TECHNICAL REPORT 01

Biodiversity development assessment report

(Part 1 of 3)

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT

ARTC Inland Rail

Narromine to Narrabri

Biodiversity development assessment report – BAM 2020

Revision E

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

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

I, Kirsten Crosby (BAAS17011) certify that this Biodiversity Development Assessment Report and the accompanying finalised credit report dated 17 August 2022 has been prepared in accordance with the requirements of (and information provided under) the Biodiversity Assessment Method 2020.

Kirsten Crosby – BAAS17011

17 August 2022

Table of contents

Table index

Figure index

Appendices

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 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 Updated 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 were undertaken between September 2018 and March 2022 of the proposal investigation corridor, in accordance with the Biodiversity Assessment Method (BAM). A biodiversity survey investigation plan was developed in consultation with, and endorsed by the Biodiversity, Conservation and Science Directorate (BCS) of the then Department of Planning, Industry and Environment (DPIE), now Department of Planning and Environment (DPE). The Biodiversity Assessment Method Calculator (BAM-C) 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.

This BDAR has been updated to meet the requirements of the BAM 2020 (DPIE 2020) as the transitional period ceased prior to approval of the proposal.

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/October 2019; and June, September, and October 2020, July and August 2021 and March 2022. Much of NSW, including the proposal site, had been subject to ongoing drought during and prior to surveys being conducted. Climatic conditions improved in 2020, and additional surveys were conducted in September, October and November 2020 to take advantage of these conditions. Thermal drone surveys were conducted in July 2021 for the Koala in the Pilliga forest and surveys by species experts (raptors and Koala) were conducted in August 2021. Targeted flora surveys were conducted in March 2022 focussing on areas of the Pilliga forest not previously accessed.

Native vegetation in the proposal site generally comprises 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 34 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.

Four threatened flora species, Cobar Greenhood (*Pterostylis cobarensis*), Pine Donkey Orchid (*Diuris tricolor*), *Commersonia procumbens* and *Tylophora linearis* were identified within the Pilliga forests. Potential habitat for an additional nine threatened flora species listed under the BC Act and/or EPBC Act is also present in the proposal site. Twenty-four threatened fauna species were recorded during surveys, and potential habitat for an additional 40 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 1,791 hectares of native vegetation, comprising around 1,211 hectares of native woodland, forest and shrubland vegetation in good condition, 580 hectares of native and derived native grassland
- removal of 654 hectares of native forest, woodland and shrubland vegetation from the Pilliga forests
- removal of an estimated 14,503 to 41,103 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 comprising 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 including the Pilliga Mouse, Corben’s Long-eared Bat, Painted Honeyeater, Regent Honeyeater, Swift Parrot and a number of small woodland birds among others
- impacts on three entities subject to serious and irreversible impacts (SAII), comprising Box Gum Woodland, Fuzzy Box Woodland and Brigalow threatened ecological communities
- significant residual impacts on fauna species as a result of interruption of connectivity and potential for mortality through train-strike
- significant impacts on threatened species listed under the EPBC Act, comprising 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 forests 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 communities.

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 completed in June 2020 and detailed flora and fauna surveys were conducted in spring 2020. Thermal drone surveys for the Koala were conducted in July 2021 and surveys with species experts in August 2021. Targeted flora surveys in more remote parts of the Pilliga forests were conducted in March 2022. The main aim of these surveys were to gain a better understanding of proposal impacts to threatened flora, to complete vegetation integrity plots outside of drought conditions and in areas previously extrapolated due to access restrictions, and to assist with minimising impact to biodiversity within the construction impact zone.

Recommended mitigation measures

Design phase

A Preliminary Fauna Connectivity Strategy has been prepared as part of the EIS to identify fauna connectivity structures and measures to improve connectivity for fauna species following construction. Key features of the proposal design with relevance to fauna connectivity are:

- Inclusion of 73 bridges along the alignment, including at large rivers and many ephemeral creeks. Fauna furniture will be included in many structures to facilitate the movement of fauna. Many fauna species 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 dedicated culverts to reinstate connectivity for terrestrial (and some arboreal) fauna species. Around 51 locations have been identified in the Pilliga forests and Bohena Creek area. The size, number and location would be confirmed during detailed design.

- Inclusion of 52 canopy bridges, predominantly located in the Pilliga forests, as well as other riparian and woodland corridors intersected by the proposal.
- Installation of barrier poles at selected bridges in the Pilliga forests.

The following mitigation measures are proposed during the design phase:

- Preparation of a Final Fauna Connectivity Strategy developed in consultation with BCS, which would draw on the preliminary Fauna Connectivity Strategy and threatened species management plans. It would include detailed assessment and design of locations for fauna crossing structures, including dedicated culverts, canopy bridges 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.

Construction phase

The following mitigation measures are proposed during the construction phase:

- mapping and fencing of sensitive areas
- pre-clearing surveys for threatened species
- installation of structures required by the Fauna Connectivity Strategy
- rehabilitation (including revegetation where required) of disturbed areas following construction, and including provision of habitat linkages within the operational rail corridor in the Pilliga forests and other forested portions of the proposal site
- 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

Following the application of appropriate avoidance and mitigation measures, the biodiversity credits required to offset the impacts of the proposal in accordance with the BAM were calculated in the BAM-C. Additional credits have been determined for fauna species and ecosystem credits to account for significant residual prescribed impacts. These comprise:

- 49,052 ecosystem credits (including 9,625 for prescribed impacts on ecosystem credit fauna species)
- 271,971 species credits (of which 87,501 are for prescribed impacts on species credit fauna species).

The Australian Government formally endorsed the NSW Biodiversity Offsets Scheme (BOS) in March 2020. Offset requirements for threatened biota listed under the EPBC Act 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.

Glossary and abbreviations

Acronym/term	Definition
ARKS	Area of Regional Koala Significance
ARTC	Australian Rail Track Corporation
BAM	Biodiversity Assessment Methodology
BAM-C	Biodiversity Assessment Method Calculator
BC Act	*Biodiversity Conservation Act 2016*
BCF	Biodiversity Conservation Fund
BCS	Biodiversity, Conservation and Science Directorate of the Department of Planning, Industry and Environment
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 Offsets Scheme
CEEC	Critically endangered ecological community
CEMP	Construction environmental management plan
CIZ	Construction impact zone
CMA	Catchment Management Authority
DAWE	Department of Agriculture, Water and the Environment (Commonwealth) (former)
DCCEEW	Department of Climate Change, Energy, the Environment and Water
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)
DNG	Derived native grassland
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

Acronym/term	Definition
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*
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
MCA	Multi-criteria analysis
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
Prescribed impacts	Additional impacts prescribed under the BC Regulation for assessment
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

Acronym/term	Definition
	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
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).
TBDC	Threatened Biodiversity Data Collection
TEC	Threatened ecological community
VI	Vegetation integrity
VIS	vegetation information system
WSP	Water Sharing Plan

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').

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.

1.1.2 Approval and assessment requirements

The proposal is critical State significant infrastructure and is subject to approval by the NSW Minister for Planning 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 and Conservation Act 1999* (EPBC Act) and requires approval from the Australian Minister for the Environment.

An Environmental Impact Statement (EIS) was prepared to support ARTC's application for approval of the proposal in accordance with the requirements of Division 5.2 of the EP&A Act. The EIS addressed the environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment (DPIE) ('the SEARs'), dated 9 September 2020.

The EIS was placed on public exhibition by DPIE for a period of 62 days, commencing on 8 December 2020, and concluding on 7 February 2021.

The EIS was also prepared to support ARTC's application for approval of the proposal under the EPBC Act.

The EIS was supported by a range of technical reports, which provide detailed assessments of the potential impacts of the proposal as they relate to the key environmental issues defined by the SEARs. This included Technical Report 1 – Biodiversity Development Assessment Report.

1.1.3 Responding to submissions and proposed amendments

During the exhibition period, interested stakeholders and members of the community were able to review the EIS online or at display locations, participate in consultation and engagement activities, and make a written submission to the DPIE for consideration in its assessment of the proposal.

ARTC has prepared a Response to Submissions report to respond to submissions received during the exhibition period.

During and following public exhibition of the EIS, ARTC has undertaken further investigations and is proposing a number of design amendments to the proposal. The aim of these amendments is to address issues raised during consultation and in submissions, and to minimise the potential impacts of the proposal where practicable, particularly in respect of land use and property, and traffic and access.

A summary of the proposed amendments is provided in Table 1.1. Further information is provided in the Amendment Report.

Table 1.1 Summary of amendments

Proposal feature	Proposed amendment
Crossing loops	Relocation of the seven crossing loops to new locations to minimise overall impacts.
Public level crossings	Changes to public level crossing numbers, locations and treatments due to changes to crossing loop locations, updated traffic data and refinement of sight distances.
Public road closures	Reduction in the number of public road and access tracks that would need to be closed, mainly as a result of the crossing loop relocations.
Public road realignments	Changes to the public roads requiring realignment to minimise property impacts.
Temporary workforce accommodation	Changes to the locations of the Narromine North and Baradine temporary workforce accommodation facilities based on consultation with key stakeholders. Mobile accommodation facilities are now proposed be provided within some of the general compounds for improved flexibility on the workforce approach.
Construction and operation footprints	Adjustments to the construction and operational footprints to accommodate the above amendments and other proposed design refinements, and to minimise the amount of disturbance where possible. In addition, drainage control areas have been added at a number of culverts to provide sufficient space outside the rail corridor for the management of flow velocities.

1.2 The proposal

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 west 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 (as amended) 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, Armatree/Tonderburine, Mt Tenandra, 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, drainage control areas, signage and fencing, and services and utilities.

Further information on the proposal is provided in the Amendment Report.

Figure 1.1 **Location of the proposal**

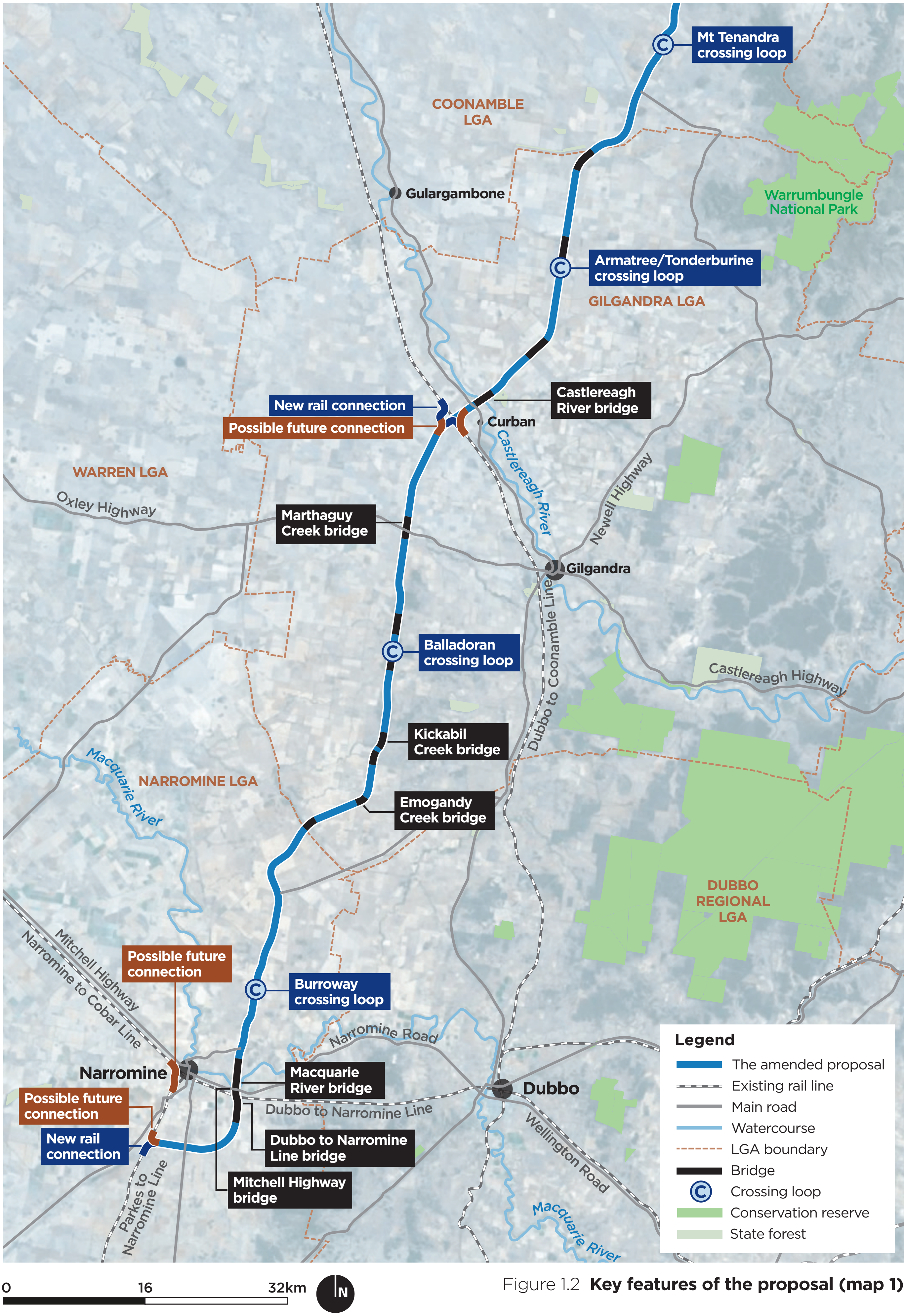


Figure 1.2 **Key features of the proposal (map 1)**

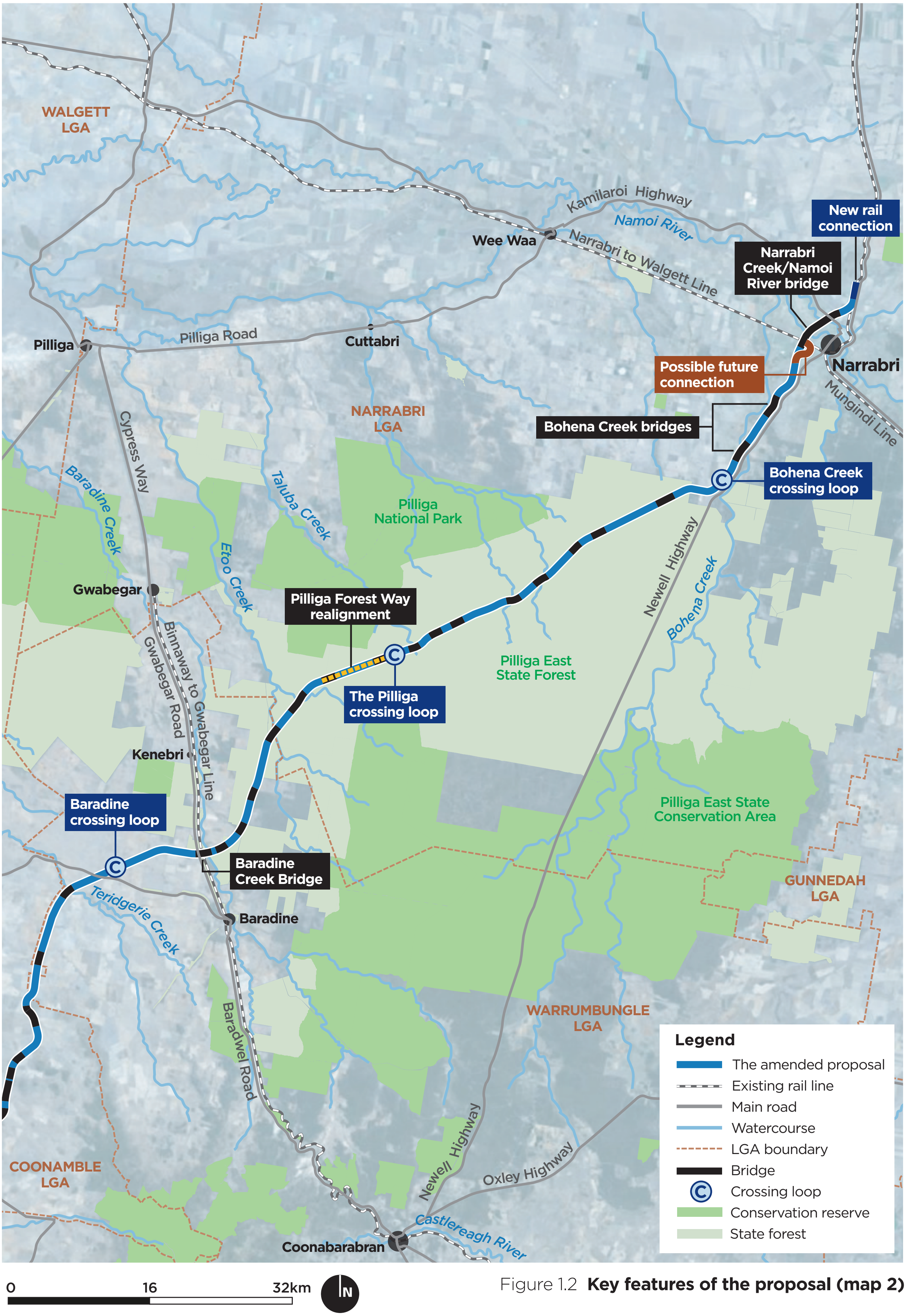


Figure 1.2 **Key features of the proposal (map 2)**

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 1.2. It is anticipated that the first phase would commence in late 2022, and is expected to take about four years to complete.

Table 1.2 Main construction phases and indicative activities

Phase	Details
Pre-construction	• Establishment of areas to receive early material deliveries • Delivery of certain materials that need to be brought to site before the main construction
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	• Construction of the proposed rail and road infrastructure, including earthworks, track, bridge and earth 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 (as amended) (see Figure 1.3):

- 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.

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 and a concrete pre-cast facility.

Further information on the indicative construction methodology and the infrastructure required to support construction is provided in the Amendment Report.

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. The proposal is expected to be operational in 2026. Inland Rail as a whole would be operational once all 13 sections are complete, which is estimated to be in 2027.

It is estimated that the proposal would be trafficked by an average of 10 trains per day (both directions) in 2026, 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 for Inland Rail as a whole would be a mix of grain, bulk freight, and other general transport trains. Total annual freight tonnages would be about 10 million tonnes in 2027, 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

Additional assessments of the potential terrestrial biodiversity impacts of constructing and operating the proposal has been undertaken since exhibition. The assessments have been undertaken to assist with considering and responding to issues raised in submissions and during consultation with stakeholders, assessing the impacts of the proposed amendments and to further progress commitments made in the EIS. The biodiversity development assessment report (BDAR), originally prepared to support the EIS, has been updated based on the additional assessments undertaken.

The purpose of this report is to assess the potential terrestrial biodiversity impacts from the construction and other operations of the proposal. This report:

- provides an updated assessment of the proposal (as amended)
- addresses the relevant SEARs listed in Table 1.3
- describes the existing environment with respect to terrestrial biodiversity
- assesses the impacts of constructing and operating the proposal on terrestrial biodiversity
- provides additional information as required to respond to issues raised in submissions and during consultation
- recommends measures to mitigate the impacts identified.

The methodology for the assessment is described in section 3.

Key changes between the exhibited BDAR and the updated BDAR are detailed in Appendix N.

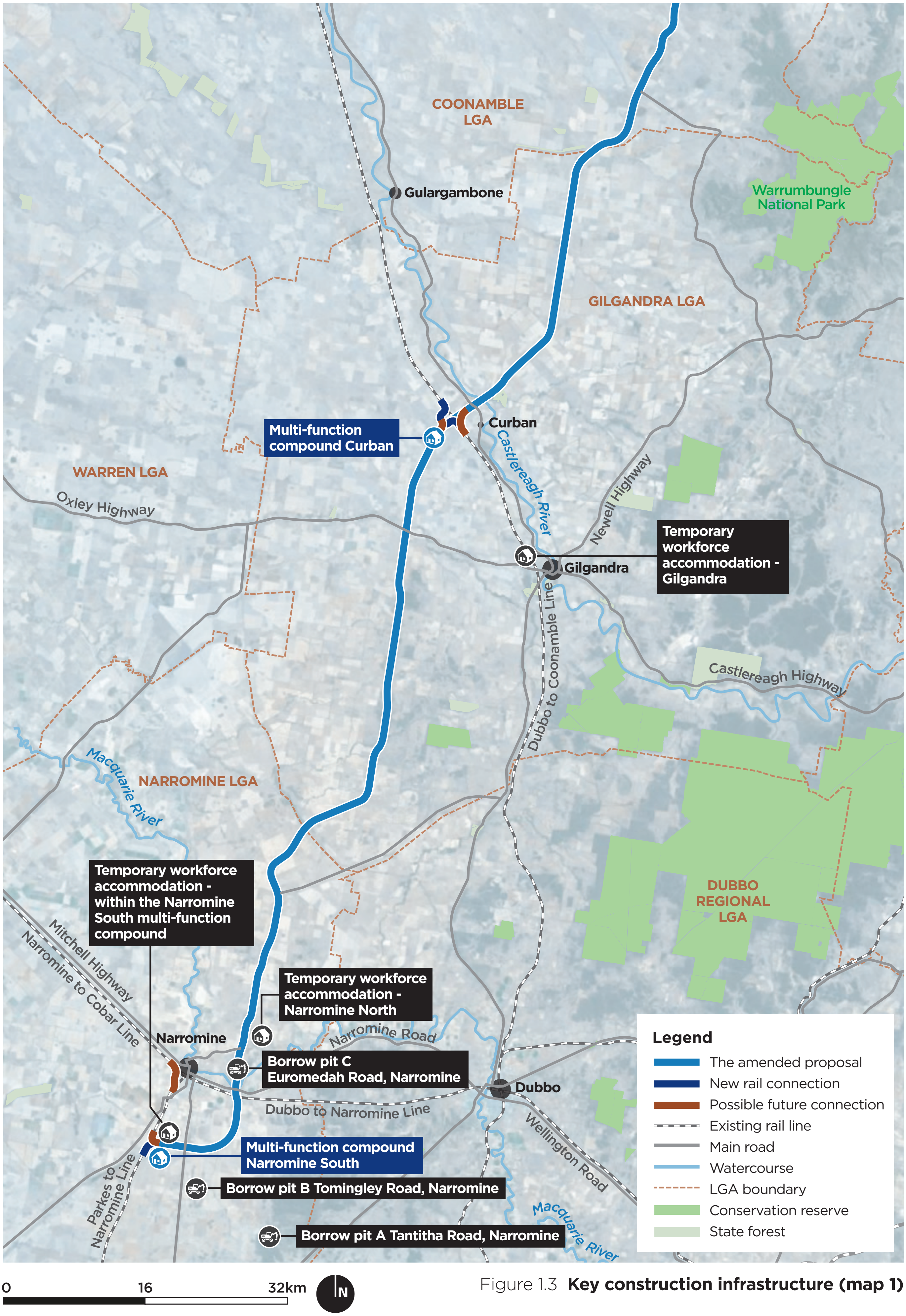


Figure 1.3 **Key construction infrastructure (map 1)**

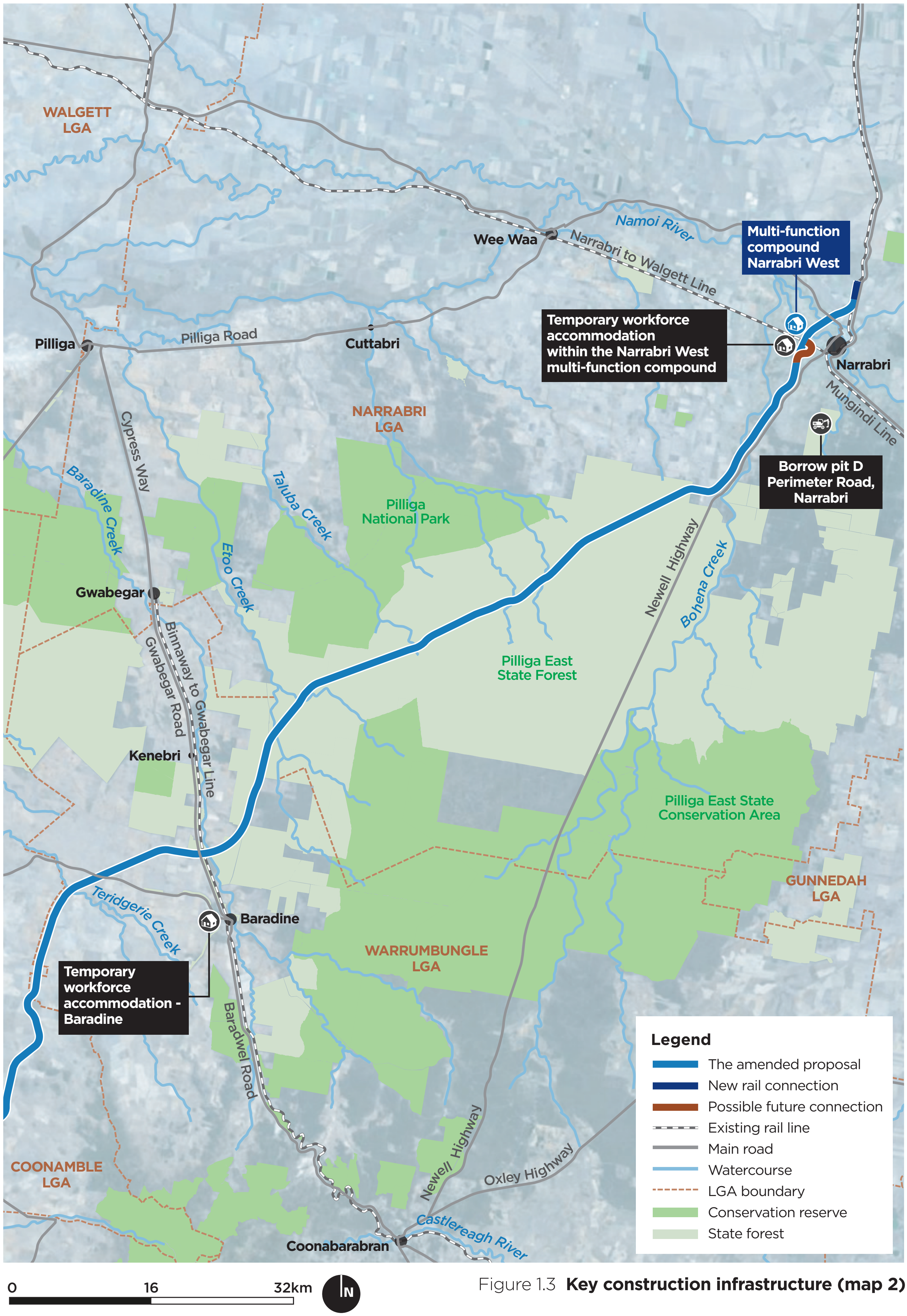


Figure 1.3 **Key construction infrastructure (map 2)**

This BDAR addresses the relevant SEARs for the EIS, as outlined in Table 1.3, the requirements of the BCS (formerly NSW Office of Environment and Heritage (OEH)) as outlined in Appendix A, and relevant guidelines and policies.

Table 1.3 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 9.3.2. Recommended management measures are provided in section 10.1. 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 9.3 (construction), section 9.4 (operation), section 10.1 (serious and irreversible impacts) and section 10.2 (prescribed impacts). Section 9.1 details the measures taken to avoid or minimise impacts. Section 13 provides the number and type of ecosystem credits required and section 13 provides the number and type of species credits required to offset the residual impacts of the proposal. Section 13 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.
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 3.14 provides the details of the accredited assessors who prepared this report.

SEAR number	Requirements	Where addressed in this report
6.5	The BDAR must include details of the measures proposed to address offset obligations.	Section 13 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 Technical Report 2 – Aquatic Ecology.
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 10.4 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*	Refer to Technical Report 2 – Aquatic Ecology and Technical Report 11 – Agriculture and Land Use.
	b. Key Fish Habitat as mapped and defined in accordance with the FM Act	
	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 Climate Change, Energy, the Environment and Water (DCCEEW) 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 DCCEEW are provided in Table 1.4.

Table 1.4 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 12
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
	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
	c. Maps displaying the above information (specific to each EPBC protected matter) overlaid with the proposed action.	Section 7

SEAR number	Requirements	Where addressed in this report
	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 10 Section 11
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 9.1 Section 9.1.2 Section 12
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 11 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 13

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 10 – discusses serious and irreversible impacts, prescribed impacts and key threatening processes
- Section 11 – described impacts on Matters of National Environmental Significance
- Section 12 – describes the mitigation measures recommended to minimise impacts during construction and operation of the proposal
- Section 13 – describes the offset requirements
- Section 14 – 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 Offsets 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 BCS 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 the Biodiversity Conservation Trust (BCT) 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 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 1.4.

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* (DPIE 2020) 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 and Heritage (OEH) 2016). Note that 2020 update was published after field surveys had been completed for the proposal
- '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 completed 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 15.

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.

Key information sources used in the preparation of this report include:

- DPIE – BCS NSW BioNet Atlas database for records of threatened species listed under the BC Act (original search undertaken in 2018, updated in 2019 and 2021) (EES 2021)
- Birdata records for threatened bird species for the stage 2 investigation area, provided under licence by Birdlife Australia (2020a)
- BCS Threatened biodiversity profile search online database for threatened ecological communities listed under the BC Act (EES 2019b)
- DCCEEW Protected Matters Online Search Tool for MNES listed under the EPBC Act and predicted to occur in the locality (DEE 2018a)
- DCCEEW online Species profiles and threats database (SPRAT) (DEE 2018b)
- FrogID dataset 2.0 and live records (FrogID 2021), which is a citizen science database of georeferenced audio recordings of frog calls that have been verified by frog experts associated with the Australian Museum
- NSW BioNet Vegetation Classification (OEH 2018c) to identify matching plant community types (PCTs) in the study area
- Biodiversity Assessment Method Calculator (BAM-C) outputs
- biodiversity assessments prepared for other major projects in the locality.

Species records from other online biodiversity databases were also reviewed, including Atlas of Living Australia, Birddata, and eBird. It is noted that these databases include data from the public that has not been independently verified, however they do provide important records and information on distribution of species and are used in conjunction with the results of the review of the key databases listed above.

3.2.2 Background research

Background research was conducted to identify:

- landscape-scale features of the study area in accordance with Chapter 3 of the BAM
- site context of the study area that includes assessing vegetation cover and patch size as required under Section 3.2 and Subsection 4.3.2 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 Chapter 4 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 Chapter 5 of the BAM (DPIE 2020).

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 2019, 2020 and 2021)
- 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 Biodiversity, Conservation and Science Directorate (BCS) of DPIE

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

ARTC and JacobsGHD have consulted with BCS 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 on 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 BCS.
- Provision of the Stage 1 methodology to BCS for approval on 18 October 2018.
- Provision of the Stage 2 methodology to BCS 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 BCS'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.
- Teleconference on 1 December 2020 to discuss preliminary review of BDAR.
- Teleconference on 4 February 2021 to discuss reallocation of derived grassland PCTs to parent communities and splitting of credit calculator into additional subregions.
- Teleconference on 30 March 2021 to discuss revised vegetation zone mapping and plot justifications. BCS also advised revised method for vegetation zone mapping of paddock trees.
- Teleconference on 27 April 2021, 11 August 2021 and 7 September 2021 to discuss the Preliminary Fauna Connectivity Strategy (Appendix J).
- Teleconference on 12 July 2021 to discuss the thermal drone survey methodology.
- Several workshops/teleconferences were held between June and August 2021 to discuss revised species polygons.
- Teleconferences on 7 September 2021 and 15 September 2021 to discuss residual prescribed impact offset calculations.
- Teleconferences on 21 October, 11 and 25 November and 9 December 2021 to discuss conversion of BDAR from BAM 2017 to BAM 2020 and updates regarding SAII assessments and prescribed impact assessment.
- Teleconference on 3 February 2022 to discuss the methodology and approach to calculating credits for prescribed impacts.

- Teleconference on 3 May 2022 to discuss the review of the updated BDAR and recommended changes calculating credits for prescribed impacts.
- Teelconference on 16 June 2022 to discuss the updated Koala expert report and updates to the method for calculating credits for prescribed impacts.

BCS 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 BCS from April to July 2020. The Stage 2 methodology was approved by BCS for use in completing the BDAR that was placed on public exhibition. The approach to preparing this Updated BDAR in accordance with the BAM 2020 guidelines has been agreed with BCS.

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 BCS, 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 DCCEEW

ARTC and JacobsGHD have also consulted with DCCEEW 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, DCCEEW was briefed on the proposed Biodiversity Investigation Plan. On completion of the BDAR, ARTC will meet with DCCEEW 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 the commencement of the field program, the area that could be accessed for field surveys in November 2018 was about 30 percent 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 and additional surveys in September, October and November 2020, August 2021 and March 2022. 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 4.2 of the BAM.

Where access to the study area and investigation corridor was not possible, a methodology was developed in consultation with the BCS 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.
- Details of access limitations are provided in section 3.6.3 and Figure 3.5. In total, 63.7 percent of the proposal site and 70.9 percent of native vegetation was accessed.

As part of the update of the BDAR from BAM 2017 to BAM 2020, derived native grassland has been assigned to the relevant parent community and scattered trees have been incorporated into the nearest vegetation zones as advised by BCS.

Non-native vegetation identification

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

Non-native vegetation included areas that were visibly cropped during field inspections. This included paddocks of cereal and pasture crops (see Photo 3.1 , Photo 3.2 and Photo 3.3).

Photo 3.1 Cereal crop classified as non-native vegetation (September 2020). Native scattered trees are classified as native vegetation

Photo 3.2 Non-native vegetation dominated by introduced species (*Echium plantagineum* – Patterson's Curse) in the ground cover stratum (September 2020). Native scattered trees are classified as native vegetation

Photo 3.3 Ploughed and cultivated land classed as non-native vegetation (October 2019)

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.

Similarly, where grasslands were observed that contained what appeared to be a mix of both native and introduced species, a vegetation integrity plot was completed to gain a better understanding of groundcover structure and composition. A patch was only assigned as a non-native grassland where there was a clear dominance of introduced species in the structure and composition. Where there was little difference between the structure and composition of non-native versus native groundcover species, a conservative approach was adopted and the patch was assigned to native vegetation (see Photo 3.4). In most cases, if a paddock was not clearly cropped or fallowed, native grasslands were mostly dominant with some degree of introduced species. Livestock grazing paddocks that had not been cropped mostly retained a higher percentage of native grass and were assigned to Category 2.

Photo 3.4 Example of derived native grassland mapped as a native PCT where a plot was used to determine percent native dominance

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, BCS 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).

Under a project specific license, BCS 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 BCS 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 BCS 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 over different years 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 2017) 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 BCS during April to July 2020. The Stage 2 methodology review by BCS has been given in principal approval and minor revision were made to provide additional clarity following the adequacy review.

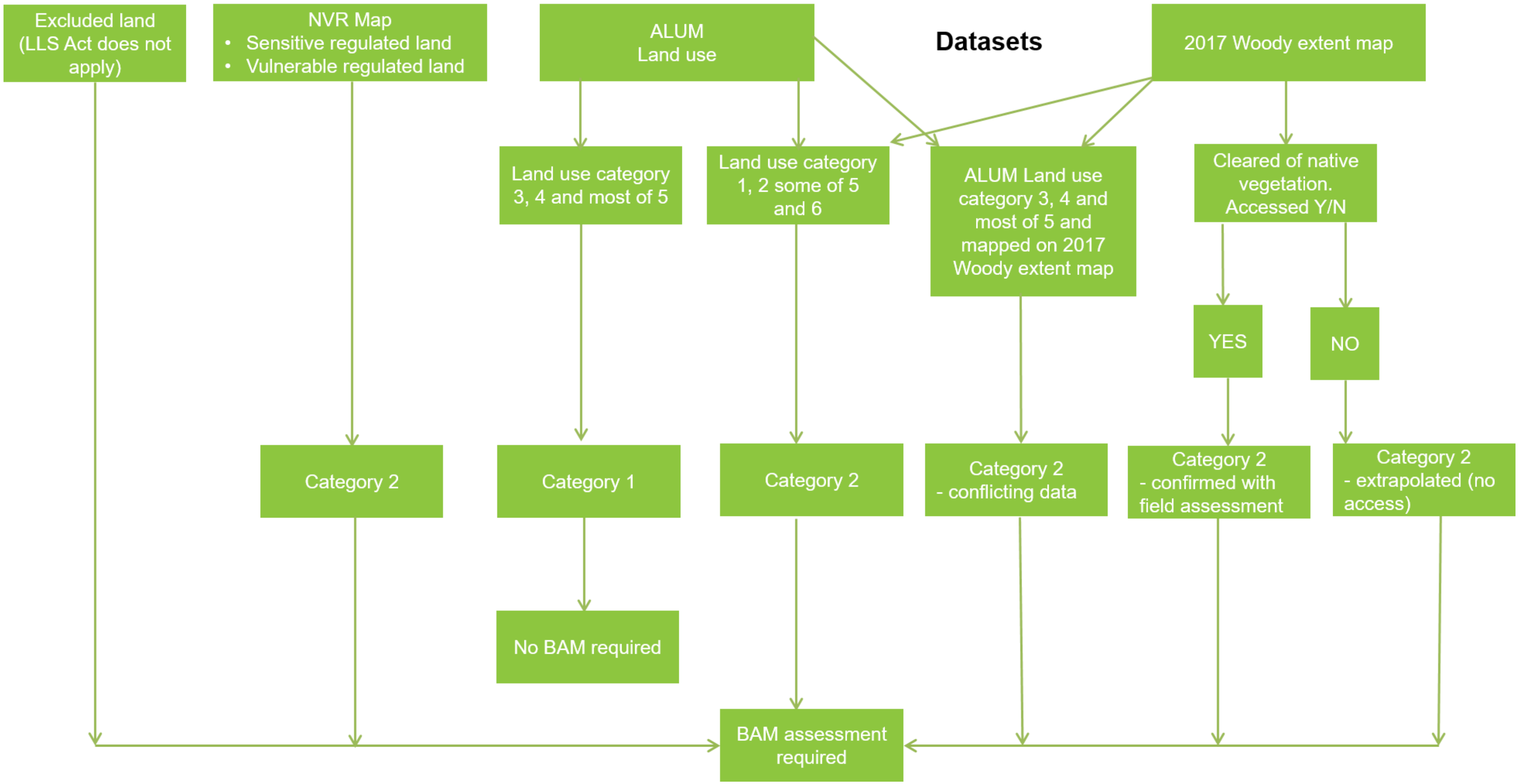


Figure 3.1 Flowchart overview of land categorisation process

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 with 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 the BAM (DPIE 2020) to obtain vegetation integrity data for the calculation of biodiversity credits. BAM plot data sheets are provided in Appendix L.

The majority of 2018 and 2019 surveys were conducted during drought conditions, which affected vegetation integrity of plots surveyed (see section 3.6.3). Following good rainfall in 2020, additional spring surveys were undertaken to take advantage of better conditions. These targeted areas of potential habitat for threatened flora species, and areas where access was previously not possible but was now available. The main aim of these surveys was 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.

Wherever possible, within land access restrictions, plots were located to comply with the minimum number of plots required by the BAM (DPIE 2020). 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
>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 194 plots were completed over the seven main survey periods. Of these, 165 have been used in subsequent credit calculations, while the remaining 29 were not used as they occurred in alternative alignments or potential borrow pit sites that were discarded as part of proposal refinement.

Forty-two PCTs were identified during field surveys across the investigation corridor with 35 occurring in the proposal site. A total of 204 plots were required for entry of vegetation zones into the seven credit calculators. The minimum number of plots required for each subregion and vegetation zone is outlined in 5.2.1. In accordance with the BCS 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 bioregion PCT benchmark data was used to reach the minimum plot number. Where benchmark data was required for a derived native grassland from a parent community, the following general parameters were approved for use by BCS project officers:

- allocate a zero value to the composition and structure attribute for ‘Tree’.
- allocate a zero value for the functional litter attribute
- allocate a zero value for the functional logs attribute
- allocate a zero value to the functional hollow attribute
- allocate a zero value to all functional tree size classes attributes (except regeneration)
- retain/allocate a one value for functional regeneration attribute
- retain all other values as is, including shrubs to account for some of the smaller chenopod type shrubs frequently observed in derived grasslands in the proposal site).

A total of 35 benchmark plots were used and 165 plots from field surveys. Due to access limitations, some plot data was used in more than one subregion assessment, due to the close proximity of plots to subregion boundaries. Justifications for each plot used in each subregion is provided in Appendix L. For those vegetation zones where more plots occurred within the construction footprint than was required, all plots were included in the vegetation zone.

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 1,293 RDPs were collected during field surveys. All field data was captured using the ArcGIS Collector application on a standard mobile device.

3.4.5 Threatened flora

Potential candidate species credit entities for the proposal site were identified and assessed in accordance with Chapter 5 and steps 1 to 4 of Section 5.2 of the BAM (DPIE 2020). 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 BCS threatened species profiles, experience and judgement of JacobsGHD ecologists and through ongoing consultation with BCS 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 3.3. 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 searches in potential habitats on private property not previously accessed.

- September 2020: two botanists over six days – vegetation integrity plots and threatened flora searches in potential habitats on private property not previously accessed and in the Pilliga.
- October 2020: two botanists over eight days – vegetation integrity plots and threatened flora searches in potential habitats on private property not previously accessed and in the Pilliga.
- November 2020: four botanists over five days – vegetation integrity plots and threatened flora searches in potential habitats on private property not previously accessed and in the Pilliga.
- August 2021: one botanist over four days – vegetation integrity plots and threatened flora searches in potential habitats on private property not previously accessed.
- March 2022: six ecologists over nine days – targeted searches for *Bertya opponens* and *Pomaderris queenslandica* in previously unaccessed portions of the Pilliga.

Surveys for threatened flora species identified in Table 3.3 were conducted on private and publicly 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 to gain a better understanding the potential habitat of the following species:

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

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 were assumed present in the proposal site for the exhibited BDAR (see section 6.1).

Additional targeted seasonal surveys were 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. Based on consultation with other ecologists and the BCS regarding the timing of surveys, survey periods for some orchid species appeared to be occurring earlier in spring 2020, and other species have also been found to flower outside their usual period throughout 2020. Subsequently, three surveys periods were undertaken across September, October and November 2020 to capture all required survey months for candidate threatened flora species and provide increased opportunity to capture survey effort in favourable conditions.

Further surveys were able to be conducted for *Bertya opponens* and *Pomaderris queenslandica in* March 2022. These surveys focussed on previously unaccessed portions of the Pilliga, with the aim to confirm whether or not these species occurred in areas where they had previously been assumed to be present.

Table 3.3 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	All year
Commersonia procumbens	V	V	Area	Aug-May
Cyperus conicus	E	-	Area	Jan-May
Desmodium campylocaulon Creeping Tick-trefoil	E	-	Area	Dec-Apr
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	Sep-Dec
Polygala linariifolia Native Milkwort	E	-	Area	Oct-Feb
Pomaderris queenslandica Scant Pomaderris	E	-	Area	All year
Pterostylis cobarensis Greenhood Orchid	V	-	Area	Sep-Nov
Senecio garlandii Woolly Ragwort	V	V	Area	All year
Swainsona murrayana Slender Darling Pea	V	V	Area	Sep
Swainsona plagiotropis Red Darling Pea	V	V	Area	Sep
Swainsona sericea Silky Swainson-pea	V	-	Area	Sep-Nov
Tylophora linearis	V	E	Area	Oct-May
Zieria ingramii Keith's Zieria	V	V	Area	Sep-Feb

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).

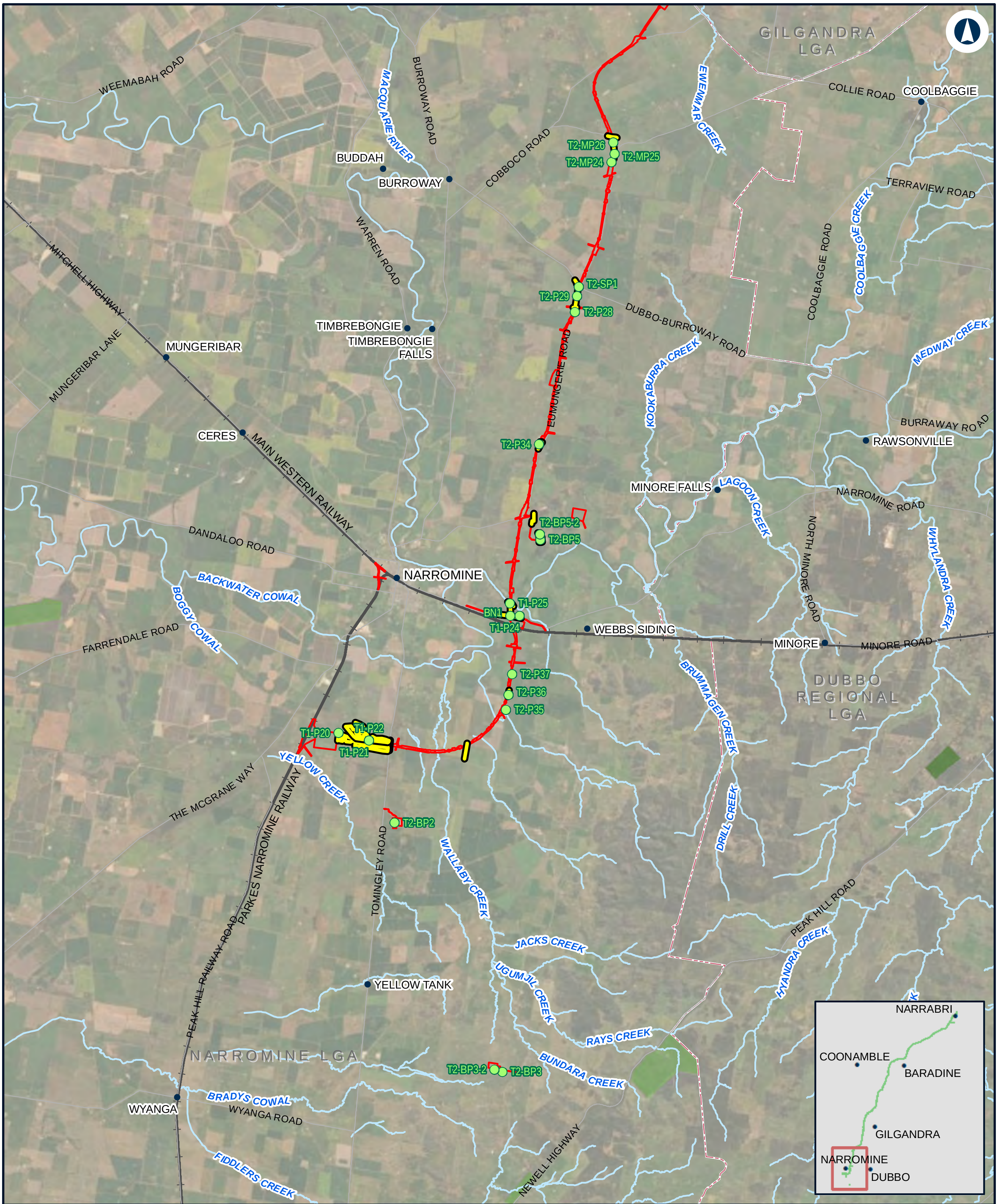
A number of GDEs, particularly above-ground ecosystems, are likely to occur in the proposal site or near the proposal site. Surface activities can have an impact on groundwater quality, levels and pressure. These, in turn, can impact surface environments down slope/stream (ie in the discharge areas).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

GDEs in the study area were assessed during field surveys via PCT and vegetation zone mapping, habitat assessments and threatened flora and fauna searches.



NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2 - MAP 1 of 6

0 3.5 7 Km

Coordinate System: GDA 1994 MGA Zone 55

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

LEGEND

- Construction impact zone
- Threatened flora survey
- Vegetation plot

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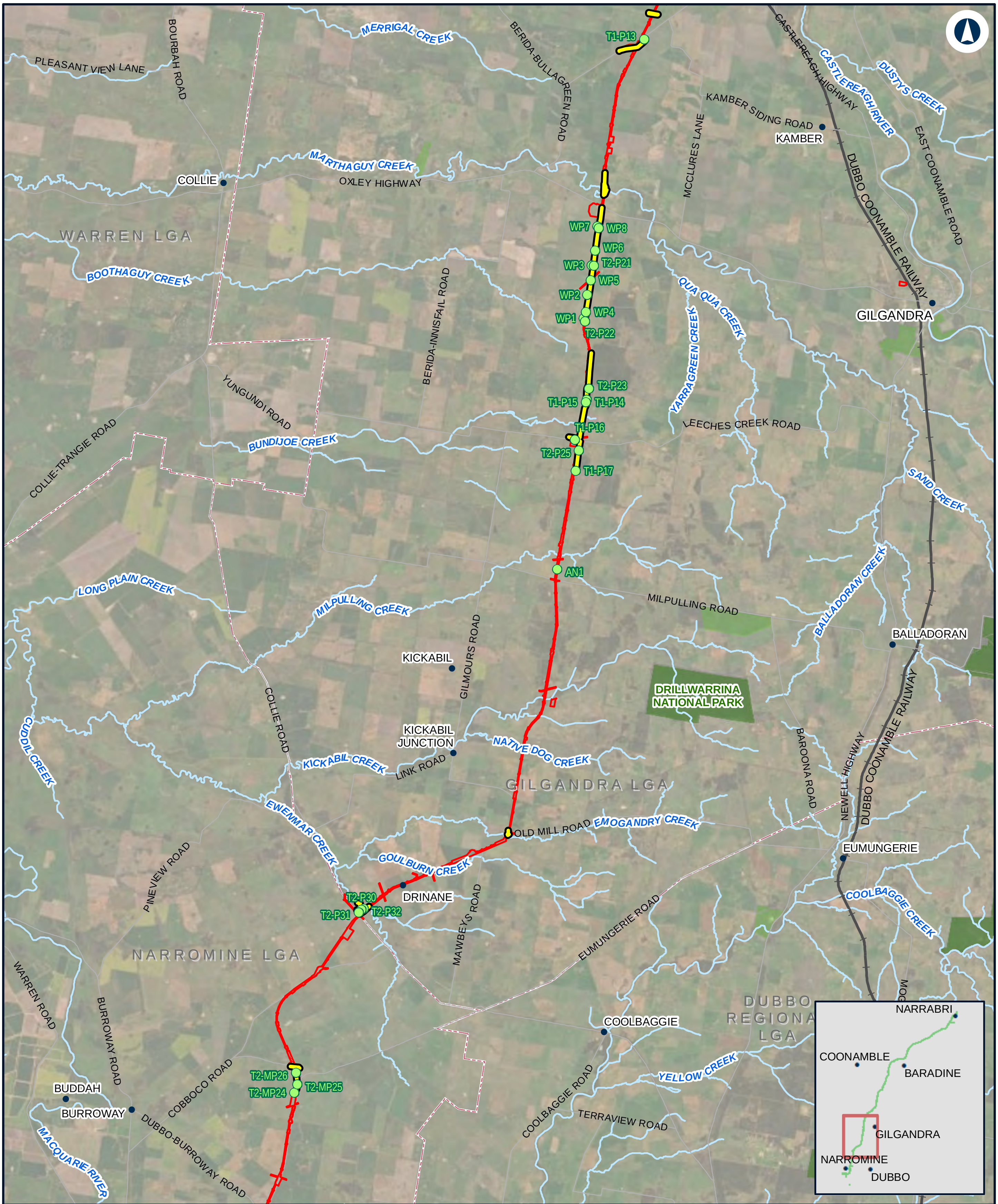

NARROMINE TO NARRABRI Vegetation integrity plot locations

Figure 3.2 - MAP 2 of 6

0 3.5 7 Km

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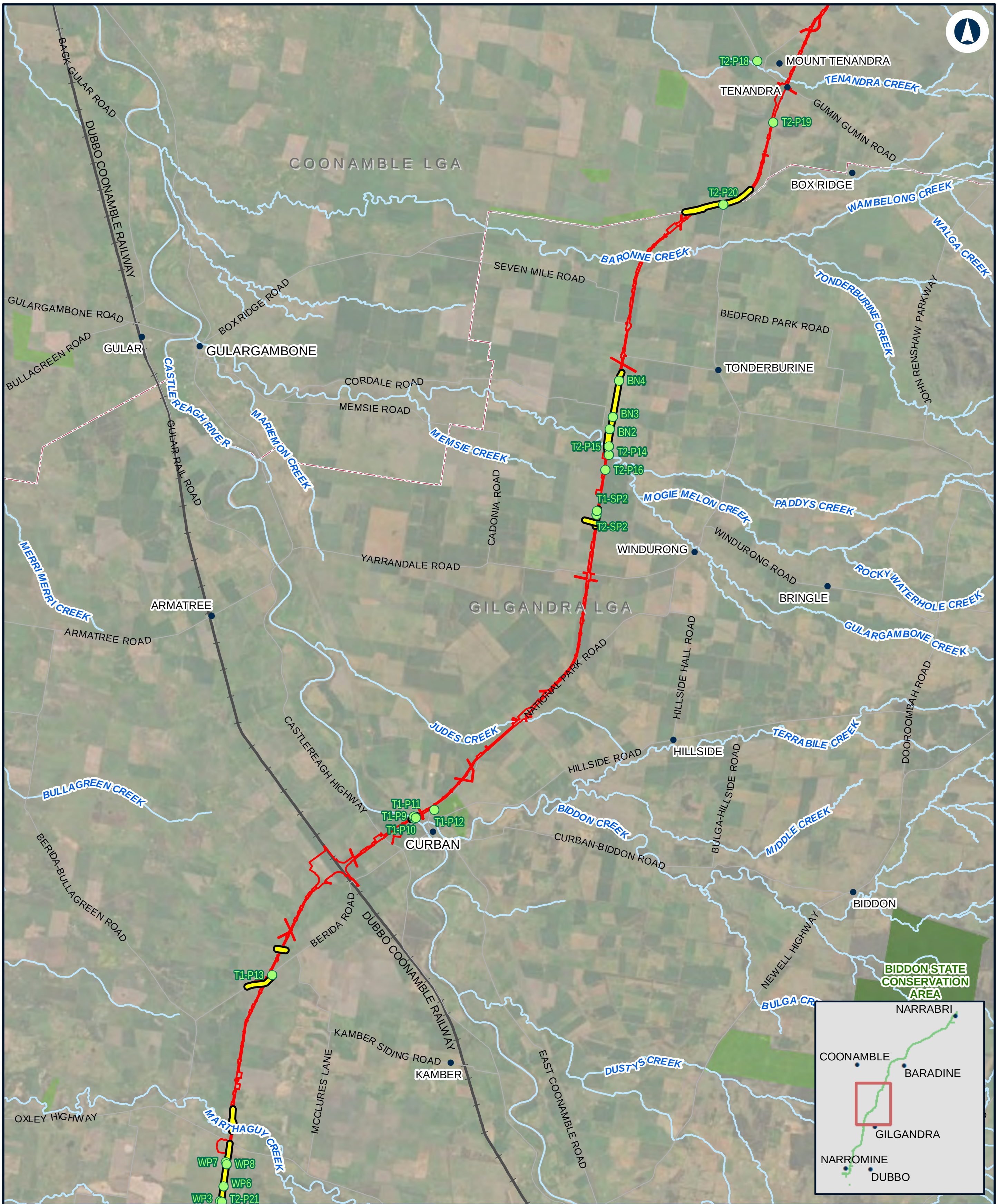

NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2 - MAP 3 of 6

0 3.5 7 Km

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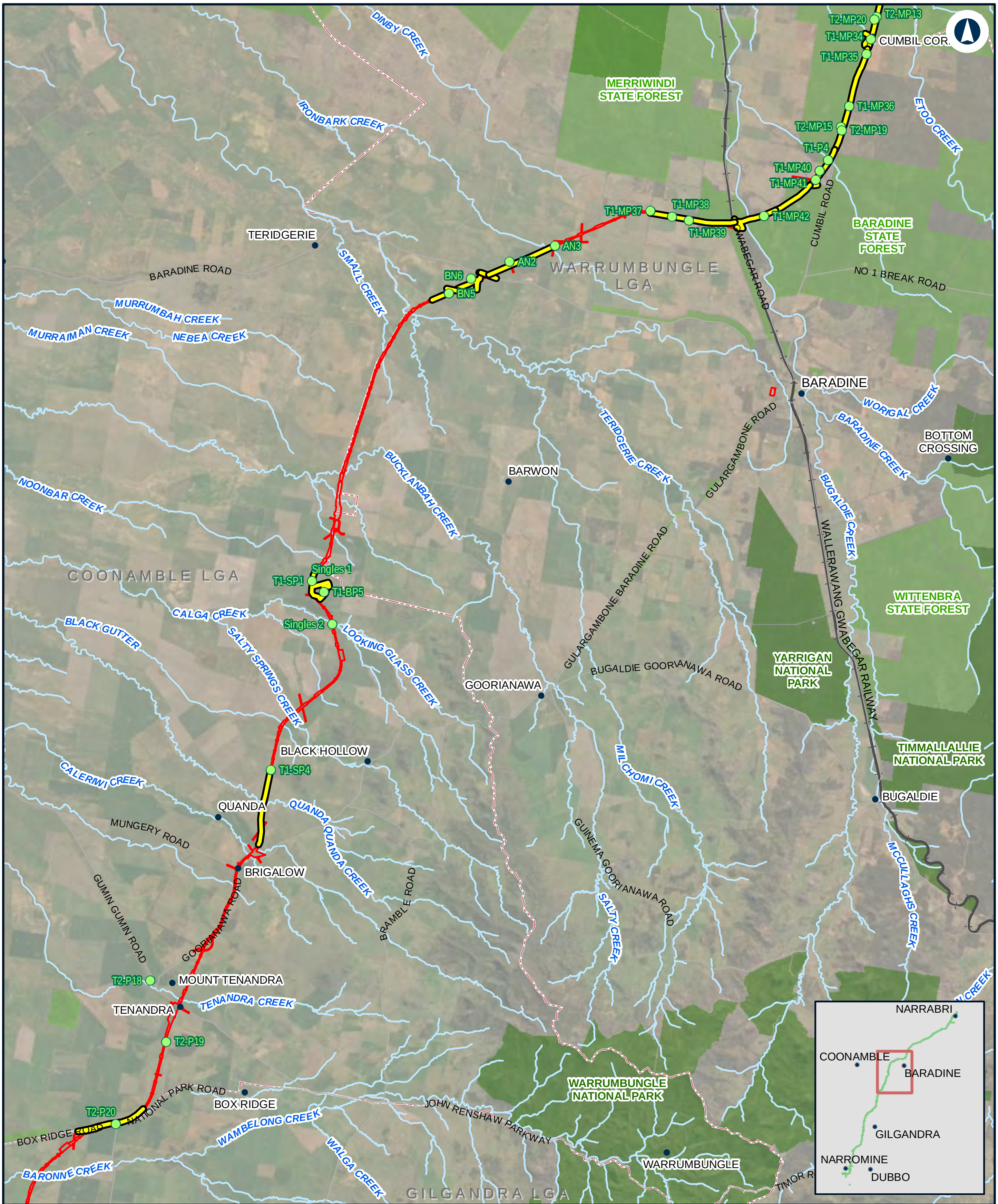

NARROMINE TO NARRABRI Vegetation integrity plot locations

Figure 3.2 - MAP 4 of 6

0 3.5 7 Km

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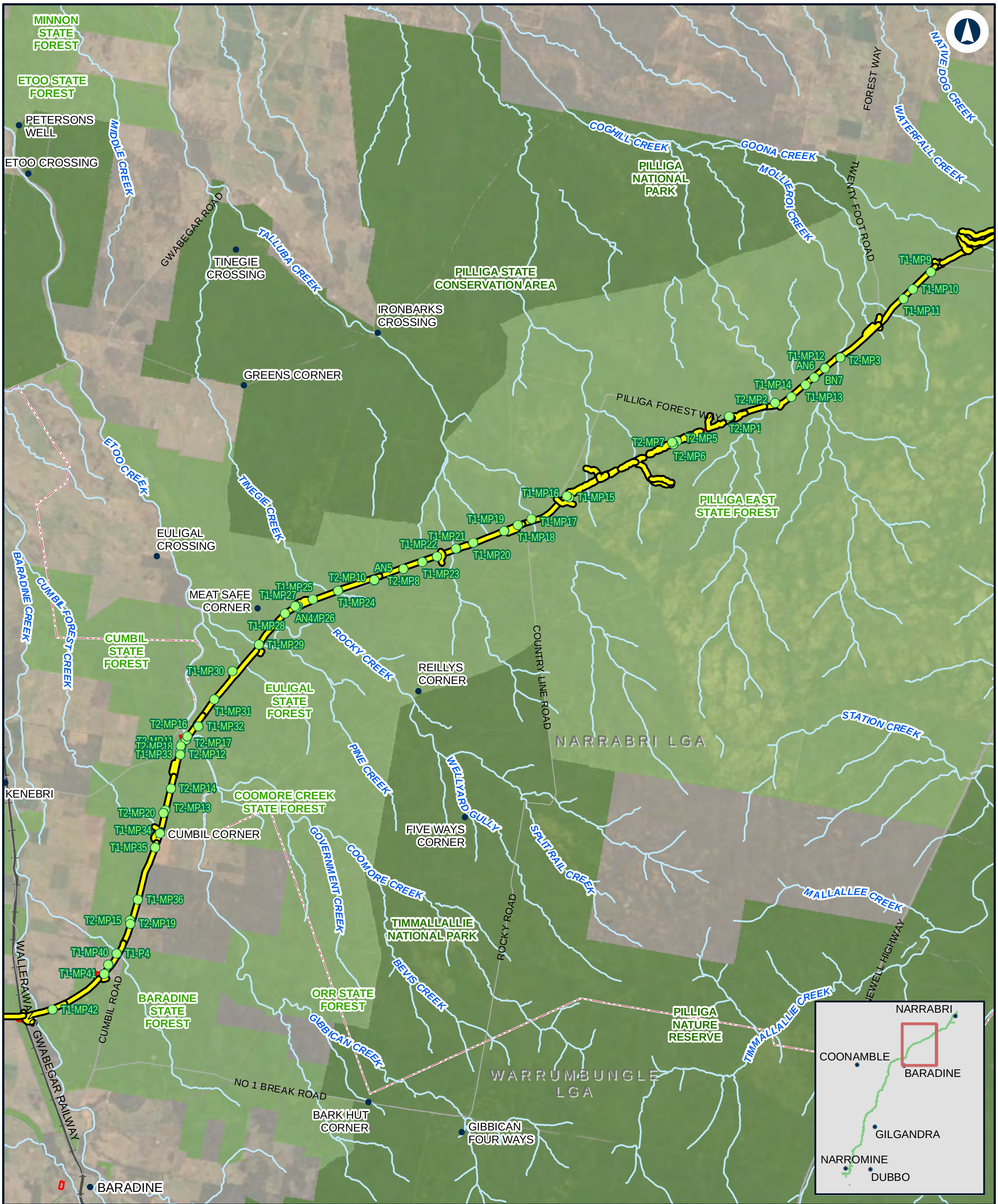

NARROMINE TO NARRABRI

Vegetation integrity plot locations

Figure 3.2 - MAP 5 of 6

0 3.5 7 Km

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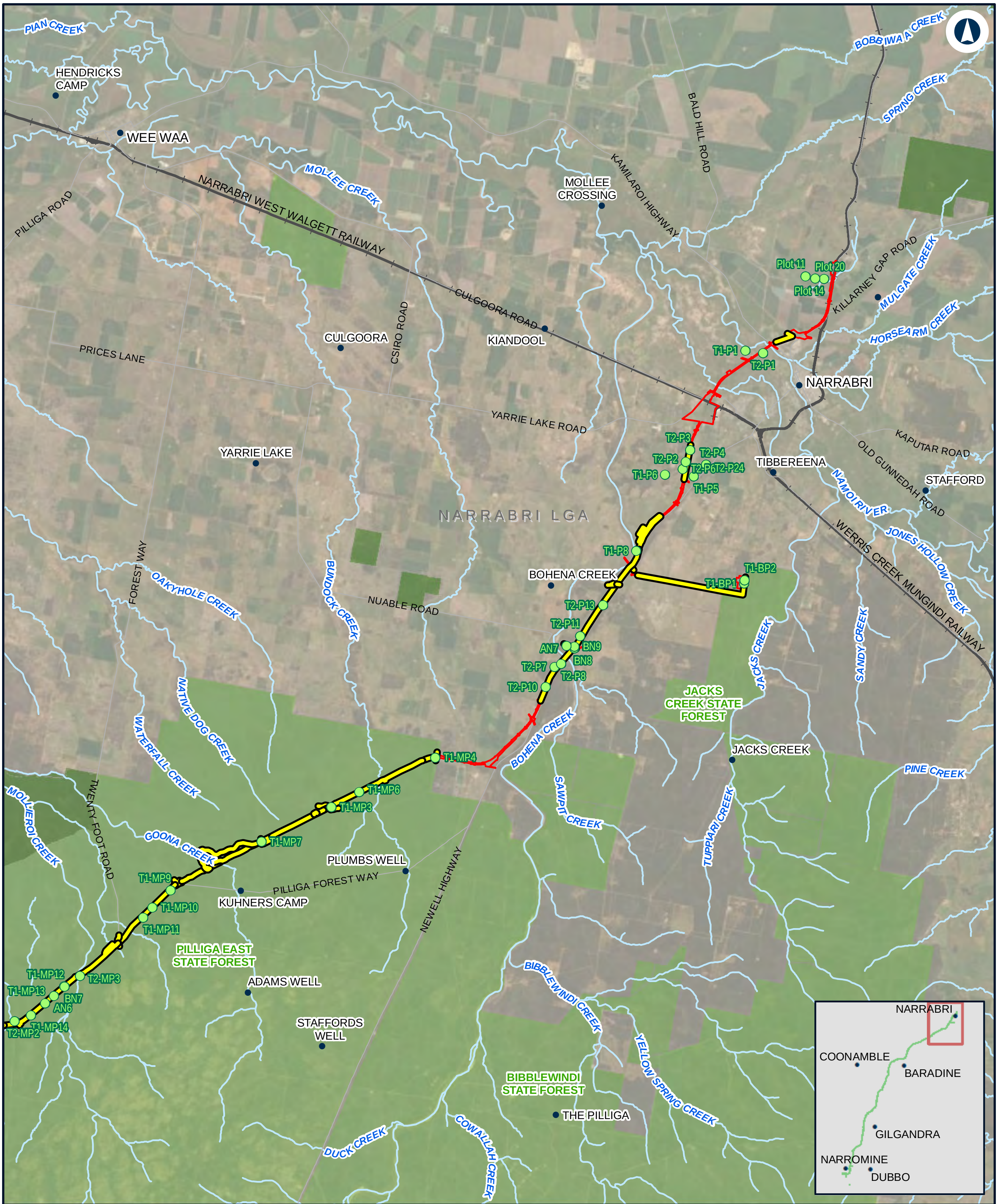

NARROMINE TO NARRABRI Vegetation integrity plot locations Figure 3.2 - MAP 6 of 6

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 DPIE
- 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, associated PCTs, vegetation cover, patch size, and the habitat resources present. If any one of the criteria set out in Subsection 5.2.1 (2) of the BAM relevant to the threatened species is not met, the subject land should be considered as unsuitable habitat for that species. No further assessment is required for that species.

Staged surveys of the investigation area were conducted between September 2018 and August 2021 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)
- spring surveys, focusing on properties not previously accessed, as well as surveys in the Pilliga (November 2020)
- nocturnal thermal drone surveys and spotlighting in the Pilliga and Bohena Creek area (July 2021)
- diurnal surveys with Koala and raptor experts along the alignment (August 2021).

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 2020/2021 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 – diurnal and nocturnal surveys along the alignment
- November 2018 – diurnal and nocturnal surveys along the alignment
- March 2019 – focus on trapping and nocturnal surveys
- August 2019 – focus on winter breeding species, diurnal and nocturnal surveys along the alignment
- September 2019 – diurnal and nocturnal surveys along the alignment
- October 2019 – diurnal and nocturnal surveys along the alignment
- June 2020 – diurnal and nocturnal surveys near Gilgandra
- November 2020 – diurnal and nocturnal surveys along the alignment
- July 2021 – diurnal and nocturnal surveys in Narromine, nocturnal drone surveys in the Pilliga and Narrabri area
- August 2021 – diurnal surveys with species experts along the alignment
- March 2022: two ecologists over nine days – diurnal surveys in combination with targeted flora searches in previously unaccessed portions of the Pilliga.

Where possible, surveys were conducted in the survey season identified by BCS, 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 3.4. 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 were undertaken in Spring 2020 to take advantage of improved weather conditions and to gain a better understanding of impacts to biodiversity within the construction impact zone.

Table 3.4 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, Jun, Aug, Sep, Oct, Nov
Active searches	Reptiles	Five-clawed Worm-skink	Narrabri area	Nov, Sep
		Pink-tailed Legless Lizard	Mt Tenandra area, Borrow Pit A	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, Jul, Aug, Sep, Oct, Nov
	Birds	Owls, Bush Stone-curlew	Various locations along the entire alignment during each survey month	Mar, Jun, Aug, Oct, Nov
	Reptiles	Pale-headed Snake	Focus on Pilliga area	Mar

Survey method	Fauna groups	Species targeted	Survey locations	Survey timing
	Reptiles	Pale-headed Snake	Narromine, Burraway, Kickabil, Castlereagh River, Narrabri area	Nov
	Mammals	Koala, Squirrel Glider, Eastern Pygmy-possum, Black-striped Wallaby, Rufous Bettong	Focus on Pilliga area	Mar, Aug, Oct, Nov
	Frogs	Sloane's Froglet	Narromine, Pilliga	Jul, Aug
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, Jul, Aug, Sep, Oct, Nov
	Birds	Owls, Bush Stone-curlew	Various locations along the entire alignment during each survey month	Mar, Jun, Aug, Oct, Nov
	Mammals	Koala	Focus on Pilliga area	Mar, Aug, Oct. Nov
Frog call recording (FrogID)	Frogs		Various locations along the entire alignment	Mar, Aug, Sep, Oct, Nov
	Frogs		Focus on Pilliga area	Mar, Jul, Aug, Sep, Oct, Nov
Thermal drone surveys	Mammals	Koala	Focus on Pilliga and Bohena Creek area	Jul
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

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 28 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). Active searches were generally conducted over two hectares in woodland patches, or along transects in road reserves. Incidental searches of shorter time periods were also undertaken while undertaking other surveys where suitable microhabitats (such as rocky areas) were encountered.

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. In total, scat searches were conducted at 30 locations. 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).

Following exhibition of the BDAR, Dr Steve Phillips of Biolink Pty Ltd was subcontracted to undertake an expert report for the Koala. Field surveys were conducted over four days along the alignment in August 2021, accompanied by accredited assessor Leigh Maloney. Further detail is provided in the expert report (see Appendix N).

Thermal drone surveys

Following exhibition of the BDAR, thermal drone surveys were undertaken by Wildlife Drones Pty Ltd in July 2021 over four nights in the Pilliga forests and one night in the Bohena Creek area to target the Koala (see Appendix N). Surveys included daytime reconnaissance of each night's route, and drone surveys between around 10:30pm and 6am each night. An experienced drone operator (operating under a CASA certified Operator's Certificate) and spotter managed the drone surveys, assisted by two ecologists on the ground to help with validating fauna species recorded by the drone. Flights were undertaken with a DJI Matrice 200 series drone with a 19 mm XT thermal camera at an altitude of 60 metres for sensing wildlife in the canopy of the forest using a grid survey pattern (or lawn mower pattern) within the defined transect study area to target the Koala. In total, the drone surveys covered 996 hectares over 113 flights (see Appendix N).

Bird surveys

Dedicated bird surveys were conducted at 36 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, observed incidentally during all surveys, and while driving between sites. This latter method is particularly suitable for raptors and rarer species.

Following exhibition of the BDAR, Dr Tony Saunders of Merops Pty Ltd was subcontracted to undertake an expert report for the Little Eagle and Square-tailed Kite. Field surveys were conducted over four days along the alignment in August 2021, accompanied by accredited assessor Leigh Maloney. Further detail is provided in the expert report (see Appendix N).

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 3.5). Sites included possible flyways along creeklines, dams and near rivers.

Table 3.5 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 3.6. 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 3.6 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 10 pm 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 3.7 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 eight nights in rural areas in November 2019, four nights in the Pilliga in March 2019, six nights across the alignment in August 2019 (including one night in the Pilliga), two nights in early October 2019, one night in June 2020, two nights in November 2020, one night in July 2021 (Narromine), and five nights in July 2021 (in conjunction with the thermal drone surveys in the Pilliga and Bohena Creek area). Spotlighting was undertaken by two ecologists using 210 lumens P14 Led Lenser torches or similar. Each survey lasted three to four 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 undertaken in conjunction with the thermal drone surveys in July 2021 was conducted between 11pm and 6am by two ecologists.

Spotlighting comprised a combination of surveys on foot (about 0.5 kilometres per hour) and slow driving surveys (five 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 or call when encountered opportunistically during surveys or during targeted searches at dams and creeks. Frog calls were recorded and verified using the Australian Museum's Frog ID app.

Call playback was undertaken on a total of 29 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 one minute), to avoid disturbance of nesting owls.

Table 3.8 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

Timing	General location	Site	Habitat
			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
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 June 2020	Gilgandra	Private	Woodland
15 November 2020	Pilliga	Cumbil State Forest Euligal State Forest	Riparian vegetation Woodland
16 November 2020	Narrabri	Bohena Creek	Riparian vegetation Woodland
5 July 2021	Narromine	Narromine multifunction compound	Farm dams and gilgai
19 July 2021	Pilliga	Baradine State Forest Cumbil State Forest	Riparian vegetation Woodland
20 July 2021	Pilliga	Euligal State Forest Pilliga East State Forest	Riparian vegetation Woodland

Timing	General location	Site	Habitat
21 July 2021	Pilliga	Pilliga East State Forest	Riparian vegetation Woodland
22 July 2021	Pilliga	Pilliga East State Forest	Riparian vegetation Woodland
23 July 2021	Narrabri	Bohena Creek	Riparian vegetation 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 one to two 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 to 30 metres apart along two transects about 30 to 50 metres apart, with Elliott As and Elliott Bs placed near each other. Trees were sprayed with a diluted honey and water mixture as an additional lure specifically for the Squirrel Glider. 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 16 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 three to four nights. Cameras were set in late August 2019 in the Pilliga and collected in late September 2019 (see Table 3.9).

Table 3.9 Camera trap effort

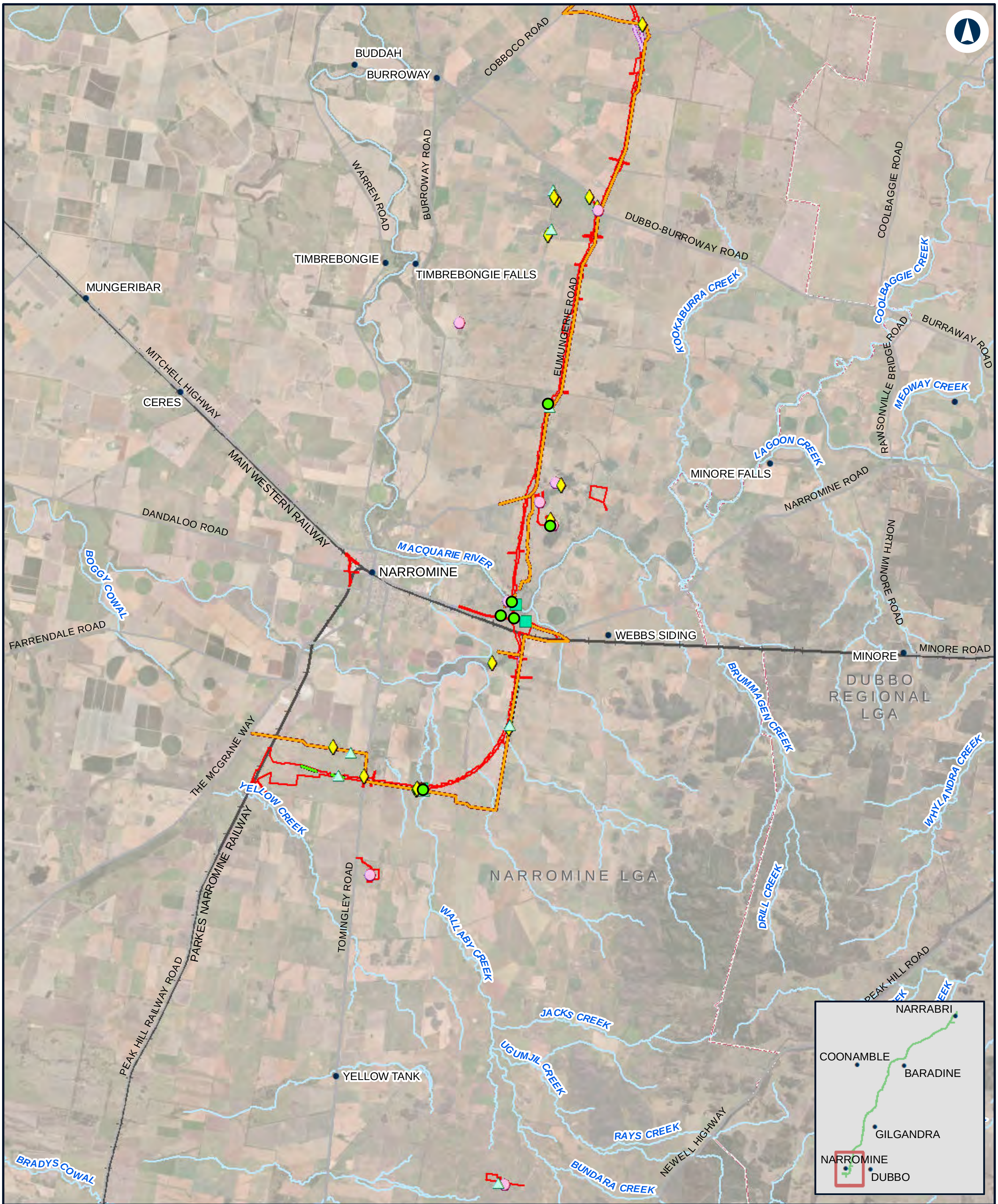
Timing	General location	Site	Habitat	Effort
November 2018	Bohena	Bohena Creek (north)	Dry creek (narrow)	3 nights
	Bohena	Bohena rest area	Forest clearing	3 nights
	Bohena	Bohena Creek (south)	Dry creek (wide)	3 nights
March 2019	Pilliga	Coolangala Creek	Dry creek (wide)	4 nights
	Pilliga	Etoo Creek	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

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.

3.5.4 Expert reports

Following exhibition of the BDAR, Dr Stephen Philips of Biolink Pty Ltd was subcontracted to undertake an expert report for the Koala and Dr Tony Saunders of Merops Pty Ltd was subcontracted to undertake an expert report for the Little Eagle and Square-tailed Kite. The experts were approved by BCS. These expert reports were considered necessary due to the difficulty of assessing the extent of impacts on the wide-ranging raptors, and the scarcity of records of the Koala. Field surveys were conducted along the alignment over four days in August 2021, accompanied by accredited assessor Leigh Maloney. Further detail is provided in the expert reports (see Appendix N).



NARROMINE TO NARRABRI

Fauna survey locations (diurnal)

Figure 3.3 - MAP 1 of 6

0 2.5 5
Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 29/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Expert survey sites
- Active search
- Bird survey
- General fauna survey
- Hollow-bearing tree transect
- Scat search
- Active search
- Bird survey (Spring 2020)
- Diurnal fauna survey
- General fauna survey

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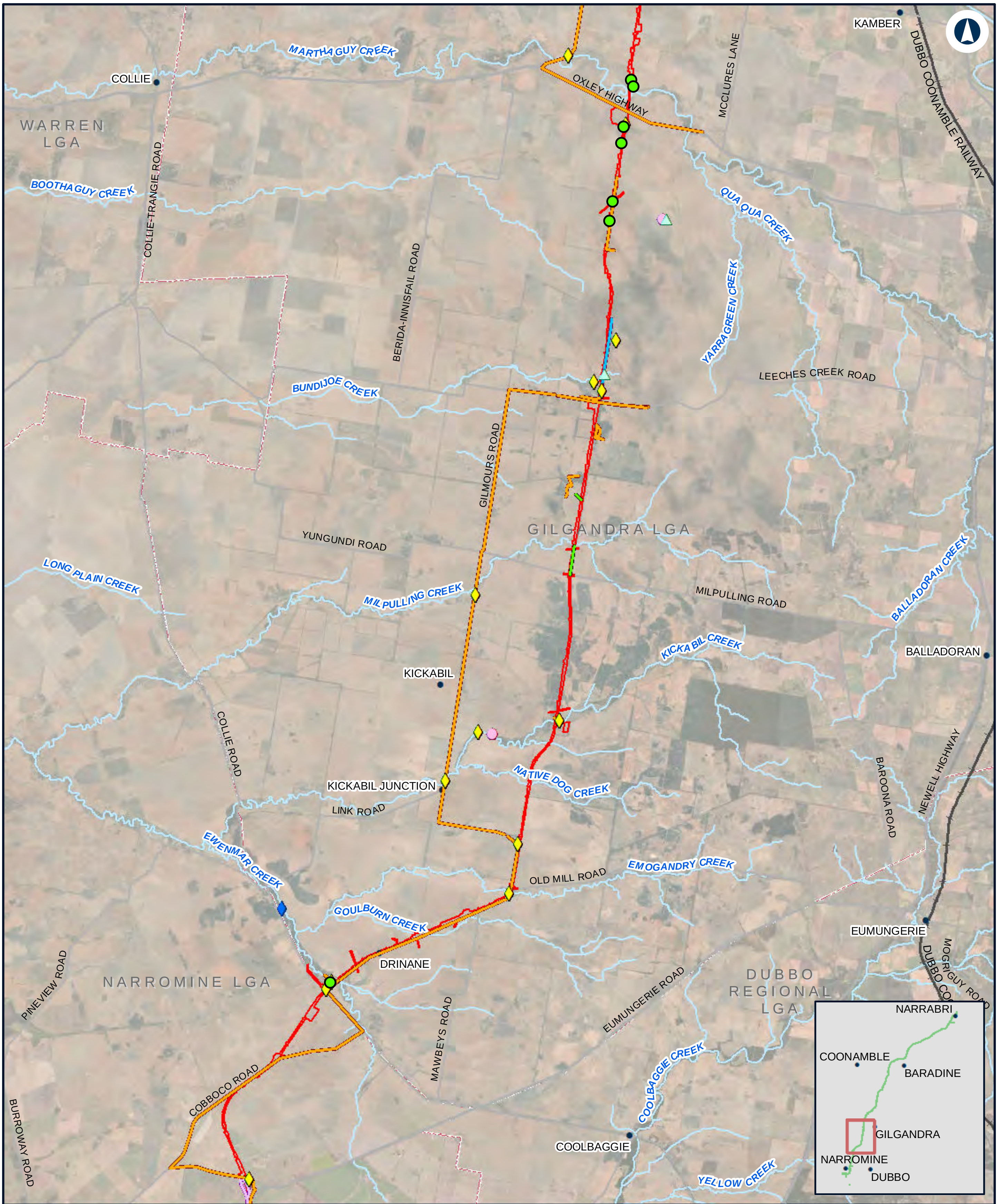

NARROMINE TO NARRABRI

Fauna survey locations (diurnal)

Figure 3.3 - MAP 2 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 29/06/2022
Paper: A4
Author: JacobsGHD
Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Expert survey sites
- Active search
- Bird survey
- General fauna survey
- Winter owl survey
- Bird survey (Spring 2020)
- Bird surveys, active searches
- Diurnal fauna survey
- General fauna survey

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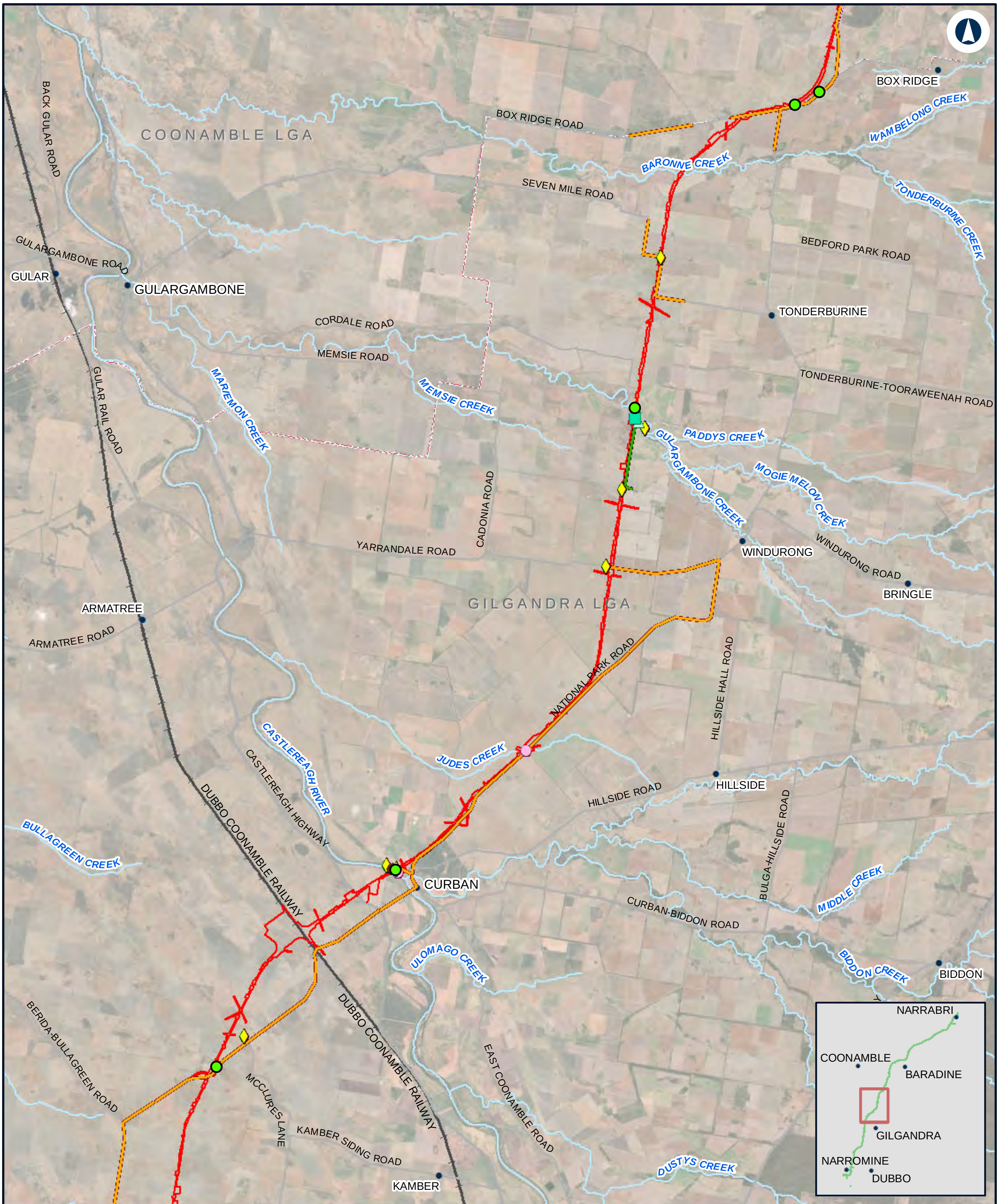

NARROMINE TO NARRABRI Fauna survey locations (diurnal) Figure 3.3 - MAP 3 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 29/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Expert survey sites
- Active search
- Bird survey
- General fauna survey
- Hollow-bearing tree transect
- Scat search
- Active search
- Bird survey
- Diurnal fauna survey
- General fauna survey

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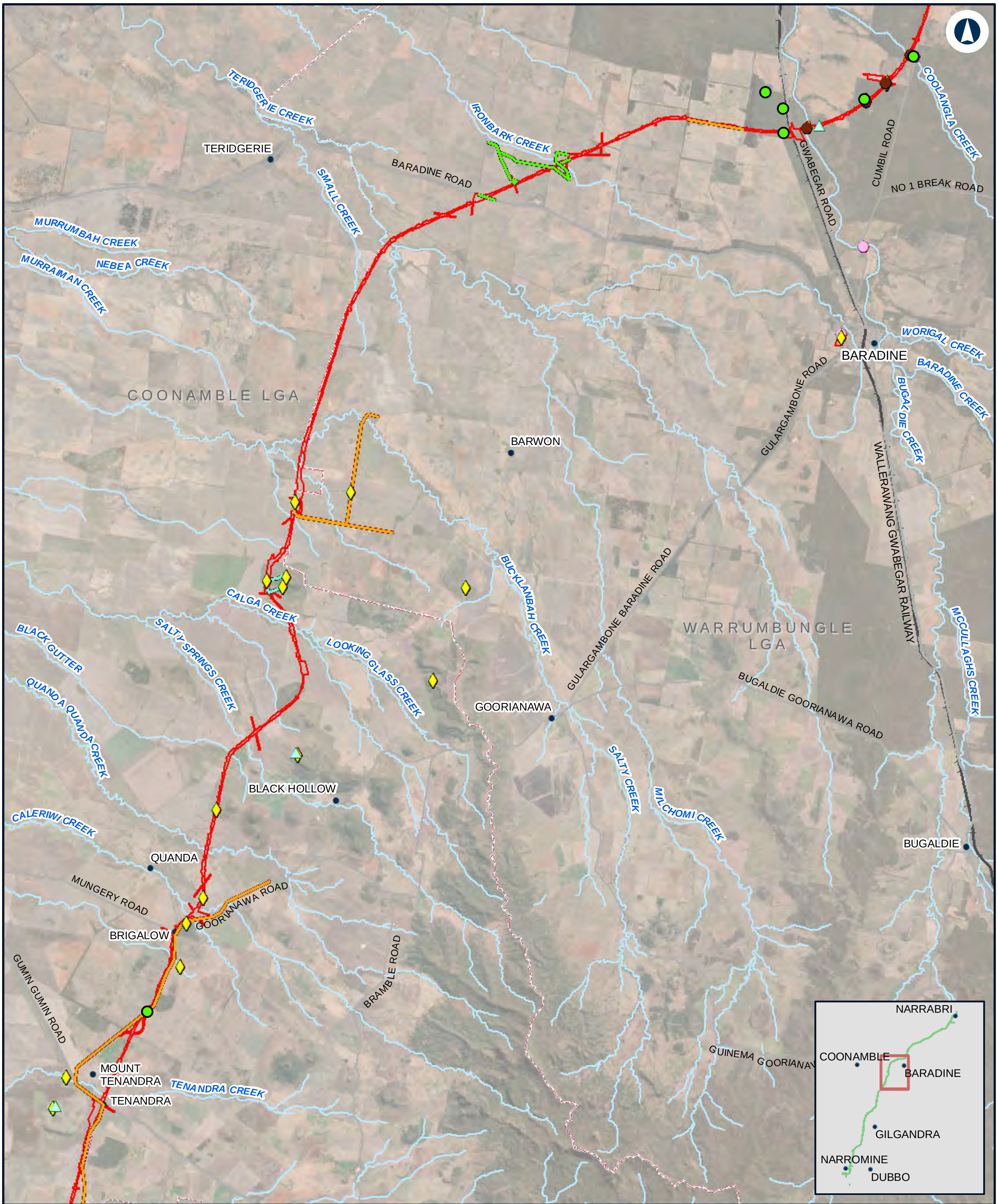

NARROMINE TO NARRABRI

Fauna survey locations (diurnal)

Figure 3.3 - MAP 4 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 29/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Expert survey sites
- Active search
- Bird survey
- General fauna survey
- Scat search
- Active search
- Bird survey (Spring 2020)
- Diurnal fauna survey
- General fauna survey

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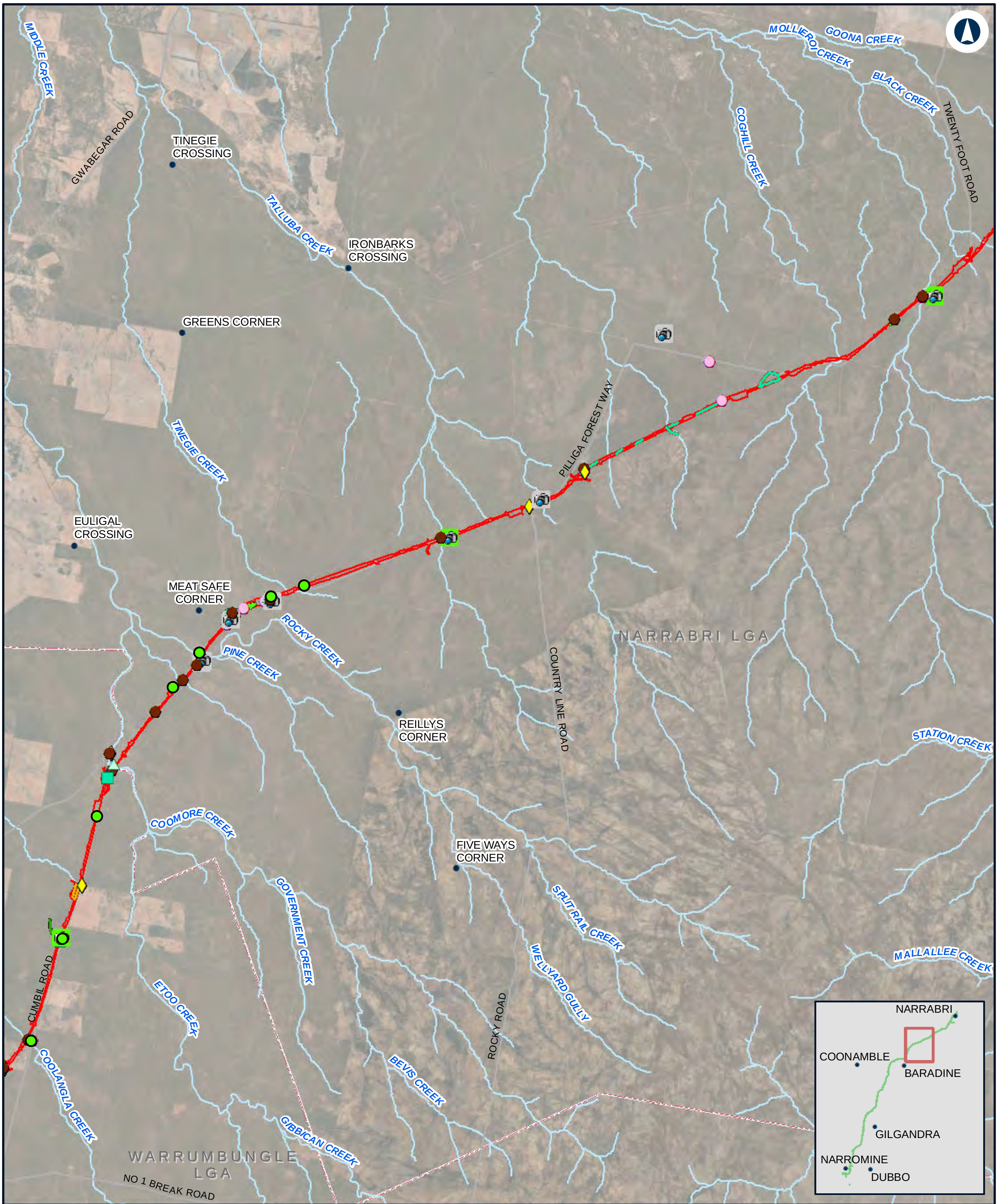

NARROMINE TO NARRABRI

Fauna survey locations (diurnal)

Figure 3.3 - MAP 5 of 6

0 2.5 5
Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 29/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Expert survey sites
- Active search
- Bird survey
- General fauna survey
- Hollow-bearing tree transect
- Scat search
- Camera
- Camera (4 weeks)
- Bird survey
- Bird survey (Spring 2020)
- Bird surveys, active searches
- Diurnal bird survey (June 2022)
- General fauna survey

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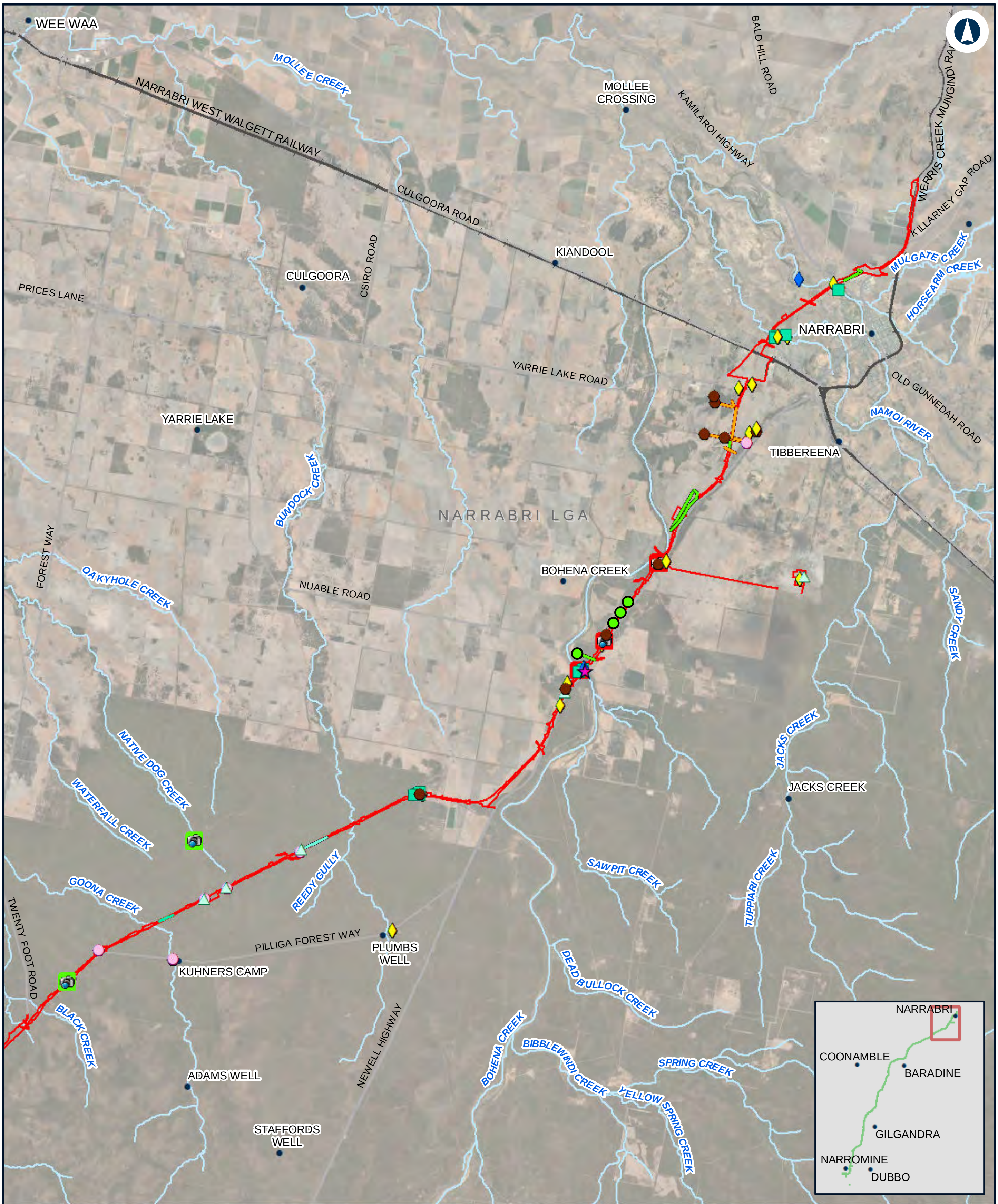

NARROMINE TO NARRABRI Fauna survey locations (diurnal) Figure 3.3 - MAP 6 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 29/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Expert survey sites
- Active search
- Bird survey
- Bridge search for roosting bats
- General fauna survey
- Winter owl survey
- Hollow-bearing tree transect
- Scat search
- Camera (3 days)
- Camera (4 weeks)
- Active search
- Bird survey (Spring 2020)
- Diurnal bird survey (June 2022)
- General fauna survey

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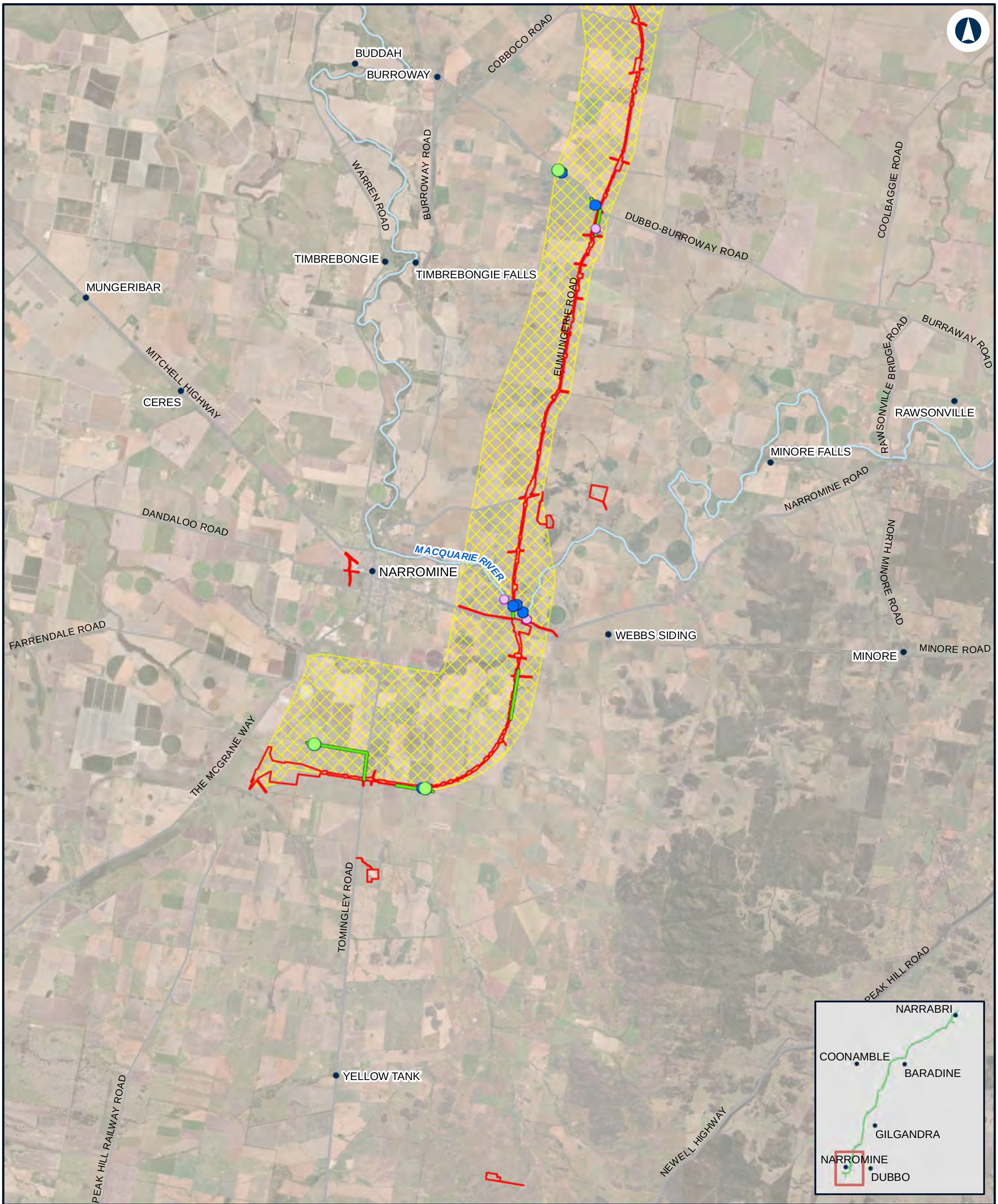

NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4 - MAP Page 1 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Investigation Corridor
- Anabat
- Call playback
- Spotlighting
- Spotlighting

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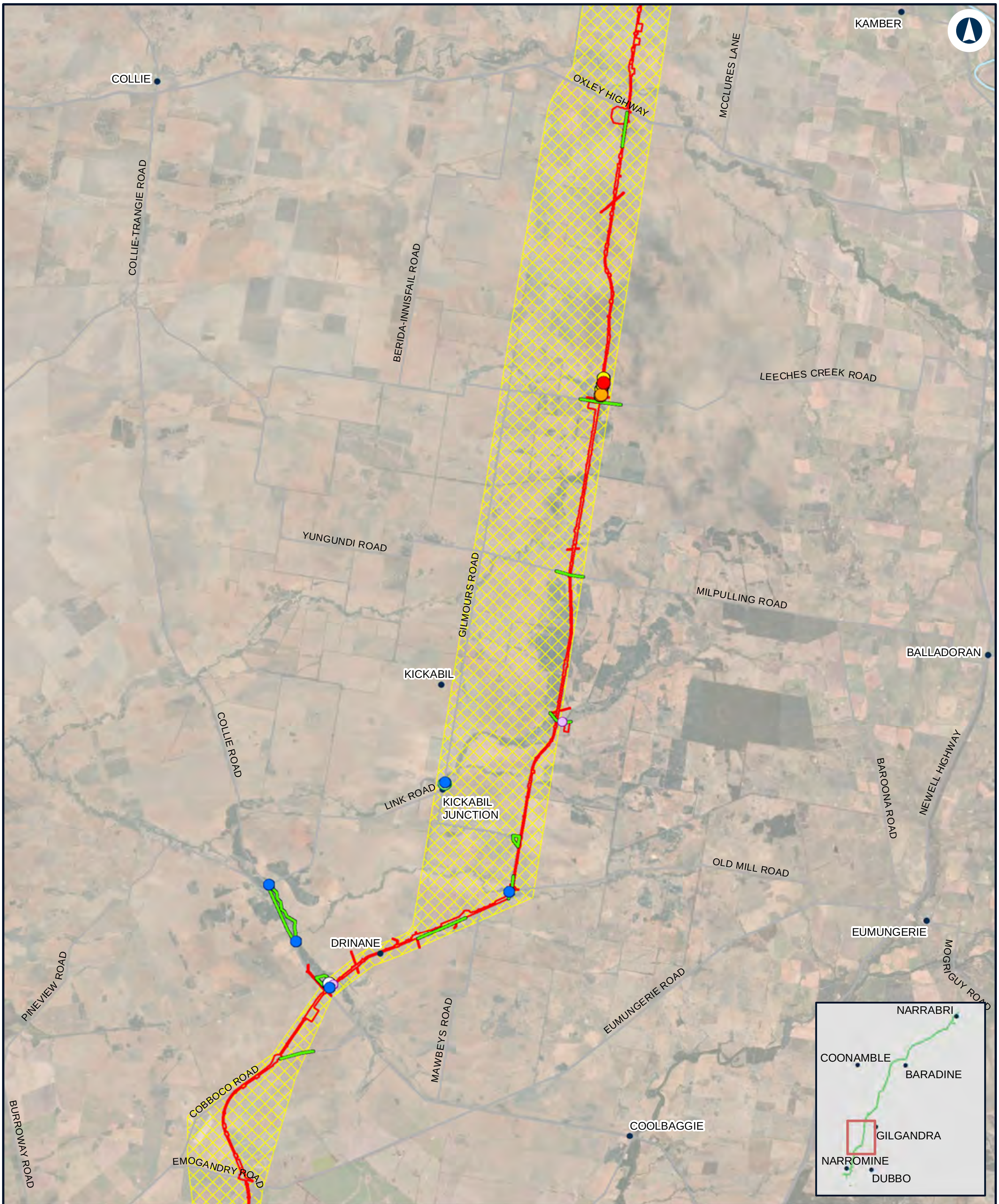

NARROMINE TO NARRABRI

Fauna survey locations (nocturnal)

Figure 3.4 - MAP Page 2 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-01
Paper: A4
Author: JacobsGHD
Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Investigation Corridor
- Anabat
- Call playback
- Harp Net (4 nights)
- Harp Net (evening)
- Pitfall
- Spotlighting
- Trapping
- Spotlighting (line)

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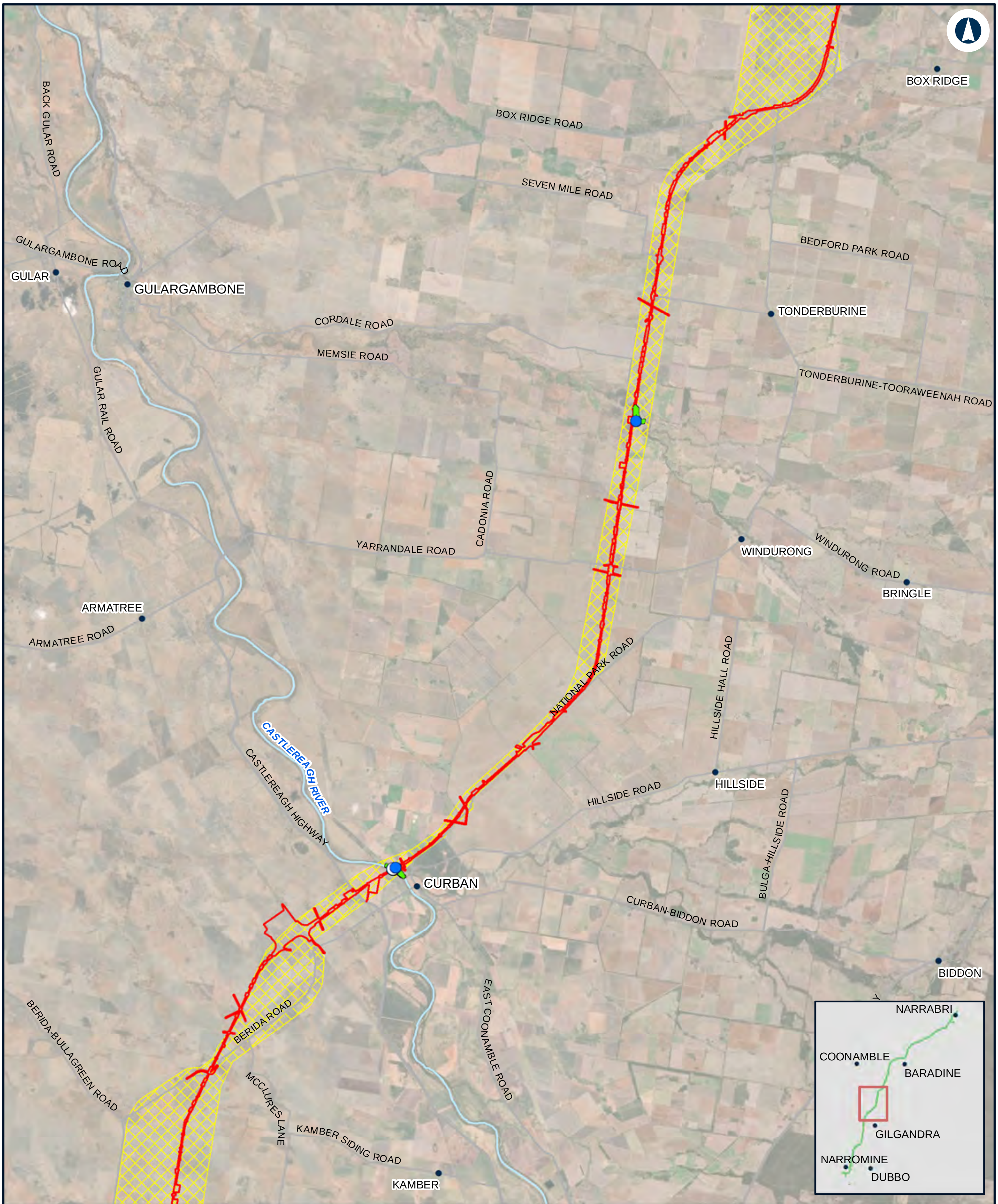

NARROMINE TO NARRABRI

Fauna survey locations (nocturnal)

Figure 3.4 - MAP Page 3 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-01 Paper: A4
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Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Investigation Corridor
- Anabat
- Call playback
- Harp Net (evening)
- Spotlighting

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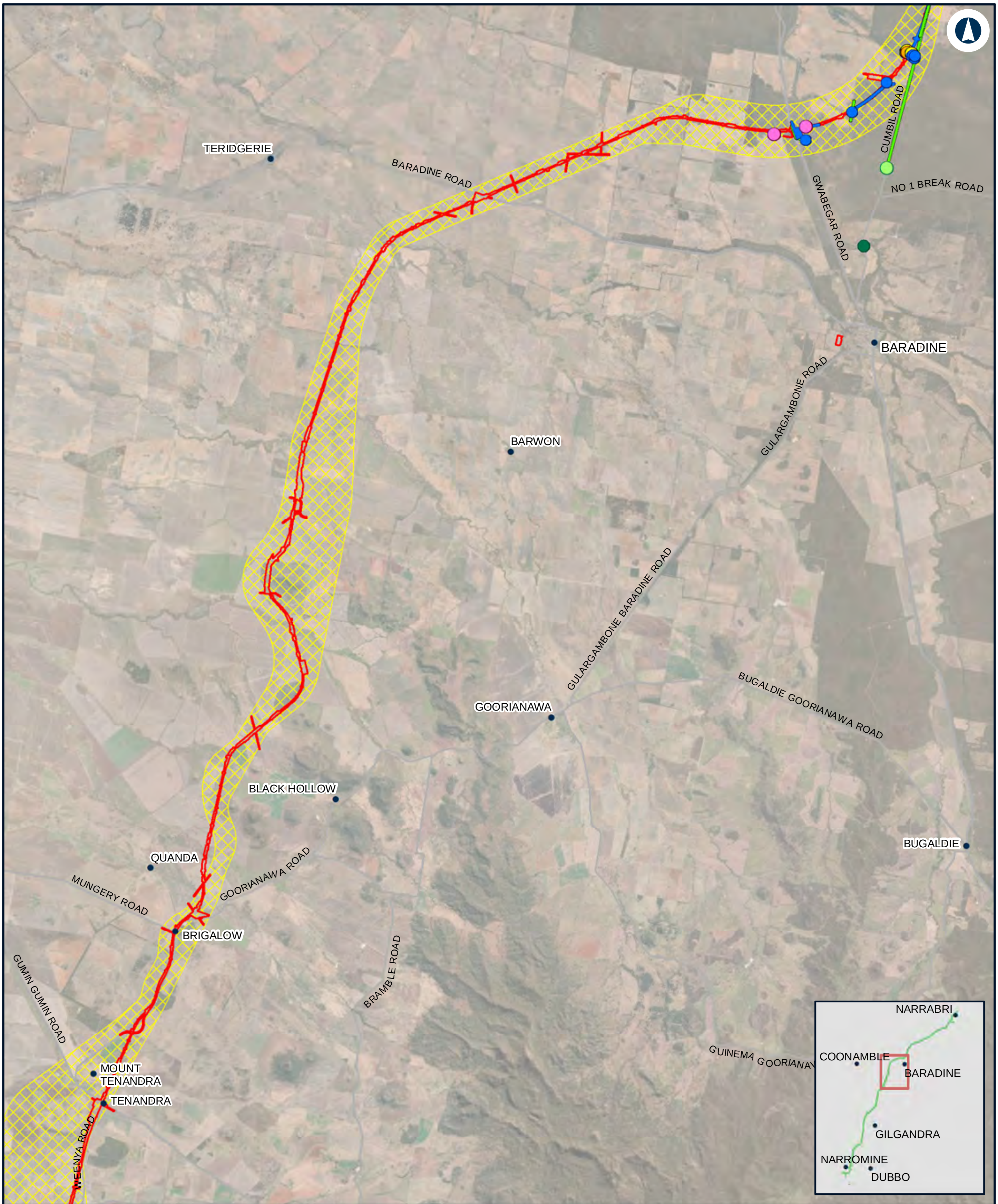

NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4 - MAP Page 4 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Investigation Corridor
- Anabat
- Call playback
- Frog survey
- Harp Net (4 nights)
- Oppurtunistic observation
- Pitfall
- Spotlighting
- Trapping
- Nocturnal thermal drone survey
- Spotlighting
- Trapline

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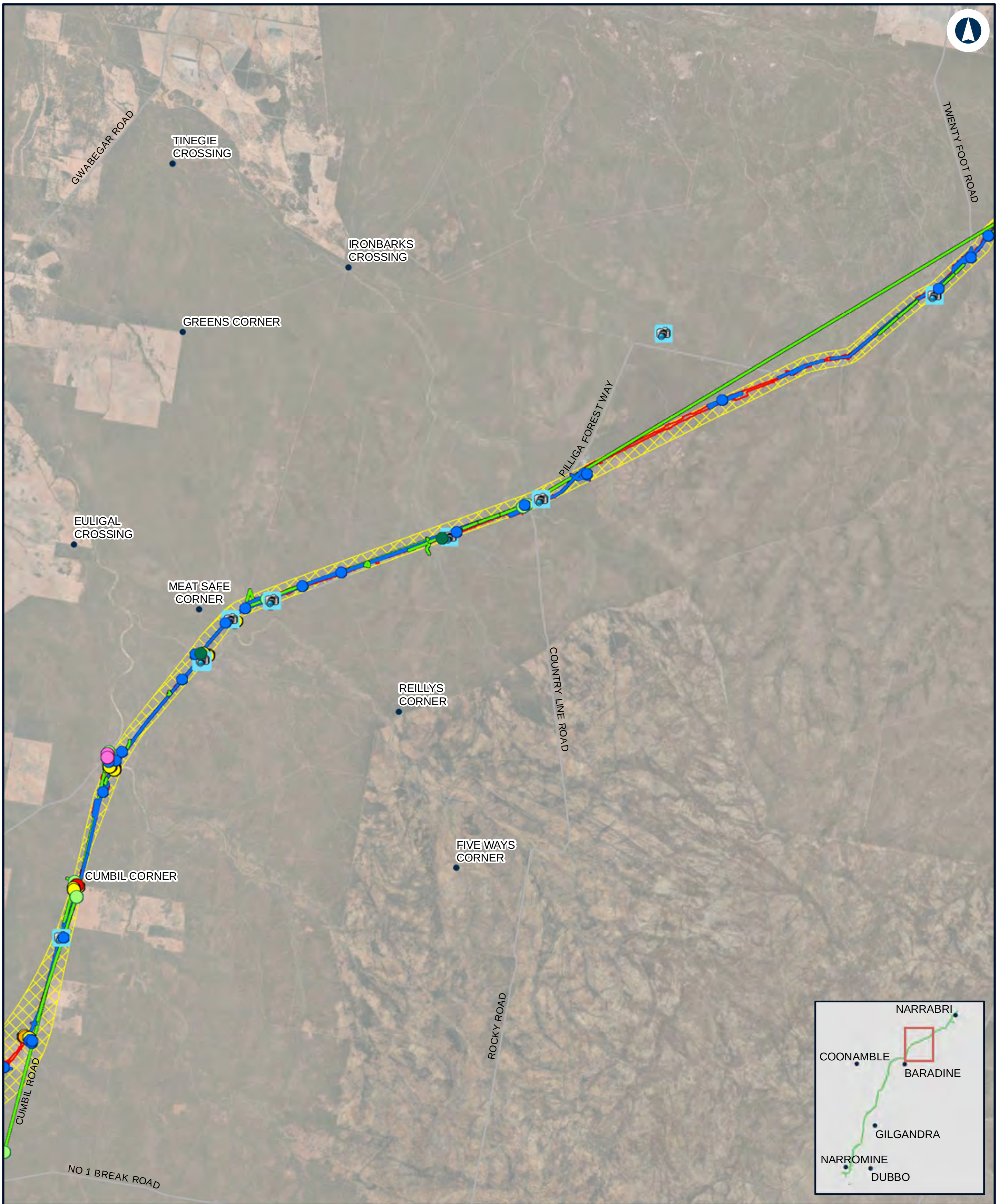

NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4 - MAP Page 5 of 6

0 2.5 5 Km

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LEGEND

- Construction impact zone
- Investigation Corridor
- Anabat
- Call playback
- Call playback - Spring 2020
- Camera
- Frog survey
- Harp Net (4 nights)
- Oppurtunistic observation
- Pitfall
- Spotlighting
- Trapping
- Nocturnal thermal drone survey
- Spotlighting
- Spotlighting - Spring 2020
- Trapline

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NARROMINE TO NARRABRI Fauna survey locations (nocturnal) Figure 3.4 - MAP Page 6 of 6

0 2.5 5 Km

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LEGEND

- Construction impact zone
- Investigation Corridor
- Anabat
- Call playback
- Call playback - Spring 2020
- Camera
- Harp Net (evening)
- Oppurtunistic observation
- Spotlighting
- Trapping
- Nocturnal thermal drone survey
- Spotlighting
- Spotlighting - Spring 2020
- 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 August 2021. Bureau of Meteorology (BOM) records for the survey date are outlined in Table 3.10. 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 the main 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. Following good rainfall in 2020, surveys were undertaken over multiple months (June, September, October and November 2020) to take advantage of better conditions. Additional targeted species credit surveys were undertaken in July and August 2021 to help refine species polygons.

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. Following good rains in 2020, it was noted during spring 2020 surveys that nocturnal animal activity was significantly higher in the Pilliga, with high insect, frog and bat activity observed during spotlighting.

Weather was cold and dry during the July and August 2021 surveys, although recent rain had led to wet ground conditions suitable for frog surveys.

Weather in the March 2022 surveys was warm and sunny. Substantial rain had fallen in previous months, providing good conditions for flora surveys.

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.

2018 and 2019 were exceptionally dry and very warm in NSW and particularly in inland NSW. 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 3.11).

Table 3.10 Daily weather observations during the survey period

Date	Min temp (ºC)	Max temp (ºC)	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

Date	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
18/11/2018	14.5	30.3	0	Narromine	Dubbo	PCT mapping, vegetation integrity plots, threatened flora searches	Incidental surveys during flora 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 (ºC)	Max temp (ºC)	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 (ºC)	Max temp (ºC)	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
June 2020							
22/06/2020	5.4	9.3	1.2	Gilgandra	Coonabarabran	Vegetation integrity plots	General surveys, nocturnal surveys, call playback, spotlighting
23/06/2020	5.0	9.2	1.4	Gilgandra	Coonabarabran	Vegetation integrity plots	General surveys, nocturnal surveys call playback, spotlighting
24/06/2020	5.0	9.3	0	Gilgandra	Coonabarabran	Vegetation integrity plots	General surveys, nocturnal surveys call playback, spotlighting

Date	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
September 2020							
21/09/2020	11.0	27.8	0	Pilliga and Pilliga Outwash subregions, borrow pit D	Narrabri	Vegetation integrity plots, threatened flora searches	
22/09/2020	15.2	26.5	0.6	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Narrabri	Vegetation integrity plots, threatened flora searches	
23/09/2020	14.5	24.1	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Narrabri	Vegetation integrity plots, threatened flora searches	
24/09/2020	17.8	22.3	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Narrabri	Vegetation integrity plots, threatened flora searches	
25/09/2020	7.8	25.9	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Narrabri	Vegetation integrity plots, threatened flora searches	
26/09/2020	3.9	19.1	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Narrabri	Vegetation integrity plots, threatened flora searches	

Date	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
October 2020							
12/10/2020	10.4	29.7	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
13/10/2020	11.1	29.9	0.4	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
14/10/2020	9.3	30.5	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
15/10/2020	8.3	29.7	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
16/10/2020	12.1	31.9	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	

Date	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
17/10/2020	14.9	33.5	0	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
18/10/2020	19.2	23.3	2.6	Pilliga and Pilliga Outwash subregions, Narrabri, Gilgandra, Narromine	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
19/10/2020	11.7	25.7	10.2	Pilliga and Pilliga Outwash subregions, Narrabri	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
20/10/2020	13.7	29.5	0	Pilliga and Pilliga Outwash subregions, Narrabri	Baradine and Narrabri	Vegetation integrity plots, threatened flora searches	
November 2020							
14/11/2020	10.4	31.2	0.2	Narromine	Trangie	Vegetation integrity plots, threatened flora searches	General surveys
15/11/2020	12.6	37.8	0	Gilgandra	Trangie	Vegetation integrity plots, threatened flora searches	General surveys
16/11/2020	15.4	40.8	0	Pilliga	Narrabri	Vegetation integrity plots, threatened flora searches	General surveys, nocturnal surveys
17/11/2020	20.8	35.8	0	Pilliga, Narrabri	Narrabri	Vegetation integrity plots, threatened flora searches	General surveys, nocturnal surveys
18/11/2020	18.0	35.6	0	Narrabri	Narrabri	Vegetation integrity plots, threatened flora searches	

Date	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
July 2021							
5/07/2021	-2.3	14.3	0.2	Narromine	Dubbo	Vegetation integrity plots	Targeted frog surveys
6/07/2021	-0.7	13.6	0	Narromine	Dubbo	Vegetation integrity plots	General surveys
19/07/2021	-0.1	11.2	0	Pilliga	Coonabarabran		Thermal drone surveys, nocturnal surveys
20/07/2021	2.6	12.0	0.8	Pilliga	Coonabarabran		Thermal drone surveys, nocturnal surveys
21/07/2021	4.9	14.1	0	Pilliga	Narrabri		Thermal drone surveys, nocturnal surveys
22/07/2021	-1.8	17.2	0	Pilliga	Narrabri		Thermal drone surveys, nocturnal surveys
23/07/2021	5.7	14.6	0	Bohena Creek	Narrabri		Thermal drone surveys, nocturnal surveys
August 2021							
9/8/2021	8.5	20.1	0	Narromine	Dubbo	Vegetation mapping	Expert surveys, supplementary fauna surveys
10/8/2021	5.1	21.0	0	Gilgandra	Dubbo	Vegetation integrity plots	Expert surveys, supplementary fauna surveys
11/8/2021	6.4	22.9	0	Pilliga	Narrabri		Expert surveys, supplementary fauna surveys
12/8/2021	13.8	24.0	0	Pilliga	Narrabri		Expert surveys, supplementary fauna surveys
March 2022							
14/03/2022	12.5	30.2	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
15/03/2022	15.9	31.1	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys

Date	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)	General survey area	Weather station	Flora surveys	Fauna surveys
16/03/2022	15.2	32.8	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
17/03/2022	16.8	32.6	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
18/3/2022	18.3	31.6	1.4	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
19/03/2022	16.4	31.2	0.2	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
20/03/2022	15.3	31.2	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
21/03/2022	15.1	32.4	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
22/03/2022	12.1	33.8	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
23/03/2022	16.8	35.4	0	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys
24/03/2022	19.7	31.9	0.2	Pilliga	Narrabri	Targeted flora searches	Supplementary fauna surveys

Table 3.11 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)	Total 2020 annual rainfall (mm)
Narromine (Dubbo station)	**529.8**	311.6	154.0	793.4
Gilgandra (Curban station)	**554.2**	286.4	188.9	787.0
Narrabri (Narrabri station)	**540.5**	376.4	206.2	771.2

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 BCS are currently preparing drought condition benchmarks, these were not yet available and based on consultation with the Dubbo office of BCS, 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 overnight 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. Of the 3,482 hectare construction impact zone (CIZ), 2,219 hectares (63.7 percent) was able to be accessed and 1,263 hectares (36.3 percent) was not able to be accessed (see Table 3.12). Areas accessed and not accessed are shown in Figure 3.5).

Table 3.12 Proportion of areas accessed and not accessed

Location	Area accessed (ha)	Area not accessed (ha)	Proportion accessed (%)
Native vegetation	1269.0	522.0	70.9
Non-native vegetation	917.9	719.8	56.0
Cleared (eg existing roads, residences etc)	32.3	20.9	60.7
Totals	2219.1	1262.7	63.7

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 those locations which 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 surveys were planned for some threatened flora species that flower in summer and/or autumn (note that advice from BCS and other botanists in the region was that they were finding species flowering outside their usual season).

However, planned surveys were cancelled in late March 2020 due to the global coronavirus (COVID-19) pandemic and associated travel restrictions. Additional targeted flora and fauna surveys were pushed into spring 2020.

Surveys with the species experts were conducted in August 2021. Surveys were shortened from five days to four days due to sudden COVID lockdowns in regional LGAs including Narromine and Gilgandra.

3.7 Likelihood of occurrence of threatened and migratory biota

Following collation of BAM-C 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, 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. Threatened species records were sourced from Bionet (EES 2019a), with an updated search conducted in February 2021 with no restriction on years (EES 2021). Records of threatened birds within a five kilometre radius of the stage 2 study area were also sourced from Birds Australia (2020). Note that no particular breeding data was recorded with any of the dual credit threatened birds in the Birds Australia dataset.

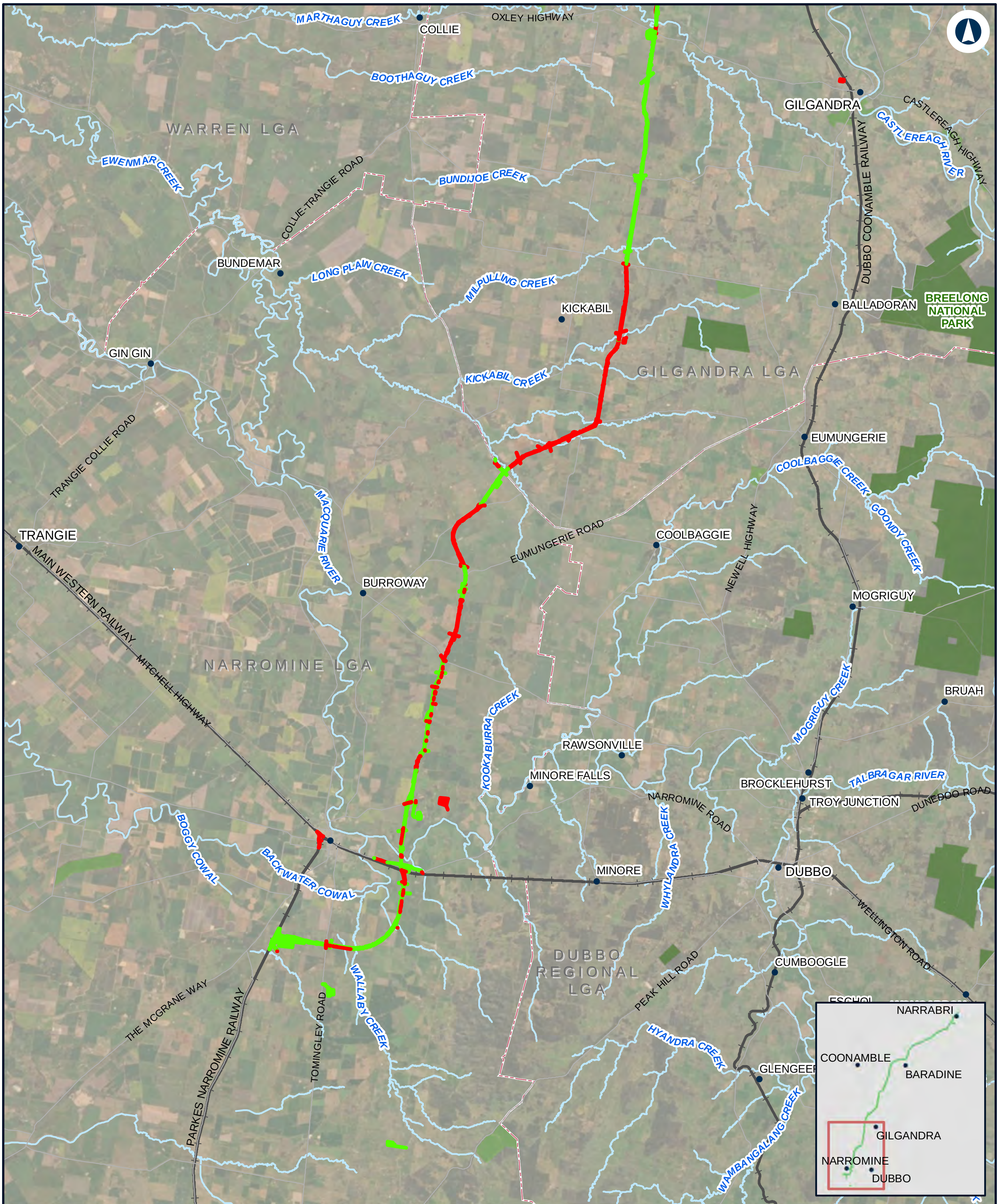
The likelihood of occurrence assessment was further refined following field surveys. The results of this assessment are provided in Appendix B.

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 3.5 - MAP 1 of 4

0 5.5 11 Km

Coordinate System: GDA 1994 MGA Zone 55

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LEGEND

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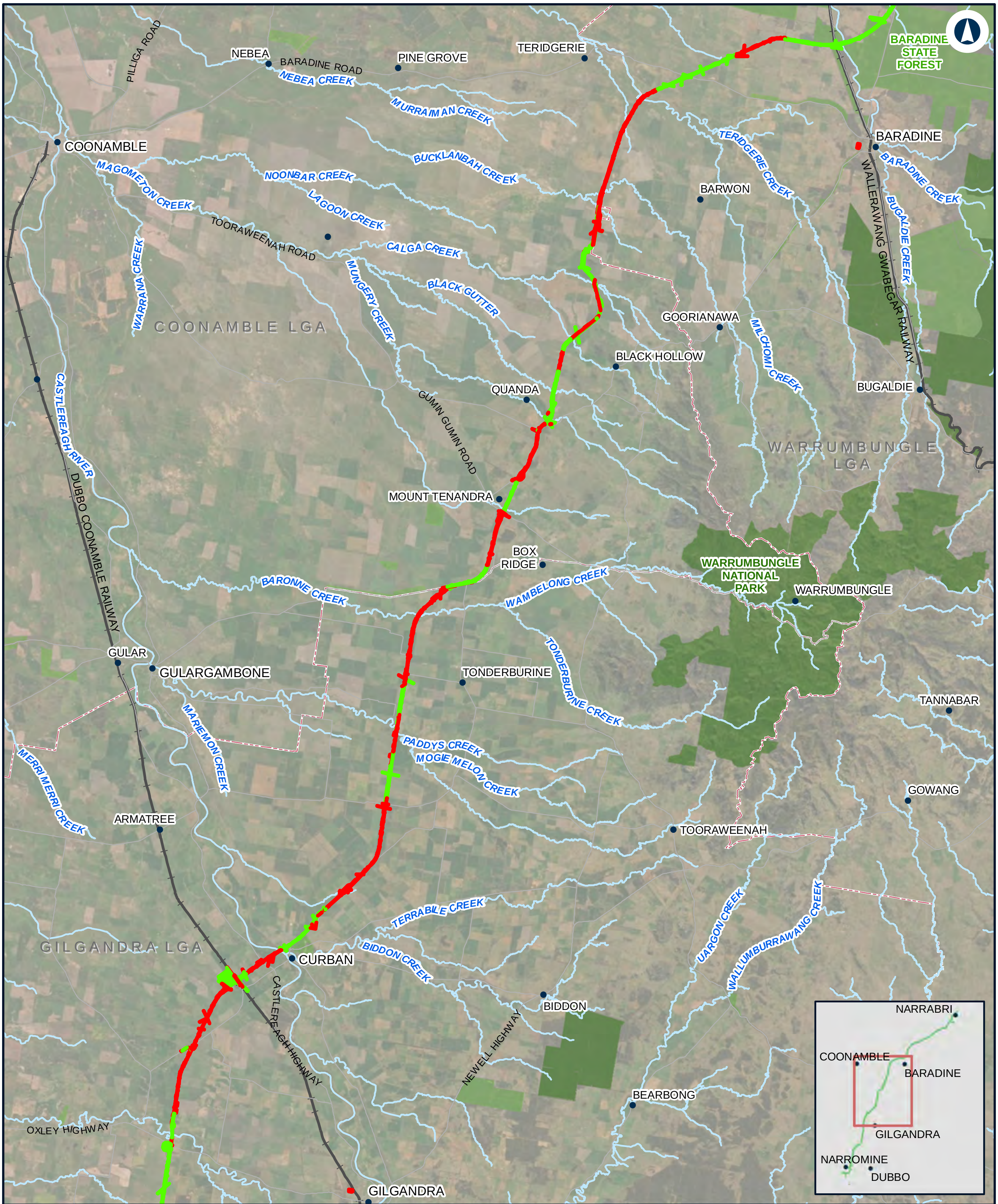

NARROMINE TO NARRABRI

Access across the proposal

Figure 3.5 - MAP 2 of 4

0 5.5 11 Km

Coordinate System: GDA 1994 MGA Zone 55

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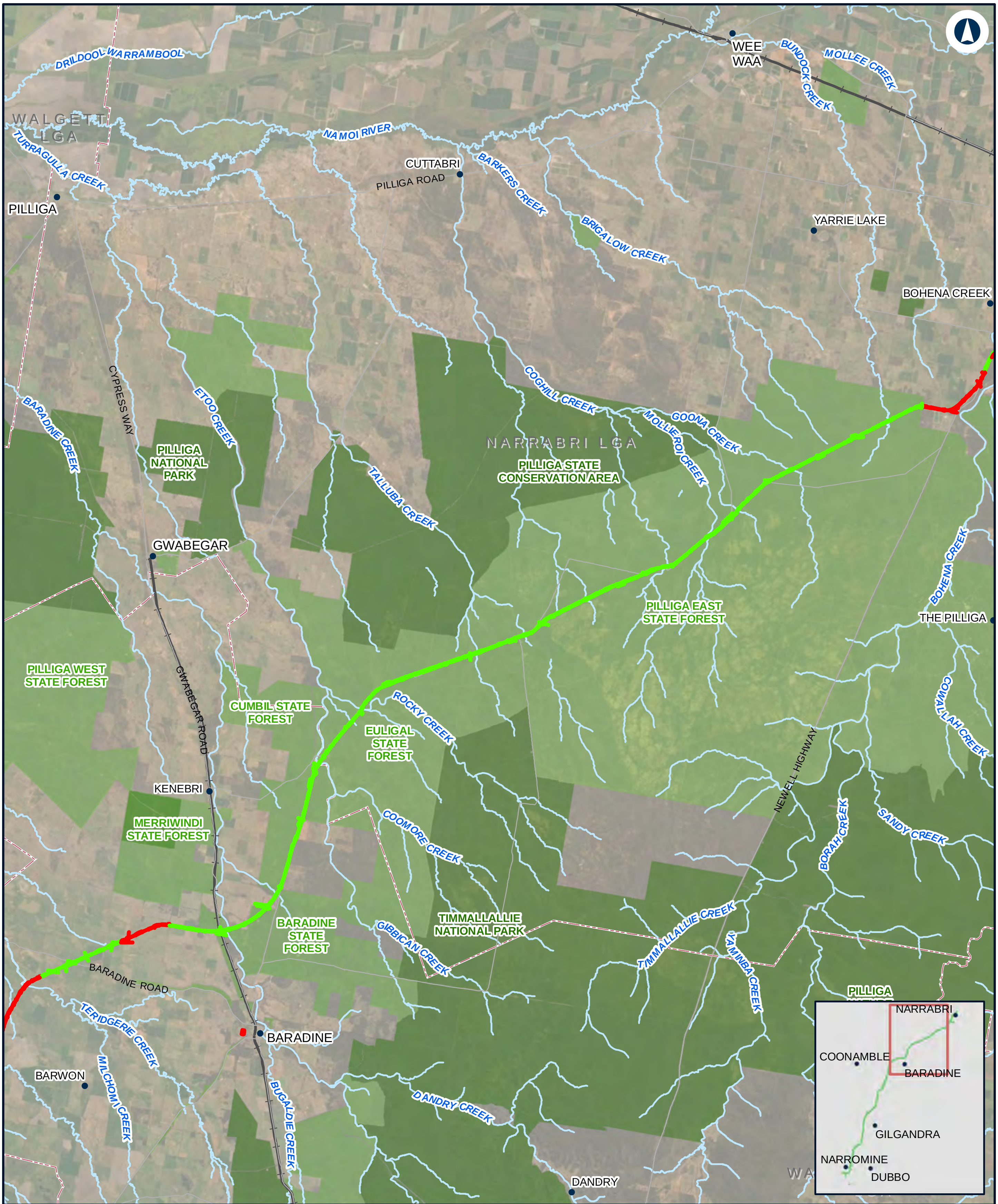

NARROMINE TO NARRABRI Access across the proposal

Figure 3.5 - MAP 3 of 4

0 5.5 11 Km

Coordinate System: GDA 1994 MGA Zone 55

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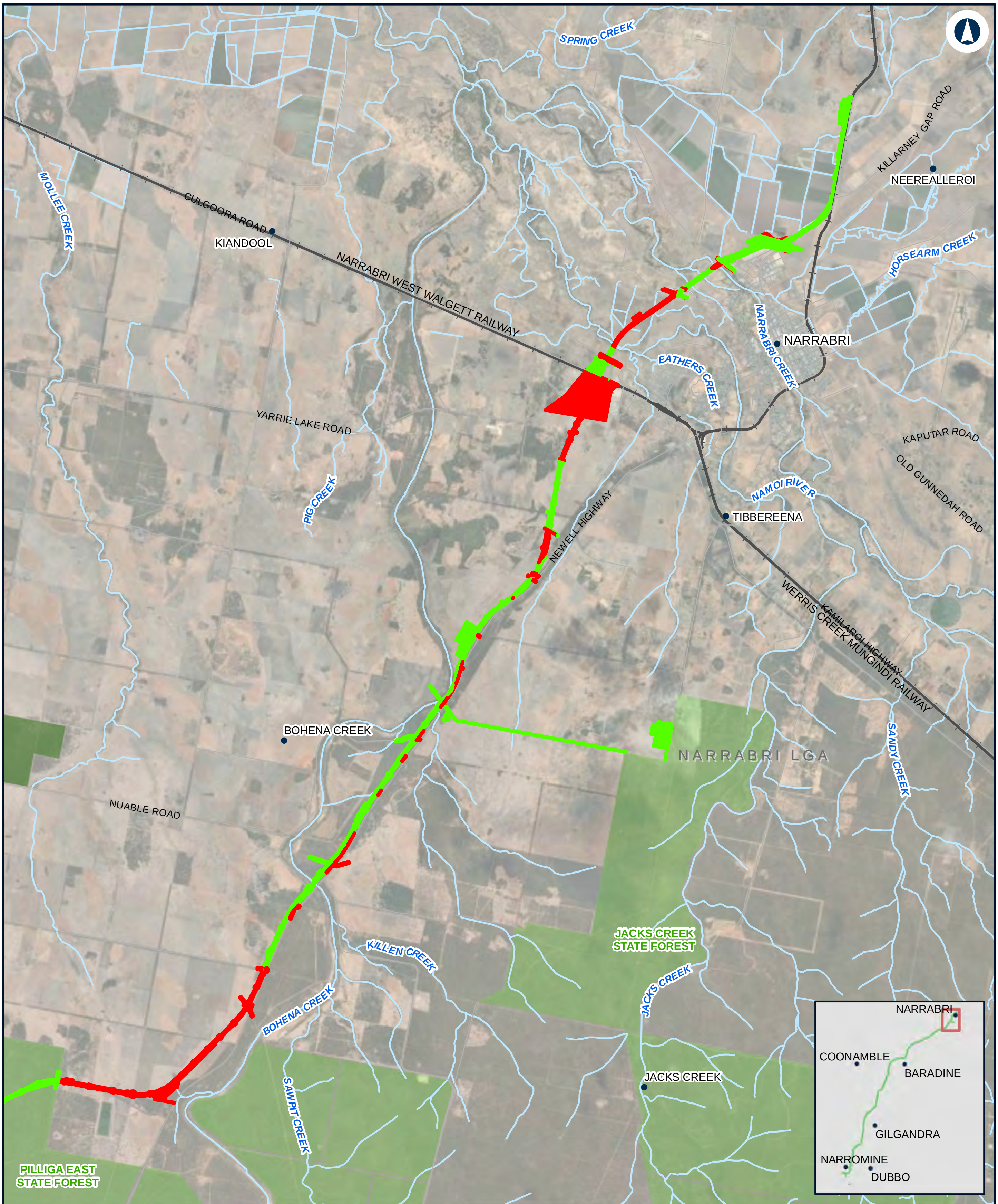

NARROMINE TO NARRABRI Access across the proposal Figure 3.5 - MAP 4 of 4

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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

LEGEND

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- No Access

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3.9 BAM calculations

3.9.1 Subregion cases

The proposal was assessed according to the methodology presented in the BAM (DPIE 2020), 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.

The BAM credit calculations were performed by Leigh Maloney and Kirsten Crosby using credit calculator version 1.4.0.00. Seven related assessment cases were set up under one parent case (000239941) for the proposal, to account for each of the IBRA subregions the proposal crosses as identified in Table 3.13.

Table 3.13 BAM-C cases

BAM-C case	IBRA region and subregion	Location
00023994/BAAS17011/21/00029283	South West Slopes bioregion, Inland Slopes subregion	Borrow pit A
00023994/BAAS17011/21/00029284	Darling Riverine Plain bioregion, Bogan Macquarie subregion	Narromine area
00023994/BAAS17011/21/00029286	Darling Riverine Plain bioregion, Castlereagh-Barwon subregion	Various sections between Gilgandra and Teridgerie
00023994/BAAS17011/21/00029285	Brigalow Belt South bioregion, Pilliga subregion	Various sections between Narromine and Narrabri
00023994/BAAS17011/21/00029287	Brigalow Belt South bioregion, Pilliga Outwash subregion	Parts of the Pilliga and Narrabri area
00023994/BAAS17011/21/00029288	Brigalow Belt South bioregion, Liverpool Plains subregion	A small section in Narrabri
00023994/BAAS17011/21/00023995	Brigalow Belt South bioregion, Northern Basalts subregion	Northern most section in Narrabri

Separate habitat suitability assessments have been undertaken for the seven subregions. Refer to section 6 and Appendix I.

Credit calculator data is included in Appendix I. The biodiversity credit reports are included in Appendix K. The data and assumptions used to perform the BAM credit calculations are summarised in section 9.

3.9.2 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 presents the results of one set of credit calculations and one biodiversity credit report for each IBRA subregion and associated assessment case (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 in 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 BCS 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. The segmented BDAR approach has been developed to facilitate the staged retirement of credits over the length of the proposal reflecting the proposed construction programming, and to allow further time for the orderly creation and procurement of the required offsets.

3.9.3 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.

3.9.4 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 (TBDC) 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 subsection 5.2.1 (7) of the BAM, the likelihood of occurrence has also taken into account different IBRA 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. Justification for species inclusion and exclusion are provided in Appendix I.

Following exhibition of the BDAR, further revision of species polygons was undertaken in consultation with BCS. The vegetation layer and all relevant supporting layers was uploaded to an internal web-based mapping portal to allow the ecologists to view the data for each species spatially. The lead BAM assessors reviewed the vegetation mapping and attributed layers, assigning Yes/No to individual vegetation polygons for the various species, and provided a justification in the attribute table.

The species polygons include areas of suitable habitat (associated PCTs, relevant vegetation zones and suitable microhabitats) where the species has been recorded or is likely to occur, or where surveys have not been conducted and the species is assumed to occur.

Areas where targeted surveys have been conducted are excluded from the species polygons. Where specific habitat features are missing or are degraded, these are noted in the attribute table, and further justification for exclusion provided in Appendix I. Species are excluded from IBRA subregions if they are not known to occur in those subregions or the patch size/vegetation cover is not suitable (ie. not a candidate species).

Justification for inclusion and exclusion of vegetation polygons for the species polygons are based on the results of field surveys, information in the TBDC, and published information regarding species distribution and habitat requirements.

Justification for species polygons for the Koala, Little Eagle and Square-tailed Kite are provided in the expert reports for these species (Appendix N).

3.9.5 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 BCS 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 BCS in early 2020. Further refinement of the species polygon methodology occurred in 2021 in consultation with BCS.

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

A methodology has been developed to assign credits for prescribed impacts (connectivity and vehicle strike) as there is no method specified in the BAM. This method relies on a combination of quantification of impacts as well as allocating values based on qualifying fauna attributes. This method is detailed in section 10.3 and has discussed with BCS at various teleconferences between September 2021 and February 2022.

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 Ben Harrington (accredited assessor number BAAS17023). Staff qualifications are presented in Table 3.14.

Table 3.14 Staff qualifications

Name	Position/Role	Qualifications	Relevant experience
Kirsten Crosby	Technical Director Biodiversity (fauna) Desktop assessment, site surveys, reporting	BSc (Zoology), PhD Accredited BAM Assessor (BAAS17011)*	15+ years
Leigh Maloney**	Senior Ecologist (flora) Desktop assessment, field surveys, reporting	BEnvSc (Hons) Accredited BAM Assessor (BAAS18086)*	17+ years
Kath Chesnut	Senior Ecologist (flora), reporting	BEnvSc (honours) Accredited BAM Assessor (BAAS17031)*	11+ years
Melissa Cotterill	Ecologist, field surveys, reporting	BSc (Biology) Accredited BAM Assessor (BAAS18127)*	10 years
Malith Weerakoon	Ecologist Desktop assessment, site surveys, reporting	BSc, MPhil. (Zoology)	5 years
Brianna Turner	Graduate Ecologist Desktop assessment, site surveys, reporting	BSc (Botany)	3 years
Jayne Tipping	Technical Director Biodiversity Technical Review	BSc (Ecology), MEnvLaw	25+ years
Ben Harrington	Review of credit calculations	BSc (Env Man), MSc (PhysGeog) Accredited BAM Assessor (BAAS17023)*	17+ years

* Refer to BCT (2020) list of accredited assessors
** Not available to complete the Updated BDAR.

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 for each subregion, 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 kilometres 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 comprises 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).

4.4 Landscape features

4.4.1 Bioregions and IBRA subregions

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. Borrow Pit A is located within the South-west Slopes Bioregion. In total, the proposal crosses seven IBRA subregions:

- South West Slopes bioregion and Inland Slopes subregion (borrow pit A)
- Darling Riverine Plain bioregion and Bogan – Macquarie subregion (Narromine area)
- Darling Riverine Plain bioregion and Castlereagh-Barwon (various sections between Gilgandra and Teridgerie)
- Brigalow Belt South bioregion and Pilliga subregion (various sections between Narromine and Narrabri)
- Brigalow Belt South bioregion and Pilliga Outwash subregion (parts of the Pilliga and Narrabri area)
- Brigalow Belt South bioregion and Liverpool Plains subregion (a small section in Narrabri).

Brigalow Belt South bioregion and Northern Basalts subregion (northernmost section in Narrabri). These subregions are described in Table 4.1.

Table 4.1 Subregion descriptions (Morgan and Terrey 1992)

Subregion	Geology	Characteristic landforms	Typical soils	Vegetation
Inland Slopes	Ordovician to Devonian folded and faulted sedimentary sequences with inter-bedded volcanic rocks and large areas of intrusive granites. Large areas of Tertiary and Quaternary alluvium.	Undulating and hilly ranges and isolated peaks set in wide valleys at the apices of the Riverina alluvial fans.	Shallow stony soils on steep slopes. Extensive red-brown earths on undulating plains and extensive grey clays on alluvium.	Dwyer's Gum on granite, Red Ironbark on sedimentary rocks Hill Red Gum, White Cypress Pine and Red Stringybark in the ranges. Grey Box woodlands with Yellow Box, White Cypress Pine and Belah on lower areas. Poplar Box, Kurrajong, Wilga and Red box Bn the north. Myall, Rosewood and Yarran on grey clays, Yellow Box, Polar Box, and Belah on alluvial loams. River Red Gum on all streams with Black Box in the west with some Lignum and River Cooba.
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.
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
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.
Liverpool Plains	Quaternary alluvial plains and outwash fans derived from Tertiary basalts. Permian and Triassic quartz sandstones with minor basalt caps.	Undulating hills and sloping plains with alluvial channels and floodplains.	Extensive black earths on low angle slopes. Brown clays, alluvial soils and red or brown texture contrast soils on slopes below sandstone.	Plains Grass, Panic, Windmill Grass and Blue Grass on black earths with occasional White Box, Yellow Box, Poplar Box and Wilga. White Box and White Cypress Pine with Rough-barked Apple, Hill Red Gum, occasional Belah and Mulga on texture contrast hillslope soils.
Northern Basalts	Tertiary basalts over Jurassic quartz sandstones and alluvial sediments derived from these.	Undulating low stony hills, long slopes with sandy wash and heavy clays in the valley floors.	Black loams on basalt ridges, deep sands on sandstone and texture contrast soils on slopes. Heavy grey clay on alluvial flats.	River Red Gum, Belah, Myall and Poplar Box on basalt flats. White Box, with Silver-leaved Ironbark, White Wood, Bull Oak and Brigalow on alluvial clays. River Red Gum on all streams.

4.4.2 NSW (Mitchell) landscape

The proposal site crosses many NSW (Mitchell) 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 (Mitchell) landscape description (DECC 2002)

NSW (Mitchell) landscape	General location	Description
Geurie Granites	Inland Slopes (Borrow Pit A)	Low ranges and rounded hills with common rock outcrop and tors on massive Devonian granite, general elevation 400 to 610 metres, local relief 180 metres. Gritty gradational red earth on the crests, red texture-contrast soil on upper slopes grading to yellow harsh texture-contrast soil along valley floors. Open forest of Red Ironbark (*Eucalyptus sideroxylon*), White Cypress Pine (*Callitris glaucophylla*), Red Stringybark (*Eucalyptus macrorhyncha*), Yellow Box (*Eucalyptus melliodora*), Blakely's Red Gum (*Eucalyptus blakelyii*), and a shrubby understorey.
Boggy Cowal Alluvial Plains	Bogan-Macquarie (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 two metres. Extensive grasslands with scattered stands of myall (*Acacia pendula*), Bimble Box (*Eucalyptus populnea*), Black Box (*Eucalyptus largiflorens*) and Belah (*Casuarina cristata*).
Castlereagh Alluvial Plains	Castlereagh-Barwon (Gilgandra to Baradine)	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 one to three 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*).

NSW (Mitchell) landscape	General location	Description
Cubbo Uplands	Pilliga subregion (Pilliga 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. 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*).

NSW (Mitchell) landscape	General location	Description
Coghill Alluvial Plains	Pilliga Outwash (Pilliga Forest, Bohena Creek)	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.
Liverpool Alluvial Plains	Liverpool Plains Subregion (central Narrabri)	Quaternary alluvial plains and outwash fans derived from Tertiary basalts. Permian and Triassic quartz sandstones with minor basalt caps. Undulating hills and sloping plains with alluvial channels and floodplains. General elevation 300 to 350 metres, local relief <10 metres. Extensive black earths and low angle slopes. Deep black and brown cracking clays, alluvial soils and red or brown texture-contrast soils on slopes below sandstone, Open grassland of Plains Grass (*Austrostipa aristiglumis*), *Panicum* spp., Windmill Grass (*Chloris truncata*) and Blue Grass (*Dicanthium sericeum*) on black earths with occasional Myall (*Acacia pendulata*), White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*), Bimble Box (*Eucalyptus populnea*) and Wilga (*Geijera parviflora*), River Red Gum (*Eucalyptus camaldulensis*) along streams.
Kaputar Slopes	Northern Basalts (northern Narrabri)	Lower slopes of the Kaputar volcanic complex with radiating finger-like ridges capped by basalt over lower Permian and Triassic quartz sandstone, lithic sandstone, silty sandstone, conglomerate and thin coal measures. General elevation 300 to 500 metres, local relief 80 metres. Shallow stony red-brown loam and clay loam in uniform profiles on basalt, yellow and yellow-brown texture-contrast profile on sandstone, deep black earths in lowest valleys. Kurrajong (*Brachychiton populneus*), Yellow Box (*Eucalyptus melliodora*), White Box (*Eucalyptus albens*), Rough-barked Apple (*Angophora floribunda*) and Blakely's Red Gum (*Eucalyptus blakelyii*) on lower slopes and valleys.

4.4.3 Rivers, streams, estuaries and wetlands

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 forests 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.

Flood-dependent ecological assets are identified in the ecological assets maps for the Macquarie Valley floodplain (DPIE 2021b) and the Lower Namoi valley floodplain (DPIE 2020c). River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion (PCT 36), which occurs along the banks of the Macquarie River, and River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (PCT 78), which occurs along the banks of the

Namoi River and Narrabri Creek (and other smaller watercourses), are identified as 'other floodplain ecosystems: flood-dependent forest/woodland (wetlands), flood dependent woodland' under the plans. No wetlands identified on the Macquarie Valley map are located within the study area, although do occur downstream (eg. the Macquarie Marshes). Wetlands are mapped on the Lower Namoi valley floodplain in the study area, however no flood-dependent shrubland wetlands were recorded during surveys.

4.4.4 Habitat connectivity

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.

Existing connectivity in the study area is shown on Figure 4.2.

See section 8.2 for a detailed discussion of connectivity.

4.4.5 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. However, these features were identified and considered within the broader study area to identify areas of habitat for threatened species in proximity to the proposal site and determine the likelihood of any impacts to these species as a result of the proposal.

The nearest karst, caves, crevices or cliffs habitat occurs in 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. The Sandstone Caves provide roosting habitat for the threatened Large-eared Pied Bat (*Chalinolobus dwyeri*). No karst, caves, crevices or cliffs were found to be present in the Pilliga forests that occur within two kilometres of the proposal and that would provide habitat for this species. No escarpment habitat suitable for Brush-tailed Rock-wallaby (*Petrogale penicillata*) is present in the proposal site.

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 in the mT Tenandra area. No caves were observed in any of these hills. Basalt outcrops as small to large, weathered rocks occurred with crevices present between rocks. Note that caves in the Warrumbungles occur in sandstone outcrops rather than basalt (eg Tara Cave). No escarpment habitat was identified that would be suitable for Brush-tailed Rock-wallaby.

Limited areas of scattered rocks are present in the study area. The lower slopes of the outlier hills near Mt Tenandra 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 by landowners. No crevices or caves were present in these areas.

Loose surface rock is present at Borrow Pit A, south of Narromine.

4.4.6 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.

4.4.7 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 millimetres 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.

4.5 Determining site context

To determine site context as required under Chapter 3 of the BAM, an assessment of native vegetation cover and patch size in accordance with Section 3.2 and Subsection 4.3.2 of the BAM have been undertaken and are outlined below.

4.5.1 Native vegetation cover

Native vegetation cover within the proposal site and buffer area was determined for each subregion in accordance with Section 3.2 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.

The proposal is predominantly linear-shaped, however in some areas a site-based approach is taken. Where there is temporary workforce accommodation or borrow pits away from the main proposal the 1500 metre buffer for non-linear development has been used. The linear-shaped proposal is buffered 500 metres along each side of the centre line except in the following instances:

- Where the impacts occur outside the 500 metre buffer because of a larger compound or passing loop then a 1500 metre buffer has been placed around these parts of the proposal and then the 500 metre buffer continues along the centreline to the north and south of the compound.
- Where the impacts occur outside the CIZ but are associated with a linear realignment of associated infrastructure (eg a road, powerline), the 500 metre centreline buffer has been retained.

Table 4.4 Native vegetation cover

Subregion	Assessment area	Total assessment area (ha)	Area of native vegetation cover (ha)	Native vegetation percent cover **before** proposal	Native vegetation percent cover **after** proposal
Inland Slopes	1500 metre buffer of the perimeter	1208.05	18.70	1.55%	0.43%
Castlereagh-Barwon	500 metres along each side of the centre line of the proposal	8056.13	1,933.63	24.00%	21.20%
Bogan-Macquarie	500 metres along each side of the centre line of the proposal and 1500 metre buffer for site-based compound and borrow pit B	5463.19	385.49	7.06%	5.97%
Pilliga	500 metres along each side of the centre line of the proposal and 1500 metres buffer for site-based compound and borrow pit C	20,335.23	10,494.24	51.61%	47.53%
Pilliga Outwash	500 metres along each side of the centre line of the proposal and 1500 metres buffer for site-based compound and borrow pit D	10,205.24	5796.10	56.80%	50.45%
Liverpool Plains	500 metres along each side of the centre line of the proposal	609.39	16.83	2.76%	1.33%
Northern Basalts	500 metres along each side of the centre line of the proposal	295.65	11.65	3.94%	1.31%

4.5.2 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 to 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. 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. This was the case for most vegetation zones given the linear nature of the proposal and connectivity with long continuous roadside patches

4.6 Summary of landscape features

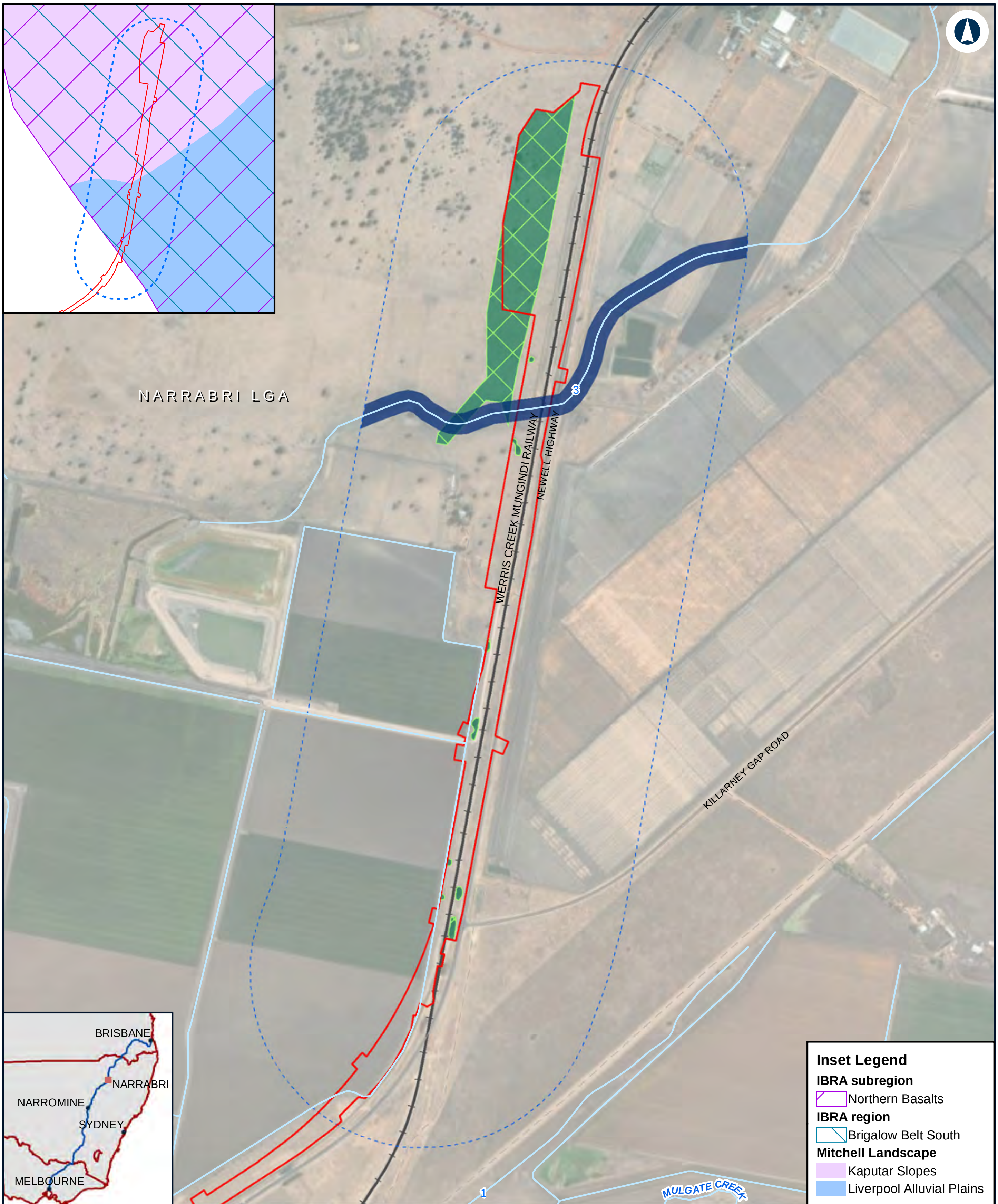
A summary of landscape features relevant to the BAM is provided in Table 4.5 and relevant features are mapped on Figure 4.1.

Table 4.5 Landscape features by location and IBRA subregion

Landscape feature	Inland Slopes	Bogan-Macquarie	Castlereagh-Barwon	Pilliga	Pilliga Outwash	Liverpool Plains	Northern Basalts
Proposal location	Borrow pit A	Narromine area	Various sections between Gilgandra and Teridgerie	Various sections between Narromine and Narrabri	Parts of the Pilliga and Narrabri area	A small section in Narrabri	Northern most section in Narrabri
Method applied for site context components	Site-based development	Linear-shaped development and site based for Narromine MFC and Borrow Pit B	Linear-shaped development	Linear-shaped development and site based for Borrow Pit C	Linear-shaped development and site based for Narrabri MFC and Borrow Pit D	Linear-shaped development	Linear-shaped development
Interim Biogeographic regionalisation of Australia (IBRA region) bioregion	South Western Slopes	Darling Riverine Plains	Darling Riverine Plains	Brigalow Belt South	Brigalow Belt South	Brigalow Belt South	Brigalow Belt South
IBRA subregion	Inland Slopes	Bogan-Macquarie	Castlereagh-Barwon	Pilliga	Pilliga Outwash	Liverpool Plains	Northern Basalts
NSW (Mitchell) landscapes	Geurie Granites	Boggy Cowal Alluvial Plains	Castlereagh Alluvial Plains	Cubbo Uplands	Coghill Alluvial plains	Liverpool Alluvial Plains	Kaputar Slopes
Native vegetation extent within buffer area after development	5.24 ha	326.34 ha	1707.89 ha	9665.43 ha	5148.74 ha	8.13 ha	3.86 ha

Landscape feature	Inland Slopes	Bogan-Macquarie	Castlereagh-Barwon	Pilliga	Pilliga Outwash	Liverpool Plains	Northern Basalts
Rivers, streams and estuaries	Intermittent unnamed watercourses	Macquarie River (9th order stream) Various other named and unnamed intermittent unnamed watercourses.	Kickabil Creek	Castlereagh River (7th order stream) Various named and unnamed intermittent unnamed watercourses.	Bohena Creek Etoo Creek Various other named and unnamed intermittent unnamed watercourses.	Namoi River (9th order stream) Narrabri Creek Various other named and unnamed intermittent unnamed watercourses.	Various other named and unnamed intermittent unnamed watercourses.
Wetlands	No wetlands occur in the proposal site or buffer area.	Small wetlands (boggy cowals) occur in the buffer area.	No wetlands occur in the proposal site or buffer area.	No wetlands occur in the proposal site or buffer area.	No wetlands occur in the proposal site or buffer area.	No wetlands occur in the proposal site or buffer area.	No wetlands occur in the proposal site or buffer area.
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	Vegetated riparian corridors (eg Macquarie River) Vegetated road reserves and paper roads Small, isolated patches of woodland within farmland Paddock trees	Vegetated riparian corridors (eg Gulargambone Creek) Vegetated road reserves and paper roads Small, isolated patches of woodland within farmland Paddock trees	Pilliga Forests Large, vegetated tracts associated with Crown land/Travelling Stock Reserves (eg Bohena Creek and along the Newell Highway) Vegetated road reserves and paper roads Small, isolated patches of woodland within farmland Paddock trees	Pilliga Forests Vegetated riparian corridors Vegetated road reserves and paper roads Small, isolated patches of woodland within farmland Paddock trees	Vegetated road reserves and paper roads Small, isolated patches of woodland within farmland Paddock trees	Vegetated riparian corridors Small, isolated patches of woodland within farmland

Landscape feature	Inland Slopes	Bogan-Macquarie	Castlereagh-Barwon	Pilliga	Pilliga Outwash	Liverpool Plains	Northern Basalts
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.	There are no areas of geological significance or soil hazard features in this subregion within the study area of the proposal.	There are no areas of geological significance in this subregion within the study area of the proposal.	Small outlying hills associated with the Warrumbungles	There are no areas of geological significance in this subregion within the study area of the proposal. However areas of sandstone gorge and caves are known from the wider locality within the Pilliga forests.	There are no areas of geological significance in this subregion within the study area of the proposal.	There are no areas of geological significance in this subregion within the study area of the proposal.
Other landscape features	There are no other landscape features or outstanding biodiversity value identified within the proposal site.						
Current percent native vegetation cover in the buffer area	2% (0-10%)	7% (0-10%)	24% (>10-30%)	52% (>30-70%)	57% (>30-70%)	3% (0-10%)	4% (0-10%)
The future percent native vegetation cover in the buffer area	1% (0-10%)	6% (0-10%)	21% (>10-30%)	48% (>30-70%)	50% (>30-70%)	1% (0-10%)	1% (0-10%)



NARROMINE TO NARRABRI Landscape Features - Northern Basalts IBRA Subregion

Figure 4.1a

0 0.2 0.4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:15,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Riparian buffer

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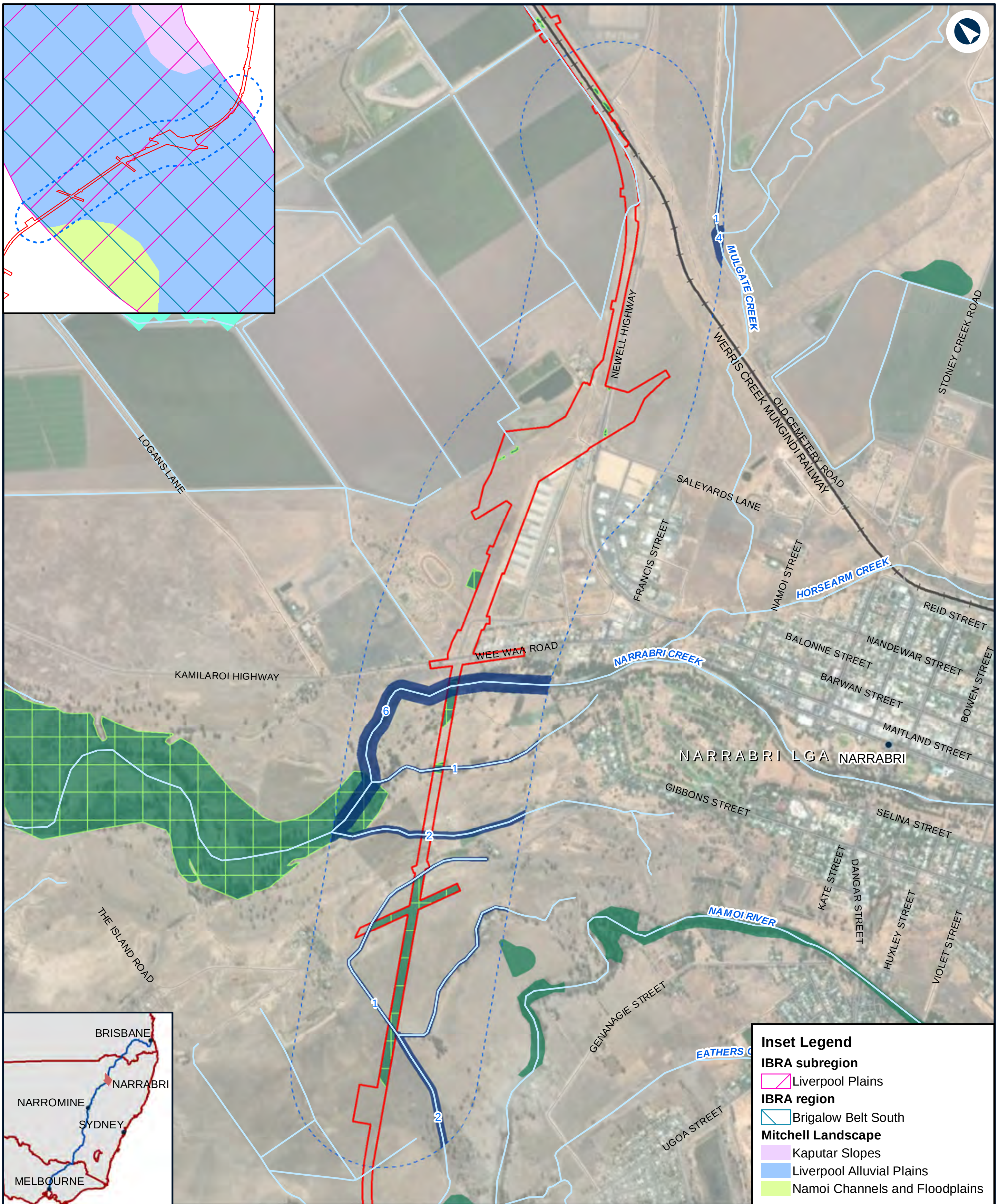

NARROMINE TO NARRABRI Landscape Features - Liverpool Plains IBRA Subregion Figure 4.1b

0 0.4 0.8 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:28,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Wetlands NSW
- Riparian buffer

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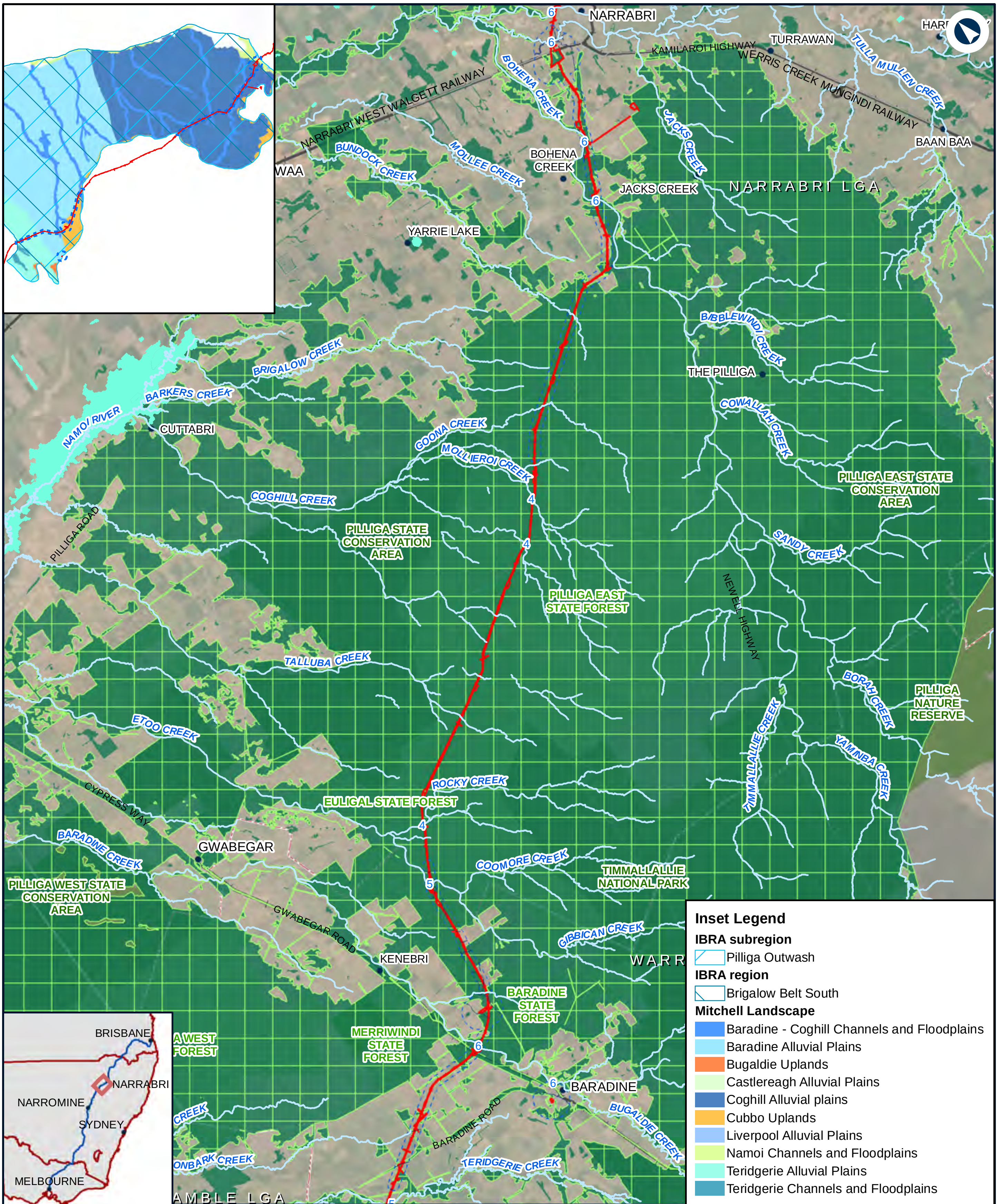

NARROMINE TO NARRABRI Landscape Features - Pilliga Outwash IBRA Subregion Figure 4.1c

0 7 14 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:470,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Wetlands NSW
- Riparian buffer

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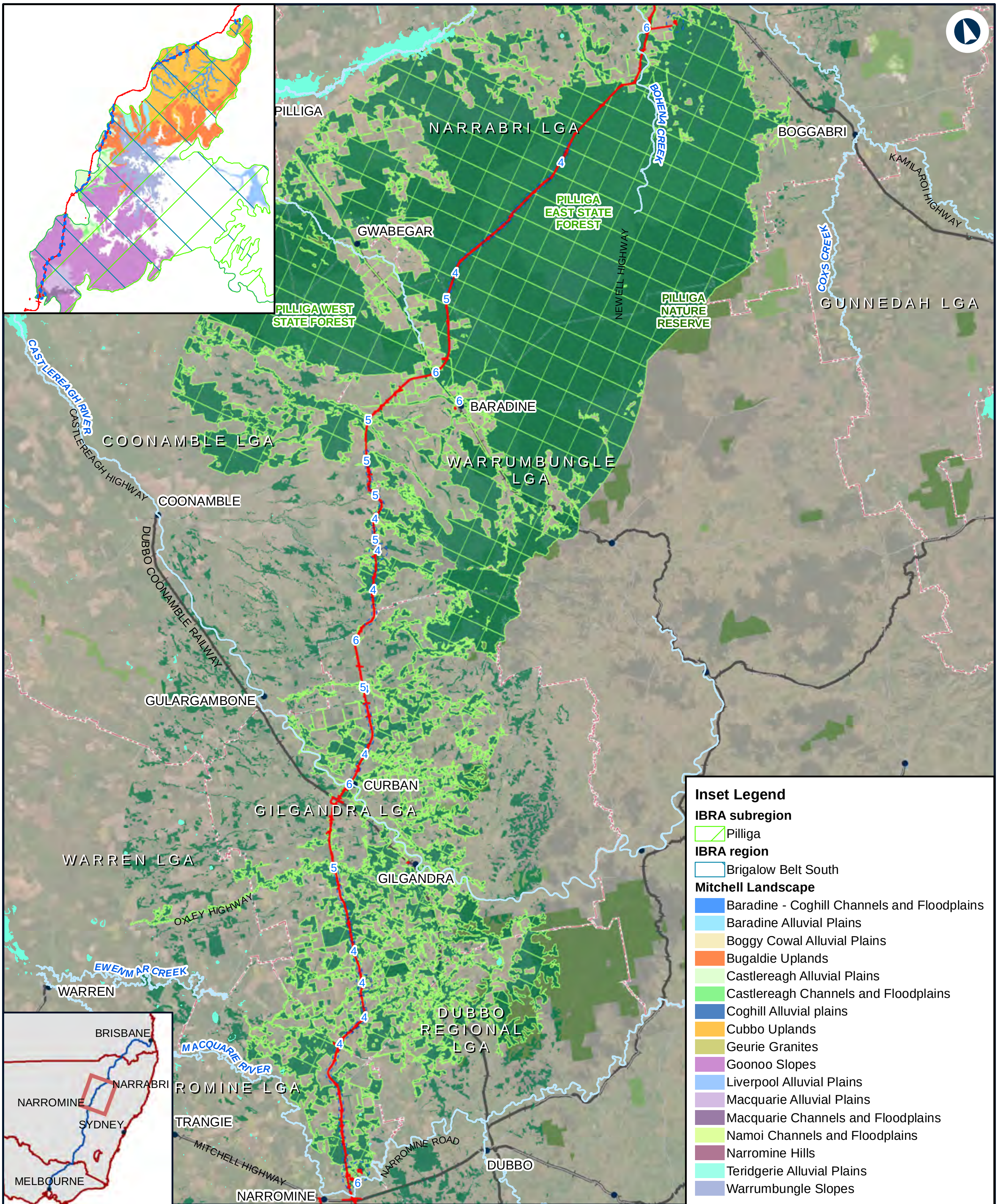

NARROMINE TO NARRABRI Landscape Features - Pilliga IBRA Subregion Figure 4.1d

0 10 20 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:1,055,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Wetlands NSW
- Riparian buffer

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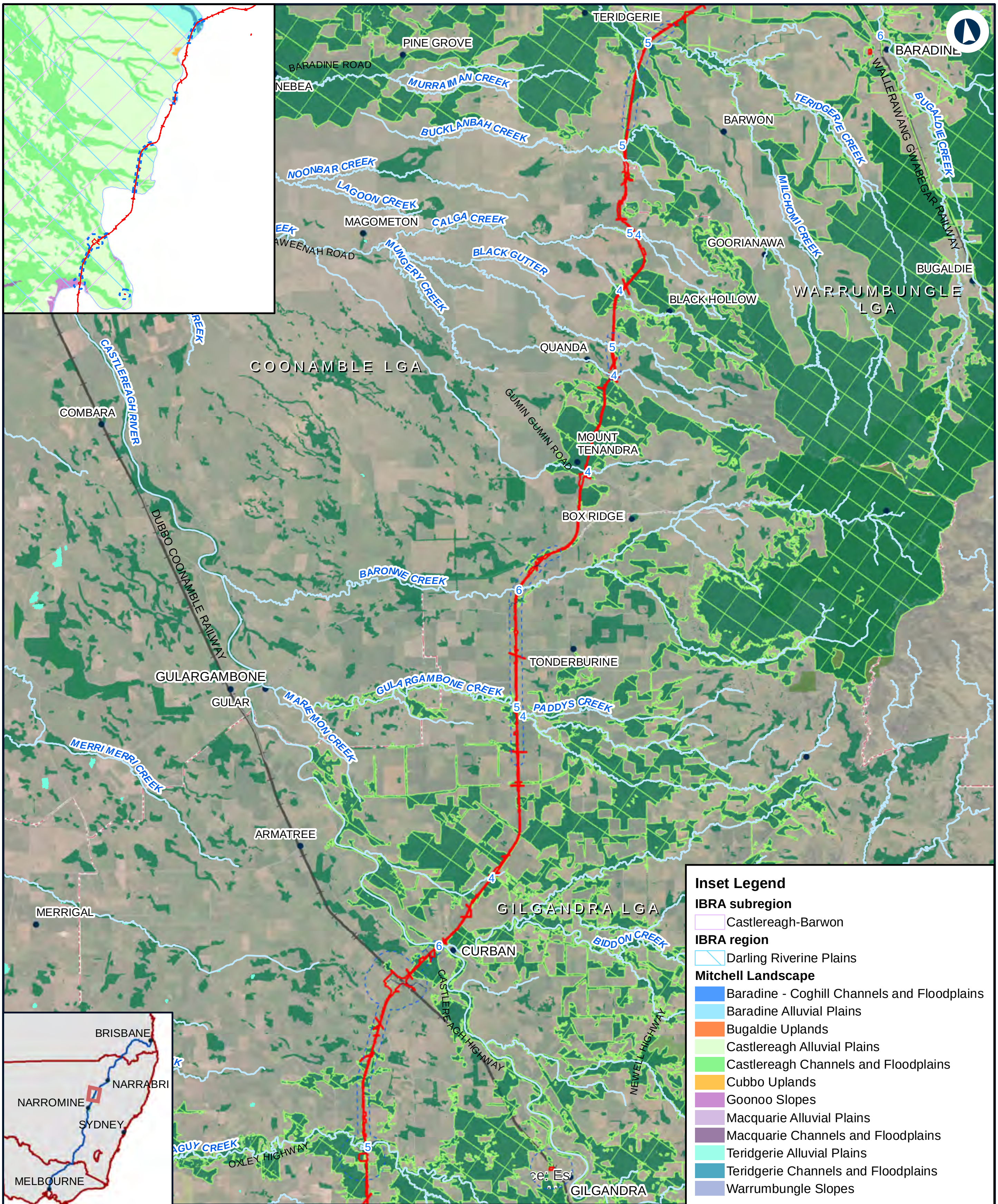

NARROMINE TO NARRABRI Landscape Features - Castlereagh-Barwon IBRA Subregion Figure 4.1e

0 6.5 13 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:415,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Wetlands NSW
- Riparian buffer

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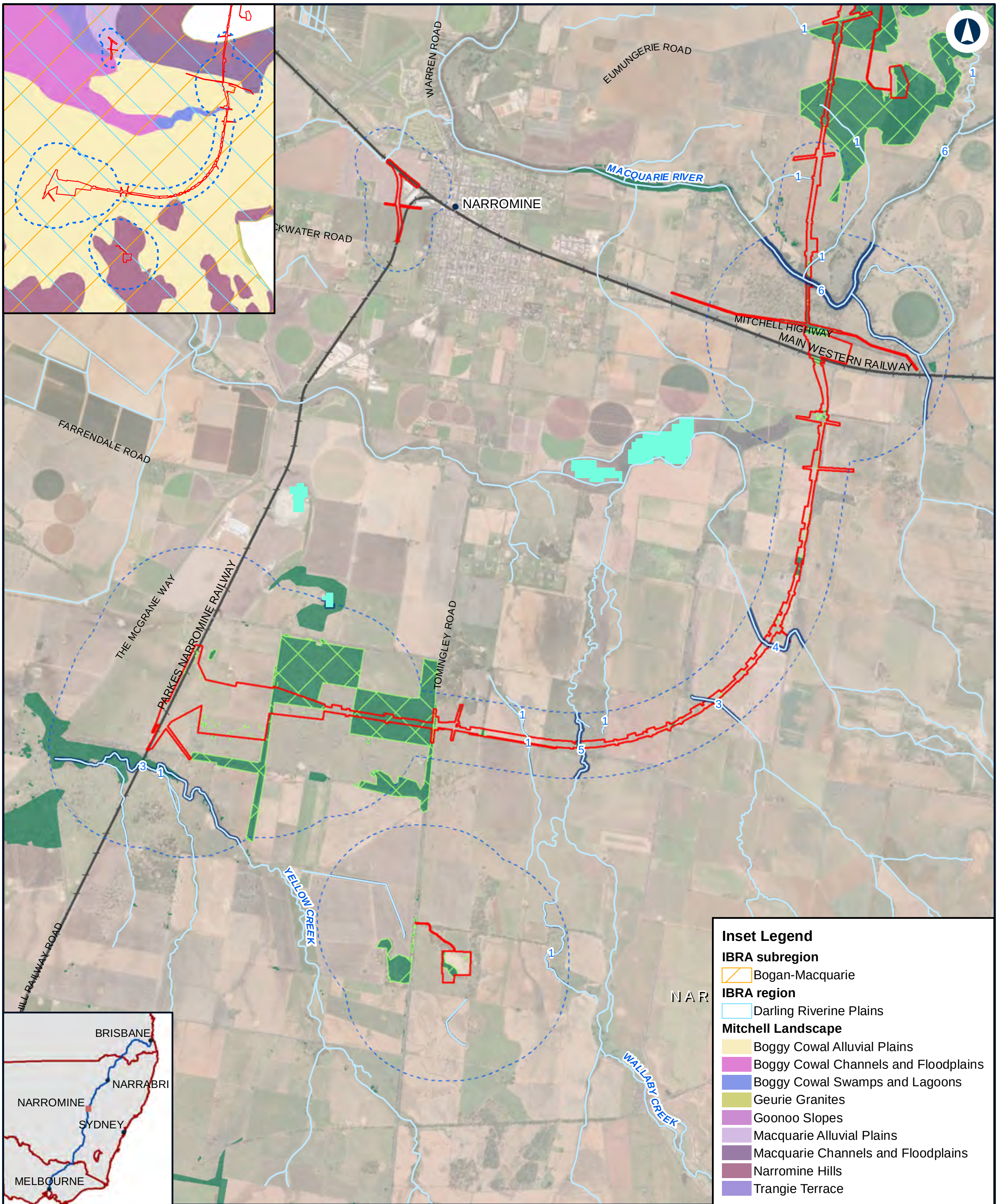

NARROMINE TO NARRABRI Landscape Features - Bogan-Macquarie IBRA Subregion Figure 4.1f

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:80,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Wetlands NSW
- Riparian buffer

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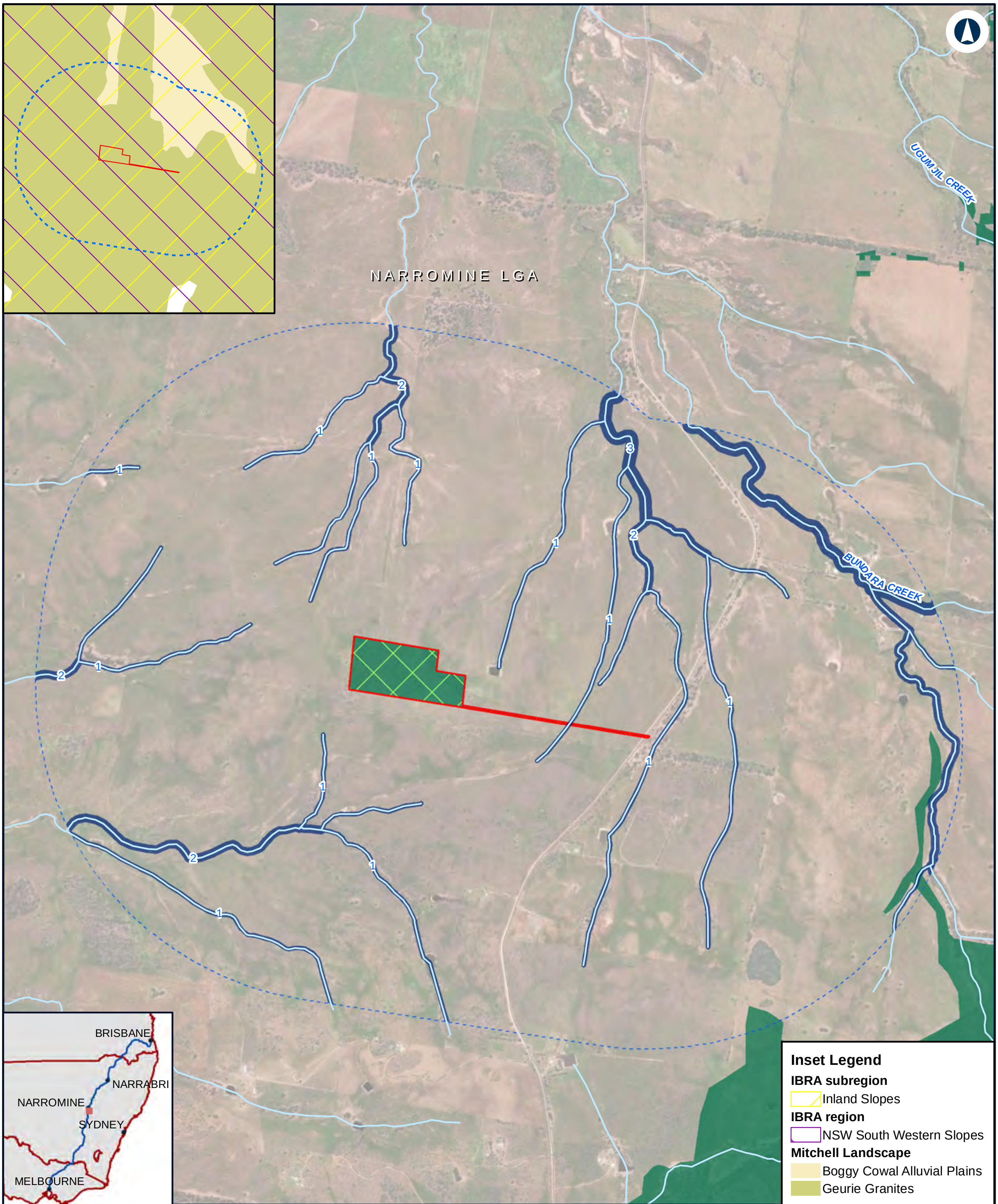

NARROMINE TO NARRABRI Landscape Features - Inland Slopes IBRA Subregion Figure 4.1g

0 0.4 0.8 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:25,000
Data Sources: Wetlands, vegetation, IBRA, Mitchell Landscapes: OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Buffer area
- Native vegetation
- Native vegetation patch size
- Riparian buffer

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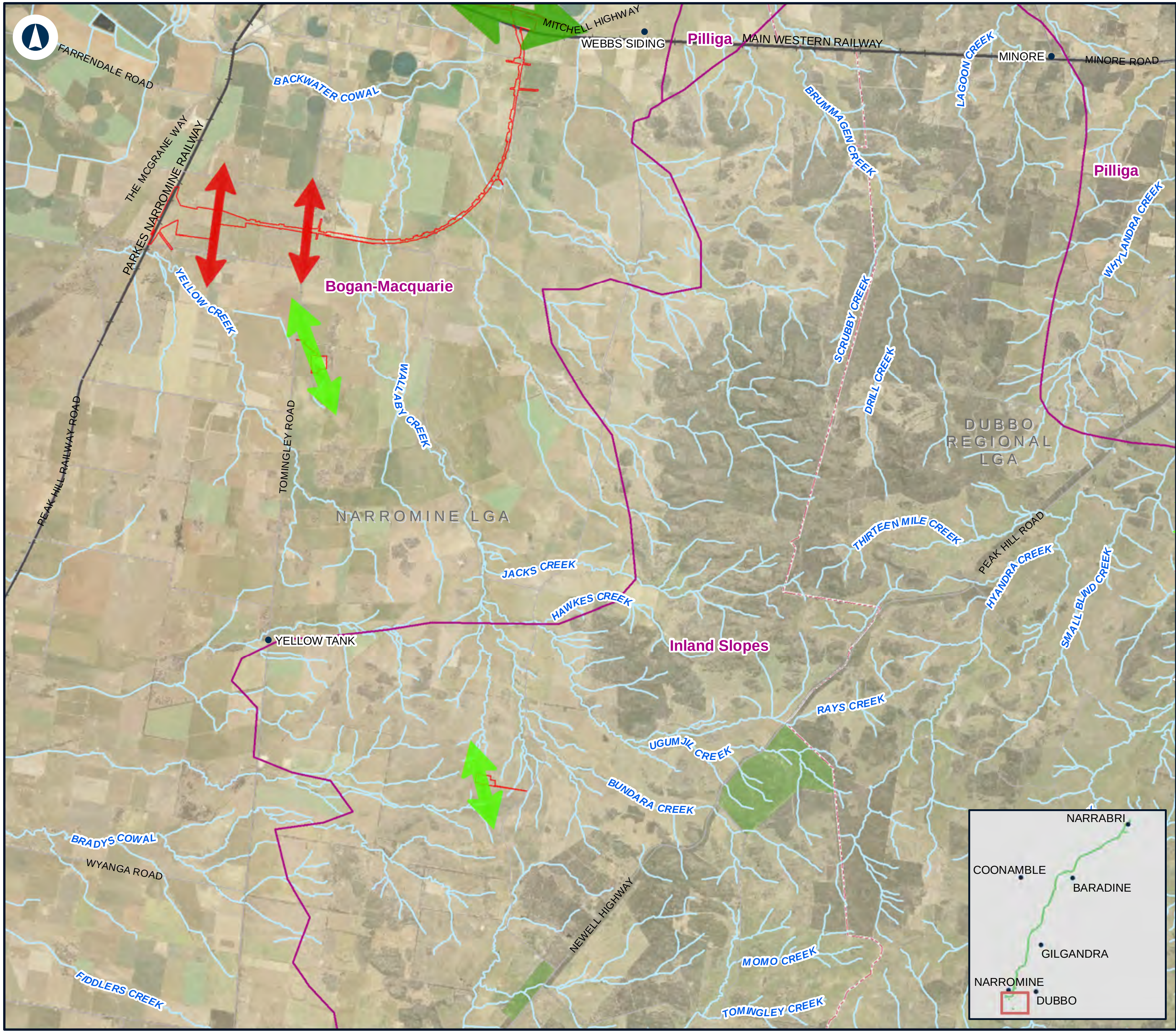

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 1 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 2.5 5 Km

Coordinate System: GDA2020 MGA Zone 55

Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS;

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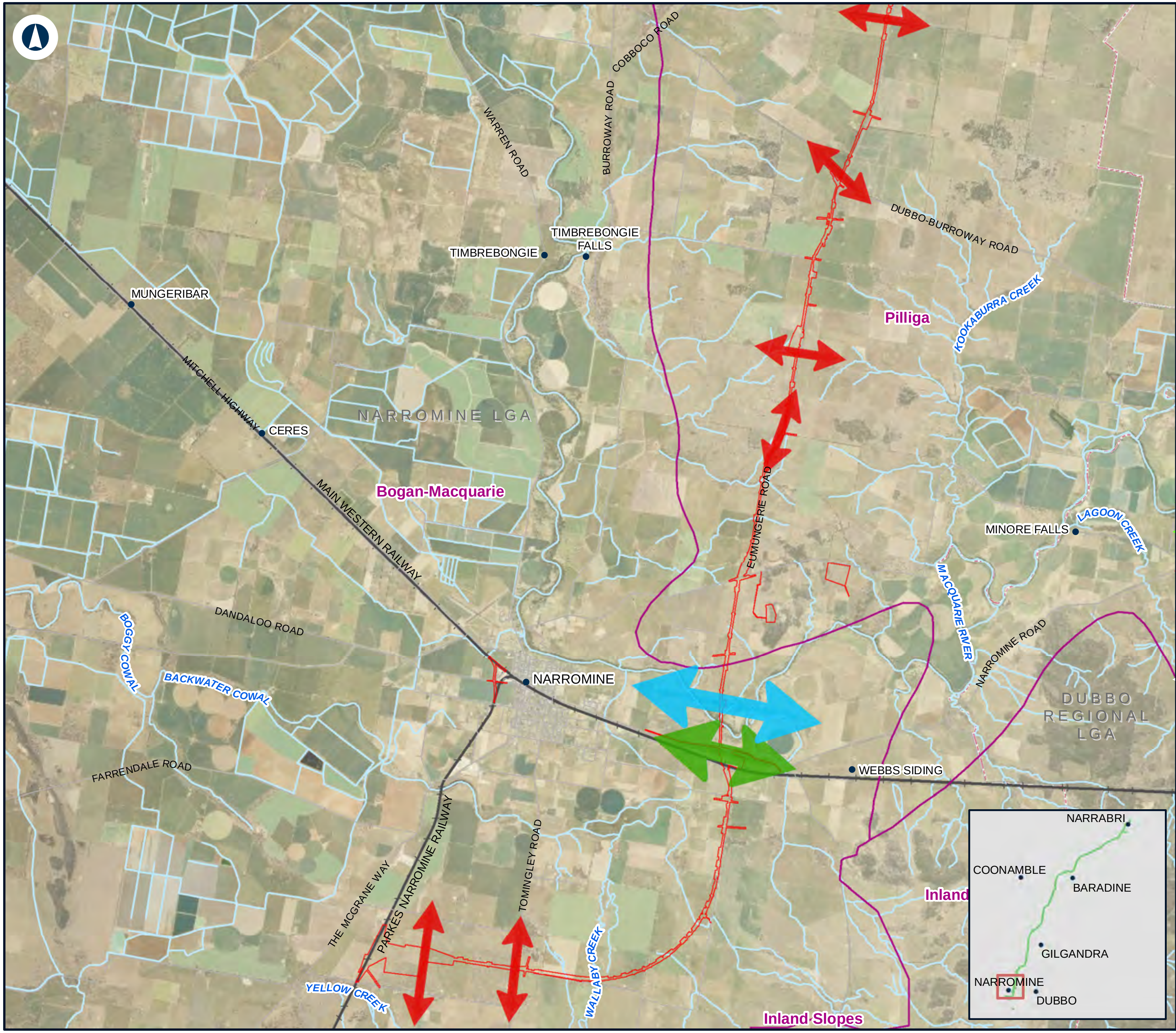

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 2 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 2.5 5 Km

Coordinate System: GDA2020 MGA Zone 55

Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS;

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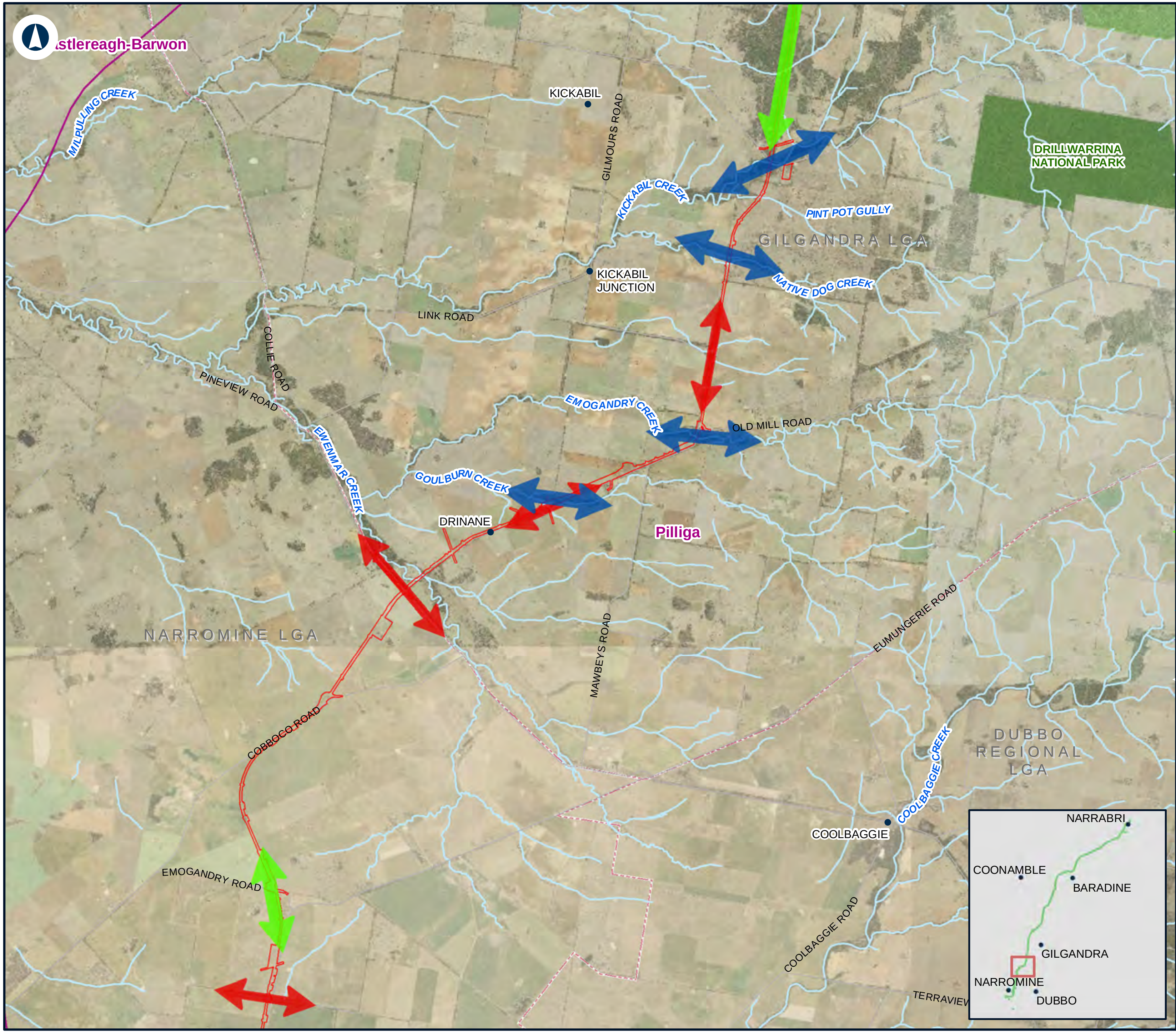

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 3 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 2 4 Km

Coordinate System: GDA2020 MGA Zone 55

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Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:130,000
Data Sources: Basemap layers: NSWSS;

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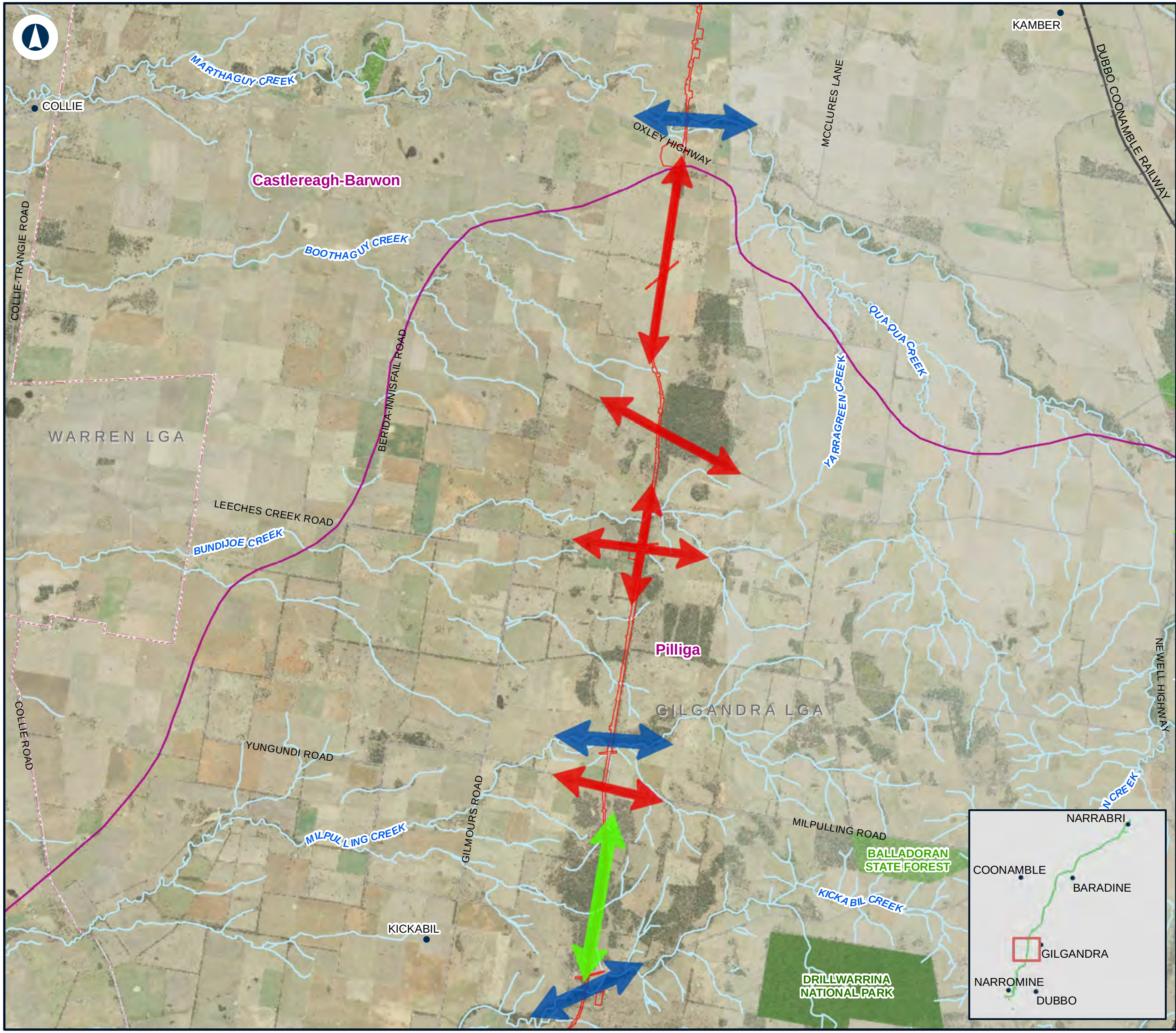

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 4 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 2.5 5 Km

Coordinate System: GDA2020 MGA Zone 55

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Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS;

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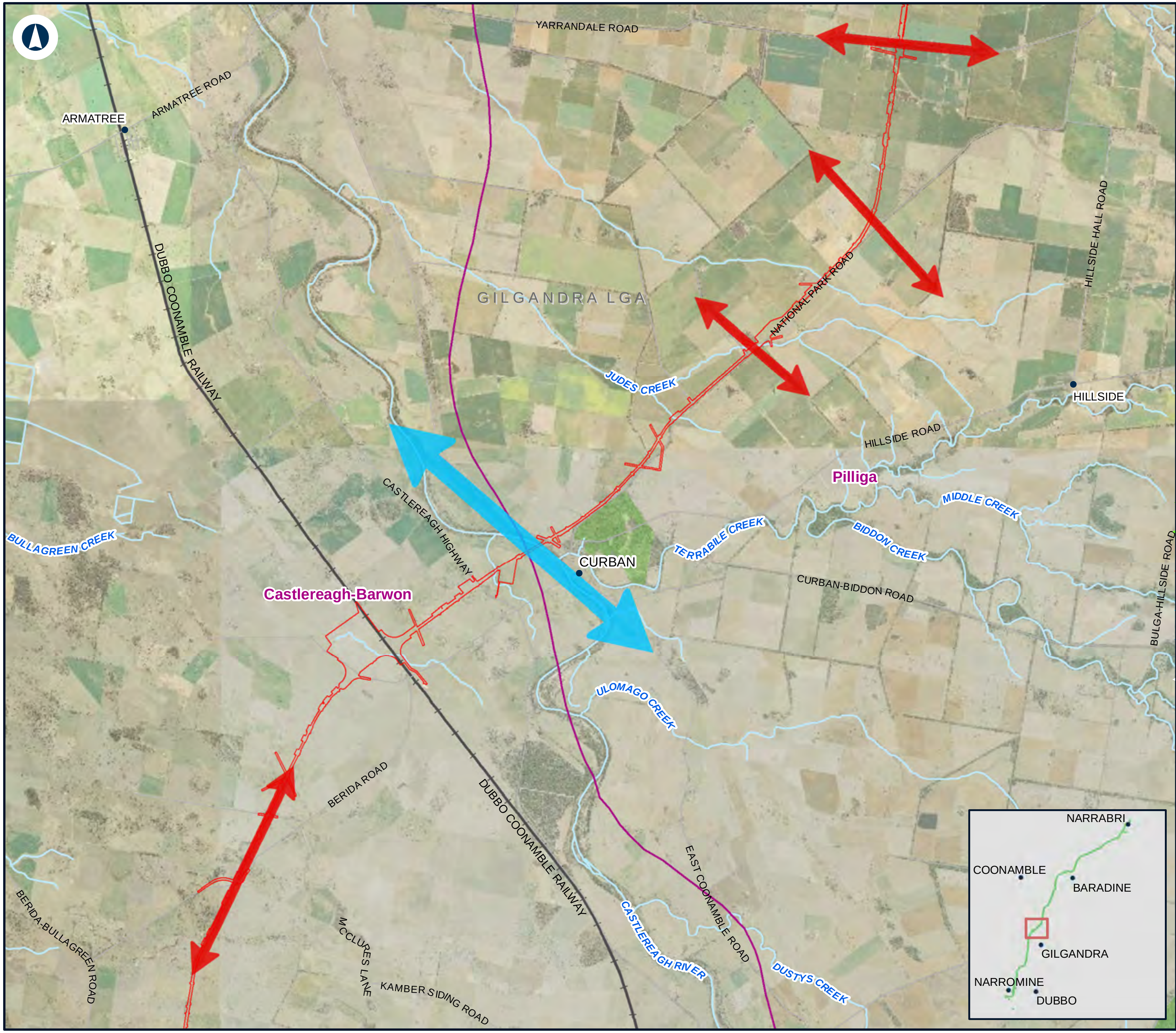

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 5 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 2 4 Km

Coordinate System: GDA2020 MGA Zone 55

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Author: JacobsGHD Scale: 1:125,000

Data Sources: Basemap layers: NSWSS;

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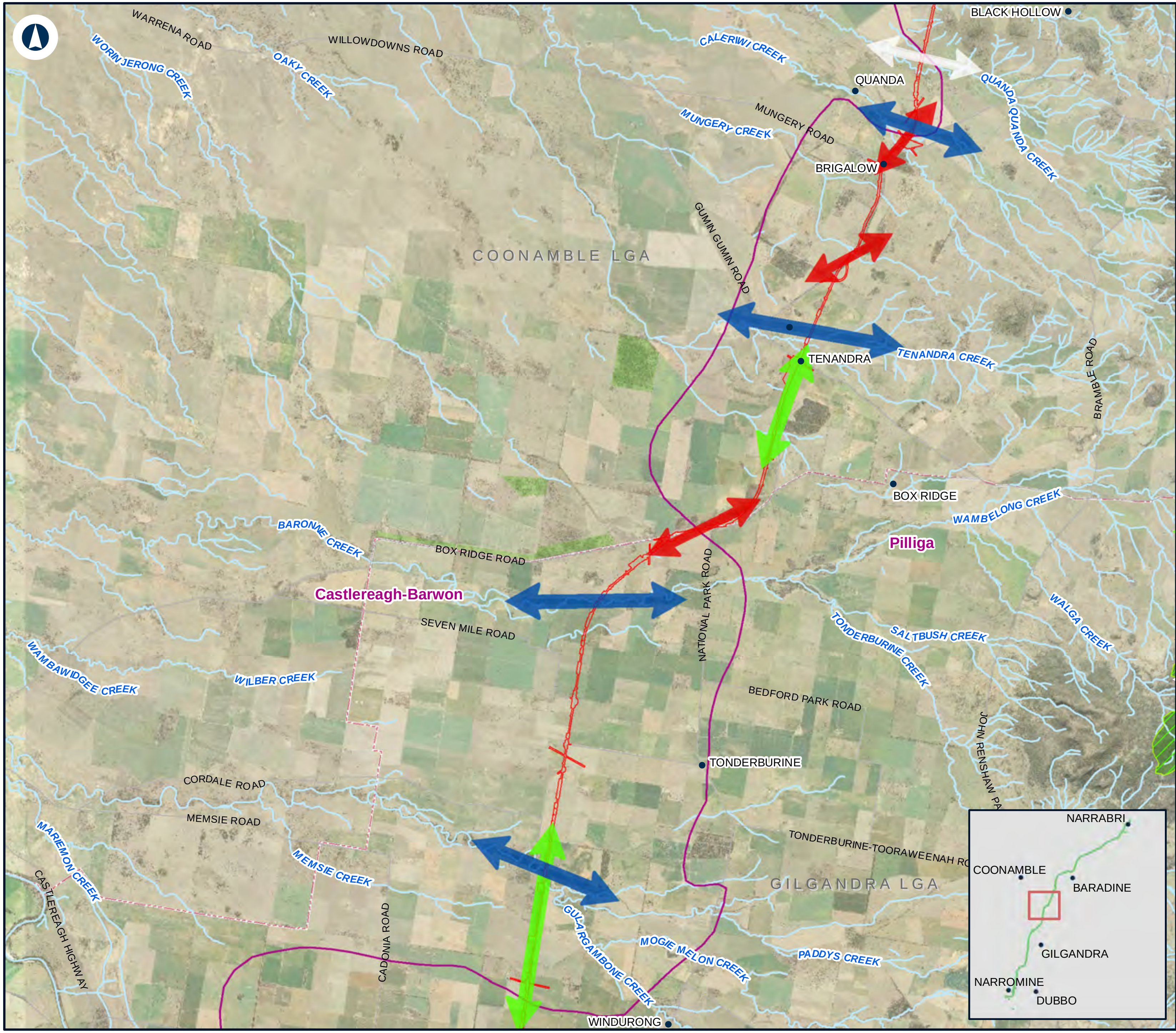
NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 6 OF 10



LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 3 6 Km

Coordinate System: GDA2020 MGA Zone 55

Date: 2021-12-01 Paper: A4

Author: JacobsGHD Scale: 1:180,000

Data Sources: Basemap layers: NSWSS;

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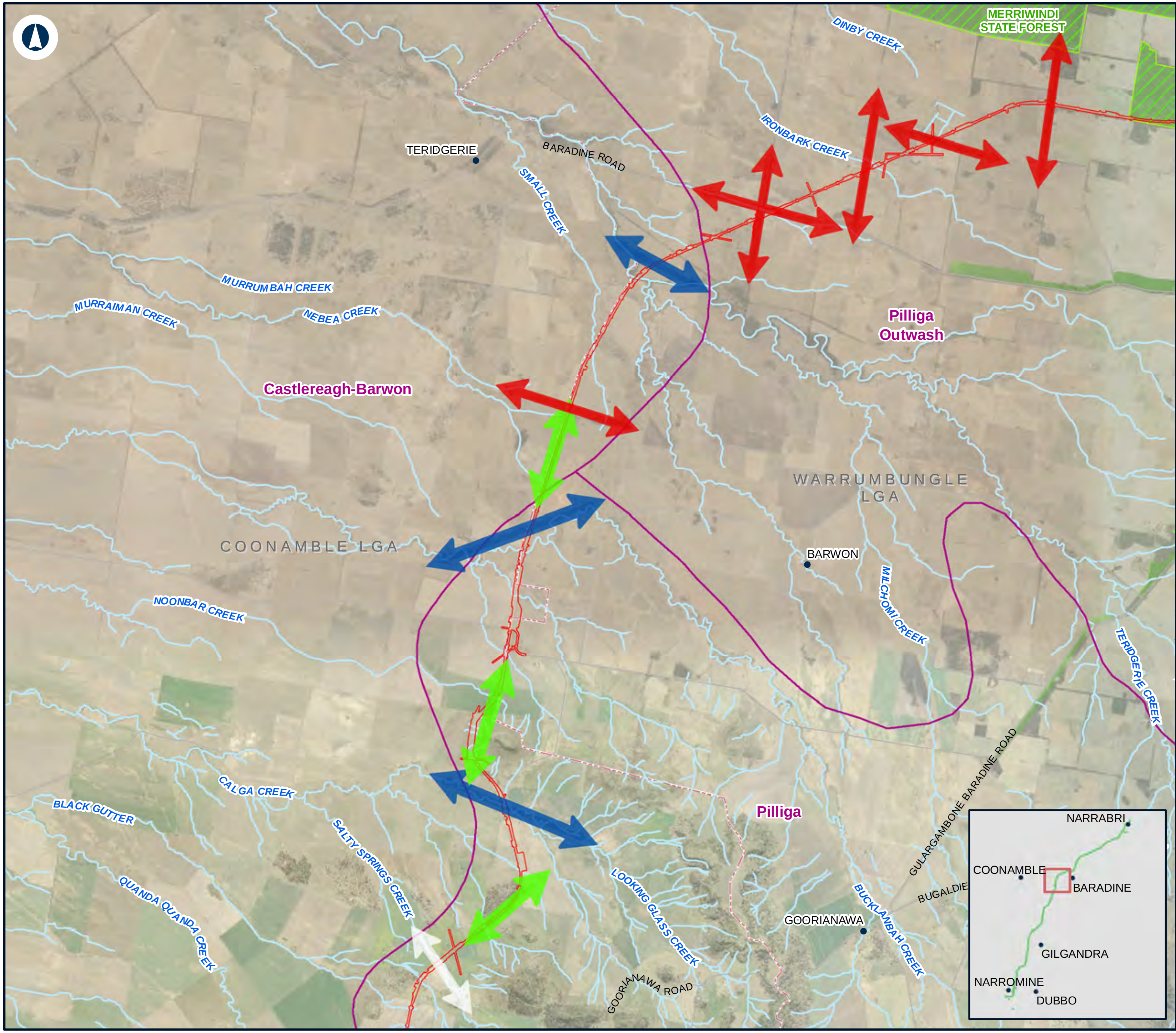

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 7 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 2.5 5 Km

Coordinate System: GDA2020 MGA Zone 55

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Date: 2021-12-01
Author: JacobsGHD
Data Sources: Basemap layers: NSWSS;
Paper: A4
Scale: 1:150,000

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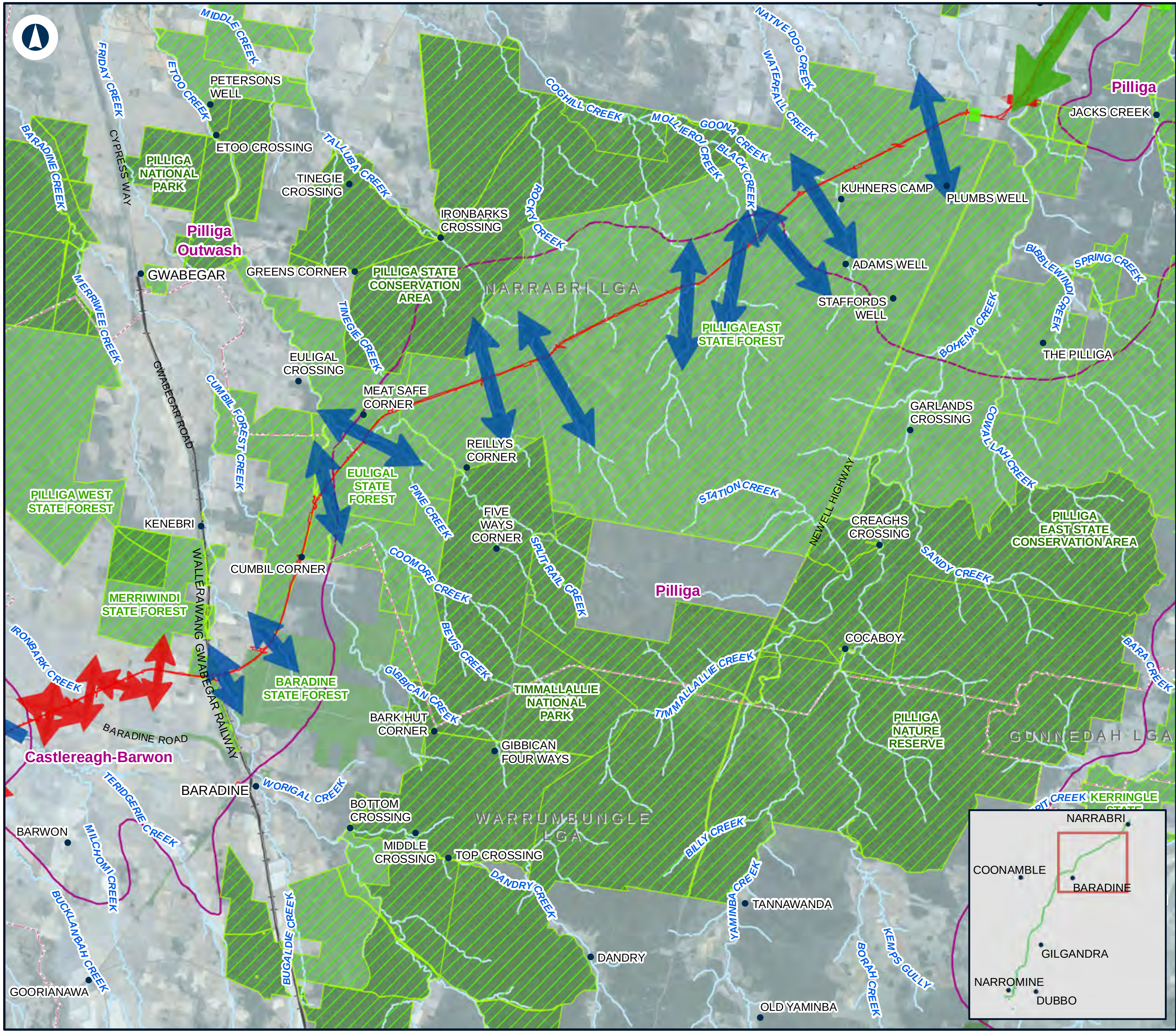
NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 8 OF 10



LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

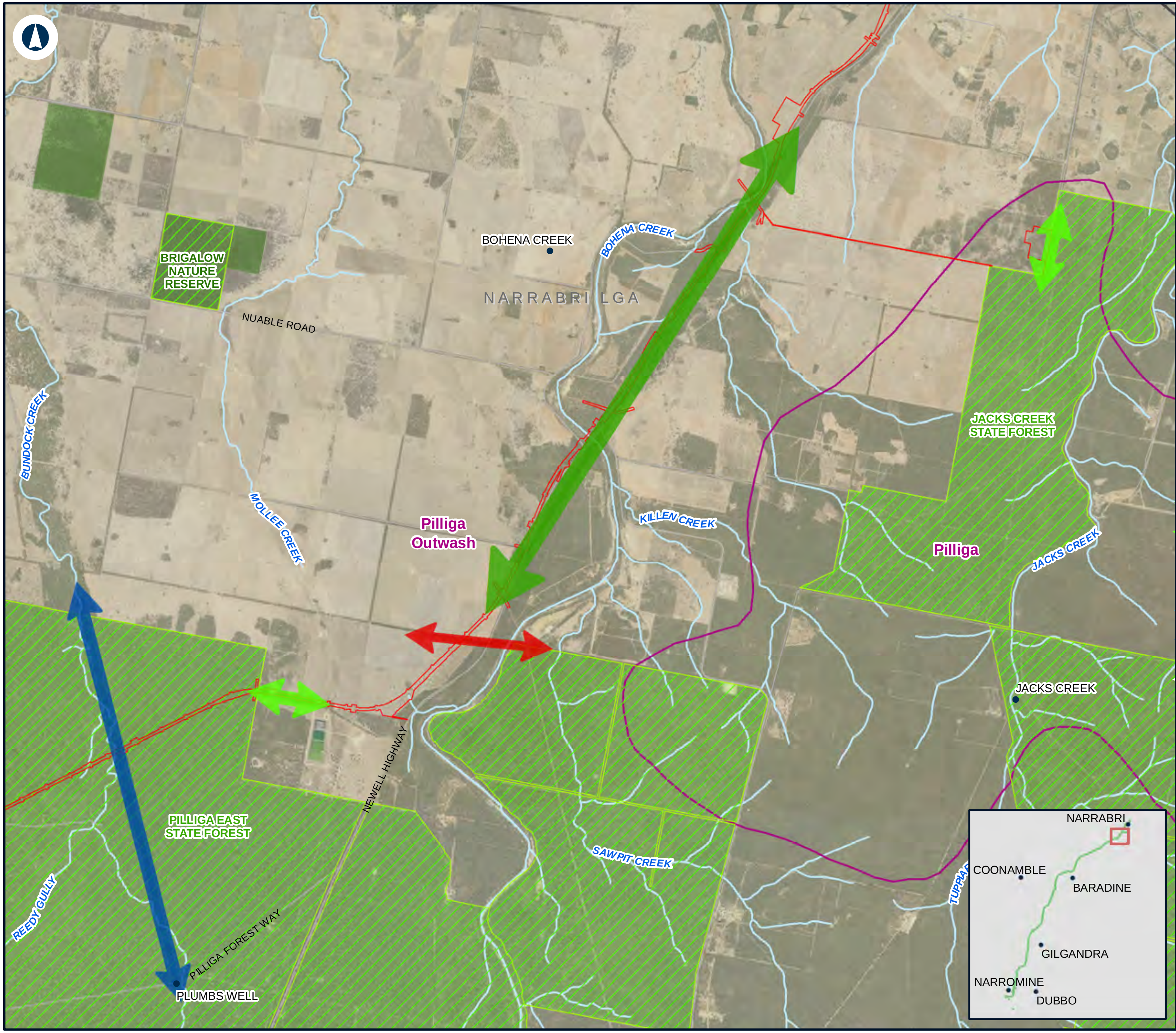
0 6.5 13 Km

Coordinate System: GDA2020 MGA Zone 55

Date: 2021-12-01 Paper: A4

Author: JacobsGHD Scale: 1:400,000

Data Sources: Basemap layers: NSWSS;



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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 9 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 1.5 3 Km

Coordinate System: GDA2020 MGA Zone 55

Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:100,000
Data Sources: Basemap layers: NSWSS;

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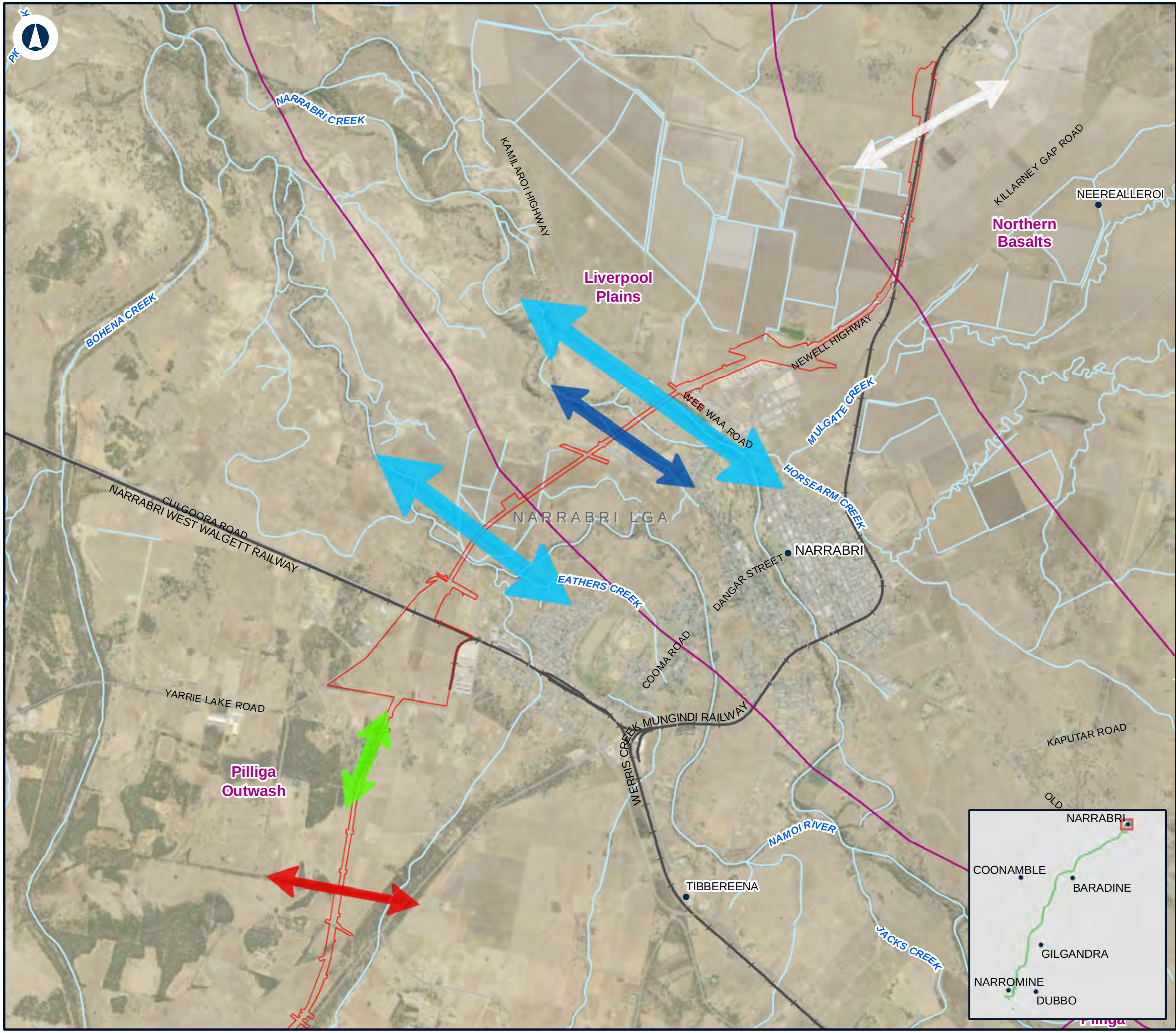

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NARROMINE TO NARRABRI

Figure 4.2: Existing (pre-construction) connectivity in the study area

MAP 10 OF 10

LEGEND

- Construction impact zone
- Pilliga IBA (important bird and biodiversity area)
- IBRA7 subregions

Connectivity

- Local connectivity - large patch
- Local connectivity - small patch
- Local connectivity - linear remnants
- Major riparian corridor
- Riparian corridor - vegetated
- Riparian corridor - minimal vegetation

0 1 2 Km

Coordinate System: GDA2020 MGA Zone 55

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Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:65,000
Data Sources: Basemap layers: NSWSS;

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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 3,429 hectares. The extent of native vegetation is about 1,791 hectares and comprises remnant native woodland patches and derived native grassland. There is approximately 1,512 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-six PCTs have been identified in the proposal site. 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, most 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 36 PCTs identified in the proposal site and justification for selection of these PCTs are in Appendix B.

5.2.1 Vegetation zones

Wherever possible, PCTs were allocated to vegetation 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 vegetation within the proposal site retained a layer of native canopy and shrub vegetation 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 78 vegetation zones were identified across the seven subregions in the proposal site. Vegetation zones were spilt by subregion and are outlined in Table 5.2. The number of vegetation zones by subregion are:

- Inland Slopes subregion – two vegetation zones
- Bogan Macquarie subregion – nine vegetation zones
- Castlereagh-Barwon subregion – 11 vegetation zones
- Pilliga subregion – 29 vegetation zones
- Pilliga Outwash subregion – 22 vegetation zones
- Liverpool Plains subregion – three vegetation zones
- Northern Basalts subregion – two vegetation zones.

Given the long length of the proposal, multiple survey teams and access restrictions, three broad condition states were identified for assigning PCTs. Where there were obvious differences in a vegetation zone outside these three broad condition states, a new condition state was allocated. Examples of this include areas where landholders had removed an entire shrub layer from a woodland patch and piled removed shrubs for burning; or patches in the Pilliga with scattered canopy trees and signs of recent (<5 years) fire. Broad condition zones were:

- Good – featuring natural vegetation structure and predominantly native understorey.
- Low – featuring natural vegetation structure but predominantly exotic or cleared understorey.
- Derived native grassland – featuring a dominance of native grasses and forbs in the ground layer but lacking other plot attributes such as canopy, shrubs, logs etc. Usually derived from a woodland parent community.

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
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
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)
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
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
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
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	Not listed	Poplar Box grassy woodlands on alluvial plains
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Not listed	Not listed
PCT 81 Western Grey Box – Cypress Pine grass shrub tall woodland in the Brigalow Belt South Bioregion	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
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Not listed	Not listed
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	Not listed	Not listed
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
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

Plant Community Type	BC Act status	EPBC Act status
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	Not listed	Not listed
PCT 185 Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland	Not listed	Not listed
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
PCT 206 Dirty Gum - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Not listed	Not listed
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
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
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
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	Not listed	Not listed
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	Not listed	Not listed
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	Not listed	Not listed
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
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

Plant Community Type	BC Act status	EPBC Act status
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Not listed	Not listed
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	Not listed	Not listed
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
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
PCT 435 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
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	Not listed	Not listed
PCT 469 White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	Not listed	Not listed
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
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
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
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	Not listed	Not listed
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	Not listed	Not listed

Table 5.2 Vegetation zones in the proposal site and seven subregions

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
NSW South Western Slopes bioregion, Inland slopes subregion									
185	1	Inland Rocky Hill Woodlands	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – DNG	20	12.10	5-25	9.6	3	3
185	2	Inland Rocky Hill Woodlands	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – Good	20	1.4	5-25	97.8	1	x1 benchmark
			Total native vegetation for Inland Slopes subregion		**13.5 ha**	**5-25**		**4**	**4**
Darling Riverine Plains bioregion, Bogan-Macquarie subregion									
36	1	Inland Riverine Forests	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good	53	2.8	101	53	2	2
49	2	Semi-arid Floodplain Grasslands	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	50	11.7	101	85.3	3	3
56	3	Floodplain Transition Woodlands	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	78	0.6	101	99.7	1	x1 benchmark
81	4	Floodplain Transition Woodlands	Western Grey Box – Cypress Pine grass shrub tall woodland in the Brigalow Belt South bioregion – Good	78	0.9	25-100	80.1	1	1
88	5	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	38	19.0	101	48.8	3	3
88	6	Pilliga Outwash Dry Sclerophyll Forests;	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	38	0.5	101	38.5	1	x1 benchmark

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
248	7	Floodplain Transition Woodlands	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW – Good	80	16.3	101	59.1	3	3
255	8	Western Slopes Dry Sclerophyll Forests	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	50	4.3	101	53.1	2	2
599	9	Western Slopes Grassy Woodlands	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions – Good	80	3.0	25-100	78	2	2
			Non-native vegetation		291.0	-		-	
			Total native vegetation for Bogan-Macquarie subregion		**59.1 ha**			**18**	
Darling Riverine Plains bioregion, Castlereagh-Barwon subregion									
27	1	Riverine Plain Woodlands	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	86	4.6	101	57.2	2	2
49	2	Semi-arid Floodplain Grasslands	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	50	122.2	101	93.8	6	5 and x1 benchmark
56	3	Floodplain Transition Woodlands	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	78	12.8	101	73.3	3	3
56	4	Floodplain Transition Woodlands	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – DNG	78	18.4	101	40.1	3	x3 benchmark

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
78	5	Inland Riverine Forests	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	60	8.7	101	58.1	3	3
88	6	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	38	13.6	101	63	3	3
88	7	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	38	3.1	101	38.5	2	x2 benchmark
145	8	Western Peneplain Woodlands	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	75	15.8	101	36.8	3	3
206	9	North-west Alluvial Sand Woodlands	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – Good	50	5.2	101	79.1	3	2 and x1 benchmark
244	10	Floodplain Transition Woodlands	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – Good	73	19.7	25-100	87.2	3	2 and x1 benchmark
444	11	Western Slopes Grassy Woodlands	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion – Good	83	1.7	101	85.1	1	1
			Non-native vegetation		408.9				
			Total native vegetation for Castlereagh-Barwon subregion		**225.7ha**			**32**	

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
Brigalow Belt South bioregion, Pilliga subregion									
27	1	Riverine Plain Woodlands	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	86	1.9	101	44.8	1	1
36	2	Inland Riverine Forests	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good	53	3.0	101	52	2	2
49	3	Semi-arid Floodplain Grasslands	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	50	91.1	101	52.9	5	5
55	4	North-west Floodplain Woodlands	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	83	3.1	101	46.6	2	2
56	5	Floodplain Transition Woodlands	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	78	6.5	25-100	53.9	3	3
78	6	Inland Riverine Forests	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	60	8.5	101	46.6	3	3
88	7	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	38	205.4	101	43.3	7	7
88	8	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Low	38	1.7	<5	45.1	1	1
88	9	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	38	49.9	101	30.2	4	2 and x2 benchmark

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
141	10	Pilliga Outwash Dry Sclerophyll Forests	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	11	29.0	101	37.7	4	4
145	11	Western Peneplain Woodlands	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	75	49.3	101	24.7	4	4
202	12	Western Slopes Grassy Woodlands	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) – Good	75	3.6	101	99.5	2	x2 benchmark
206	13	North-west Alluvial Sand Woodlands	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – Good	50	4.9	101	41.6	2	2
244	14	Floodplain Transition Woodlands	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – Good	73	24.2	25-100	35.5	4	4
255	15	Western Slopes Dry Sclerophyll Forests	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	50	7.9	101	36.8	3	3
256	16	Inland Rocky Hill Woodlands	Green Mallee tall mallee woodland on rises in the Pilliga – Goonoo regions, southern Brigalow Belt South Bioregion – Good	23	0.3	101	41.5	1	1
394	17	North-west Slopes Dry Sclerophyll Woodlands	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good, fire affected	36	11.1	101	24.6	3	3
394	18	North-west Slopes Dry Sclerophyll Woodlands	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	36	35.6	101	44.7	4	6

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
394	19	North-west Slopes Dry Sclerophyll Woodlands	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – DNG	36	15.4	101	40.4	3	x3 benchmark
397	20	Pilliga Outwash Dry Sclerophyll Forests	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga – Warialda region, Brigalow Belt South Bioregion – Good	45	3.1	101	44.8	2	2
398	21	Western Slopes Dry Sclerophyll Forests	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	27	203.0	101	66.1	7	7
399	22	Western Slopes Dry Sclerophyll Forests	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga – Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	10	22.9	101	55.9	4	4
404	23	Western Slopes Dry Sclerophyll Forests	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Good	9	25.1	101	51.1	4	4
406	24	Western Slopes Dry Sclerophyll Forests	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests – Good	6	2.4	101	57	2	2
409	25	Western Slopes Dry Sclerophyll Forests	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	17	0.8	101	47.2	1	1
414	26	Western Slopes Dry Sclerophyll Forests	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion – Good, fire affected	40	7.3	101	28.8	3	3
469	27	Western Slopes Dry Sclerophyll Forests	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion – Good	33	1.0	101	38.6	1	1

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
746	28	Western Slopes Dry Sclerophyll Forests	Brown Bloodwood - Cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion – Good	40	2.1	101	45.6	2	2
1384	29	Pilliga Outwash Dry Sclerophyll Forests	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion – Good	75	8.8	101	80	3	3
			Non-native vegetation		766.5	-		-	
			Total native vegetation for Pilliga subregion		**828.8 ha**			**87**	
Brigalow Belt South bioregion, Pilliga Outwash subregion									
35	1	Brigalow Clay Plain Woodlands	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Goondiwindi, Brigalow Belt South bioregion – Good	90	1.4	101	62.6	1	1
35	2	Brigalow Clay Plain Woodlands	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Goondiwindi, Brigalow Belt South bioregion – DNG	90	5.9	101	37.7	3	x3 benchmark
49	3	Semi-arid Floodplain Grasslands	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	50	98.0	101	51	5	5
78	4	Inland Riverine Forests	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	60	10.7	101	86.2	3	2 and x1 benchmark
78	5	Inland Riverine Forests	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – DNG	60	1.3	101	40.8	1	x1 benchmark
88	6	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	38	72.6	101	52.5	5	5

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
88	7	Pilliga Outwash Dry Sclerophyll Forests	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	38	36.3	101	40.6	4	x4 benchmark
141	8	Pilliga Outwash Dry Sclerophyll Forests	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	11	1.9	101	30.9	1	1
145	9	Western Peneplain Woodlands	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	75	5.8	101	31.9	3	3
148	10	Pilliga Outwash Dry Sclerophyll Forests	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	50	46.2	101	58.6	4	4
148	11	Pilliga Outwash Dry Sclerophyll Forests	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 – DNG	50	95.4	101	35.8	5	3 and x2 benchmark
168	12	Riverine Chenopod Shrublands	Derived Copperburr shrubland of the NSW northern inland alluvial floodplains – Good	0	0.2	101	88.1	1	x1 benchmark
394	13	North-west Slopes Dry Sclerophyll Woodlands;	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	36	19.0	101	56.1	3	3
397	14	Pilliga Outwash Dry Sclerophyll Forests	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good	45	14.7	101	52.6	3	5
398	15	Western Slopes Dry Sclerophyll Forests	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	27	170.9	101	59.5	6	6

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
398	16	Western Slopes Dry Sclerophyll Forests	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 (Moderate, shrubs removed)	27	8.4	101	49.6	3	3
399	17	Western Slopes Dry Sclerophyll Forests	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	10	31.9	101	56.9	4	4
435	18	North-west Slopes Dry Sclerophyll Woodlands	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – Good	58	0.3	101	100	1	x1 benchmark
435	19	North-west Slopes Dry Sclerophyll Woodlands	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – DNG	58	5.1	101	40.4	2	x2 benchmark
473	20	Western Slopes Dry Sclerophyll Forests	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	30	19.2	101	55.5	3	3
473	21	Western Slopes Dry Sclerophyll Forests	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 – DNG	30	0.9	101	8.2	1	1
589	22	Western Slopes Grassy Woodlands	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion – Moderate, logged	83	1.0	101	44	1	1

PCTID	Veg zone #	Vegetation class	Vegetation zone – condition	PCT % cleared	Area (ha)	Patch size class	VI Score	Minimum number of plots required	Plots completed
			Non-native vegetation		101.1			63	
			Total native vegetation for Pilliga Outwash subregion		**647.4 ha**				
Brigalow Belt South bioregion, Liverpool Plains subregion									
168	1	Riverine Chenopod Shrublands	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – Good	0	7.1	<5	88.9	3	1 and x2 benchmark
78	2	Inland Riverine Forests	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	60	1.4	101	42	1	1
55	3	North-west Floodplain Woodlands	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	83	0.2	101	65.5	1	1
			Non-native vegetation		48.3	-	-	-	-
			Total native vegetation for Liverpool Plain subregion		**8.7 ha**			**5**	
Brigalow Belt South bioregion, Northern Basalts subregion									
49	1	Semi-arid Floodplain Grasslands	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	50	7.1	101	28.6	3	3
55	2	North-west Floodplain Woodlands	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	83	0.7	101	65.5	1	1
-			Non-native vegetation		21.9	-		-	
			Total native vegetation for Northern Basalts subregion		**7.8 ha**			**4**	

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 5.4). All five equivalent PCTs are more than 80 percent 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.

In accordance with Section 4.2.2 of the BAM, a TEC equivalency assessment has been prepared for each PCT that has a listed TEC equivalent in the BAM-C (see Table 5.3).

Table 5.3 TEC equivalency assessment for TEC listed in the BAM-C

PCT ID	Plant Community Type	Subregions occurrence in CIZ	BAM-C listed TEC	TEC assessment
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good and DNG	Castlereagh-Barwon, Pilliga	Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	**Yes**. The occurrence of this community occurs in one patch at the boundary of two subregions. The canopy is dominated by Weeping Myall with a forb rich understorey layer, including *Einadia nutans*, *Austrostipa scabra*, *Bulbine semibarbata* and *Chloris truncata*.
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	Bogan-Macquarie, Pilliga, Pilliga Outwash, Northern Basalts	Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	**No**. Weeping Myall within the CIZ is restricted to one patch. Although there is PCT 49 between this patch of Weeping Myall and the next patch of native woodland vegetation to the north (PCT88), the small number of scattered paddock trees within this grassland in the wider patch are Pilliga Box. In addition, the derived grassland form of Weeping Myall extends further to the south outside the CIZ and would not be impacted by the proposal. No other areas of Weeping Myall were observed in the CIZ or the adjacent wider study area and therefore no areas of PCT 49 have been attributed to being a separate vegetation zone that could be part of this TEC.
35	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – Good and DNG	Pilliga Outwash	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	**Yes**. This community occurs as both good condition and derived native grassland forms of the community south of Narrabri. The good condition vegetation zone is characterised by an overstorey of Brigalow with grasses of *Chloris truncata* and *Eleocharis* spp. in the understorey. The derived native grassland vegetation zone is characterised by an understorey of wiregrasses (*Aristida* spp) and *Calotis* spp.

PCT ID	Plant Community Type	Subregions occurrence in CIZ	BAM-C listed TEC	TEC assessment
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good and DNG	Pilliga	Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregions; or Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	**No.** No Coolibah or Black Box trees were recorded anywhere in the CIZ or the wider investigation corridor during surveys. The occurrence of PCT 55 was dominated by Belah grading into PCT 88 dominated by Pilliga Box. In addition, the occurrence of this PCT did not occur on grey soils that are periodically waterlogged or similar water environments. The soils in this section were very sandy and graded into a sand-based community (PCT206) to the north). Similarly, no Weeping Myall patches, or individual trees occur in the wider investigation corridor anywhere near the occurrence of PCT55. Therefore, the occurrence of PCT 55 is not likely to be either the TEC Coolibah Black Box Woodland or Weeping Myall Woodland.
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good and DNG	Castlereagh-Barwon, Pilliga	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions or Artesian spring ecological community in the great artesian basin	**No**. The occurrence of this community is dominated by Poplar Box and scattered Belah in an open grassy woodland with scattered shrubs. The canopy layer is not dense as the Brigalow community tends to be. The understorey is dominated by *Chloris* spp. and has been heavily grazed. There is no Brigalow within this PCT where it occurs in the CIZ or wider investigation corridor. **Yes – EPBC act listed community**. Although this PCT is not BC Act listed TEC, it does meet the listing criteria for the Poplar Box grassy woodland community listed under the EPBC Act due to the dominance in the canopy of Poplar Box and the open grassy woodland structure with a forb rich ground layer.

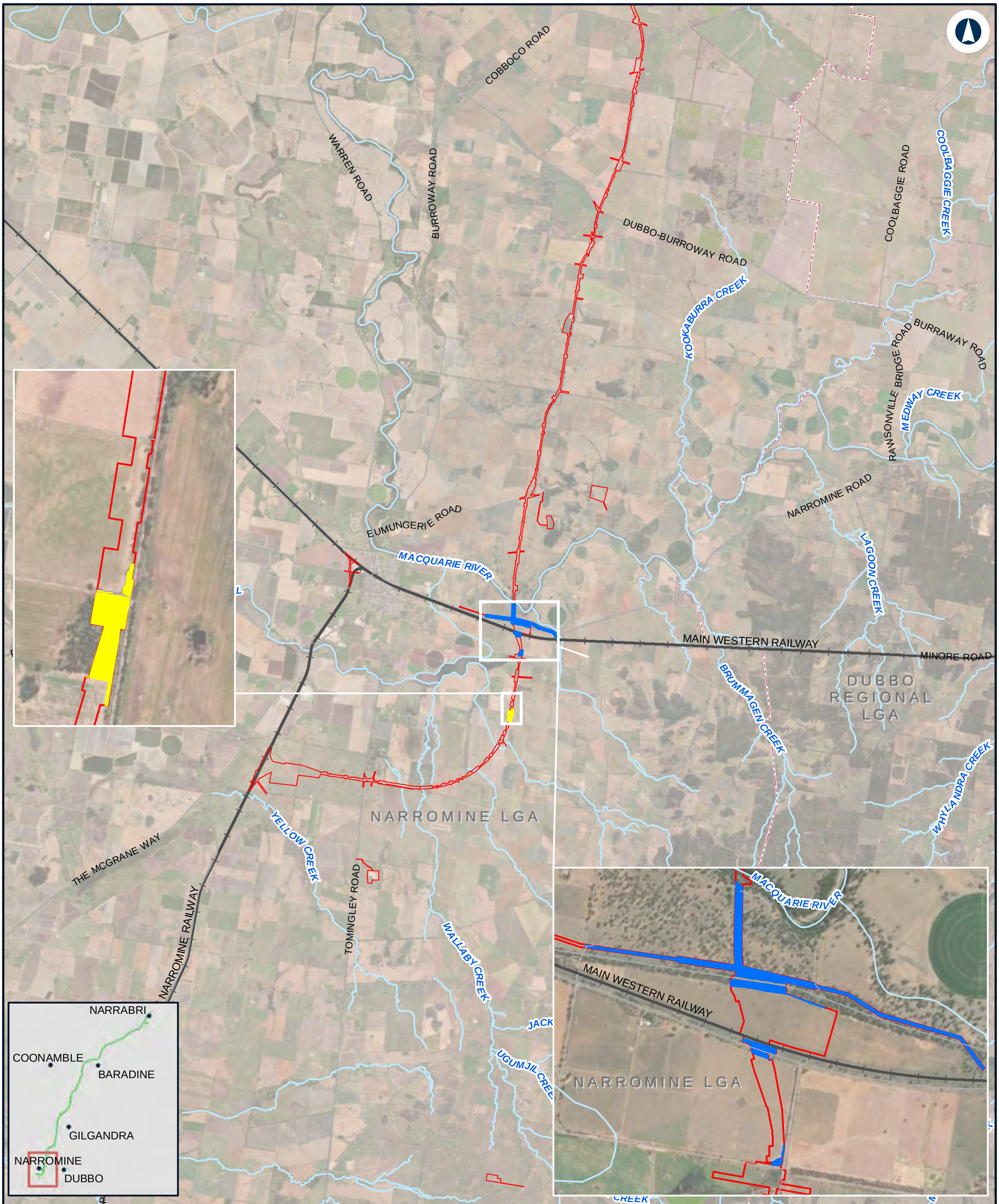
PCT ID	Plant Community Type	Subregions occurrence in CIZ	BAM-C listed TEC	TEC assessment
81	Western Grey Box – Cypress Pine grass shrub tall woodland in the Brigalow Belt South bioregion	Bogan- Macquarie	Not listed in BAM-C. Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	**Yes.** Although no TEC option is available to select in the BAM-C, this community occurs on the gently rising slope south of the Macquarie River. The canopy is mostly Inland Grey Box with scattered trees of Fuzzy Box and some regrowth White Cypress Pine in on the roadside corridor. Grades in to PCT 248 closer to the Macquarie River to the north and PCT 599 immediately to the south, which are both grassy woodlands. PCT 248 in the proposal site occurs in the Darling Riverine Plains IBRA region and Bogan-Macquarie IBRA subregion, which is not associated with this TEC in the final determination. Given the location of the patch near the edge of this subregion, and the appropriate species and physiographic location, a conservative approach has been taken and this PCT is considered to be Inland Grey Box Woodland. **Yes – EPBC Act listed community**. The listing advice for the community under the EPBC Act includes the Darling Riverine Plains IBRA region.
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good and DNG	Castlereagh-Barwon, Pilliga, Pilliga Outwash	Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	**No**. the occurrence of this PCT was dominated by open woodlands of Rosewood and Belah with some scattered occurrences of Wilga. The ground layer was heavily impacted by agricultural grazing in all sites and occurred on deep cracking clays with very friable soils. No Weeping Myall trees were observed within the CIZ or wider investigation corridor where this PCT occurred.
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – Good	Pilliga, Pilliga Outwash, Liverpool Plains	Artesian spring ecological community in the great artesian basin	**No**. The occurrence of this PCT is rising up out of major rivers and watercourses, including the Namoi River that have been subject to more intensive periods of grazing and farming practices. The occurrence of this PCT does not contain any evidence of natural springs and therefore does not form part of the TEC.
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) – Good	Pilliga	Fuzzy Box woodland on alluvial soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South bioregions	**Yes**. A patch of Fuzzy Box was observed in roadside vegetation which extended to private property where there was no access. PCT assumed to extend unto private property until change in elevation and soil type observed from extrapolated data.

PCT ID	Plant Community Type	Subregions occurrence in CIZ	BAM-C listed TEC	TEC assessment
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – Good and DNG	Castlereagh-Barwon, Pilliga	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	**No**. The occurrence of this community is dominated by Poplar Box in open grassy woodland with small dense patches of Poplar Box regrowth. The understorey is dominated by *Chloris* spp. There is no Brigalow within this PCT where it occurs in the CIZ or wider investigation corridor. **Yes – EPBC Act listed community**. Although this PCT is not BC Act listed TEC, it does meet the listing criteria for the Poplar Box grassy woodland community listed under the EPBC Act due to the dominance in the canopy of Poplar Box and the open grassy woodland structure with a forb rich ground layer.
248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW – Good	Bogan-Macquarie	Not listed in BAM-C. Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	**Yes.** Although no TEC option is available to select in the BAM-C, this community contains a wide mix of canopy species, including Inland Grey Box, Poplar Box and Fuzzy Box. It occurs on the rising alluvial plains south of the Macquarie River. The area within the CIZ is mostly Poplar Box, however, it is connected to a wider patch that extends to the crown reserve and roadside remnants that are dominated by Grey Box and meets the listing criteria for this community due to the dominance of Inland Grey Box. PCT 248 in the proposal site occurs in the Darling Riverine Plains IBRA region and Bogan-Macquarie IBRA subregion, which is not associated with this TEC in the final determination. Given the location of the patch near the edge of this subregion, and the appropriate species and physiographic location, a conservative approach has been taken and this PCT is considered to be Inland Grey Box Woodland. **Yes – EPBC Act listed community**. The listing advice for the community under the EPBC Act includes the Darling Riverine Plains IBRA region.
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – Good and DNG	Pilliga Outwash	White Box Yellow Box Blakely's Red Gum Woodland	**Yes.** The woodland and derived native grassland vegetation zones of this community occur as one continuous connected patch with the canopy dominated by White Box and White Cypress Pine and the groundcover dominated by native grassy species, including *Chloris truncata* and *Aristida* spp, *Rytidosperma* spp and *Austrostipa* spp.

PCT ID	Plant Community Type	Subregions occurrence in CIZ	BAM-C listed TEC	TEC assessment
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion – Moderate, logged	Pilliga Outwash	White Box Yellow Box Blakely’s Red Gum Woodland	**No.** The occurrence of this PCT is restricted to one small patch in a recently and heavily logged property. The canopy layer of White Box had been completely removed with felled trees left on the ground and the ground layer, including the soil, was heavily disturbed from tracked heavy machinery. Although the community extended further to the north, this had also been logged and was in very poor condition. The few remaining smaller White Cypress Pine and some scattered grasses are unlikely to still meet the listing criteria for this community due to a lack of canopy and groundcover structure and lack of connectivity to any remaining occurrence of this PCT in the wider study area.
599	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions – Good	Bogan-Macquarie	Not listed in BAM-C. But is White Box Yellow Box Blakely’s Red Gum Woodland	**Yes**. Although no TEC option is available to select in the BAM-C, this PCT is known to be associated with the White Box Yellow Box Blakely’s Red Gum Woodland. The canopy is dominated by Yellow Box and Blakley’s Red Gum with a forb rich understorey, including *Goodenia* spp, *Eryngium ovinum* and *Calotis lappulacea*. PCT 599 in the proposal site occurs in the Darling Riverine Plains IBRA region and Bogan-Macquarie IBRA subregion, which is not associated with this TEC in the BC Act final determination or EPBC listing advice. Given the location of the patch near the edge of this subregion, and the appropriate species and physiographic location, a conservative approach has been taken and this PCT is considered to be White Box Yellow Box Blakely’s Red Gum Woodland.
1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion – Good	Pilliga	Fuzzy Box woodland on alluvial soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South bioregions	**No**. This PCT occurs as one continuous patch within the Pilliga forests. it is dominated by White Cypress Pine and Buloke with scattered Narrow-leaved Ironbark. There is large stem count regrowth of Buloke and the ground layer is not grassy. No Fuzzy Box were observed in this patch or in adjoining vegetation patches to the north or south. Due to the lack of grassy understorey component and no Fuzzy Box within the CIZ or wider investigation corridor in this area, the occurrence of this PCT does not form part of this TEC.

Table 5.4 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	6.5
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	35	90	7.3
Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions	202	75	3.6
Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	248 81	80 78	16.3 0.9
White Box Yellow Box Blakely's Red Gum Woodland	599 435	80 58	3.0 5.4



NARROMINE TO NARRABRI

Threatened Ecological Communities

Figure 5.1 - MAP 1 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions
- White Box Yellow Box Blakelys Red Gum woodland

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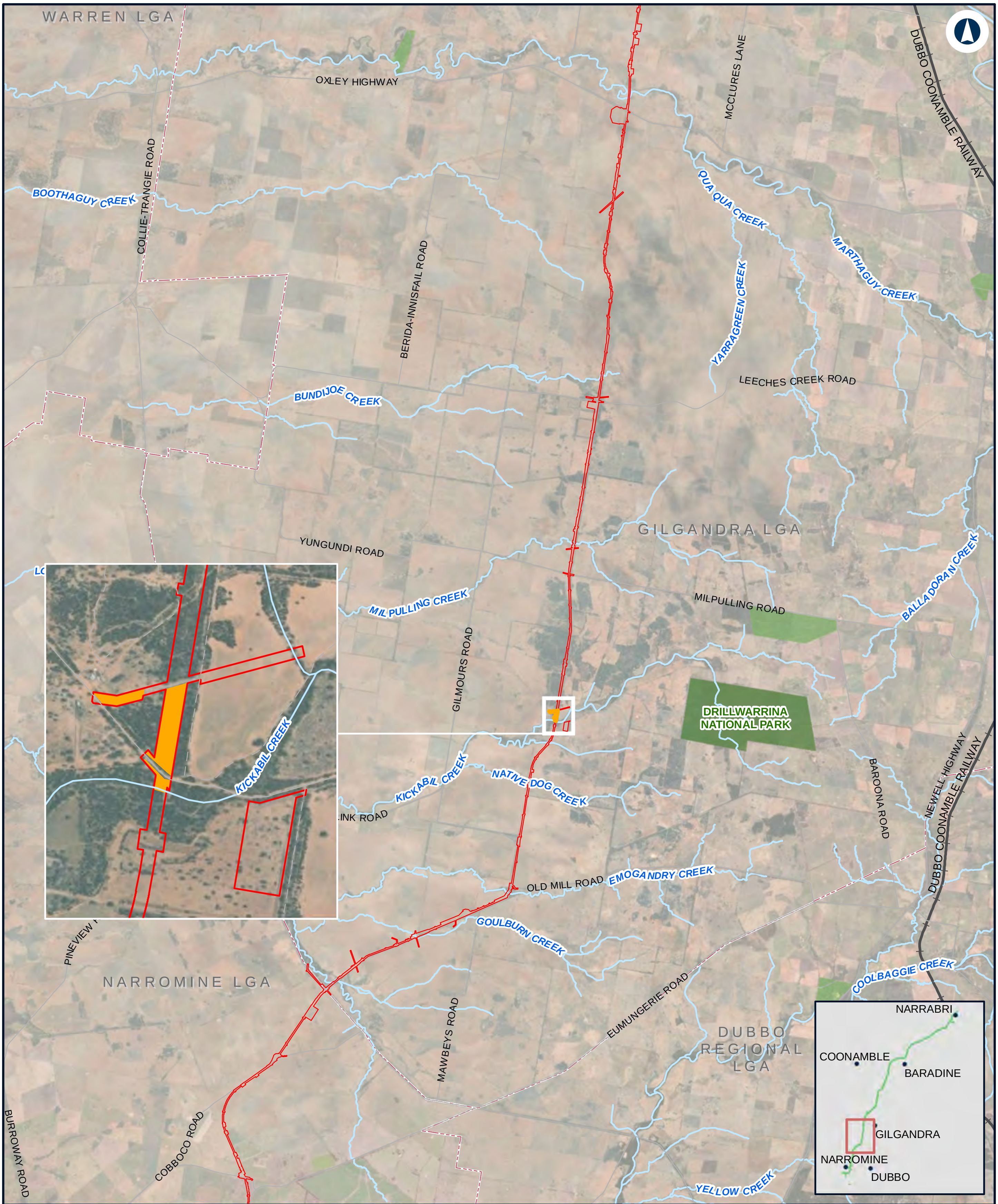

NARROMINE TO NARRABRI Threatened Ecological Communities Figure 5.1 - MAP 2 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions

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NARROMINE TO NARRABRI

Threatened Ecological Communities

Figure 5.1 - MAP 3 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21
Paper: A4
Author: JacobsGHD
Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions

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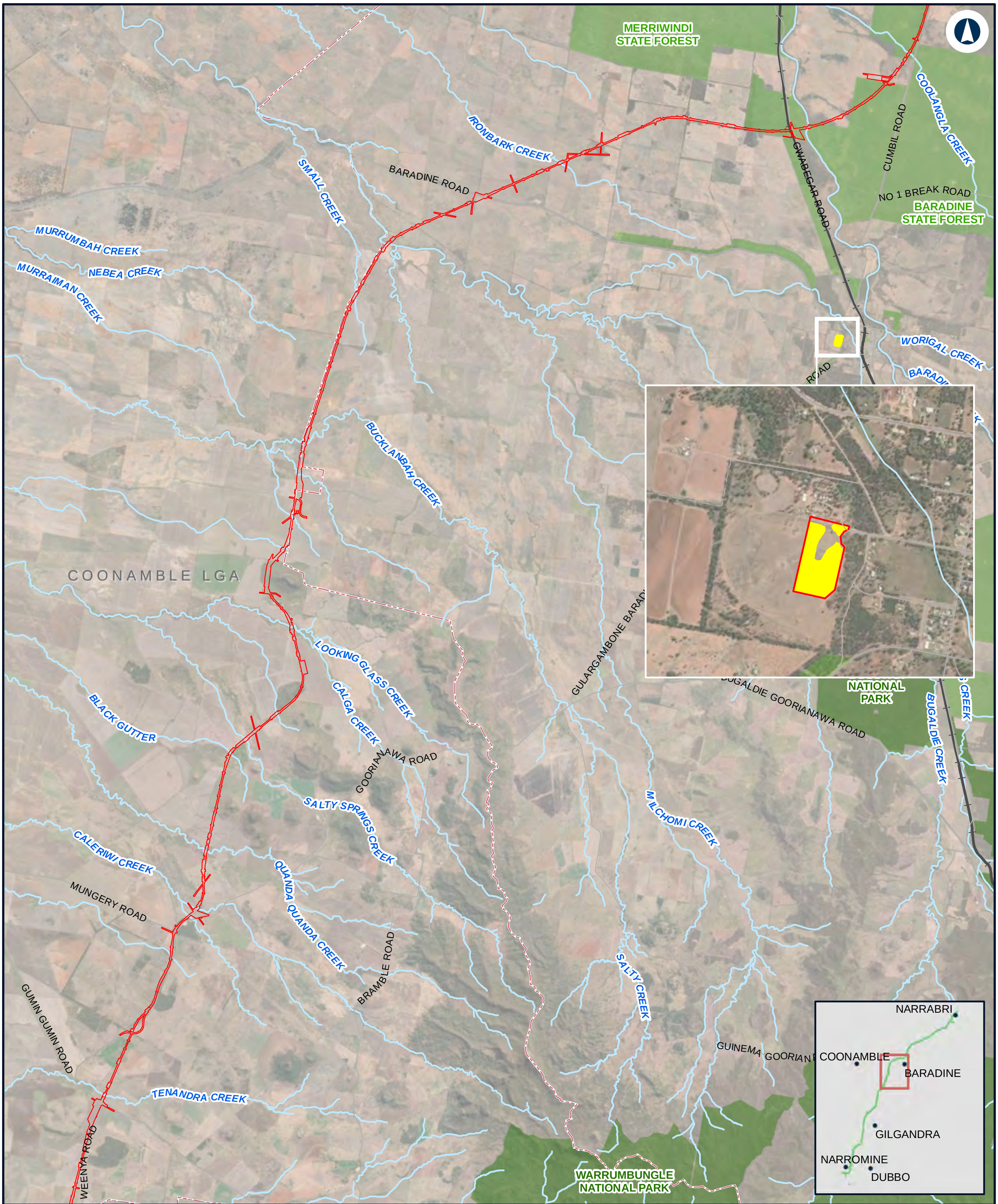

NARROMINE TO NARRABRI Threatened Ecological Communities Figure 5.1 - MAP 4 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- White Box Yellow Box Blakelys Red Gum woodland

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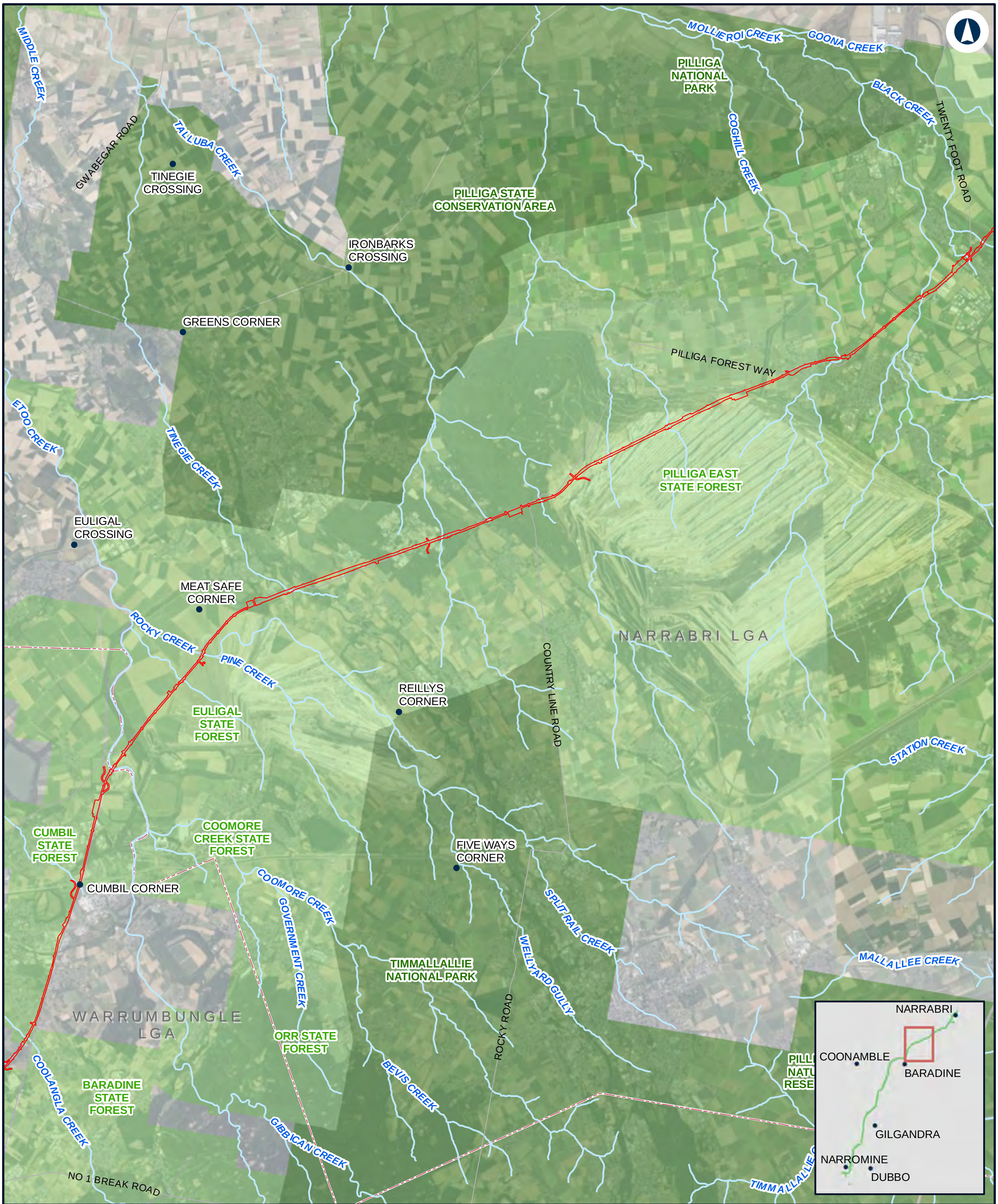

NARROMINE TO NARRABRI Threatened Ecological Communities

Figure 5.1 - MAP 5 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

LEGEND

Construction impact zone

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

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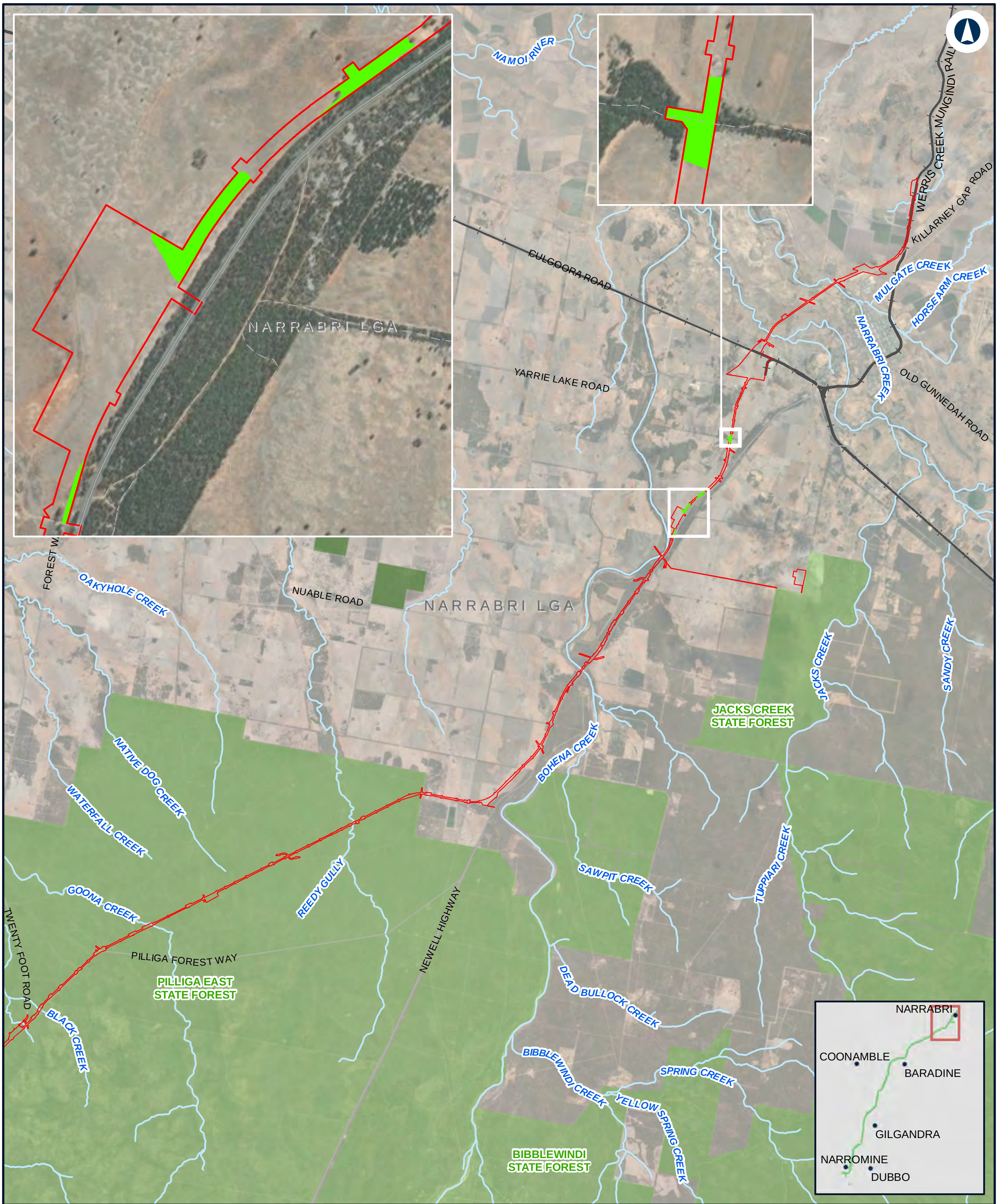

NARROMINE TO NARRABRI Threatened Ecological Communities Figure 5.1 - MAP 6 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions

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5.3 Flora species

A total of 599 species from 78 families were identified within the study area during field surveys, including 483 native species and 116 exotic species (Appendix E). The most species diverse families recorded were *Poaceae* (121 species), *Fabacaea* (61 species) and *Asteraceae* (62 species).

Four threatened flora species were identified within the study area during field surveys (see section 6.1).

5.4 Non-native vegetation

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

Other frequently recorded species within introduced grasslands 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 ferocissimum*)
- 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 Travelling stock reserves

Travelling stock reserves (TSRs) are parcels of Crown land originally reserved for the use of travelling stock (Local Land Services, 2015). The TSR network is now utilised for a series of purposes, including:

- travelling stock, emergency stock refuge and transport of stock to market
- providing biodiversity corridors
- providing access and connection to country for Aboriginal peoples
- maintaining cultural heritage.

The proposal crosses or passes close to several TSRs:

- Webbs Siding: Mitchell Highway near High Park Road, Narromine. This is a large reserve adjacent to the Macquarie River, vegetated predominantly with PCT 248 Mixed Box Woodland and PCT 36 along the river banks.
- Bugabada: Collie Road, Kickabil. This is a narrow, linear reserve alongside Collie Road, vegetated with PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland.
- Buramilong: Berida Road, Collie. This small reserve is predominantly vegetated with PCT 56 Poplar Box - Belah woodland.
- Callangoan, Terrabile. This is a narrow, linear reserve on the northern side of the Castlereagh River at Curban, vegetated with PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland.
- Newell Highway between The Pilliga and Narrabri West. This is a wide reserve following the Newell Highway, and is vegetated with PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland. PCT 148 Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland and PCT 473 Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest.
- Yarrie Lake Road, Narrabri West. This is a narrow, linear roadside strip that is predominantly cleared within the proposal site.

5.7 Groundwater dependent ecosystems

5.7.1 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).

5.7.2 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.

5.7.3 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.

5.7.4 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.

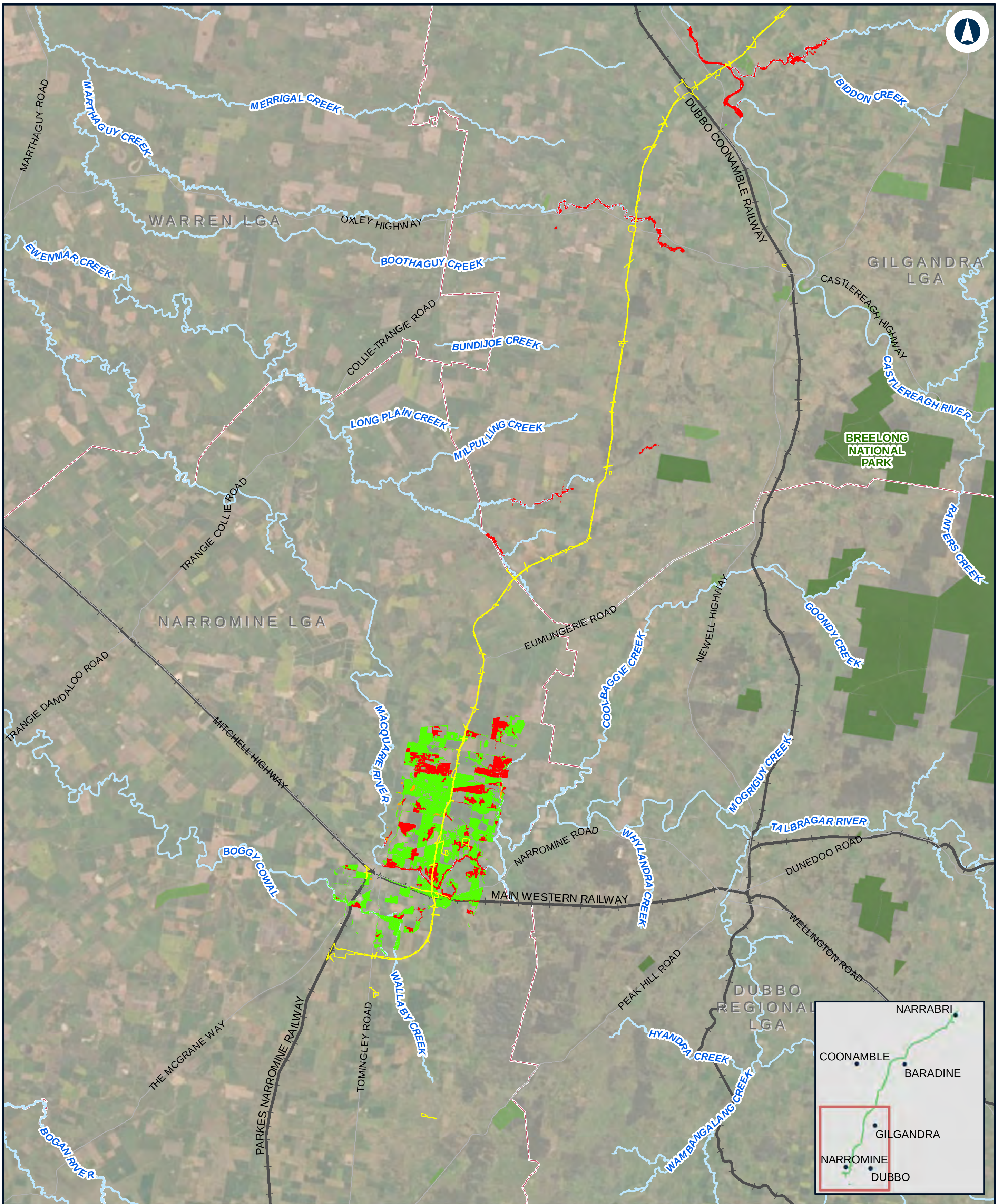
The Macquarie River, Castlereagh River and Namoi River are mapped as low potential aquatic GDEs. Larger creeks, including Bohena Creek, Mollieroi Creek, Etoo Creek, Baradine Creek, Teridgerie Creek, Marthaguy Creek, Kickabil Creek and Wallaby Creek are mapped as moderate potential aquatic GDEs.

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 forests 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 5.2 - MAP 1 of 3

0 7 14 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:500,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- High potential GDE - from regional studies
- Moderate potential GDE - from regional studies
- Low potential GDE - from regional studies

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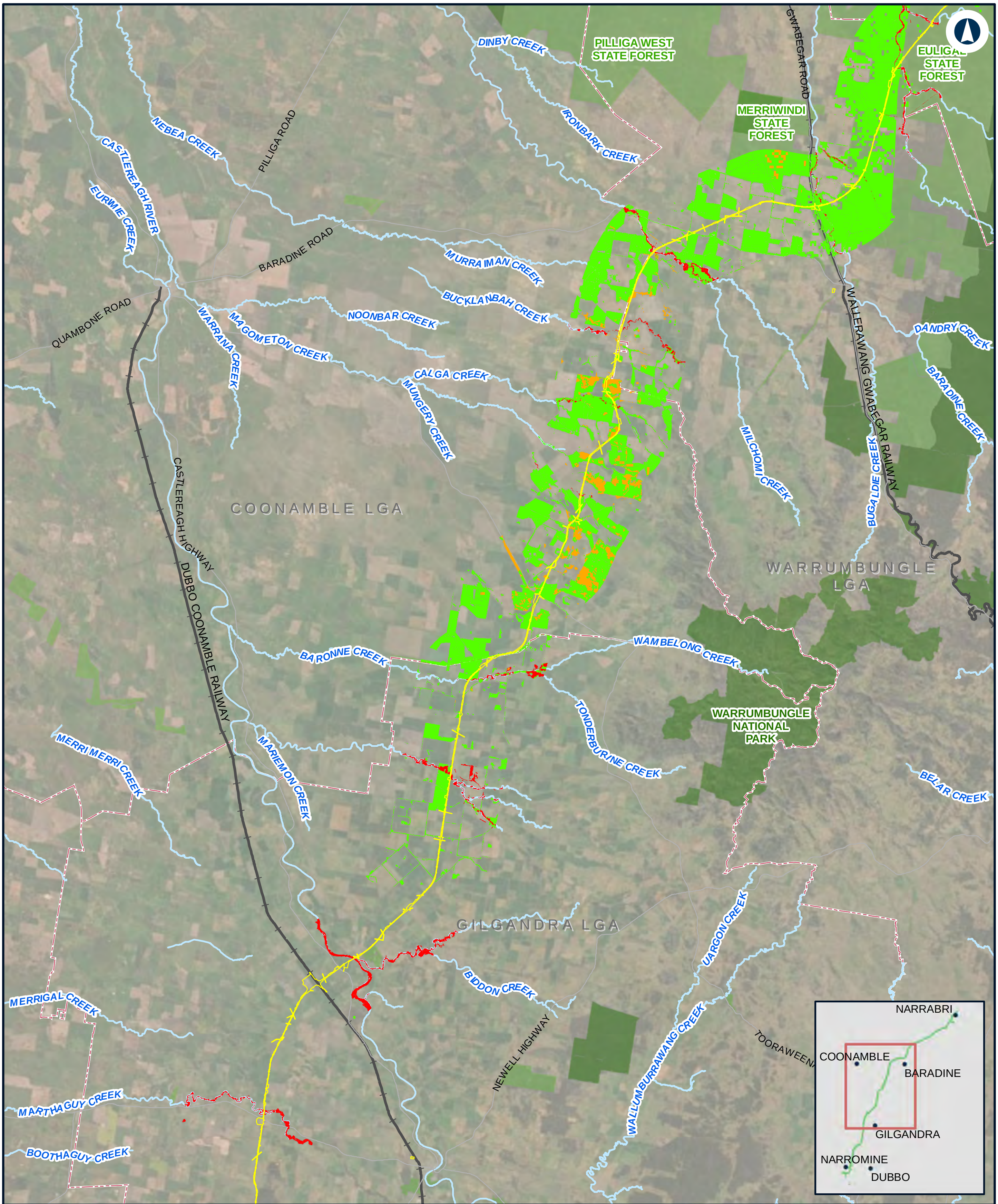

NARROMINE TO NARRABRI Terrestrial Groundwater Dependent Ecosystems Figure 5.2 - MAP 2 of 3

0 7 14 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-01 Paper: A4
Author: JacobsGHD Scale: 1:500,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- High potential GDE - from regional studies
- Moderate potential GDE - from regional studies
- Low potential GDE - from regional studies

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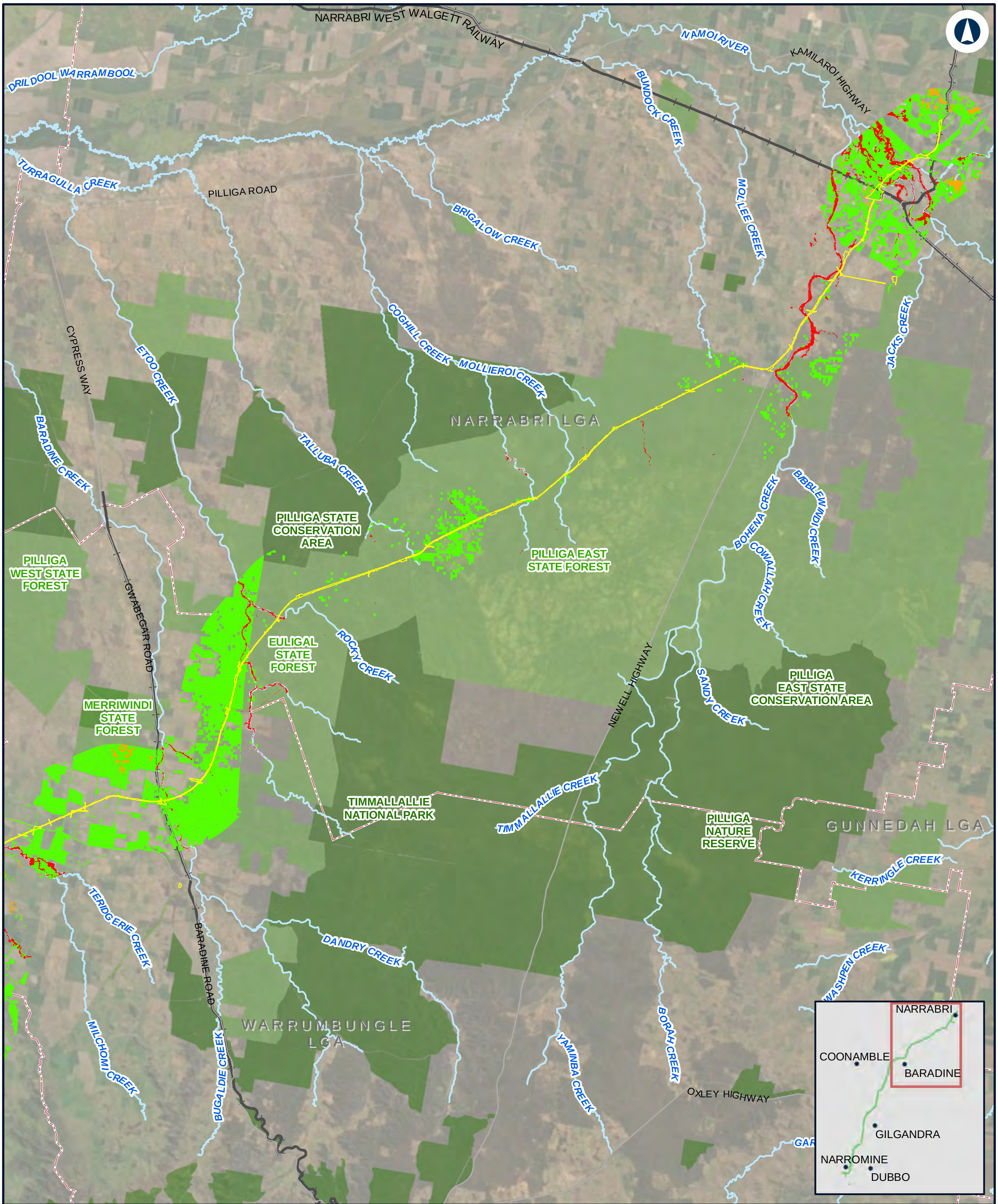

NARROMINE TO NARRABRI Terrestrial Groundwater Dependent Ecosystems Figure 5.2 - MAP 3 of 3

0 7 14
Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-01 Paper: A4
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- Low potential GDE - from regional studies

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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 (TBDC) 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 the BAM (DPIE 2020). The list of confirmed candidate threatened flora species is in Table 6.1. These species were subjected to targeted survey. Initial targeted flora surveys were conducted during drought conditions in 2018 and 2019. Supplementary targeted surveys were conducted in 2020 when increased rainfall and favourable survey conditions enabled suitable survey conditions for most candidate flora species. Additional surveys specifically targeting *Bertya opponens, Pomaderris queenslandica* and *Tylophora linearis* were undertaken in March 2022.

Four threatened flora species were recorded during targeted surveys (see Figure 6.1):

- *Pterostylis cobariensis* – about 499 individual plants recorded from the Pilliga forests (part Pilliga and Pilliga Outwash subregions)
- *Diuris tricolor* – about 28 individual plants recorded in the Pilliga forests (part Pilliga and Pilliga Outwash subregions)
- *Commersonia procumbens* – about 60 individuals were recorded on Pilliga Forest Way and adjacent drains (Pilliga subregion), adjacent to the proposal site
- *Tylophora linearis* – three individual plants recorded in the Pilliga forests (Pilliga subregion).

Commersonia procumbens could not be reliably excluded from occurring in surveyed areas. There are multiple records for this species in close proximity to the proposal site in the Pilliga, and individuals were recorded growing on Pilliga Forest Way in March 2022 (potentially responding to recent disturbance from grading). The PCTs, soil types and topography in the Pilliga provide good suitable potential habitat for the species, including the occurrence of known associated species. However, for positive identification, the species is required to be surveyed within one to two years of fire or disturbance. While targeted surveys for this species in the Pilliga included roadsides and earth windrows that are regularly disturbed, few plants were observed in these areas and no fires had occurred in the proposal site for at least five years. Therefore, a precautionary approach was adopted, and the species was assumed to be present in areas of suitable potential habitat in accordance with the TBDC and known PCTs (see Appendix B and Appendix I).

Due to the lack of access and some constraints to survey conditions despite repeated surveys outside drought conditions in 2020 some threatened flora species could not be excluded from occurring at the proposal site. Nine other species had targeted surveys completed in accessible areas of the proposal site but were not recorded. Where access was not possible and associated PCTs occur in the proposal site, species presence is assumed.

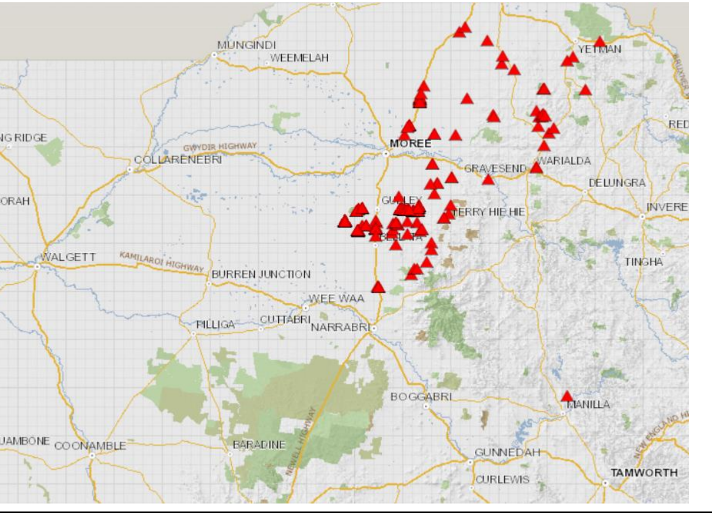
Several species could be reliably discounted as occurring within the study area based on the habitat types present and/or the known distribution of the species. Detailed justification for the exclusion of candidate species is provided in Appendix I and summarised in Table 6.1 and/or the 'habitat/constraints' fields in the credit calculator.

There is an existing record for Coolabah Bertya (*Bertya opponens*) near the Bohena Creek rest area in the proposal site. Targeted surveys for *Bertya opponens* have been conducted on multiple occasions within the recommended survey period (October 2018, March 2019, September 2020, October 2020, November 2020) with no observations of new or previous records. The previous record is for five plants (two seedlings and three juveniles) and occurs in the construction impact zone (CIZ). The location of the records is immediately adjacent to Bohena Creek rest area and is subject to informal camping and a network of frequently used motorbike tracks. Given the lack of evidence of the species at this location over multiple survey periods, it is presumed to no longer occur at Bohena Creek. This species was not observed in any other location, including during targeted surveys within the proposal site throughout the Pilliga forests. 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). A reference population in Jacks Creek State Forest was visited prior to March 2022 surveys. Visibility was high during all survey periods. Given the lack of evidence of this species during surveys, it is considered to be absent from the proposal site.

Table 6.1 Candidate flora species credit species summary justifications for survey and inclusion

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Bertya opponens Coolabah Bertya	Yes, one record of five plants near Bohena Creek in proposal site	No – surveyed.	**Surveys –** This species was known from adjacent to Bohena Creek Rest area on the Newell Highway within the proposal site (five individuals have been previously recorded). No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in October 2018, March 2019, September 2020, October 2020, November 2020 and March 2022 including at the location of the previous record at Bohena Creek. 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).
Commersonia procumbens	Yes. Recorded at multiple locations in the Pilliga	Yes – assumed presence (due to drought and lack of fire disturbance conditions) and records immediately adjacent to the proposal site.	**Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March 2019, September 2020, October 2018 and 2020, November 2020 and March 2022. Individuals were recorded growing on Pilliga Forest Way in March 2022, potentially following grading of the road. The species is likely to occur and drought conditions and lack of fire are likely to have been a large contributing factor to species absence during most surveys. The species is assumed present based on previous records, suitable potential habitat and discussions with BCS accountable officers.
Cyperus conicus	Yes. One record in northern Pilliga and north east of Narrabri	Yes – assumed presence for some areas. No – surveyed for some areas.	**Surveys –** No evidence of the species was recorded in small areas of limited suitable habitat areas surveyed in the proposal site in March 2019. One specimen of the *Cyperus* genus from near Narrabri was sent to the Royal Botanic Gardens for verification and the species was not *Cyperus conicus*. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further surveys are recommended in these areas pre-construction to further exclude species presence where possible.
Desmodium campylocaulon	No	No – no surveyed	**Habitat constraint –** In NSW grows on cracking black soils. **Geographic distribution and lack of suitable microhabitats** a small amount of suitable potential habitat occurs in grasslands and derived grasslands in the Northern Basalts subregion. It was not recorded in these grasslands in this subregion despite targeted survey effort. There are no suitable black clay soils on the edges of the Castlereagh Barwon subregion where the proposal clips the eastern edge of the subregion in a number of locations and the species was removed from this subregion based on a lack of suitable potential habitats.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Dichanthium setosum	Yes	Yes – assumed presence for some areas. No – surveyed for some areas.	**Habitat constraint –** usually associated with heavy basaltic black soils and red brown loams with clay subsoil. **Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in November 2020, March 2019 and November 2018. Some areas where the species was previously assumed to occur in 2019 were resurveyed in November 2020 and no individuals were recorded. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained.
Digitaria porrecta Finger Panic Grass	No	No – excluded	This species has been excluded as a candidate species due to there being no records within the locality. Records near Coonabarabran are over 25 years old and located over 30 kilometres to the east of the study area at the closest point. There are two records about 10 kilometres to the north-west of Narrabri located along road reserves. Suitable potential grassland areas in the Pilliga subregion and Castlereagh-Barwon subregions were heavily impacted by agricultural activities, including grazing and were therefore considered unsuitable. No species polygon prepared.
Diuris tricolor Pine Donkey Orchid	Yes. Recorded at multiple locations in the Pilliga	Yes – recorded. Yes – assumed presence for some areas. No – surveyed for some areas.	**Surveys –** This species was recorded in September and October 2020 in the Pilliga forests in the Pilliga and Pilliga Outwash subregions. All areas where the species was previously assumed to occur in 2019 were resurveyed in September and October 2020. Species polygons have been refined based on species observations in the spring 2020 survey period. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties between Narromine and Gilgandra and near Narrabri. Further surveys are recommended in these areas pre-construction to further exclude species presence where possible.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Homopholis belsonii Belsons Panic	No	No – surveyed in some locations No – excluded in some locations.	**Surveys –** Species habitat lies primarily in the north of the study area near Narrabri, with potential habitat in the area around Gilgandra. Vegetation communities with alluvial clay soils that have the potential to support the species are found within these areas. Potential habitat within the Northern Basalts and Liverpool Plains subregion is considered not likely to occur based on consultation with BCS species accountable officers. In addition, surveys in suitable grassland habitats in these subregions was conducted and the species was not recorded. 
Homoranthus darwinioides Fairy Bells	No	No – excluded	**Habitat constraint –** occurs on thin sandy soil on sandstone outcrops and sloping ridges. **Geographic distribution and lack of suitable microhabitats** Generally associated with ridges and slopes, mostly on sandstone. The proposal site traverses mostly flat and gently undulating plains and does not traverse any rocky ridges or hillsides. Known associated PCTs within the proposal site occur on flat plains or on mostly existing cleared and disturbed farming land that are existing and proposed borrow pit sites. Limited suitable potential habitat is present in the proposal site as outlined above, and the species was not recorded incidentally during other targeted species surveys and therefore no species polygon has been prepared.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Lepidium monoplocoides Winged Peppercress	Yes. Known from near Narrabri	Yes – assumed presence for some areas. No – surveyed for some areas	**Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in November 2019 and 2020. Some areas where the species was previously assumed to occur in 2019 were resurveyed in November 2020 and no individuals were recorded. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further surveys are recommended in these areas pre-construction to further exclude species presence where possible.
Lepidium aschersonii Spiny Peppercress	Yes. Multiple records from near Narrabri	Yes – assumed presence for some areas. No – surveyed for some areas.	**Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March 2019, October 2019 and 2020, September 2020 and November 2019 and 2020. Some areas where the species was previously assumed to occur in 2019 were resurveyed in November 2020 and no individuals were recorded. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further surveys are recommended in these areas pre-construction to further exclude species presence where possible.
Monotaxis macrophylla Large-leafed Monotaxis	No	No – excluded	**Habitat constraint –** Requires fire for germination and grows on rocky ridges and hillsides. **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 incidentally during other targeted species surveys, and therefore no species polygon has been prepared.

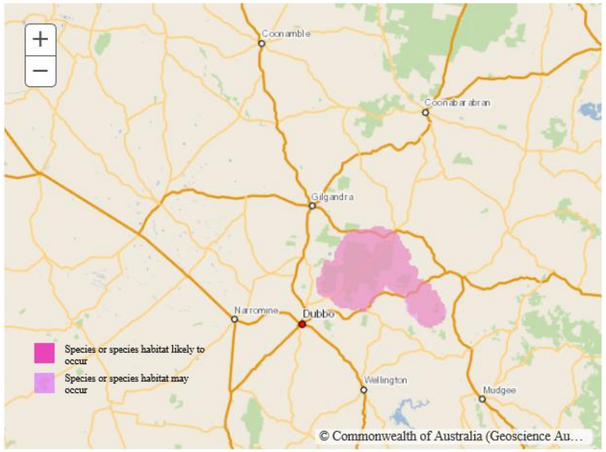
Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Platyzoma microphyllum Braid Fern	No	No – excluded	**Habitat constraint –** Occurs on sandy or swampy soils or in clay soils adjacent to streams and lagoons and subject to periodic flooding. **Geographic distribution and lack of suitable microhabitats** Species only known from the Yetman district near the Queensland border. No PCTs listed in the TBDC for this species occur in the proposal site. This species is predicted to occur in the Castlereagh-Barwon subregion but no potential habitats in sandy or swampy clay soils subject to periodic flooding occur in the proposal site. The nearest records are from about 200 kilometres to the north east of the proposal site. Field surveys using a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers were used to survey for other species. Threatened flora traverses did not identify this species incidentally during other targeted species surveys, therefore no species polygon has been prepared.
Polygala linariifolia Native Milkwort	Yes. Recorded at multiple locations in the Pilliga	No – surveyed for some areas. Yes – assumed presence for some areas.	**Surveys –** Although there are multiple records and suitable habitat within the Pilliga forests, no evidence of this species was recorded in suitable habitat areas surveyed in the proposal site in March 2019, October (2019 and 2020) and November 2020. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further seasonal surveys are recommended in these areas pre-construction to further exclude species presence where possible.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Pomaderris queenslandica Scant Pomaderris	No	No – surveyed for some areas. Yes – assumed presence for some areas.	Found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks. **Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in March 2019, September 2020, October 2018 and 2020, November 2020 and March 2022. **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 potential habitat 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 where accessible. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in some private properties near Narrabri. Further surveys may be undertaken pre-construction to further exclude species presence where possible.
Prasophyllum sp. *Wybong*	No	No – excluded	Commonwealth listed species only known to occur in open eucalypt woodland and grassland. **Geographic distribution** Species is predicted but not known from the Pilliga and Pilliga Outwash subregions. While there are a number of suitable potential PCTs present for this species, they are mostly restricted to more grassy open sites which are not common in the areas to be directly impacted in the Pilliga. In addition no other *Prasphyllum* species were recorded during targeted survey in appropriate survey seasons.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Pterostylis cobarensis Cobar Greenhood	Yes. Recorded at multiple locations in the Pilliga	Yes – recorded. Yes – assumed presence for some areas. No – surveyed for some areas.	**Surveys –** This species was recorded at multiple locations in the Pilliga forests in the Pilliga and Pilliga Outwash subregions during targeted surveys in October 2020 for the proposal. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further seasonal surveys recommended in these areas pre-construction to further exclude species presence where possible.
Senecio garlandii Woolly Ragwort	No	No – surveyed	**Surveys –** Suitable habitat restricted to PCT185 in borrow pit A. Occurrence of this PCT in the proposal site is mostly derived grassland with no rocky outcrops of sheltered slopes. Species not recorded and no species polygon prepared.
Sida rohlenae Shrub Sida	No	No – excluded	**Habitat constraint –** known from flood out areas, creek banks and at the base of rocky hills, which do not occur in the proposal site. **Geographic distribution and lack of suitable microhabitats** Known to grow on flood out areas, creek banks and at the base of rocky hills. Known only from Castlereagh-Barwon subregion where the proposal is on the western boundary of the subregion. Within this subregion, associated PCTs are 49, 56, 88 and 244 and these PCTs have been heavily impacted by past and ongoing agriculture, including clearing and cropping. Within this subregion creek banks were able to be surveyed and accessed during multiple survey months (eg Castlereagh River, Gulargambone Creek) and the species was not recorded. No flood out areas occur in the proposal site in the subregion. The proposal skirts the base of Mount Tenandra and some unnamed hills near Black Hollow on private property. Field surveys using a combination of vegetation integrity plots and threatened flora traverses with five metre increments between observers were used to survey for other species. Threatened flora traverses did not identify this species incidentally during targeted surveys for other species, therefore no species polygon has been prepared.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Swainsona murrayana Slender Darling Pea	Yes. Recorded from roadside reserves in the mid and southern segments	No – surveyed for some areas. Yes – assumed presence for some areas.	**Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in September 2020. Some areas where the species was previously assumed to occur in 2019 were resurveyed in September 2020 and no individuals were recorded. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further surveys recommended in these areas pre-construction to further exclude species presence where possible.
Swainsona plagiotropis Red Darling Pea	No	No – surveyed	**Habitat constraint –** Grassland in heavy red soils. **Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in September 2020. While other non-threatened *Swainsona* species were recorded in low numbers outside the Bogan-Macquarie subregion where this species is known to occur, this species was not recoded despite suitable survey conditions and targeted surveys across derived grasslands. **Geographic distribution –** Mainly known from the Murray Valley and south western plains of NSW mostly around Jerilderie. The nearest record to the proposal site is north west of Warren about 67 kilometres west of the proposal site. Suitable PCTs restricted to PCT49 in the Bogan-Macquarie subregion. The proposal in this subregion is at the western extent of this subregion near Narromine. No heavy red soils were recorded from this area and 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 in PCT 49 in September 2020 and the species was not recorded. Therefore, no species polygon has been prepared.
Swainsona sericea Silky Swainson-pea	No	No – surveyed for some areas. Yes – assumed presence for some areas.	Sometimes found in association with cypress-pines *Callitris* spp. but habitat on the plains is not well known. **Surveys –** No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site in September, October and November 2020. While other non-threatened *Swainsona* species were recorded in low numbers, this species was not recoded despite suitable survey conditions and targeted surveys across derived grasslands and woodland communities. 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.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
			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. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further seasonal surveys recommended in these areas pre-construction to further exclude species presence where possible.
Tylophora linearis	Yes. Recorded at multiple locations in the Pilliga	Yes – recorded in some areas. Yes – assumed presence for some areas. No – surveyed for some areas.	This species was recorded from three locations in the Pilliga forests in October 2020. Species polygon prepared. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in sections of the Pilliga where access has been difficult and some private properties near Narrabri. Further seasonal surveys are planned in some of these areas pre-construction to further exclude species presence where possible.

Common name Scientific name	BioNet records in locality	Presence	Survey and polygon justification
Zieria ingramii Keith's Zieria	No	Yes – assumed presence for some areas. No – surveyed for some areas.	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**: The species was not observed during targeted surveys in the Pilliga in September to October 2020 and November 2019 (see section 3.6). **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. Where appropriate survey was completed and the species was not recorded, the species polygon has been removed from those areas and for other areas where access was not possible, species polygon areas were retained. The species is assumed to occur in remote sections of the Pilliga where access has been difficult. Further seasonal surveys are planned in some of these areas pre-construction to further exclude species presence where possible.

6.1.2 Potential habitat for threatened flora

Three threatened flora species were recorded in the construction footprint, and one adjacent to the proposal site (Figure 6.1). An additional nine species are assumed to be present despite not being recorded based on recent and known records in the study area and locality, access constraints 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 244 fauna species were recorded during field surveys (Appendix F). This comprised 10 frog species, 37 reptile species, 163 bird species, and 45 mammal species (including up to 18 microbat species). Thirteen introduced species were recorded. Threatened and migratory fauna species recorded during surveys are detailed in Table 6.2 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 6.2 Threatened and migratory fauna species recorded during surveys

Common name	Scientific name	BC Act	EPBC Act	Credit type	SAII
Barking Owl	*Ninox strenua*	V	-	Species (breeding)/ Ecosystem	No
Black Falcon	*Falco subniger*	V	-	Ecosystem	No
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis*	V	-	Ecosystem	No
Brown Treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	V	-	Ecosystem	No
Dusky Woodswallow	*Artamus cyanopterus cyanopterus*	V	-	Ecosystem	No
Flame Robin	*Petroica phoenicea*	V	-	Ecosystem	No
Fork-tailed Swift	*Apus pacificus*		M	NA	NA
Glossy Black-cockatoo	*Calyptorhynchus lathami*	V	V	Species (breeding)/ Ecosystem	No

Common name	Scientific name	BC Act	EPBC Act	Credit type	SAII
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis*	V	-	Ecosystem	No
Little Eagle	*Hieraaetus morphnoides*	V	-	Species (breeding)/ Ecosystem	No
Rufous Fantail	*Rhipidura rufifrons*		M	NA	NA
Speckled Warbler	*Chthonicola sagittata*	V	-	Ecosystem	No
Spotted Harrier	*Circus assimilis*	V	-	Ecosystem	No
Superb Parrot	*Polytelis swainsonii*	V	V	Species (breeding)/ Ecosystem	No
Turquoise Parrot	*Neophema pulchella*	V		Ecosystem	No
Varied Sittella	*Daphoenositta chrysoptera*	V	-	Ecosystem	No
White-throated Needletail	*Hirundapus caudacutus*	-	V, M	NA	NA
Corben's Long-eared Bat	*Nyctophilus corbeni*	V	V	Ecosystem	No
Large Bent-winged Bat	*Miniopterus orianae oceanensis*	V	-	Species(breeding) /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*	E	E	Species	No
Rufous Bettong	*Aepyprymnus rufescens*	V		Species	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 6.3. 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 6.3 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. • Five-clawed Worm-skink – not recorded, but may occur in the Narrabri area.	• Little Eagle – would forage over agricultural land. • Square-tailed Kite – not observed during surveys, but could forage over agricultural land. • Squirrel Glider – recorded in Pilliga. Could use these habitats in the Narrabri area.
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.	• 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.	• 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 areas.

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
	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.	• 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.	
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.	• 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.	• 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 – possible diggings and tracks recorded, 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
	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. 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).	• Painted Honeyeater – known to occur. • Swift Parrot – may occur on rare occasions. • Regent Honeyeater – may occur on rare occasions.	• Large-eared Pied Bat – probable record at Trap site 5. No caves, scarps, cliffs, rock overhangs and disused mines located within two kilometres of the alignment in the Pilliga. • Bush Stone-curlew – occasional scattered records known from the Pilliga. • Barking Owl – two probable records during surveys in the Pilliga, which contains the largest population of the species in NSW. • Masked Owl – occasional scattered records known from the Pilliga. • Little Eagle – occasional scattered records known from the Pilliga. • Square-tailed Kite – 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
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	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	• 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.	• Barking Owl – Two probable records at Etoo Creek and Rocky Creek. 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

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
	are dependent on the grassy or grass/shrub mosaic understory to forage or nest. Creek line vegetation has been subject to less logging and grazing, but moderate fire impacts (Date et al 2002).	• Painted Honeyeater – known to occur. • Swift Parrot – may occur on rare occasions. • Regent Honeyeater – may occur on rare occasions.	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 two kilometres of the alignment in the Pilliga. • Pale-headed Snake – one individual recorded on Cumbil Forest Road on a warm evening after rain.
Rivers and associated riparian vegetation	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.	• Grey-crowned Babbler – recorded at the Castlereagh River. • Eastern Bentwing Bat – probable record at the Macquarie River and Castlereagh River.	• 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.

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
 Macquarie River, Narromine	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.	• 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.	• 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.
Creeks and associated riparian vegetation in agricultural land	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.	• 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.

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
 Ewenmar Creek	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.		• 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
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 forests. 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.
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 by landowners. Rocky area of low topographic relief occurs 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 6.4. For each confirmed predicted threatened species, the vegetation zone association is provided in Appendix K. Species that are not confirmed predicted species for various subregions are identified in Table 6.5. The proposal site is considered to be outside the usual distribution of four of these species, and one species in considered extinct in the area.

Table 6.4 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	Yes
Black Falcon	*Falco subniger*	Moderate	Yes
Black-breasted Buzzard	*Hamirostra melanosternon*	Moderate	
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus 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*	Moderate	Yes
Eastern Grass Owl	*Tyto longimembris*	Moderate	
Eastern Osprey	*Pandion cristatus*	Moderate	
Five-clawed Worm-skink	*Anomalopus mackayi*	High	
Flame Robin	*Petroica phoenicea*	Moderate	Yes
Flock Bronzewing	*Phaps histrionica*	High	
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*	Moderate	Yes
Grey-headed Flying-fox	*Pteropus poliocephalus*	High	
Hall's Babbler	*Pomatostomus halli*	Moderate	
Hooded Robin (south-eastern form)	*Melanodryas cucullata*	Moderate	
Koala	*Phascolarctos cinereus*	High	Yes

Common name	Scientific name	Sensitivity to gain	Recorded on site during surveys?
Kultarr	*Antechinomys laniger*	High	
Large Bent-winged Bat	*Miniopterus orianae oceanensis*	High	Yes
Little Eagle	*Hieraaetus morphnoides*	Moderate	Yes
Little Lorikeet	*Glossopsitta pusilla*	High	
Little Pied Bat	*Chalinolobus picatus*	High	Yes
Magpie Goose	*Anseranas semipalmata*	Moderate	
Malleefowl	*Leipoa ocellata*	High	
Major Mitchell's Cockatoo	*Lophochroa leadbeateri*	Moderate	
Masked Owl	*Tyto novaehollandiae*	High	
Northern Free-tailed Bat	*Ozimops lumsdenae*	Moderate	
Painted Honeyeater	*Grantiella picta*	Moderate	
Pied Honeyeater	*Certhionyx variegatus*	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	Yes
Varied Sittella	*Daphoenositta chrysoptera*	Moderate	Yes
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	High	
White-fronted Chat	*Epthianura albifrons*	Moderate	
White-throated Needletail	*Hirundapus caudacutus*	High	Yes
Woma	*Aspidites ramsayi*	Moderate	
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	High	Yes

Table 6.5 Predicted threatened fauna species not considered to be present in the proposal site (by IBRA subregion)

Common name	Inland Slopes	Bogan Macquarie	Castlereagh-Barwon	Pilliga	Pilliga Outwash	Liverpool Plains	Northern Basalts
Brown Treecreeper *Climacteris picumnus victoriae*	Not in BAM-C	Geographic constraint – proposal site not located east of the Newell Highway	Not in BAM-C	NA	Not in BAM-C	NA	Not in BAM-C
Eastern Osprey *Pandion cristatus*	Not in BAM-C	Vagrant – outside usual range	Not in BAM-C	Not in BAM-C	Not in BAM-C	Not in BAM-C	Not in BAM-C
Glossy Black-cockatoo *Calyptorhynchus lathami*	Habitat constraints: no Allocasuarina or Casuarina species	NA	NA	NA	NA	NA	NA
Powerful Owl *Ninox strenua*	Not in BAM-C	Not in BAM-C	Not in BAM-C	Vagrant – outside usual range	Not in BAM-C	Vagrant – outside usual range	Not in BAM-C
Red-tailed Black-cockatoo *Calyptorhynchus banksii samueli*	Not in BAM-C	Geographic constraint – proposal site located south of Nyngan	NA	Not in BAM-C	Not in BAM-C	Not in BAM-C	Not in BAM-C
White-bellied Sea-eagle *Haliaeetus leucogaster*	Habitat constraints: no waterbodies or rivers	NA	NA	NA	NA	NA	NA

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 the BAM (DPIE 2020). The list of confirmed candidate threatened species is presented in Table 6.6; 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 Appendix I, with a summary provided in Table 6.7. The 'habitat/constraints' fields in the credit calculator has been updated where relevant.

Table 6.6 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
Australian Bustard *Ardeotis australis*	Yes. 5 records within 20 kilometres (OEH 2020a)	All year (**Mar, Jun, Jul, Aug, Sep, Oct, Nov**)	No – surveyed (all IBRA subregions)/ vagrant	No evidence of the species was recorded over multiple field surveys between September 2018 and August 2021. Birdlife International (2021) maps the distribution as being north-west of the Pilliga and Nyngan, and curving south to Mildura and Hay and into western Victoria. There were no local records prior to the main surveys being undertaken (EES 2020a/ Birdlife Australia 2020a), however three birds (two males and 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 kilometres west of the study area), and one individual at Eulah Creek in 2006 (about 15 kilometres east of Narrabri) (Birdlife Australia 2020). 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 extirpated in the Pilliga area (Date et al 2002).

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Bush Stone-curlew *Burhinus grallarius*	Yes. 15 records in the locality, mainly in the Pilliga-Narrabri area.	All year (**Mar, Jun, Jul, Aug, Sep, Oct, Nov**)	Yes – surveyed Bogan-Macquarie, Castlereagh Barwon, Pilliga, Pilliga Outwash, Liverpool Plains)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site. However, the species is likely to occur in low densities. This species is assumed present in areas not surveyed based on previous records and presence of suitable potential habitat.
			No – surveyed (Northern Basalts)	No suitable habitat present
			Not in BAM-C case (Inland Slopes)	No suitable habitat present
Eastern Osprey *Pandion cristatus*	No.	April – November (**Aug, Sep, Oct, Nov**)	No – surveyed (Bogan-Macquarie)	No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site near Narromine. No stick nests were observed in riparian areas. This species is predominantly a coastal species, with few records inland.
Glossy Black-cockatoo *Calyptorhynchus lathami*	Yes. 180 records in the locality, mainly in the Pilliga-Narrabri area.	January - September (**Mar**, **Jun, Jul, Aug, Sep**, Oct, Nov)	Yes – surveyed (Pilliga, Pilliga Outwash, Castlereagh-Barwon)	This species was recorded at a number of locations during surveys in the Pilliga and Narrabri areas, although no nest trees were recorded. As noted in the TBDC, larger patches and more intact landscapes are required for breeding. Glossy Black-cockatoos tend to nest in the same areas as other nesting pairs. Because pairs prefer to nest close to one another, areas with a relatively high density of suitable nest hollows will be favoured for nesting (Cameron 2006). Nest trees are assumed present based on suitable potential habitat in the Pilliga and Bohena Creek area, and larger forested areas on private land near Gilgandra.
			No – surveyed (Inland Slopes, Bogan-Macquarie , Liverpool Plains, Northern Basalts)	No Glossy Black-cockatoos were recorded outside the Pilliga/Narrabri area during any of the many surveys conducted for the proposal, including surveys during the breeding season. As noted in the TBDC, larger patches and more intact landscapes are required for breeding. Given the lack of evidence of the species in these areas during surveys, and generally fragmented habitat, no breeding habitat is considered present.

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Square-tailed Kite *Lophoictinia isura*	Yes. 26 records in the locality, mainly in the Pilliga-Narrabri area.	September – January (Mar, Jun, Jul, Aug, **Sep, Oct, Nov**)	Yes – expert report (Bogan-Macquarie, Castlereagh-Barwon, Pilliga, -Pilliga Outwash, Liverpool Plains, Northern Basalts)	No individuals were recorded during surveys, however large areas of suitable habitat are present in these IBRA subregions. An expert report was prepared by Dr Tony Saunders for this species. Based on the locations of potential breeding habitat along the proposal site and the distance between adjacent breeding pairs found in the literature, it was estimated that up to 61 breeding pairs of Little Eagle may occur along the proposal site. At least sixteen of these are likely to occur within the 80 kilometres long Pilliga forests section of the proposal site, but there may be more as some adjacent nests can be less than 5 kilometres from each other.
			Not in BAM-C case (Inland Slopes)	No suitable habitat is present within the CIZ in the Inland Slopes or Northern Basalts IBRA subregion. No individuals were observed in this area. No potential raptor nests observed in these areas.
Barking Owl *Ninox connivens*	Yes. 333 records in the locality, mainly in the Pilliga.	May – December (Mar, **Jul, Aug, Sep, Oct, Nov**)	Yes – surveyed (Pilliga, Pilliga Outwash) Yes – surveyed/ assumed present (Bogan-Macquarie, Castlereagh-Barwon, Liverpool Plains)	Two likely Barking Owls were recorded in the Pilliga forests during surveys, one at Etoo Creek (Pilliga Outwash IBRA subregion) and one at Rocky Creek (Pilliga IBRA subregion). The Pilliga is known to support a large population of this species. The species is likely to occur elsewhere and drought conditions are likely to have been a large contributing factor to species absence. Nest trees are assumed present at various creeklines in the identified subregions based on previous records and presence of suitable potential habitat.
			Not in BAM-C case (Inland Slopes, Northern Basalts)	No suitable breeding habitat is present within the CIZ in the Inland Slopes IBRA subregion.

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Masked Owl *Tyto novaehollandiae*	Yes. 8 records in the Pilliga area.	May – August (Mar, **Jul, Aug**, Sep, Oct, Nov)	Yes – surveyed/ assumed present (Castlereagh-Barwon, Pilliga, Pilliga Outwash)	Known from the Pilliga and scattered records near Kickabil. 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 habitat, and the species likely abundance in the area.
			No – surveyed (Bogan-Macquarie, Liverpool Plains)	No evidence of the species was recorded during surveys in suitable habitat areas surveyed in the Bogan-Macquarie or Liverpool Plains IBRA subregions.
			Not in BAM-C case (Inland Slopes, Northern Basalts)	No suitable breeding habitat is present within the CIZ in the Inland Slopes IBRA subregion.
Little Eagle *Hieraaetus morphnoides*	Yes. 31 records in the locality, scattered along the alignment.	August – October (Mar, Jun, Jul, **Aug, Sep, Oct**, Nov)	Yes – expert report (Bogan-Macquarie, Castlereagh-Barwon, Pilliga, -Pilliga Outwash, Liverpool Plains, Northern Basalts)	No individuals were recorded during surveys, however large areas of suitable habitat are present in these IBRA subregions. An expert report was prepared by Dr Tony Saunders for this species. Based on the locations of potential breeding habitat along the proposal site and the distance between adjacent breeding pairs found in the literature, it is estimated that up to 52 breeding pairs of Square-tailed Kite may occur along the proposal site. At least twelve of these are likely to occur within the 80 kilometres long Pilliga forests section of the proposal site, but there may be more as some adjacent nests can be less than 7 kilometres from each other.
			Not in BAM-C case (Inland Slopes)	No suitable habitat is present within the CIZ in the Inland Slopes IBRA subregion. No individuals were observed in this area. No possible raptor nests observed in this area.
Red-backed Button-quail *Turnix maculosus*	None	All year (**Mar**, **Jun**, **Aug**, **Sep**, **Oct**, **Nov)**	No – surveyed/vagrant (Bogan-Macquarie) Not in BAM-C case (all other subregions)	No evidence of the species was recorded during surveys. The Red-backed Button-quail is recorded only infrequently in NSW, with most records from the NSW North Coast. Very rarely occurs inland and is highly unlikely to occur in the proposal site. There are historical records south as far as Sydney and three outlying records from western NSW (a breeding record from Finley in 1954; the Macquarie Marshes in 1955; and Coolabah in 2000).

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Squatter Pigeon *Geophaps scripta*	None	All year (**Mar**, **Jun, Aug, Sep, Oct**, **Nov**)	No – surveyed/vagrant (Bogan-Macquarie, Castlereagh Barwon) Not in BAM-C case (all other subregions)	No evidence of the species was recorded during surveys. This species was previously considered extinct in NSW, however, there have been recent sightings on the border of NSW and Queensland. Records of the species are concentrated on the northwestern slopes, Bourke and Cobar, near Louth west of White Cliffs, and 150 kilometres NNE of Broken Hill (Higgins and Davies 1996). Since 1975 there have only been nine records of the Squatter Pigeon in NSW (Morris 1993). Recent records are all located on the Queensland border north-east of Moree (EES 2021). It is highly unlikely to occur in the proposal site.
White-bellied Sea-Eagle *Haliaeetus leucogaster*	Yes. 6 records in the locality.	Jul – Dec (Mar, Jun, **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.
Eastern Pygmy-possum *Cercartetus nanus*	Yes. 11 records in the locality, predominantly from the Pilliga-Narrabri area.	Oct – Mar (**Mar,** Jul, Aug, Sep, **Oct, Nov**)	Yes – surveyed/assumed present (Pilliga, Pilliga Outwash, Liverpool Plains)	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 in areas with a high degree of connectivity (ie the Pilliga forests) based on previous records, suitable potential habitat and discussions with BCS accountable officers.
			Not in BAM-C case (Inland Slopes, Bogan-Macquarie, Castlereagh Barwon, Northern Basalts)	No suitable habitat present or outside species distribution

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Koala *Phascolarctos cinereus*	Yes. 633 records in the locality, predominantly from the Pilliga-Narrabri area.	All year (**Mar, Jun, Jul, Aug, Sep, Oct, Nov**)	Yes – expert report (Castlereagh-Barwon, Pilliga, Pilliga Outwash, Liverpool Plains)	Surveys for the Koala were undertaken at various locations along the proposal site between 2018 and 2022. Survey methods included scat searches, diurnal surveys, spotlighting, call playback and use of remote cameras. Scats were recorded at Coolangala Creek and Etoo Creek only. Thermal drone surveys conducted in the Pilliga in July 2021 recorded one Koala near Baradine Creek in the Pilliga forest. A separate field survey was conducted by Koala expert Dr Steve Phillips in August 2021 to build on this previous work. During this survey of 34 sites along the proposal site Koala scats were recorded in one located north-west of Gilgandra. Dr Steve Phillips has prepared an expert report in accordance with the BAM (see Appendix N). Dr Steve Phillips undertook a review of PCT associations and preferred Koala feed trees to identify potentially suitable habitat for the Koala in the study area. This identified up to 1422.63 hectares of potentially suitable habitat in the proposal site. Of this, only 5.77 ha contains primary Koala habitat (ie habitat dominated by preferred feed trees), and 105.66 hectares contains secondary class A Koala habitat (habitat where preferred feed trees are subdominant). A review of Koala records was used to identify areas of generational persistence along the N2N alignment (ie. habitat supporting breeding populations). Three areas of Koala generational persistence were apparent in the study area, two located around the area of Baradine and Etoo Creeks in the Pilliga, the third located to the southwest of Narrabri at the northern end of the Pilliga. This includes the locations where Koalas were recorded by JacobsGHD and the thermal drone surveys. There is a paucity of Koala records between Narromine and Baradine, which is supported by the recording of scats at only one location to the north-west of Gilgandra. The area of suitable Koala habitat was refined for the species polygon based on the areas of generational persistence and positive survey locations, as these are locations where populations have been recorded in the proposal site. Areas of derived native grassland and other unsuitable habitat areas have been excluded. A final species polygon area of 260.44 ha has been mapped.

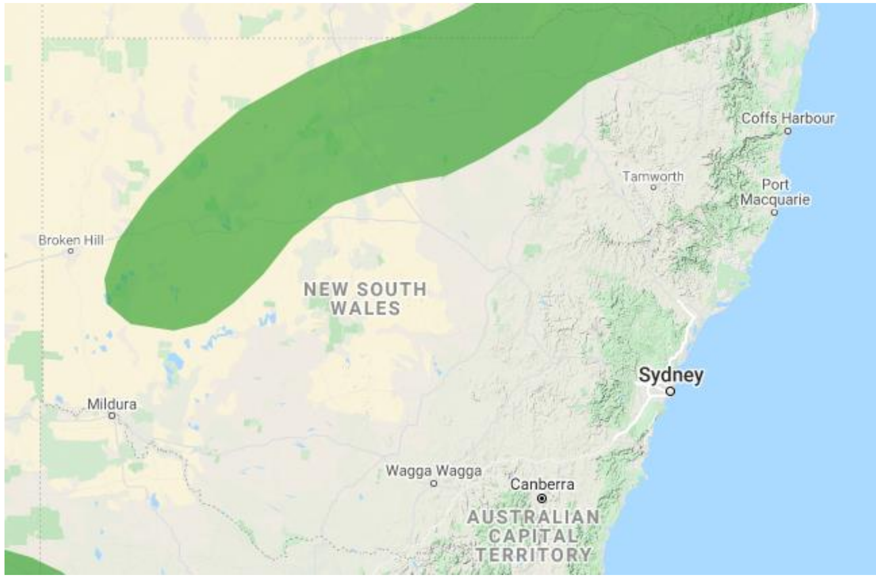
Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
			No – expert report (Bogan-Macquarie, Inland Slopes)	While potentially suitable Koala habitat is present, there was no evidence during surveys by JacobsGHD or the Koala expert. As described above, a review of generational persistence within areas of potentially suitable habitat was undertaken. Areas with no evidence of Koala breeding populations have been excluded from the species polygon. Further deail is provided in the expert report prepared by Dr Steve Phillips (see Appendix N).
			Not in BAM-C case (Northern Basalts)	No suitable habitat in CIZ.
Rufous Bettong *Aepyprymnus rufescens*	Yes. 3 records in the Pilliga.	All year (**Mar**, **Jul, Aug, Sep, Oct**, **Nov**)	Yes – surveyed/ assumed present (Pilliga, Pilliga Outwash)	Possible diggings of the Rufous Bettong were recorded in sandy soils in the north of the Pilliga in March 2022. A number of conical and larger diggings were recorded at this location, as well as possible footprints. Triggs (1996) notes that on softer soils diggings are often larger and less well defined, and that sometimes a number of holes can be found together as the Rufous Bettong digs up large areas of ground when searching for beetle larvae. No evidence of the species was recorded in suitable habitat areas surveyed in the proposal site via remote cameras and spotlighting. The species is likely to occur and its low densities and cryptic nature (small nocturnal species) are likely to have been a large contributing factor to lack of definitive evidence during surveys. The species is assumed present throughout much of the Pilliga forests based on previous records and presence of suitable potential habitat and discussions with the BCS accountable officer.
			Not in BAM-C case (Inland Slopes, Bogan-Macquarie, Castlereagh-Barwon, Liverpool Plains, Northern Basalts)	No habitat is considered present in areas outside the Pilliga forests given this species is highly susceptible to fragmentation and predation by feral predators, and lack of connectivity with areas of potential habitat. This was confirmed by the BCS accountable officer for the species.

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Squirrel Glider *Petaurus norfolcensis*	Yes. 22 records in the locality, predominantly from the Pilliga-Narrabri area.	All year (**Mar, Jul, Aug, Sep, Oct, Nov**)	Yes – surveyed (Pilliga) Yes – surveyed/ assumed present (Pilliga Outwash, Liverpool Plains) Not in BAM-C case (Inland Slopes, Bogan-Macquarie, Castlereagh-Barwon, Northern Basalts)	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 to occur throughout the Pilliga, and may also occur within roadside remnants, riparian vegetation and patches in agricultural land. Outside known range, lack of connectivity with extant populations and/or no suitable habitat.
Pale-headed Snake *Hoplocephalus bitorquatus*	Yes. 14 records in the Pilliga-Narrabri area.	November – March (**Mar,** Oct, **Nov**)	Yes – surveyed/assumed present (Castlereagh Barwon, Pilliga, Pilliga Outwash, Liverpool Plains)	This species was recorded during surveys in close proximity to the proposal site and potential habitat occurs in the Pilliga and Narrabri areas. This species is assumed present at various locations based on previous records and presence of suitable potential habitat.
			No – surveyed (Bogan-Macquarie)	No evidence during surveys in the Narromine area.
			Not in BAM-C case (Inland Slopes, Northern Basalts)	No suitable habitat in CIZ in these subregions.

Common name *Scientific name*	BioNet records in locality (EES 2020a)	Survey months (months surveyed)*	Presence	Justification
Pink-tailed Legless Lizard *Aprasia parapulchella*	None	Sep-Nov (**Sep, Oct, Nov**)	No -surveyed (Pilliga)	Not recorded during surveys. Volcanic habitat in the Pilliga subregion is associated with outlying hills of the Warrumbungles. The proposal skirts around the outside of these, and the geology within the proposal site near these hills is sedimentary rock. There are no local records in this area, which is outside the physiographic region which the species is usually associated with.
			Not in BAM-C case (all other subregions)	No suitable rocky habitat present.

Bold: surveys conducted in months identified in the Threatened Species Profile Database

Table 6.7 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
Red-tailed Black-cockatoo (inland species) *Calyptorhynchus banksia samueli*	None	Species/ Ecosystem	None	**Geographic constraint – south of Nyngan** The Red-tailed Black-cockatoo (inland subspecies) is known to occur around watercourses extending in an arc along the Darling River from Wentworth in the south to Bourke and then through to Brewarrina in the north. It extends east to Walgett and perhaps Boggabilla on the Barwon and south through to the Macquarie Marshes. This is mapped by Birdlife International (2021) – see below. The proposal site in the Castlereagh-Barwon IBRA subregion is located at the eastern edge of the IBRA subregion, well away from the large rivers associated with the Darling River. The proposal site in the Bogan-Macquarie IBRA subregion is south of Nyngan, which is outside the distribution of this species.  **Surveys** No individuals were observed during any surveys in the study area. There are no local records.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
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 (DPIE 2020b).
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 (DPIE 2020b).
Bristle-faced Freetail Bat *Setirostris eleryi*	None	Species	Vagrant (Castlereagh-Barwon)	**Outside distribution** Four of the five locality records of this species reported from NSW are concentrated on the northern North-west Slopes (Scotts 2012), with the fifth from near Bourke (Pennay 2006). The proposal site is located at the very southern edge of the Castlereagh-Barwon IBRA subregion. While riparian woodland is present is located in scattered locations within the Castlereagh-Barwon IBRA subregion, the species was not recorded during surveys, and these locations are over 280 kilometres from Gundabooka National Park and the Bonshaw area. Central Australian individuals have been found to be associated with ephemeral drainage lines adjacent to ranges (Reardon and Pennay 2008). This is similar for the NSW records. Waterways in the Castlereagh-Barwon IBRA subregion that are crossed by the proposal are not located adjacent to any ranges. **Surveys**: No individuals were trapped in harp nets set in November 2018 or March 2019. 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 possible calls of this species were recorded and no individuals trapped. Given the above points, the Bristle-faced Freetail Bat is highly unlikely to occur in the proposal site.
			Habitat constraints (Northern Basalts)	No land within 500 metres of watercourses or dams surrounded by eucalypts containing hollows present in the Northern Basalts IBRA subregions.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Large-eared Pied Bat *Chalinolobus dwyeri*	Yes. Three records in the Pilliga	Species	Cliffs (within two kilometres 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 two kilometres 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 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 2019b), and there are no records of the species in this area (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 *Miniopterus orianae oceanensis*	Yes	Species/ Ecosystem (Breeding habitat)	Caves (cave, tunnel, mine, culvert or other structure) Species polygon: All breeding habitat including the cave, or other features, used for breeding and the area immediately surrounding this feature (100 metre buffer).	**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). 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 a 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 (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.
Brush-tailed Phascogale *Phascogale tapotafa*	No	Species	None	**Removed from IBRA subregion** In NSW Brush-tailed Phascogales are mainly found east of the Great Dividing Range although there are occasional records west of the divide (DPIE 2020a). A record existed in the Atlas of Living Australia of a Brush-tailed Phascogale near Narromine. The record information has it as ANWC M06009 and the locality as Wahgunyah, Glenbrook, via Singleton, collected in 1972. GHD's accredited assessor Kirsten Crosby contacted the CSIRO on 16 March 2021 and the CSIRO have updated this record with the correct data from near Singleton, removing this species from the Narromine area (email received 17 March 2021). The BCS accountable officer for the species also agreed that this record was likely to be invalid. As such, the species is not considered to occur in the Bogan-Macquarie IBRA region. This species was not identified in the BAM-C for any other subregion.

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 kilometre of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or cliff lines)	**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, near 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. These small hillsides are relatively isolated and subject to disturbance from stock and feral animals. Historically the species occurred in central NSW, however these populations 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.
Black-breasted Buzzard *Hamirostra melanosternon*	None	Species/ //Ecosystem (Nest trees)	Waterbodies (land within 40 metres 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. BCS Accountable Officers noted that individuals may occur on occasion but would be vagrant and non-breeding (teleconference with BCS, 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 distribution of the species to the west of the study area.

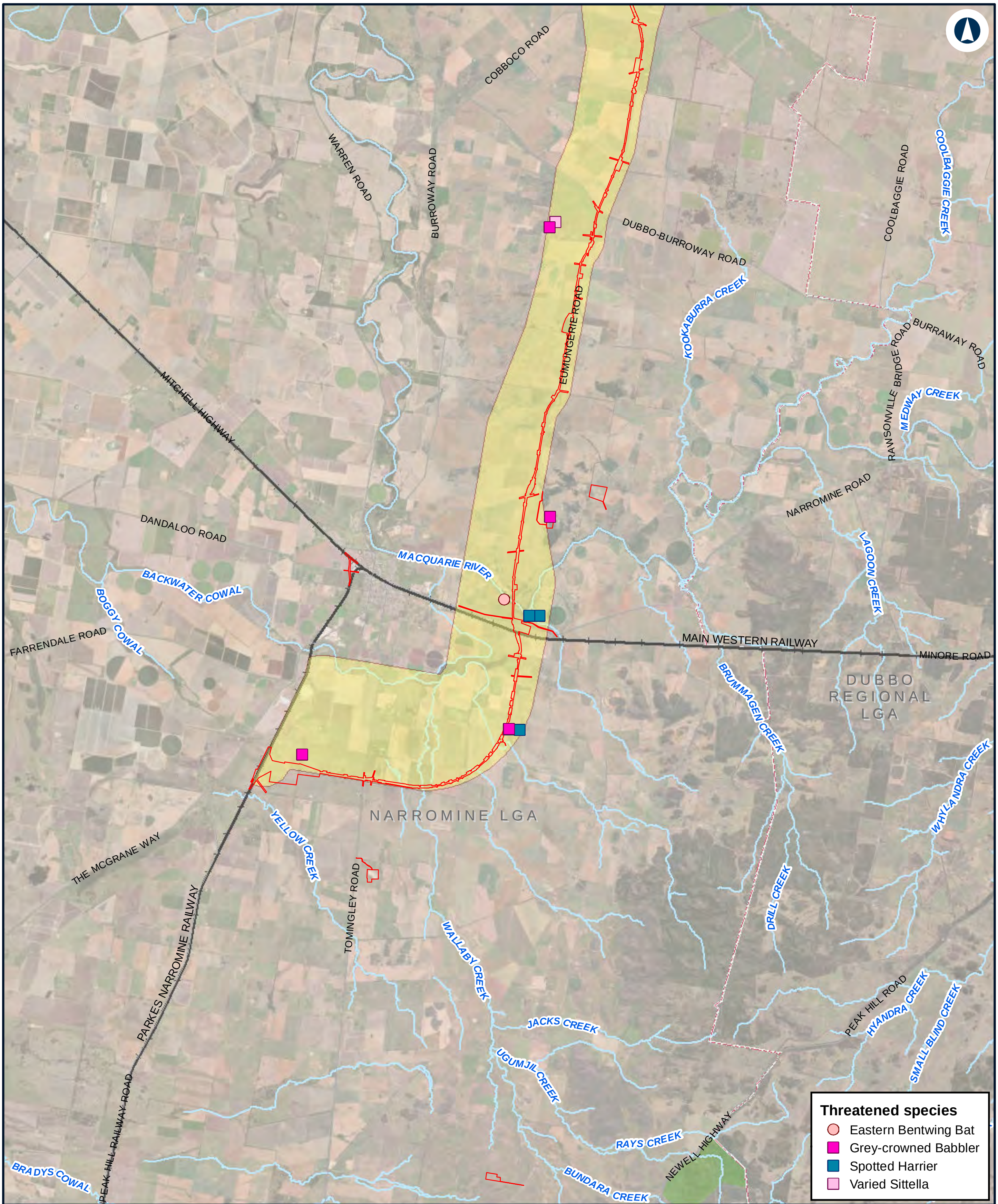
Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
				 Given the location of the proposal site outside the breeding distribution of the species, a species polygon has not been prepared for this species. Foraging habitat is an ecosystem credit for this species.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
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 distribution of the species to the west of the study area.  BCS accountable officers noted that individuals may occur on occasion but would be vagrant and non-breeding (teleconference with BCS, 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). BCS 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 BCS, February 2020). This is supported by the distribution map of the species which shows the proposal site as being located in the non-breeding area of the species' range (Birdlife International 2021). 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
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).  The compiled distribution map provided by BirdLife International species range maps similarly shows the main distribution of the species well to the east of the study area.

Common name *Scientific name*	BioNet records in locality	Credit type	Habitat constraint	Justification
Grey-headed Flying-fox *Pteropus poliocephalus*	Yes. Five records	Species /Ecosystem (Breeding habitat)	Other (breeding camps)	**Surveys**: multiple survey periods between September 2018 and August 2021 (see section 3.6). No individuals recorded during surveys. **No roost camps present**. Grey-headed Flying-foxes are generally found within 200 kilometres 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 surveys, and lack of evidence of any roost camps, no species polygon has been prepared. Foraging habitat is an ecosystem credit for this species.
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 and July and August 2021. 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, and lack of evidence of this species during surveys, 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

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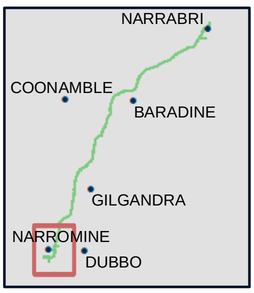
LEGEND

- Construction impact zone
- Investigation Corridor



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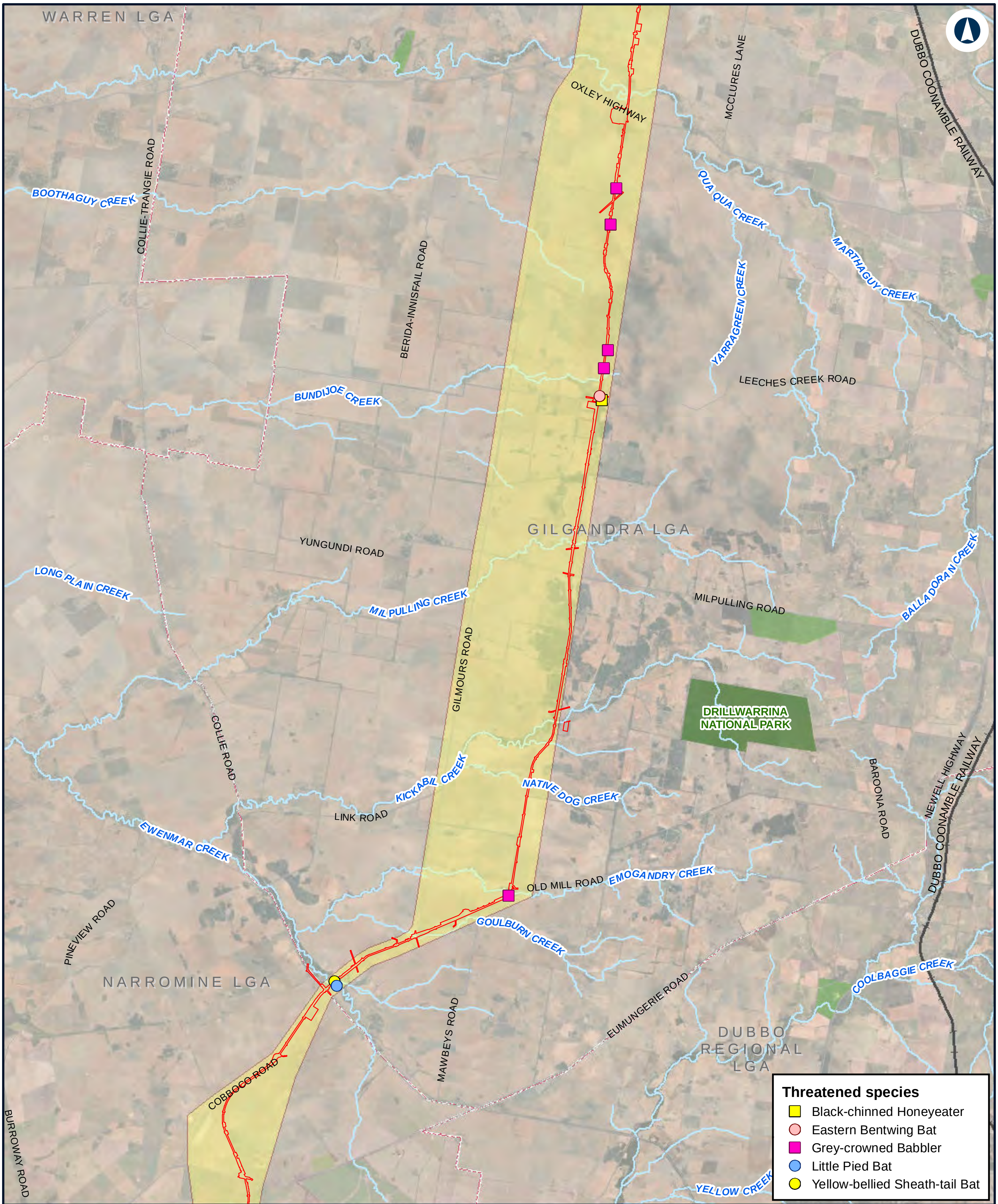

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys Figure 6.1 MAP 2 OF 6

0 2.5 5 Km

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- Construction impact zone
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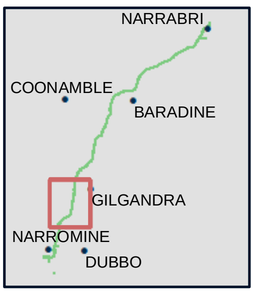

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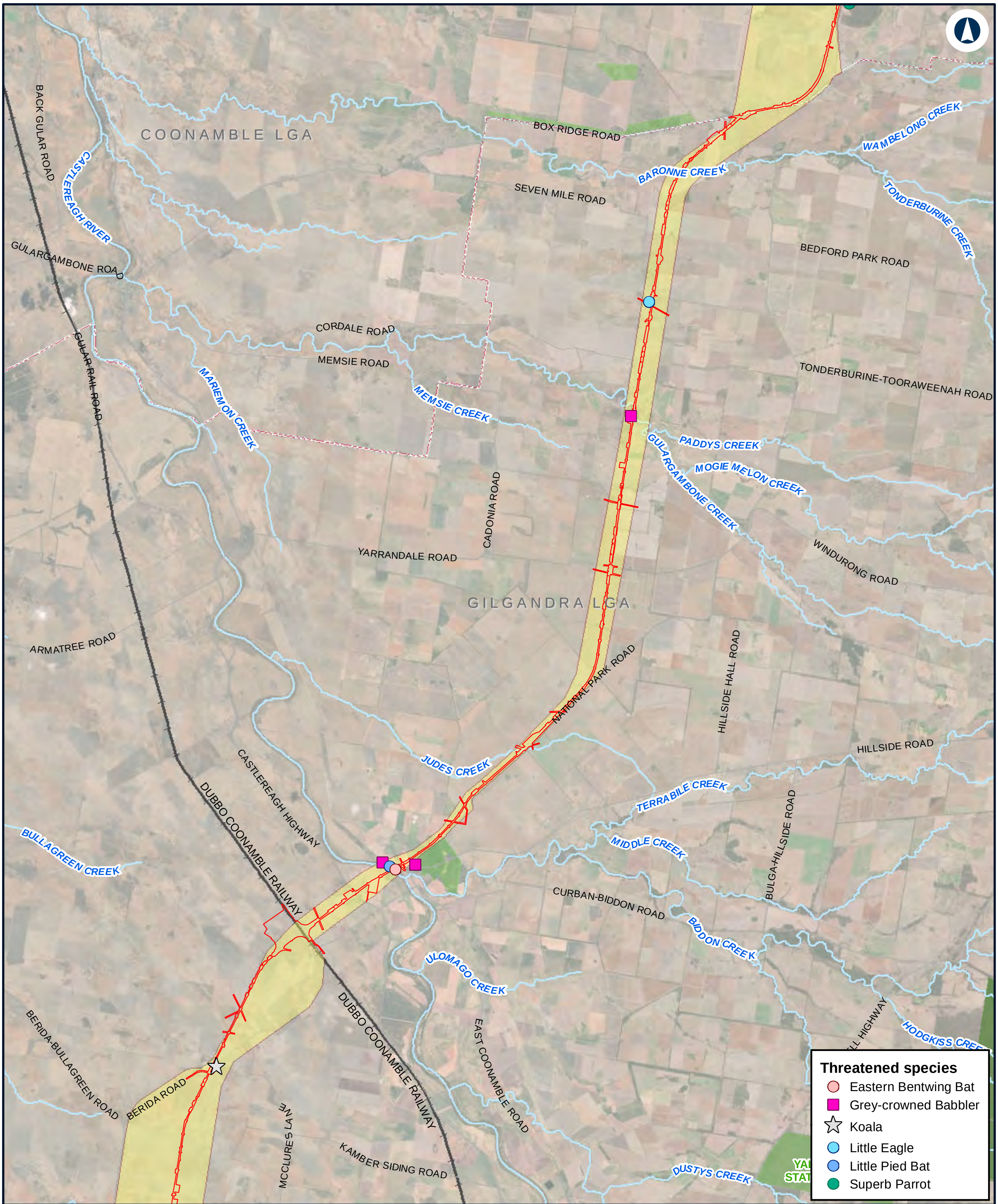

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys Figure 6.1 MAP 3 OF 6

0 2.5 5 Km

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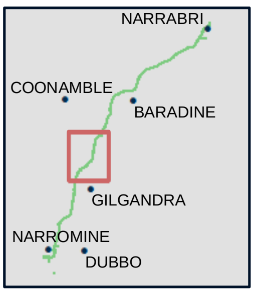
- Construction impact zone
- Investigation Corridor



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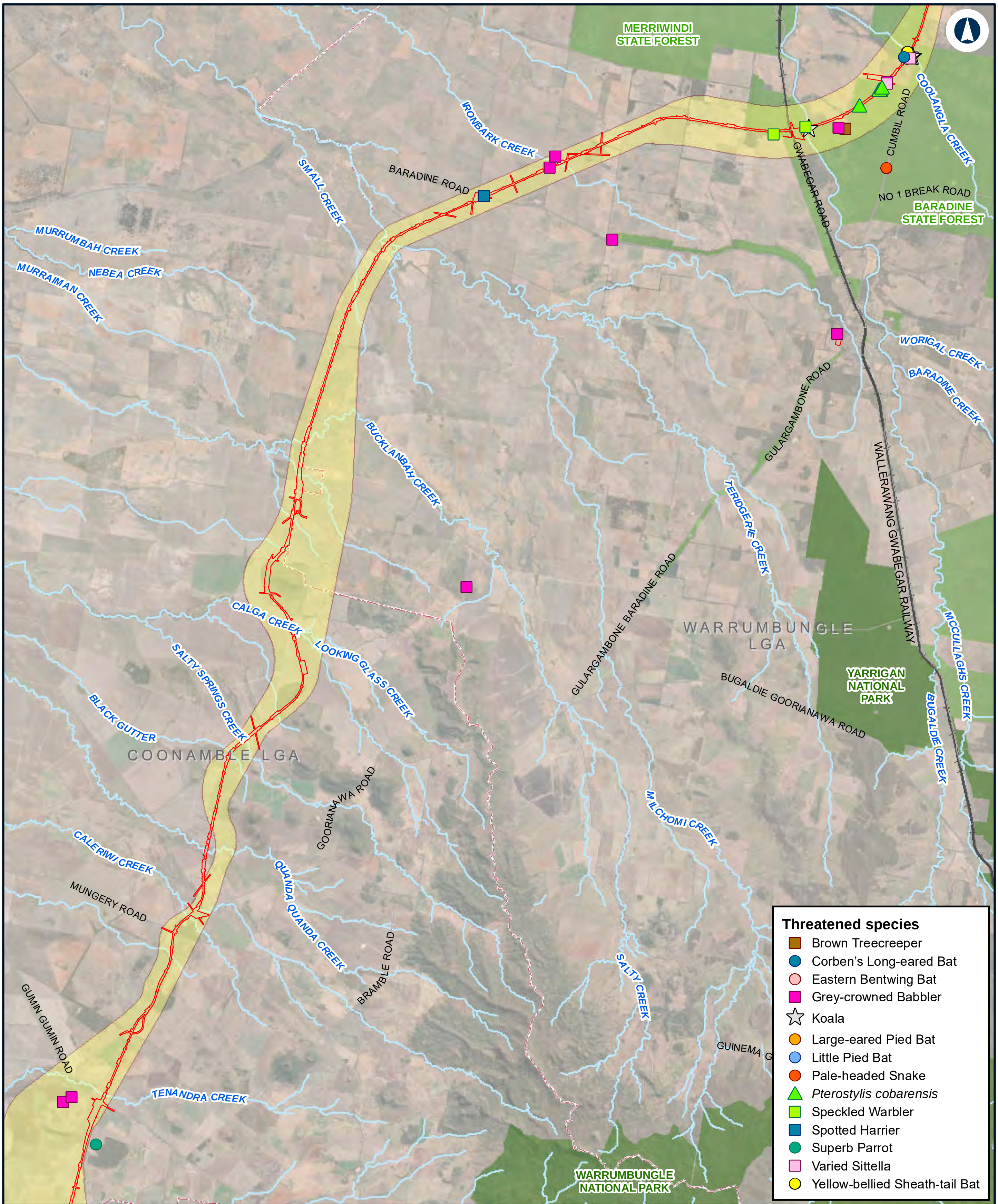

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys Figure 6.1 MAP 4 OF 6

0 2.5 5 Km

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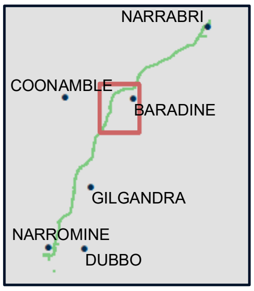
- Construction impact zone
- Investigation Corridor



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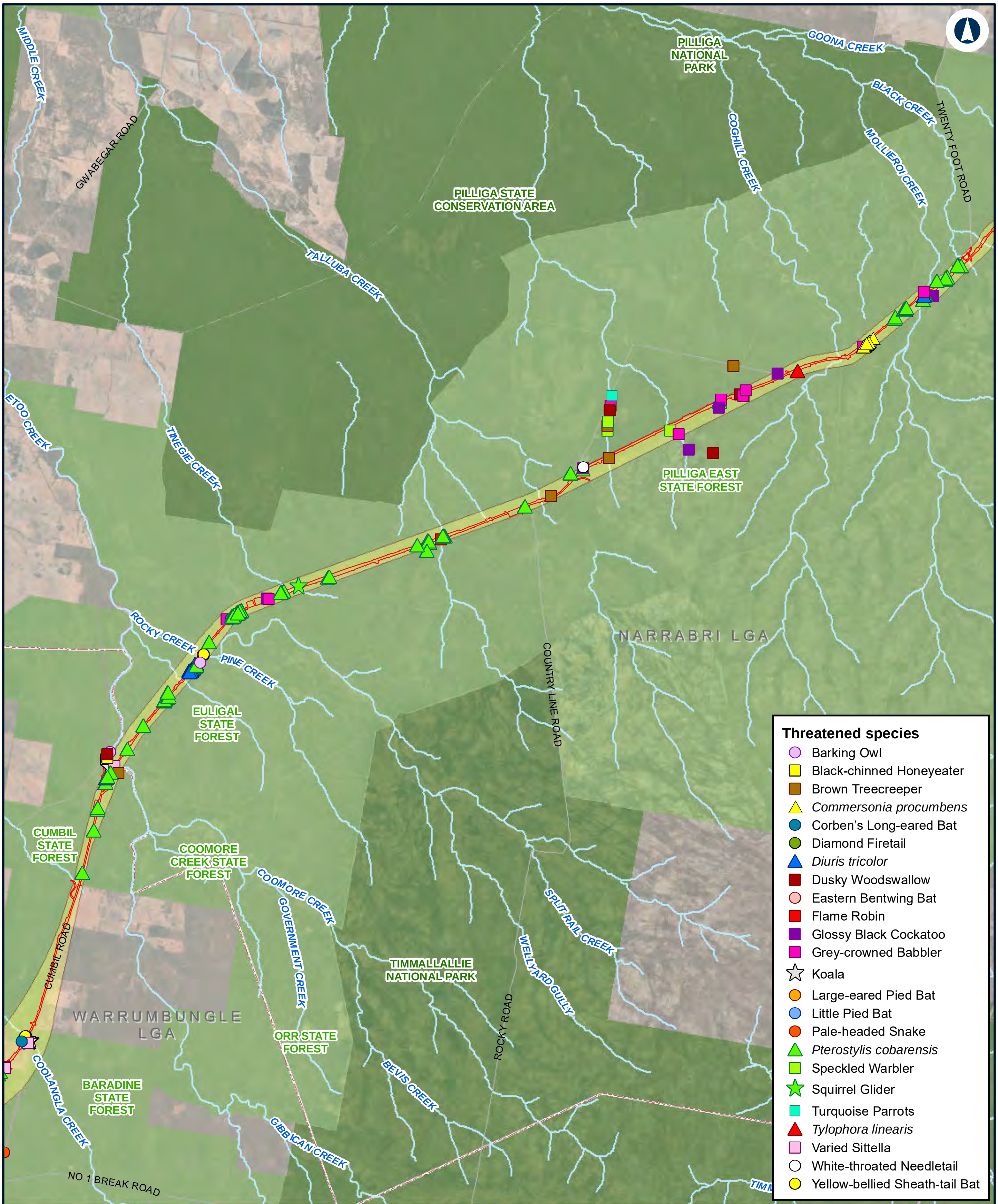

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys Figure 6.1 MAP 5 OF 6

0 2.5 5 Km

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LEGEND

- Construction impact zone
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NARRABRI
COONAMBLE
BARADINE
GILGANDRA
NARROMINE
DUBBO

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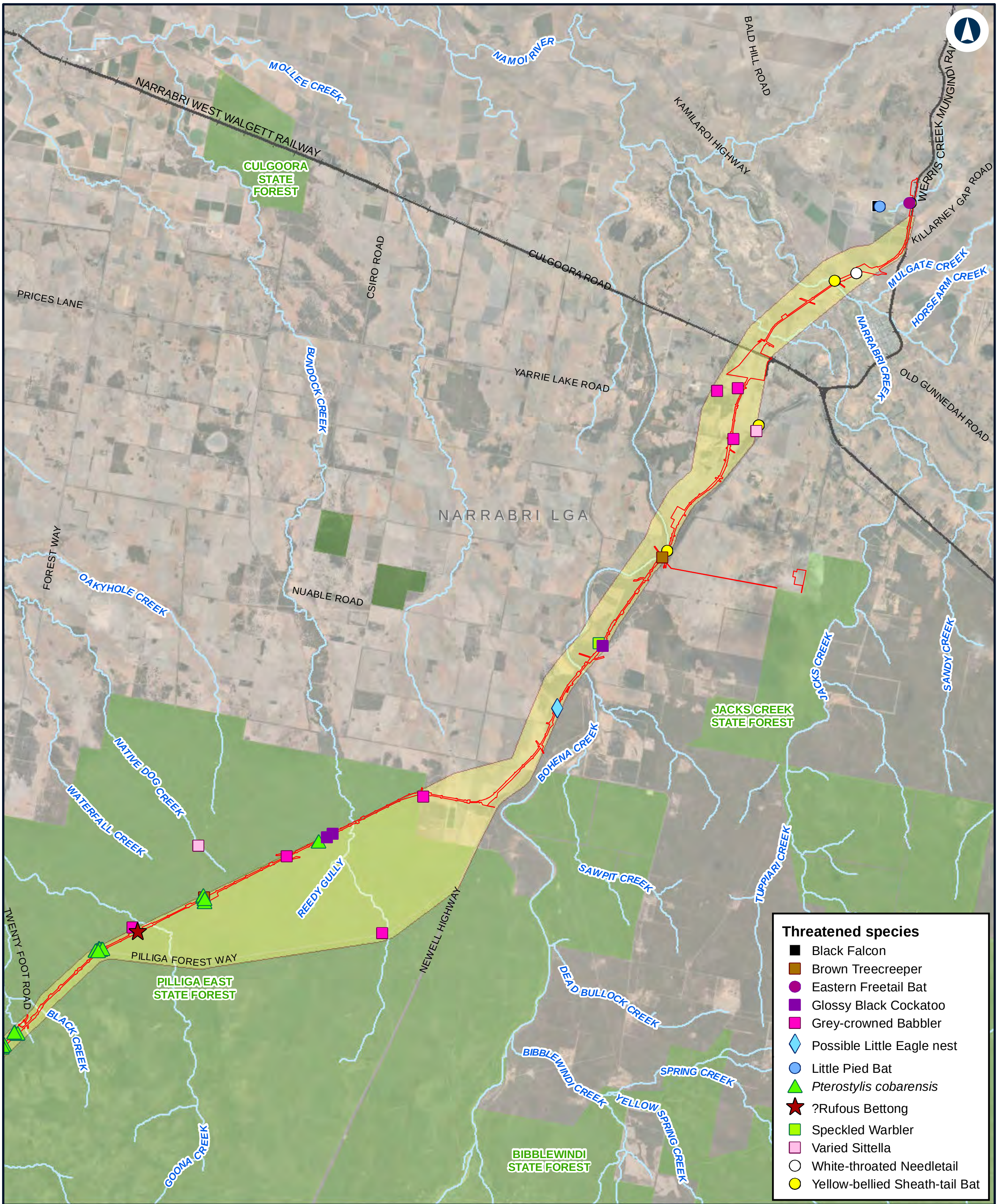

NARROMINE TO NARRABRI Threatened flora and fauna species recorded during surveys

Figure 6.1 MAP 6 OF 6

0 2.5 5 Km

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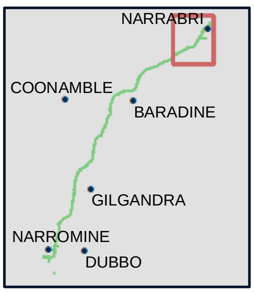

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7. Matters of National Environmental Significance

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	6.5
Brigalow (*Acacia harpophylla* dominant and co-dominant)	35	E	7.3
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia	81 and 248	E	17.2
Poplar Box grassy woodland on alluvial plains	56 and 244	E	76.3
White Box-Yellow Box- Blakely's Red Gum Grassy Woodland and Derived Native Grassland	435 and 599	CE	8.4
		Total	**115.7 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, some parts of its occurrence within the proposal are dominated by Belah and did not contain >50 percent Poplar Box to meet EPBC listing guidelines.

7.2 Threatened species

Five threatened fauna species and one flora 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*	E	One individual recorded via thermal drone surveys in the Pilliga. Scats were recorded at two locations in the Pilliga area and one north-west of Gilgandra during surveys. Scattered records occur elsewhere in the region (EES 2019a). Further detail is provided in Appendix I and Appendix N.
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.
Glossy Black-cockatoo	*Calyptorhynchus lathami lathami*	V	Various groups (pairs a group of three) and individuals recorded in the Pilliga and Bohena Creek area. Chewed cones recorded in the Pilliga. No Glossy Black-cockatoos were recorded outside the Pilliga/Narrabri area during any of the many surveys conducted for the proposal. The stronghold for this species is the Pilliga, and it could occur elsewhere where large patches of vegetation occur in the study area. This species was listed under the EPBC Act in August 2022.
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.

Common name	Scientific name	EPBC Act	Record
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	Recorded during November 2020 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			
	Commersonia procumbens	V	Not recorded during surveys. Known to occur within the Pilliga forests in study area and assumed to occur based on suitable habitats but lack of recent fire in these habitats for species detection.
Bluegrass	*Dichanthium setosum*	V	Not recorded during surveys. Known to occur in the wider locality at the northern and southern end of the proposal.
Spiny Peppercress	*Lepidium aschersonii*	V	Not recorded during surveys. Known to occur in study area between the northern end of the Pilliga and Narrabri. Assumed to occur from some areas not able to be access during target surveys near Narrabri.
Winged Peppercress	*Lepidium monoplocoides*	E	Not recorded during surveys. Known to occur east of study area near Narrabri.
Slender Darling Pea	*Swainsona murrayana*	V	Not recorded during surveys. Known to occur in the wider locality along length of proposal.
	Tylophora linearis	E	Recorded during surveys within the Pilliga forests in the proposal site.
Keith's Zieria	*Zieria ingramii*	E	Not recorded during surveys. Known to occur in the locality east of Gilgandra in Goonoo State Forest.

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

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 percent 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 (DEE 2017a):

- have previously been identified as internationally important for the species, or sites that
- support at least 18 individuals of the species.

There are records of the Latham's Snipe at Narrabri Lake and in the Pilliga (EES 2019a). Narrabri Lake (which is outside the proposal site) has the potential to support at least 18 individuals of the species, however it is unlikely that this many individuals would occur at any farm dams or dams in the Pilliga given the small size and limited vegetation cover. No important habitat for this species occurs 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). Three migratory species, the Rufous Fantail (*Rhipidura rufifrons*), Fork-tailed Swift (*Apus pacificus*) and White-throated Needletail (*Hirundapus caudacutus)* were recorded during surveys. The proposal site intersects with core non-breeding range of these species (see Table 7.3). 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).

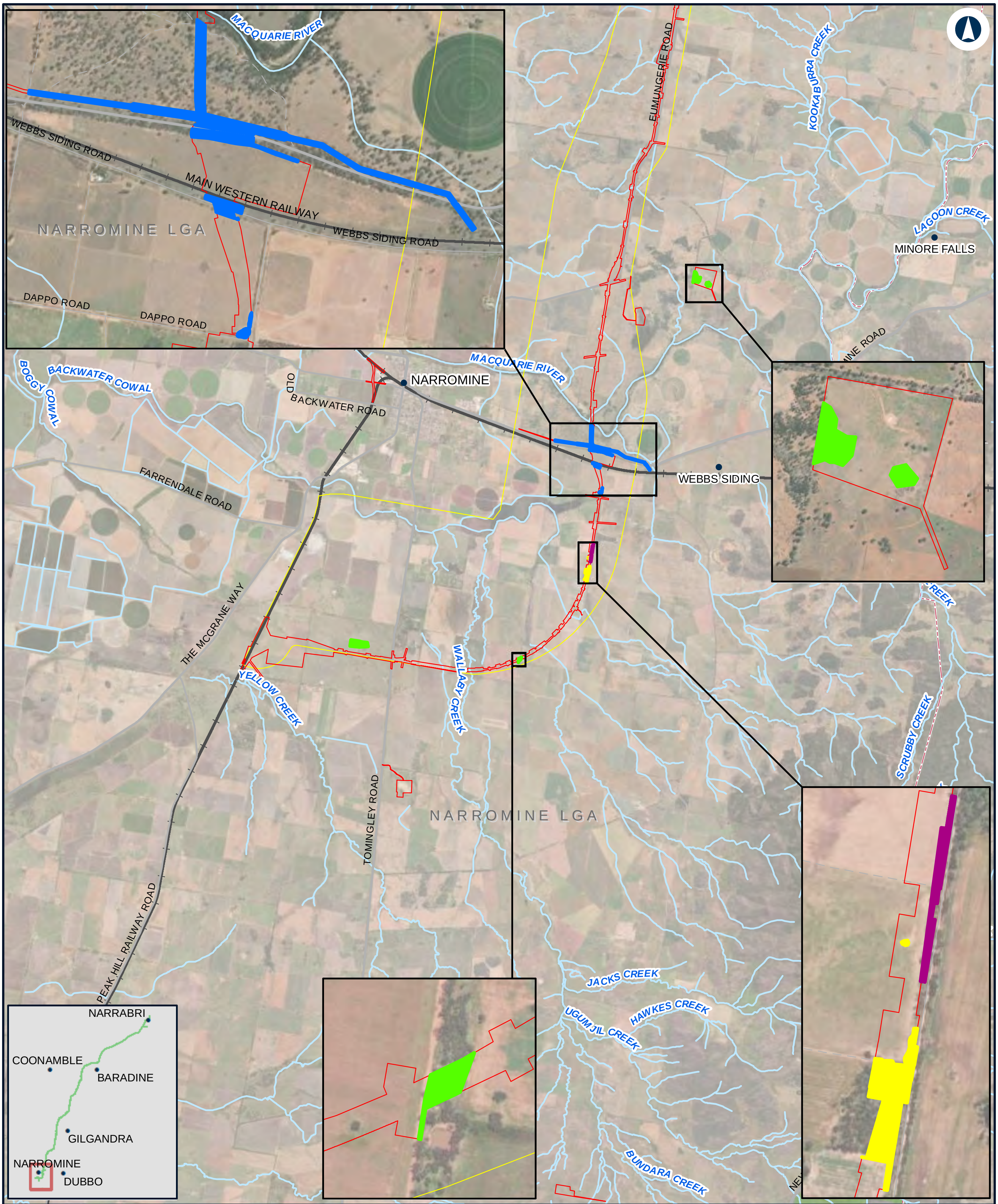
Table 7.3 EPBC Act migratory species recorded during surveys or with important habitat present

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 percent) (DoE 2015). The proposal site is located within the core non-breeding range (DoE 2015).
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	Recorded during surveys in the Pilliga. The proposal site is located within the core non-breeding range, but not the core breeding range (DoE 2015).

Common name	Scientific name	Important habitat (DoE 2015)	Record
		used including dry eucalypt forests and woodlands and Brigalow shrublands.	
Satin Flycatcher	*Miagra cyanoleuca*	The core breeding distribution of the Satin Flycatcher is in the eucalypt forests and woodlands along the east coast and across south-eastern mainland Australia and Tasmania. On mainland Australia the species is a high-attitude breeder.	One individual was recorded at the Castlereagh River in September. The species is unlikely to breed in the proposal site. The proposal site is located outside the core range of the species (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.	Three individuals were observed above Narrabri on one occasion during surveys. The proposal site is located within the core non-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 7.1 - MAP 1 of 9

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LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Grey Box (Eucalyptus microcarpa) Grassy Woodlands and derived native grasslands of South-eastern Australia
- Poplar Box grassy woodland on alluvial plains
- White Box - Yellow Box - Blakeys Red Gum Grassy Woodland and Derived Native Grassland
- Inland Grey Box Woodland

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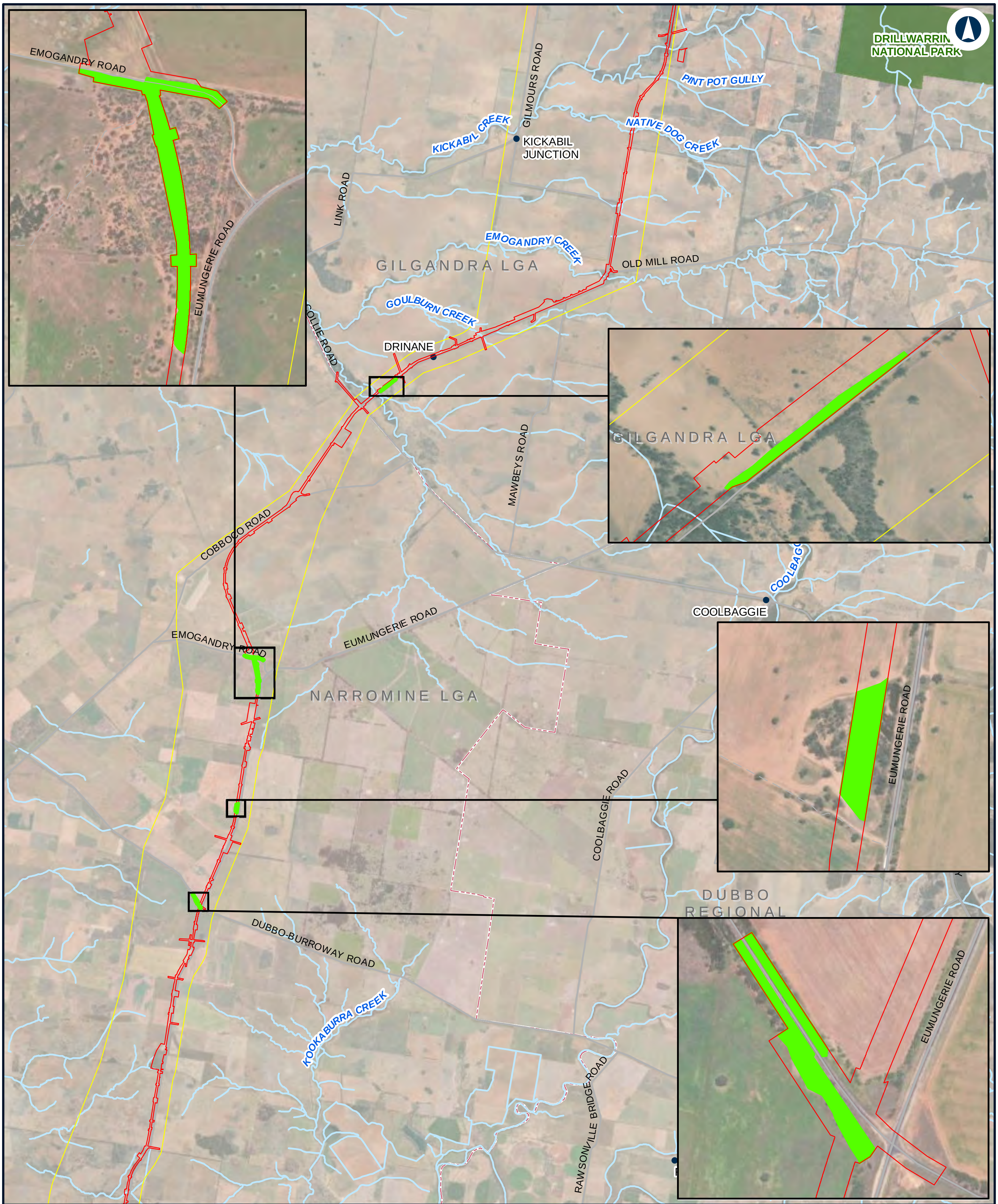

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1 - MAP 2 of 9

0 2 4 Km

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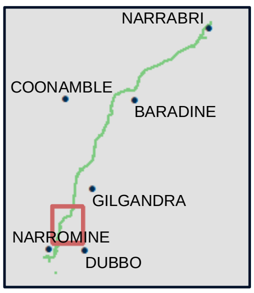
LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Poplar Box grassy woodland on alluvial plains



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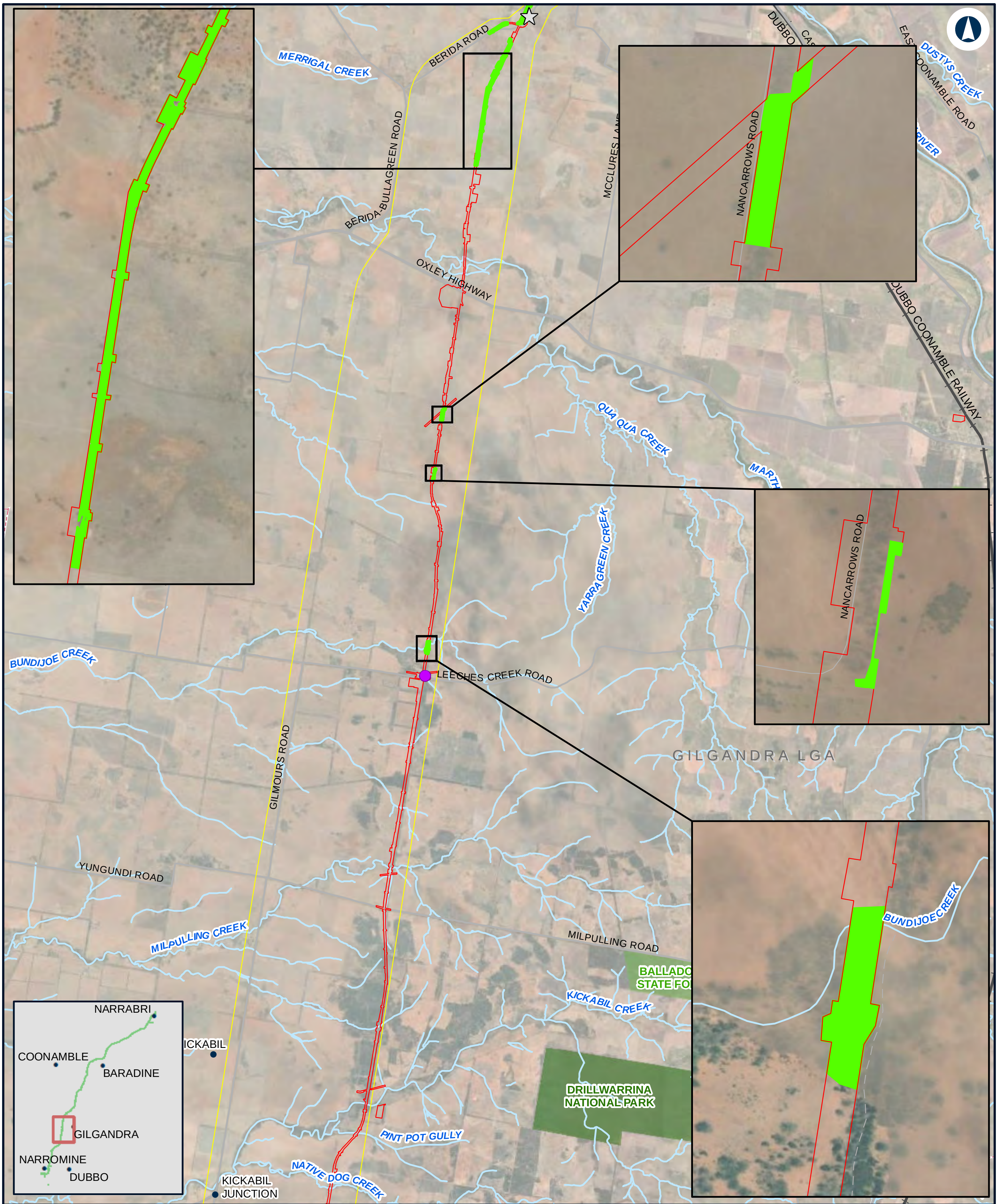

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1 - MAP 3 of 9

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 28/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Poplar Box grassy woodland on alluvial plains
- Fork-tailed Swift
- Koala

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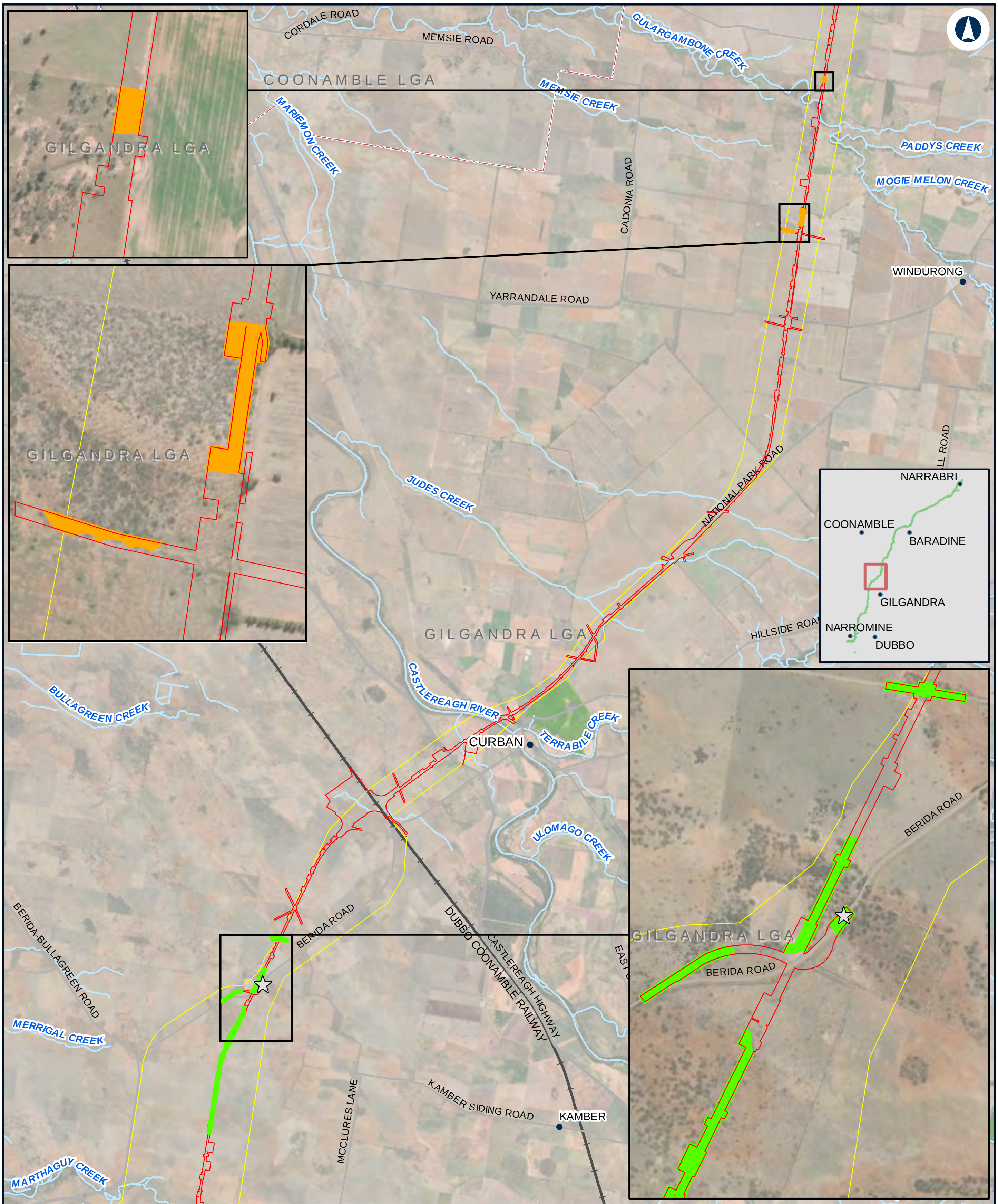

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1 - MAP 4 of 9

0 2 4 Km

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Date: 28/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Poplar Box grassy woodland on alluvial plains
- Weeping Myall Woodlands
- Koala

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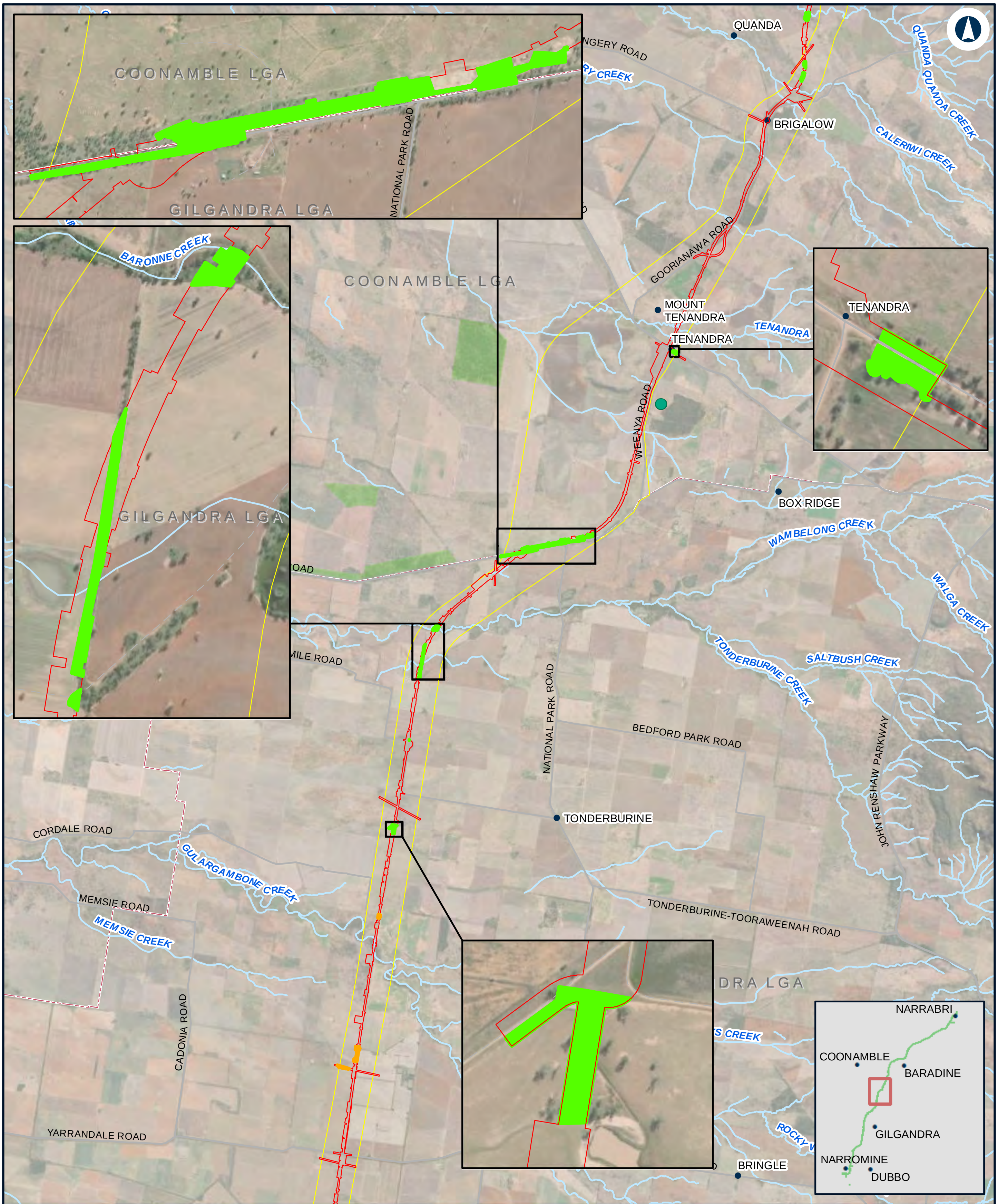

NARROMINE TO NARRABRI

Matters of National Environmental Significance

Figure 7.1 - MAP 5 of 9

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 28/06/2022
Paper: A4
Author: JacobsGHD
Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Poplar Box grassy woodland on alluvial plains
- Weeping Myall Woodlands
- Superb Parrot

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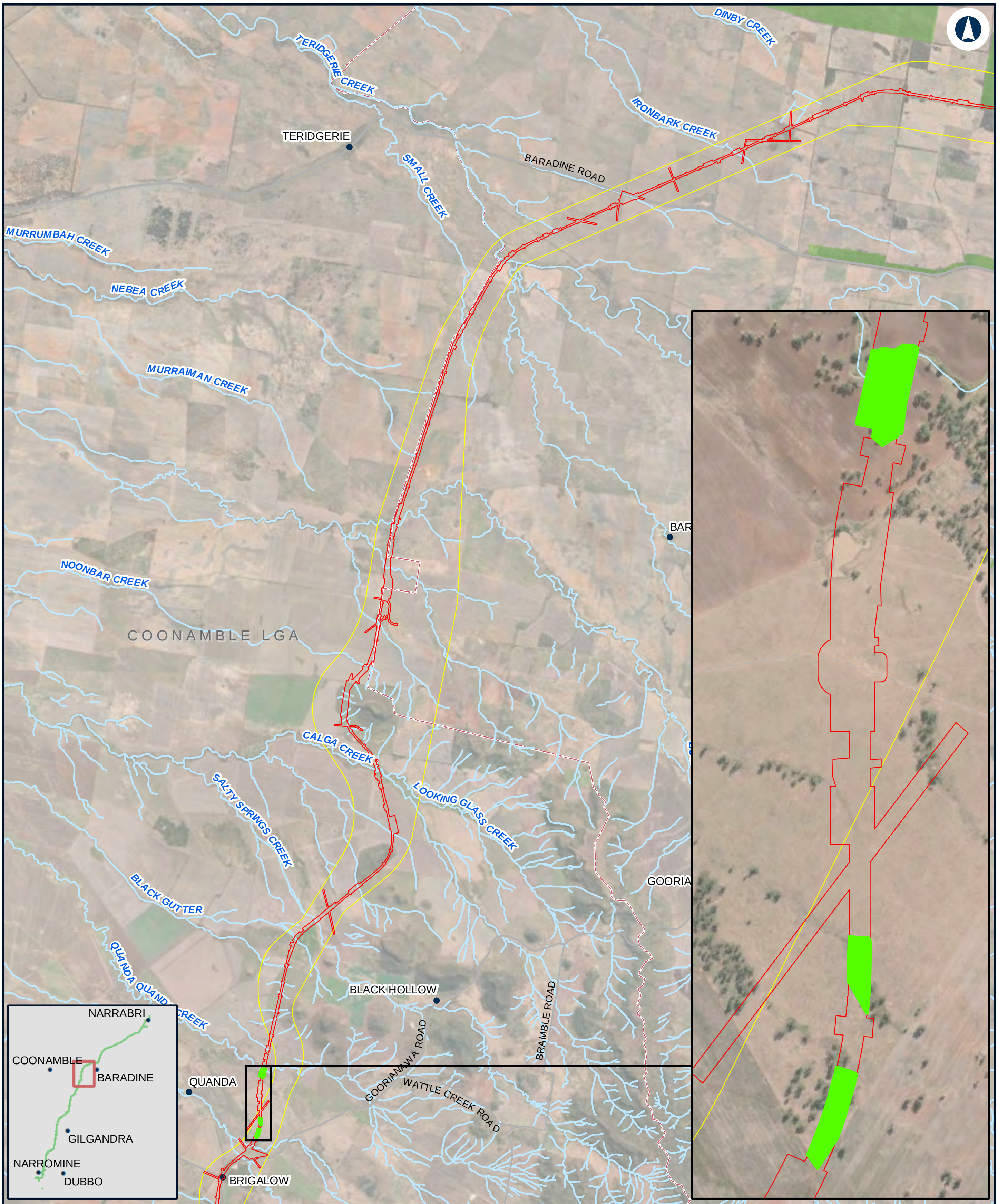

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1 - MAP 6 of 9

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 28/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Poplar Box grassy woodland on alluvial plains

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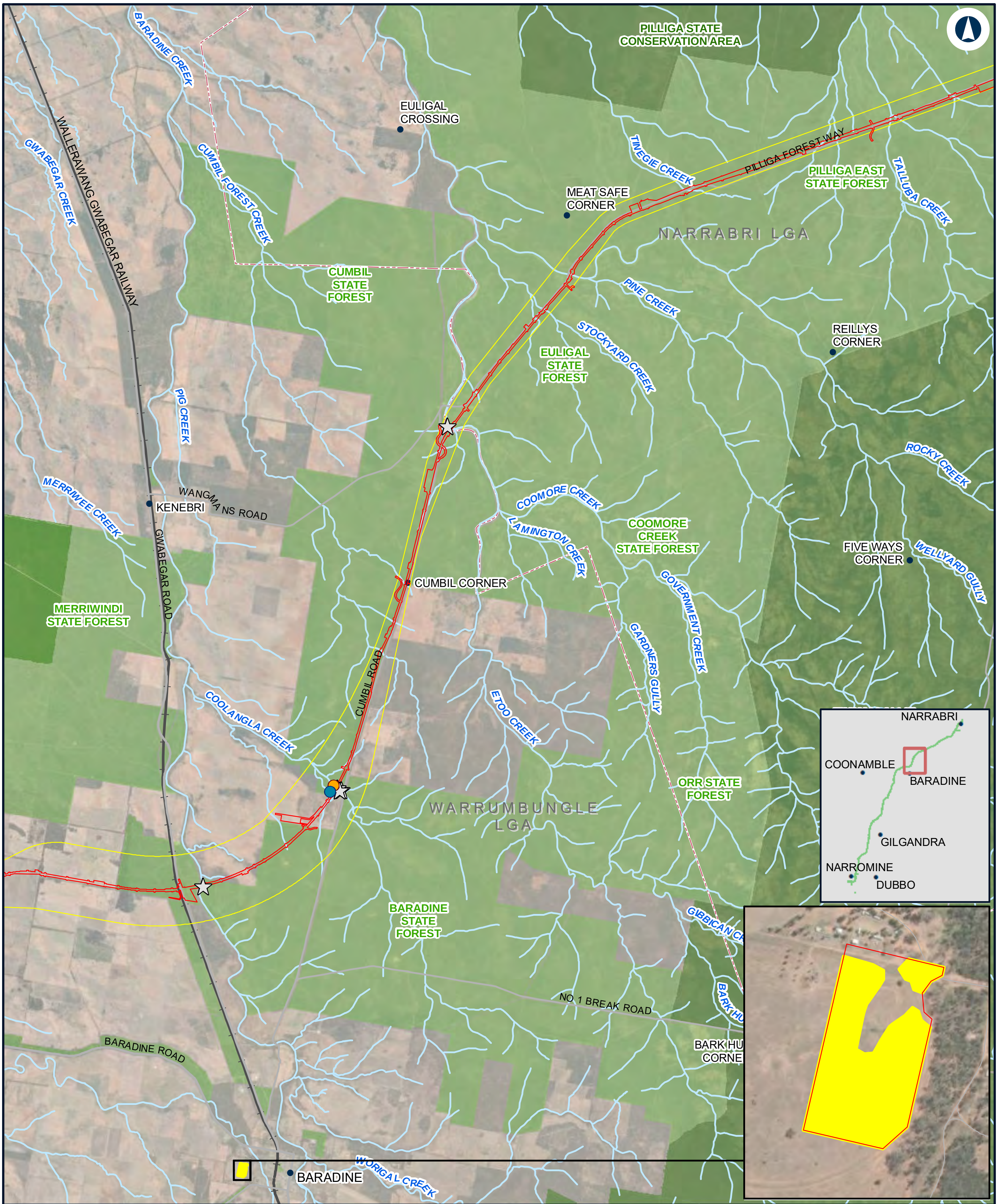

NARROMINE TO NARRABRI | Matters of National Environmental Significance | Figure 7.1 - MAP 7 of 9

0 2 4 Km

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Date: 28/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- White Box - Yellow Box - Blakeys Red Gum Grassy Woodland and Derived Native Grassland
- Corben's Long-eared Bat
- Koala
- Large-eared Pied Bat

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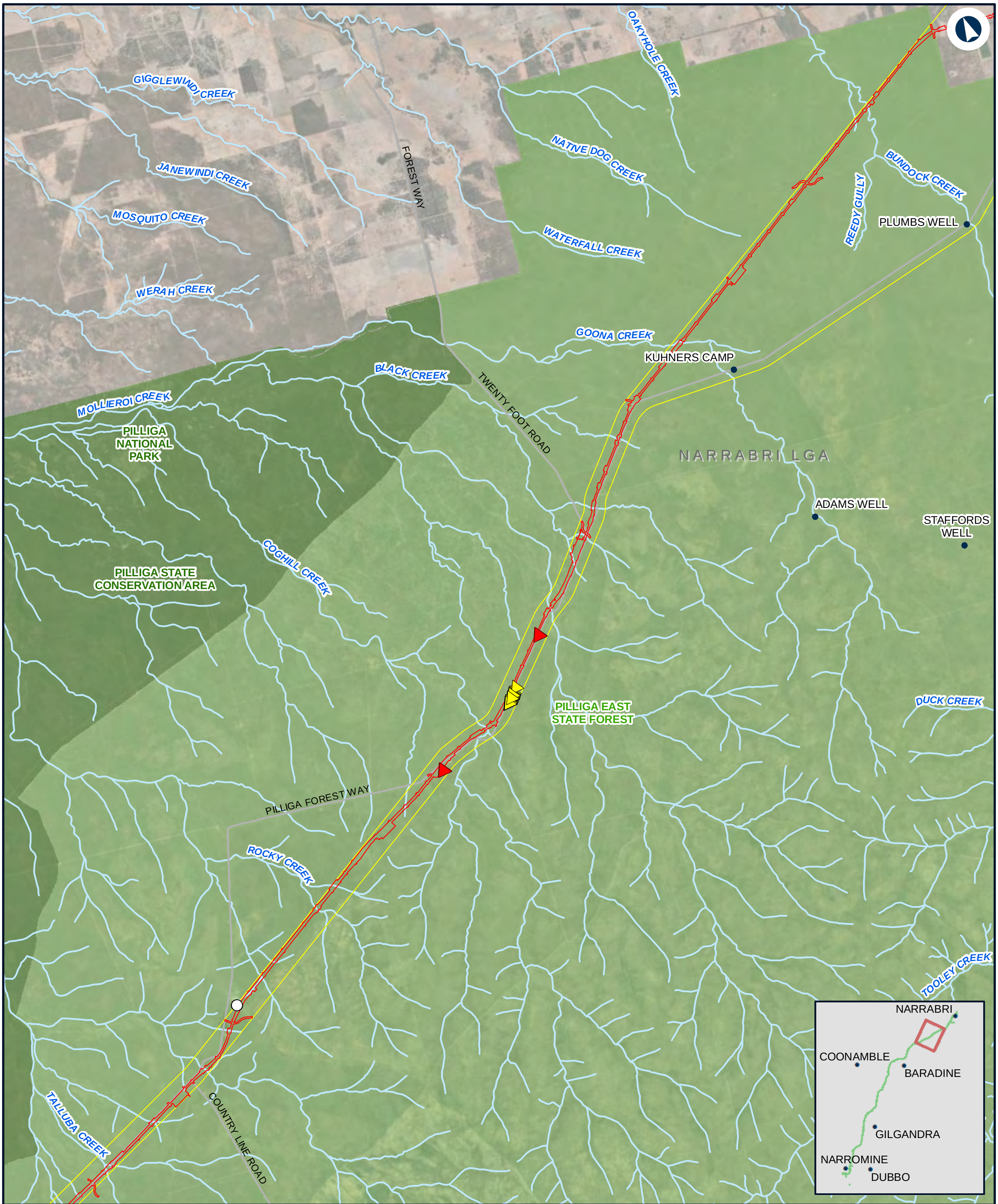

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1 - MAP 8 of 9

0 2 4 Km

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Date: 28/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- *Commersonia procumbens*
- *Tylophora linearis*
- White-throated Needletail

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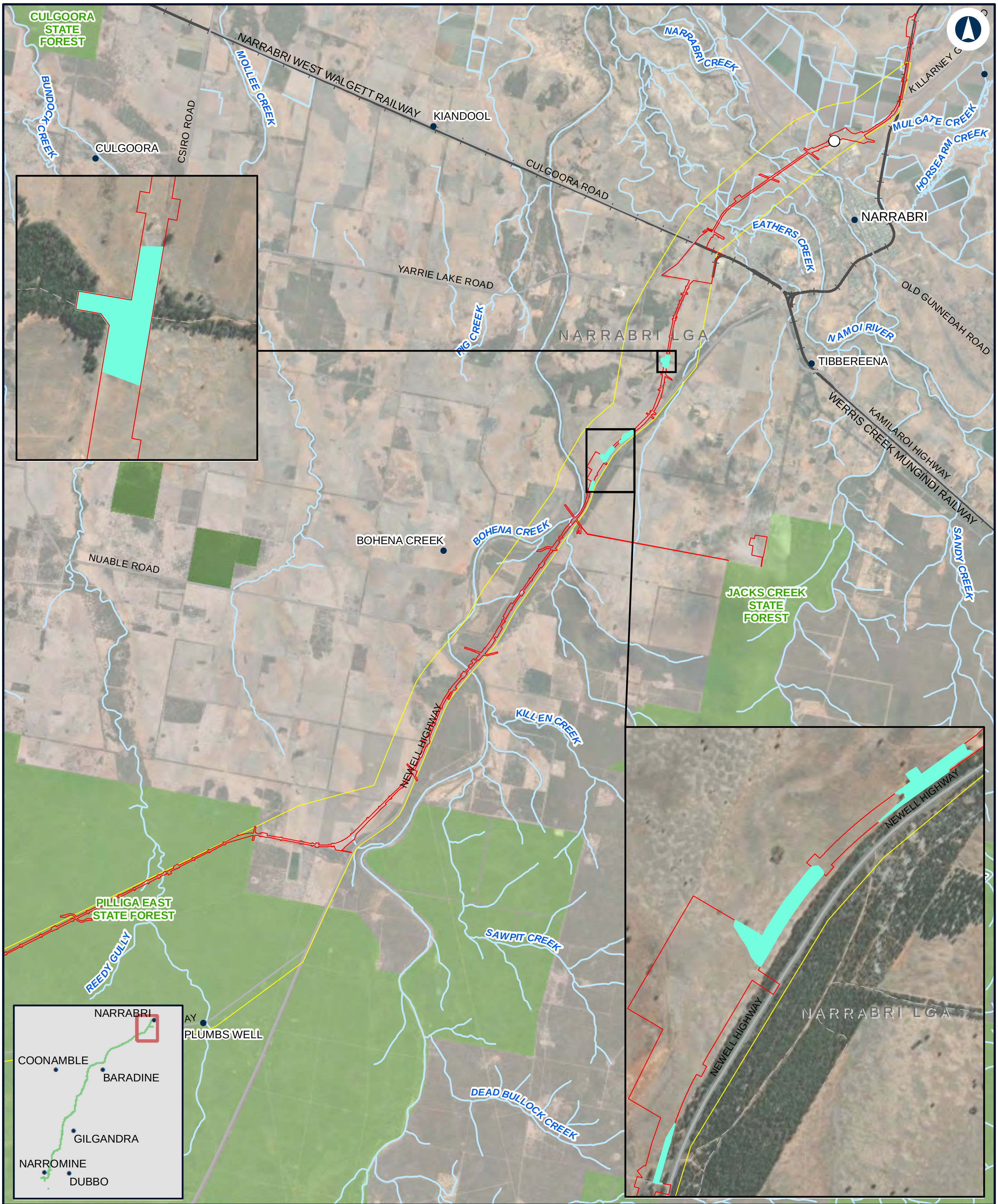

NARROMINE TO NARRABRI Matters of National Environmental Significance Figure 7.1 - MAP 9 of 9

0 2 4 Km

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Date: 28/06/2022 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Phase 2 - Investigation Corridor
- Brigalow (Acacia harpophylla dominant and co-dominant)
- White-throated Needletail

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8. Identification of prescribed additional biodiversity values

8.1 Introduction

The Biodiversity Conservation Regulation 2017 (BC Regulation) (clause 6.1) identifies additional biodiversity impacts to which the BOS applies. These 'prescribed impacts' are the impacts on biodiversity values which are not related to, or are in addition to, native vegetation clearing and habitat loss. These types of impacts are used by the decision-maker to inform the determination and conditions of consent for developments. These include:

a. on the habitat of threatened entities including:
   i. karst, caves, crevices, cliffs, rocks and other geological features of significance,
   ii. human-made structures, or
   iii. non-native vegetation
b. on areas connecting threatened species habitat, such as movement corridors
c. that affect water quality, water bodies and hydrological processes that sustain threatened entities
d. on threatened and protected animals from turbine strikes from a wind farm (not relevant to this proposal)
e. on threatened species or fauna that are part of a TEC from vehicle strikes.

The BDAR must identify the relevant prescribed impacts and the suite of threatened species that use or rely on the habitat values or would be affected by the impact, as specified in BAM section 6. The likelihood, extent and magnitude of prescribed impacts must then be assessed using the approach specified in the BAM section 8.3. Those of relevance to this proposal are described in the sections below.

8.2 Habitat connectivity

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 have been 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. These areas are particularly important for mobile species such as birds and bats.

A detailed assessment of connectivity values is provided in Table 8.1. Existing connectivity is mapped on Figure 4.2.

Table 8.1 Connectivity values

Criteria	Connectivity feature	Discussion
Where corridors or other areas of connectivity link habitat for threatened entities, the assessor must: (a) prepare a list of threatened entities that are likely to use or are a part of the connectivity or corridor		• Barking Owl • Masked Owl • Black Falcon • Little Eagle • Spotted Harrier • Square-tailed Kite • Glossy Black-cockatoo • Superb Parrot • Bush Stone-curlew • Black-chinned Honeyeater (eastern subspecies) • Brown Treecreeper (eastern subspecies) • Dusky Woodswallow • Flame Robin • Grey-crowned Babbler (eastern subspecies) • Painted Honeyeater • Regent Honeyeater • Speckled Warbler • Swift Parrot • Varied Sittella • White-throated Needletail • Koala • Black-striped Wallaby • Rufous Bettong • Eastern Pygmy-possum • Pilliga Mouse • Squirrel Glider • Corben's Long-eared Bat • Large Bent-winged Bat • Large-eared Pied Bat • Little Pied Bat • Yellow-bellied Sheathtail-bat • Five-clawed worm skink • Pale-headed Snake
(b) describe the importance of the connectivity to threatened entities, particularly for maintaining movement that is crucial to the species' life cycle (based on published literature and other reliable sources).	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. 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). As the largest single area of remnant woodland in NSW, the Pilliga also provides important habitat for a number of other threatened bird species, many of which benefit from the connectivity of this large area. These include small, less mobile woodland birds such as the Speckled Warbler, Grey-crowned Babbler, Brown Treecreeper, Hooded Robin, Diamond Firetail and Varied Sitella; raptors such as the Little Eagle and Square-tailed Kite; Barking and Masked Owls; the terrestrial Bush Stone-curlew; and more mobile woodland birds such as the Dusky Woodswallow, Painted, Regent and Black-chinned Honeyeaters.

Criteria	Connectivity feature	Discussion
		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 percent 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	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).
	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 and 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 percent 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).

Criteria	Connectivity feature	Discussion
		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). 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, Squirrel Glider and potentially the Eastern Pygmy-possum 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	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). 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.

Criteria	Connectivity feature	Discussion
	Specific movement	A number of species migrate for particular parts of their life cycle or have seasonal movements. These species may use any of the connectivity values described above as part of their movement across the study area: • **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. This species would occur in the study area outside its breeding season. • **Regent Honeyeater**. The Regent Honeyeater breeds at four main locations in NSW and disperses outside the breeding season to foraging habitat. It is an occasional non-breeding visitor to the study area. • **Swift Parrot**. The Swift Parrot breeds in Tasmania and migrates to the mainland outside the breeding season. It is an occasional non-breeding visitor to the study area. • **Painted Honeyeater.** This species exhibits seasonal north-south movements governed principally by the fruiting of mistletoe, with which its breeding season is closely aligned (Barea and Watson 2007).

8.3 Vehicle strike

A number of fauna species are likely to be at risk of vehicle strike during construction and train strike during operation (Table 8.2). Refer to section 10.2 and Appendix J for further discussion.

Table 8.2 Vehicle strike risk

Impact	Description	
Where the proposal may result in vehicle strike on threatened fauna, or animals that are part of a TEC, the assessor must:		
a. identify potential impact locations on the Site Map, and	Parts of the proposal site is located adjacent to roads, or crossroads and access tracks. Construction of the entire proposal would increase the risk of vehicle strike through the movement of construction vehicles, particularly in forested areas. Operation of the proposal has the potential to result in injury and mortality through train strike along the length of the rail line, with a high risk in forested areas.	
b. prepare a list of threatened fauna or animals that are part of a TEC at risk of vehicle strike.	Koala Black-striped Wallaby Rufous Bettong Pilliga Mouse Eastern Pygmy-possum Squirrel Glider Corben's Long-eared Bat Large-eared Pied Bat Little Pied Bat Pale-headed Snake	Barking Owl Masked Owl Bush Stone-curlew Brown Treecreeper Diamond Firetail Flame Robin Grey-crowned Babbler Hooded Robin Speckled Warbler Varied Sittella

8.4 Human-made structures

The proposal is located predominantly in agricultural or forested land, however some human-made structures of relevance to threatened fauna are present (Table 8.3).

Table 8.3 Habitats associated with human-made structures

Impact	Description
1. If human-made structures (e.g. bridges, culverts, abandoned buildings) provide habitat for threatened species, the assessor must: a. Provide a description of the type of human-made structure habitat	Human-made structures that may be of relevance include old buildings, sheds and wooden telegraph poles.
b. Prepare a list of threatened species that use these features as habitat	Large bent-winged Bat (roosting) Little Pied Bat (roosting) Yellow-bellied Sheath-tail Bat (roosting)
c. Describe how each threatened species could, or does, use the human-made structure as habitat (based on published literature and other reliable sources)	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).

8.5 Non-native vegetation

Habitats associated with cropped land and planted trees are detailed in Table 8.4

Table 8.4 Habitats associated with non-native vegetation

Impact	Description
If non-native vegetation provides habitat for threatened species, the assessor must: a. Provide a description of the type of non-native vegetation habitat	A large proportion of the proposal site comprises cleared or cropped land (about 1,638 hectares). Small areas of planted trees (eg windbreaks) also occur. These provide habitat for common fauna species.
b. Prepare a list of threatened species that use these features as habitat	Spotted Harrier Little Eagle Large Bent-winged Bat Five-clawed Worm-skink
c. Describe how each threatened species could, or does, use the non-native vegetation as habitat (based on published literature and other reliable sources)	The Spotted Harrier eats terrestrial birds (such as quail and pipits), mammals (rabbits and rodents), reptiles and large insects. It rarely easts carrion (Debus 2019). This species was observed foraging over cropped land near Narromine and around planted roadside shrubs near Gilgandra. The Little Eagle hunts mammals, birds and reptiles. It occasionally eats carrion. In the south of its range it prefers young rabbits, while in the north it prefers birds, and in the arid zone reptiles (small goannas, dragons and large skinks) (Debus 2019). This species may forage over cropped land and in planted vegetation. The Large Bent-winged Bat and Yellow-bellied Sheath-tail Bat forage in a range of habitats, including above grassland. These species fly within a few metres of the ground over grassland, catching a range of insects (Churchill 2008). These species may forage above cropped land. The 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.

8.6 Karst, caves cliffs, rocks and other geological features of significance

No areas of karst, caves, crevices or cliffs are present in the proposal site (see section 4.4.5). The incidence and value of rocky outcrops to threatened species is discussed in Table 8.5.

Table 8.5 Geological features of significance

Impact	Description
1. If karst, caves crevices, cliffs, rocks or other geological features of significance are on the site, the assessor must:	No areas of karst, caves, crevices or cliffs are present in the proposal site (see section 4.4.5). Limited areas of scattered rocks are present in the study area. The lower slopes of the outlier hills associated with the Warrumbungle Range near Mt Tenandra 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 by landowners. No crevices or caves were present in these areas. Loose surface rock is present at Borrow Pit A, south of Narromine.
Prepare a list of threatened entities that use or are likely to use these habitat features on the subject land and within the surrounding assessment area	Surface rock can provide habitat for Pink-tailed Legless Lizard (*Aprasia parapulchella*). The occurrence of the species appears to be correlated to the underlying geology with most occurrences on intermediate volcanics.
Describe how these features provide habitat for, or are used by, each threatened entity (based on published literature and other reliable sources).	The Pink-tailed Legless Lizard 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 at this location (see Appendix I). Volcanic habitat in the Pilliga subregion is associated with outlying hills of the Warrumbungles. The proposal skirts around the outside of these, and the geology within the proposal site near these hills is sedimentary rock. There are no known records in this area (see Appendix I).

8.7 Water bodies, water quality and hydrological processes

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).

Table 8.6 Habitats associated with waterbodies

Impact	Description
1. Where water bodies or any hydrological processes that sustain threatened entities occur on the subject land, the assessor must: a. prepare a list of threatened entities that may use or depend on water bodies or hydrological processes for all or part of their life cycle or	Australian Painted Snipe Australasian Bittern
b. prepare a list of threatened entities that will be, or are likely to be impacted by changes to existing water bodies or hydrological processes or the construction of a new water body	While these species may occur on occasion, the proposal is unlikely to alter water bodies or hydrological processes such that habitat values for these species are affected
c. describe the habitat provided for each threatened entity by the water body or hydrological process, including consideration of water quality, volume, flow paths and seasonal patterns (based on published literature and other reliable sources)	**Australian Painted Snipe** The Australian Painted Snipe is a wading bird inhabiting shallow, terrestrial, freshwater (occasionally brackish) wetlands in all states of Australia. These wetlands include temporary and permanent lakes, swamps, clay pans, inundated/waterlogged grasslands or saltmarsh, dams, rice crops, sewage dams and bore drains (DAWE 2020b). Australian Painted Snipe breeding habitat requirements may be quite specific: shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby. Nest records are all, or nearly all, from or near small islands in freshwater wetlands, provided that these islands are a combination of very shallow water, exposed mud, dense low cover and sometimes some tall dense cover (Rogers et al. 2005). There are a small number of records of this species within 20 kilometres of the alignment, including a creekline in agricultural land north of Dubbo, Carmel Lagoon (a farm dam) north-west of Baradine, and Narrabri Lake (EES 2019b, Birdata 2020). Limited wetland habitat is present in the study area. No preferred breeding habitat (islands in freshwater wetlands) is present, however areas of tall emergent reeds are present at the Castlereagh River and Namoi River, which may provide marginal breeding habitat. Small areas of mudflats and emergent reeds were observed near Narrabri Creek and Namoi River that could provide habitat for the species. Emergent reeds occur in the sandy bed of the Castlereagh River. Small areas of mudflats were observed near small remnant ponds. When under higher flows, areas of mudflats would reduce. **Australian Bittern** The Australasian Bittern is a relatively large wetland bird (66 to 76 centimetres long) occurring in Australia in south east Queensland, south east Australia, Tasmania and south

Impact	Description
	west Western Australia (DAWE 2020b). This species favours terrestrial wetlands vegetated with tall, dense vegetation dominated by sedges, rushes and/or reeds (flora species from the genera *Phragmites, Cyperus, Eleocharis, Juncus, Typha, Baumea, Bolboschoenus* and *Gahnia*) on muddy/peaty substrates. The Australasian Bittern forages in still water of 30 centimetres maximum depth at the edges of pools or waterways, or platforms/mats of vegetation over deep water (DAWE 2020b). Knowledge of the breeding habitats is poor, however data indicates that the species breeds in relatively deep, densely vegetated freshwater swamps and pools. The species builds nests in deep cover over shallow water (DAWE 2020b). Large numbers of bitterns may breed in rice crops of the New South Wales' Riverina each year (Bitterns in Rice Project 2018). There is one record of the species within 20 kilometres of the 300 kilometres alignment (EES 2019b). No Birdata (2020) records occur near the alignment. The study area is unlikely to support a population of this species. Limited wetland habitat is present in the study area. Small areas of mudflats and emergent reeds were observed near Narrabri Creek and Namoi River that could provide habitat for the species. Emergent reeds occur in the sandy bed of the Castlereagh River. Small areas of mudflats were observed near small remnant ponds. When under higher flows, areas of mudflats would reduce.

9. Impact assessment

9.1 Avoid and minimise impacts

9.1.1 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 forests 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 proposal investigation corridor, as did reviews of regional vegetation mapping.

Potential sites for borrow pits were initially identified through a public expression of interest released by ARTC in early 2019. Geotechnical and environmental investigations and analysis were undertaken for 26 shortlisted sites, which was refined to 16 sites and then to four sites. Biodiversity surveys were conducted at sixteen sites and results of these surveys fed into the selection of the final four borrow pits. A number of potential borrow pit and haul road sites were heavily vegetated and contained high habitat values, while others were in predominantly cleared or partially cleared locations. None of the heavily vegetated sites were included in the final four sites. Following extraction of required material from the borrow pits, all facilities would be removed and the pits would be stabilised and rehabilitated. Rehabilitation of the borrow pits would be undertaken in accordance with the borrow pit rehabilitation strategy.

The proposal was purposefully modified to avoid impacts to biodiversity values in particular locations and especially threatened biota (Table 9.1).

Table 9.1 Measures to avoid impacts

Impact type	Measures
Direct impacts	• 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.

9.1.2 Design measures to minimise impacts

Design features that minimise direct impacts on biodiversity values are detailed in Table 9.2.

Table 9.2 Measures to minimise impacts

Impact type	Measures
Direct impacts	• The need for many bridges along the alignment allows opportunities for retention of connectivity and all bridges have been designed to minimise impacts so far as practicable. Many fauna species use dry creek beds and riparian vegetation for movement through the landscape. The retention of these areas would 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 to 12 metres above ground level) would allow some retention of groundcover and riparian vegetation, and allow fauna to move under the rail line
Prescribed impacts	• The retention of groundcover and shrub vegetation within the operational rail corridor presents an opportunity for minimising impacts on connectivity • Dedicated fauna culverts have been proposed in the Pilliga forests and Bohena Creek area, targeting species including the Koala, Black-striped Wallaby, Rufous Bettong, Eastern Pygmy-possum, and Pilliga Mouse

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 commencement of construction:

- surveys of previously unassessed properties where possible to better quantify impacts and identify site-specific mitigation measures
- narrowing of the construction impact zone where feasible in areas of higher biodiversity value.

9.2 Proposed measures to mitigate impacts

A range of mitigation measures are proposed in section 12 to minimise impacts on biodiversity and will be included in the Construction Environment Management Plan (CEMP). Mitigation measures relating to direct, indirect and prescribed impacts are summarised in Table 9.3.

Table 9.3 Measures to mitigate impacts

Impact type	Measures
Direct impacts	• Mapping and fencing of sensitive areas to minimise additional vegetation clearing • 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 • Staged rehabilitation (including revegetation where required) of disturbed areas following construction. • Further surveys targeting threatened species, in order to confirm the extent of impacts and provide specific mitigation measures if required during construction
Indirect impacts	• 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
Prescribed impacts	• Preparation of a fauna connectivity strategy, including detailed assessment and design of locations for fauna crossing structures, including dedicated underpasses, canopy bridges 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 Appendix J

9.3 Construction impacts

Construction of the proposal would result in direct impacts within a 3,429 hectare disturbance footprint, including 1,791 hectares of native vegetation as shown in Appendix G. The proposal includes impacts on around 1,211 hectares of native woodland, shrubland and forest vegetation in good condition, 580 hectares of native and derived native grassland. The proposal would impact 654 hectares of native vegetation (forest, woodland and grassland) within the Pilliga forests.

9.3.1 Construction direct impacts

Rail infrastructure

Direct impacts on native vegetation

The proposal would remove up to 1,791 hectares of native vegetation.

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 1,791 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 12.1.2). 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 1,791 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 1,173 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 9.4.

Direct impacts on fauna and habitat values

The proposal would result in the removal of 1,638 hectares of exotic grassland or cropland and 580 hectares of derived native grassland 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. In addition, the proposal would remove 39 hectares of shrubland vegetation, which provides habitat for small mammals, reptiles and small birds.

Construction would require the permanent removal of a maximum area of 1,211 hectares of woodland, forest and shrubland habitat, including large areas containing mature trees, hollow-bearing trees (see Table 9.5), trees with mistletoe, flowering shrubs and other foraging resources. 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.

A summary of direct impacts on flora and fauna habitat values is provided in Table 9.4.

Direct impacts on habitat in the Pilliga forests

The proposal would have substantial impacts on fauna habitats within the Pilliga forests. Construction of the proposal would clear a gap of ranging between 33 metres to 400 metres wide (with about 29 percent in the 50-60 metres category, and averaging a width 89 metres) along a 73 kilometre alignment in the Pilliga. This would be exacerbated where the alignment is parallel to Pilliga Forest Way. This new gap in the forest would 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).

Impacts on habitat within Travelling Stock Reserves

The proposal impacts several TSRs. The proposal would remove native vegetation and habitat for threatened flora and fauna at the following locations:

- Webbs Siding: Mitchell Highway near High Park Road, Narromine. A large viaduct would be located within this TSR. Construction would remove areas of PCT 248 Mixed Box Woodland and PCT 36 River Red Gum woodland along the river banks. Connectivity would be retained under the viaduct.
- Bugabada: Collie Road, Kickabil. The proposal would remove a small area of vegetation from adjacent to the intersection of Collie Road and Old Mill Road.
- Buramilong: Berida Road, Collie. The proposal would remove PCT 56 Poplar Box - Belah woodland from within this small reserve. Surrounding area is predominantly cleared for agriculture. Remaining vegetation would have limited value for fauna, other than as stepping-stone habitat within the wider landscape.
- Callangoan, Terrabile. The proposal would remove a small area of PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland from this reserve, which runs parallel to the Castlereagh River at Curban. Riparian vegetation that occurs along the river and would be retained provides better quality habitat for native flora and fauna than the habitats present in the TSR.

- Newell Highway between The Pilliga and Narrabri West. The proposal would remove a long, linear strip of forested vegetation parallel to the Newell Highway from within this TSR. The TSR would become narrower, particularly in the north where Bohena Creek curves in towards the highway. The TSR and riparian corridor associated with Bohena Creek would, however, continue to provide a wildlife corridor alongside the highway and north towards Narrabri.
- Yarrie Lake Road, Narrabri West. The proposal would remove a negligible area of disturbed vegetation from the narrow, linear roadside strip.

Removal of hollow-bearing trees

The proposal would remove 1,034 hectares of native forest and woodland that contains hollow-bearing trees, resulting in the removal of a substantial number of hollows. 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 14,503 and 38,398 hollow-bearing trees based on these estimates (see Table 9.5), 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 percent of hollow-bearing trees not accounted for), while for those dominated by ironbark species the total has been multiplied by 1.3 (ie 30 percent of hollow-bearing trees not accounted for). This increased the number of hollow-bearing trees that may be lost to between 16,114 and 41,103 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 9.4 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, Pine Donkey Orchid, *Tylophora linearis* 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 12.1.1).	Impacts of vehicle strike (including train strike) are discussed in detail in Appendix J. Fauna connectivity measures and fencing are discussed in more detail in Appendix J.
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 10.2.2.

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 forests 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 10.2.7. Impacts on fish habitat are discussed in the aquatic ecology assessment.
Removal of hollow-bearing trees	The proposal will potentially remove between 14,503 and 41,103 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 9.5). 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 9.5 for calculations of loss of hollow-bearing trees.

Table 9.5 Loss of hollow-bearing trees

PCT ID	Vegetation zone	Area (ha)	Average number of HBTs per veg zone plot	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone	Ironbark adjustment (average)	Ironbark adjustment (maximum)
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	6.5	0	0	0	0	0	0	0	0
35	Brigalow – Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – DNG	5.9	0	0	0	0	0	0	0	0
35	Brigalow – Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – Good	1.4	1	1	10	10	14	14	14	14
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good	5.8	1.67	3	17	30	96	173	92	165
49	Partly derived Windmill Grass – Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Derived	19.5	0	0	0	0	0	0	0	0
49	Partly derived Windmill Grass – Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	310.6	0	0	0	0	0	0	0	0
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	4.0	1	1	10	10	40	40	40	40
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – DNG	18.4	0	0	0	0	0	0	0	0
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	19.8	1.5	4	15	40	297	791	278	740
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – DNG	1.3	0	0	0	0	0	0	0	0

PCT ID	Vegetation zone	Area (ha)	Average number of HBTs per veg zone plot	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone	Ironbark adjustment (average)	Ironbark adjustment (maximum)
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion –Good	29.4	1.2	3	12	30	353	882	328	819
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion – Good	0.9	3	3	30	30	27	27	0	0
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	89.8	0	0	0	0	0	0	0	0
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	310.6	0.94	4	9	40	2920	12424	2839	12080
88	Pilliga Box – White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Low	1.7	1	1	10	10	17	17	17	17
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	30.9	0	0	0	0	0	0	0	0
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – DNG	5.8	0	0	0	0	0	0	0	0
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	65.1	1.4	3	14	30	912	1954	862	1848
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 – DNG	95.4	0		0	0	0	0	0	0
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	46.2	0.5	1	5	10	231	462	254	509
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – Derived	7.3	0	0	0	0	0	0	0	0
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – Good	12.1	0	0	0	0	0	0	0	0

PCT ID	Vegetation zone	Area (ha)	Average number of HBTs per veg zone plot	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone	Ironbark adjustment (average)	Ironbark adjustment (maximum)
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – DNG	1.4	0	0	0	0	0	0	0	0
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – Good	3.6	2	3	20	30	72	108	72	108
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) – Good	10.1	1.2	4	12	40	122	405	122	405
206	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – Good	43.9	1.14	3	11	30	501	1318	463	1219
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – good	16.3	1.67	3	17	30	272	488	265	475
248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW – Good	95.4	0		0	0	0	0	0	0
255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	12.1	1	1	10	10	121	121	134	134
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion – Good	0.3	0	0	0	0	0	0	0	0
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – DNG	15.4	0	0	0	0	0	0	0	0
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	54.6	1	1	10	10	546	546	710	710
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good, fire affected	11.1	0	0	0	0	0	0	0	0

PCT ID	Vegetation zone	Area (ha)	Average number of HBTs per veg zone plot	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone	Ironbark adjustment (average)	Ironbark adjustment (maximum)
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good	17.8	1.5	6	15	60	267	1067	261	1044
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	373.9	1.5	3	15	30	5608	11216	7291	14581
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 (Moderate, shrubs removed)	8.4	0.67	4	7	40	56	337	73	438
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	54.8	2.14	7	21	70	1173	3838	1019	3332
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Good	25.1	1.25	3	13	30	314	753	408	979
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests – Good	2.4	1	2	10	20	24	48	26	53
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	0.8	1	1	10	10	8	8	8	8
414	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion – Good, fire affected	7.3	0.33	10	3	100	24	731	24	731
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – DNG	5.1	0	0	0	0	0	0	0	0

PCT ID	Vegetation zone	Area (ha)	Average number of HBTs per veg zone plot	Maximum HBT in a plot per veg zone	Average HBT/ha	Maximum HBT/ha	Total HBT per zone	Maximum HBT per zone	Ironbark adjustment (average)	Ironbark adjustment (maximum)
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – Good	0.3	1	1	10	10	3	3	3	3
444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion – Good	1.7	1	1	10	10	17	17	23	23
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion – Good	1.0	0	0	0	0	0	0	0	0
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 – DNG	0.9	0	0	0	0	0	0	0	0
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	19.2	1.67	2	17	20	321	384	353	423
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion – Moderate, logged	1.0	1	1	10	10	10	10	11	11
599	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions – Good	3.0	4.5	7	45	70	137	213	126	196
746	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion – Good	2.1	0	0	0	0	0	0	0	0
1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion – Good	8.8	0	0	0	0	0	0	0	0
	Total	**1791.0**					**14,503**	**38,398**	**16,114**	**41,103**

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 9.6 and are included in the total impacts of the proposal.

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 9.6 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 2.2 hectare linear strip of PCT 88 (Pilliga Box - White Cypress Pine - Buloke shrubby woodland) and 11.7 hectares of PCT 49 (Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland) 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 5.1 hectares of PCT 148 (Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland) in good condition and an additional 87.9 hectares of PCT148 that occurs as derived native grassland.	Assumed habitat for the threatened flora species *Lepidium monoplocoides, Lepidium aschersonii, Cyperus conicus, Pomaderris queenslandica, Diuris tricolor, Polygala linarifolia* and *Tylophora linearis* 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 9.7.

Following extraction of all required material from the borrow pits, all facilities would be removed and the borrow pits 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 9.7 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 entirely with PCT 185 (Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland) in two different conditions. Most of the site is derived native grassland with a small area of regrowth 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 13.5 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	Borrow pit 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 4.1 hectares of PCT 255 (Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland), located adjacent to the existing quarry. Areas of crops 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. 5.8 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 0.4 hectares of PCT 88 (Pilliga Box - White Cypress Pine - Buloke shrubby woodland) and 7.7 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. 4.8 hectares of cropped land would be removed.	No threatened flora is known or assumed to be present in borrow pit C. 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 occur on 20.8 hectares of recently 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 and leading to the haul road (2.1 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.	No threatened flora is known or assumed to be present in borrow pit D. 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 in the northern section and derived native grassland in the southern section. 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.

9.3.2 Indirect impacts on native vegetation and habitat

A summary of indirect impacts associated with the proposal is provided in Table 9.8.

Table 9.8 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.

Impact	Description
	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.
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 percent 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 10.2.7 for a discussion of prescribed impacts associated with hydrology.

9.4 Operation impacts

9.4.1 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 9.9.

Table 9.9 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. The height of double-stacked containers further increases the risk of train strike for aerial or gliding fauna. 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. 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 10 trains per day (both directions) in 2026, increasing to about 14 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 (Appendix J). These include bridges, underpasses and canopy bridges.	Impacts of vehicle strike (including train strike) are discussed in detail in section 10.2.3 Fauna connectivity measures and fencing are discussed in more detail in Appendix J.
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 crossing loops and sections where the rail line is parallel to Pilliga Forest Way the gap will be much wider (for example between 60-120 metres wide). The proposal will compound fragmentation caused by Pilliga Forest Way and other cleared tracks, as well as other roads elsewhere in the alignment. 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 (Appendix J). These include bridges, underpasses and canopy bridges.	Fauna connectivity measures are discussed in more detail in section Appendix J.

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.	
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 9.3.2, weeds can reduce quality of vegetation and thus impact fauna and flora habitats. Mitigation measures	

Impact	Description	Further detail
	to minimise the risk of weed introduction and spread are provided in section 14.5. 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).	

9.4.2 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.

9.5 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.

9.6 Cumulative impact

9.6.1 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). Construction of the proposal would clear a gap of ranging between 33 metres to 400 metres wide (with about 29 percent in the 50-60 metres category, and averaging a width 89 metres) along a 73 kilometre alignment in the Pilliga. This would be exacerbated where the alignment is parallel to Pilliga Forest Way.

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

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

In addition, the reintroduction of locally extinct mammals in Pilliga State Conservation Area (the RLEM project) was also assessed for cumulative impacts. This project required the clearing of vegetation for some infrastructure and the installation of a predator-proof fence around the reserve. This project is located about seven kilometres to the north-west of the proposal site in the Pilliga (AWC and Envirokey 2017). This project adds to the cumulative loss and fragmentation of native vegetation and associated habitats such as hollow-bearing trees in the region but doesn't substantially change the assessment of cumulative impacts provided in the exhibited EIS.

9.6.2 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 9.10. 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) – 33.4 hectares (8.4 hectares for the proposal / 25 hectares from other projects)
- Brigalow (BC Act) – 43.81 hectares (7.3 hectares for the proposal / 36.51 hectares from other projects)
- Fuzzy Box Woodland (BC Act) – 11.6 hectares (3.6 hectares for the proposal / 8.0 hectares from other projects)
- Myall Woodland (BC Act) – 24.44 hectares (6.5 hectares for the proposal / 17.94 hectares from other projects)
- Inland Grey Box Woodland (BC Act) – 56.2 hectares (17.2 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.

9.6.3 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 9.10 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 2020)	Construction of approximately 183 kilometres of upgraded track between Narrabri and North Star	Removal of 890.41 hectares of native vegetation	**BC Act** Brigalow: 17.21 hectares Myall Woodland: 17.94 hectares Carbeen Open Forest community in the Darling Riverine Plains and Brigalow Belt South Bioregions: 0.51 hectares Coolibah - Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregions: 1.74 hectares **EPBC Act** Weeping Myall Woodland: 9.16 hectares Natural grassland on basalt and Fine-textured Alluvial Plains: 432.07 hectares Coolibah - Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregions: 1.74 hectares Brigalow (*Acacia harpophylla* dominant and codominant) EEC: 16.13 hectares	**Species credit impacts** Removal of 66 individuals of *Digitaria porrecta* (Finger Panic Grass) Removal of 255 individuals of *Homopholis belsonii* (Belson's Panic) Removal of 432.07 hectares of habitat for *Desmodium campylocaulon* (Creeping Tick-trefoil) Removal of 175.25 hectares of Koala habitat **Ecosystem credit impacts** Removal of up to 890.41 hectares of habitat for a range of ecosystem 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)	**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
			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)	
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

Project	Description	Impacts on native vegetation	Impacts on threatened ecological communities	Impacts on threatened species
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
RLEM project	Clearing for a fence and infrastructure for the reserve located in the Pilliga forests.	Removal of about 62 hectares of native vegetation	No impact on threatened ecological communities.	Removal of at least 26 *Tylophora linearis* plants Removal of hundreds of *Commersonia* plants Removal of potential habitat for *Diuris tricolor* and *Pterostylis cobarensis* Removal of 62 hectares of habitat for a range of threatened fauna species

9.7 Changes following public exhibition period

Changes to the Construction Impact Zone (CIZ) occurred following submission of the EIS as design development was progressed. Furthermore, detailed consultation with BCS project officers following submission also led to revision of the methodology for preparing the species polygons, as well as contracting the preparation of three expert reports. Due to the protracted time period for the resolution of some aspects of the proposal in consultation with DPIE, the final EIS and supporting documentation was not able to be submitted and approved by DPIE prior to the transition period of the BAM 2017 ending. This BDAR has therefore been updated to meet the requirements of BAM 2020. These various changes following amendments from the exhibited EIS are detailed in Table 9.11.

Table 9.11 Changes to impact areas following exhibition

Component/species	Impact area (exhibition) BAM 2017	Impact area (Revised BDAR) BAM 2020)	Reason for change (BAM 2020 version)	Increase/ decrease
CIZ	3,258	3,429	Increase in the overall CIZ	Increase
Native vegetation and species habitats	1,732	1,791	Increase in clearing of native vegetation and fauna habitats	Increase
Bertya opponens	13.85 ha (4 individuals)	0 ha	Removal of area at Bohena Creek as assumed presence, given lack of evidence in multiple surveys. Detailed surveys conducted in areas of the Pilliga previously unsurveyed to confirm absence.	Decrease
Diuris tricolor	629.97	388.5	Positive identification of 28 individual plants and reduction in clearing impacts of known and assumed habitat following additional surveys. Increase as a result of increase to area of CIZ for flood mitigation	Decrease
Commersonia procumbens	565.14	573.1	Slight increase in clearing impacts to assumed habitat based on revised vegetation zone mapping and review of TBDC. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Lepidium aschersonii	10.27	338.7	Increased clearing impacts to assumed habitat followed by reduction through additional targeted surveys in some areas where access became available. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Lepidium monoplocoides	194.29	177.5	Reduction in clearing impacts to assumed habitat through additional targeted surveys in some previously assumed habitat areas where access became available. Some increases as a result of increase to area of CIZ for flood mitigation. Reduction in some areas due to changes in vegetation mapping	Decrease
Polygala linariifolia	565.86	263.2	Reduction in clearing impacts to assumed habitat through targeted surveys in some previously assumed habitat areas where access became available. Some increases as a result of increase to area of CIZ for flood mitigation. Reduction in some areas due to changes in vegetation mapping	Decrease

Component/species	Impact area (exhibition) BAM 2017	Impact area (Revised BDAR) BAM 2020)	Reason for change (BAM 2020 version)	Increase/ decrease
Pterostylis cobariensis	193.04 (1 individual)	442.9 (495 individuals)	Additional records for 495 individuals following additional targeted surveys and increased clearing impacts on known and assumed habitat. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Swainsona murrayana	43.58	50.0	Slight increase in clearing impacts to assumed habitat. Reduction in some areas through targeted surveys where access became available but additional assumed habitat areas based on review of TBDC. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Tylophora linearis	582.50	37.9	Positive identification of three individual plants and reduction in clearing impacts on known and assumed habitat	Decrease
Cyperus conicus	0	50.8	Impacts on assumed habitat which could not be excluded in some areas due to lack of access and the occurrence of associated PCTs. Increase as a result of increase to area of CIZ for flood mitigation	Candidate species previously assessed as 'not on site'. Changed to assumed presence following consulation with BCS.
Dichanthium setosum	0	3.5	Impacts on assumed habitat which could not be excluded in some areas due to lack of access and the occurrence of associated PCTs	Candidate species previously assessed as 'not on site'. Changed to assumed presence following consulation with BCS.
Pomaderris queenslandica	0	9.06	Impacts on assumed habitat which could not be excluded in some areas due to lack of access and the occurrence of associated PCTs. Increase as a result of increase to area of CIZ for flood mitigation	Candidate species previously assessed as 'not on site'. Changed to assumed presence following consulation with BCS.

Component/species	Impact area (exhibition) BAM 2017	Impact area (Revised BDAR) BAM 2020)	Reason for change (BAM 2020 version)	Increase/ decrease
Swainsona sericea	0	78.9	Impacts on assumed habitat which could not be excluded in some areas due to lack of access and the occurrence of associated PCTs	Candidate species previously assessed as 'not on site'. Changed to assumed presence following consulation with BCS.
Zieria ingramii	0	48.6	Impacts on assumed habitat which could not be excluded in some areas due to lack of access and the occurrence of associated PCTs	Candidate species previously assessed as 'not on site'. Changed to assumed presence following consulation with BCS.
Barking Owl	24.29	258.4	Increase in area of impact for potential breeding habitat based on consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Bush Stone-curlew	337.29	551.0	Increase in area of impact for potential habitat based on revised vegetation zone mapping, review of TBDC and consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Eastern Pygmy-possum	707	836.1	Increase in area of impact for potential habitat based on consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Glossy Black-cockatoo	30.55	324.7	Increase in area of impact for potential breeding habitat based on consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation. Change in survey months allowing some additional areas of assumed presence to be removed	Increase

Component/species	Impact area (exhibition) BAM 2017	Impact area (Revised BDAR) BAM 2020)	Reason for change (BAM 2020 version)	Increase/ decrease
Koala	718.26	260.4	Decrease in area of impact for important habitat based on the species expert report and results of thermal drone surveys. Increase as a result of increase to area of CIZ for flood mitigation	Decrease
Little Eagle	15.9	465.4	Increase area of impact for potential breeding habitat based on the species expert report. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Masked Owl	7.25	186.0	Increase in area of impact for potential breeding habitat based on consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Pale-headed Snake	206.7	286.8	Increase in area of impact for potential habitat of the Pale-headed Snake based on revised consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Rufous Bettong	244.35	357.9	Increase in area of impact for potential habitat based on consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Square-tailed Kite	35.09	407.5	Increase in area of impact for potential breeding habitat based on the species expert report. Increase as a result of increase to area of CIZ for flood mitigation	Increase
Squirrel Glider	688.3	651.6	Slight decrease in area of impact for potential habitat of the Squirrel Glider based on revised vegetation zone and habitat mapping and consultation with BCS project officers regarding assumption of presence and taking into account areas where surveys have been undertaken. Increase as a result of increase to area of CIZ for flood mitigation	Decrease

10. Assessment of impacts required by the BAM

10.1 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 (DPIE 2019).

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 (DPIE 2019).

10.1.1 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.

No assessment of serious and irreversible impacts has been prepared for the Squatter Pigeon. This species was not recorded during surveys and is highly unlikely to occur or be impacted by the proposal given there are very few records in NSW and most of these are from near the border with Queensland (see Appendix I).

One flora species identified as an SAII entity has previously been recorded in the proposal site, Coolabah Bertya (*Bertya opponens*). A detailed assessment in accordance with section 9.1 of the BAM is provided in Table 10.1.

10.1.2 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 10.2, Table 10.3 and Table 10.4 in accordance with the BAM. A threshold of impacts has not been identified for these communities and any impact to these SAII entities is at the discretion of the accredited assessor. Based on the assessment for each of the SAII entities in Table 10.2, Table 10.3 and Table 10.4, 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 10.1 Assessment of serious and irreversible impacts for *Bertya opponens*

Criteria	Assessment
1. Current status	
a. evidence of rapid decline (Principle 1, clause 6.7(2)(a) BC Regulation) presented by an estimate of the: i. decline in population of the species in NSW in the past 10 years or three generations (whichever is longer), or ii. decline in population of the species in NSW in the past 10 years or three generations (whichever is longer) as indicated by: an index of abundance appropriate to the species; decline in geographic distribution and/or habitat quality; exploitation; effect of introduced species, hybridisation, pathogens, pollutants, competitors or parasites	The *Bertya opponens* population within Jacks Creek State Forest has historically been reported to comprise up to five million plants (NPWS 2002), however it is expected to have declined from this estimate over the past 10 years based on previous records (BCS 2021). Stage 1 and 2 of the Narrabri Coal Mine, adjacent to Jacks Creek State Forest, were found to support up to 26,654 individuals across 210.5 hectares of native vegetation that would be lost as a result of this project. The on-site offset package for this project includes the protection of nearly 380 hectares of Red Ironbark – Brown Bloodwood shrubby woodland (not affected by any direct or indirect impacts of this project) and a further 297 hectares of the same vegetation type occupied by B. opponens which is located within the 1,168 hectares affected by subsidence. The offset provides an estimated 327,094 plants (outside the area affected by surface impacts and subsidence), with an additional estimated 169,184 plants within the subsidence area (a total of approximately 500,000 plants) (Ecological 2014). An estimated 15,345 plants would be lost as a result of Stage 3 of the same project (Whitehaven Coal 2019). The previous record near Bohena Creek rest area which occurs within the CIZ comprised five individuals (two juveniles and three seedlings). This group of plants is isolated from the main population within Jack's Creek State Forest, about 15 kilometres to the east. These individuals were not able to be relocated despite multiple surveys, and it is assumed they no longer occur. The original site, on a property near Coolabah, is the only site in far-western NSW where the species is known to still exist, although the population is senescent and not in good health. This population comprises 500-600 plants but there are indications that there were perhaps two to three times this number originally with senescent individuals either dying or being blown-out gradually over the past 20 years ((NPWS 2002). A population was known from private property near Cobar but this population has not been seen since 1982 and is possibly now extinct (OEH 2020b). The Gibraltar Range National Park population comprises approximately 20 plants at an advanced age. The Kangaroo River State Forest population comprises about 500 individuals (NPWS 2002). BAM Support has no information relating to this principle.

Criteria	Assessment
b. evidence of small population size (Principle 2, clause 6.7(2)(b) BC Regulation) presented by: i. an estimate of the species' current population size in NSW, and ii. an estimate of the decline in the species' population size in NSW in three years or one generation (whichever is longer), and iii. where such data is available, an estimate of the number of mature individuals in each subpopulation, or the percentage of mature individuals in each subpopulation, or whether the species is likely to undergo extreme fluctuations	BAM Support has no information relating to this principle. Given this species has been recorded in very high numbers it is does not meet this principle.
c. evidence of limited geographic range for the threatened species s (Principle 3, clause 6.7(2)(c) BC Regulation) presented by: i. extent of occurrence ii. area of occupancy iii. number of threat-defined locations (geographically or ecologically distinct areas in which a single threatening event may rapidly affect all species occurrences), and iv. whether the species' population is likely to undergo extreme fluctuations	Estimated EOO = <100 km^2 Estimated AOO = 32 km^2 Number of locations = 3-4
d. evidence that the species is unlikely to respond to management (Principle 4, clause 6.7(2)(d) BC Regulation) because: i. known reproductive characteristics severely limit the ability to increase the existing population on, or occupy new habitat (eg species is clonal) on, a biodiversity stewardship site ii. the species is reliant on abiotic habitats which cannot be restored or replaced (eg karst systems) on a biodiversity stewardship site, or iii. life history traits and/or ecology is known but the ability to control key threatening processes at a biodiversity stewardship site is currently negligible (eg frogs severely impacted by chytrid fungus).	BAM Support has no information relating to this principle. *Bertya opponens* is known to be threatened by the following: • Inappropriate fire regimes. Risk of population decline if fire frequency is less than three years or greater than 20 years. • Clearing and fragmentation of habitat for agriculture. • Invasion of habitat by introduced weeds. • Browsing by feral goats. • Road and fire trail construction and maintenance. • Risk of local extinction because populations are small and distribution is restricted.

Criteria	Assessment
Impact assessment	
a. the impact on the species' population (Principles 1 and 2) presented by: i. an estimate of the number of individuals (mature and immature) present in the subpopulation on the subject land (the site may intersect or encompass the subpopulation) and as a percentage of the total NSW population, and	*Bertya opponens* was not observed in any survey period despite multiple survey attempts to relocate the known record within the proposal site. Targeted surveys were conducted throughout most of the alignment through the Pilliga forests and Bohena Creek areas in multiple survey periods between September 2018 and March 2022. A population of *Bertya opponens* was previously known to occur at Bohena Creek, however this population was not able to be located despite multiple surveys between 2018 and 2020. As such, it is assumed this population no longer occurs. This portion of the species polygon has been removed following advice provided by BCS in November 2021. The species had been assumed to be present in areas of PCT 398 where access was not possible (parts of segment 10 in the Pilliga forests). These areas were not able to be accessed due to thick regrowth and distance from vehicle tracks making navigation extremely slow and unsafe. Targeted surveys were conducted in March 2022 in these areas, with multiple ecologists to minimise safety issues and improve potential for detection. No individuals were recorded in these areas. As such, the species is considered to be absent from the proposal site.
ii. an estimate of the number of individuals (mature and immature) to be impacted by the project and as a percentage of the total NSW population, or	No *Bertya opponens* were recorded in the surveys in the Pilliga and Bohena Creek area.
iii. if the species' unit of measure is area, provide data on the number of individuals on the site, and the estimated number that will be impacted, along with the area of habitat to be impacted by the project	Not applicable
b. impact on geographic range (Principles 1 and 3) presented by: i. the area of the species' geographic range to be impacted by the project in hectares, and a percentage of the total AOO, or EOO within NSW	No occupied habitat for the species would be removed.
ii. the impact on the subpopulation as either: all individuals will be impacted (subpopulation eliminated); OR impact will affect some individuals and habitat; OR impact will affect some habitat, but no individuals of the species will be directly impacted	No subpopulation was recorded in the CIZ during targeted surveys. No individuals were recorded elsewhere near the alignment when travelling along tracks or walking into the project site. The only subpopulation observed was the reference population at Jacks Creek State Forest, located around 15 kilometres away from the proposal site. There is potential for the species to occur elsewhere in the Pilliga.

Criteria	Assessment
iii. to determine if the persisting subpopulation that is fragmented will remain viable, estimate (based on published and unpublished sources such as scientific publications, technical reports, databases or documented field observations) the habitat area required to support the remaining population, and habitat available within dispersal distance, and distance over which genetic exchange can occur (eg seed dispersal) and pollination distance for the species	The CIZ generally ranges between 50-80 metres wide in the species polygon for this species, with larger gaps of 120-190 metres present where compound sites would be located. This species tends to respond to mechanical disturbance (eg track maintenance), and if present would likely increase in densities along the edge of the rail corridor. The primary mechanism for pollen dispersal in *Bertya opponens* is probably wind given that the flowers lack chemical and colour attractants and the styles and anthers are exposed. However, European honeybees have been observed visiting Bertya sp. Cobar-Coolabah flowers (NPWS 2002). Wind and bees would be able to travel across these gaps, allowing for continues genetic interchange across the rail corridor, if individuals occur in nearby areas. Seed dispersal is via explosive release, with seeds likely to fall relatively close to the parent plant. Movement by water may aid seed dispersal (NPWS 2002). Provision of bridges and drainage culverts would allow seed dispersal across the rail corridor at riparian corridors.
iv. to determine changes in threats affecting remaining subpopulations and habitat if the proposed impact proceeds, estimate changes in environmental factors including changes to fire regimes (frequency, severity); hydrology, pollutants; species interactions (increased competition and effects on pollinators or dispersal); fragmentation, increased edge effects, likelihood of disturbance; and disease, pathogens and parasites.	The proposal has the potential to further introduce a number of invasive flora species to areas of potential habitat for *Bertya opponens*. Introduction of weed species via vehicles and machinery operating in the proposal site could occur, as vehicles would be required to traverse a large area and variety of landscapes, including highly modified agricultural land and disturbed roadsides containing an abundance of introduced and invasive flora species. In addition to invasive flora, a number of feral fauna such as rabbits, feral pigs and goats can impact the species. Impacts from these species include habitat degradation, grazing and introduction of weed species. It is unlikely that the proposal will further facilitate the spread or establishment of feral fauna species in the proposal site. Disturbance can stimulate seed banks and create a trigger for germination. This species tends to respond to mechanical disturbance (eg track maintenance), and if present would likely increase in densities along the edge of the rail corridor. Given the lack of evidence of the species in the proposal site or nearby areas, the proposal is unlikely to indirectly impact any subpopulations.

Table 10.2 Assessment of serious and irreversible impacts for Box-Gum Woodland

Criteria	Assessment
1. Current status	
a. evidence of rapid decline (Principle 1, clause 6.7(2)(a) BC Regulation) as the current total geographic extent of the TEC in NSW AND the estimated reduction in geographic extent of the TEC since 1970 (not including impacts of the proposal)	Box Gum Woodland has declined by up to 96 percent in some areas. Austin et al. (2000) found the community had been reduced to less than one percent of its pre-European extent in the Central Lachlan region. Comparable degrees of reduction have been documented for NSW south western slopes and southern Tablelands (estimated <4 percent remaining, Thomas et. al. 2000), and for the Holbrook area (estimated <7 percent remaining, Gibbons and Boak (2000). Box Gum Woodland has had a reduction in geographic extent of ≥90 percent since 1750 or ≥80 percent since 1970.
b. extent of reduction in ecological function for the TEC using evidence that describes the degree of environmental degradation or disruption to biotic processes (Principle 2, clause 6.7(2)(b) BC Regulation) indicated by: i. change in community structure ii. change in species composition iii. disruption of ecological processes iv. invasion and establishment of exotic species v. degradation of habitat, and vi. fragmentation of habitat	Box Gum Woodland has been drastically reduced in area and highly fragmented because of clearance for cropping and pasture improvement. Austin et al. (2000) found the community had been reduced to less than one percent of its pre-European extent in the Central Lachlan region. Comparable degrees of reduction have been documented for NSW south western slopes and southern Tablelands (estimated <4 percent remaining, Thomas et. al. 2000), and for the Holbrook area (estimated <7 percent remaining, Gibbons and Boak (2000). Gibbons and Boak (2000) found remnants of woodlands dominated by *Eucalyptus albens, E. melliodora* and *E. blakelyi* were severely fragmented. Threats include: further clearing (for cropping, pasture improvement or other development); deterioration of remnant condition (caused by firewood cutting, increased livestock grazing, weed invasion, inappropriate fire regimes, soil disturbance and increased nutrient loads); degradation of the landscape in which remnants occur (including soil acidification, salinity, and loss of connectivity between remnants).
c. evidence of restricted geographic distribution for the threatened species s (Principle 3, clause 6.7(2)(c) BC Regulation) presented by: i. extent of occurrence ii. area of occupancy iii. number of threat-defined locations	Box Gum Woodland occurs in an arc along the western slopes and tablelands of the Great Dividing Range. Its extent ranges from Southern Queensland through NSW to Victoria. The extent of occurrence of this TEC is 263,778 square kilometres.
d. evidence that the TEC is unlikely to respond to management (Principle 4, clause 6.7(2)(d) BC Regulation)	This TEC is likely to respond to management practices such as weed control and revegetation. Eucalyptus dominated grassy woodland communities are, in general, capable of responding to management (*pers. obs*). Standard environmental management measures such as weed control, supplementary planting, maintenance of natural fire regimes and treatment of pest fauna are likely to result in positive responses in the composition and ecological function of the community.

Criteria	Assessment
Impact assessment	
a. the impact on the geographic extent of the TEC (Principles 1 and 3) by estimating the total area of the TEC to be impacted by the proposal: i. in hectares, and	The proposal would result in an impact on a SAII entity through the proposed removal of up to 8.4 hectares of Box-Gum Woodland, comprising three hectares of PCT 599 near Narromine and 5.4 hectares of PCT 435 near Baradine. These patches are located approximately 200 kilometres apart. PCT 599 occurs as a small roadside patch south of the Macquarie River near Narromine. Although no TEC option is available to select in the BAM-C, this PCT is known to be associated with the White Box Yellow Box Blakely's Red Gum Woodland elsewhere. The canopy is dominated by Yellow Box and Blakley's Red Gum with a forb rich understorey, including *Goodenia* spp, *Eryngium ovinum* and *Calotis lappulacea*. PCT 599 in the proposal site occurs in the Darling Riverine Plains IBRA region and Bogan-Macquarie IBRA subregion, which is not associated with this TEC in the BC Act final determination or EPBC listing advice. Given the location of the patch near the edge of this subregion, and the appropriate species and physiographic location, a conservative approach has been taken and this PCT has been assumed to be commensurate with White Box Yellow Box Blakely's Red Gum Woodland. PCT 435 occurs at Camp Cypress, in Baradine. The woodland and derived native grassland vegetation zones of this community occur as one continuous connected patch with the canopy dominated by White Box and White Cypress Pine and the groundcover dominated by native grassy species, including *Chloris truncata* and *Aristida* spp, *Rytidosperma* spp and *Austrostipa* spp.
ii. as a percentage of the current geographic extent of the TEC in NSW	This clearing equates to 0.00003 percent of the extent of occurrence.
b. the extent that the proposed impacts are likely to contribute to further environmental degradation or the disruption of biotic processes (Principle 2) of the TEC by: i. estimating the size of any remaining, but now isolated, areas of the TEC; including areas of the TEC within 500 m of the development footprint or equivalent area for other types of proposals	Impacts on this SAII entity south of Narromine will result in the reduction in the overall size of the patch but will not result in the fragmentation of any patches. The proposal will remove about three hectares from the patch, and about 2.5 hectares would be retained to the west of the proposal. Broad-scale regional vegetation mapping indicates that there are scattered patches of Box-Gum Woodland in the vicinity of Mt Tenandra, north-east of Gilgandra. None of the vegetation with the proposal site or surrounds near this location was identified as Box-Gum Woodland during surveys of the wider investigation area. As such, it is likely that this vegetation is not Box-Gum Woodland. Vegetation to be impacted at Baradine is part of a larger patch, with the derived grassland form extending across the Baradine showground. Canopy vegetation also extends around the showground and has wider connectivity in the area, including travelling stock reserves along Gulargambone-Baradine Road to the south, Baradine Road to the west, and Gwabegar Road and the Pilliga forests to the north. Removal of 5.4 hectares in this area would result in a reduction in the amount of this SAII entity, however, would not result in any new fragmentation or isolation of retained vegetation as the area to be removed is located on the edge of a much larger patch.

ii. describing the impacts on connectivity and fragmentation of the remaining areas of TEC measured by: distance between isolated areas of the TEC, presented as the average distance if the remnant is retained AND the average distance if the remnant is removed as proposed, and estimated maximum dispersal distance for native flora species characteristic of the TEC, and other information relevant to describing the impact on connectivity and fragmentation, such as the area to perimeter ratio for remaining areas of the TEC as a result of the development.	The proposal will result in further fragmentation of the vegetation in the locality including the local occurrences of Box-Gum Woodland (from PCT 599 south of Narromine, and PCT 435 near Baradine), which would likely comprise an important area of the community due to the limited area remaining across the landscape. The proposal would remove three hectares from the edge of an existing patch connected to remnant roadside vegetation and adjacent paddock trees south of Narromine. The remaining woodland would be a 2.5-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. As noted above, Box Gum Woodland is not listed as occurring in the Bogan-Macquarie IBRA subregion, however a conservative approach has been taken as this PCT can be associated with this TEC, and the patch is located near the south-western extent of this subregion, near the listed extent of the threatened community. No other patches of Box-Gum Woodland have been mapped in the buffer area, likely due to a combination of unrefined broad-scale mapping and the location of the site. Given the presence of large areas of cropped and grazed land in the immediate area, The proposal would remove 5.4 hectares of PCT 435 at Baradine, of which 0.3 hectares is in good condition and 5.1 hectares is derived native grassland. The proposal will not result in any fragmentation in this area, as the vegetation to be removed is on the edge of a much larger patch. Impacts resulting from the proposal would result in a comparable degree of fragmentation to that currently experienced by this patch of vegetation. The proposal will not fragment the TEC from other stands of vegetation; rather, retained areas of this TEC are contiguous with surrounding vegetation. Despite this, the area to perimeter ratio for the remaining area of the TEC will increase slightly, as a result of the development footprint layout, and location of the TEC within the study area. This area is proposed for a temporary accommodation site, and the derived native grassland may be subject to temporary impacts only. This area is regularly subject to temporary impacts as it is part of the Baradine Showground, and regularly hosts events, including the Baradine Show, which results in regular disturbance of this patch of derived native grassland. The small area of good quality vegetation would be removed from the edge of a larger patch. This vegetation is part of a wider patch, extending across the showground. Canopy vegetation also extends around the showground and has wider connectivity in the area, including travelling stock reserves along Gulargambone-Baradine Road to the south, Baradine Road to the west, and Gwabegar Road and the Pilliga forests to the north. Dispersal studies suggest that eucalypt pollen can disperse over distances of over one kilometre, although most is distributed within 200 metres and seed crops are dominated by genetic material from nearby trees (Byrne et al. 2008; Broadhurst 2013). Eucalypt seeds lack any aerodynamic features, so their dispersal is largely influenced by factors such as tree height, canopy width, seed weight and wind strength. In light winds, light seeds are calculated to disperse around 50 metres, with heavier seeds only dispersing around 20 metres. Some eucalypt seeds may also be dispersed

Criteria	Assessment
	further by water, birds (eg uneaten seeds) and insects (eg accidental movement by stingless bees) (Booth, 2017). For small, isolated patches such as the one near Narromine, there is limited opportunity for dispersal of dominant canopy species given surrounding agricultural practices. Dispersal of seeds at the Baradine site Is likely to continue, as the area to be removed is located on the edge of a much larger patch. Similarly dispersal of groundcover and shrub layer species at Baradine is unlikely to be impacted, however dispersal of these species at Narromine would be impeded by surrounding cleared land.
iii. describing the condition of the TEC according to the vegetation integrity score for the relevant vegetation zone(s) (Section 4.3) including the relevant composition, structure and function condition scores for each vegetation zone	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 78. 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. White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion (PCT 435) in good condition (0.4 ha) and as a derived native grassland (5 ha) form of this community was recorded at a proposed temporary workforce accommodation site. This PCT is also commensurate with Box Gum Woodland SAII. No plots were collected within this PCT vegetation zone as the site due to no access. Benchmark values were entered for this PCT and VI score is very high at 100. Development impacts are likely to be restricted to the proposal site. Given the mitigation measures specified in section 12, 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.

Table 10.3 Assessment of serious and irreversible impacts for Fuzzy Box Woodland

Criteria	Assessment
1. Current status	
a. evidence of rapid decline (Principle 1, clause 6.7(2)(a) BC Regulation) as the current total geographic extent of the TEC in NSW AND the estimated reduction in geographic extent of the TEC since 1970 (not including impacts of the proposal)	Fuzzy Box Woodland has had a 95 percent decline in extent since 1750. Less than five percent of Fuzzy Box Woodland on alluvial soils of the Western Slopes, Darling Riverine Plains and Brigalow Belt South bioregions is estimated to remain compared to pre-European times due to past clearing. This TEC meets reduction in geographic extent of ≥90 percent since 1750 or ≥80 percent since 1970.
b. extent of reduction in ecological function for the TEC using evidence that describes the degree of environmental degradation or disruption to biotic processes (Principle 2, clause 6.7(2)(b) BC Regulation) indicated by: i. change in community structure ii. change in species composition iii. disruption of ecological processes iv. invasion and establishment of exotic species v. degradation of habitat, and vi. fragmentation of habitat	Less than five percent of Fuzzy Box Woodland on alluvial soils of the Western Slopes, Darling Riverine Plains and Brigalow Belt South bioregions is estimated to remain compared to pre-European times due to past clearing. Other symptoms of degradation prevail, including the senescence of relict plants, lack of regeneration due to grazing, lack of fire and weed invasion
c. evidence of restricted geographic distribution for the threatened species s (Principle 3, clause 6.7(2)(c) BC Regulation) presented by: i. extent of occurrence ii. area of occupancy iii. number of threat-defined locations	Estimated extent of occurrence = four square kilometres Estimated area of occupancy = four square kilometres Estimated total current extent = <400 hectares Number of threat-defined locations = 1
d. evidence that the TEC is unlikely to respond to management (Principle 4, clause 6.7(2)(d) BC Regulation)	This TEC is likely to respond to management practices such as weed control and revegetation. Eucalyptus dominated grassy woodland communities are, in general, capable of responding to management (*pers. obs*). Standard environmental management measures such as weed control, supplementary planting, maintenance of natural fire regimes and treatment of pest fauna are likely to result in positive responses in the composition and ecological function of the community.

Criteria	Assessment
Impact assessment	
a. the impact on the geographic extent of the TEC (Principles 1 and 3) by estimating the total area of the TEC to be impacted by the proposal: i. in hectares, and	The proposal would result in an impact on a SAII entity through the proposed removal of 3.6 hectares of Fuzzy Box Woodland (PCT 202).
ii. as a percentage of the current geographic extent of the TEC in NSW	The loss of 3.6 hectares equates to 0.9 percent of the estimated total current extent of the community.
b. the extent that the proposed impacts are likely to contribute to further environmental degradation or the disruption of biotic processes (Principle 2) of the TEC by: i. estimating the size of any remaining, but now isolated, areas of the TEC; including areas of the TEC within 500 m of the development footprint or equivalent area for other types of proposals	Within the proposal footprint, one patch of vegetation commensurate with the Fuzzy Box Woodland SAII entity was observed in roadside vegetation (refer to Figure 10.2). This patch extended into adjacent private property where there was no access available for further survey work to ground truth the extent of the community. PCT 202 has been assumed to extend further into that private property until there is a change in elevation and soil type, as observed from extrapolated data. The total size of this patch has not been verified, however based on extrapolated data, it is assumed that it is about nine hectares in size in total, and the patch of this community that would remain if the proposal is constructed is estimated to be at least 5.4 hectares. The proposal would result in the creation of an 80 metre wide gap between remaining patches of vegetation assumed to be commensurate with this SAII entity.
ii. describing the impacts on connectivity and fragmentation of the remaining areas of TEC measured by: distance between isolated areas of the TEC, presented as the average distance if the remnant is retained AND the average distance if the remnant is removed as proposed, and estimated maximum dispersal distance for native flora species characteristic of the TEC, and other information relevant to describing the impact on connectivity and fragmentation, such as the area to perimeter ratio for remaining areas of the TEC as a result of the development.	The proposal will result in the fragmentation of vegetation commensurate with this SAII entity in the locality. The proposal would remove an 80 metre wide strip of this community, leaving a gap of about 80 metres between remnants. While there is some existing fragmentation as a result of existing dirt roads, the existing gap between remnants is quite narrow and does not represent a barrier to movement for any dispersal agents of this community. Given that the estimated total extent of this community is less than 400 hectares, large patches such as the one to be impacted by the proposal are likely to comprise an important area of the community due to the limited amount remaining across its estimated extent of occurrence. About 5.4 hectares of this community would remain following construction of the proposal, however this area is made up of the two patches that would remain following construction of the proposal, which would create an 80 metre wide gap between the two remnants. These remnants would likely be subject to an increase in indirect impacts as a result of the proposal and increased edge effects due to the increase in fragmentation. As noted in the SAII assessment for Box Gum Woodland above, eucalypt pollen can travel distances of over one kilometre, but seed dispersal is generally limited to within close proximity of the parent tree. Some eucalypt seeds may also be dispersed further by water,

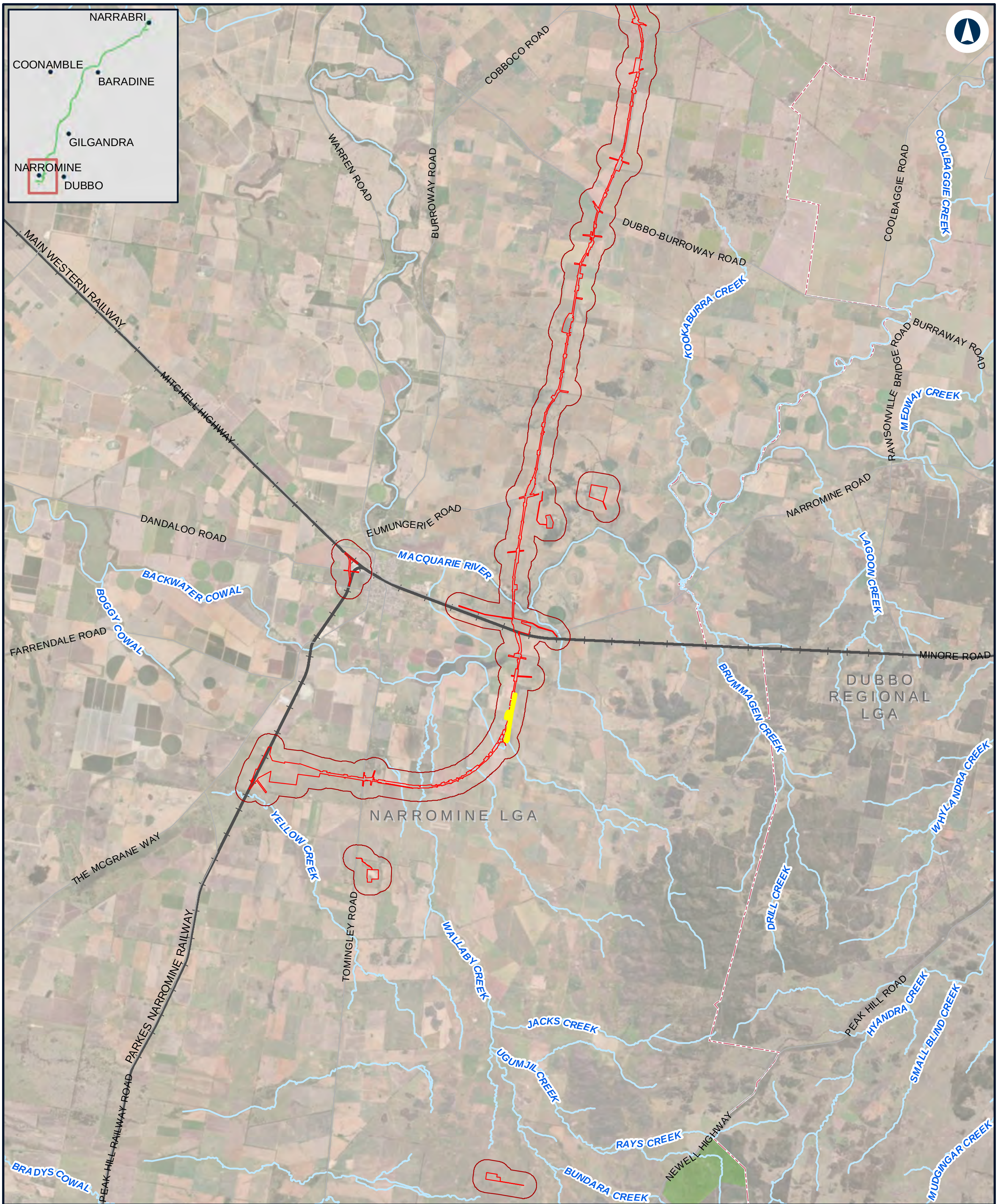
Criteria	Assessment
	birds (eg uneaten seeds) and insects (eg accidental movement by stingless bees) (Booth, 2017).
iii. describing the condition of the TEC according to the vegetation integrity score for the relevant vegetation zone(s) (Section 4.3) including the relevant composition, structure and function condition scores for each vegetation zone	The ecological community is associated with the vegetation zone Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (PCT 202) in good condition, which has a vegetation integrity score (VI) of 99.5. The high VI score for the community is attributed to the use of benchmark data for plots to achieve the required plot number for the zone area. This was necessary due to the lack of access to private property where the majority of the patch occurs. The plots that were completed in this community were within the road reserve where vegetation is likely in lower condition than that within the broader patch. However the patch is unlikely to achieve benchmark values given existing pressures from adjacent land uses and an actual VI score as high as 99.5 is unlikely.

Table 10.4 Assessment of serious and irreversible impacts for Brigalow Woodland

Criteria	Assessment
1. Current status	
a. evidence of rapid decline (Principle 1, clause 6.7(2)(a) BC Regulation) as the current total geographic extent of the TEC in NSW AND the estimated reduction in geographic extent of the TEC since 1970 (not including impacts of the proposal)	Brigalow Woodland has declined 88 percent since the 1960's. Mapping of "Brigalow soils" in the early 1960s gives an area of potential habitat for this community in NSW of 115,300 hectares (Isbell 1962). Recent vegetation mapping of the northern wheatbelt has found that only 13,500 hectares remains of this community and that it is severely fragmented. This community meets reduction in geographic extent of ≥90 percent since 1750 or ≥80 percent since 1970.
b. extent of reduction in ecological function for the TEC using evidence that describes the degree of environmental degradation or disruption to biotic processes (Principle 2, clause 6.7(2)(b) BC Regulation) indicated by: i. change in community structure ii. change in species composition iii. disruption of ecolo gical processes iv. invasion and establishment of exotic species v. degradation of habitat, and vi. fragmentation of habitat	The degree of reduction due to degradation is unknown.

Criteria	Assessment
c. evidence of restricted geographic distribution for the threatened species s (Principle 3, clause 6.7(2)(c) BC Regulation) presented by: i. extent of occurrence ii. area of occupancy iii. number of threat-defined locations	Estimated extent of occurrence = 70,467 square kilometres Estimated area of occupancy = 4,348 square kilometres Estimated total current extent = 13500 to 35396 hectares No threat-defined locations have been identified.
d. evidence that the TEC is unlikely to respond to management (Principle 4, clause 6.7(2)(d) BC Regulation)	This TEC may respond to management practices such as weed control and revegetation. Woodland communities are, in general, capable of responding to management (*pers. obs*). Standard environmental management measures such as weed control, supplementary planting, maintenance of natural fire regimes and treatment of pest fauna are likely to result in positive responses in the composition and ecological function of the community.
Impact assessment	
a. the impact on the geographic extent of the TEC (Principles 1 and 3) by estimating the total area of the TEC to be impacted by the proposal: i. in hectares, and	Brigalow Woodland has been recorded in the Narrabri and Bohena Creek area, at the northern end of the proposal site (refer to Figure 10.2). The proposal would result in an impact on the SAII entity through the removal of 7.3 hectares of PCT 35 (including 1.3 hectares of woodland and 5.9 hectares of derived native grassland). PCT 35 occurs in a long linear woodland section that is part of a larger patch of the community that runs parallel to the Newell Highway and extending onto small adjacent private properties. It then extends to derived native grasslands of this community on private properties within the proposal site and wider study area. The good condition vegetation zone is characterised by an overstorey of Brigalow with grasses of *Chloris truncata* and *Eleocharis* spp. in the understorey. The derived native grassland vegetation zone is characterised by an understorey of wiregrasses (*Aristida* spp) and *Calotis* spp. It is likely that the derived native grassland form extends further into private properties that the area that is mapped.
ii. as a percentage of the current geographic extent of the TEC in NSW	The loss of 7.3 hectares equates to up to 0.05 percent of the estimated total current extent of the community (about 13,500-35,396 hectares).
b. the extent that the proposed impacts are likely to contribute to further environmental degradation or the disruption of biotic processes (Principle 2) of the TEC by: i. estimating the size of any remaining, but now isolated, areas of the TEC; including areas of the TEC within 500 m of the development footprint or equivalent area for other types of proposals	There is about 56.4 hectares of this community within 500 metres of the proposal footprint, including the 7.3 hectares that would be impacted by the proposal. Within the assessment area, this community exists as remnants along roadsides as well as within private land. There is an existing degree of fragmentation of remnants, as shown on Figure 10.2, including the Newell Highway, however this would be amplified by the construction and operation of the proposal. Following construction of the proposal, about 49.1 hectares of this community would remain within 500 metres of the development footprint.

Criteria	Assessment
ii. describing the impacts on connectivity and fragmentation of the remaining areas of TEC measured by: distance between isolated areas of the TEC, presented as the average distance if the remnant is retained AND the average distance if the remnant is removed as proposed, and estimated maximum dispersal distance for native flora species characteristic of the TEC, and other information relevant to describing the impact on connectivity and fragmentation, such as the area to perimeter ratio for remaining areas of the TEC as a result of the development.	The proposal would result in further fragmentation to this community within the locality. As noted above, this community exists as remnants along roadsides and within private land. The proposal would result in the creation of a new, additional gap of between 40 to 100 metres between remnants, that would otherwise not exist. The proposal will remove 7.2 hectares of vegetation commensurate with this SAII entity from the northern and southern edges of an existing patch. Much of this vegetation to be cleared is derived native grassland adjacent to the woodland areas, and already subject to disturbance from agriculture. One small area of good quality Brigalow to be removed occurs within a vegetated 'laneway' along a property boundary and would create a gap of 160 metres between remnant areas. The remaining vegetation in the large, connected patch along the Newell Highway 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. Vegetation that is retained is likely to be subject to increased indirect impacts resulting from the proposal. These would be in addition to the impacts already occurring given the community occurs as roadside vegetation and within private properties used for agricultural purposes. Suckering is the main means of reproduction for Brigalow, as it does not flower every year, and seed production is rare (Johnson 1964). If mature Brigalow trees are removed from a site (eg by clearing), and many suckers are produced, Brigalow can take the form known as 'sucker Brigalow', where all Brigalow plants have a low branching habit and are generally less than four metres in height (Johnson 1964). High densities of suckers may develop into 'whipstick Brigalow' after about 30 years, which consists of high densities of many straight, slender stems (4 to 8 metres tall), with spindly or dead lower branches (Johnson 1964). Clearing may result in additional suckering of plants along the edge of the proposal site.
iii. describing the condition of the TEC according to the vegetation integrity score for the relevant vegetation zone(s) (Section 4.3) including the relevant composition, structure and function condition scores for each vegetation zone	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 good condition with a vegetation integrity score (VI) of 61.1 and the derived native grassland with a VI score of 62.6. The vegetation to be cleared generally occurs on the edge of a larger patch, with other scattered patches occurring throughout the northern end of segment 11 in the investigation area and wider study area and locality. The areas to be removed form part of a viable patch that is connected to other patches of this and other native vegetation communities in the study area. 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.



NARROMINE TO NARRABRI SAII Assessment: threatened ecological communities Figure 10.1 - MAP 1 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Extended veg - OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Construction impact zone 500m buffer
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions
- White Box Yellow Box Blakelys Red Gum woodland

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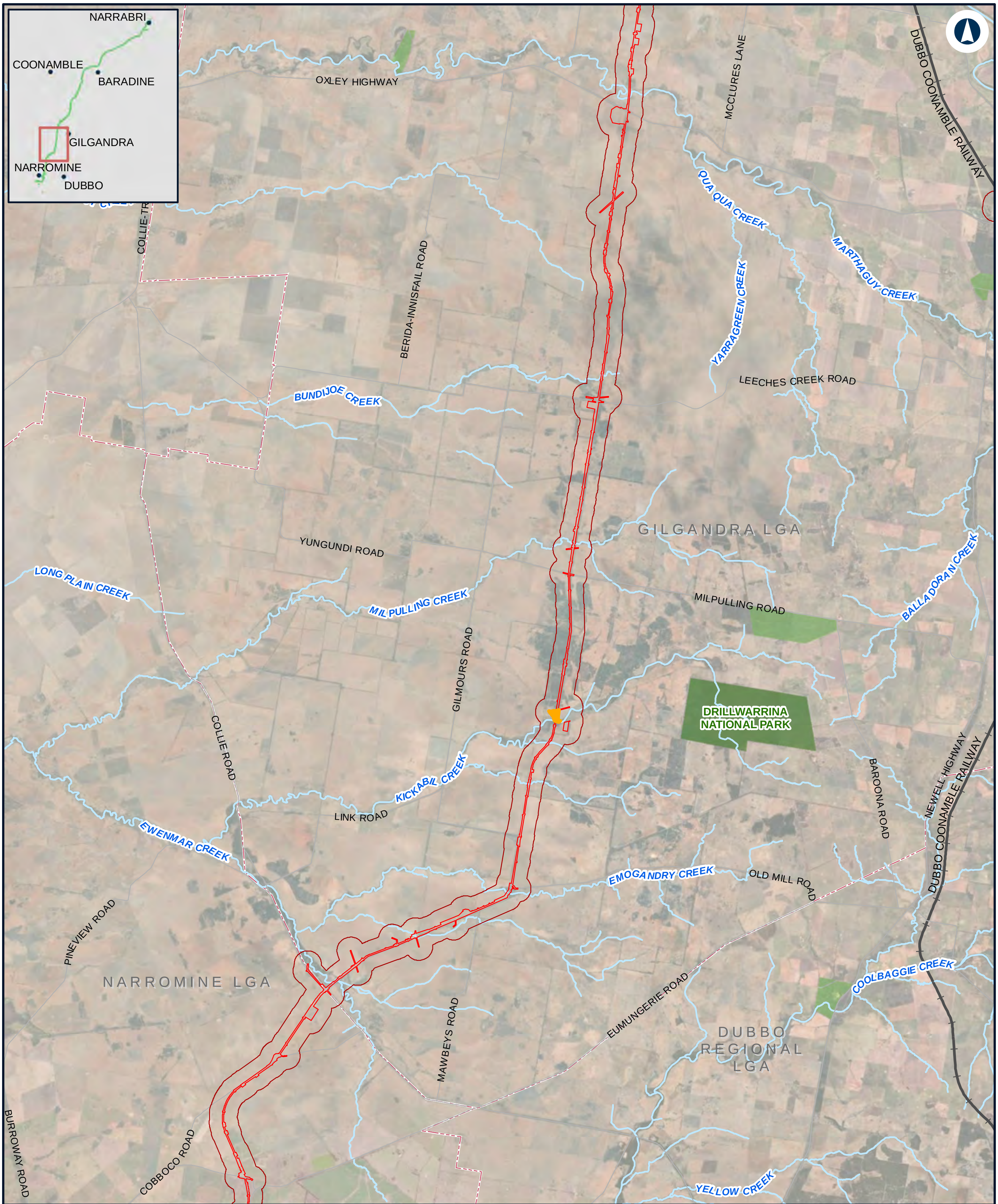

NARROMINE TO NARRABRI SAII Assessment: threatened ecological communities Figure 10.1 - MAP 2 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Extended veg - OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Construction impact zone 500m buffer
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions
- White Box Yellow Box Blakelys Red Gum woodland

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NARROMINE TO NARRABRI SAII Assessment: threatened ecological communities Figure 10.1 - MAP 3 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Extended veg - OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Construction impact zone 500m buffer
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions
- White Box Yellow Box Blakely Red Gum woodland

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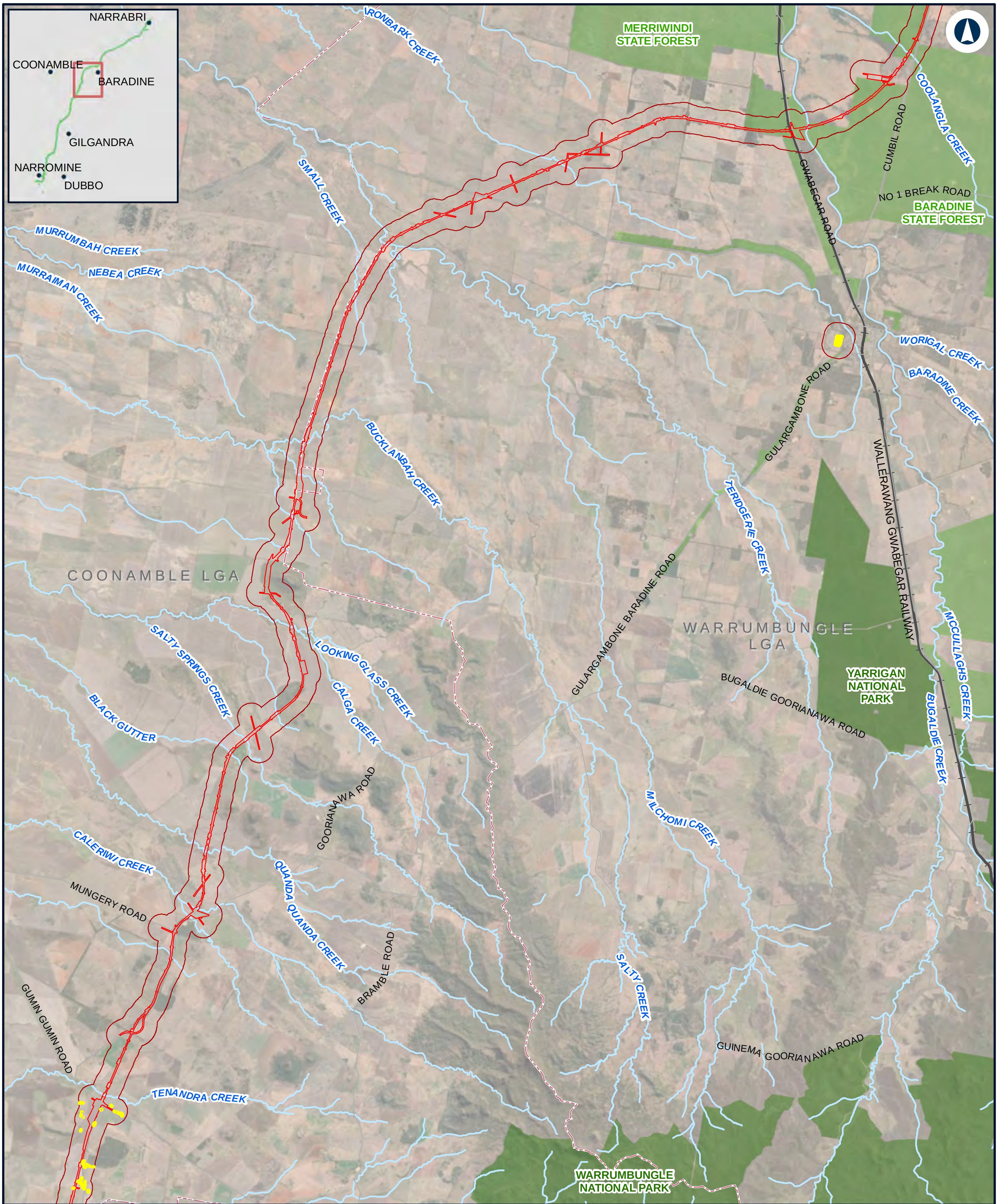

NARROMINE TO NARRABRI SAII Assessment: threatened ecological communities Figure 10.1 - MAP 4 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Extended veg - OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Construction impact zone 500m buffer
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions
- White Box Yellow Box Blakelys Red Gum woodland

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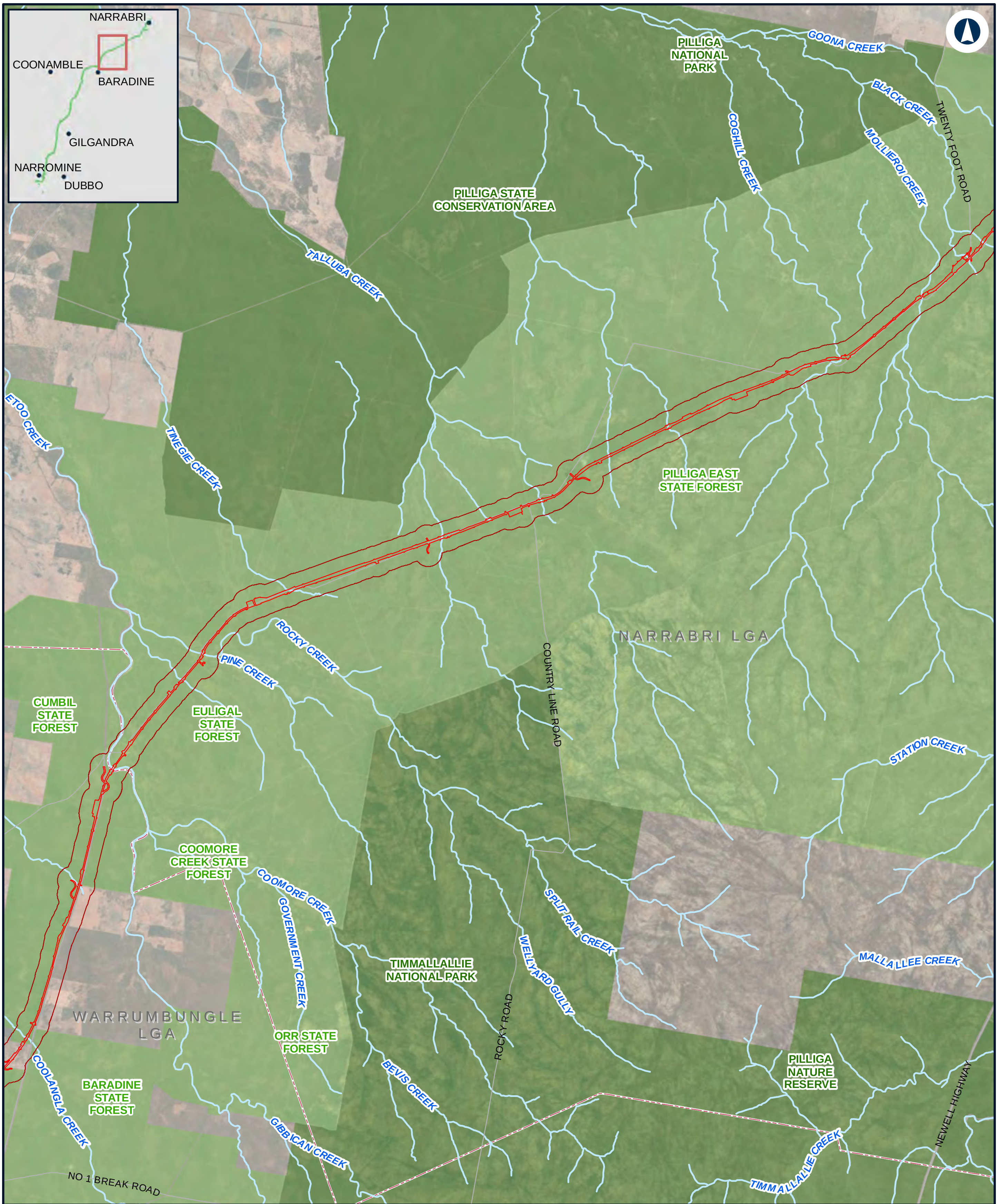

NARROMINE TO NARRABRI SAII Assessment: threatened ecological communities Figure 10.1 - MAP 5 of 6

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-12-21 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Extended veg - OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Construction impact zone 500m buffer
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions
- White Box Yellow Box Blakelys Red Gum woodland

INLAND RAIL ARTC

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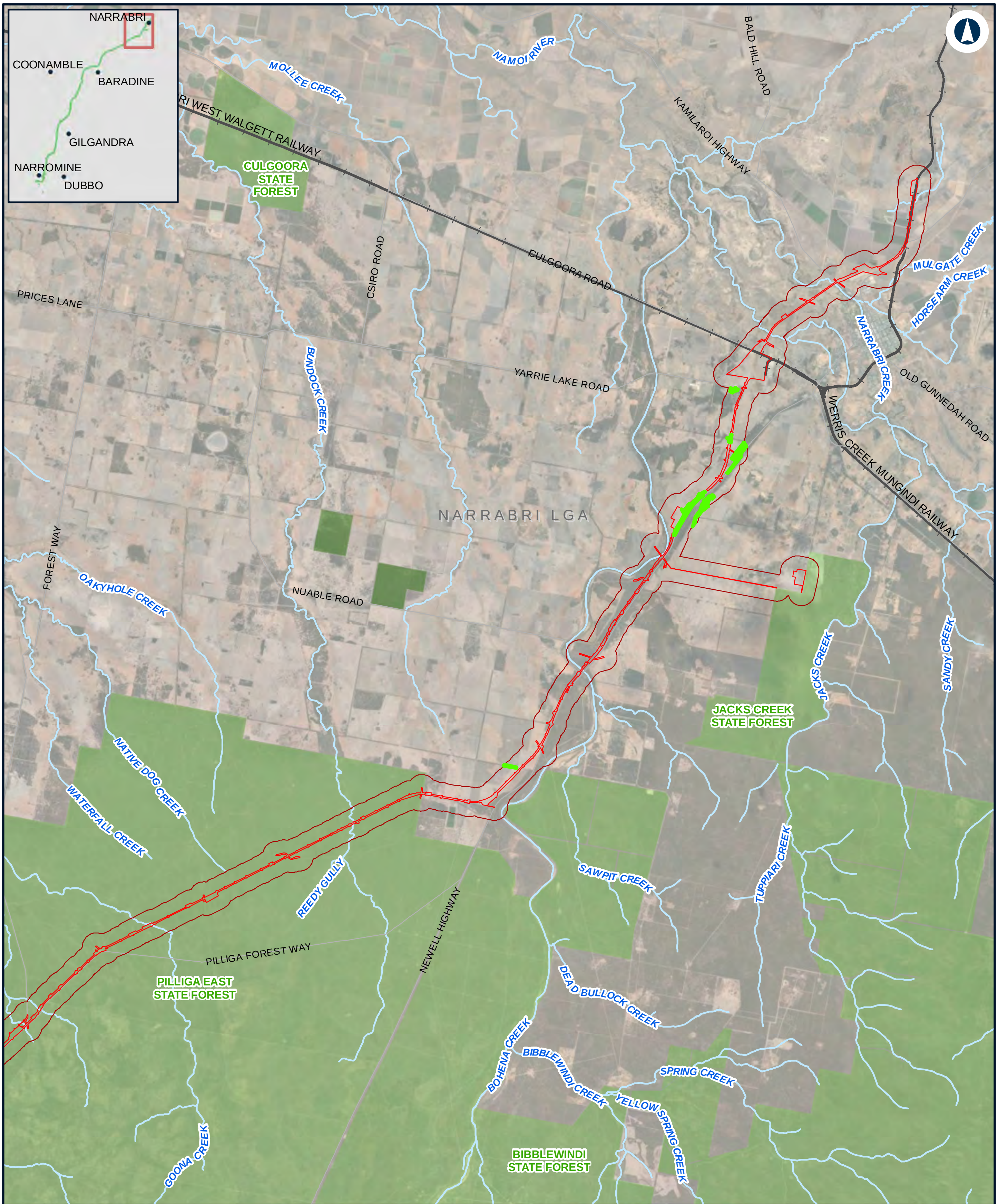

NARROMINE TO NARRABRI SAII Assessment: threatened ecological communities Figure 10.1 - MAP 6 of 6

Coordinate System: GDA 1994 MGA Zone 55

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Author: JacobsGHD Scale: 1:200,000
Data Sources: Extended veg - OEH; Basemap layers: NSWSS, esri;

LEGEND

- Construction impact zone
- Construction impact zone 500m buffer
- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions
- White Box Yellow Box Blakelys Red Gum woodland

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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10.2 Prescribed biodiversity impacts

10.2.1 Introduction

As discussed in section 8.1, the BC Regulation prescribes impacts that must be assessed in addition to direct impacts relating to vegetation clearing. The BDAR must include an assessment of these prescribed impacts of the proposal on threatened entities and their habitat, and describe:

a. the nature, extent, frequency, duration and timing of prescribed impacts that may occur:

i. during construction

ii. during operation

iii. that are uncertain (predictions should be made)

b. the consequences of prescribed impacts on biodiversity values

c. any limitations to data, assumptions and predictions about impacts on biodiversity.

Prescribed impacts of the proposal are described in the sections below. The potential for significant residual prescribed impacts is discussed further in section 10.3.

10.2.2 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.

An assessment of the width of clearing along the alignment has been undertaken to investigate impacts on connectivity. The width of the alignment was calculated at 100 metre intervals and categorised into 10 metre ranges. Note that these calculations include the rail line, as well as crossing loops and compound sites, some of which are over 400 metres wide. Around 24 percent of the non-Pilliga segments and 29 percent of the Pilliga segment were in the 50 to 60 metre wide range, and around 34 percent of the non-Pilliga segments and 36 percent of the Pilliga segment are below 60 metres in width. The average width of the alignment (taken at 100 metre intervals) is 97 metres outside the Pilliga and 89 metres in the Pilliga forests. See Figure 10.2, Figure 10.3 and Table 10.5.

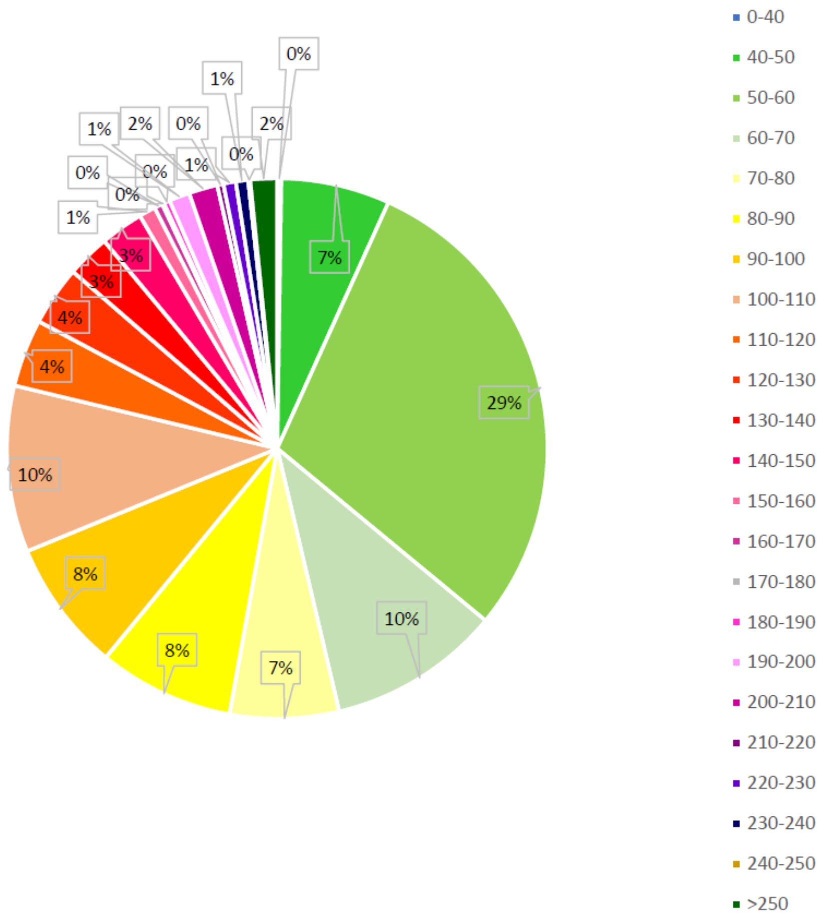

Figure 10.2 Gap width ranges of the proposal through the Pilliga forests

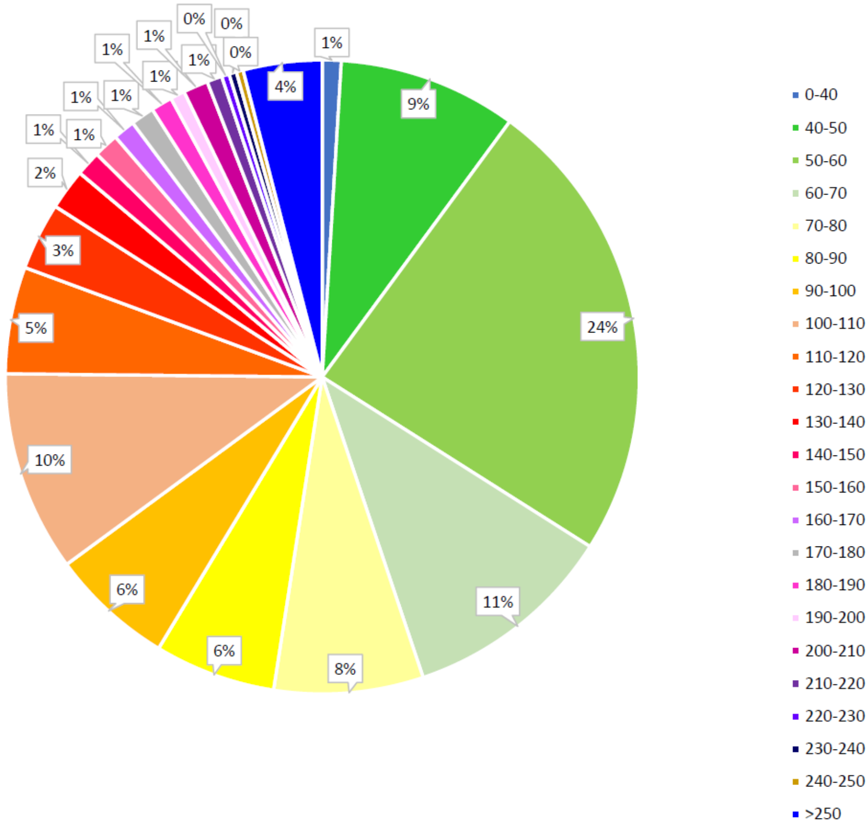

Figure 10.3 Gap width ranges of the proposal outside the Pilliga forests

Table 10.5 Clearing widths along the rail alignment

	Percent (%) of CIZ		
Width (m)	Pilliga segment	Non-Pilliga segments	Total
<50	7	10	9
<60	36	34	32
<70	46	45	42
<100	69	65	61
<150	92	87	82
<200	95	93	94
>200	5	7	6

Impacts on connectivity values are assessed in Table 10.6. Given the scale of the proposal, and the low densities that many of the terrestrial fauna occur in, impacts on populations of threatened fauna are uncertain and therefore difficult to quantify. A Preliminary Fauna Connectivity Strategy has been prepared for the proposal (see Appendix J). The potential for significant residual impacts on connectivity values is discussed further in section 10.3.

Table 10.6 Impacts on connectivity values

Criteria	Connectivity feature or species	Discussion
(a) describe the nature, extent and duration of short and long-term impacts (during operation, during construction, that are uncertain)	Pilliga forests	Construction of the proposal would clear a gap of ranging between 33 metres to 400 metres wide (with about 29 percent in the 50 to 60 metres category, and averaging a width of 89 metres) along a 73 kilometre alignment in the Pilliga. This would be exacerbated where the alignment is parallel to Pilliga Forest Way. In some areas, a narrow band of vegetation would remain between the road and the rail corridor. The proposal will substantially 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 several different types of barriers to fauna. Operational impacts of the proposal are 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). **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).

Criteria	Connectivity feature or species	Discussion
		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 8.3. 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.
	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 kilometre long, Castlereagh River > 600 metres long, Namoi River/Narrabri Creek > three 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.

Criteria	Connectivity feature or species	Discussion
	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.

Criteria	Connectivity feature or species	Discussion
b) predict the consequences of the impacts for the persistence of the threatened entities identified in Subsection 6.1.3, taking into consideration mobility, abundance, range and other relevant life history factors. c) justify predictions of impacts with relevant literature and other published sources of information and describe any limitations to data, assumptions and predictions about impacts on biodiversity).	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 forests would create a barrier to movement, affecting home ranges of individual Koalas, and impacting movement corridors. Elsewhere along the alignment, the proposal would fragment habitat links for Koalas seeking to access habitats either side of the rail line. Noise from trains may also affect distribution of home ranges, and reduce species density near the rail line, further impacting connectivity and movement. Noise disturbances has been shown to significantly influence the ranging patterns of Koalas, with individuals moving perpendicular to and away from noise (Phillips 2016). Noise may also affect macropod species. Impacts on gene flow may be mitigated to some degree 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). Locations for 97 dedicated fauna culverts have been proposed in the Pilliga, with many of these targeting these species. Appropriate furniture would be included in culverts that are located with the areas of generational persistence of the Koala. 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. No large culverts are located away from drainage lines in the Pilliga, and as such, connectivity in forested areas away from riparian areas would be more severely impacted. The inclusion of dedicated culverts in these areas would be investigated in detailed design. Further discussion of bridges and culverts are provided in Table 12.4 and Appendix J. 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 or species	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 would be at or near the limit of the species gliding distance, and certain age or sex classes may be differentially impacted, limiting crossing potential. The ability of gliders to cross the rail corridor would also 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 canopy bridges at regular intervals through the Pilliga. Positions would be determined during detailed design to ensure locations are appropriate. Canopy bridges are also proposed at various bridges, with additional locations to be determined during detailed design (see Appendix J).
	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. Locations for 97 dedicated fauna culverts have been proposed in the Pilliga forests, with a number of these targeting the Pilliga Mouse. Over 130 drainage culverts are also included in the design which may provide incidental passage. Further discussion of bridges and culverts are provided Table 12.4 and Appendix J. 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 may be able to cross the rail line using culverts, although this depends on behaviour of the species (willingness to use culverts) and potentially treatment of culverts. Retention or rehabilitation of

Criteria	Connectivity feature or species	Discussion
		groundcover and shrub cover is proposed in the operational rail corridor to provide linkages, including to dedicated underpasses. Monitoring of culvert use is recommended as little information on culvert use exists for this genus (see section 12.2). 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 and canopy bridges. 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. Locations for 97 dedicated fauna culverts have been proposed in the Pilliga forests which would provide crossing opportunities for this species. Over 130 drainage culverts are also included in the design and would provide incidental passage for this species. Most culverts in the Pilliga will be 7.3 metres wide (perpendicular to the rail). 67 canopy bridges are also proposed, predominantly in the Pilliga. There is anecdotal evidence of the Long-tailed Pygmy-possum (*Cercartetus caudatus*) using a canopy bridge, based on presence of scats under the bridge (Goosem et al 2011). Retention or rehabilitation of groundcover and shrub cover is proposed in the operational rail corridor to provide linkages, including to dedicated underpasses. Further discussion of connectivity structures is provided in Table 12.4 and Appendix J.

Criteria	Connectivity feature or species	Discussion
		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.
	Woodland birds	Many threatened woodland bird species were recorded or are well known from the Pilliga forests. These species are at risk of injury and mortality from train strike during operation of the rail line. Some less mobile species may find the new open clearing of the rail alignment, or widening of the road gap where the alignment parallels existing roads, to present a barrier to localised movement in the short term, and potentially gene flow between populations in the longer term. Given the low numbers of trains that would travel through the Pilliga, and the large areas of available habitat, the risk of train strike is considered to be relatively low. The risk of a disruption to population connectivity is however significant for smaller, less mobile species, or those which avoid crossing larger open areas. Species which may suffer some population fragmentation by restriction of movement across the new rail alignment may include the Diamond Firetail, Brown Treecreeper, Flame Robin, Grey-crowned Babbler, Hooded Robin, Speckled Warbler, and potentially Varied Sittella. These species are considered less mobile due to one or more factors, including their small home ranges, weaker flight, or an aversion to large clearings or openings in the forest. The majority of woodland birds studied in a systematic literature review by CSIRO exhibit similar gap crossing and inter-patch crossing distance thresholds, with gaps of around 100 metres creating a barrier to movement (Doerr et al. 2010). The gap that would be created by the rail corridor ranges in width, with around 29 percent being 50-60 metres wide, and averaging 89 metres wide in the Pilliga forests. Larger gaps are present at compound sites and crossing loops. Retention or rehabilitation of groundcover and shrub cover is proposed in the operational rail corridor to provide linkages, particularly to retain connectivity for these species and maintain gene flow across the rail corridor. It is also likely that species that forage on the ground could make use of riparian connectivity present at the proposed bridge crossings within the Pilliga forests and elsewhere, and these are likely to provide gene flow between populations of these species over the medium to long term. Other more mobile threatened woodland bird species such as the Dusky Woodswallow and Regent, Painted and Black-chinned Honeyeaters are not likely to find the clearance area a barrier to movement, and would continue to utilise resources and move across the woodland as a single contiguous area.

Criteria	Connectivity feature or species	Discussion
	Raptors	Threatened raptor species, including the Little Eagle and Square-tailed Kite would occur in the Pilliga. These species are considered to be at some risk of injury and mortality from train strike during operation of the rail line, particularly if drawn to the trackside area to feed on wildlife killed by train strike. Given the low numbers of trains that would travel through the Pilliga per day, low population density of these species, and the large areas of available habitat, the risk of train strike is considered to be relatively low. The risk of a disruption to population connectivity is very low for these highly mobile species, which are not likely to find the clearance area a barrier to movement and would continue to utilise resources and move across the woodland as a single contiguous area.
	Owls	The Barking Owl and Masked Owl are known to occur in the Pilliga, with the Pilliga population of the Barking Owl being the largest in inland NSW. These species are considered to be at some 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, the risk of train strike is considered to be relatively low, however the use of creeklines as flyways for these species could increase the risk of mortality. The risk of a disruption to population connectivity is very low for these highly mobile species, which are not likely to find the clearance area a barrier to movement and would continue to utilise resources and move across the woodland as a single contiguous area.
	Parrots and cockatoos	A number of threatened parrot and cockatoo species were recorded, or are known from the Pilliga, including the Glossy Black-cockatoo, Little Lorikeet, Turquoise Parrot and Superb Parrot. These species are considered to be at some risk of injury and mortality from train strike during operation of the rail line, particularly as the seed-eating species may be drawn to feed in the open clearing of the rail alignment. Given the low numbers of trains that would travel through the Pilliga, and the large areas of available habitat, the risk of train strike is considered to be relatively low. The risk of a disruption to population connectivity is very low for these highly mobile species, which are not likely to find the clearance area a barrier to movement and would continue to utilise resources and move across the woodland as a single contiguous area.
	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, and species that use riparian corridors as flyways. 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.

Criteria	Connectivity feature or species	Discussion
	Pale-headed Snake	The Pale-headed Snake was recorded near a drainage line in the Pilliga forests during surveys, and is known to occur in riparian areas associated with the Namoi River. Radio-tracking of snakes on the Namoi River (Fitzgerald et al. 2010) found individuals were sedentary and moved only short distances (up to 134 metres in that study). This species is arboreal and relies heavily on old and dead standing trees with hollows and exfoliating bark for shelter sites, as it shelters during the day between loose bark and tree-trunks, or in hollow trunks and limbs of dead trees (EES 2019b). Its main prey is tree frogs although lizards and small mammals are also taken (EES 2019b). As such, the populations may tend to be associated with watercourses, billabongs and other flood-prone areas (Fitzgerald et al. 2010). The species is at risk of mortality from train strike. Given the low numbers of trains that would travel through the Pilliga, and the large areas of available habitat, the risk of train strike is considered to be relatively low. Connectivity will be provided via the many bridges and culverts at creek crossings. The large viaduct that crosses the Namoi River and Narrabri Creek would provide good connectivity in this area.

10.2.3 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 10.7. A Preliminary Fauna Connectivity Strategy has been prepared for the proposal that identifies various measures to allow safe passage of fauna (see Appendix J). The potential for significant residual impacts as a result of vehicle strike is discussed further in section 10.3.

Table 10.7 Impacts of vehicle strike during construction

Criteria	Discussion
(a) predict the likelihood of vehicle strike to each relevant species, taking into consideration mobility, abundance, range and other relevant life cycle 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. 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.
(b) estimate vehicle strike rates with supporting data or literature, where 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.
(c) predict the consequences of the impacts for the persistence of the relevant species	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 percent (Netherlands), to 36 percent (USA) and 38 percent (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 9.8.

Table 10.8 Impacts of vehicle strike during operation

Criteria	Discussion
(a) predict the likelihood of vehicle strike to each relevant species, taking into consideration mobility, abundance, range and other relevant life cycle 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 percent 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 to 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 or during dispersal. Given the low densities at which they occur in the study area, risk is likely to be low. Koalas would be able to pass safely under the rail line at bridges and dedicated culverts. 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.

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). The clearing width for the proposal would be close to, or exceed, its maximum gliding ability, although in some areas where trees are sufficiently tall, individuals may still successfully cross the rail corridor. Operation of the rail line would, however, create a risk of injury and mortality from train strike. The height of trains (for example those carrying double-stacked containers) further increases the risk of injury and mortality as this species may collide with a train if attempting to glide across the rail corridor.

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.

Owls and raptors

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 percent 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 species is a scavenger, but it less likely for threatened species such as the Little Eagle and Square-tailed Kite, which hunt live prey.

Criteria	Discussion
	Woodland birds Species that predominantly forage on the ground would be at higher risk of train strike, particularly while flying from perches to feeding areas. These include species such as the Diamond Firetail, Flame Robin, Grey-crowned Babbler, Hooded Robin, and Speckled Warbler. Most of these species would be more likely to forage adjacent to the rail line rather than on the rail line. Given the low numbers of trains that would travel through the Pilliga, and the large areas of available habitat, the impact of train strike at a population level is considered to be low. Species that forage in the canopy or on trunks, such as the Varied Sittella and Brown Treecreeper, would have a lower risk of train-strike. Brown Treecreepers and several other bird species have been recorded moving into sites where coarse woody debris has been added (Mac Nally et al. 2002; Mac Nally and Horrocks 2007). This may be a useful mitigation measure to make some areas of the rail corridor more attractive and therefore encourage movement of this and other species at these locations. This treatment may also increase the risk of mortality from train-strike. To minimise this risk, it could be used in areas where the rail corridor is in cuttings. Given the low numbers of trains that would travel through the Pilliga, the increased risk of train strike is unlikely to outweigh the benefit of increasing movement options. **Bats** Microbats are likely to use gaps in vegetation such as roads, creeklines and the rail corridor for movement. Microbat species are at risk of train strike when foraging or travelling along flyways in the Pilliga and other areas of the proposal site. Train strike risk would be highest at night and for species which forage in clearings and below the canopy (such as Corben's Long-eared Bat), with minimal risk during the day given the usually nocturnal habits of these species. Microbat movement and behaviour is also affected by artificial light. Some bat species are attracted to insects that gather at lights, while other species avoid illuminated areas (Patriarca and Debernardi 2010). Lights from trains may attract some species, increasing their risk of mortality from train strike, but may deter other species from the vicinity of the rail line. **Pale-headed Snake** The Pale-headed Snake appears to favour habitats close to riparian areas (EES 2019b). Radio-tracking of snakes on the Namoi River (Fitzgerald et al. 2010) found individuals were sedentary and moved only short distances. Operation of the rail line would create a risk of injury and mortality from train strike for this species during nocturnal foraging. The risk is likely to be low given the species sedentary nature.
(b) estimate vehicle strike rates with supporting data or literature, where available	The proposal estimates the train traffic rate to be an average of 10 trains per day (both directions) in 2026, increasing to about 14 trains per day (both directions) in 2040. Given this relatively low traffic, the risk of wildlife-train collisions is likely to be relatively low (as compared to roads).
(c) predict the consequences of the impacts for the persistence of the relevant species	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.

Criteria	Discussion
	A range of mitigation measures to minimise injury and mortality from train strike are recommended in section 12.

10.2.4 Human-made structures

Removal of old buildings, sheds 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 in the wider area 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.

10.2.5 Non-native vegetation

Impacts on fauna that utilise cropped land and planted trees are discussed in Table 10.9.

Table 10.9 Habitats associated with non-native vegetation

Impact	Description
a. describe the nature, extent and duration of short-term and long-term impacts (during operation, during construction, that are uncertain)	Spotted Harrier Little Eagle Large Bent-winged Bat Five-clawed Worm-skink
b. predict the consequences of impacts on threatened entities identified in subsection 6.1.2	The Spotted Harrier eats terrestrial birds (such as quail and pipits), mammals (rabbits and rodents), reptiles and large insects. It rarely easts carrion (Debus 2019). This species was observed foraging over cropped land near Narromine and around planted roadside shrubs near Gilgandra. The Little Eagle hunts mammals, birds and reptiles. It occasionally eats carrion. In the south of its range it prefers young rabbits, while in the north it prefers birds, and in the arid zone reptiles (small goannas, dragons and large skinks) (Debus 2019). This species may forage over cropped land and in planted vegetation. The Large Bent-winged Bat and Yellow-bellied Sheath-tail Bat forage in a range of habitats, including above grassland. These species fly within a few metres of the ground over grassland, catching a range of insects (Churchill 2008). These species may forage above cropped land. The 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 loss of cropped land and planted trees will further increase the reduction in foraging habitat for these species in the locality. Given the large areas of non-native vegetation in the

Impact	Description
	surrounding areas, and linear nature of the proposal, this is unlikely to have a substantial impact on these species.

10.2.6 Karst, caves cliffs, rocks and other geological features of significance

Given the lack of caves, karst and cliffs in the study area, and that the study area is not considered suitable habitat for the Pink-tailed Worm-lizard (see Appendix I), no assessment of impacts on geological features is considered necessary.

10.2.7 Water bodies, water quality and hydrological processes

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.

Under operational conditions there are no significant changes in flooding regimes, eg afflux and duration near the Macquarie River, Namoi River and Narrabri Creek. No change in flood connectivity is expected for these flood-dependent ecological assets.

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. The Australian Bittern and Australasian Painted Snipe are only likely to occur as occasional visitors to the study area and are unlikely to be affected by changes to water quality or hydrology (see Appendix M).

10.3 Potential for significant residual prescribed impacts

10.3.1 Introduction

A summary of prescribed impacts and associated mitigation measures is provided in Table 10.10. The key prescribed impacts on fauna resulting from the proposal include impacts on connectivity and impacts from vehicle strike.

Prescribed impacts are difficult to quantify compared to direct, or even indirect, impacts (DPIE 2019b). The consent authority has the discretion to increase the number of biodiversity credits to be retired (or other conservation measures to be undertaken), if the justification is due to environmental, social and economic impacts of the proposed development (see section 7.13(4) BC Act and clause 6.1.2 (b) BC Regulation). Given there is no set method for determining a suitable quantum of credits to offset a prescribed impact, the assessor should clearly document the decision pathway and justification for suggested credit numbers or other compensatory actions in the BDAR. Any biodiversity credits proposed are then additional to the baseline number of biodiversity credits determined by the BAM (DPIE 2019b).

The following section provides a quantification of the impact from changes to connectivity, the mobility potential of species and risk from train strike to provide a risk assessment of overall impact. An assessment of the proposed mitigation measures outlined in the Preliminary Fauna Connectivity Strategy (see Appendix J) is then provided. A matrix is then applied to outline a suggested credit ratio for species and ecosystem credits.

Table 10.10 Summary of prescribed impacts

Prescribed impact	Description	Mitigation	Residual impacts
Connectivity	The proposal will create a linear barrier to the movement of fauna and flora species, particularly within the Pilliga	A Preliminary Fauna Connectivity Strategy is provided in Appendix J which outlines various connectivity structures and measures to minimise the impacts of the proposal on connectivity.	Potential for significant residual impacts. See below for further discussion.
Movement	The ability of wide-ranging species to move between breeding and foraging areas is unlikely to be affected by the proposal	No specific mitigation is proposed.	No significant residual impacts are likely.
Vehicle strike	The proposal would increase the risk of vehicle strike, particularly within the Pilliga, and during operation of the rail line.	A Preliminary Fauna Connectivity Strategy is provided in Appendix J which includes fauna fencing and crossing structures to minimise fauna mortality.	Potential for significant residual impacts. See below for further discussion.
Areas of geological significance and rocks	No areas of karst, caves, crevices or cliffs are present in the proposal site. There would be negligible impact on embedded surface rock that could provide habitat for threatened reptiles	No specific mitigation is proposed.	No significant residual impacts are likely.
Human-made structures and non-native vegetation	The proposal would remove areas of non-native vegetation that may provide some foraging habitat for threatened fauna. Human-made structures such as sheds and telegraph poles that may provide roosting habitat for microbats would be removed.	Pre-clearing surveys and fauna relocation protocols are recommended during construction (see section 12).	No significant residual impacts are likely.
Hydrological impacts	Given the generally ephemeral nature of the waterways in the proposal site changes to hydrology are likely to be minimal in the context of impacts on riparian habitat relevant to threatened species	Many bridges and culverts are included in the design of the proposal to allow water flow across the proposal site. Standard environmental controls, including management of sedimentation and erosion are proposed in section 12.	No significant residual impacts are likely.

10.3.2 Overview of fauna sensitivity to impacts on connectivity

Separating the impacts of habitat loss and fragmentation on species can be complex as fragmentation necessarily contains elements of loss (Mallarach and Marull 2006). The barrier impact cannot be measured in meaningful absolute terms, being always dependent on the diverse natural systems or landscapes that are affected (Kettunen et al 2007). The barrier effects of transportation corridors due to road/rail avoidance should be distinguished clearly from the effects due to mortality, as both causes lead to reduced individuals crossing transportation corridors, but the mechanisms are fundamentally different and require different mitigation (Fahrig and Rytwinski 2009).

Functional connectivity within landscapes is a result of a species' use of the landscape. For functional connectivity to exist, landscape elements allowing the species' use of the landscape, including movement of species within the landscape, need to be in place. The nature and scale of these elements can differ significantly between species and consequently species-specific requirements need to be carefully considered, for example, when developing suitable management/conservation strategies for species at a broader landscape level (Kettunen et al 2007). The permeability of a transportation corridor can even be specific to groups of individuals within a species (sex, age, or life history stage) (Kerth and Melber 2009, Steen et al. 2006). For example, a corridor acts as a barrier when certain individuals overtly avoid crossing or coming near the corridor. Alternatively, when individuals are susceptible to mortality as a consequence of crossing a corridor, the corridor acts as a filter to movement (Bennett et al 2011).

The following traits are associated with vulnerability to habitat fragmentation (Henle et al 2004):

- Rarity (low natural abundance): Low abundance exacerbates a species' sensitivity to the removal of links between individuals or populations and the subsequent exposure of remaining populations to extinction through demographic and environmental stochasticity.
- Niche breadth and habitat specificity: Generalist species can exploit a wide range of resources and have a broad niche; whereas specialists are more limited in the resources they exploit and are less able to switch if these resources become depleted or fragmented.
- High individual area requirement: species with large area needs, ie species with large home ranges, which are primarily those at high trophic levels, are more vulnerable to fragmentation.
- Dispersal ability: Dispersal ability describes the ability of individuals to move through the landscape. Dispersal ability is highly variable between and within taxonomic groups and there may be behavioural adaptations that limit the dispersal ability of species into seemingly suitable habitat. This sensitivity factor is also scale-dependent.
- Reproductive potential and longevity: Reproductive potential and longevity have an important effect on sensitivity to habitat fragmentation by determining the number of individuals able to colonise new areas and by buffering against fluctuations in population size.

As noted previously, there is substantial literature regarding impacts from roads, but less on rail, however there are many similarities between the two. There are three main road characteristics that are considered to contribute to behavioural responses of wildlife and thus the barrier effects of roads (and to a certain extent rail as well): (1) traffic volume, (2) road width, and (3) road surface (Fahrig and Rytwinski 2009, Forman and Alexander 1998). Traffic density is a significant deterrent to wildlife movement (Forman et al. 2002). Traffic volume, corridor width and structure of the rail line are likely to affect different fauna. Initially the rail line will support 10 trains a day, increasing to 14 trains. Noise from trains may result in some fauna moving away from the rail corridor or adjusting their home ranges to avoid the rail corridor, although given the relatively low traffic, the effect of noise is likely to of less concern than the width of the gap.

For the proposal, the width of the rail corridor varies between around 40 to 60 metres. Larger gaps up to around 95 metres wide are created where compound sites are located adjacent to the rail corridor. For 36 percent of the Pilliga segment the rail corridor is less than 60 metres wide (see section 10.2.2). This gap will be permeable to certain species, but difficult to cross for other species. Species that are averse to open areas would likely avoid the rail corridor, although occasional crossings may occur.

Factors that increase a species risk of mortality can include traffic volume, vehicle speed, time of year (eg dispersal periods, breeding season), time of day (diurnal vs nocturnal species), corridor attractiveness (eg present of water sources, foraging habitat) (DPIE 2020). For the proposal, for much of the proposal length there would be a single track, meaning that the danger zone is relatively small compared to the width of the corridor. Initially the rail line will support 10 trains a day, increasing to 14 trains. Given the low traffic and generally single track, the potential for wildlife vehicle collision are also substantially lower than would be the case for a highway, for example. The impact of train strike is therefore considered to be a lesser impact for the proposal than impacts of reduced connectivity and impacts on mobility.

Forman et al (2003) summarised the vulnerability of fauna species to the various road effects depending on key ecological criteria (see Table 10.11).

Table 10.11 Fauna sensitivity to road impacts

Characteristics making a species vulnerable to road effects (from Forman et al. 2003)	Road mortality	Habitat loss	Reduced connectivity
Attraction to road habitat	❖		
High intrinsic mobility	❖		
Habitat generalist	❖		
Multiple-resource needs	❖		❖
Large area requirement/low density	❖	❖	❖
Low reproductive rate	❖	❖	❖
Behavioural avoidance			❖

10.3.3 Risk matrix assessment of threatened species likely to be affected by the proposal

An assessment of the biology and ecology of the threatened species likely to be affected by the proposal has been undertaken to assess the sensitivity of species to changes in connectivity and the impact of train strike (see Appendix J). Note that impact of habitat loss is covered under the BAM-C, so is not included here. This assessment focusses on species credit species, and ecosystem species most likely to be affected by impacts on connectivity, and is restricted to the Pilliga segment only, as that is where key impacts on connectivity and from rail strike will occur. Species such as the Swamp Harrier and Black Falcon are not included, given they are open habitat specialists. The Five-clawed Worm-lizard is not included as its key habitat area in the proposal site is being bridged by the viaduct over the Namoi River and Narrabri Creek floodplain, and thus impacts on connectivity are not considered to be significant for this species.

This assessment takes into account the vulnerability of each species to reduced connectivity and train strike, and the potential benefits of mitigation. A matrix has then been applied to identify a percent additional liability of credits required to offset these prescribed impacts for species credits. The following process has been followed:

- assessment of each species' sensitivity to reduced connectivity
- assessment of each species' risk of train strike

- calculation of a sensitivity to impact score to the above impacts
- assessment of the benefits of mitigation (crossing structures) for each species
- creation of a matrix based on the sensitivity to impacts versus the benefits of mitigation, in order to assign a sliding scale of additional credits for each species
- calculation of additional species and ecosystem credits to account for prescribed impacts.

10.3.4 Sensitivity to reduced connectivity and risk of train strike

Species have been given a score for the vulnerability to reduced connectivity and their ability to cross the gap (train-strike risk) (Table 10.12). The gap threshold has been identified through a literature review (see Appendix J) and the justification is summarised in the table. The percent of the Pilliga that is crossable is based on the assessment of gap widths along the CIZ (see section 8.2). The mobility disruption score for each species is the residual per cent impassable (the inverse of crossable).

This sensitivity assessment is based on the species' physical capability in optimal conditions, and does not take into account behaviour, which is addressed in later tables. Note that this assessment is also based on clearing with no mitigation (ie. total clearing of vegetation and no connectivity measures). The reduction of impact through mitigation is addressed in later tables.

Table 10.12 Vulnerability to loss of connectivity

Species	Notes	Gap threshold (m)	% Pilliga crossable	Mobility disruption (% Pilliga impassable)
Koala	Koalas are known to use scattered paddock trees (Barth et al 2019), and mobility between patches in rural areas does not appear to be compromised by the absence of corridors of trees (White, 1999). Limited gap to <200 metres for the purpose of this assessment.	<200	95	5
Rufous Bettong	Little information available. Limited to large tracts of native vegetation. Has been sighted on tracks in the Pilliga Forest, so assumed gap threshold is <60 metres.	<60	36	64
Black-striped Wallaby	White (2004) noted that the species can occur in grassland adjacent to forest. Likely to be able to move across gaps in the forest (Bionet). Assumed gap threshold is <100 metres given ability to occur in open areas.	<100	69	31
Eastern Pygmy-possum	Typically, individuals move 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).	<50	7	93
Pilliga Mouse	Gap crossing threshold not known. Gap threshold assumed to be <50 metres.	<50	7	93
Squirrel Glider	The Squirrel Glider has a mean glide distance in a horizontal plane of 21.5 +/- 0.9 metres (with a maximum of 47 metres) and a mean glide angle of 28.5 +/- 0.8° (see Goldingay and Taylor 2009).	<50	7	93
Pale-headed Snake	This species would rely on riparian corridors for movement. It is recorded on forest trails, so has some ability to crossed cleared land. Fitzgerald et al (2010) found individuals were sedentary and moved only short distances (up to 134 metres in that study). Gap threshold assumed to be <150 metres.	<150	92	8
Bush Stone-curlew	Bush Stone-curlews are a terrestrial predator adapted to stalking and running. They prefer landscapes that give them good visibility at ground level, so they usually inhabit areas with bare ground or low ground cover and widely spaced trees and shrubs, which may encourage them into the rail corridor. Some local movements occur when they are not breeding, known to occur in open urban areas (Bionet). Gap threshold assumed to be over 250 metres.	>250	100	0

Species	Notes	Gap threshold (m)	% Pilliga crossable	Mobility disruption (% Pilliga impassable)
Little Eagle	In Victoria highest reporting rates for the species were in the Mid and Lower Murray Valley where wetlands and irrigated farmlands adjoin River Red Gum woodlands and forest (Emison el atl 1987). Observed in open country during surveys for the project. Gap threshold assumed to be >250 metres.	>250	100	0
Square-tailed Kite	Square-tailed Kite are about 13 kilometres apart, with a density of one pair per 170 square kilometres, and home range of roughly 50 square kilometres (Lutter et al. 2004). Often observed soaring high above vegetation. Gap threshold assumed to be >250 metres.	>250	100	0
Barking Owl	Barking Owl territories in the Pilliga were estimated by Milledge (2004) by fitting a polygon of about 6000 hectares (based on Schedvin et al. 2001), Wide-ranging species able to cross large areas. Gap threshold assumed to be >25 0 metres.	>250	100	0
Masked Owl	The Masked Owl has a home range of 800 to 1200 hectares (Kavanagh 2002). Gap threshold assumed to be >250 metres.	>250	100	0
Glossy Black-cockatoo	Glossy Black-Cockatoos breed semi-colonially and pairs defend only the immediate area of the nest hollow, ranging widely to forage (NSW Scientific Committee 2008). Often observed flying well above vegetation. Gap threshold assumed to be >250 metres.	>250	100	0
Corben’s Long-eared Bat	Wide-ranging species (Churchill 2008). Gap threshold assumed to be >250	>250	100	0
Large-eared Pied Bat	Wide-ranging species (Churchill 2008). Gap threshold assumed to be >250 metres.	>250	100	0
Little Pied Bat	Wide-ranging species (Churchill 2008). Gap threshold assumed to be >250 metres.	>250	100	0
Yellow-bellied Sheath-tail bat	Wide-ranging species, known to forage in open farmland (Churchill 2008). Gap threshold assumed to be >250 metres.	>250	100	0
Large Bentwing Bat	Wide-ranging species, known to forage in open areas, and travel large distances between maternity caves and non-breeding habitat (Churchill 2008). Gap threshold assumed to be >250 metres.	>250	100	0

Species	Notes	Gap threshold (m)	% Pilliga crossable	Mobility disruption (% Pilliga impassable)
Brown Treecreeper	Robertson and Radford (2009) found that treecreepers appeared reluctant to cross gaps of more than ~60 metres between patches of vegetation. Gap threshold assumed to be <60 metres.	<60	36	64
Diamond Firetail	This species is likely to be affected by gaps of more than 100 metres between patches (as shown in Doerr et al. 2010). Gap threshold assumed to be <100 metres.	<100	69	31
Flame Robin	Seasonal and altitudinal migrant, moving from slopes to plains (EES 2021b). This species is likely to be affected by gaps of more than 100 metres between patches (as shown in Doerr et al. 2010). Gap threshold assumed to be <100 metres.	<100	69	31
Grey-crowned Babbler	Grey-crowned Babblers in and around Dubbo have been recorded occasionally crossing open areas of up to 200 metres between trees, including treeless sports grounds (Lambert and Ford 2016). Gap threshold assumed to be <200 metres.	<200	95	5
Hooded Robin	This species is likely to be affected by gaps of more than 100 metres between patches (as shown in Doerr et al. 2010). Gap threshold assumed to be <100 metres.	<100	69	31
Speckled Warbler	This species is likely to be affected by gaps of more than 100 metres between patches (as shown in Doerr et al. 2010). Gap threshold assumed to be <100 metres.	<100	69	31
Varied Sittella	This species is likely to be affected by gaps of more than 100 metres between patches (as shown in Doerr et al. 2010). Gap threshold assumed to be <100 metres.	<100	69	31
Turquoise Parrot	The Turquoise Parrot prefers to feed within 100 metres of the nest, but ranges up to 1.4 kilometres away. Most movements are less than 10 kilometres, often along treed corridors (NSW Scientific Committee 2008). Gap threshold assumed to be <100 metres.	<100	69	31
Superb Parrot	Superb Parrots are highly mobile, but its movement ecology is poorly understood (Baker-Gabb 2011). Given their migratory/nomadic nature, this species is considered able to cross large gaps. Gap threshold assumed to be >250m.	>250	100	0

An assessment of the likelihood of a species being struck by a train has been undertaken, taking into account the species ecology, morphology, and the percent of the Pilliga that is crossable by the species under the proposed design (Table 10.13).

Factors taken into account for the behavioural aspects relative to crossing gaps and avoiding train strike (risk of fatality) include:

- Body size and agility
- Mobility and location of movement (eg terrestrial, aerial etc)
- Willingness to move through open areas.

Different fauna guilds have been assigned a risk of fatality out of 100 based on these factors (see notes in Table 10.13).

Table 10.13 Train strike risk

Species	Gap threshold (m)	% Pilliga crossable	% Risk of fatality*	Train strike risk (% crossable x % fatality risk)
Koala	>200	95	95	90.25
Rufous Bettong	<60	36	75	27.00
Black-striped Wallaby	<100	69	75	51.75
Eastern Pygmy-possum	<50	7	50	3.50
Pilliga Mouse	<50	7	50	3.50
Squirrel Glider	<50	7	50	3.50
Pale-headed Snake	<150	92	100	87.40
Bush Stone-curlew	>250	100	50	50.00
Little Eagle	>250	100	5	5.00
Square-tailed Kite	>250	100	5	5.00
Barking Owl	>250	100	20	20.00
Masked Owl	>250	100	20	20.00
Glossy Black-cockatoo	>250	100	5	5.00
Corben’s Long-eared Bat	>250	100	20	20.00
Large-eared Pied Bat	>250	100	20	20.00
Little Pied Bat	>250	100	20	20.00
Yellow-bellied Sheath-tail bat	>250	100	10	10.00
Large Bentwing Bat	>250	100	10	10.00
Brown Treecreeper	<60	36	30	10.80
Diamond Firetail	<100	69	30	20.70
Flame Robin	<100	69	30	20.70
Grey-crowned Babbler	<200	95	30	28.50
Hooded Robin	<100	69	30	20.70
Speckled Warbler	<100	69	30	20.70
Varied Sittella	<100	69	10	6.90
Turquoise Parrot	<100	69	30	20.70

Species	Gap threshold (m)	% Pilliga crossable	% Risk of fatality*	Train strike risk (% crossable x % fatality risk)
Superb Parrot	>250	100	30	30.00
*** Key to fatality risk:**				
Mammals				
Slow, terrestrial	95			
Mobile, terrestrial or volant	75			
Small, terrestrial	50			
Aerial, below canopy	20			
Aerial, above canopy	10			
Birds				
Large, terrestrial	50			
Small woodland – ground foraging	30			
Riparian	20			
Small woodland – canopy foraging	10			
Above canopy	5			
Reptile				
Sedentary, terrestrial	100			

An individual species' sensitivity to prescribed impacts is comprised of two parts, defined by the species ability or inability to cross the gap. When a species is unable to cross the gap they are vulnerable to impacts of reduced connectivity. When a species is capable of crossing the gap they are vulnerable to train strike. It is likely that most species they will suffer from a combination of the two impacts as a result of their gap threshold, represented by the sensitivity rating.

The sensitivity rating score has been calculated by adding the vulnerability to connectivity score to the train strike risk score to give a rating score 0-100 (Table 10.4). This sensitivity rating score has been divided into various risk categories:

- Extreme: 75-100
- Major: 50-74
- Moderate: 25-49
- Low: 11-24
- Minor: 0-10.

Table 10.14 Sensitivity rating

Species	Mobility disruption (from Table 10.12)	Train strike risk from Table 10.13)	Score	Risk category
Koala	5.00	90.25	95.25	Extreme
Rufous Bettong	64.00	27.00	91.00	Extreme
Black-striped Wallaby	31.00	51.75	82.75	Extreme
Eastern Pygmy-possum	93.00	3.50	96.50	Extreme
Pilliga Mouse	93.00	3.50	96.50	Extreme
Squirrel Glider	93.00	3.50	96.50	Extreme
Pale-headed Snake	8.00	87.40	95.40	Extreme
Bush Stone-curlew	0.00	50.00	50.00	Major
Little Eagle	0.00	5.00	5.00	Minor
Square-tailed Kite	0.00	5.00	5.00	Minor
Barking Owl	0.00	20.00	20.00	Low
Masked Owl	0.00	20.00	20.00	Low
Glossy Black-cockatoo	0.00	5.00	5.00	Minor
Corben's Long-eared Bat	0.00	20.00	20.00	Low
Large-eared Pied Bat	0.00	20.00	20.00	Low
Little Pied Bat	0.00	20.00	20.00	Low
Yellow-bellied Sheath-tail bat	0.00	10.00	10.00	Minor
Large Bentwing Bat	0.00	10.00	10.00	Minor
Brown Treecreeper	64.00	10.80	74.80	Major
Diamond Firetail	31.00	20.70	51.70	Major
Flame Robin	31.00	20.70	51.70	Major
Grey-crowned Babbler	5.00	28.50	33.50	Moderate
Hooded Robin	31.00	20.70	51.70	Major
Speckled Warbler	31.00	20.70	51.70	Major
Varied Sittella	31.00	6.90	37.90	Moderate
Turquoise Parrot	31.00	20.70	51.70	Major
Superb Parrot	0.00	30.00	30.00	Moderate

10.3.5 Potential benefit from mitigation

Measures are included in the proposal to minimise the impacts on connectivity and from train strike. Fauna connectivity measures would be incorporated into the design of the proposal. These comprise several dedicated fauna structures, including dedicated culverts, canopy bridges and barrier poles, and drainage structures that would also be used by fauna, such as bridges and culverts. Landscaping following clearing would maintain connectivity and encourage fauna use of crossing structures, and to also cross the gap of their own accord.

Structures that are included in the design that would assist with safe fauna movement across the rail corridor are discussed in section 12.1.4 and the preliminary Fauna Connectivity Strategy (Appendix J), and summarised in Table 10.15.

It is recognised that not all structures may actually be used by their target species, and as such each structure has been assigned a weighting for each species to take into account potential issues relating to species distribution and behavioural attributes. It is noted that while connectivity measures are targeting impacts from both the barrier to movement and train strike, these variables are also interrelated. As such, a single weighting (on a scale of 0-100 percent) is used for each structure. The justification for the weightings assigned is provided in Table 10.15.

It is also noted that there are a number of species that do not have any proposed mitigation structures given their mode of movement (ie aerial species that fly above the canopy).

Table 10.15 Connectivity structures

Structure	Description	Number in the Pilliga	Comments	**Weighting/specifications**
Rail bridges and viaducts	Designed for large river and creek crossings. Span large distances (over 25 metres and up to 344 metres long). Maximum clearance the underneath the bridge ranges from at least 1.8 metres (two bridges), over 2.2 metres (three bridges) to over 3 metres (18 bridges). Allow for retention of riparian vegetation and provide dry passage for terrestrial fauna. Also likely to provide some passage for other fauna such as small birds.	23	Bridges are generally considered effective at allowing fauna passage. The use of bridges by fauna will depend on a variety of factors, including the length of the bridge, the height above the ground, species distribution, size, and inclination to move under the rail line. Given the length of the bridges, average clearance, and that creeks in the Pilliga are dry for the majority of the year, all bridges are considered to provide dry fauna passage.	Terrestrial fauna (medium to large -sized mammals and Pale-headed Snake): 75 percent Small mammals (Eastern Pygmy-Possum and Pilliga Mouse): 50 percent (noting that shading may reduce connectivity of vegetation under bridges) Woodland birds and microbats: 50 percent (noting that these aerial species need to fly under the bridges)
Dedicated underpasses	Culverts included in the design to directly benefit terrestrial fauna rather than to channel water. Include a variety of fauna furniture depending on the target species. The location of dedicated culverts was chosen to maximise height of culverts and avoid flood-prone areas. All culverts are assumed to comprise banks of three 2.4 metre wide culverts to maximise aperture (width x length) and openness (width x height x length).	51	Dedicated culverts have been shown to be used by a wide variety of fauna groups. For example, culverts on the north coast of NSW have been shown to be used regularly by species such as the Rufous Bettong (Goldingay et al 2022). Underpasses were positioned along the route through the Pilliga to increase opportunities for crossing. Fauna furniture (eg horizontal timber poles) is included where appropriate for the target species distribution and size of the culvert. The use of dedicated underpasses by fauna will depend on a variety of factors, including the size of the culvert, species distribution, size, and inclination to move through the culvert.	Culvert height suitability: • Small - medium-sized culverts (height 0.9 and 1.2 metres) – Pilliga Mouse – Eastern Pygmy-possum – Rufous Bettong – Pale-headed Snake • Medium-sized culverts (height 1.5 and 1.8 metres) – Black-striped Wallaby, and fauna noted above – Large-sized culverts (height 2.2, 2.7, 3, and 3.3 metres) – Koala (due to need to include furniture), and fauna listed above – Weighting 50% as not all culverts may be used, or located within home range of target species

Structure	Description	Number in the Pilliga	Comments	**Weighting/specifications**
Drainage culverts	Designed for smaller creek crossings for drainage and flooding. May provide some fauna passage when dry, but not designed for fauna passage. No fauna furniture included.	92	Drainage culverts are considered less likely than dedicated underpasses to provide fauna passage as no fauna furniture is included. However, fauna are known to move through drainage culverts.	Pale-headed Snake Weighting 25 percent as not specifically designed for fauna passage
Canopy bridges	Canopy bridges included in the design to connect canopy vegetation and provide passage for arboreal fauna. Can be hung over the rail line, or underneath rail bridges (where height permits).	52	Canopy bridges provide for genetic connectivity, dispersal movements and home range movements of arboreal species. The use of canopy bridges may be affected by species distribution and location of home ranges.	Eastern Pygmy-possum, Squirrel Glider; weighting of 50 percent as not all canopy bridges may be used, or located within home range of target species Pale-headed Snake, weighting of 10 percent as species use of canopy bridges not known
Barrier poles	Proposed as a pilot study to test the efficacy of this method. Designed to prevent birds flying into the side of trains at creek crossings.	6	Bridges can represent a risk for flying species as they tend to cross above them. Bridges can be flanked by barrier poles to ensure safe passage for aerial species well above moving rail traffic. This is a measure that has not been trialled previously in Australia, and its efficacy is not well understood.	Barking Owl, Masked Owl, microbats: weighting of 25 percent as efficacy unknown

The number of connectivity structures relevant to each species has been assessed. This has included review of the number of structures present within the species polygon or area of potential habitat in the Pilliga (Table 10.16). Some species may use a number of different structures (eg. the Eastern Pygmy-possum), while other species have only one relevant connectivity structure (eg. Squirrel Glider).

The number of structures has been adjusted by the weighting in Table 10.15. The frequency of mitigation structures (adjusted number of structures based on the weighting above) per kilometre of affected habitat has then been calculated (Table 10.16).

Table 10.16 Connectivity structures by species and linear impact

Measure (number in Pilliga)	Target species	Number	Weighting	Adjusted number	Length of impacted habitat (km)	Occurrence (km of habitat /number)	Adjusted occurrence (km of habitat /adj no)	Structure/km (number/km of habitat)	Adjusted structure/km of habitat *
Bridge or viaduct (23)	Koala	8	0.75	6	21.21	2.7	3.5	0.38	0.28
	Black-striped Wallaby	23	0.75	17.25	73	3.2	4.2	0.32	0.24
	Rufous Bettong	15	0.75	11.25	41.79	2.8	3.7	0.36	0.27
	Eastern Pygmy-possum	21	0.5	10.5	67.91	3.2	6.5	0.31	0.15
	Pilliga Mouse	23	0.5	11.5	10	0.4	0.9	2.30	1.15
	Pale-headed Snake	23	0.75	17.25	19.64	0.9	1.1	1.17	0.88
	Brown Treecreeper	18	0.5	9	73	4.1	8.1	0.25	0.12
	Diamond Firetail	18	0.5	9	73	4.1	8.1	0.25	0.12
	Flame Robin	18	0.5	9	73	4.1	8.1	0.25	0.12
	Hooded Robin	18	0.5	9	73	4.1	8.1	0.25	0.12
	Speckled Warbler	18	0.5	9	73	4.1	8.1	0.25	0.12
	Bush Stone-curlew	18	0.5	9	73	4.1	8.1	0.25	0.12
	Grey-crowned Babbler	18	0.5	9	73	4.1	8.1	0.25	0.12
	Corben's Long-eared Bat	18	0.5	9	73	4.1	8.1	0.25	0.12
	Large-eared Pied Bat	18	0.5	9	73	4.1	8.1	0.25	0.12
	Little Pied Bat	18	0.5	9	73	4.1	8.1	0.25	0.12
	Yellow-bellied Sheath-tail bat	18	0.5	9	73	4.1	8.1	0.25	0.12
	Eastern Bentwing	18	0.5	9	73	4.1	8.1	0.25	0.12

Measure (number in Pilliga)	Target species	Number	Weighting	Adjusted number	Length of impacted habitat (km)	Occurrence (km of habitat /number)	Adjusted occurrence (km of habitat /adj no)	Structure/km (number/km of habitat)	Adjusted structure/km of habitat *
Dedicated Underpass (51)	Koala	5	0.5	2.5	21.21	4.2	8.4	0.24	0.12
	Black-striped Wallaby	35	0.5	17.5	73	2.1	4.2	0.48	0.24
	Rufous Bettong	28	0.5	14	41.79	1.5	3.0	0.67	0.34
	Eastern Pygmy-possum	49	0.5	24.5	67.91	1.4	2.8	0.72	0.36
	Pilliga Mouse	51	0.5	25.5	10	0.8	1.6	1.22	0.61
Drainage (92)	Pale-headed Snake	40	0.1	4	19.64	0.5	4.9	2.04	0.20
Canopy bridge (52)	Squirrel Glider	38	0.5	19	49.58	1.3	2.6	0.77	0.38
	Eastern Pygmy-possum	50	0.5	25	67.91	1.4	2.7	0.74	0.37
Barrier poles (6)	Barking Owl	4	0.25	1	30	7.5	30.0	0.13	0.03
	Masked Owl	3	0.25	0.75	30	10.0	40.0	0.10	0.03
	Corben's Long-eared Bat	6	0.25	1.5	73	12.2	48.7	0.08	0.02
	Large-eared Pied Bat	6	0.25	1.5	73	12.2	48.7	0.08	0.02
	Little Pied Bat	6	0.25	1.5	73	12.2	48.7	0.08	0.02
	Yellow-bellied Sheath-tail bat	6	0.25	1.5	73	12.2	48.7	0.08	0.02
	Eastern Bentwing	6	0.25	1.5	73	12.2	48.7	0.08	0.02

* Note that some species have multiple relevant structures. The values in this column have been added together for the following table

The potential benefit from mitigation measures discussed above (connectivity structures and barrier poles) has been assigned a rating (low – high, as well as no need for mitigation) (Table 10.17). This rating has taken into account the number and type of connectivity measures for each species adjusted for efficacy, potential use and distance (Table 10.16). The following mitigation ratings have assigned depending on frequency of mitigation structures:

- Not required: 100
- Good: 75
- Moderate: 60
- Low: 30
- Poor: 10
- Not possible: 0.

The requirement for mitigation is based on the risk of fatality, with the score here the opposite of the risk of fatality score provided in Table 10.13 (ie. 100-risk of fatality score).

The mitigation score has then been calculated by multiplying the mitigation rating by the requirement for mitigation as a percent. The mitigation score represents how well the mitigation measures counteract the risk of fatality, which is why the rating goes in the opposite direction to the requirement for mitigation. This score is then given a mitigation category as follows:

- Not required >90
- High: 60-89
- Moderate: 30-59
- Low: 10-29
- Poor: <10.

Table 10.17 Mitigation rating

Species	Adjusted structure per km	Mitigation measures	Mitigation rating	Requirement (inverse of risk of fatality)	Mitigation score (rating x requirement)	Mitigation category
Koala	0.61	Moderate (1 per 2-3 km)	60	5.00	3.00	Poor
Rufous Bettong	0.59	Moderate (1 per 2-3 km)	60	25.00	15.00	Low
Black-striped Wallaby	1.39	Good (1 per km)	75	25.00	18.75	Low
Eastern Pygmy-possum	1.77	Good (1 per km)	75	50.00	37.50	Moderate
Pilliga Mouse	7.40	Good (1 per km)	75	50.00	37.50	Moderate
Squirrel Glider	0.77	Moderate (1 per 2-3 km)	60	50.00	30.00	Low
Pale-headed Snake	3.21	Good (1 per km)	75	5.00	3.75	Poor
Bush Stone-curlew	0.25	Low (<1 per 5 km)	30	50.00	15.00	Low
Barking Owl	0.13	Poor (<1 per 10 km)	10	80.00	8.00	Low
Masked Owl	0.10	Poor (<1 per 10 km)	10	80.00	8.00	Low
Corben's Long-eared Bat	0.33	Low (<1 per 5 km)	30	80.00	24.00	Low
Large-eared Pied Bat	0.33	Low (<1 per 5 km)	30	80.00	24.00	Low
Little Pied Bat	0.33	Low (<1 per 5 km)	30	80.00	24.00	Low
Yellow-bellied Sheath-tail bat	0.33	Low (<1 per 5 km)	30	90.00	27.00	Low
Large Bentwing Bat	0.33	Low (<1 per 5 km)	30	90.00	27.00	Low
Brown Treecreeper	0.25	Low (<1 per 5 km)	30	70.00	21.00	Low
Diamond Firetail	0.25	Low (<1 per 5 km)	30	70.00	21.00	Low
Flame Robin	0.25	Low (<1 per 5 km)	30	70.00	21.00	Low

Species	Adjusted structure per km	Mitigation measures	Mitigation rating	Requirement (inverse of risk of fatality)	Mitigation score (rating x requirement)	Mitigation category
Grey-crowned Babbler	0.25	Low (<1 per 5 km)	30	70.00	21.00	Low
Hooded Robin	0.25	Low (<1 per 5 km)	30	70.00	21.00	Low
Speckled Warbler	0.25	Low (<1 per 5 km)	30	70.00	21.00	Low
Varied Sittella	0	Not possible	0	90.00	0.00	Low
Turquoise Parrot	0.08	Poor (<1 per 4 km)	30	70	21.00	Low
Superb Parrot	0	Not required	100	70	70.00	High
Little Eagle	0	Not required	100	95.00	95.00	Not required
Square-tailed Kite	0	Not required	100	95.00	95.00	Not required
Glossy Black-cockatoo	0	Not required	100	95.00	95.00	Not required

10.3.6 Additional credits for prescribed impacts (connectivity and vehicle strike)

The results of the sensitivity analysis (section 10.3.4) and mitigation analysis (section 10.3.5) have been used to create a risk matrix. This matrix has been applied to identify a percent additional liability of credits required to offset these prescribed impacts for species credits (see Table 10.18). The average of the additional credits has been used to identify a mark-up for ecosystem credits to allow for impacts on predicted species.

The percent additional liability has taken into account specific mitigation measures (including number and types of connectivity structures). Any changes to the proposed mitigation measures or landscaping could result in changes to the credit liability. It is assumed that the connectivity structures proposed here and in the Preliminary Fauna Connectivity Strategy are the minimum requirements. Any changes to the number or type of connectivity structures constructed for the proposal would be subject to a revised assessment and review and approval by BCS prior to the construction of these elements. While specific landscaping treatments have been proposed to mitigate connectivity impacts in section 12.1, these have not been included in the calculation of additional credits for prescribed impacts as it is not appropriate to detail the specific spatial extent and composition of each treatment at this phase of the proposal development. Once these are developed in the detailed design phase, there may be opportunities for future revisions of credit liabilities for certain species, in consultation with BCS..

Table 10.18 Risk matrix and credit mark-up (rating) for prescribed impacts

Impact	Minor	Low	Moderate	Major	Extreme
Mitigation category					
Not required	3%	8%	8%	30%	45%
High	8%	8%	15%	45%	60%
Moderate	8%	15%	45%	60%	90%
Low	30%	45%	60%	90%	150%
Poor	45%	60%	90%	150%	225%

A summary of the risk matrix assessment results and associated credit mark-up for each relevant species credit species is provided in Table 10.19. The credit mark-up of ecosystem credit species has been averaged to find a mark-up for ecosystem credits. This has then been assigned to woodland and forest vegetation. No markup has been assigned to grassland or derived native grassland.

Table 10.19 Summary of risk assessment and credit mark-up for the Pilliga segment

Species	Impact Score	Risk Category	Mitigation Score	Benefit category	Credit mark-up (%)
Candidate species					
Koala	95.25	Extreme	3.00	Poor	225.00
Rufous Bettong	91.00	Extreme	15.00	Low	150.00
Black-striped Wallaby	82.75	Extreme	18.75	Low	150.00
Eastern Pygmy-possum	96.50	Extreme	37.50	Moderate	90.00
Pilliga Mouse	96.50	Extreme	37.50	Moderate	90.00

Species	Impact Score	Risk Category	Mitigation Score	Benefit category	Credit mark-up (%)
Squirrel Glider	96.50	Extreme	30.00	Low	150.00
Pale-headed Snake	100.00	Extreme	3.75	Poor	225.00
Bush Stone-curlew	50.00	Major	15.00	Low	90.00
Little Eagle	5.00	Minor	95.00	Not required	3.00
Square-tailed Kite	5.00	Minor	95.00	Not required	3.00
Barking Owl	20.00	Low	8.00	Low	45.00
Masked Owl	20.00	Low	8.00	Low	45.00
Glossy Black-cockatoo	5.00	Minor	95.00	Not required	3.00
Predicted Species					
Corben’s Long-eared Bat	20.00	Low	24.00	Low	45.00
Large-eared Pied Bat	20.00	Low	24.00	Low	45.00
Little Pied Bat	20.00	Low	24.00	Low	45.00
Yellow-bellied Sheath-tail bat	10.00	Minor	27.00	Low	30.00
Large Bentwing Bat	10.00	Minor	27.00	Low	30.00
Brown Treecreeper	74.80	Major	21.00	Low	90.00
Diamond Firetail	51.70	Major	21.00	Low	90.00
Flame Robin	51.70	Major	21.00	Low	90.00
Grey-crowned Babbler	33.50	Moderate	21.00	Low	60.00
Hooded Robin	51.70	Major	21.00	Low	90.00
Speckled Warbler	51.70	Major	21.00	Low	90.00
Varied Sittella	37.90	Moderate	0.00	Low	60.00
Turquoise Parrot	51.70	Major	21.00	Low	90.00
Superb Parrot	30.00	Moderate	70.00	High	15.00
Average credit mark-up for predicted species					69

Credit calculations are detailed in section 13. Additional species credits required for prescribed impacts in the Pilliga segment are summarised in Table 10.20. Additional ecosystem credits calculated based on a 69 percent mark-up on non-grassland vegetation types are summarised in Table 10.21. A breakdown by segment is provided in Table 13.2

Table 10.20 Additional species credits required to offset prescribed impacts in the Pilliga segment

Species	BAM-C Credits	Prescribed impact mark-up (%)	Additional credits	Total credits
Barking Owl	6,314	45	2,841	9,155
Bush Stone-curlew	9,986	90	8,987	18,973
Eastern Pygmy-possum	17,111	90	15,400	32,511
Glossy Black-cockatoo	6,571	3	197	6,768
Koala	5,704	225	12,834	18,538
Little Eagle	6,118	3	184	6,302
Masked Owl	4,385	45	1,973	6,358
Pale-headed Snake	4,895	225	11,014	15,909
Rufous Bettong	10,530	150	15,795	26,325
Square-tailed Kite	5,241	3	157	5,398
Squirrel Glider	12,079	150	18,119	30,198
Total	**88,934**		**87,501**	**176,435**

Table 10.21 Additional ecosystem credits required to offset prescribed impacts

Vegetation zone	Ecosystem credits calculated for Segment 10	Additional prescribed impact credits
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	1,281	884
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (Good)	433	299
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion (Good)	5	3
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good)	926	639
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good, fire affected)	102	70
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion (Good)	286	197
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 (Good)	8,779	6,058
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 (Moderate, shrubs removed)	157	109
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (Good)	977	674
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests (Good)	481	332
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests (Good)	51	35
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 (Good)	13	9

Vegetation zone	Ecosystem credits calculated for Segment 10	Additional prescribed impact credits
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion (Good)	79	55
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion (Good)	9	6
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion (Good)	354	255
Grand Total		9,625

10.4 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 10.22 below. The proposal is not a KTP in itself, but would exacerbate KTPs during construction and operation. Mitigation measures to limit the impacts of these KTPs (where possible) are discussed in section 12.

Table 10.22 Key threatening processes

KTP	Listing	Discussion
Clearing of native vegetation	BC Act EPBC Act	The proposal includes the clearing of about 1,173 hectares of native woodland, 38 hectares of native shrubland and about 580 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 12 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 12).
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 12).
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.
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,

KTP	Listing	Discussion
		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 percent 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 12.
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 12.
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 12).
Competition from feral honeybees	BC Act	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.
Competition and grazing by the feral European rabbit	BC Act EPBC Act	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.

KTP	Listing	Discussion
Competition and habitat degradation by Feral Goats, *Capra hircus* Linnaeus 1758	BC Act	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.
Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*)	BC Act	
Predation by feral cats	BC Act EPBC Act	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 12.
Predation by the European Red Fox	BC Act EPBC Act	
Importation of Red Imported Fire Ants into NSW	BC Act	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 12.
Invasion of the Yellow Crazy Ant (*Anoplolepis gracilipes*) into NSW	BC Act	
Novel biota and their impact on biodiversity	EPBC Act	
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 12).
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.

KTP	Listing	Discussion
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.

11. Potential impacts on Matters of National Environmental Significance

11.1 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 11.1. Note that Poplar Box grassy woodland on alluvial plains was listed under the EPBC Act following referral of the proposal.

Table 11.1 EPBC threatened ecological communities in the proposal site

Threatened ecological community	EPBC Act Status	Potential impacts	Significant impact likely
Weeping Myall Woodlands	E	6.5 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	7.2 hectares to be removed including 5.9 hectares of derived native grassland and 1.3 hectares of woodland.	No
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia	E	15.9 hectares to be removed including 1.1 hectares of paddock trees.	No
Poplar Box grassy woodland on alluvial plains	E	76.3 hectares to be removed from scattered and isolated smaller patches across the mid sections of the alignment and includes 18 hectares of derived native grassland.	No
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE	8.0 hectares to be removed from two patches more than 200 kilometres apart.	No
	Total	**111.5 hectares**	

11.2 Threatened species

Impacts on threatened species have been assessed in sections 9 and 10 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 11.2. Note that the Glossy Black-cockatoo was listed under the EPBC Act following referral of the proposal.

Table 11.2 Significance of impacts on EPBC Act listed threatened flora and fauna species

Name	EPBC Act	Potential impacts	Significant impact likely?
Fauna			
Koala	V	1,173 hectares of woodland and forest to be removed along a 300 kilometre linear alignment generally about 50 metres wide. Of this, 260.4 hectares has been identified as occupied habitat, of which 257.5 ha located in the Pilliga and Bohena Creek areas. Impacts on connectivity, however dedicated culverts and various bridges in the area of occupied habitat proposed to maintain connectivity.	Yes
Corben's Long-eared Bat	V	1,107.4 hectares of suitable woodland and forest containing hollow-bearing trees to be removed along a 300 kilometre linear alignment. Of this, 615 hectares would be removed in the Pilliga forests. Between 14,503 and 41,103 hollow-bearing trees estimated to be removed.	Yes
Large-eared Pied Bat	V	649 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	647.1 hectares of potential habitat in the Pilliga forests to be removed along a 73 kilometres linear alignment generally about 50 metres wide. This includes 31 hectares of PCT 141 which is preferred breeding habitat, and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*, also identified as habitat for this species. Impacts on connectivity, however dedicated culverts in potential breeding habitat and elsewhere in the Pilliga are proposed.	Yes
Glossy Black-cockatoo	V	324.7 hectares of known and potential habitat to be removed. Of this, 224 hectares would be removed in the Pilliga forests (segment 10). Between 14,503 and 41,103 hollow-bearing trees are estimated to be removed as a result of the project, which includes hollows suitable for this species.	No

Name	EPBC Act	Potential impacts	Significant impact likely?
Painted Honeyeater	V	1,107.4 hectares of suitable woodland and forest to be removed along a 300 kilometres linear alignment generally about 50 metres wide. Of this, 615 hectares would be removed in the Pilliga forests. Removal of a large number of mistletoe (key foraging and breeding habitat).	Yes
Superb Parrot	V	1,173 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, 615 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 Legless Lizard	V	No direct impacts on preferred habitat. No connectivity with known populations.	No
Regent Honeyeater	CE	286.8 hectares of woodland and forest habitat containing preferred feed species to be removed from relevant IBRA subregions along the 300 kilometres linear alignment that may provide foraging habitat for this species (critical foraging habitat). No impact on breeding habitat. No impact on important foraging areas identified by Birdlife Australia in the south of the Pilliga.	Yes
Swift Parrot	CE	732.9 hectares of woodland and forest containing preferred feed trees to be removed from relevant IBRA subregions along the 300 kilometre linear alignment. No impact on important foraging areas identified in the east of the Pilliga. No impact on breeding habitat.	Possible
White-throated Needletail	V	1,173 hectares of 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			
Bertya opponens Coolabah Bertya	V	No evidence of the species was recorded in the Pilliga forests or elsewhere during surveys. Population previously known from Bohena Creek not able to be found and is considered extinct.	No
Commersonia procumbens	V	572.9 hectares of potential habitat to be removed.	Yes
Dichanthium setosum Bluegrass	V	3.5 hectares of assumed presence potential habitat to be removed.	No
Lepidium aschersonii Spiny Peppercress	V	338.7 hectares of assumed presence potential habitat to be removed.	Yes
Lepidium monoplocoides Winged Peppercress	E	175.8 hectares of assumed presence potential habitat to be removed.	Yes
Swainsona murrayana Slender Darling Pea	V	53.1 hectares of potential habitat to be removed but species not recorded from targeted surveys in these locations.	No
Tylophora linearis	E	16 hectares of known habitat and 21.9 hectares of assumed presence potential habitat to be removed.	Yes
Zieria ingramii Keith's Zieria	E	48.6 hectares of assumed presence potential habitat to be removed.	No

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

11.3 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 11.3.

Table 11.3 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 1,791 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?
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
Satin Flycatcher	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
White-throated Needletail	Large tracts of native vegetation, particularly forest, may be a key habitat requirement for species. The proposal will remove 1,173 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

11.4 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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12. Recommended mitigation measures

12.1 Environmental safeguards

12.1.1 Detailed design and pre-construction

Measures proposed for detailed design and pre-construction to mitigate the risk of biodiversity impacts are provided in Table 12.1.

Table 12.1 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	Vegetation clearing would be limited to the minimum necessary to construct the proposal and allow for its effective operation.	Effective	Measures meet best practice management of flora and fauna on construction projects.	Pre-construction
		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	Harm to threatened fauna species	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 flora pre-clearance survey	Additional threatened flora surveys should be completed prior to clearing for the threatened species likely to be impacted by the proposal, including • *Diuris tricolor* in the Pilliga forests • *Pterostylis cobariensis* in the Pilliga forests • *Tylophora linearis* in the Pilliga forests. Surveys would include seed collection where possible.	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 BCS 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 NSW Biodiversity Offsets Scheme and in consultation with BCS. This would include 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
Fauna connectivity	Fragmentation of fauna habitat, population fragmentation	A detailed fauna connectivity strategy would be prepared with reference to the preliminary framework provided in Appendix J and would include investigation and design of: • locations for fauna crossing structures in the Pilliga forests, including bridges and dedicated underpasses for threatened fauna (such as the Koala and Pilliga Mouse in areas of preferred habitat), canopy bridges at regular intervals, and wooden barrier poles at selected bridges • the provision of localised fencing to direct fauna to crossing structures • fauna furniture to be included in the design of bridges and dedicated underpasses where appropriate to encourage crossings by koalas and other native fauna. • landscaping of the rail corridor to encourage movement of fauna across the gap. It is expected that the fauna connectivity structures listed in the register of proposed	Potentially effective	Measures meet best practice management of fauna on construction projects. Some new and emerging technologies are proposed to be trialled to improve connectivity or minimise train-strike of fauna. Barrier poles have not been tested in Australia but have been found to be effective in some situations in other studies. Bridges, dedicated underpasses, canopy bridges provide some crossing options, however, will not entirely mitigate the presence of the rail line.	Pre-construction

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
		connectivity structures in Appendix J would be further developed in detailed design and constructed as proposed. If any changes occur to the proposed number, type or location of connectivity structures, an appropriate level of assessment would be conducted, in consultation with BCS, to confirm any changes to credit liabilities for the proposal. The fauna connectivity strategy would include monitoring and reporting requirements in relation to the operational performance of the final measures.		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	
Train strike	Fauna mortality	The Preliminary Fauna Connectivity Strategy (Appendix J) would guide detailed design of fencing. The final fauna connectivity strategy would show locations where fencing is required to reduce the risk of fauna mortality. These would include: • stock fencing in agricultural areas to minimise the risk of stock-train collisions, and risk of mortality of native fauna such as macropods and emus • fauna fencing to direct fauna to dedicated crossing locations.	Potentially effective	Fencing minimises entry of fauna into the rail corridor but does not entirely prevent it. Fencing of the Pilliga forests would result in a barrier to movement, and thus fauna fencing is only proposed in select locations.	Pre-construction

12.1.2 Construction

Measures proposed for construction to mitigate the risk of biodiversity impacts are provided in Table 12.2.

Table 12.2 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 to protect biodiversity and minimise the potential 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 structures, including wooden telegraph poles and old buildings to be removed • searches for nest trees and hollow-bearing trees • identification of hollow-bearing trees and logs requiring fauna rescue, relocation or other 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 high biodiversity value (eg threatened ecological communities, known threatened plant populations etc) 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 within the construction footprint that are not required as part 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
		To improve fauna connectivity across the rail corridor, habitat linkages would be included in the rail corridor where practicable and consistent with the safe operation and maintenance of Inland Rail. Linkages would involve retaining or rehabilitating groundcovers and low shrubs, with a focus on those areas of the rail corridor within the Pilliga forests and other areas of connected vegetation. Rehabilitation or revegetation is to occur as soon as possible to minimise the lag between impact and mitigation. As part of construction planning, opportunities to minimise construction clearing within the rail corridor would be investigated for high value connectivity areas.	Likely to be effective	Measure is proposed to reduce the cleared gap and provide supplementary cover for fauna.	Construction

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	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

12.1.3 Operation

The main risks that are likely to impact biodiversity during operation of the proposal and the proposed mitigation measures are provided in Table 12.3.

Table 12.3 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 including impacts on fauna as a result of train operations and associated rail maintenance activities) would be monitored in accordance with the fauna connectivity strategy. This would include recording of wildlife collisions with trains, and monitoring of use of crossing structures by target species (including the Pilliga Mouse, Squirrel Glider and Eastern Pygmy-possum) and feral predators. The threatened species management plans will include appropriate adaptive management measures to address situations where fauna connectivity and population impact thresholds are exceeded.	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 proposal is still likely to result in fragmentation of populations of some species with lower dispersal abilities.	Operation
Train strike	Fauna mortality	The performance of fauna connectivity measures (including impacts on fauna as a result of train operations and maintenance activities such as mortality through train-strike) will be monitored. The threatened species management plans will include appropriate adaptive management measures to	Potentially effective	Measures meet best practice management of flora and fauna on construction projects.	Operation

Risk	Potential impacts	Recommended measures to avoid, mitigate or minimise impacts	Likely effectiveness	Justification for likely effectiveness	Recommended timing of implementation
		address situations where fauna connectivity and population impact thresholds are exceeded.		Adaptive design is recommended to allow for improvements.	
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

12.1.4 Fauna connectivity

Fauna connectivity structures and measures

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). Animals use non-wildlife passes (ie those placed and designed for purposes other than to allow wildlife crossing, like drainage culverts), and 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). A recent study on the north coast of NSW confirms the value of underpasses for a range of medium-large mammals including target species for this project, and that habitat adjoining underpasses exert a strong influence on their use (Goldingay et al 2022).

Fauna connectivity measures would be incorporated into the design of the proposal (see Table 12.4). The 73 bridges and viaducts would provide dry passage for fauna along riparian corridors. Certain bridges would also include fauna furniture and canopy bridges to encourage fauna movement. A number of fauna structures are also proposed, including 97 dedicated fauna culverts and 67 canopy bridges. A total of 280 drainage culverts have been identified that could include raised ledges to improve fauna passage opportunities. Emerging and new measures such as barrier poles and targeted removal of ballast should also be trialled. Fencing and revegetation would be required to encourage fauna use of dedicated structures.

Fauna connectivity strategy

A Preliminary Fauna Connectivity Strategy is provided in Appendix J. This provides details of the various measures and outlines the monitoring and reporting requirements that would need to be prepared as part of the detailed design phase. Monitoring would also include assessing the effectiveness of proposed crossing structures or mitigation devices at reducing barrier effects and the incidence of train strike. The final fauna connectivity strategy must include adaptive management, and implementation of additional mitigation measures if required. The final fauna connectivity strategy must be prepared in consultation with BCS as a condition of consent.

Table 12.4 Fauna connectivity structures and mitigation devices

Structure type	Description and effectiveness	Locations
Bridges	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. Fauna furniture (horizontal wooden poles attached to the outer piers) is recommended in some locations 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 (if this does not interfere with flooding).	Examples of crossings and lengths are provided below: Major crossings: • Macquarie River (over one kilometre 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 four kilometres long). Provides clearance of 12.7 metres over Narrabri Creek and 12 metres over Namoi River creek. Has a clearance of over five metres over various roads and large areas of agricultural land. Pilliga Forest: • Baradine Creek (over 200 metres long) • Etoo Creek (over 300 metres long) • Rocky Creek (over 100 metres long) • Coghill Creek (over 150 metres long) • Bundock Creek (over 100 metres long).
Pole barriers	Pole barriers are recommended along bridges 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.	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).

Structure type	Description and effectiveness	Locations
Dedicated fauna culverts	Dedicated fauna culverts are proposed for the Pilliga forests and Bohena Creek area to encourage safe movement of terrestrial and arboreal fauna. Dedicated fauna culverts are proposed in areas where drainage culverts are not present. A total of 51 locations have been identified as being potentially suitable. The number, size and location of dedicated fauna culverts would be confirmed during detailed design. Fauna furniture (such as horizontal wooden poles) is recommended in areas of the Pilliga mapped as the Koala species polygon. Fauna furniture may also be used in other dedicated culverts to encourage use by species such as the Eastern Pygmy-possum. A natural substrate is also recommended for fauna such as the Rufous Bettong, Black-striped Wallaby and Pilliga Mouse. Revegetation at the approaches to the culverts would also assist with increasing the efficacy of these structures for connectivity. Fauna fencing may also be included at dedicated culverts. Alternatively, fauna may be channelled to culverts via a combination of 1:2 batters and revegetation.	Pilliga forest and Bohena Creek area
Combined drainage/fauna passage culverts	Numerous 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). Culverts would be dry most of the time as most drainage lines are subject to ephemeral flows only. Dry ledges are proposed for combined culverts to allow dry passage by fauna following rain events. Revegetation at the approaches to the culverts would also assist with increasing the efficacy of these structures for connectivity.	Combined culverts are proposed in forested locations where there is suitable height of culverts for ledges to be included.
Canopy bridges	Canopy bridges provide for genetic connectivity, dispersal movements and home range movements of non-gliding arboreal fauna, such as the Antechinus species, and possums, as well as gliders. Canopy bridges are recommended at 67 locations along the alignment, with the majority in the Pilliga forests. Canopy bridges are also proposed at major river crossings and other large creek crossings, if there is suitable height above the waterway. The precise locations would be determined during detailed design as part of the fauna connectivity strategy.	Pilliga forests, Macquarie River, Castlereagh River, Bohena Creek, Namoi River, Narrabri Creek

Structure type	Description and effectiveness	Locations
Fencing	The rail line will be fenced where it is located in agricultural land to prevent mortality of stock. Fencing of areas where grazing occurs in the Pilliga is also recommended. Stock fencing 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 dedicated 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. The increased negative barrier effect that would be caused by fencing would outweigh the potential reduction in train strike mortality. Fencing at drainage lines may cause blockage and damage to structures, and is thus not proposed.	Pilliga forests, Bohena Creek
Removal of ballast	Removing the gravel below pairs of sleepers would create a gap that may be used by small vertebrates to cross under the sleepers. In the Pilliga, this option could be considered for sections where there are larger distances between culverts.	Pilliga forests

12.2 Adaptive management for uncertain impacts

As noted earlier in this BDAR, the impacts of rail infrastructure on Australian fauna have had limited study. Similarly, there has been limited research regarding the efficacy of fauna crossing structures on rail lines. Given the low densities or cryptic nature of some threatened species, there is also limited information available for these species, making assessments of potential impacts difficult to quantify.

Baseline and operational monitoring of fauna are likely to provide useful scientific research in this field. 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. There is also the opportunity for innovative research and mitigation measures to be developed and implemented. Baseline and operational monitoring are likely to provide substantial research outputs that will be beneficial to knowledge of the threatened species and impacts of linear infrastructure in Australia. Research outputs could also be used to refine management measures as local conditions become better understood.

Further detail on monitoring is provided in the Preliminary Fauna Connectivity Strategy in Appendix J.

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13. Offsetting

13.1 BC Act – Offset for affected threatened biota

Impacts associated with the proposal that require offsetting include the removal of 1,791 hectares of native vegetation, and associated habitat for threatened biota.

13.1.1 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 is required is not yet known. Any application of offset trading rules would be documented in an addendum report.

PCT 81 and PCT 244 could not be selected within the BAM-C as the TEC of Inland Grey Box in the Bogan-Macquarie and Castlereagh-Barwon IBRA subregions respectively, and PCT 599 could not be selected within the BAM-C as the TEC of White Box Yellow Box Blakely’s Red Gum Woodland in the Bogan-Macquarie IBRA subregion. This is because these TECs are not associated with these subregions under the BC Act. It is however, recognised that these PCTs in the proposal site are located in close proximity to IBRA subregions that these TECS are associated with (Inland Slopes and Pilliga), and the composition of the vegetation meets the NSW and Commonwealth listing criteria for these TECs. Ongoing consultation with BCS has found no way of changing the subregion association within the BAM-C. However, recognising that these TECs do occur, trading rules would still apply to these PCTs and would be applied for this proposal. There would be no change to credit obligations.

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.

13.1.2 Ecosystem credits

The data from the fieldwork and mapping was entered into version 1.4.0.00 of the BAM credit calculator (version 50) 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 1,791 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 all 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 13.2).

A total of 39,427 ecosystem credits were calculated for the proposal for direct removal of native vegetation and threatened species habitat using the BAM-C, with an additional 9,625 calculated for prescribed impacts in the Pilliga segment (totalling 49,052 ecosystem credits). Ecosystem credits that would be required to offset the impacts of the proposal in each IBRA subregion are shown in Table 13.2. Ecosystem credit requirements by segment (see Table 13.2) 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, and additional credits assigned for prescribed impacts as per the methodology outlined in sections 10.3 and 13.1.4.

Table 13.1 Ecosystem credits (including hollow-bearing tree credits) and impact area by subregion

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
NSW South Western Slopes bioregion, Inland slopes subregion						
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – Good	1.4	97.8	0	51	51
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – DNG	12.1	9.6	0	0	0
	Total native vegetation impact area and ecosystem credits for Inland Slopes subregion	**13.5 ha**			**51**	**51**
Darling Riverine Plains bioregion, Bogan-Macquarie subregion						
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good	2.8	63.3	0	65	65
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	11.7	74.1	0	437	0
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	0.6	99.7	0	30	30
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion – Good	0.9	80.1	0	36	36
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	19.0	57.3	0	348	348
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	0.5	38.5	0	7	0
248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW – Good	16.3	74.5	0	482	482
255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	4.3	53.1	0	100	100

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
599	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions – Good	3.0	78	0	117	117
	Total native vegetation impact area and ecosystem credits for Bogan-Macquarie subregion	**59.1 ha**			**1622**	**1178**
Darling Riverine Plains bioregion, Castlereagh-Barwon subregion						
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	4.6	57.2	0	132	0
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	122.2	93.8	0	5,015	0
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	12.8	73.3	0	469	469
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – DNG	18.4	40.1	0	369	0
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	8.7	58.1	0	221	221
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	13.6	63.0	0	321	321
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	3.1	38.5	0	45	0
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	15.8	36.8	0	291	291
206	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – Good	5.2	79.1	0	180	180
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – good	19.7	87.2	0	859	859
444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion – good	1.7	85.1	0	72	72

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
	Total native vegetation impact area and ecosystem credits for Castlereagh-Barwon subregion	**225.8 ha**			**7,974**	**2413**
Brigalow Belt South bioregion, Pilliga subregion						
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	1.9	44.8	0	43	0
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good	3.0	52	0	68	68
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	91.1	52.9	0	2,110	0
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	3.1	46.6	0	72	72
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	6.5	53.9	0	175	175
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	8.5	46.6	0	173	173
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	205.4	43.3	0	3,336	3,336
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Low	1.7	45.1	0	29	29
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	49.9	30.2	0	565	0
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	29.0	37.7	0	410	0
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	49.3	24.7	0	608	608

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) – Good	3.6	99.5	0	179	179
206	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – Good	4.9	41.6	0	89	89
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – Good	24.2	35.5	0	430	430
255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	7.9	36.8	0	127	127
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion – Good	0.3	41.5	0	5	0
394	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	35.6	44.7	0	596	596
394	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good, fire affected	11.1	24.6	0	102	0
394	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – DNG	15.4	40.4	0	233	0
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good	3.1	44.8	0	52	0
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	203.0	64.7	0	5,029	5,029
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	22.9	55.9	0	480	480
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Good	25.1	51.1	0	481	481
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests – Good	2.4	57	0	51	51

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
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	0.8	47.2	0	14	14
414	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion – Good, fire affected	7.3	28.8	0	79	0
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	1	38.6	0	14	0
746	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion – Good	2.1	45.6	0	36	0
1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion – Good	8.8	80	0	352	0
	Total native vegetation impact area and ecosystem credits for Pilliga subregion	**828.9 ha**			**15,938**	**11,937**
Brigalow Belt South bioregion, Pilliga Outwash subregion						
35	Brigalow – Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Goondiwindi, Brigalow Belt South bioregion – Good	1.4	62.6	0	44	44
35	Brigalow – Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – DNG	5.9	37.7	0	111	0
49	Partly derived Windmill Grass – Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	98.0	51	0	2,186	0
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	10.7	86.2	0	404	404
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – DNG	1.3	40.8	0	23	0
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	72.6	52.5	0	1,430	1,430
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG	36.3	40.6	0	552	0

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	1.9	30.9	0	22	0
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	5.8	31.9	0	92	92
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	46.2	58.6	0	1,185	1,185
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 – DNG	95.4	35.8	0	1,493	0
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplains-Good	0.2	88.1	0	7	0
394	Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	19.0	56.1	0	399	399
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good	14.7	52.6	0	290	290
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	170.9	59.5	0	3,815	3,815
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 (Moderate, shrubs removed)	8.4	49.6	0	156	156
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	31.9	56.9	0	681	681
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – Good	0.3	100	0	19	19
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – DNG	5.1	40.4	0	129	0

PCT ID	Vegetation zone – condition	Impact area (ha)	Current VI score	Future VI score	TOTAL Ecosystem credits required	HBT credits required
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	19.2	55.5	0	400	400
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 – DNG	0.9	8.2	0	0	0
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion – Moderate, logged	1.0	44	0	22	22
	Total native vegetation impact area and ecosystem credits for Pilliga Outwash subregion	**647.1 ha**			**13,460**	**8,937**
Brigalow Belt South bioregion, Liverpool Plains subregion						
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	0.2	65.5	0	7	7
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	1.4	42.0	0	26	0
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – derived	7.1	88.9	0	237	0
	Total native vegetation for Liverpool Plain subregion	**8.7 ha**			**270**	**7**
Brigalow Belt South bioregion, Northern Basalts subregion						
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – derived	7.1	28.6	0	89	0
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	0.7	65.5	0	23	23
	Total native vegetation for Northern Basalts subregion	**7.8 ha**			**112**	**23**
Total ecosystem credits					**39,427**	**24,546**

Table 13.2 Ecosystem credits required to offset impacts of the proposal by segment

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
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 (Good)	11.7	437	0	437
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	3.6	66	0	66
SEGMENT 1 – TOTAL ecosystem credits required		**503**	**0**	**503**
SEGMENT 2 – Curban multi-function compound				
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	1.5	37	0	37
SEGMENT 2 – TOTAL ecosystem credits required		**37**	**0**	**37**
SEGMENT 3 – Narrabri multi-function compound				
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (Good)	0.2	9	0	9
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 (Good)	6.4	164	0	164
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 (DNG)	86.6	1,357	0	1,357
SEGMENT 3 – TOTAL ecosystem credits required		**1,530**	**0**	**1,530**
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 (Good)	1.4	50	0	50
SEGMENT 4 – TOTAL ecosystem credits required		**50**	**0**	**50**

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
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 (Good)	4.3	99	0	99
SEGMENT 5 – TOTAL ecosystem credits required		**99**	**0**	**99**
SEGMENT 6 – Borrow pit C and haul road				
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	0.4	7	0	7
PCT 255 Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion (Good)	7.9	127	0	127
SEGMENT 6 – TOTAL ecosystem credits required		**134**	**0**	**134**
SEGMENT 7 – Borrow pit D and haul road				
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 (Good)	2.6	61	0	61
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion (Good)	2.1	36	0	36
SEGMENT 7 – TOTAL ecosystem credits required		**97**	**0**	**97**
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 (Good)	5.8	132	0	132
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (Good)	113.8	3,526	0	3,526
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (Good)	3.1	72	0	72
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW (Good)	19.8	670	0	670

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW (DNG)	18.4	369	0	369
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (Good)	3.1	76	0	76
PCT 81 Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	0.9	36	0	36
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	142	2,346	0	2,346
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (DNG)	49.0	556	0	556
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Low)	1.7	28	0	28
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion (Good)	3.6	179	0	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 (Good)	10.1	269	0	269
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) (Good)	15.4	274	0	274
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW (Good)	16.3	481	0	481
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good)	4.2	70	0	70
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (DNG)	15.4	233	0	233
PCT 469 White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	1.0	14	0	14

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
PCT 599 Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion (Good)	3.0	118	0	118
SEGMENT 8 – TOTAL ecosystem credits required		**9,449**	**0**	**9,449**
SEGMENT 9 – Alignment (Curban to Pilliga)				
PCT 27- Weeping Myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South Bioregion (Good)	6.5	173	0	173
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (Good)	166.3	5,087	0	5,087
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (Good)	14.1	319	0	319
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	84.9	1,516	0	1,516
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (DNG)	4.6	62	0	62
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion (Good)	65.1	900	0	900
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion (DNG)	5.8	92	0	92
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) (Good)	28.5	1,015	0	1,015
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion (Good)	2.9	57	0	57
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion (Good)	0.3	20	0	20
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion (DNG)	5.1	128	0	128
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion (Good)	1.7	74	0	74

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion (Good)	0.6	14	0	14
SEGMENT 9 – TOTAL ecosystem credits required		**9,457**	**0**	**9,457**
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 (Good)	4.3	95	0	95
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	69.9	1,281	884	2,165
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (DNG)	2.4	36	0	36
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (Good)	29.0	433	299	732
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion (Good)	0.3	5	3	8
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good)	50.4	926	639	1,565
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good, fire affected)	11.1	102	70	172
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion (Good)	14.9	286	197	483
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 (Good)	371.2	8,779	6,058	14,837
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 (Moderate, shrubs removed)	8.4	157	109	266
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (Good)	46.2	977	674	1,651

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests (Good)	25.1	481	332	813
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests (Good)	2.4	51	35	86
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 (Good)	0.8	13	9	22
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion (Good)	7.3	79	55	134
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion (Good)	0.4	9	6	15
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion (Good)	8.8	354	255	609
SEGMENT 10 – TOTAL ecosystem credits required		**14,064**	**9,625**	**23,689**
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 (Good)	1.4	45	0	45
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (DNG)	5.9	110	0	110
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (Good)	34	690	0	690
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (Good)	0.9	29	0	29
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (Good)	11.9	424	0	424
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (DNG)	1.3	24	0	24

Vegetation zones by segment	Impact area (ha)	Ecosystem credits required	Additional prescribed impact credits	Total ecosystem credits required with prescribed impacts
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	9.2	181	0	181
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (DNG)	33.9	516	0	516
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 (Good)	39.8	1,021	0	1,021
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 (DNG)	8.8	138	0	138
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains (Good)	7.3	244	0	244
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (Good)	8.7	185	0	185
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 (Good)	19.2	400	0	400
SEGMENT 11 – TOTAL ecosystem credits required		**4,007**	0	**4,007**
GRAND TOTAL – TOTAL ecosystem credits required (all segments)		**39,427**	**9,625**	**49,052**

13.1.3 Species credits

The proposal site is known to support 11 species credit species and an additional 13 that are assumed to be present due to limited site access and poor survey conditions due to prolonged drought.

The 13 candidate flora species and 11 candidate fauna species require a total of 184,470 species credits (see Table 13.3 and Appendix K), as calculated by the BAM-C, and an additional 87,501 credits for prescribed impacts (271,971 in total).

Species credit requirements by segment (see) have been prorated based on the total number of credits required for each species and the area of each species polygon within each segment, with additional species credits for prescribed impacts also assigned as per the methodology outlined in sections 10.3 and 13.1.4.

Table 13.3 Species credit requirements for the proposal by subregion

Species	Habitat impact (ha)	Species credits required
Darling Riverine Plains bioregion and Castlereagh-Barwon subregion		
Barking Owl (*Ninox connivens*)	7.5	251
Bush Stone-curlew (*Burhinus grallarius*)	23.2	836
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	1.3	54
Koala (*Phascolarctos cinereus*)	2.9	106
Little Eagle (*Hieraaetus morphnoides*)	25.3	662
Masked Owl (*Tyto novaehollandiae*)	8.4	290
Pale-headed Snake (*Hoplocephalus bitorquatus*)	18.4	615
Slender Darling Pea (*Swainsona murrayana*)	42.3	1,771
Square-tailed Kite (*Lophoictinia isura*)	23.4	634
Winged Peppercress (*Lepidium monoplocoides*)	36.2	944
	Subtotal	**6,163**
Darling Riverine Plains bioregion and Bogan-Macquarie subregion		
Bush Stone-curlew (*Burhinus grallarius*)	8	226
Little Eagle (*Hieraaetus morphnoides*)	13.3	289
Pale-headed Snake (*Hoplocephalus bitorquatus*)	11.4	367
Square-tailed Kite (*Lophoictinia isura*)	13.3	289
	Subtotal	**1,171**
Brigalow Belt South bioregion and Pilliga subregion		
Barking Owl (*Ninox connivens*)	123.6	3,558
Bluegrass (*Dichanthium setosum*)	3.5	174
Bush Stone-curlew (*Burhinus grallarius*)	311.9	8,189
Cobar Greenhood (*Pterostylis cobarensis*)	267.9	6,674
Commersonia procumbens	321.1	9,552
Eastern Pygmy-possum (*Cercartetus nanus*)	511.2	13,542
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	192.1	5,309
Keith's Zieria (*Zieria ingramii*)	48.6	1,605

Species	Habitat impact (ha)	Species credits required
Koala (*Phascolarctos cinereus*)	12.0	266
Little Eagle (*Hieraaetus morphnoides*)	246.7	4,861
Masked Owl (*Tyto novaehollandiae*)	109.3	3,238
Native Milkwort (*Polygala linariifolia*)	49.6	1,053
Pale-headed Snake (*Hoplocephalus bitorquatus*)	154.0	4,204
Pine Donkey Orchid (*Diuris tricolor*)	145.2	2,888
Rufous Bettong (*Aepyprymnus rufescens*)	178.3	5,395
Silky Swainson-pea (*Swainsona sericea*)	78.9	2,472
Slender Darling Pea (*Swainsona murrayana*)	7.8	250
Spiny Peppercress (*Lepidium aschersonii*)	121.4	3,169
Square-tailed Kite (*Lophoictinia isura*)	234.4	4,664
Squirrel Glider (*Petaurus norfolcensis*)	379.0	9,821
Tylophora linearis	32.1	1,071
Subtotal		**91,955**
Brigalow Belt south bioregion and Pilliga Outwash subregion		
Barking Owl (*Ninox connivens*)	127.3	3,639
Bush Stone-curlew (*Burhinus grallarius*)	206.2	5,910
Cobar Greenhood (*Pterostylis cobarensis*)	174.7	4,582
Commersonia procumbens	251.9	7,186
Cyperus conicus	50.8	1,164
Eastern Pygmy-possum (*Cercartetus nanus*)	324.1	9,255
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	131.3	3,933
Koala (*Phascolarctos cinereus*)	245.2	6,921
Little Eagle (*Hieraaetus morphnoides*)	180.3	3,950
Masked Owl (*Tyto novaehollandiae*)	68.1	2,015
Native Milkwort (*Polygala linariifolia*)	213.6	4,970
Pale-headed Snake (*Hoplocephalus bitorquatus*)	102.1	3,081
Pine Donkey Orchid (*Diuris tricolor*)	243.0	4,288
Rufous Bettong (*Aepyprymnus rufescens*)	179.6	5,205
Scant Pomaderris (*Pomaderris queenslandica*)	9.1	267
Spiny Peppercress (*Lepidium aschersonii*)	217.4	5,063
Square-tailed Kite (*Lophoictinia isura*)	136	2,996
Squirrel Glider (*Petaurus norfolcensis*)	271.8	7,797
Tylophora linearis	5.8	165
Winged Peppercress (*Lepidium monoplocoides*)	139.6	2,766
Subtotal		**85,153**

Species	Habitat impact (ha)	Species credits required
Brigalow Belt south bioregion and Liverpool Plains subregion		
Bush Stone-curlew (*Burhinus grallarius*)	0.2	4
Eastern Pygmy-possum (*Cercartetus nanus*)	0.2	4
Little Eagle (*Hieraaetus morphnoides*)	0.2	3
Pale-headed Snake (*Hoplocephalus bitorquatus*)	0.5	10
Square-tailed Kite (*Lophoictinia isura*)	0.2	3
Squirrel Glider (*Petaurus norfolcensis*)	0.2	4
Subtotal	1.5	**28**
Total		**184,470**

Table 13.4 Species credits required to offset impacts of the proposal by segment

Species	Habitat impact (ha)	Risk rating	Species credits required	Total with prescribed impacts
Segment 3 – Narrabri multi-function compound				
Bush Stone-curlew (*Burhinus grallarius*)	0.23	2	10	10
Cyperus conicus	5.49	2	162	162
Eastern Pygmy-possum (*Cercartetus nanus*)	1.12	2	33	33
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	6.47	2	191	191
Native Milkwort (*Polygala linariifolia)*	92.75	2	1,732	1,732
Pine Donkey Orchid (*Diuris tricolor*)	92.75	1.5	1,299	1,299
Scant Pomaderris (Pomaderris queenslandica)	5.49	2	162	162
Spiny Peppercress (*Lepidium aschersonii*)	92.75	2	1,733	1,733
Squirrel Glider (*Petaurus norfolcensis*)	6.31	2	186	186
Winged Peppercress (*Lepidium monoplocoides*)	92.75	2	1,733	1,733
Segment 3 – total species credits	**396.11**	**-**	**7,241**	**7,241**
Segment 5 – Borrow pit B				
Little Eagle (*Hieraaetus morphnoides*)	3.26	1.5	66	66

Species	Habitat impact (ha)	Risk rating	Species credits required	Total with prescribed impacts
Square-tailed Kite (*Lophoictinia isura*)	3.26	1.5	66	66
Segment 5 – total species credits			**132**	**132**
Segment 6 – Borrow pit C				
Bush Stone-curlew (*Burhinus grallarius*)	0.09	2	2	2
Eastern Pygmy-possum (*Cercartetus nanus*)	8.08	2	150	150
Squirrel Glider (*Petaurus norfolcensis*)	8.11	2	150	150
Segment 6 – total species credits			**302**	**302**
Segment 7– Borrow pit D				
Bush Stone-curlew (*Burhinus grallarius*)	0.58	2	17	17
Eastern Pygmy-possum (*Cercartetus nanus*)	4.18	2	112	112
Square-tailed Kite (*Lophoictinia isura*)	2.12	1.5	36	36
Squirrel Glider (*Petaurus norfolcensis*)	4.33	2	116	116
Segment 7 – total species credits			**281**	**281**
Segment 8 – Narromine to Curban				
Barking Owl (*Ninox connivens*)	22.38	2	599	599
Bluegrass (*Dichanthium setosum*)	3.50	2	174	174
Bush Stone-curlew (*Burhinus grallarius*)	101.5	2	2,248	2,248
Cobar Greenhood (*Pterostylis cobarensis*)	55.43	2	1,261	1,261
Eastern Pygmy-possum (*Cercartetus nanus*)	112.81	2	2,478	2,478
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	42.59	2	1,020	1,020
Koala (*Phascolarctos cinereus*)	2.9	2	106	106
Little Eagle (*Hieraaetus morphnoides*)	81.60	1.5	1,467	1,467
Masked Owl (*Tyto novaehollandiae*)	22.38	2	598	598

Species	Habitat impact (ha)	Risk rating	Species credits required	Total with prescribed impacts
Native Milkwort (*Polygala linariifolia)*	46.73	2	991	991
Pale-headed Snake (*Hoplocephalus bitorquatus*)	55.93	2	1,450	1,450
Pine Donkey Orchid (*Diuris tricolor*)	59.55	1.5	982	982
Silky Swainsona-pea (*Swainsona sericea)*	27.17	2	761	761
Slender Darling-pea (*Swainsona murrayana)*	34.99	2	1,374	1,374
Spiny Peppercress (*Lepidium aschersonii*)	57.43	2	1,170	1,170
Square-tailed Kite (*Lophoictinia isura*)	72.77	1.5	1,332	1,332
Squirrel Glider (*Petaurus norfolcensis*)	112.11	2	2,511	2,511
Tylophora linearis	3.50	2	174	174
Winged Peppercress (*Lepidium monoplocoides*)	26.09	2	663	663
Segment 8 – total species credits			**21,359**	**13,473**
Segment 9 – Curban to Pilliga				
Barking Owl (*Ninox connivens*)	13.13	2	367	367
Bush Stone-curlew (*Burhinus grallarius*)	93.37	2	2,401	2,401
Cobar Greenhood (*Pterostylis cobarensis*)	11.82	2	310	310
Commersonia procumbens	0.33	2	9	9
Eastern Pygmy-possum (*Cercartetus nanus*)	63.80	2	1,459	1,459
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	19.81	2	455	455
Koala (*Phascolarctos cinereus*)	30.39	2	110	110
Little Eagle (*Hieraaetus morphnoides*)	67.32	1.5	1,240	1,240
Masked Owl (*Tyto novaehollandiae*)	13.67	2	396	396
Native Milkwort (*Polygala linariifolia)*	0.69	2	18	18

Species	Habitat impact (ha)	Risk rating	Species credits required	Total with prescribed impacts
Pale-headed Snake (*Hoplocephalus bitorquatus*)	28.76	2	830	830
Rufous Bettong (*Aepyprymnus rufescens*)	2.56	2	67	67
Pine Donkey Orchid (*Diuris tricolor*)	11.14	2	219	219
Slender Darling-pea (*Swainsona murrayana)*	15.00	2	647	647
Spiny Peppercress (*Lepidium aschersonii*)	0.69	2	18	18
Square-tailed Kite (*Lophoictinia isura*)	63.55	1.5	1,170	1,170
Squirrel Glider (*Petaurus norfolcensis*)	65.35	2	1,496	1,496
Winged Peppercress (*Lepidium monoplocoides*)	10.79	2	299	299
Segment 9 – total species credits			**11,511**	**11,511**
Segment 10 – Pilliga				
Barking Owl (*Ninox connivens*)	218.82	2	6,314	9,155
Bush Stone-curlew (*Burhinus grallarius*)	337.28	2	9,986	18,973
Cobar Greenhood (*Pterostylis cobarensis*)	343.46	2	9,005	9,005
Commersonia procumbens	572.56	2	16,725	16,725
Cyperus conicus	5.06	2	119	119
Eastern Pygmy-possum (*Cercartetus nanus*)	596.18	2	17,111	32,511
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	223.95	2	6,571	6,768
Koala (*Phascolarctos cinereus*)	222.41	2	5,704	18,538
Little Eagle (*Hieraaetus morphnoides*)	277.04	1.5	6,118	6,302
Masked Owl (*Tyto novaehollandiae*)	146.04	2	4,385	6,358
Native Milkwort (*Polygala linariifolia)*	82.33	2	2,390	2,390
Pale-headed Snake (*Hoplocephalus bitorquatus*)	168.97	2	4,895	15,909

Species	Habitat impact (ha)	Risk rating	Species credits required	Total with prescribed impacts
Pine Donkey Orchid (*Diuris tricolor*)	178.64	1.5	3,913	3,913
Rufous Bettong (*Aepyprymnus rufescens*)	355.25	2	10,530	26,325
Silky Swainsona-pea (*Swainsona sericea)*	51.77	2	1,711	1,711
Spiny Peppercress (*Lepidium aschersonii*)	144.92	2	4,359	4,359
Square-tailed Kite (*Lophoictinia isura*)	235.57	1.5	5,241	5,398
Squirrel Glider (*Petaurus norfolcensis*)	419.32	2	12,079	30,198
Tylophora linearis	32.1	2	1,062	1,062
Winged Peppercress (*Lepidium monoplocoides*)	8.76	2	216	216
Zieria ingramii	48.62	2	1,605	1,605
Segment 10 – total species credits		-	**130,039**	**217,540**
Segment 11 – Pilliga to Narrabri				
Barking Owl (*Ninox connivens*)	4.02	2	168	168
Bush Stone-curlew (*Burhinus grallarius*)	16.35	2	501	501
Cobar Greenhood (*Pterostylis cobarensis*)	31.85	2	680	680
Commersonia procumbens	0.14	2	4	4
Cyperus conicus	40.20	2	883	883
Pine Donkey Orchid (*Diuris tricolor*)	46.08	1.5	763	763
Eastern Pygmy-possum (*Cercartetus nanus*)	49.56	2	1,458	1,458
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	31.84	2	1,059	1,059
Koala (*Phascolarctos cinereus*)	93.44	2	1,373	1,373
Little Eagle (*Hieraaetus morphnoides*)	36.20	1.5	874	874
Masked Owl (*Tyto novaehollandiae*)	3.87	2	164	164
Native Milkwort (*Polygala linariifolia)*	40.74	2	892	892
Pale-headed Snake (*Hoplocephalus bitorquatus*)	33.17	2	1,102	1,102

Species	Habitat impact (ha)	Risk rating	Species credits required	Total with prescribed impacts
Rufous Bettong (*Aepyprymnus rufescens*)	0.07	2	3	3
Scant Pomaderris (*Pomaderris queenslandica*)	3.56	2	105	105
Spiny Peppercress (*Lepidium aschersonii*)	42.94	2	952	952
Square-tailed Kite (*Lophoictinia isura*)	29.84	1.5	741	741
Squirrel Glider (*Petaurus norfolcensis*)	35.73	2	1,084	1,084
Winged Peppercress (*Lepidium monoplocoides*)	37.74	2	799	799
Segment 11 – total species credits	**577.34**		**13,605**	**13,605**
GRAND TOTAL SPECIES CREDITS – all segments			**184,470**	**271,971**

13.1.4 Prescribed impacts

The proposal would result in the clearing of a substantial area of native vegetation, particularly in the Pilliga forests. This clearing would create a gap in the forest that would impact connectivity and movement of fauna, and the operation of the rail line would create a wildlife-vehicle collision risk, further impacting fauna species. The BAM does not have a methodology to calculate biodiversity credits to offset a prescribed impact, however under section 7.13(4) BC Act and clause 6.1.2 (b) BC Regulation the consent authority has the discretion to increase the number of biodiversity credits to be retired (or other conservation measures to be undertaken) to account for the environmental impacts of the proposed development. Given there is no set method for determining a suitable quantum of credits to offset a prescribed impact, a framework and justification for additional credits has been developed for this BDAR for residual prescribed impacts (see section 10.3). Species credit fauna species have been assigned a sliding scale of additional credits depending on their sensitivity to fragmentation and risk of vehicle strike and potential benefit of mitigation measures (see section 10.3.6). A similar approach was taken for ecosystem credit species, and the average of the percent increase for these species has been assigned to ecosystem credits (see section 10.3.6). The final commitment to offsetting the prescribed impacts would be included in the conditions of consent for the proposal. In total, an additional 87,501 species credits are required (Table 13.5), and 9,625 ecosystem credits (Table 13.6).

Table 13.5 Additional species credits required to offset prescribed impacts in the Pilliga segment

Species	BAM-C Credits in Pilliga segment	Prescribed impact mark-up (%)	Additional credits
Barking Owl	6,314	45	2,841
Bush Stone-curlew	9,986	90	8,987
Eastern Pygmy-possum	17,111	90	15,400
Glossy Black-cockatoo	6,571	3	197
Koala	5,704	225	12,834

Species	BAM-C Credits in Pilliga segment	Prescribed impact mark-up (%)	Additional credits
Little Eagle	6,118	3	184
Masked Owl	4,385	45	1,973
Pale-headed Snake	4,895	225	11,014
Rufous Bettong	10,530	150	15,795
Square-tailed Kite	5,241	3	157
Squirrel Glider	12,079	150	18,119
Total	**88,934**		**87,501**

Table 13.6 Additional ecosystem credits required to offset prescribed impacts

Vegetation zone	Ecosystem credits calculated by the BAM-C	Additional prescribed impact credits
PCT 27 Weeping Myall open woodland of the Darling Riverine Plains bioregion and Brigalow Belt South Bioregion (Good)	175	0
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (DNG)	111	0
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (Good)	44	0
PCT 36 River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion (Good)	133	0
PCT 49 Partly derived Windmill Grass - copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (Good)	8,937	0
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (Good)	102	0
PCT 56 Poplar Box – Belah woodland on clay-loam soils on alluvial plains of north-central NSW (DNG)	369	0
PCT 56 Poplar Box – Belah woodland on clay-loam soils on alluvial plains of north-central NSW (Good)	674	0
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (DNG)	23	0
PCT 78 River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (Good)	824	0
PCT 81 Western Grey Box – cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	36	0
PCT 88 Pilliga Box – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion (DNG)	1,169	0

Vegetation zone	Ecosystem credits calculated by the BAM-C	Additional prescribed impact credits
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Good)	5,435	884
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (Low)	29	0
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (Good)	432	299
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion (DNG)	92	0
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion (Good)	899	0
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 (DNG)	1,493	0
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 (Good)	1,185	0
PCT 168 Derived Copperburr shrubland of the NSW northern inland alluvial floodplains (Good)	244	0
PCT 185 Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland mainly in the NSW South Western Slopes Bioregion (Good)	51	0
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion (Good)	179	0
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 (Good)	269	0
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) (Good)	1,289	0
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW (Good)	482	0
PCT 255 Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion (Good)	227	0
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion (Good)	5	3
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (DNG)	233	0

Vegetation zone	Ecosystem credits calculated by the BAM-C	Additional prescribed impact credits
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good)	995	639
PCT 394 Narrow-leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions (Good, fire affected)	102	70
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion (Good)	342	197
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 (Good)	8,844	6,058
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 (Moderate, shrubs removed)	156	109
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (Good)	1,161	674
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests (Good)	481	332
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests (Good)	51	35
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 (Good)	14	9
PCT 414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion (Good)	79	55
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion (DNG)	129	0
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion (Good)	19	0
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion (Good)	72	0
PCT 469 White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	14	0
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 (Good)	400	0

Vegetation zone	Ecosystem credits calculated by the BAM-C	Additional prescribed impact credits
PCT 589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion (Good)	22	6
PCT 599 Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion (Good)	117	0
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion (Good)	36	0
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion (Good)	352	255
Grand Total	**39,427**	**9,625**

13.2 EPBC Act – Offset for affected threatened biota

13.2.1 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 published under clause 6.5 of the Biodiversity Conservation Regulation 2017 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.

13.2.2 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 five flora species, and for the Koala (see Table 13.7). Ecosystem credits have been calculated for impacts on habitat for Corben's Long-eared Bat and the Painted Honeyeater (eucalypt forest and woodland in the alignment), the Pilliga Mouse (woodland and shrubland habitat in the Pilliga), the Regent Honeyeater and Swift Parrot (preferred foraging habitat in appropriate IBRA subregions) (see Table 13.8). A breakdown of ecosystem credits for each species is provided in Table 13.9. Note that offsets are not calculated for threatened entities that were listed under the EPBC Act following determination of the project as a controlled action (ie. Poplar Box Woodland and the Glossy Black-cockatoo).

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 13.7 Offset requirements for MNES – species credits under the BAM

Species	Credit type	Area of impact	Credits required
Commersonia procumbens	Species	573 hectares of potential habitat (assumed presence)	16,738
Lepidium aschersonii	Species	338.8 hectares of potential habitat (assumed presence)	8,232
Lepidium monoplocoides	Species	175.8 hectares of potential habitat (assumed presence)	3,710
Tylophora linearis	Species	16 hectares of known habitat and 37.9 hectares of known and potential habitat (assumed presence)	1,236
Koala	Species	260.4 hectares of occupied habitat has been identified in the expert report	7,293 18,538 with prescribed impacts

Table 13.8 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	24,497 33,377 with prescribed impacts	1,107.4 hectares (total area of known and potential habitat). Hollow-bearing trees provide roosting and breeding habitat for this species.	All woodland and forest PCTs (not including DNG and logged zones)	Hollow-bearing trees Vegetation in moderate-good condition
Painted Honeyeater	24,497	1,107.4 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	13,798 23,571 with prescribed impacts	647.1 hectares of potential habitat. This includes 29 hectares of Broombush habitat and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia.*	Preferred habitat in PCTs 141, 394, 398, 404 and 409	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	6,549	286.8 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)	15,269	732.9 hectares containing preferred feed trees would be removed, much of this in the Pilliga.	Preferred feed trees present in PCTs 88, 397, 398 and 399	Vegetation in moderate-good condition

Table 13.9 Offset requirements for MNES – ecosystem credit requirements for fauna species by PCT

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	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	6.5	175	0	0	1.9	43	0	0
PCT 35 Brigalow- Belah open forest/woodland on alluvial plains often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	1.4	44	0	0	0	0	0	0
PCT 36 River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	5.8	133	0	0	0	0	0	0
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	4.0	102	0	0	0	0	0	0
PCT 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	19.9	775	0	0	0	0	0	0

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	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	29.3	824	0	0	0	0	0	0
PCT 81 Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	0.9	36	0	0	0	0	0	0
PCT 88 Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	312.3	5,564/6,347	69.9	1,281/2,190	0	0	278.02	4,766
PCT 141 Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	0	0	29	298/730	0	0	0	0
PCT 145 Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains bioregion	0	0	0	0	0	0	0	0

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
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	46.2	1185	0	0	0	0	0	0
PCT 185 Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland mainly in the NSW South Western Slopes Bioregion	1.4	51	0	0	0	0	0	0
PCT 202 Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	3.6	179	0	0	0	0	0	0
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	10.1	269	0	0	0	0	0	0

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	43.9	1,289	0	0	24.2	430	0	0
PCT 248 Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	16.3	482	0	0	0	0	0	0
PCT 255 Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion	12.2	227	0	0	0	0	0	0
PCT 256 Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	0.3	5/8	0.3	5/8	0	0	0	0

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 394 Narrow - leaved Ironbark - White Cypress Pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	65.7	1,097/1,805	61.5	1,028/1,736	54.6	995	0	0
PCT 397 Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga-Warialda region, Brigalow Belt South Bioregion	17.8	342/539	14.9	286/483	3.1	52	17.8	342
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	382.3	9,000/15,1706	379.3	8,936/15,106	203.0	5,029	382.3	9000
PCT 399 Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	54.8	1,161/1,834	46.2	977/1,650	0	0	54.8	1,161

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 404 Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	25.1	481/813	25.1	481/813	0	0	0	0
PCT 406 White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	2.4	51/86	2.4	51/86	0	0	0	0
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	0.8	14/24	0.8	13/23	0	0	0	0
414 White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South bioregion	7.3	79/134	7.3	79/134	0	0	0	0

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
PCT 435 White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	0.3	19	0	0	0	0	0	0
PCT 444 Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	1.7	72	0	0	0	0	0	0
PCT 469 White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	1	14	0	0	0	0	0	0
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	19.2	400	0	0	0	0	0	0

Plant Community Type	Corben's Long-eared Bat, Painted Honeyeater Entire alignment		Pilliga Mouse Pilliga (segment 10) only		Regent Honeyeater Preferred foraging habitat (Pilliga and Liverpool Plains IBRA subregions)		Swift Parrot Preferred foraging habitat (Pilliga Outwash, Pilliga and Liverpool Plains IBRA subregions)	
	Impact area (ha)	Ecosystem credits required/with prescribed impacts (microbat only)	Impact area (ha)	Ecosystem credits required/with prescribed impacts	Impact area (ha)	Ecosystem credits required	Impact area (ha)	Ecosystem credits required
589 White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	1	22/28	0.4	9/15	0	0	0	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	3.0	117	0	0	0	0	0	0
PCT 746 Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	2.1	36	0	0	0	0	0	0
PCT 1384 White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	8.8	352/595	8.8	352/597	0	0	0	0
Total	**1,107.4**	**24,4997/33,377**	**645.9**	**13,798/23,571**	**286.8**	**6,549**	**732.9**	**15,269**

14. Conclusions

14.1 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.

14.2 Surveys

The field surveys were undertaken between September 2018 and March 2022. The years 2018 and 2019 were exceptionally dry in NSW, 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. However, supplementary surveys under more favourable climatic conditions were conducted in June, September, October and November 2020. This allowed for collection of additional BAM plot data, refining of vegetation zone mapping and targeted survey of threatened flora in suitable climatic conditions. Additional targeted surveys were conducted in July 2021 (thermal drone surveys), August 2021 (expert surveys) and March 2022 (targeting Coolabah Bertya, Scant Pomaderris and *Tylophora linearis*).

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 BCS to determine how PCTs would be identified in the absence of field data.

Thirty-six PCTs of which five are TECs listed under the BC Act and five are listed TECs 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.

Four threatened flora species were identified within the study area during the field survey. *Commersonia procumbens,* Cobar Greenhood (*Pterostyils cobarensis*), Pine Donkey Orchid (*Diuris tricolor*) and *Tylophora linearis* were recorded in the Pilliga forests. Habitat for nine additional threatened flora species is assumed to be present in the proposal site (*Lepidium monoplocoides*, *Lepidium aschersonii, Zieria ingramii, Swainsona sericea, Swainsona murrayana, Dichanthium setosum, Cyperus conicus, and Pomaderris queenslandica).* Targeted surveys confirmed the absence of a number of threatened flora species, including Coolabah Bertya.

Twenty-three threatened fauna species listed under the BC Act (of which seven are species credit species or dual credit species requiring offsets) were recorded during surveys. Potential habitat for an additional four species credit or dual credit species is also present. Five threatened fauna species and three migratory fauna species listed under the EPBC Act were recorded during surveys, and potential habitat for various additional threatened and migratory is also present.

14.3 Potential impacts

14.3.1 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 1,791 hectares of native vegetation. The proposal includes impacts on around 1,173 hectares of native woodland and forest vegetation in good condition, 38 hectares of shrubland vegetation, and 580 hectares of native and derived native grassland. The proposal would impact 654 hectares of native vegetation within the Pilliga forests.

The loss of over 1,173 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 14,503 and 41,103 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 ranging between 33 metres to 400 metres wide (with about 29 percent in the 50-60 metres category, and averaging a gap width of 89 metres) 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.

14.3.2 Impacts on threatened ecological communities listed under the BC Act

The proposal would impact the following threatened ecological communities listed under the BC Act:

- 6.5 hectares of Myall Woodland in the Darling Riverine Plains, Brigalow Bet South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions
- 7.3 hectares of Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (Brigalow Woodland)
- 3.6 hectares of Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions (Fuzzy Box Woodland)

- 17.2 hectares of Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions
- 8.4 hectares of White Box Yellow Box Blakely's Red Gum Woodland (Box-Gum Woodland).

14.3.3 Serious and irreversible impacts

An assessment of potentially serious and irreversible impacts has been provided for Box-Gum Woodland, Fuzzy Box Woodland, Brigalow Woodland and Coolabah Bertya. The following impacts are likely for these entities:

- The proposal would remove about 8.4 hectares of Box-Gum Woodland which represents about 0.3 percent of the community within the Pilliga subregion. This patch occurs as already isolated roadside vegetation variable up to 20 metres wide with copping on all four sides.
- The proposal would remove 3.6 hectares of Fuzzy Box Woodland which represents about 1.16 percent of the mapped community within the Pilliga subregion.
- The proposal would remove 7.3 hectares of Brigalow Woodland from within a 10 hectare patch represents about 0.006 percent of the mapped community within the Pilliga Outwash subregion.

Patches of these three communities occur adjacent to the proposal.

- No impacts on Coolabah Bertya are likely. Individuals of Coolabah Bertya (two juveniles and three seedlings) previously recorded could not be relocated despite multiple survey attempts and no other individuals were recorded. Large populations of the species occur to the east in Jacks Creek State Forest. The species was assumed present in some remote parts of the northern Pilliga forests, however targeted surveys in March 2022 confirmed the absence of this species.

None of the other species credit species relevant to the proposal are candidate SAII species.

14.3.4 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. A Preliminary Fauna Connectivity Strategy (see Appendix J) has been prepared to outline the proposed mitigation measures and monitoring required to minimise impacts from changes to connectivity and risk of train strike.

Adverse impacts on connectivity would occur particularly in the Pilliga forests. The clearing of a gap ranging between 33 metres to 400 metres wide (with about 29 percent in the 50-60 metres category, and averaging a width of 89 metres) along a 73 kilometre alignment in the Pilliga forests would create a barrier to fauna movement and risk of mortality through train strike, and could result in fragmentation of populations and impacts on gene flow. A total of 73 rail bridges are included in the proposal, including 23 in the Pilliga forest. 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. At least 51 dedicated culverts will be constructed in the Pilliga forests, targeting a range of terrestrial and arboreal fauna species. Drainage culverts may also act as underpasses for terrestrial fauna. Other connectivity measures including canopy bridges and barriers on bridges are also proposed. Together, these design features would help minimise the impacts on connectivity.

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.

An assessment of the biology and ecology of the threatened species likely to be affected by the proposal has been undertaken to assess the sensitivity of species to changes in connectivity and the impact of train strike, and the potential benefit of proposed mitigation measures (see Appendix J) in order to determine the residual prescribed impacts of the proposal. The BAM does not calculate biodiversity credits to offset a prescribed impact, however under section 7.13(4) BC Act and clause 6.1.2 (b) BC Regulation the consent authority has the discretion to increase the number of biodiversity credits to be retired (or other conservation measures to be undertaken) to account for the environmental impacts of the proposed development. Given there is no set method for determining a suitable quantum of credits to offset a prescribed impact, a framework and justification for additional credits has been developed for this BDAR for residual prescribed impacts.

14.3.5 Impacts on MNES

The proposal would impact the following threatened ecological communities listed under the EPBC Act:

- 6.5 hectares of Weeping Myall Woodland, from an already isolated and fragmented patch within a cropping matrix
- 7.2 hectares of Brigalow (*Acacia harpophylla* dominant and co-dominant), from within a 10 hectare patch
- 15.9 hectares of Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia, from within a larger 50 hectare patch
- 76.3 hectares of Poplar Box grassy woodland, scattered across more than 20 smaller isolated patches within a farming matrix and as scattered paddock trees (note that this community was listed under the EPBC Act following referral of the proposal)
- 8.0 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 and as a derived native grassland connected to woodland within Baradine at a proposed temporary workforce accommodation.

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 four species:

- *Commersonia procumbens* (573.1 hectares of assumed potential habitat impacted)
- *Tylophora linearis* (16 hectares of known habitat impacted and 21.9 hectares assumed potential habitat impacted)

- *Lepidium monoplocoides* (175.8 hectares of assumed potential habitat impacted)
- *Lepidium aschersonii* (338.7 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 (260.4 hectares of occupied habitat impacted)
- Corben's Long-eared Bat (1,107.4 hectares of assumed potential habitat impacted)
- Pilliga Mouse (647.1 hectares of assumed potential habitat impacted)
- Painted Honeyeater (1,107.4 hectares of assumed potential habitat impacted)
- Regent Honeyeater (286.8 hectares containing preferred feed trees)
- Swift Parrot (732.9 hectares containing preferred feed trees).

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).

14.4 Offset requirements

Offsets are required for residual impacts that cannot be avoided or mitigated. Credit requirements for the proposal calculated using the BAM-C include:

- 49,052 ecosystem credits (including 9,625 for prescribed impacts on ecosystem credit fauna species)
- 271,971 species credits (of which 87,501 are for prescribed impacts on species credit fauna species).

Species credits have been calculated for the following species:

- Bluegrass (*Dichanthium setosum*)
- Cobar Greenhood (*Pterostylis cobarensis*)
- *Commersonia procumbens*
- *Cyperus conicus*
- Keith's Zieria (*Zieria ingramii*)
- Native Milkwort (*Polygala linariifolia*)
- Pine Donkey Orchid (*Diuris tricolor*)
- Scant Pomaderris (*Pomaderris queenslandica*)
- Silky Swainson-pea (*Swainsona sericea*)
- 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.

A matrix has then been applied to identify a per cent additional liability of credits required to offset prescribed impacts for species credits. Species credit fauna species have been assigned a sliding scale of additional credits depending on their sensitivity to fragmentation and risk of vehicle strike and potential benefit of mitigation measures. A similar approach was taken for ecosystem credit species, and the average of the per cent increase for these species has been assigned to ecosystem credits.

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.

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 habitat for the Koala. Ecosystem credits have been calculated for the remaining threatened fauna species.

14.5 Mitigation

A Preliminary Fauna Connectivity Strategy has been prepared and would be further developed and finalised during detailed design and in consultation with BCS. Bridges and viaducts would allow maintenance of riparian and floodplain vegetation connectivity, and given the generally dry nature of many would provide areas of dry passage for fauna to pass underneath for much of the time. Certain bridges and viaducts would also include fauna furniture and rope bridges to enhance connectivity. Dedicated fauna underpasses are proposed at 97 locations in the Pilliga forests to improve connectivity for species including the Koala, Rufous Bettong, Black-striped Wallaby, Eastern Pygmy-possum and Pilliga Mouse. The many drainage culverts may also act as underpasses for some terrestrial fauna where dimensions and culvert conditions are adequate. Of the almost 600 drainage culverts included in the design, 280 culverts have been identified that would include raised ledges to improve connectivity, particularly in the Pilliga and larger riparian corridors. Canopy bridges are proposed to provide connectivity for the Squirrel Glider and Eastern Pygmy-possum, with 53 located in the Pilliga forests and seven outside the Pilliga forests. Barrier poles are also proposed in the Pilliga to minimise the risk of train strike for aerial fauna at creek crossings. Together, these design features would help minimise the impacts on connectivity. The final connectivity strategy would outline the various structures and their locations, and the proposed 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
- potential reductions in credit liability if no evidence of the species are found in areas of assumed presence.

Use of detection dogs is recommended for targeted surveys for Koalas and some flora species. Thermal drone surveys may also be of use for certain fauna 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
  - revegetation within the rail corridor to encourage movement of fauna.

The following mitigation measures are proposed for the operational phase:

- preparation and implementation of a weed and pest management strategy
- implementation of the final fauna connectivity strategy, including monitoring of use of fauna connectivity structures by threatened species and pest species, and fauna mortality from train strike.

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15. 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

AWC and EviroKey (2017). Review of Environmental Factors. Proposed construction and operation of conservation fencing and associated infrastructure and reintroduction of locally extinct mammals in the Pilliga State Conservation Area. A report prepared for Australian Wildlife Conservancy on behalf of NSW Office of Environment and Heritage.

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.

Bennett, Victoria J.; Smith, Winston P.; Betts, Matthew G. (2011). Toward understanding the ecological impact of transportation corridors. Gen. Tech. Rep. PNW-GTR-846. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 40 p.

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

BirdLife International (2021). Species factsheet: *Ardeotis australis*. Downloaded from http://www.birdlife.org

BirdLife International (2021) Species factsheet: *Polytelis swainsonii*. Downloaded from http://www.birdlife.org

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.

Booth, T.H. (2017). Going nowhere fast: a review of seed dispersal in eucalypts. *Australian Journal of Botany*, 65, 401–410.

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.

Broadhurst LM (2013). A genetic analysis of scattered yellow box (*Eucalyptus melliodora* A.Cunn. ex Schauer, Myrtaceae) and their restored cohorts. *Biological Conservation* 161, 48–57. doi:10.1016/j.biocon.2013.02.016

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

Byrne M, Hines B (2004). Phylogeographical analysis of cpDNA variation in *Eucalyptus loxophleba* (Myrtaceae). *Australian Journal of Botany* 52, 459–470. doi:10.1071/BT03117

Cameron, M. (2006). Nesting habitat of the glossy black-cockatoo in central New South Wales. *Biological Conservation* 127: 402-410.

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

DAWE (2020f). National Recovery Plan for the Painted Honeyeater, Commonwealth of Australia 2020. https://www.environment.gov.au/system/files/consultations/fd1a0737-64f0-42bb-b282-74a05af2dad4/files/draft-national-recovery-plan-painted-honeyeater.pdf

DAWE (2021). Species profiles and threats database.

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. (2001). Surveys of the Barking Owl and Masked Owl on the north-west slopes of New South Wales. *Corella* 25: 5-11.

Debus, S.J.S. (2002). Distribution, taxonomy, status and major threatening processes of owls of the Australasian Region. In Newton, I., Kavanagh, R., Olsen, J. & Taylor, I. (Eds), Ecology and Conservation of Owls, CSIRO, Melbourne.

Debus. S. and Chafer, C. (1994). The Powerful Owl *Ninox strenua* in New South Wales. *Australian Birds* 28: S21-S39.

Debus, S.J.S. and Rose, A.B. (1994). The Masked Owl *Tyto novaehollandiae* in New South Wales, *Australian Birds* 28 (Supplement): S40-S64.

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 (2008c). Rapid Fauna Habitat Assessment of the Sydney Metropolitan Catchment Management Authority Area. Department of Environment and Climate Change, Hurstville

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 (2019a). Guidance to assist a decisionmaker to determine a serious and irreversible impact. NSW Department of Planning, Industry and Environment.

DPIE (2019b). Biodiversity Assessment Method Operational Manual Stage 2. NSW Department of Planning, Industry and Environment.

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

DPIE (2020c). Floodplain Management Plan for the Lower Namoi Valley Floodplain. https://www.industry.nsw.gov.au/water/plans-programs/plans/valleys/lower-namoi

DPIE (2021). Keeping up with the Superb Parrot. https://www.environment.nsw.gov.au/news/keeping-up-with-the-superb-parrot

DPIE (2021b). Floodplain Management Plan for the Macquarie Valley Floodplain. https://www.industry.nsw.gov.au/water/plans-programs/plans/valleys/macquarie

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

Ecological (2014). Narrabri Coal Mine Stage 1 and 2 Biodiversity Offset Strategy. Report prepared for Narrabri Coal Operations Pty Ltd.

EES (2019). *Biodiversity Assessment Methods Calculator User Guide*. Accessed at https://www.environment.nsw.gov.au/research-and-publications/publications-search/biodiversity-assessment-method-user-guide

EES (2019a). *NSW BioNet Database*. 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

EES (2021). *NSW BioNet Database*. Database search updated in February 2021. Accessed at: https://www.environment.nsw.gov.au/asmslightprofileapp/account/login?ReturnUrl=%2fAtlasApp%2fDefault.aspx

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.

Fahrig, L., and Rytwinski, T., (2009). Effects of roads on animal abundance: an empirical review and synthesis. *Journal of the Ecological Society*. 14: 21.

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.

Forman, R. and L. E. Alexander. (1998). Roads and their major ecological effects. *Annual Review of Ecology, Evolution, and Systematics* 29: 207-231.

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:

FrogID (2021). FrogID. Australian Museum, Sydney. Available: http://www.frogid.net.au

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.

Glossy Black Conservancy (2010). Glossy Black-Cockatoo Conservation Guidelines: For South-Eastern Queensland and far North-Eastern New South Wales. Glossy Black Conservancy

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.

Goldingay, R.L., Rohweder, D., Taylor, B. D. and Parkyn, J.L. (2022). Use of road underpasses by mammals and a monitor lizard in eastern Australia and consideration of the prey-trap hypothesis. *Ecology and Evolution ;12:e9075. https://doi.org/10.1002/ece3.9075*

Gosper, C., (2002). Darling Riverine Plains Biodiversity Survey Technical Report, NSW National Parks and Wildlife Service Western Regional Assessments Unit, Dubbo.

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.

Henle, K., Davies, K.F., Kleyer, M., Magules, C. and Settele, J. (2004). Predictors of species sensisitvity to fragmentation. *Biodiversity and Conservation 13:* 207-251.

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 RW (1964) Ecology and control of Brigalow in Queensland. Queensland Department of Primary Industries. 1-92.

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.

Kavanagh, R.P., Debus, S.J.S., Rose, A.B. and Turner, R.J., 1995. Diet and habitat of the Barking Owl *Ninox connivens* in New South Wales. *Australian Bird Watcher* 16: 137-144.

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)

Kerth, G.; and Melber, M. (2009). Species-specific barrier effects of a motorway on the habitat use of two threatened forest-living bat species. *Biological Conservation* 142: 270–279

Kettunen, M, Terry, A., Tucker, G. & Jones A. (2007). Guidance on the maintenance of landscape features of major importance for wild flora and fauna – Guidance on the implementation of Article 3 of the Birds Directive (79/409/EEC) and Article 10 of the Habitats Directive (92/43/EEC). Institute for European Environmental Policy (IEEP), Brussels, 114 pp. & Annexes.

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.

Mallarach, J.M. and Marull, J. (2006) Impact assessment of ecological connectivity at the regional level: recent developments in the Barcelona Metropolitan Area, *Impact Assessment and Project Appraisal*, 24:2, 127-137, DOI: 10.3152/147154606781765228

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.

Mooney PA & Pedler LP (2005) Recovery plan for the South Australian subspecies of the Glossy Black-Cockatoo (*Calyptorhynchus lathami halmaturinus*): 2005-2010. Department for Environment and Heritage, South Australia.

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). Brigalow Belt South: Vertebrate fauna survey, analysis and modelling project. NSW Western Regional Assessments.

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

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

Patriarca, Elena & Debernardi, Paolo. (2010). Bats and light pollution. Technical paper.

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.

Phillips, S.S. (2016). Aversive behaviour by koalas (*Phascolarctos cinereus*) during the course of a music festival in northern New South Wales, Australia. *Australian Mammaology* 28: 158-163.

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.

Reardon, T. B., Adams, M., McKenzie, N. L., and Jenkins, P. (2008). A new species of Australian freetail bat *Mormopterus eleryi* sp. nov.(Chiroptera: Molossidae) and a taxonomic reappraisal of *M. norfolkensis* (Gray). *Zootaxa* 1875, 1–31.

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.

Shelly, D. (2006). Observations on the ecology of the Barking Owl Ninox connivens within the lower Macquarie River floodplain of New South Wales. *Australian Zoologist*; 33: 283–289.

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., and van der Ree, R. (2015). Field methods to evaluate the impacts of roads on wildlife. In R. van der Ree, D. J. Smith, & C. Grilo (Eds.), Handbook of road ecology (pp. 82–95). West Sussex: Wiley.

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.

Steen, D.A., Aresco, M.J., Beilke, S.G., Compton, B.W., Condon, E.P., Dodd, C.K., Forrester, H., Gibbons, J.W., Greene, J.L., Johnson, G., Langen, T.A., Oldham, M.J., Oxier, D.N., Saumure, R.A., Schueler, F.W., Sleeman, J.M., Smith, L.L., Tucker, J.K., and Gibbs, J.P., (2006). Relative vulnerability of female turtles to road mortality. *Animimal Conserveration* 9, 269–273. http://dx.doi.org/10.1111/j.1469-1795.2006.00032.x.

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.

TSSC. (2009). Approved Conservation Advice for *Prasophyllum sp. Wybong*. Threatened Species Scientific Committee. Accessed. http://www.environment.gov.au/biodiversity/threatened/species/pubs/81964-listing-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.

Umwelt (2020). July 2020 addendum to the Inland Rail: Narrabri to North Star 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.

Whitehaven Coal (2019). Narrabri Underground Extension Project: Biodiversity Development Assessment Report.

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.