**				**151**
SEGMENT 5 – Borrow pit B and haul road					
PCT 255 - Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion	4.08	36.8		Not listed	66
SEGMENT 5 - TOTAL area impacted and ecosystem credits required	**4.08**				**66**

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
SEGMENT 6 – Borrow pit C and haul road					
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	0.41	49.3	0	Not listed	8
PCT 255 - Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion	7.69	36.8	0	Not listed	124
SEGMENT 6 – TOTAL area impacted and ecosystem credits required	**8.1**				**132**
SEGMENT 7 – Borrow pit D and haul road					
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	0.15	50.9	0	Not listed	3
PCT 398 Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	2.40	61.2	0	Not listed	55
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	2.12	45.6	0	Not listed	36
SEGMENT 7 – TOTAL area impacted and ecosystem credits required	**4.67**				**94**
SEGMENT 8 – Alignment (Narromine to Curban)					
PCT 36 River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	5.08	51.9	0	Not listed	115
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	134.07	36.9	0	Not listed	2165
PCT55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	0.21	44.7	0	Not listed	5
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	19.50	57.8	0	Not listed	564
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	2.84	50.9	0	Not listed	63
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	110.12	49.3	0	Not listed	2046

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (degraded)	1.65	45.1	0	Not listed	36
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	1.28	88.9*	0	Not listed	43
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	3.59	99.5*	0	Fuzzy Box woodland	179
PCT 206 Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	12.66	67.9*	0	Not listed	376
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	10.36	40.4	0	Not listed	220
PCT 247 Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion	5.67	77.3*	0	Not listed	191
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	14.71	64.0*	0	Inland Grey Box woodland	470
PCT 250 Derived tussock grassland of the central western plains and lower slopes of NSW	6.57	91.6*	0	Not listed	225
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	11.21	48	0	Not listed	202
PCT 436 Derived Kurrajong grassy open woodland / isolated trees in the Brigalow Belt South Bioregion and Nandewar Bioregion	5.98	12.0	0	Not listed	0
PCT 599 Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	2.21	58.1	0	Box-Gum Woodland	64
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	96.20	33.2	0	Not listed	1199
SEGMENT 8 – TOTAL area impacted and ecosystem credits required	**443.91**				**8163**

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
SEGMENT 9 – Alignment (Curban to Pilliga)					
PCT 27- Weeping Myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South Bioregion	3.05	83.5*	0	Weeping Myall Woodland	127
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	27.99	36.9	0	Not listed	452
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	11.61	50.9	0	Not listed	259
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	85.12	49.3	0	Not listed	1581
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion	53.99	23.9	0	Not listed	645
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	21.48	40.4	0	Not listed	457
PCT 250 Derived tussock grassland of the central western plains and lower slopes of NSW	76.27	91.6*	0	Not listed	2620
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	2.30	51.2	0	Not listed	44
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	1.62	54.9	0	Not listed	33
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	6.11	100	0	Box-Gum Woodland	305
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	1.11	66.6	0	Not listed	37
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	0.73	44.0	0	This patch does not meet EEC criteria	16
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	36.99	33.2	0	Not listed	461

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
SEGMENT 9 – TOTAL area impacted and ecosystem credits required	**328.37**				**7037**
SEGMENT 10 – Alignment (Pilliga)					
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	4.41	36.9	0	Not listed	71
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	68.66	49.3	0	Not listed	1275
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	29.47	38.5	0	Not listed	425
PCT 256 - Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	0.27	41.3	0	Not listed	4
PCT 394 Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	47.57	48	0	Not listed	857
PCT 394 Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (derived, fire affected)	10.87	24.6	0	Not listed	100
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	13.48	24.6	0	Not listed	259
PCT 398 Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	358.88	61.2	0	Not listed	8232
PCT 398 Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion (derived, shrubs removed)	8.50	49.3	0	Not listed	157
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	43.89	54.9	0	Not listed	903
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	23.05	62.9	0	Not listed	544
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	2.30	57.0	0	Not listed	49

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
PCT 409 Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	0.82	47.2	0	Not listed	15
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion	7.32	55.9	0	Not listed	153
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	0.50	44.0	0	Not listed	11
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	0.49	33.2	0	Not listed	6
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	8.77	94.6*	0	Not listed	415
SEGMENT 10 – TOTAL area impacted and ecosystem credits required	**629.25**				**13476**
SEGMENT 11 – Alignment (Pilliga to Narrabri)					
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	0.6	61.1	0	Brigalow woodland	19
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	7.88	36.9	0	Not listed	127
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	11.62	50.9	0	Not listed	259
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	9.67	49.3	0	Not listed	179
PCT 148 Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	39.93	86.1*	0	Not listed	1504
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	7.27	88.9*	0	Not listed	243
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	8.20	54.9	0	Not listed	169
PCT 411 - Buloke - White Cypress Pine woodland on outwash plains in the Piliga Scrub and Narrabri region, Brigalow Belt South Bioregion	8.76	99.7*	0	Not listed	327

Vegetation Zone / PCT	Area (ha)	Current vegetation integrity score	Future vegetation integrity score	BC Act status	Ecosystem credits required
PCT 473 - Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	15.25	55.5	0	Not listed	318
PCT 619 Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion	93.44	33.2	0	Not listed	1165
SEGMENT 11 – TOTAL area impacted and ecosystem credits required	**202.62**				**4310**
GRAND TOTAL – TOTAL area impacted and ecosystem credits required (all segments)	1731.82				**34,820**

12.1.3 Species credits

The proposal site is known to support six species credit species and an additional 14 that are assumed to be present due to limited site access and poor survey conditions due to prolonged drought.

The nine candidate flora species and 11 candidate fauna species require a total of 160,421 species credits (see Table 12.3 and Appendix K). None of the species credit species are candidate SAII species. Species credit requirements by segment (see Table 12.4) have been prorataed based on the total number of credits required for each species and the area of each species polygon within each segment.

Table 12.3 Species credit requirements for the proposal

Species	Potential habitat impacted (ha)	Species credits required
Barking Owl (*Ninox connivens*)	24.29	687
Bush Stone-curlew (*Burhinus grallarius*)	337.29	8992
Cobar Greenhood (*Pterostylis cobarensis*)	193.04	5631
Commersonia procumbens	565.14	16,431
Coolbah Bertya (*Bertya opponens*)	4.0	8
Eastern Pygmy-possum (*Cercartetus nanus*)	707	20,696
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	30.55	975
Koala (*Phascolarctos cinereus*)	718.26	20,562
Little Eagle (*Hieraaetus morphnoides*)	15.9	376
Masked Owl (*Tyto novaehollandiae*)	7.25	189
Native Milkwort (*Polygala linariifolia*)	565.86	16,258
Pale-headed Snake (*Hoplocephalus bitorquatus*)	206.70	6128
Pine Donkey Orchid (*Diuris tricolor*)	629.97	13,639
Rufous Bettong (*Aepyprymnus rufescens*)	244.35	7,109
Slender Darling Pea (*Swainsona murrayana*)	43.58	978
Spiny Peppercress (*Lepidium aschersonii*)	10.27	259
Square-tailed Kite (*Lophoictinia isura*)	35.09	765
Squirrel Glider (*Petaurus norfolcensis*)	688.3	20,483
Tylophora linearis	582.50	16,902
Winged Peppercress (*Lepidium monoplocoides*)	194.29	3353
TOTAL	**5803.63**	**160,421**

Table 12.4 Species credits required to offset impacts of the proposal by segment

Species	Potential habitat impacted (ha)	Risk rating	Species credits required
Segment 1 – Narromine multi-function compound			
Koala (*Phascolarctos cinereus*)	2.17	0.25	62
Segment 1 – total species credits			62
Segment 3 – Narrabri multi-function compound			
Winged Peppercress (*Lepidium monoplocoides*)	87.04	2	1502
Koala (*Phascolarctos cinereus*)	5.11	0.25	146
Segment 2 – total species credits			1648
Segment 5 - Borrow pit B			
Koala (*Phascolarctos cinereus*)	4.08	0.25	117
Segment 5 – total species credits			117
Segment 6 - Borrow pit C			
Koala (*Phascolarctos cinereus*)	8.10	0.25	232
Pine Donkey Orchid (*Diuris tricolor*)	7.69	1.5	166
Segment 6 – total species credits			398
Segment 7- Borrow pit D			
Pine Donkey Orchid (*Diuris tricolor*)	2.11	1.5	46
Cobar Greenhood (*Pterostylis cobarensis*)	2.11	2	62
Native Milkwort (*Polygala linariifolia*)	2.11	2	61
Tylophora linearis	2.11	2	61
Koala (*Phascolarctos cinereus*)	4.67	0.25	134
Bush Stone-curlew (*Burhinus grallarius*)	2.24	0.25	60
Masked Owl (*Tyto novaehollandiae*)	0.16	0.25	4
Pale-headed Snake (*Hoplocephalus bitorquatus*)	0.16	0.25	5
Squirrel Glider (*Petaurus norfolcensis*)	4.67	0.25	139
Segment 7 – total species credits			572
Segment 8 - Narromine to Curban			
Pine Donkey Orchid (*Diuris tricolor*)	39.31	1.5	851
Koala (*Phascolarctos cinereus*)	33.78	0.25	967
Bush Stone-curlew (*Burhinus grallarius*)	70.58	0.25	1882
Masked Owl (*Tyto novaehollandiae*)	1.60	0.25	43
Barking Owl (*Ninox connivens*)	0.61	0.25	17
Little Eagle (*Hieraaetus morphnoides*)	5.69	0.25	134
Square-tailed Kite (*Lophoictinia isura*)	7.41	0.25	161
Segment 8 – total species credits			4055

Species	Potential habitat impacted (ha)	Risk rating	Species credits required
Segment 9 – Curban to Pilliga			
Pine Donkey Orchid (*Diuris tricolor*)	32.24	1.5	698
Slender Darling Pea (*Swainsona murrayana*)	35.65	2	800
Koala (*Phascolarctos cinereus*)	73.06	0.25	2092
Bush Stone-curlew (*Burhinus grallarius*)	23.87	0.25	636
Masked Owl (*Tyto novaehollandiae*)	1.66	0.25	44
Barking Owl (*Ninox connivens*)	1.92	0.25	54
Little Eagle (*Hieraaetus morphnoides*)	4.06	0.25	96
Segment 9 – total species credits			4420
Segment 10 - Pilliga			
Cobar Greenhood (*Pterostylis cobarensis*)	146.00	2	4,259
Commersonia procumbens	565.14	2	16,431
Pine Donkey Orchid (*Diuris tricolor*)	533.37	1.5	11,547
Native Milkwort (*Polygala linariifolia*)	563.75	2	16,197
Slender Darling Pea (*Swainsona murrayana*)	7.32	2	164
Tylophora linearis	565.14	2	16,397
Winged Peppercress (*Lepidium monoplocoides*)	13.48	2	233
Koala (*Phascolarctos cinereus*)	493.25	0.25	14,120
Bush Stone-curlew (*Burhinus grallarius*)	224.80	0.25	5993
Masked Owl (*Tyto novaehollandiae*)	1.83	0.25	49
Barking Owl (*Ninox connivens*)	15.53	0.25	439
Little Eagle (Hieraaetus morphnoides)	2.07	0.25	49
Square-tailed Kite (*Lophoictinia isura*)	21.32	0.25	465
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	26.80	0.25	855
Pale-headed Snake (*Hoplocephalus bitorquatus*)	166.21	0.25	4,927
Rufous Bettong (*Aepyprymnus rufescens*)	244.35	0.25	7,109
Eastern Pygmy-possum (*Cercartetus nanus*)	622.06	0.25	18,210
Squirrel Glider (*Petaurus norfolcensis*)	592.59	0.25	17,574
Segment 10 – total species credits			135,018
Segment 11 – Pilliga to Narrabri			
Coolbah Bertya (*Bertya opponens*)	4 plants	2	8
Cobar Greenhood (*Pterostylis cobarensis*)	44.93	2	1310
Pine Donkey Orchid (*Diuris tricolor*)	15.25	1.5	331
Spiny Peppercress (*Lepidium aschersonii*)	10.27	2	259
Tylophora linearis	15.25	2	442
Slender Darling Pea (*Swainsona murrayana*)	0.61	2	14

Species	Potential habitat impacted (ha)	Risk rating	Species credits required
Winged Peppercress (*Lepidium monoplocoides*)	93.77	2	1618
Koala (*Phascolarctos cinereus*)	94.04	0.25	2692
Bush Stone-curlew (*Burhinus grallarius*)	15.80	0.25	421
Masked Owl (*Tyto novaehollandiae*)	2.0	0.25	53
Barking Owl (*Ninox connivens*)	6.23	0.25	176
Little Eagle (*Hieraaetus morphnoides*)	4.08	0.25	97
Square-tailed Kite (*Lophoictinia isura*)	6.36	0.25	139
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	3.75	0.25	120
Pale-headed Snake (*Hoplocephalus bitorquatus*)	40.33	0.25	1196
Eastern Pygmy-possum (*Cercartetus nanus*)	84.94	0.25	2486
Squirrel Glider (*Petaurus norfolcensis*)	93.43	0.25	2770
Segment 11 – total species credits			14132
GRAND TOTAL – species credits (all segments) 160,421			

12.2 EPBC Act – Offset for affected threatened biota

12.2.1 Offset requirement

The proposal has been determined a controlled action due to impacts on threatened species and ecological communities listed under the EPBC Act.

The NSW Government and Australian Government finalised amendments to the Assessment Bilateral Agreement after changes to NSW legislation, and the Amending Agreement no. 1 was signed on 24 March 2020. The Australian Government formally endorsed the NSW Biodiversity Offsets Scheme (BOS) through the *EPBC Act Condition-setting Policy* (DAWE 2020).

Under the bilateral agreement, only one decision including conditions on approval is made by NSW, accounting for NSW MNES. The EPBC Act condition setting policy (DAWE 2020) notes that where a project demonstrates compliance with an endorsed state or territory policy, the proponent will not be required to simultaneously comply with the corresponding Australian Government policy. As such, ARTC is not required to calculate offsets separately using the *EPBC Act offsets policy* (DSEWPAc 2012) and associated calculator, unless offsets are required for a species not listed under the BC Act.

To meet offsets required for Commonwealth listed entities for controlled actions under the NSW BOS, ARTC retains the ability to:

- retire biodiversity credits based on the like-for-like provisions in the Biodiversity Conservation Regulation 2017
- fund biodiversity conservation actions that are listed in the Ancillary rules: Biodiversity conservation actions and directly benefit the threatened entity impacted
- pay into the Biodiversity Conservation Fund, noting it is ARTC's responsibility to notify the Biodiversity Conservation Trust (BCT) that their payment is for a controlled action, as the BCT is required to meet the Commonwealth offset requirement component in a like-for-like manner.

12.2.2 Offset strategy

This BDAR includes the identification and assessment of potentially affected MNES. The proposal is likely to have a significant impact on at least seven species that are also listed under the BC Act. No threatened species that are not listed under the BC Act would be significantly impacted by the proposal. Offset requirements have been calculated in accordance with BAM, and will be delivered in accordance with the BOS and BC Act, pursuant to the agreement bilateral. Species credits have been calculated in accordance with the BAM for the two flora species, and for important habitat for the Koala (see Table 12.5). Ecosystem credits have been calculated for impacts on habitat for the Corben's Long-eared Bat, Pilliga Mouse, Painted Honeyeater, Regent Honeyeater, Swift Parrot (see Table 12.6. A breakdown of ecosystem credits for each species is provided in Table 12.7.

As noted above, ARTC is managing the offset strategy for the Inland Rail program as a whole. Offset requirements under the EPBC Act will be included in this strategy. When ARTC or the BCT secure direct offsets they will need to be the relevant species credits and ecosystem credits that are associated with each of the significantly impacted EPBC Act-listed species in order to meet the 'like-for-like' requirement of the agreement bilateral.

Table 12.5 Offset requirements for MNES – species credits under the BAM

Species	Credit type	Area of impact	Credits required
Commersonia procumbens	Species	565.14 hectares of potential habitat	16,431
Lepidium monoplocoides	Species	194.29 hectares of potential habitat	3,353
Tylophora linearis	Species	582.52 hectares of potential habitat	16,902
Koala	Species (important habitat)	718.26 hectares of important habitat	20,562

Table 12.6 Offset requirements for MNES – ecosystem credit species under the BAM

Species	Ecosystem Credits	Area of impact	Vegetation zones	Habitat values required for like-for-like offsets
Corben's Long-eared Bat	24,545	1,125 hectares (total area of known and potential habitat). Hollow-bearing trees provide roosting and breeding habitat for this species.	All woodland and forest PCTs	Hollow-bearing trees Vegetation in moderate-good condition
Painted Honeyeater	24,545	1,125 hectares (total area of potential habitat). Preferred habitat would include areas with higher densities of mistletoes.	Mistletoes recorded in plots in PCTs 27, 244, 394	Vegetation in moderate-good condition Presence of mistletoes
Pilliga Mouse	13,399	630 hectares of potential habitat. This includes 29 hectares of Broombush habitat and 457 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia.*	Preferred habitat in PCTs 141, 394, 398, 404, 409, and 414	Vegetation in moderate-good condition Include areas dominated by Broombush (*Melaleuca uncinata*) and areas containing an understorey of *Acacia burrowii* with a *Corymbia trachyphloia* overstorey
Regent Honeyeater	10,508	1,125 hectares (total area of potential habitat). 479 hectares containing preferred feed trees would be removed, much of this in the Pilliga.	Preferred feed trees present in PCTs 27, 244, 397, 398	Vegetation in moderate-good condition
Swift Parrot (possible significant impact)	15,018	717 hectares of potential foraging habitat containing preferred feed species for this species, of which 511 hectares is in the Pilliga	Preferred feed trees present in PCTs 88, 397, 398 and 399	Vegetation in moderate-good condition

Table 12.7 Offset requirements for MNES – ecosystem credit requirements for fauna species by PCT

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 27 Weeping Myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South Bioregion	3.05	127			3.05	127		
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	0.61	19						
PCT 36 River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	5.08	115						
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	0.21	5						
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	19.5	564						

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	26.23	585						
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	277.79	5166	68.66	1275			277.79	5166
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	29.47	425	29.47	425				
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion	53.99	645						
PCT 148 Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the Brigalow Belt South Bioregion	45.04	1697						

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 185 Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland mainly in the NSW South Western Slopes Bioregion	1.37	0						
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	3.59	179						
PCT 206 Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	12.66	376						
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	31.84	677			31.84	677		
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	14.71	470						

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 255 Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion	11.77	190						
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	0.27	4	0.27	4				
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	69.66	1159	58.44	957	58.44	957		
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	15.78	303	13.48	259	15.78	303	15.78	303
PCT 398 Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	369.78	8444	367.38	8389	369.78	8444	369.78	8444

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	53.71	1105	43.89	903			53.71	1105
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	23.05	544	23.05	544				
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	2.3	49	2.3	49				
PCT 409 Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	0.82	15	0.82	15				
PCT 411 Buloke - White Cypress Pine woodland on outwash plains in the Piliga Scrub and Narrabri region, Brigalow Belt South Bioregion	8.76	327						

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion	7.32	153	7.32	153				
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	6.11	305						
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	1.11	37						
PCT 473 Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	15.26	318						
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	1.23	27	0.5	11				

Plant Community Type	Corben's Long-eared Bat, Regent Honeyeater, Painted Honeyeater	Entire alignment	Pilliga Mouse	Pilliga (segment 10) only	Regent Honeyeater	Preferred foraging habitat	Swift Parrot	Preferred foraging habitat
	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 599 Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	2.21	64						
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	2.12	36						
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	8.77	415	8.77	415				
Total	**1125.17**	**24545**	**624.35**	**13399**	**478.89**	**10508**	**717.06**	**15018**

13. Conclusions

13.1 Proposal background

The proposal is large scale linear infrastructure and will have adverse impacts on biodiversity primarily through vegetation and habitat removal, habitat fragmentation and loss of connectivity.

Detailed environmental investigations have been conducted for the proposal. These investigations included an initial broader study area to identify key constraints early in the design process and assist with avoiding and minimising impacts so far as practicable.

During the development of the proposal, a number of alternate alignments and wider investigations corridors were assessed to assist with identification of the preferred alignment. These were developed in response to the results of ongoing environmental investigations.

Much of the southern and central portion of the proposal is located in land cleared for agriculture. This comprises a mix of cropped land and native grassland used for livestock. Areas of native woodland are also located in agricultural land. In the northern end of the proposal site, large sections are located in areas dominated by vegetation associated with state forests of the Pilliga. The proposal also passes through heavily vegetated areas associated with travelling stock reserves, such as at Bohena Creek near Narrabri and the Macquarie River at Narromine.

13.2 Surveys

The field surveys were undertaken between September 2018 and October 2019. 2018 and 2019 were exceptionally dry in NSW and particularly in inland NSW, and also very warm. Given these prevailing drought conditions, lower plant species diversity was likely to be present during the various field surveys. This in turn can affect identification of PCTs, distribution of vegetation zones and the likelihood of detecting threatened flora species.

The study area was occupied by multiple landowners and featured a variety of land uses at the time of the field surveys. Access was not able to be obtained for the entire study area. Where property access was available, allocation of PCTs was conducted as per Section 5.2 of the BAM. Where access to the study area was not possible, a methodology was developed in consultation with the BCD to determine how PCTs would be identified in the absence of field data.

Thirty-nine PCTs of which five are TECs listed under the BC Act and five are listed TESs under the EPBC Act, have been identified in the construction footprint. While some of the native grasslands in the investigation corridor are naturally occurring, some occur as derived grasslands that are continuous with the understories of the remnant woodland patches in the study area and are considered to be derived from the clearing of the original woodland PCT.

One threatened flora species was identified within the study area during the field survey. *Pterostyils cobarensis* (Cobar Greenhood) was recorded at one location in Pilliga East State Forest. *Bertya opponens* (Coolabah Bertya) is known from adjacent to Bohena Creek rest area on the Newell Highway within the proposal site, although none were observed during surveys. Habitat for six other threatened flora species is assumed to be present in the proposal site.

Seventeen threatened fauna species (of which six are species credit species listed under the BC Act) and one migratory fauna species listed under the EPBC Act were recorded during surveys. Potential habitat for an additional seven species credit species and various species listed under the EPBC Act is also present.

13.3 Potential impacts

13.3.1 Impacts on native vegetation and fauna habitats

Construction of the proposal would result in direct impacts along a 306 kilometre alignment, including the removal of 1,732 hectares of native vegetation. The proposal includes impacts on around 1,125 hectares of native woodland and forest vegetation in good condition, 600 hectares of derived native grassland (including about six hectares of derived Kurrajong grassy open woodland / isolated trees), and about seven hectares of wetland vegetation. The proposal would impact 630 hectares of native vegetation within the Pilliga forests.

The loss of over 1,125 hectares of native forest and woodland will result in the removal of foraging and breeding habitat for these species, and result in the removal of a substantial number of hollow-bearing trees (estimated to be between 13,079 and 29,930 hollow-bearing trees). The loss of such a large number of hollow-bearing trees will have a substantial impact on local populations of threatened fauna reliant on these habitat features, such as the Glossy Black-cockatoo, Barking Owl, Squirrel Glider, Corben's Long-eared Bat and other microbat species.

The proposal would have substantial impacts on fauna habitats, particularly within the Pilliga forests. A clearing corridor of generally 50 metres wide and 73 kilometres long would create a new gap in the forest, result in the loss of numerous hollow-bearing trees and other habitat features such as heathy areas, and is likely to encourage the spread of weeds and pests (including feral predators) through the forest.

13.3.2 Impacts on threatened ecological communities listed under the BC Act

The proposal would impact the following threatened ecological communities listed under the BC Act:

- 3.05 hectares of Myall Woodland in the Darling Riverine Plains, Brigalow Bet South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions
- 0.61 hectares of Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (Brigalow Woodland)
- 3.59 hectares of Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions (Fuzzy Box Woodland)
- 14.71 hectares of Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions
- 8.32 hectares of White Box Yellow Box Blakely's Red Gum Woodland (Box-Gum Woodland).

13.3.3 Serious and irreversible impacts

An assessment of potentially serious and irreversible impacts has been provided for Box-Gum Woodland, Fuzzy Box Woodland and Brigalow Woodland. The proposal is unlikely to result in serious and irreversible impacts to these communities as:

- The removal of about 8.32 hectares of Box-Gum Woodland represents about 0.3 per cent of the community within the subregion. This patch occurs as already isolated roadside vegetation variable up to 20 metres wide with copping on all four sides.
- The removal of 3.59 hectares of Fuzzy Box Woodland represents about 1.16 per cent of the mapped community within the Pilliga subregion.

- The removal of 0.61 hectares of Brigalow Woodland from within a 10 hectare patch represents about 0.006 per cent of the mapped community within the Pilliga Outwash subregion.
- Patches of these communities occur adjacent to the proposal.

None of the species credit species relevant to the proposal are candidate SAII species.

13.3.4 Prescribed impacts

Detailed assessment has been provided for prescribed impacts in accordance with the BAM. In particular, the proposal would have impacts on habitat connectivity, species movement and vehicle strike.

Adverse impacts on connectivity would occur particularly in the Pilliga. The clearing of a generally 50 metre wide gap along a 73 kilometre alignment in the Pilliga would create a barrier to fauna movement, and could result in fragmentation of populations and impacts on gene flow. A total of 73 rail bridges and about 630 banks of drainage culverts are included in the proposal. These bridges will allow some maintenance of riparian and floodplain vegetation, and given the generally ephemeral nature of many watercourses will provide areas of dry passage for fauna to pass underneath for much of the time. Drainage culverts will also act as underpasses for terrestrial fauna for much of the time. Additional dedicated culverts are proposed in areas of Pilliga Mouse habitat where no drainage culverts are required. Together, these design features will help minimise the impacts on connectivity. Mitigation measures including glider poles are also proposed.

Threatened species with particular movement patterns that occur in the study area include the Superb Parrot, Regent Honeyeater, Swift Parrot and Large Bent-winged Bat. These species make long distance movements between foraging and breeding areas. The construction and operation of the proposal is unlikely to impact the movement patterns of these species. While habitat will be removed along the alignment, alternate foraging (and/or breeding) habitat will remain in adjacent areas. Construction of the proposal would not affect movement of these species, given their high mobility and ability to traverse large areas of cleared land.

A range of fauna species are at risk of vehicle strike during construction and train strike during operation of the proposal. Given the low number of train movements proposed, risk of wildlife-train collisions are likely to be relatively low, although would occur on occasion. Fauna connectivity measures including bridges and culverts and mitigation measures such as barrier poles at bridges and fencing in agricultural areas are likely to reduce the risk of vehicle and train strike. Further mitigation measures may be required as a result of monitoring during operation.

13.3.5 Impacts on MNES

The proposal would impact the following threatened ecological communities listed under the EPBC Act:

- 3.05 hectares of Weeping Myall Woodland, from an already isolated and fragmented patch within a cropping matrix
- 0.61 hectares of Brigalow (*Acacia harpophylla* dominant and co-dominant), from within a 10 hectare patch
- 14.71 hectares of Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia, from within a larger 50 hectare patch

- 31.84 hectares of Poplar Box grassy woodland, scattered across more than 10 smaller isolated patches within a farming matrix
- 2.21 hectares of White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grassland. This patch occurs as already isolated roadside vegetation of a total of about 20 metres wide within a farming matrix.

A significant impact is not likely for these communities given the relatively small areas to be removed compared to other vegetation in the area.

The proposal would impact potential habitat for six threatened flora species listed under the EPBC Act. Significant impacts are likely for three species:

- *Commersonia procumbens* (565.14 hectares of assumed potential habitat impacted)
- *Tylophora linearis* (582.51 hectares of assumed potential habitat impacted)
- *Lepidium monoplocoides* (194.29 hectares of assumed potential habitat impacted).

The proposal would impact known or potential habitat for at least nine threatened fauna species and three migratory fauna species listed under the EPBC Act. A significant impact is likely for the following species:

- Koala (718.26 hectares of assumed potential habitat impacted)
- Corben's Long-eared Bat (1125 hectares of assumed potential habitat impacted)
- Pilliga Mouse (624 hectares of assumed potential habitat impacted)
- Painted Honeyeater (1125 hectares of assumed potential habitat impacted)
- Regent Honeyeater(1125 hectares of assumed potential habitat impacted)
- Swift Parrot (717 hectares of assumed potential habitat impacted).

This is due to the large area of habitat to be removed and impacts on connectivity (all species), and substantial numbers of hollow-bearing trees to be removed (for Corben's Long-eared Bat).

13.4 Offset requirements

Offsets are required for residual impacts that cannot be avoided or mitigated. Credit requirements for the proposal calculated using the BAMC include:

- 34,820 ecosystem credits are required for the proposal
- 160,421 species credits are required.

Species credits have been calculated for the following species:

- Cobar Greenhood (*Pterostylis cobarensis*)
- *Commersonia procumbens*
- Coolbah Bertya (*Bertya opponens*)
- Native Milkwort (*Polygala linariifolia*)
- Pine Donkey Orchid (*Diuris tricolor*)
- Slender Darling Pea (*Swainsona murrayana*)
- Spiny Peppercress (*Lepidium aschersonii*)
- *Tylophora linearis*
- Winged Peppercress (*Lepidium monoplocoides*)
- Barking Owl (*Ninox connivens*)

- Bush Stone-curlew (*Burhinus grallarius*)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Glossy Black-cockatoo (*Calyptorhynchus lathami*)
- Koala (*Phascolarctos cinereus*)
- Little Eagle (*Hieraaetus morphnoides*)
- Masked Owl (*Tyto novaehollandiae*)
- Pale-headed Snake (*Hoplocephalus bitorquatus*)
- Rufous Bettong (*Aepyprymnus rufescens*)
- Square-tailed Kite (*Lophoictinia isura*)
- Squirrel Glider (*Petaurus norfolcensis*).

The proposal has been segmented into 11 separate construction segments, with the ecosystem and species credits prorated across each of the segments. Given the scale and complexity of Inland Rail projects and the large quantity of credits required, there is a risk that the time taken to retire credits for the entire proposal as required by the BC Act could delay commencement of construction. This approach of presenting the 11 construction segments in the BDAR would provide valuable flexibility to the Principal Contractor during construction. Credits for each segment would be fully retired before construction commenced for each segment.

ARTC is managing the offset strategy for the entire Inland Rail program, and have invited landowners within 100 kilometres of the route in NSW to contact them regarding establishing a Biodiversity Stewardship Site so that ARTC can purchase the appropriate credits. ARTC would also consider other potential possibilities including identifying and purchasing their own sites and retiring credits. Where credits are not available for purchase, ARTC would make a payment into the BCF.

Additional targeted seasonal surveys are proposed to be undertaken in Spring 2020, to assist in further refining the extrapolation of plant community types and assumed species presence due to survey limitations documented in this report. Additional surveys are likely to include vegetation integrity plots in previously extrapolated areas and targeted species credit surveys for:

- *Commersonia procumbens*
- *Tylophora linearis*
- *Lepidium monoplocoides*
- *Pterostylis cobarensis*
- *Lepidium aschersonii*
- *Diuris tricolor*
- *Bertya opponens*

The results of these findings would be documented in an addendum biodiversity report and included as part of the addendum biodiversity report following public exhibition.

EPBC Act offset requirements have been calculated in accordance with the BAM, and would be delivered in accordance with the BOS and BC Act, pursuant to the agreement bilateral. Like-for-like offsets are required for species likely to be significantly impacted by the proposal. Species credits have been calculated in accordance with the BAM for two flora species listed under the EPBC Act, and for important habitat for the Koala. Ecosystem credits have been calculated for the remaining threatened fauna species.

13.5 Mitigation

A total of 73 rail bridges and about 630 banks of drainage culverts are included in the proposal. These bridges will allow some maintenance of riparian and floodplain vegetation connectivity, and given the generally dry nature of many will provide areas of dry passage for fauna to pass underneath for much of the time. Drainage culverts will also act as underpasses for some terrestrial fauna to use these features where design dimensions and culvert conditions are adequate. Together, these design features will help minimise the impacts on connectivity. A connectivity strategy would be prepared that would outline the various structures and their locations, monitoring of threatened species and efficacy of connectivity structures.

Additional targeted threatened species surveys are recommended prior to construction. These would enable:

- identification of flora populations that may require avoidance and mitigation during construction
- identification of nest trees (where possible) in the proposal site for the Glossy Black-cockatoo, Barking Owl, Masked Owl, Little Eagle and Square-tailed Kite.

Use of detection dogs is recommended for targeted surveys for Koalas and some flora species.

The following mitigation measures are proposed for the construction phase:

- preparation of a biodiversity management sub-plan to the CEMP, including:
  - measures for the protection of sensitive areas outside the proposal site during construction
  - weed and pest management measures
  - procedures for the management and assessment of unexpected finds
  - pre-clearing surveys, including surveys to identify and manage removal of hollow-bearing trees
  - management of fauna and habitat features during clearing
  - rehabilitation of disturbed areas following construction.

The following mitigation measures are proposed for the operational phase:

- preparation and implementation of a weed and pest management strategy
- implementation of a fauna connectivity strategy, including monitoring of use of fauna connectivity structures by threatened species and pest species, and fauna mortality from train strike.

14. References

ABC (2014). *Could there be as few as 50 koalas left in the Pilliga?* Kelley Fuhler for ABC New England North West. 15 December 2104. Accessed at: https://www.abc.net.au/local/stories/2014/12/15/4148934.htm

ABC (2014). How many Glossy Black Cockatoos in the Pilliga State Forest? Andrew Dunkley for ABC Western Plains. 21 January 2014. Accessed at: http://www.abc.net.au/local/stories/2014/01/15/3925945.htm

Abson, R.N. (2004). *The use by vertebrate fauna of the Slaty Creek Wildlife Underpass, Calder Freeway, Black Forest, Macedon, Victoria.* Master's Thesis.

Accad, A., Neldner, V.J., Wilson, B.A. and Niehus, R.E. (2006). *Remnant vegetation in Queensland. Analysis of remnant vegetation 1997-1999-2000-2003, including regional ecosystem information*. Queensland Herbarium, QLD Environmental Protection Agency.

AMBS (2001). *Fauna Underpass Monitoring Stage Two, Episode Three, Bulahdelah to Coolongolook,* July 2001. Australian Museum Business Services Consulting report for Roads and Traffic Authority.

AMBS (2002a). *Fauna underpass monitoring, Stage One - Final Report - Brunswick Heads*. Australian Museum Business Services Consulting report for Roads and Traffic Authority.

AMBS (2002b). *Fauna underpass monitoring, Stage One - Final Report – Taree*. Australian Museum Business Services Consulting report for Roads and Traffic Authority.

AMBS (2002c). *Fauna underpass monitoring, Stage One - Final Report - Bulahdelah to Coolongolook*. Australian Museum Business Services Consulting report for Roads and Traffic Authority.

AMBS (2009). *Investigation of the Impact of Roads on Koalas: Progress Report for January - March 2009*. Australian Museum Business Services Consulting report for Roads and Traffic Authority.

AMBS (2011). *Investigation of the impact of roads on koalas*. Prepared by Australian Museum Business Services, Sydney, for the NSW Roads and Traffic Autho

Andrews, A. (1990). Fragmentation of habitat by roads and utility corridors: a review. *Australian Zoologist* 26: 130-142.

Ascensao, F. and Capinha, C. (2017). Aliens on the Move: Transportation Networks and Non-native Species. Chapter 5 of Railway Ecology. Ed Borda-de-Agua, L., Barrientos, R., Beja, P. and Pereira, H.M. Springer Open.

Atlas of Living Australia (2019). Online database. Accessed at: https://www.ala.org.

Atlas of Living Australia (2020a). Black-breasted Buzzard https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:c89b8b74-f2bb-4a39-a6a9-e6573d36d557

Atlas of Living Australia (2020b). Major Mitchell's Cockatoo https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0217f06f-664c-4c64-bc59-1b54650fa23d

Atlas of Living Australia (2020c). Powerful Owl

https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0217f06f-664c-4c64-bc59-1b54650fa23d

Austin, M.P., Cawsey, E.M., Baker, B.L., Yialeloglou, M.M., Grice, D.J. and Briggs, S.V. (2000). Predicted vegetation cover in the Central Lachlan Region. CSIRO, Canberra.

Australian Museum (2019a). Pale-headed Snake. Accessed at: https://australianmuseum.net.au/learn/animals/reptiles/pale-headed-snake/

Australian Museum (2019b). Black-striped Wallaby. Accessed at: https://australianmuseum.net.au/learn/animals/mammals/black-striped-wallaby/?gclid=EAIaIQobChMIxYHKve2o4gIVEw4rCh1fVA2jEAAYASAAEgIr9_D_BwE

Ayers, D., S. Nash and K. Baggett (Eds) (1996). Threatened Species of Western New South Wales. Hurstville: NSW NPWS.

Babińska-Werka, J., Krauze-Gryz, D., Wasilewski, M., and Jasińska, K. (2015). Effectiveness of an acoustic wildlife warning device using natural calls to reduce the risk of train collisions with animals. *Transportation Research Part D*, 38, 6–14.

Backs, J.A.J., Nychka, J.A.,, and St Clair, C.C. (2017). Warning systems triggered by trains could reduce collisions with wildlife. *Ecological Engineering* 106: 563–569.

Baker-Gabb, D. (2011). National Recovery Plan for the Superb Parrot *Polytelis swainsonii*. Department of Sustainability and Environment, Melbourne.

Ball and Goldingay (2008) Can wooden poles be used to reconnect habitat for a gliding mammal? *Landscape and Urban Planning* 87, 140-146.

Barber, J.R., Fristrup, K. M., Brown, C. L., Hardy, A. R., Angeloni, L. M. and Crooks, K. R. (2009). Conserving the wild life therein - Protecting park fauna from anthropogenic noise. *Park Science* 26 (3).

Bard, A.M. Smith, H.T., Egensteiner, E.D., Mulholland, R., Harber, T.V., Heath, G.W., Miller, W.J.B. and Weske, J.S. (2002). A simple structural method to reduce road-kills of Royal Terns at bridge sites. *Wildlife Society Bulletin*. 30:603-605.

Barrett G, Silcocks A, Barry S, Cunningham R, Poulter R (2003). *The New Atlas of Australian. Birds*. RAOU: Melbourne.

Barrientos, R. and Borda-de-Agua (2017). Railways as Barriers for Wildlife: Current Knowledge. Chapter 4 of *Railway Ecology*. Ed Borda-de-Agua, L., Barrientos, R., Beja, P. and Pereira, H.M. Springer Open.

Bee, M. A. and Swanson, E. M. (2007). Auditory masking of anuran advertisement calls by road traffic noise. *Animal Behaviour,* 74(6), 1765–1776. https://doi.org/10.1016/j.anbehav.2007.03.019

Bell, D., Hunter, J. and Montgomery, L. (2012). 'Ephemeral wetlands of the Pilliga Outwash, northwest NSW'. *Cunninghamia* **12**: 181-190.

Benítez-López, A., Alkemade, R., and Verweij, P. A. (2010). The impacts of roads and other infrastructure on mammal and bird populations: A meta-analysis. *Biological Conservation* 143: 1307–1316.

Benson, J.S. (2006). NSW Vegetation Classification and Assessment: Introduction – the classification, database, assessment of protected areas and threat status of plant communities. *Cunninghamia* 9(3): 331-381, Sydney.

Bhattacharya, M., Primack, R.B. and Gerwin, J. (2003). Are roads and railroads barriers to bumblebee movement in a temperate suburban conservation area? *Biological Conservation* 109(1): 37-45

Birdlife Australia (2020a). Birdata records. Data provided for the proposal area under licence by Birdlife Australia.

Birdlife Australia (2020b). Bush Stone-curlew. http://www.birdlife.org.au/bird-profile/bush-stone-curlew

BirdLife International (2018). *Lathamus discolor*. The IUCN Red List of Threatened Species 2018: e.T22685219A130886700. http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22685219A130886700.en . Downloaded on 01 May 2019.

BirdLife International (2019). *Important Bird Areas factsheet: Pilliga*. Downloaded from http://datazone.birdlife.org/site/factsheet/pilliga-iba-australia on 07/01/2019

Bitterns in Rice Project (2018). Accessed at http://www.bitternsinrice.com.au/

Bladon, R. V., Dickman, C. R. and Hume, I. D. (2002). Effects of habitat fragmentation on the demography, movements and social organisation of the eastern pygmy possum (*Cercartetus nanus*) in northern NSW. *Wildlife Research* 29, 105–116.

BOM (2018). Dubbo and Narrabri weather stations. Accessed at http://www.bom.gov.au/climate/data/stations/

BOM (2020). Groundwater Dependent Ecosystems Atlas. Accessed at http://www.bom.gov.au/water/groundwater/gde/

Bond, A. and Jones, D. (2008) Temporal trends in use of fauna friendly underpasses and overpasses. Wildlife Research 35. 103-112.

Borda-de-Agua, L., Barrientos, R., Beja, P. and Pereira, H.M. (2017). *Railway Ecology*. Springer Open.

Bowen, M. and Goldingay, R. (2000). Distribution and status of the Eastern Pygmy Possum (*Cercartetus nanus*) in NSW. *Australian Mammalogy* 21:153-164.

Brandle, R. and Moseby, K. E. (1999). Comparative ecology of two populations of *Pseudomys australis* in northern South Australia. *Wildlife Research* 26, 541–564.

Budzic, K. A. and Budzic, K. M. (2014). A preliminary report of amphibian mortality patterns on railways. *Acta Herpetologica*, 9: 103–107.

Butler, D.W. (2007). Recovery plan for the "Brigalow (*Acacia harpophylla* dominant and codominant)" endangered ecological community (draft of 1 May 2007). Report to the Department of the Environment and Water Resources, Canberra. Qld National Parks and Wildlife Service, Brisbane

Cann, B., Williams, J.E. and Shields, J.M., (2002). Monitoring large forest owls and gliders after recent logging in production regrowth forests of the mid-north coastal region of NSW. In Newton, I., Kavanagh, R.P., Olsen, J., & Taylor, I.R. *Ecology and Conservation of Owls*.

Carter, O. (2010). National Recovery Plan for the Spiny Peppercress *Lepidium aschersonii*. Department of Sustainability and Environment, Melbourne.

Carvalho, F., Santos, S. M., Mira, A. and Lourenco, R. (2017). Methods to Monitor and Mitigate Wildlife Mortality in Railways. Chapter 3 of *Railway Ecology*. Ed Borda-de-Agua, L., Barrientos, R., Beja, P. and Pereira, H.M. Springer Open.

Centre for Plant Biodiversity Research (CPBR) 2008, *Swainsona murrayana*, Australia's Virtual Herbarium records, Accessed http://www.anbg.gov.au/cgi-bin/avh.cgi.

Child, K. (1983). Railways and moose in the central interior of BC: A recurrent management problem. *Alces*, 19: 118–135.

Christie, P. (2004). Extension of the known breeding range of the Superb Parrot. *Corella* 28: 75-78.

Churchill, S. (2008). *Australian Bats*, Allen and Unwin, Australia.

Clevenger, A.P., Chruszcz, B. and Gunson, K. (2002). Drainage culverts as habitat linkages and factors affecting passage for mammals. *Journal of Applied Ecology* 38, 1340–1349.

Copeland, L. M. (2008). *Conservation status of Tylophora linearis P.I.Forst. in NSW*. Report to the NSW Scientific Committee, Sydney.

Cropper, S. (1993). *Management of endangered plants*, CSIRO Publications, Melbourne.

Date, E.M., Ford, H.A. and Recher, H.F. (2002). Impacts of logging, fire and grazing regimes on bird species assemblages of the Pilliga woodlands of NSW. *Pacific Conservation Biology* 8: 177-195.

Davidson, I., Scammell, A., O'Shannassy, P., Mullins, M. and Learmoth, S. (2005). Travelling stock reserves: refuges for stock and biodiversity? *Ecological Management and Restoration* 6: 5-15.

DAWE (2020a). EPBC Act Condition-setting Policy. Department of Agriculture, Water and the Environment. https://www.environment.gov.au/epbc/publications/condition-setting-policy

DAWE (2020b). Directory of Important Wetlands in Australia. Accessed at https://www.environment.gov.au/water/wetlands/australian-wetlands-database/directory-important-wetlands

DAWE (2020c). *Protected Species in Bushfire Affected Areas*. Australian Government. Accessed 12 March 2020. Accessed via https://www.environment.gov.au/biodiversity/bushfire-recovery/research-and-resources

DAWE (2020d). Register of Critical Habitat. Accessed at https://www.environment.gov.au/cgi-bin/sprat/public/publicregisterofcriticalhabitat.pl

DAWE (2020e). National Flying Fox Web Viewer. Online resource. https://www.environment.gov.au/biodiversity/threatened/species/flying-fox-monitoring

Dawson, S.J., Adams, P.J., Moseby, K.E., Waddington, K.I., Kobryn, H.T., Batemna, P.W. and Fleming, P.A. (2017). Peak hour in the bush: linear anthropogenic clearings funnel predator and prey species. *Austral Ecology 43:* 159-171.

Debus, S. (1998) The birds of prey of Australia: a field guide. Oxford University Press, Melbourne.

Debus, S. (2010). Surveys of the Barking Owl and Masked Owl on the north-west slopes of New South Wales. *Corella* 25: 5-11.

Debus. S. and Chafer, C. (1994). The Powerful Owl *Ninox strenua* in New South Wales. *Australian Birds* 28: S21-S39.

Debus, S.J.S., Hatfield, T.S., Ley, A.J. and Rose, A.B. (2007). Breeding biology and diet of the Wedge-tailed Eagle *Aquila audax* in the New England region of New South Wales. *Australian Field Ornithology*, 24(3), p.93.

DEC (2004a). *Wildlife corridors*. Department of Environment and Conservation. Accessed at http://www.environment.nsw.gov.au/resources/nature/landholderNotes15WildlifeCorridors.pdf

DEC (2004b). *Threatened biodiversity survey and assessment: Guidelines for developments and activities (2004 working draft)*. Department of Environment and Conservation. Accessed at https://www.environment.nsw.gov.au/research-and-publications/publications-search/threatened-biodiversity-survey-and-assessment

DECC (2002). *Descriptions for NSW (Mitchell) Landscapes Version 2 (2002)*. Department of Environment and Climate Change, Sydney NSW.

DECC (2005). *Swainsona murrayana* – profile, http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10779.

DECC (2006). NSW Recovery Plan for the Large Forest Owls: Powerful Owl (*Ninox strenua*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*Tyto novaehollandiae*) DEC, Sydney.

DECC (2008). Approved Recovery Plan for the Koala (*Phascolarctos cinereus*).

DECC (2008b). Approved Recovery Plan for the Brush-tailed Rock-wallaby (*Petrogale penicillata*). https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Recovery-plans/brush-tailed-rock-wallaby-petrogale-penicillata-recovery-plan-080138.pdf

DECC (2009). *NSW State of Environment Report*. Department of Environment, Climate Change and Water: Sydney, Australia, p. 255.

DECC (2010). *National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Accessed on 19 March 2020. Accessed at: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/white-box-yellow-box-blakelys-red-gum-grassy-woodland-and-derived-native-grassland-national

DEE (2016). *Threat abatement plan for competition and land degradation by rabbits*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016.

DEE (2017a). *EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*. http://www.environment.gov.au/epbc/publications/shorebirds-guidelines

DEE (2017b). *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa)* . Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017.

DEE (2019a). Protected Matters Search Tool. Accessed at https://www.environment.gov.au/epbc/pmst/index.html

DEE (2019b). Species Profile and Threats Database (SPRAT). Accessed at https://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

DEH (2005). Australian Threatened Species: Bush Stone-curlew (*Burhinus grallarius*). https://www.environment.gov.au/system/files/resources/ceebef10-c480-4ced-a026-bb5a241b70d4/files/tsd05bush-stone-curlew.pdf

DEH (2006). *Management of Phytophthora Cinnamomi for Biodiversity Conservation in Australia*. Department of Environment and Heritage, Canberra.

del Hoyo, J.A. and Elliott, J. (1997). *Handbook of Birds of the World; Vol. 4 Sandgrouse to Cuckoos.* Barcelona: Lynx Edicions.

DERM (2011). *National recovery plan for the large-eared pied bat Chalinolobus dwyeri*. Department of Environment and Resource Management. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DEWHA (2008). Approved Conservation Advice for *Rulingia procumbens*. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/12903-conservation-advice.pdf

DEWHA (2008). Approved Conservation Advice for *Swainsona murrayana* (Slender Darling-pea). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/6765-conservation-advice.pdf

DEWHA (2008). Threat abatement plan for competition and land degradation by unmanaged goats. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-unmanaged-goats

DEWHA (2010a). Survey guidelines for Australia's threatened bats. Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999. http://www.environment.gov.au/resource/survey-guidelines-australias-threatened-bats-guidelines-detecting-bats-listed-threatened

DEWHA (2010b). Survey guidelines for Australia's threatened birds. Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999. http://www.environment.gov.au/publications/survey-guidelines-australias-threatened-birds-guidelines-detecting-birds-listed-threatened

DEWHA (2010c). Survey guidelines for Australia's threatened birds. Guidelines for detecting frogs listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999. https://www.environment.gov.au/resource/survey-guidelines-australias-threatened-frogs-guidelines-detecting-frogs-listed-threatened

DEWHA (2010d). Survey guidelines for Australia's threatened mammals. Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999. http://www.environment.gov.au/resource/survey-guidelines-australias-threatened-mammals-guidelines-detecting-mammals-listed

DEWHA (2010e). Survey guidelines for Australia's threatened reptiles. Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999. http://www.environment.gov.au/resource/survey-guidelines-australias-threatened-reptiles-guidelines-detecting-reptiles-listed

Dique, D.S., Thompson, J., Preece, H.J., de Villiers, D.L. and Carrick, F.N. (2003). Dispersal patterns in a regional koala population in south-east Queensland. *Wildlife Research* 30: 281 – 290.

DLWC (2002). The NSW State Groundwater Dependent Ecosystems Policy. Accessed at http://www.water.nsw.gov.au/__data/assets/pdf_file/0005/547844/groundwater_dependent_ecosystem_policy_300402.pdf

DoE (2013). *Draft survey guidelines for Australia's threatened orchids*. http://www.environment.gov.au/resource/draft-survey-guidelines-australias-threatened-orchids

DoE (2014). *EPBC Act referral guidelines for the vulnerable koala (combined populations of Queensland, New South Wales and the Australian Capital Territory*). http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala

DoE (2015a). *Referral guideline for 14 birds listed as migratory species under the EPBC Act*. http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-migratory-birds

DoE (2015b). Conservation advice *Grantiella picta* Painted Honeyeater. http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf

DoE (2016). *National recovery plan for the Regent Honeyeater*. https://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-regent-honeyeater-anthochaera-phrygia-2016

DoE (2020). *Dichanthium setosum* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat

DoE (2020). *Homopholis belsonii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Dorsey, B., Olsson, M. and Rew, L. J. (2015). Ecological effects of railways on wildlife. In R. van der Ree, D. J. Smith, & C. Grilo (Eds.), *Handbook of Road Ecology* (pp. 219–227). West Sussex: Wiley.

DPI (2013). *Policy and guidelines for fish habitat conservation and management*. Department of Primary Industries. Accessed at https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/634694/Policy-and-guidelines-for-fish-habitat.pdf

DPI (2016). *Myrtle rust: Primefact 1417*. First edition. Plant Biosecurity & Product Integrity. Orange

DPIE (2020). *Surveying threatened plants and their habitats. NSW survey guide for the Biodiversity Assessment Method*.NSw Department of Planning, Industry and Environment.

DPIE (2020b). BAM Important Area Maps. https://webmap.environment.nsw.gov.au/Html5Viewer291/index.html?viewer=BAM_ImportantAreas

DSE (2010). National recovery plan for the Winged Peppercress (*Lepidium monoplocoides*). Victorian Department of Sustainability and Environment. http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-winged-peppercress-lepidium-monoplocoides

DSEWPaC (2011). *Survey guidelines for Australia's threatened reptiles*. Department of Sustainability, Environment, Water, Population and Communities. http://www.environment.gov.au/system/files/resources/eba674a5-b220-4ef1-9f3a-b9ff3f08a959/files/survey-guidelines-reptiles.pdf

DSEWPaC (2012). *Environment Protection and Biodiversity Conservation Act 1999 - Environmental Offsets Policy*. Accessed at https://www.environment.gov.au/system/files/resources/12630bb4-2c10-4c8e-815f-2d7862bf87e7/files/offsets-policy_2.pdf

Duffy, A. M. Lumsden, L. F. Caddle,C.R. Chick,R.R. and Newell G. R. (2000). The efficacy of AnaBat ultrasonic detectors and harptraps for surveying microchiropterans in south-eastern Australia. *Acta Chiropterologica* 2:127–144

Eby, P. and Law, B. (2008). Ranking the feeding habitats of Grey-headed flying foxes for conservation management.Department of Environment and Climate Change and Water (NSW) & The Department of Environment, Water, Heritage and the Arts http://www.environment.nsw.gov.au/resources/threatenedspecies/GHFFmainreport.pdf

EES (2019a). *NSW BioNet Database* of threatened species listed under the BC Act. Accessed at: https://www.environment.nsw.gov.au/asmslightprofileapp/account/login?ReturnUrl=%2fAtlasApp%2fDefault.aspx

EES (2019b). *NSW BioNet Vegetation Classification.* Accessed at https://www.environment.nsw.gov.au/research/Visclassification.htm

EES (2019c). T*hreatened biodiversity profile search*. Accessed at http://www.environment.nsw.gov.au/threatenedspecies/

EES (2020a). *Guideline for applying the Biodiversity Assessment Method at severely burnt sites*.

EES (2020b). BAM Important Areas. Accessed at https://webmap.environment.nsw.gov.au/Html5Viewer291/index.html?viewer=BAM_ImportantAreas

EES (2020c). Guidance to assist a decisionmaker to determine a serious and irreversible impact. Accessed at https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-offsets-scheme/serious-and-irreversible-impacts

Elton, C. S. (1958). *The ecology of invasions by animals and plants*. Chicago: University of Chicago Press.

eSPADE [v2.0]. (2020). NSW Soil and Land Information. Accessed at https://www.environment.nsw.gov.au/eSpade2Webapp.

Fairfull, S. and Witheridge, G. (2003). *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*. NSW Fisheries. Accessed at https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/633505/Why-do-fish-need-to-cross-the-road_booklet.pdf

Farmer, A. (1993). The effects of dust on vegetation - a review. *Environmental Pollution* 79: 63-75.

Fischer, J. and Lindenmayer, D. (2002). Small patches can be valuable for biodiversity conservation: two case studies on birds in southeastern Australia. *Biological Conservation* 106: 129–136.

Fisher, A. M. and D. C. Goldney. (1997). Use by birds of riparian vegetation in an extensively fragmented landscape. *Pacific Conservation Biology* 3:275–288.

Fitzgerald, M., Lazell, B. and Shine, R. (2010). Ecology and conservation of the Pale-headed Snake (*Hoplocephalus bitorquatus*, Elapidae). *Australian Zoologist* 35: 283-290.

Forman, R.T.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R.L., Goldman, C.R., Heanue, K., Jones, J., Swanson, F., Turrentine, T. and Winter, T.C. (2003). *Road ecology: science and solutions*, Island Press, Washington.

Forster, P. I., Binns, D., Robertson, G. R. (2004). Rediscovery of *Tylophora linearis* P.I.Forst. (Apocynaceae: Asclepiadoideae) from NSW, with revision of its conservation status to vulnerable. *Austrobaileya,* 6(4): 941-947.

Fox, B. J. and Briscoe, D. A. (1980). *Pseudomys pilligaensis*, a new species of murid rodent from the Pilliga Scrub, northern NSW. *Australian Mammalogy* 3: 109-26.

Fox, S., Potts, J.M., Pemberton, D. and Crosswell, D. (2018). Roadkill mitigation: trailling virtual fence devices on the west coast of Tasmania. *Australian Mammalogy* 41:

Garnett, S.T. and G.M. Crowley. (2000). *The Action Plan for Australian Birds*. Environment Australia, Canberra, Australia.

Garnett, S.T., Szabo, J.K. and Dutson. G. (2011). The Action Plan for Australian Birds 2010. Birds Australia, CSIRO Publishing, Melbourne.

Gelbard, J. L. and Belnap, J. (2003). Roads as conduits for exotic plant invasions in semiarid landscape. *Conservation Biology* 17:420–432.

Gibbons, P., Lindenmayer, D.B., Barry, S.C. and Tanton, M.T. (2000). Hollow formation in eucalypts from temperate forests in south-eastern Australia. *Pacific Conservation Biology* 6: 218-228.

Gibeau, M. L. and Herrero, S. (1998). Roads, rails and Grizzly bears in the Bow River Valley, Alberta. In G. L. Evink, P. Garrett, D. Zeigler, & J. Berry (Eds.), *Proceedings of the international conference on wildlife ecology and transportation* (pp. 104–108). Florida Department of Transportation, Tallahassee, Florida, USA.

Goldingay R. and Jackson S.M. (2004). A review of the ecology of the Petauridae. In *The Biology of Australian Possums and Gliders*. (Eds R Goldingay & SM Jackson) pp. 376-400. (Surrey Beatty: Sydney).

Goldingay, R.L. and Taylor, B.D. (2009). Gliding performance and its relevance to gap crossing by the squirrel glider (*Petaurus norfolcensis*)', *Australian Journal of Zoology* 57(2): 99-104.

Goldingay, R.L., Rohweder, D. and Taylor, B. D. (2013). Will arboreal mammals use rope bridges across a highway in eastern Australia. *Australian Mammalogy*: 35, 30-38.

Goldingay, RL and Dobner, B (2014). Home range areas of koalas in an urban area of north-east New South Wales. *Australian Mammalogy*, 36, 74-80.

Gundersen, H., and Andreassen, H. P. (1998). The risk of moose *Alces alces* collision: A predictive logistic model for moose-train accidents. *Wildlife Biology*, 4: 103–110.

Hansen, M. J. and Clevenger, A. P. (2005). The Influence of Disturbance and Habitat on the Presence of Non-Native Plant Species along Transport Corridors. *Biological Conservation* 125: 249-259. https://doi.org/10.1016/j.biocon.2005.03.024

Harden G. J. (ed.) (2002). *Flora of New South Wales*, vol. 4. University of NSW Press. Kensington, New South Wales.

Harris, J.M. (2008). *Cercartetus nanus* (Diprotodontia: Burramyidae). *Mammalian Species* 815: 1-10.

Harris, J.M., Goldingay, R.L. and Brooks, L.O. (2014). Population ecology of the eastern pygmy-possum (*Cercartetus nanus*) in a montane woodland in southern New South Wales. *Australian Mammalogy* 36: 212-218.

Heske, E. J. (2015). Blood on the tracks: Track mortality and scavenging rate in urban nature preserves. *Urban Naturalist*, 4: 1–13.

Hesse, P., and Humphreys, G. (2001). Pilliga landscapes, quaternary environment and geomorphology. In J. Dargavel, D. Hart, and B. Libbis (Eds.), Perfumed Pineries: Environmental history of Australia’s Callitris forests (pp. 79–87). Centre for Resource and Environmental Studies, The Australian National University.

Hibberd J. K. and Soutberg T. L. (1991). Roadside reserve condition 1977–89 in the Southern Tablelands of New South Wales. In: *Nature Conservation 2: The Role of Corridors* (eds D. A. Saunders and R. J. Hobbs), pp. 177– 186. Surrey Beatty & Sons, Chipping Norton.

Higgins, P.J. (1999). *Handbook of Australian, New Zealand & Antarctic Birds. Volume 4, Parrots to Dollarbird*. Oxford University Press.

Hofmann, J. E. (2009). Records of nine-banded armadillos, *Dasypus novemcinctus* in Illinois. *Transactions of the Illinois State Academy of Science*, 102, 95–106.

Holderegger, R. and Di Giulio, M. (2010). The genetic effects of roads: A review of empirical evidence. *Basic and Applied Ecology*, 11: 522–531.

Hoolihan, D. and Goldizen. A. (1998). The grouping dynamics of the black-striped wallaby. *Wildlife Research*, 25: 467-473.

Hoye GA and Schulz M (2008). Large-eared Pied Bat *Chalinolobus dwyeri* pp. 531–532 In: *Mammals of Australia* 3rd edition (eds. S Van Dyck and R Strahan), Australian Museum, Sydney.

Hoye, G.A. (2005). Recovery plan for the large-eared pied bat *Chalinolobus dwyeri*. Fly By Night Bat Surveys Pty Ltd. Queensland Parks and Wildlife Service. Brisbane

Invasive Plants and Animals Committee (IPAC). (2016). Australian Weeds Strategy 2017 to 2019. Accessed at https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/pests-diseases-weeds/consultation/aws-final.pdf

Ito, T. Y., Lhagvasuren, B., Tsunekawa, A., Shinoda, M., Takatsuki, S., Buuveibaatar, B., et al. (2013). Fragmentation of the habitat of wild ungulates by anthropogenic barriers in Mongolia. *PLoS ONE*, 8, e56995.

Ito, T. Y., Miura, N., Lhagvasuren, B., Enkhbileg, D., Takatsuki, S., Tsunekawa, A., et al. (2005). Preliminary evidence of a barrier effect of a railroad on the migration of Mongolian gazelles. *Conservation Biology*, 19, 945–948.

Ito, T. Y., Okada, A., Buuveibaatar, B., Lhagvasuren, B., Takatsuki, S., & Tsunekawa, A. (2008). One-sided barrier effect of an international railroad on Mongolian gazelles. *Journal of Wildlife Management*, 72, 940–943.

Jackson, S.D. (2000). Overview of Transportation Impacts on Wildlife Movement and Populations. Pp. 7-20 In Messmer, T.A. and B. West, (eds) Wildlife and Highways: Seeking Solutions to an Ecological and Socio-economic Dilemma. The Wildlife Society. http://www.wildlifecrossings.info/beta2.htm

JacobsGHD, (2020a). *ARTC Inland Rail Narromine to Narrabri Aquatic Ecology Assessment*.

JacobsGHD, (2020b). *ARTC Inland Rail Narromine to Narrabri Groundwater Assessment*.

Johnson, M., Reich, P. and MacNally, R. (2007). Bird assemblages of a fragmented agricultural landscape and the relative importance of vegetation structure and landscape pattern. *Wildlife Research* 34: 185-193.

Johnstone, D. (undated). Bird Routes of Baradine and the Pilliga. http://visitbaradine.com.au/images/Bird%20brochure%20package%20for%20PDF%20FINAL2.pdf

Kaczensky, P., Knauer, F., Krze, B., Jonozovic, M., Adamic, M., and Gossow, H. (2003). The impact of high speed, high volume traffic axes on brown bears in Slovenia. *Biological Conservation*, 111, 191–204.

Kammonen, J. (2015). Foraging behaviour of *Myotis mystacinus* and *M. brandtii* in relation to a big road and railway in south-central Sweden. Bachelor's thesis. Uppsala: Uppsala Univeristy.

Kavanagh, R. P., and Barrott, E. (2001). Koala populations in the Pilliga Forests. In '*Perfumed Pineries: Environmental History of Australia's Callitris Forests'*. (Eds J. Dargavel, D. Hart, and B. Libbis.) pp. 93–103. (Centre for Resource and Environmental Studies, Australian National University: Canberra.)

Kavanagh, R.P. (2002). Comparative diets of the Powerful owl (*Ninox strenua*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*Tyto novaehollandiae*) in southeastern Australia. In '*Ecology and Conservation of Owls'*. (Eds Pp. 175-191. CSIRO Publishing.

Kavanagh, R.P. (2004) Distribution and conservation status of possums and gliders in New South Wales. In *The Biology of Australian Possums and Gliders*. pp. 130-148. Surrey Beatty and Sons.

Kerle A and Paull D (2004). Recent decline of Common Brushtail and Common Ringtail Possums in the Pilliga forests, New South Wales? In 'The Biology of Australian Possums and Gliders'. (Eds R Goldingay & SM Jackson) pp. 85-90. (Surrey Beatty: Sydney).

Kerle, A (2004). A cautionary tale: decline of the Common Brushtail Possum *Trichosurus vulpecula* and Common Ringtail Possum *Pseudocheirus peregrinus* in the woodlands of the western slopes and plains of New South Wales. In 'The Biology of Australian Possums and Gliders'. (Eds R Goldingay & SM Jackson) pp. 71-84. (Surrey Beatty: Sydney)

Knight, A. R. (2015). The case for Sloane's Froglet: Generating ecological knowledge with the intent to benefit biodiversity. PhD Thesis, Charles Sturt University.

Kuginis, L. Williams, J. P. Byrne, G. and Serov, P. (2012). Risk assessment guidelines for groundwater dependent ecosystems, Volume 4 - The ecological value of groundwater sources on the coastal plains of NSW and the risk from groundwater extraction. NSW Department of Primary Industries. Accessed at http://www.water.nsw.gov.au/__data/assets/pdf_file/0011/548336/gde_risk_assessment_guidelines_volume_4_part07_split-02.pdf

Law, B. Chidel, M. and Turner, G. (2000). The use by wildlife of paddock trees. *Pacific Conservation Biology* 6(2):130-143.

Law, B., Chidel, M. and Britton. A. (2013). High predation risk for a small mammal: the eastern pygmypossum (*Cercartetus nanus*). *Australian Mammalogy* 35: 149-152

Law, B., Doty, A., Chidel, M. and Brassil, T. (2018). Bat activity before and after a severe wildfire in Pilliga forests: Resilience influenced by fire extent and landscape mobility? *Austral Ecology* 43: 706-718.

Law, B., Gonsalves, L., Chidel, M. and Brassil, T. (2016). Subtle use of a disturbance mosaic by the south-eastern long-eared bat (*Nyctophilus corbeni*): an extinction-prone, narrow space bat. *Wildlife Research* 43: 153-168.

Law, B, Chidel, M. and Tap, P. (2011). Bat activity in ephemeral stream-beds in the Pilliga forests: clarifying the importance of flyways and buffer widths in open forest and woodland. In '*The Biology and Conservation of Australasian Bats*.' January 2011, edited by Law., B, Eby., P, and Lunney., D

Lee, K.E., Seddon, J.M., Corley, S.W., Ellis, W.A.H., Johnston, S.D., De Villiers, D.L., Preece, H.J. and Carrick, F.N. (2010). Genetic variation and structuring in the threatened koala populations of Southeast Queensland. *Conservation Genetics* 11: 2091–2103

Leigh, J., R. Boden and J. Briggs (1984). *Extinct and Endangered Plants of Australia*. Melbourne, Victoria: Macmillan.

Legislative Council Portfolio Committee 7 (2020). Koala populations and habitat in New South Wales / Portfolio Committee No. 7 – Planning and Environment [Sydney, N.S.W.] Report no. 3.

Lengagne, T. (2008). Traffic noise affects communication behaviour in a breeding anuran, Hyla arborea. *Biological Conservation* 141(8): 2023-2031

Li, B., Wang, Y., and Zhang, M. (2007). Guard against invasion of Rattus norvegicus into Tibet along Qinghai-Tibet railway. *Research of Agricultural Modernization*, 3, 24.

Li, Z., Ge, Ch., Li, J., Li, Y., Xu, A., Zhou, K., et al. (2010). Ground-dwelling birds near the Qinghai-Tibet highway and railway. *Transportation Research Part D*, 15: 525–528.

Lindenmayer D., Cunningham R., Crane M., Montague-Drake R. and Michael D. (2010). The importance of temperate woodland in travelling stock reserves for vertebrate biodiversity conservation. *Ecological Management and Restoration* 11: 27-30.

Little, S.J., Harcourt, R.G. and Clevenger, A.P. (2002) Do wildlife passages act as prey-traps? *Biological Conservation* 107: 135-145

LPMA (2010). *Assessing the Values and Management of the NSW Travelling Stock Reserve Network for Biodiversity and Optimal Management in the Hunter Valley*. Report on Methodology and Findings. Land and Property Management Authority, Sydney.

Lucas, P.S., de Carvalho, R.G. and Grilo, C. (2017). Railway Disturbances on Wildlife: Types, Effects, and Mitigation Measures. Chapter 6 of '*Railway Ecology*'. Ed Borda-de-Agua, L., Barrientos, R., Beja, P. and Pereira, H.M. Springer Open.

Lunney, A.B.K., Predavec, M., Sonawane, I., Kavanagh, R., Barrott-Brown, G., Phillips, S., Callaghan, J., Mitchell, D., Parnaby, H., Paull, D.C., Shannon, I., Ellis, M., Price, O. and Milledge, D. (2017). The remaining koalas (*Phascolarctos cinereus*) of the Pilliga forests, north-west NEW South Wales: Refugial persistence or a population on the road to extinction?. *Pacific Conservation Biology* 23(3) 277-294.

Lunney, D., Crowther, M. S., Wallis, I., Foley, W. J., Lemon, J., Wheeler, R. and Stalenberg, E. (2012). Koalas and climate change: a case study on the Liverpool Plains, northwest New South Wales. In D. Lunney and P. Hutchings (Eds.), Wildlife and Climate Change: Towards robust conservation strategies for Australian fauna (pp. 150–168). Retrieved from http://dx.doi.org/10.7882/FS.2012.020 2

Lunney, D., Predavec, M., Miller, I., Kavanagh, R., Barrott-Brown, G., Phillips, S. and Milledge, D. (2017). The remaining koalas of the Pilliga forests, northwest NSW: refugial persistence or a population on the road to extinction? *Pacific Conservation Biology* 23. http://dx.doi.org/10.1071/PC17008

MacLeod, N.D. (2002). Watercourses and riparian areas, in '*Managing and conserving grassy woodlands*'. eds. S McIntyre, JG McIvor and KM Heard. (CSIRO Publishing, Collingwood, Vic.): pp. 143-176.

Manning, A.D., Lindenmayer, D.B. and Barry, S.C. (2004). The conservation implications of bird reproduction in the agricultural "matrix": a case study of the vulnerable Superb Parrot of south-eastern Australia. *Biological Conservation*. 120:363-374.

Marchant, S. and Higgins, P.J. (1993). *Handbook of Australian, New Zealand and Antarctic birds (vol. 2)*. Oxford University Press. Melbourne

Marcus Lincoln Smith. (2003). *Aquatic Ecology in Environmental Impact Assessment - EIA Guideline*. NSW Department of Planning

Mavromihalis, J. (2010). *National Recovery Plan for the Winged Peppercress Lepidium monoplocoides*. Department of Sustainability and Environment, Melbourne.

McAlpine, C.A., J.R. Rhodes, J.G. Callaghan, M.E. Bowen, D. Lunney, D.L. Mitchell, D.V. Pullar and H.P. Possingham (2006). The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. *Biological Conservation*. 132:153-165.

McKnight T. L. (1977). *The Long Paddock. Australia’s Travelling Stock Routes*. University of New England, Armidale.

Menkhorst, P.W. Weavers, B.W. and Alexander, J.S.A. (1988). Distribution, habitat and conservation status of the Squirrel Glider *Petaurus norfolcensis* (Petauridae: Marsupialia) in Victoria. *Australian Wildlife Research* 15: 59-71.

Menkins, I. (1998). Draft report for survey of *Homopholis belsonii* C.E. Hubb. on the Darling Downs. Toowoomba and Region Environment Council Inc.

Milledge, D. (2004). Large owl territories as a planning tool for vertebrate fauna conservation in the forests and woodlands of eastern Australia. In *Conservation of Australia’s Forest Fauna*. Second ed. Ed D. Lunney. Pp 493-507. Royal Zoological Society of NSW.

Milledge, D. (2011). *National Significance: The Ecological Values of Pilliga East Forest and the Threats Posed by Coal Seam Gas Mining 2011-2012*. A report prepared for the Northern Inland Council for the Environment and the Coonabarabran and Upper Castlereagh Catchment and Landcare Group.

Mills, L. S. Hayes, S. G. Baldwin, C. Wisdom, M. J. Citta, J. Mattson, D. J. and Murphy, K. (1996). Factors leading to different viability predictions for a grizzly bear data set. *Conservation Biology* 10:863-873.

Mitchell, P., (1990). The Home Ranges and Social Activity of Koalas - a quatitative analysis. pp l7l - 187 in *Biology of the Koala*, ed by A.K.Lee, K.A.Handasyde and G.D.Sanson. Surrey Beatty & Sons. Sydney.

Morgan, G. and Terrey, J. (1992). *Nature conservation in western NSW*. National Parks Association, Sydney

Morgan, J.W. and Williams, N.S.G. (2015). The ecology and dynamics of temperate native grasslands in south-east Australia. In: Williams, N.S.G., A. Marshall & J.W. Morgan, eds. *Land of Sweeping Plains: Managing and Restoring the Native Grasslands of South-eastern Australia*.

Morton S. R. (1990). The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. In: *Australian ecosystems: 200 years of utilisation, degradation and reconstruction. Proceedings of the Ecological Society of Australia 16*. (Eds D. A. Saunders, A. J. M. Hopkins and R. A. How.) pp. 201–213. (Surrey, Beatty and Sons: Chipping Norton.)

Muzzi, P. D. and Bisset, A. R. (1990). The effectiveness of ultrasonic wildlife warning devices to reduce moose fatalities along railway corridors. *Alces*, 26, 37–43.

Narrabri Courier (2020). Have you busted a bustard lately? Article 18 June 2020. https://narrabricourier.com.au/2020/06/18/have-you-busted-a-bustard-lately/

Narrabri Shire and LLS (2013). *Narrabri Lake Bird List*. Brochure.

Neibuhr, B.B.S, Wosniack, M.E., Santos, M.C., Rapaso, E.P., Viswanathan, G.M., da Luz, M.G.E. and Pie, M.R. (2015). Survival in patchy landscapes: the interplay between dispersal, habitat loss and fragmentation. *Scientific Reports* volume 5, Article number: 11898 (2015).

Nentwig, W. and Kobelt, M. (2010). Spiders (Araneae). *BioRisk 4: Alien Terrestrial Arthropods of Europe* 4: 131–147

Newsome, A.E. and Corbett, L.K. (1975). Outbreaks of rodents in semi-aridand arid Australia: causes, preventions and evolutionary considerations. In *Rodents in Desert Environments*. (Eds I. Prakash and P. K. Ghosh.) pp. 117–153.

Norman, J.A., Phillips, S.S., Blackmore, C.J., Goldingay, R. and Christidis, L. (2019). Integrating measures of long-distance dispersal into vertebrate conservation planning: scaling relationships and parentage-based dispersal analysis in the koala. *Conservation Genetics* 20: 1163-1174.

NPWS (2002). *Bertya sp. Cobar-Coolabah (Cunningham & Milthorpe s.n., 2/8/73) Recovery Plan*. NSW National Parks and Wildlife Service. Hurstville NSW.

NPWS (2003). *Draft Recovery Plan for the Barking Owl*. NSW National Parks and Wildlife Service, Hurstville, NSW.

NPWS (2015). *Pilliga Nature Reserve Plan of Management*. NSW Government- OEH.

NSW RFS (2004). *Threatened species hazard reduction list: Part 1- Plants*, NSW Rural Fire Service.

NSW RFS (2004). *Threatened species hazard reduction list: Part 1- Plants*, NSW Rural Fire Service.

NSW Scientific Committee (2001). *Eastern Pygmy Possum - vulnerable species listing*. NSW Scientific Committee Final Determination.

NSW Scientific Committee (2008a). Glossy-Black Cockatoo *Calyptorhynchus lathami;* Review of current information in NSW.

NSW Scientific Committee (2008b). Squirrel Glider *Petaurus norfolcensis*; Review of current information in NSW.

NSW Scientific Committee (NSW SC) (2008c). *Swainsona murrayana* Review of current information in NSW. Unpublished report arising from the Review of the Schedules of the Threatened Species Conservation Act 1995. NSW Scientific Committee, Hurstville.

OEH (2011). Little Eagle *Hieraaetus morphnoides* - proposed vulnerable species listing. Office of Environment and Heritage. Accessed at https://www.environment.nsw.gov.au/determinations/littleeaglepd.htm

OEH (2016). NSW Guide to Surveying Threatened Plants. Office of Environment and Heritage. Accessed at https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Threatened-species/guide-surveying-threatened-plants-160129.pdf

OEH (2017). *Biodiversity Assessment Method*. Office of Environment and Heritage.

OEH (2018a). *Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method*. Office of Environment and Heritage. https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Threatened-species/species-credit-threatened-bats-survey-guide-180466.pdf

OEH (2018b). *A review of koala tree use across NSW*. https://www.environment.nsw.gov.au/research-and-publications/publications-search/a-review-of-koala-tree-use-across-new-south-wales

EES (2019a). *Biodiversity Assessment Methods Calculator User Guide*. Accessed at https://www.environment.nsw.gov.au/research-and-publications/publications-search/biodiversity-assessment-method-user-guide

OEH (2019b). *Framework for the spatial prioritisation of koala conservation actions in NSW*.

OEH (undated*). Conservation Management Notes: Corridors and Connectivity*. https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Conservation-management-notes/corridors-connectivity-conservation-management-notes-110657.pdf

Officer-Environment and Community, (2018). *Mangoola Open Cut- Glencore- Translocation Management Plan*. Accessed https://www.mangoolamine.com.au/en/publications/ManagementPlans/2018%20Mangoola%20Coal%20Translocation%20Plan.pdf.

Osborne W. S. and Jones S. R. (1995) *Recovery Plan for the Pink-tailed Worm Lizard*, Technical Report 10. ACT Parks and Conservation Service, Canberra

Paull D. (2009). Habitat and post-fire selection of the Pilliga Mouse *Pseudomys pilligaensis* in Pilliga East State Forest. *Pacific Conservation Biology*. 15, 254-267

Paull, D. C. and Date, E.M. (1999). Patterns of decline in the native mammal fauna of the north-west slopes of NSW. *Australian Zoologist* 39: 210-224.

Paull, D.C. (2006). The biology and ecophysiology of the Pilliga Mouse *Pseudomys pilligaensis* and the Common Dunnart *Sminthopsis murina* in Pilliga East State Forest. Master of Science Thesis – Zoology, University of New England, Armidale, NSW.

Paull, D.C. Milledge, D. Spark, P. Townley S. and Taylor K. (2014). Identification of important habitat for the Pilliga Mouse Pseudomys pilligaensis. *Australian Zoologist*. 37, 15-22.

Pelletier, S. K., Carlson, L., Nein, D. amd Roy, R. D. (2006). Railroad crossing structures for spotted turtles: Massachusetts Bay Transportation Authority—Greenbush rail line wildlife crossing demonstration project. In C. L. Irwin, P. Garrett, & K. P. McDermott (Eds.), *Proceedings of the 2005 International conference on ecology and transportation* (pp. 414–425). Raleigh: North Carolina State University.

Pennay, M. (2008). A maternity roost of the large-eared Pied Bat *Chalinolobus dwyeri* (Ryan) (Microchiroptera: Vespertilionidae) in central NSW Australia. *Australian Zoologist* 34: 564 – 569.

Pennay, M. (2010). Personal communication by email, 19 January 2010. NSW Department of Environment, Climate Change and Water.

Pennay, M. Law, B. and Reinhold, L. (2004). *Bat calls of NSW: Region based guide to the echolocation calls of Microchiropteran bats*. NSW Department of Environment and Conservation. environment.gov.au/system/files/resources/2f420bf1-d9e4-44ec-a69c-07316cb81086/files/survey-guidelines-bats.pdf

Phillips, S.S. (2000). Population Trends and the Koala Conservation Debate. *Conservation Biology* 14(3): 650-659.

PlantNET (2020). NSW Flora Online. Accessed at http://plantnet.rbgsyd.nsw.gov.au/search/simple.htm

Predavec, M. (1994). Population dynamics and environmental changes during natural irruptions of Australian desert rodents. *Wildlife Research* 21,569–582.

Predavec, M. (2016). *NSW Koala population case studies*. https://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0003/94521/Koala-population-case-studies.pdf

Proctor, M. F., McLellan, B. N., Strobeck, C. and Barclay, R. M. R. (2005). Genetic analysis reveals demographic fragmentation of grizzly bears yielding vulnerably small populations. *Proceedings of the Royal Society of London. Series B*, 272 : 2409–2416.

QLD DEHP (2013). Species profile - *Bertya opponens*. Accessed at https://apps.des.qld.gov.au/species-search/details/?id=11323

Quin D.G. (1995) Population Ecology of the Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider (*P. breviceps*) (Marsupialia:Petauridae) at Limeburners Creek, on the Central North Coast of NSW. *Wildlife Research* 22: 471-505.

Quin, D.G., Smith, A.P. and Green, S.W. (2004) Habitat preferences of squirrel gliders (*Petaurus norfolcensis*) and sugar gliders (*Petaurus breviceps*) in sympatry, pp. 350-68. Goldingay and S.M. Jackson (Eds.) *The Biology of Australian Possums and Gliders*. Surrey Beatty, Sydney.

Reijnen, R., Foppen, R., ter Braak, C. and Thissen, J. (1995). 'The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads'. *Journal of Applied Ecology* 32, 187- 202.

Riley, S., Pollinger, J.P., Sauvajot, R.M., York, E.C., Bromley, C., Fuller, T.K. and Wayne, R.K. (2006). FAST TRACK: A southern California freeway is a physical and social barrier to gene flow in carnivores. *Molecular Ecology*. https://doi.org/10.1111/j.1365-294X.2006.02907.x

Rogers, D., Hnace, I., Paton, S., Tzaros, C., Griffioen, P., Herring, M., Jaensch, R., Oring, L., Silcocks, A. and Weston, M. (2005). The breeding bottleneck: breeding habitat and population decline in the Australian Painted Snipe. Status and Conservation of Shorebirds in the East Asian-Australasian Flyway. *Proceedings of the Australasian Shorebirds Conference*, 13–15 December 2003, Canberra, Australia.

Rowley, J.J.L., Callghan, C.T., Cutajar, T., Portway, C., Potter, K., Mahoney, S., Trembath, D.F., Flemons, P. and Woods, A. (2019). FrogID: Ciltizen Scientists Provide validated biodiversity data on frogs of Australia. *Herpetological Conservation and Biology* 14(1):155–170.

RGBT (2017). Plantnet. Royal Botanic Gardens Trust. http://plantnet.rbgsyd.nsw.gov.au/floraonline.htm

RTA (2009). *Use of fauna passage structures on RTA roads*. NSW Roads and Traffic Authority.

Sandpiper Ecological (2014). *Threatened glider aerial crossings targeted surveys. Woolgoolga to Ballina Pacific Highway upgrade sections 3-11*. Report prepared for Roads and Maritime Services.

Santos, S. M., Carvalho, F. and Mira, A. (2011). How long do the dead survive on the Road? Carcass persistence probability and implications for road-kill monitoring surveys. *PLoS ONE*, 6, e25383.

Santos, S.M., Carvalho, F. and Mira, A. (2017). Current Knowledge on Wildlife Mortality in Railways. Chapter 2 of *Railway Ecology*. Ed Borda-de-Agua, L., Barrientos, R., Beja, P. and Pereira, H.M. Springer Open.

Schaub, A. Ostwald, J. and Siemers, B. M. (2008). Foraging bats avoid noise. *Journal of Experimental Biology.* 211: 3174-3180; doi: 10.1242/jeb..022863

Seddon, J., Briggs, S. and Doyle, S. (2002). *Little River Catchment Biodiversity Assessment*. NSW National Parks and Wildlife Service, Canberra.

Serov, P., Kuginis, L. and Williams, J.P. (2012). *Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework*, NSW Department of Primary Industries, Office of Water, Sydney.

Sharp, D. and Simon B. (2001). *Ausgrass: Encyclopedia of Australian Grasses*. Canberra: CSIRO Publishing & Australian Biological Resources Study.

Sharpe, D.J. and Goldingay, R.L. (1998) Feeding behaviour of the squirrel glider at Bungawalbin Nature Reserve, north-eastern New South Wales. *Wildlife Research* 25: 243-54.

Short, J. and Milkovitis, G. (1990). Distribution and status of the brush-tailed rock-wallaby in south-eastern Australia. *Australian Wildlife Research* 17: 169–179.

Shwiff, S.A., Smith, H.T., Bard, A.M., Harbor, T.V. and Engeman, R.M. (2003). *An Economic Analysis of a Simple Structural Method to Reduce Road-Kills of Royal Terns at Bridges*. USDA National Wildlife Research Center - Staff Publications. 270. https://digitalcommons.unl.edu/icwdm_usdanwrc/270

SKM (2013). *Woolgoolga to Ballina Pacific Highway Upgrade. Submissions / Preferred Infrastructure Report. Appendix J Supplementary biodiversity assessment*. Report prepared for Roads and Maritime Services.

Smiles, B., Merchant, C. and Proft, K. (2011). *The NSW travelling stock routes and reserves network*. National Parks Association of NSW. https://www.nature.org.au/media/172026/6-the-tsr-network-heritage-habitat-and-livelihood-2011.pdf

Smith, D.J., van der Ree, R. and Rosell, C. (2015). Wildlife crossing structures: an effective strategy to restore or maintain wildlife connectivity across roads. Pp 172-183 in *Handbook of Road Ecology* ed van der Ree, R., Smith, D.J. and Grilo, C. Wiley Blackwell.

Smith, W.J.S. and Robertson, P. (1999). National Recovery Plan for the Striped Legless Lizard (*Delma impar*) *1999-2003*. NSW National Parks and Wildlife Service & Wildlife Profiles Pty Ltd.

Soanes, K. and R. van der Ree. (2009). Highway impacts on arboreal mammals and the use and effectiveness of novel mitigation techniques. Pages 441-451 in P. J. Wagner, D. Nelson, and E. Murray, editors. *International Conference on Ecology and Transportation*. Duluth, Minnesota, USA

Soanes, K., Lobo, M.C., Vesk, P.A., Moore, J., McCarthy, M.A. and van der Ree, R. (2013). Movement re-established but not restored: Inferring the effectiveness of road-crossing mitigation for a gliding mammal by monitoring use. *Biological Conservation* 159, 434-441.

Soderquist, T. (2009). How extensive is southern Australia's largest Barking Owl population? *Wingspan* 19: 31-33.

Spark, P. (2015). Survey of eight wildlife atlas locations for Sloane's Froglet - *Crinia sloanei* between Dubbo and Mungindi as per OEH contract PO4500585307. Office of Environment and Heritage (NSW), Sydney, NSW, Australia. 26 p.

Spooner, P. and Lunt, I. (2004). The influence of land-use history on roadside conservation values in an Australian agricultural landscape. *Australian Journal of Botany* 52: 445-458.

Stanton, M. (2011). Barking Owl Diet in the Pilliga Forests of Northern New South Wales. Masters Thesis. University of New England.

Suckling, G.C. (1995). Squirrel Glider. pp. 234-235 in *The Mammals of Australia*. Ed R. Strahan. Reed Books, Sydney.

Sutherst, B., Cleland, E., Szabo, J. and Rogers, G. (2008). A Protected Corridor for Travelling Stock and Biodiversity. The case for conservation of the NSW TSRs and Qld SRN. Conference paper at '*Travelling Stock Networks: Biodiversity Highway of the Eastern Inland*' Conference, Sydney.

Swift Parrot Recovery Team (2001). Swift Parrot Recovery Plan. Department of Primary Industries, Water and Environment, Hobart.

Taylor, B. D. and R. L. Goldingay. (2009). Can road-crossing structures improve population viability of an urban gliding mammal? *Ecology and Society* 14(2): 13

Taylor, B.D. and Goldingay, R.L. (2003) Cutting the carnage: wildlife usage of road culverts in north-eastern New South Wales. *Wildlife Research* 30: 529-537.

TfNSW (2017). *NSW Sustainable Guidelines Version 4.0*. Transport for NSW.

TMR (2010). *Fauna Sensitive Road Design Manual. Volume 2: Preferred Practices Technical Document*. Department of Transport and Main Roads, Queensland Government.

Tokushima, H. and Jarman, P. (2008). Ecology of the rare but irruptive Pilliga mouse (*Pseudomys pilligaensis*). II. Demography, home range and dispersal. *Australian Journal of Zoology* 56: 375–387.

Tokushima, H., Green, S.W. and Jarman, P. (2008). Ecology of the rare but irruptive Pilliga mouse (*Pseudomys pilligaensis*). I. Population fluctuation and breeding season. *Australian Journal of Zoology* 56: 363–373.

Traill BJ, and Lill A (1997). Use of tree hollows by two sympatric gliding possums, the Squirrel Glider *Petaurus norfolcensis* and the Sugar Glider *P. breviceps. Australian Mammalogy* 20, 79-88.

Tremblay, M. and St. Clair, C.C. (2009). Factors Affecting the Permeability of Transportation and Riparian Corridors to the Movements of Songbirds in an Urban Landscape. *Journal of Applied Ecology*. 46: 1314–1322.

Trémont, R.M. and Whalley R.D.B. (1993a). Draft final report for survey for *Homopholis belsonii*. Department of Botany, University of New England.

TSSC (2012). *Listing advice for* Phascolarctos cinereus *(Koala)*. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-listing-advice.pdf.

TSSC (2013). Advice to the Minister for the Environment from the Threatened Species Scientific Committee (the Committee) on Amendment to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Accessed http://www.environment.gov.au/biodiversity/threatened/species/pubs/12993-listing-advice.pdf

TSSC (2019). Conservation advice *Botaurus poiciloptilus* Australasian Bittern. Threatened Species Scientific Committee http://www.environment.gov.au/biodiversity/threatened/species/pubs/1001-conservation-advice-18012019.pdf

TSSC. (2008a.) Approved Conservation Advice for *Swainsonia murrayana* (Slender Darling-pea). Threatened Species Scientific Committee. Accessed http://www.environment.gov.au/biodiversity/threatened/species/pubs/6765-conservation-advice.pdf.

TSSC. (2008b). Approved Conservation Advice for *Rulingia procumbens*. Threatened Species Scientific Committee. Accessed http://www.environment.gov.au/biodiversity/threatened/species/pubs/12903-conservation-advice.pdf.

TSSC. (2008c). Approved Conservation Advice for *Tylophora linearis*. Threatened Species Scientific Committee. Accessed http://www.environment.gov.au/biodiversity/threatened/species/pubs/55231-conservation-advice.pdf.

TSSC. (2008d). Approved Conservation Advice for *Homopholis belsonii*. Threatened Species Scientific Committee. Accessed http://www.environment.gov.au/biodiversity/threatened/species/pubs/2406-conservation-advice.pdf.

Tulloch A.I. and Dickman C.R. (2006). Floristic and structural components of habitat use by the eastern pygmy-possum (*Cercartetus nanus*) in burnt and unburnt habitats. *Wildlife Research* 33: 627–637.

Turbil, C. and Ellis, M. (2006). Distribution and abundance of the south eastern form of the greater long-eared bat *Nyctophilus timoriensis. Australian Mammalogy* 28: 1–6.

Umwelt (2017a). Inland Rail: Narrabri to North Star EIS Biodiversity Assessment Report. Report prepared for ARTC.

Umwelt (2017b). Inland Rail: Parkes to Narromine EIS Biodiversity Assessment Report. Report prepared for ARTC.

van der Grift, E. A. (1999). Mammals and railroads: Impacts and management implications. *Lutra*, 42, 77–98.

van der Grift, E. A. (1999). Mammals and railroads: Impacts and management implications. *Lutra*, 42, 77–98.

van der Grift, E. A. and Kuijsters, H. M. J. (1998). Mitigation measures to reduce habitat fragmentation by railway lines in the Netherlands. In G. L. Evink, P. Garrett, D. Zeigler, & J. Berry (Eds.), *Proceedings of the international conference on wildlife ecology and transportation* (pp. 166–170). Florida Department of Transportation, Tallahassee, Florida, USA.

van der Ree, R., and G. C. Suckling. (2008). Squirrel glider. Pages 235–236 in S. Van Dyck and R. Strahan, edit. *Mammals of Australia*. Third edition. New Holland Publishers, Sydney, Australia.

van der Ree, R., Clarkson, D.T., Holland, K., Gulle, N. and Budden M. (2008). *Review of Mitigation Measures used to deal with the Issue of Habitat Fragmentation by Major Linear Infrastructure*, Report for Department of Environment, Water, Heritage and the Arts (DEWHA).

van der Ree, R., Smith, D.J. and Grilo, C. (2015). *Handbook of Road Ecology.* Wiley Blackwell.

van Dyck, S. and Strahan, R. (2008). *The mammals of Australia*. New Holland Publishers.

VicRoads (2012). *Fauna sensitive road design guidelines*.

Webster, R. (1988). *The Superb Parrot: a survey of the breeding distribution and habitat requirements*. Australian National Parks & Wildlife Service, Canberra.

White, T.C.R. (1973). The establishment, spread and host range of Paropsis charybdis Stal. *Pacific Insects*, 15, 59–66.

Williams, N., Marshall, A. and Morgan, J. (2015). *Land of Sweeping Plains- Managing and restoring the native grasslands of south-eastern Australia.* CSIRO Publishing: Victoria, Australia.

Wooldridge, A., Nicholson, A., Muller, R., Cook, W., Winkler, M., Jenkins, B., Grant, S., Agar, B. and Brennan, N. (2012). *Hydrogeological Landscapes for the Western Central West Catchment – Final Report*. NSW Office of Environment and Heritage, Department of Premier and Cabinet, Wagga Wagga.

Ziembicki, M. (2009). Ecology and movements of the Australian Bustard *Ardeotis australis* in a dynamic landscape. School of Earth and Environmental Sciences. Doctor of Philosophy Thesis. University of Adelaide. https://digital.library.adelaide.edu.au/dspace/bitstream/2440/61906/8/02main.pdf

Zuberogoitia, I., del Real, J., Torres, J. J., Rodríguez, L., Alonso, M., de Alba, V., et al. (2015). Testing pole barriers as feasible mitigation measure to avoid bird vehicle collisions (BVC). *Ecological Engineering*, 83: 144–151.

Appendices

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