Santos

NARRABRI GAS PROJECT

Biodiversity Management Plan

PHASE 1

0041-150-PLA-0009

Date	Revision	Reason for Issue	Author	Checked	Approved
11 November 2022	0B	For approval	Eco Logical Australia / Onward Consulting	RM/LD	TD

Santos

Prepared by:

Title	Name	Signature	Date
Senior Ecologist, Eco Logical Australia	Dan Watts	DW	11 November 2022
Principal Ecologist and Consultant, Eco Logical Australia	Matthew Dowle	MD	11 November 2022
Senior Environmental Manager, Onward Consulting	S. van der Meulen		11 November 2022

Reviewed by:

Title	Name	Signature	Date
Principal Environmental Consultant, Eco Logical Australia	Rachel Murray	RMurray	11 November 2022
Team Leader Environment - Approvals	Liz Dunlop		11 November 2022

Approved by:

Title	Name	Signature	Date
Development Manager NSW	Todd Dunn		11 November 2022

This document has been prepared by Onward Consulting to comply with the Narrabri Gas Project conditions of consent and has relied upon the relevant information available at the time of writing and all findings, conclusions or recommendations contained herein are based thereon. This document is for the use of Santos Ltd and no responsibility will be taken for its use by other parties. Santos Ltd may, at its discretion, use this document to inform regulators and the public.

ONWARD CONSULTING

Onward document number:
NGP-001P-0B PLN

Document review history

In accordance with consent condition D4, this document has been reviewed as follows:

Review Date	Reason for review	Reviewed by	Revision required (Y/N)

Acronyms and abbreviations

Acronym	Description
AWC	Australian Wildlife Conservancy
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016*
BMP	Biodiversity Management Plan
BOMP	Biodiversity Offset Management Plan
BCD	The former Biodiversity Conservation Division within DPE
BCF	Biodiversity Conservation Fund
BCS	The Biodiversity, Conservation & Science directorate within DPE (formerly BCD)
BCT	Biodiversity Conservation Trust
BVT	Biometric Vegetation Type
Cth	Commonwealth
CoC	Conditions of consent for the NGP SSD 6456
CSG	coal seam gas
DCCEEW	Cth Department of Climate Change, Energy, the Environment and Water
DPE	NSW Department of Planning and Environment
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2021
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPL	environment protection licence under the POEO Act
EQuIS	Environmental Quality Information System
FCNSW	Forestry Corporation of New South Wales
kg	kilogram
kg/ha	kilograms per hectare
L	litre
LGA	Local Government Area
m	metre
mm	millimetre
MEG	Regional NSW - Mining, Exploration and Geoscience (formerly the Division of Resources and Geoscience)
MNES	Matters of National Environmental Significance
NPWS	NSW National Parks and Wildlife Service
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PAL	petroleum assessment lease under the PO Act

Acronym	Description
PCT	Plant Community Types
PEL	petroleum exploration licence under the PO Act
PO Act	*Petroleum (Onshore) Act 1991* (NSW)
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
POEO Regulation	Protection of the Environment Operations (General) Regulation 2022
PPL	petroleum production lease under the PO Act
PPLA	petroleum production lease application under the PO Act
RMP	Rehabilitation Management Plan
RTS	Response to Submissions
SRTS	Supplementary Response To Submissions
SMS	Santos Management System
SSD	State Significant Development
TEC	Threatened ecological communities
TSC Act	Former NSW *Threatened Species Conservation Act 1995*
WoNS	Weeds of National Significance

Table of contents

Tables

Figures

1. Introduction

1.1 Background

Resource exploration has been occurring in the north-western area of NSW since the 1960s; initially for oil, but more recently for coal and gas. Santos NSW Pty Ltd began exploring for natural gas from coal seams in north-western NSW in 2008 and is currently conducting coal seam gas (**CSG**) exploration and appraisal activities within Petroleum Exploration Licence (**PEL**) 238, Petroleum Assessment Lease (**PAL**) 2 and Petroleum Production Lease (**PPL**) 3, located in the Gunnedah Basin about 20 kilometres (**km**) south-west of the town of Narrabri. Activities in PAL 2 have focussed on the Bibblewindi and Bohena CSG pilots, whilst recent activities in PEL 238 have focussed on the Dewhurst and Tintsfield CSG pilots.

The Narrabri Coal Seam Gas Utilisation Project (Wilga Park Power Station and associated infrastructure) operates under an existing Part 3A approval under the *Environmental Planning and Assessment Act 1979* (NSW) (**EP&A Act**). It was originally approved in 2008, with various modifications approved between 2011 and 2019. It encompasses a gas gathering system, a compressor and associated flare, a gas flow line from Bibblewindi to Wilga Park within a 10 metre (**m**) corridor with a riser at Leewood and an expansion of the existing Wilga Park Power Station from 12 to 40 megawatts.

1.2 Narrabri Gas Project

On 30 September 2020, Santos NSW (Eastern) Pty Ltd (**Santos**) obtained consent for State significant development (**SSD**) 6456 to develop the Narrabri Gas Project (**NGP**) (**the Project**). The Project includes the progressive installation of up to 850 new gas wells on up to 425 new well pads over approximately 20 years and the construction and operation of gas processing and water treatment facilities. The Project area covers about 950 square kilometres (95,000 hectares) in size with the Project footprint only directly impacting approximately 1% of that area.

Four phases of development are defined under the consent, including:

- Phase 1 - exploration and appraisal;
- Phase 2 - construction activities for production wells and related infrastructure;
- Phase 3 - gas production operations; and
- Phase 4 - gas well and infrastructure decommissioning, rehabilitation and closure.

Phase 1 of the Project is defined in the consent as the phase of the development comprising ongoing exploration and appraisal activities in the Project area, including:

- seismic surveys;
- core and chip holes;
- construction and operation of pilot wells (up to 25 wells on up to 25 well pads across the project area); and
- pilot well ancillary infrastructure, including access tracks, gas and water gathering lines, water balance tanks, safety flaring infrastructure, utilities and services, and environmental monitoring equipment including groundwater monitoring bores.

Santos plans to continue exploration and appraisal of the resource in the near term until a final investment decision can be made. The exploration and appraisal activities will include continued operation of Santos' existing wells, infrastructure and facilities in PEL 238 and PAL 2, and construction and operation of new core holes, pilot wells and supporting infrastructure permitted under Phase 1.

Santos' existing exploration and appraisal activities in PEL 238 and PAL 2 include:

- Tintsfield Pilot;
- Bibblewindi East Pilot;
- Bibblewindi West Pilot;
- Dewhurst North Pilot;
- Dewhurst South Pilot;
- Dewhurst northern and southern flow lines;
- Leewood Water Management Facility including ponds, water treatment plant and irrigation area;
- Bibblewindi Facility including gathering system, water balance tank, compressor and flare; and
- Bibblewindi to Leewood buried gas pipeline.

These exploration and appraisal activities will continue as part of the Narrabri Gas Project. The initial, new-appraisal Phase 1 scope is a relatively minor extension to these existing exploration and appraisal activities.

The Phase 1 scope is planned to include the construction and operation of:

- 4 coreholes;
- 6 pilot wells;
- 2 deep reservoir monitoring bores (converted coreholes);
- new shallow water monitoring bores;
- associated linear infrastructure;
- seismic surveys (length and location to be determined); and
- continued operation of Santos' existing exploration and appraisal activities.

The full definitions of the approved activities for Phases 2, 3 and 4 of the Project are provided in the consent.

1.3 Purpose and scope of Plan

This Biodiversity Management Plan (**BMP** or the **Plan**) was prepared by suitably qualified and experienced persons, as listed in the document control tables, approved by the Planning Secretary in letter dated 7 April 2021. The BMP has been prepared for Phase 1 of the Project in accordance with SSD 6456 condition of consent (**CoC**) A23. Staging of the BMP was approved by the Planning Secretary on 14 April 2021.The Plan will be updated prior to Phase 2.

The BMP provides a framework for the management of biodiversity values associated with the Project. More specifically, the Plan describes the specific management actions required to avoid, minimise, mitigate, rehabilitate and offset impacts on these values. This includes all reasonable and feasible measures to prevent, or where prevention is not reasonable and feasible, minimise any material harm to the environment as required under CoC A1.

It has been developed in accordance with the requirements of approval conditions of PEL 238; PAL 2; PPL 3; compliance conditions of Environment Protection Licence (**EPL**) 20350; SSD 6456 conditions of consent, particularly CoC B51, and the applicable regulatory framework regarding biodiversity management in NSW.

The Plan applies to the construction and operation of Phase 1 activities only. It will be revised, updated and approved prior to development of subsequent phases to reflect additional gas production infrastructure and associated activities, if any; updated operational procedures and any revised lease or licence conditions.

The Plan provides the Biodiversity Offset Strategy (**BOS**), Koala Research Program (**KRP**) proposal and Pest Plant and Animal Control Protocol, provided respectively as Attachment 1, Attachment 2 and Attachment 3.

The BMP and the three related sub-plans apply to operational areas and areas of surface disturbance where applicable only, except for the BOS to the extent described within that document.

This Plan will be implemented once approved by the Planning Secretary, as required by CoC B52.

1.4 Objectives

The objectives of this Plan are to manage, monitor and provide a reporting framework for the potential impacts of the Project on biodiversity values within the Project area throughout its design, construction and operation. The Plan has been developed to complement other management plans and forms part of the Project Environmental Management Strategy (**EMS**).

1.5 Consultation

This Plan has been prepared in consultation with the NSW Department of Planning and Environment (**DPE**) Biodiversity, Conservation & Science (**BCS**) directorate (formerly the Biodiversity Conservation Division [**BCD**]), the Cth Department of Climate Change, Energy, the Environment and Water (**DCCEEW**), the Forestry Corporation of NSW (**FCNSW**), Narrabri Shire Council (**Council**) and the Biodiversity Advisory Group (**BAG**). The primary objective of consultation was to seek feedback from relevant stakeholders during development of this Plan to ensure agreement with the proposed approach to biodiversity management.

The Biodiversity Offset Strategy has been prepared in consultation with the NSW Department of Regional NSW - Mining, Exploration and Geoscience (**MEG**) (formerly the Division of Resources and Geoscience), in addition to the agencies referred to above.

The comments received from the various stakeholders predominantly focussed on the timing for the retirement of credits, the transitioning between species and ecosystem credits, monitoring, survey techniques and rehabilitation.

Consultation records and how matters raised during consultation have been addressed in the Plan are included in Appendix A.

1.6 Structure of this Plan

The structure of this Plan is as follows:

Sections

Section 1	Provides an introduction to the Project and the context, scope, purpose and objectives of this Plan.

Section 2	Defines the roles and responsibilities of personnel involved with the Project, including staff, consultants, contractors and service providers.
Section 3	Outlines the statutory provisions relevant to the biodiversity management, the compliance conditions and any relevant codes, standards, policies and guidelines
Section 4	Describes and illustrates the existing environment of the Project area
Section 5	Describes the direct and indirect potential biodiversity impacts associated with the Project
Section 6	Describes the proposed biodiversity management measures to be implemented
Section 7	Provides a copy of the Koala Research Program proposal
Section 8	Details the biodiversity offsets mechanism and provides a summary of the strategy
Section 9	Describes the biodiversity monitoring program
Section 10	Provides a risk assessment and contingency plan
Section 11	Presents a trigger action response plan to assess and respond to abnormal conditions using adaptive management principles
Section 12	Provides details on the process that is implemented to manage data and records in a consistent, efficient and effective manner
Section 13	Describes the evaluation and review process of this BMP
Section 14	Provides the details regarding the management of complaints
Section 15	References
Section 16	Glossary

Appendices

Appendix A	Consultation records
Appendix B	Consent conditions relevant to this Plan
Appendix C	Ecological Scouting Framework
Appendix D	Clearing Procedure
Appendix E	Reporting template for vegetation and threatened flora removal
Appendix F	Seed Collection Procedure
Appendix G	Soundscape analysis

Attachments

Attachment 1	Biodiversity Offset Strategy
Attachment 2	Koala Research Program proposal
Attachment 3	Pest Plant and Animal Control Protocol

1.7 Interaction with related plans

The Biodiversity Management Plan is a part of the project EMS. The structure of the Biodiversity Management Plan, Pest Plant and Animal Control Protocol and other related management plans are intricately linked with the Field Development Protocol and Field Development Plans. The protocol and management plans provide a framework for the development of Field Development Plans. The proposed design for the Field Development Plans will provide the specific details for the location of infrastructure and the associated management and monitoring activities to be included in the final management plans. A conceptualisation of the interactions between these plans and the timing of application is provided in Figure 1.1.

The current Phase Field Development Plan is prepared and updated concurrently with relevant phase-specific updates to this Plan as required. This approach will be maintained throughout the life of the Project to ensure adaptive management principals are applied.

1.8 Distribution

Key Project documents will be kept up to date and made publicly available on the Project website in accordance with CoC D13. A detailed list of included documents can be found in section 4.4 of the EMS.

The approved Plan will be implemented in accordance with condition B52. A copy of the approved Plan is available to all Santos personnel via the Santos intranet. In accordance with consent condition D13, the latest copy can also be found on the Project website.

As required by specific licence, approval or code of practice conditions, once approved a copy of this Plan will be available at the Santos Operations Centre located at 300 Yarrie Lake Road in Narrabri. This is where operational and field staff commence and finish each workday.

Note that any printed copies of this Plan are uncontrolled.

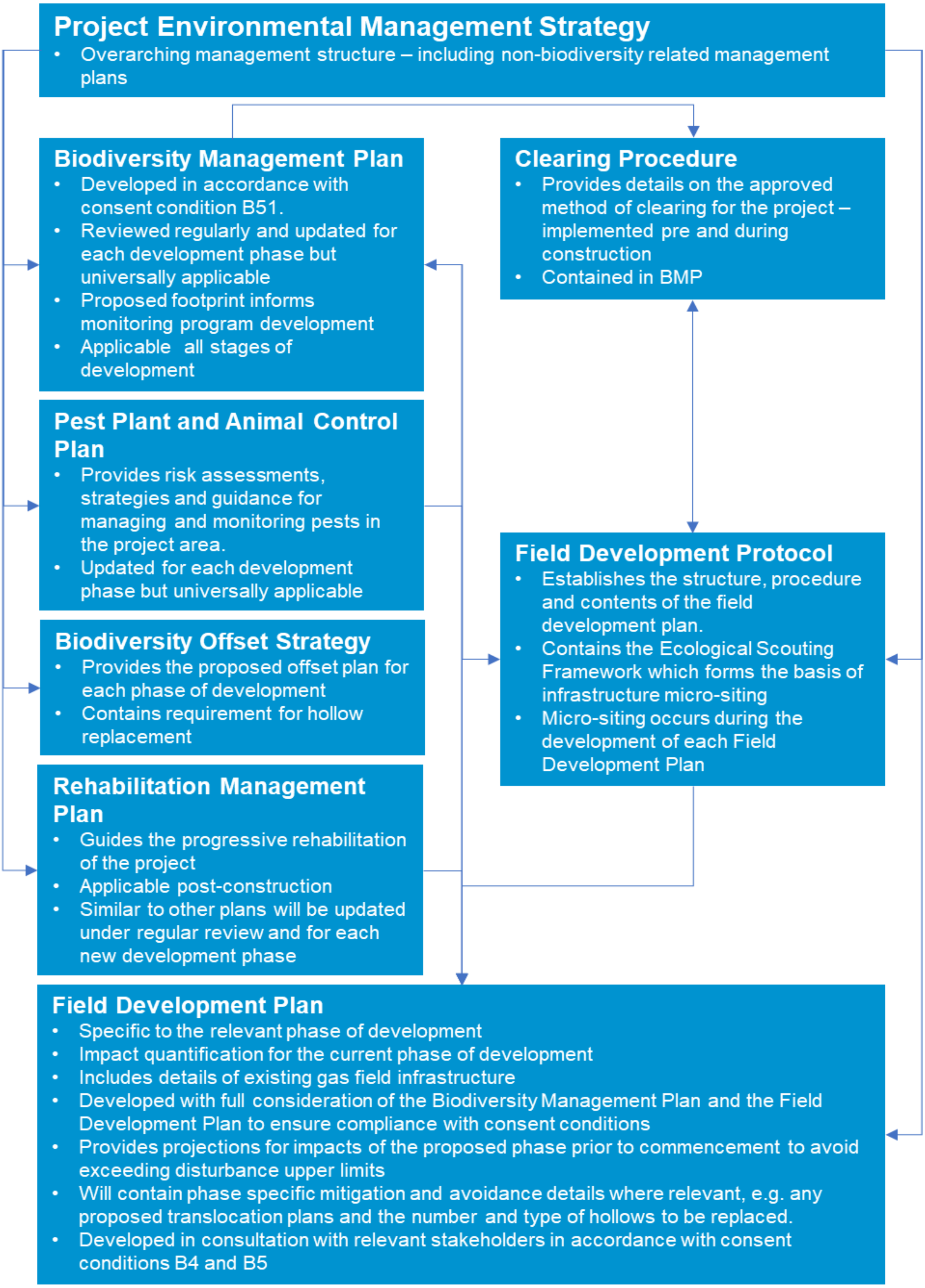


Figure 1.1 - Overview of management plan and field development integration

2. Roles and responsibilities

All Santos employees and contractors involved in the Narrabri Gas Project are responsible for the environmental performance of their activities and for complying with all legal requirements and obligations. All Project personnel will be made aware of and comply with approval requirements of the activities they undertake and potential environmental impacts from all activities will be managed in accordance with the Project's relevant management plan(s).

In accordance with consent condition D1, the EMS sets out the roles, responsibilities, authorities and accountabilities of all key personnel involved in the environmental management of the Project, including the requirements and obligations in this Plan. All roles, responsibilities and accountabilities have been assigned in accordance with Santos Management System *SMS-MS_14 People Management Standard*.

A Biodiversity Advisory Group (**BAG**) has been established for the Project in accordance with condition B50. The BAG's membership was approved by the Planning Secretary on 31 March 2021 and includes:

- a representative from BCS;
- 3 representatives of the scientific community; and
- 3 relevant community representatives.

The BAG meets at least twice annually to advise on project-related biodiversity matters and was integral to development of the BMP. The BAG is an advisory committee and has no compliance or enforcement functions.

3. Regulatory requirements

The Project is permissible with development consent under the *State Environmental Planning Policy (Resources and Energy) 2021*, and is identified as a 'State significant development' under Section 4.38 of the EP&A Act and the *State Environmental Planning Policy (Planning Systems) 2021*.

The Project was subject to the SSD assessment and approval provisions of Division 4.1 of Part 4 of the EP&A Act and has been granted approval as an SSD under the EP&A Act and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) (EPBC 2014/7376).

The Project will be carried out in accordance with the:

- relevant existing development consents and activity approvals;
- the conditions of relevant tenements including PEL 238, PAL 2, PPL 3;
- the provisions of the *Petroleum (Onshore) Act 1991* (NSW) (**PO Act**) and relevant codes of practice and guidelines;
- the requirements of the *Biodiversity Conservation Act 2016* (NSW) (**BC Act**) and the *Biosecurity Act 2015* (NSW) (NSW **Biosecurity Act 2015**);
- EPL 20350 issued by the NSW Environment Protection Authority (**EPA**) and the provisions of the *Protection of the Environment Operations Act 1997* (NSW) (**POEO Act**);
- the conditions of consent for the NGP SSD 6456.

3.1 Compliance conditions

Compliance conditions associated with the following licence(s), lease(s) and consent(s) are or will be relevant to this Plan:

- PEL 238, granted on 1 September 1980 and most recently renewed on 12 April 2022;
- PAL 2, granted on 30 October 2007;
- PPL 3, granted on 15 December 2003;
- PPLs 13, 14, 15 and 16, once issued;
- EPL 20350, as varied; and
- SSD 6456.

3.1.1 PEL 238, PAL 2 and PPL 3

Licence condition 5 of PEL 238 is relevant to rehabilitation management. Lease condition 5 of PAL 2 and PPL 3 states that disturbed land must be rehabilitated to a sustainable/agreed end land use to the satisfaction of the Director-General.

These requirements have been addressed in the Rehabilitation Management Plan and associated appendices.

3.1.2 EPL 20350

'Petroleum exploration, assessment and production' is a scheduled activity listed in Schedule 1 of the POEO Act. Under Section 48 of this Act, all scheduled activities are required to hold an environment protection licence. EPL 20350 is held for Santos' current CSG activities in PEL 238, PAL 2 and PPL 3.

There are no specific conditions that relate to biodiversity management, however all general conditions are applicable to minimise environmental harm. Note that the EPL may be varied from time to time and therefore the most recent version of the EPL must be reviewed when assessing compliance.

3.1.3 Development Consent SSD 6456

There are a number of SSD 6456 consent conditions directly relevant to this Plan for Phase 1, with the key conditions B51 and B52 provided in full below. Table B1 in Appendix B specifies where each of the requirements of all the relevant SSD 6456 consent conditions are addressed in this Plan.

Note that the consent conditions related to biodiversity offset requirements and the retirement of credits are fully addressed in the BOS, provided as Attachment 1.

Consent condition B51 states that prior to the commencement of Phase 1, Santos must prepare a Biodiversity Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:

- (a) be prepared by a suitably qualified and experienced person/s approved by the Planning Secretary;
- (b) be prepared in consultation with the BCS, DCCEEW, FCNSW, Council and the Biodiversity Advisory Group;
- (c) describe the short term, medium and long-term measures to be undertaken to manage vegetation and fauna habitat in the project area including measures to avoid and/ or minimise impacts on threatened ecological communities;
- (d) describe how biodiversity management would be integrated with similar measures in the Water Management Plan and Rehabilitation Management Plan;
- (e) describe the measures to be implemented for undertaking micro-siting investigations for the Field Development Plan, including procedures for
  - (i) desk top review and ground surveys for all proposed gas field infrastructure; and
  - (ii) managing any threatened species or ecological communities identified during the investigations, including measures to avoid and/or minimise disturbance of threatened species or ecological communities; and
- (f) include a Biodiversity Offset Strategy that:
  - (i) is prepared in consultation with MEG (in addition to the agencies referred to in (b) above), in relation to the potential for resource sterilisation;
  - (ii) is prepared consistent with the NSW Biodiversity Offsets Policy for Major Projects;
  - (iii) describes how the biodiversity credits in Tables 8, 9 and 10 of the CoC will be identified, secured and retired;
  - (iv) prioritises land-based offsets for retiring ‘Phase 2 Credits’ identified in Tables 8, 9 and 10 of the CoC;
  - (v) describes the staging of credit retirements and associated surface disturbance areas; and
  - (vi) describes how threatened species under the EPBC Act would be suitably offset;
- (g) include a Koala Research Program that:
  - (i) is designed to determine the location and size of remnant Koala populations in the Pilliga Forest;
  - (ii) investigates why suitable areas of habitat may not be occupied by Koalas; and
  - (iii) guides adaptive management of the Koala population in the project area and any land-based offset areas used to retire species credits for the Koala;

(h) describe the measures to be implemented within approved disturbance areas in the Project area to:

  (i) minimise the amount of clearing and employ temporary vegetation strategies;

  (ii) minimise impacts on fauna, including undertaking pre-clearance surveys and targeted clearing windows and protocols to minimise impacts during key breeding seasons for threatened bats and birds;

  (iii) maximise the salvage, transplanting and/or propagation of any threatened flora found during pre-clearance surveys, in accordance with the *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee et al., 2004), where reasonable and feasible; and

  (iv) maximise the salvage of resources, including tree hollows, vegetation and soil resources, for beneficial reuse, including fauna habitat enhancement;

(i) describes the measures to be implemented in the Project area to:

  (i) minimise impacts on fauna habitat resources such as hunting and foraging areas, habitat trees, fallen timber and hollow-bearing trees;

  (ii) enhance the quality of vegetation, vegetation connectivity and wildlife corridors including through the assisted regeneration and/or targeted revegetation of appropriate canopy, sub-canopy, understorey and ground strata;

  (iii) introduce naturally scarce fauna habitat features such as nest boxes and salvaged tree hollows and promote the use of these introduced habitat features by threatened fauna species;

  (iv) manage any potential conflicts with Aboriginal heritage values;

  (v) protect vegetation and fauna habitat outside of the approved disturbance areas;

  (vi) manage potential indirect impacts on threatened flora and fauna species;

  (vii) manage the collection and propagation of seed from the local area;

  (viii) control weed, including measures to avoid and mitigate the spread of noxious weeds;

  (ix) control feral pests with consideration of actions identified in relevant threat abatement plans;

  (x) control erosion;

  (xi) manage any grazing and agriculture;

  (xii) control access to vegetated or revegetated areas; and

  (xiii) manage bushfire hazards;

(j) include a seasonally based program to monitor and report on the effectiveness of the above measures, progress against the detailed performance and completion criteria in the RMP, and improvements that could be implemented to improve biodiversity outcomes;

(k) identify the potential risks to the successful implementation of the Biodiversity Offset Strategy, and include a description of the contingency measures to be implemented to mitigate against these risks; and

(l) include details of who would be responsible for monitoring, reviewing, and implementing the Plan.

Consent condition B52 states that Santos must implement the Biodiversity Management Plan once approved by the Planning Secretary.

3.1.4 EPBC approval 2014/7376

There are a number of EPBC 2014/7376 consent conditions that are directly relevant to biodiversity management. However, since this version of the BMP is only applicable to Phase 1 of the Project, only those conditions that are relevant to Phase 1 are provided in full below. Table B2 in Appendix B specifies where each of the requirements of EPBC 2014/7376 consent condition 25 are addressed in this Plan.

Note that consent conditions related to biodiversity offset requirements and the retirement of credits are detailed in the BOS, provided in Attachment 1.

Consent condition 2 requires Santos to clear no more than 989 hectares of native vegetation within the project area and must not clear outside the project area.

Consent condition 25 requires Santos to comply with conditions B43 – B52 of SSD 6456 as they relate to the following matters:

a) Brigalow woodland (Brigalow – Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion);
b) Weeping Myall woodland (Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions);
c) Regent Honeyeater (*Anthochaera phrygia*) ;
d) Koala (*Phascolarctos cinereus*);
e) Spotted-tail Quoll (*Dasyurus maculatus*);
f) Swift Parrot (*Lathamus discolor*);
g) Superb Parrot (*Polytelis swainsonii*) ;
h) South-eastern Long-eared Bat (*Nyctophilus corbeni*);
i) Pilliga Mouse (*Pseudomys pilligaensis*);
j) *Bertya opponens*;
k) *Lepidium aschersonii*;
l) *Lepidium monoplocoides*;
m) *Commersonia procumbens*; and
n) *Tylophora linearis*.

3.2 Relevant codes, standards, policies and guidelines

3.2.1 Translocation guidelines

The first edition of the *Guidelines for the Translocation of Threatened Plants in Australia* (**Translocation Guidelines**) was published in 1997, developed by the Australian Network for Plant Conservation for the translocation of threatened plants for conservation purposes as a result of resolutions from the Australian Network of Plant Conservation conference in Hobart in 1993. The second edition was published in 2004.

Although a third edition was published in 2018, the second (2004) edition is applicable to the Project, as referenced in CoC B51.

3.2.2 Biodiversity Offsets Policy

The *NSW Biodiversity Offsets Policy for Major Projects* (**Offsets Policy**) clarifies and standardises biodiversity impact assessment and offsetting for major project approvals in NSW. It was published in 2014 by the then NSW Office of Environment and Heritage (**OEH**) to provide a standard method for assessing impacts of major projects on biodiversity and determining offsetting requirements.

The Offsets Policy reduces the need for case-by-case negotiations, including debates around the adequacy of assessments. It also provides increased certainty to proponents, allowing offsetting requirements to be known and factored in during the planning phase of a project.

The *Framework for Biodiversity Assessment* (OEH, 2014) underpins the Offsets Policy. It contains the assessment methodology that is adopted by the policy to quantify and describe the impact assessment requirements and offset guidance that apply to Major Projects.

3.3 Framework for Biodiversity Assessment to Biodiversity Assessment Method transition

Since the EIS (and accompanying Ecological Impact Assessment and Biodiversity Assessment Report) was submitted, the Framework for Biodiversity Assessment has been replaced with the Biodiversity Assessment Method under the NSW Biodiversity Offset Scheme. The Biodiversity Offset Scheme provides a new approach for determining the quantum of credits required to offset a development and generated from the establishment of a Biodiversity Stewardship Site. The Project was assessed under the Framework for Biodiversity Assessment and the credit requirement in the CoC is calculated in this framework. Where a project has an existing obligation to obtain and retire BioBanking credits under a consent and the credits required do not exist, an application for an '*assessment of reasonable equivalence*' of biodiversity credits (henceforth referred to as 'reasonable equivalence') must be made to DPE. The conversion provides an equivalent quantum of Biodiversity Offset Scheme credits that allows the Project to meet its offset obligation within the new framework. Refer to the project BOS for more detailed information regarding the assessment of reasonable equivalence.

3.4 EIS commitments

In the EIS Chapter 31, and updated in Appendix B of the Response to Submissions, Santos committed to the implementation of a number of measures pending Project Approval and a final investment decision. The EIS commitments relevant to biodiversity management have been reproduced in Table 3.1, in accordance with consent condition D3(c) which states that Santos must ensure that (where relevant) the management plans include any relevant commitments or recommendations identified in the EIS.

Table 3.1 - EIS commitment relevant to biodiversity management

Number	EIS Commitment relevant to biodiversity management
1.2	A project wide environmental management strategy, comprising a number of sub-plans to be used throughout the planning and design, construction, operation and decommissioning and rehabilitation stages of the project are described in Chapter 30. The sub-plans are[1]: • … • Biodiversity Management Plan • Pest, Plant and Animal Control Plan [part of the Biodiversity Management Plan]; • …
6.1	A Biodiversity Management Plan will be implemented and will include a Significant Species Management Plan.
6.2	Vegetation clearance and threatened flora removal would be recorded to ensure it is within the approved limits

[1] Only the plans relevant to biodiversity management have been listed. The full list of sub-plans is provided in the EMS section 3.5.

Number	EIS Commitment relevant to biodiversity management
6.3	Vegetation will be cleared in accordance with the clearing procedure provided in Appendix D to minimise impacts to fauna during vegetation removal.
6.4	Hollow reinstallation or replacement will be offset at a ratio of 1:1 for hollows greater than 300mm.
6.5	Open trenches will be inspected each morning and where fauna is found it will be removed by a suitably qualified fauna handler. Data would be collected on the species captured, the number of individuals captured and capture locations.
6.6	The disturbance limit for direct impact on native vegetation is 988.8 ha. To minimise clearing during sensitive (fauna breeding) periods, less than 50 per cent (494 ha.) of the disturbance will be outside the most preferred period from March to June, and less than 20 per cent (197 ha.) of this disturbance will be during the least preferred period from September to January.
6.7	Rehabilitation of impacted areas will occur in accordance with the Rehabilitation Strategy.
6.8	Driving from dusk through to dawn will be minimised, due to high faunal activity.
6.9	'Fauna friendly' exclusion fencing (without barbed wire) will be installed around well sites during operation unless determined otherwise under a land access agreement.
6.10	Lighting will be designed to meet Australian Standard AS 4282-1997 *Control of the obtrusive effects of outdoor lighting*[2] and the Australian / New Zealand Standard AS/NZS 1158:2010 *Lighting for roads and public spaces for roadways and plant*, as applicable. The design and operation of night lighting would also consider the good lighting design principles documented in *Dark Sky Planning Guideline: Protecting the observing conditions at Siding Spring* (NSW Department of Planning and Environment 2016)
6.11	Prior to earthworks, weeds listed as noxious under the NSW *Noxious Weeds Act 1993*[3] that are present on the site will be removed or treated with herbicide to prevent or reduce their spread.
6.12	Feral animals will be managed in accordance with a Pest Plant and Animal Control Protocol
6.13	A biodiversity offset strategy will be finalised and implemented.

As described in section 13 of this Plan and section 8 of the EMS, this Plan will be subject to regular evaluation and review. This will include the EIS commitments to ensure they remain current, applicable, and generally improve the environmental performance of the Project.

In relation to Commitment 6.1, the Significant Species Management Plan (SSMP) has been effectively incorporated into this document, the BMP. The BMP meets the intended purpose of the SSMP and as a result a separate SSMP is not required to be further developed.

3.5 Overview of interaction with other plans

The Biodiversity Management Plan is a part of the Project EMS. The Plan is developed and implemented with consideration of other relevant plans within the EMS, the Field Development Protocol and the relevant Field Development Plan. The current Phase Field Development Plan is prepared concurrently with relevant phase-specific updates to this Plan as required. This approach will be maintained throughout the life of the Project to ensure adaptive management principles are applied. The BMP has been prepared to integrate with the Rehabilitation Management Plan. A flow chart with an overview of the interaction between the EMS, the management plans, the Field Development Protocol and the Field Development Plan is provided previously in Figure 1.1).

[2] AS 4282: 1997 *Control of the obtrusive effects of outdoor lighting* has been superseded by AS 4282: 2019 *Control of the obtrusive effects of outdoor lighting*.

[3] The *Noxious Weeds Act 1993* (NSW) has been repealed, and replaced by the *Biosecurity Act 2015* (NSW).

4. Existing environment

4.1 Overview

4.1.1 The Pilliga

The Pilliga represents the largest block of remnant vegetation in NSW, west of the Great Dividing Range. It is comprised mainly of State Forests managed for timber production, as well as significant areas of conservation reserves.

In recognition of the high ecological and landscape value of the Pilliga, over 240,000 ha of conservation reserve have been gazetted under the NSW *National Park and Wildlife Act 1974* (**NP&W Act**) since the 1960s. Approximately half of the Pilliga is now reserved under the NP&W Act, with the other half retained as State Forest for commercial timber production, recreation and mineral extraction.

4.1.2 Landscape context

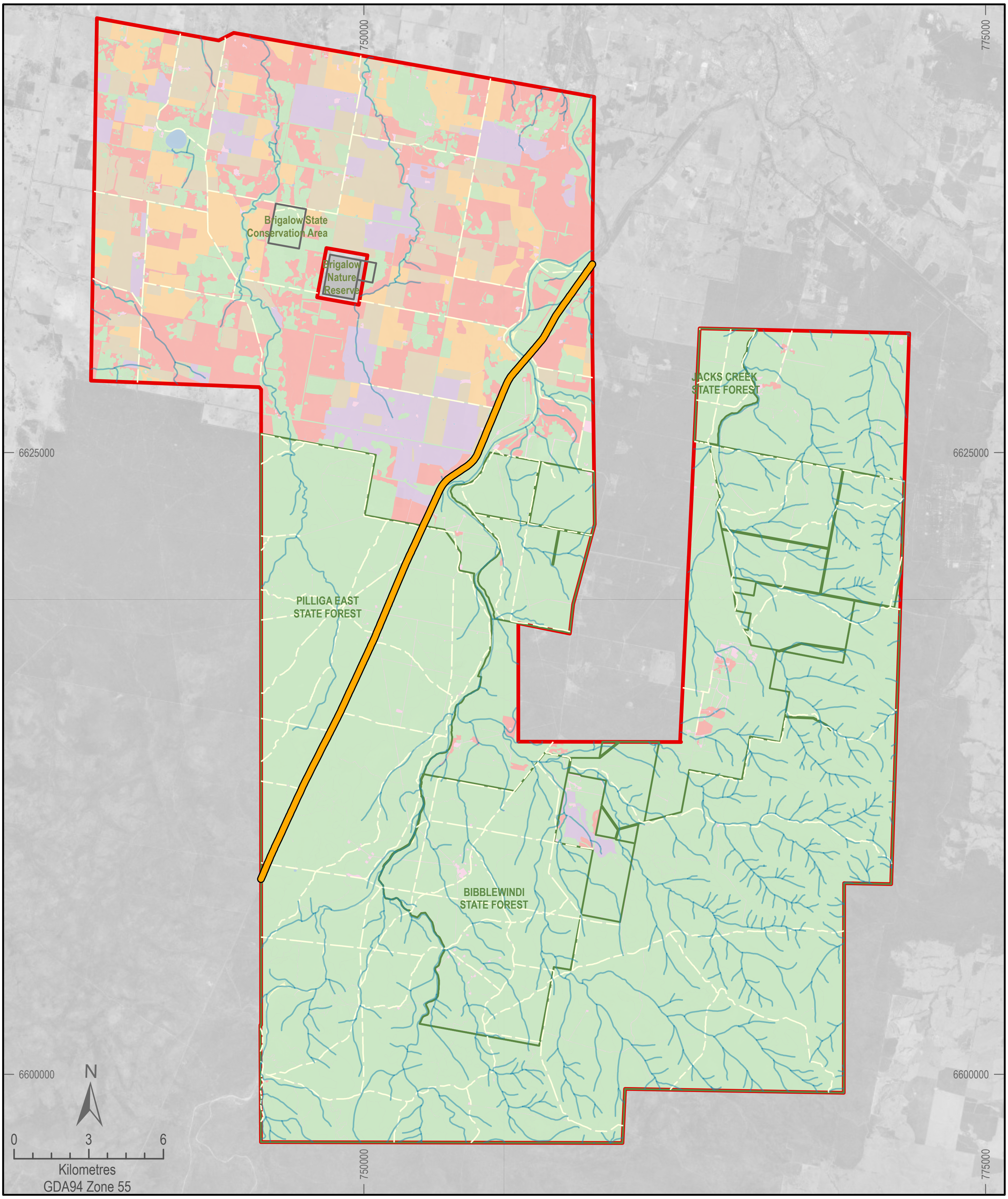
The Pilliga and the project area are located within the southern part of the Brigalow Belt South Bioregion, which extends over NSW and Queensland, with the majority in Queensland. In NSW, the bioregion covers an area of 52,409 km^2, which represents 18.7 % of the total bioregion (NPWS, 2000a).

The bioregion is divided into seven subregions in NSW: Liverpool Plains, Liverpool Range, Northern Outwash, Northern Basalt, Pilliga Outwash, Pilliga and Talbragar Valley. Of these, the project area is situated in the Pilliga and Pilliga Outwash subregions. These subregions are characterised by occurring on Mesozoic bedrock containing extensive sandstone hills and coarse sandy soils (Pilliga), and on the plains of deep sandy texture dominated by alluvial and colluvial sediments (Pilliga Outwash) (NPWS, 2000a, 2000b).

4.1.3 Land use

Within the NSW section of the Brigalow Belt South Bioregion, the majority of land (approximately 85 %) is freehold land. Much of this is used for agricultural purposes, where cropping (dryland and irrigation farming) and grazing / pastoral activities dominate (NPWS, 2000a, 2000b). Approximately 5 % of the NSW sections of the bioregion are used by the forestry industry and 4 % forms Crown lands and conservation reserves. Other land uses include mining (mainly coal) and apiary industries.

Land use was mapped for the EIS and classified into the following categories; cleared, creek bed, dam, derived native grassland, native vegetation, cropping, improved pasture and previous evidence of pasture improvement, as presented in Figure 4.1. This mapping indicated that native vegetation covers approximately 75 % of the Project area whilst derived native grassland consists of approximately 10 % of the Project area. Agricultural areas of cropping, improved pasture or areas with evidence of previous pasture improvement together consist approximately 14 % of the Project area.



Santos

ONWARD CONSULTING

LEGEND

- NGP boundary
- NPWS Estate
- State Forest
- Highway
- Roads
- Watercourses

Land use type

- Derived native grassland
- Native vegetation
- Other - cropping
- Other - improved Pasture
- Other - previous evidence of pasture improvement
- Other - creek bed
- Other - dam
- Other - cleared

NARRABRI GAS PROJECT

Figure 4.1

Land Use within the NGP Boundary

4.2 Vegetation and flora

4.2.1 Vegetation communities

Vegetation communities (known as Plant Community Types - PCTs) within the Project area were attributed in accordance with the NSW Vegetation Classification and assessment (Benson et al. 2010). Twenty-two plant communities occur within the Project area, covering an area of 80,398 hectares (ha) and 14,678 ha of 'other' for approximately 95,077 ha within the Project area. These communities and corresponding biometric vegetation types are as detailed in Table 4.1 and shown in Figure 4.2.

Table 4.1 - Vegetation communities within the Project area

Plant community name (Identification number)[a,b]	Biometric Vegetation Type (BVT) identification number
Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions (27)	NA219
Brigalow – Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (35)	NA117
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (55)	NA102
River Red Gum riparian tall woodland / open forest wetland in the Nandewar and Brigalow Belt South Bioregions (78)	NA193
Pilliga Box – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion (88)	NA179
Broombush – wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (141)	NA121
Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South (including Pilliga) and Nandewar Bioregions (202)	NA141
Green Mallee tall Mallee woodland on rises in the Pilliga – Goonoo regions, southern BBS Bioregion (256)	NA292
Inland Scribbly Gum – White Bloodwood – Red Stringybark – Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP – Pilliga region in the BBS Bioregion (379)	NA294
Poplar Box – White Cypress Pine shrub grass tall woodland of the Pilliga – Warialda region, BBS Bioregion (397)	NA324
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 BBS Bioregion (398)	NA314
Red gum – Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga – Goonoo sandstone forests, BBS Bioregion (399)	NA255
Rough-barked Apple – red gum – cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region (401)	NA338
Mugga Ironbark – White Cypress Pine – gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion (402)	NA307
Red Ironbark – White Bloodwood -/+ Burrows Wattle heathy woodland on sandy soil in the Pilliga forests (404)	NA326
White Bloodwood – Red Ironbark – cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions (405)	NA390
White Bloodwood – Motherumbah – Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests (406)	NA389

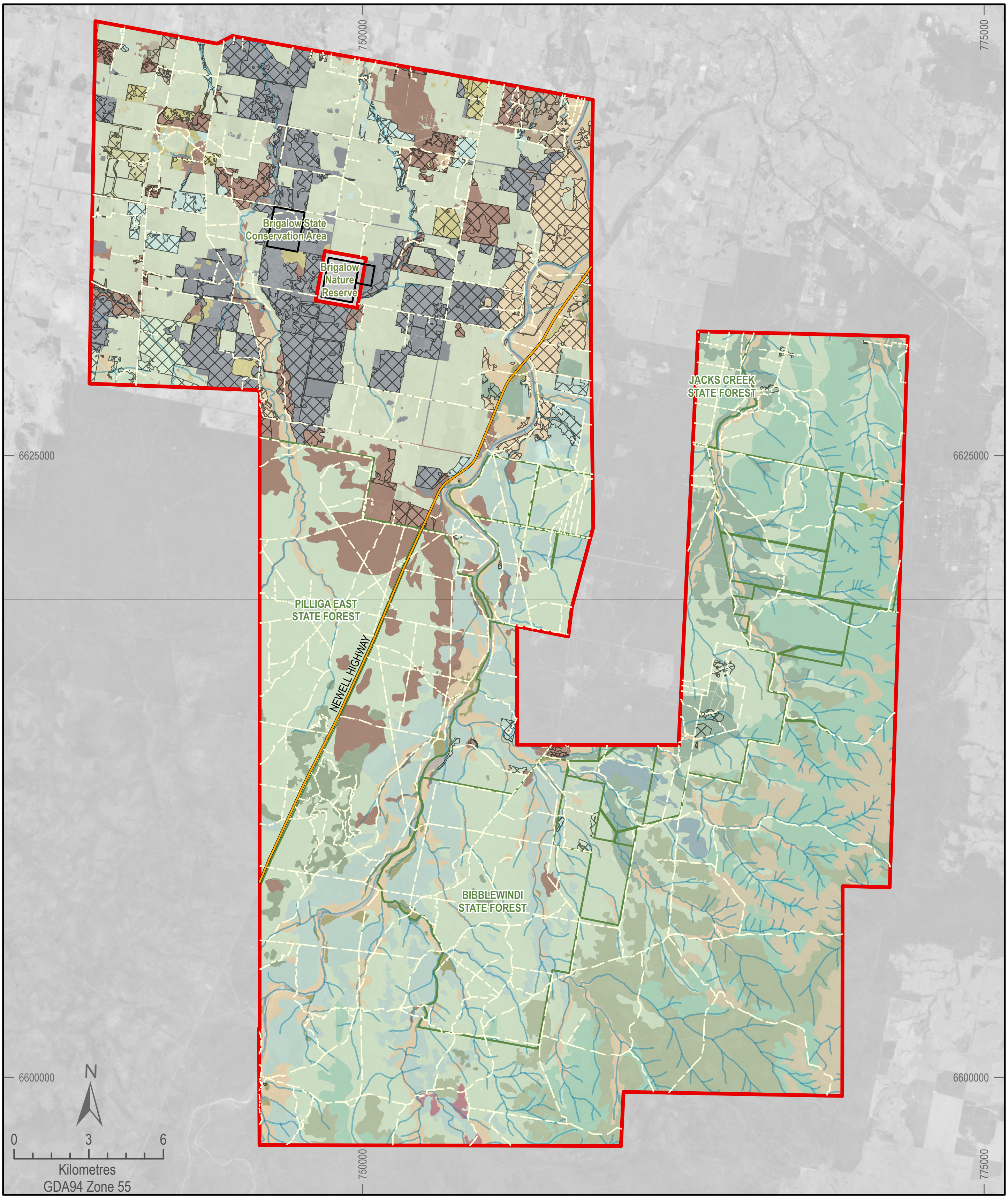
Plant community name (Identification number)[a,b]	Biometric Vegetation Type (BVT) identification number
Dirty Gum (Baradine Gum) – Black Cypress Pine – White Bloodwood shrubby woodland of the Pilliga forests and surrounding region (408)	NA279
White Cypress Pine – Silver-leaved Ironbark – Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion (418)	NA409
Spur-wing Wattle heath on sandstone substrates in the Goonoo-Pilliga forests Brigalow Belt South Bioregion (425)	NA363
Carbeen – White Cypress Pine – Curracabah – White Box tall woodland on sand in the Narrabri-Warialda region of the Brigalow Belt South Bioregion (428)	NA267
White Bloodwood – Dirty Gum (Baradine Gum) – Rough Barked Apple – Black Cypress Pine heathy open woodland on deep sand in the Pilliga forests (40X)[c]	NA390
Cleared, creek bed, dams and improved pasture (Other)	-

Notes:

a - Plant community as per *NSW Vegetation Classification and Assessment* (Benson et al 2010).

b - Communities listed under the BC Act and/or EPBC Act are highlighted in **bold**.

c - Plant community type ID40X does not correspond with the plant community types of the NSW Vegetation Classification Assessment. This community is most closely related to plant community type ID405.



Santos

ONWARD CONSULTING

LEGEND

- NGP boundary
- State Forest
- NPWS Estate
- Highway
- Roads and tracks
- Watercourses

Plant community types

0	141	401	418	
27	202	402	425	
35	256	404	428	
55	379	405	Derived native grassland	
78	397	406		
88	398	408		
	399	40X		

NARRABRI GAS PROJECT

Figure 4.2

Vegetation Communities within the NGP Boundary

4.2.2 Threatened Ecological Communities

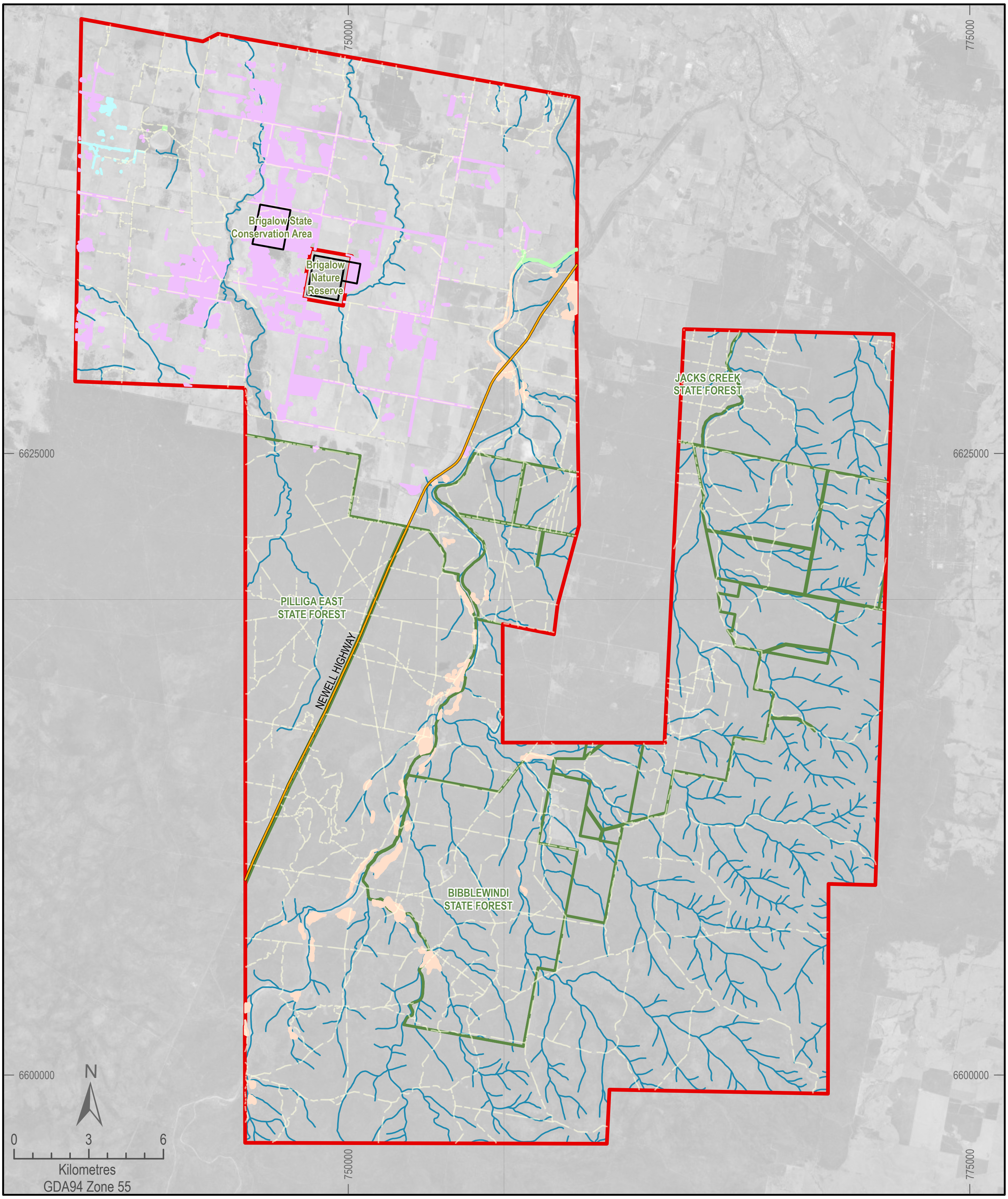
Four Endangered Ecological Communities (**EECs**) listed under the BC Act and/or EPBC Act were recorded within the Project area during field surveys and have the potential to be impacted as a result of the Project. These communities within the Project area are listed in Table 4.2 and the distribution based on listing status in Figure 4.3.

Table 4.2 - Vegetation communities within the Project area

Name (plant community identification number)[a]	Conservation status[b]	
	BC Act	EPBC Act
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (BC Act) or Brigalow (*Acacia harpophylla* dominant and co-dominant) (EPBC Act) (35)	E	E
Carbeen Open Forest Community in the Darling Riverine Plains and Brigalow Belt South Bioregions (428)	E	-
Myall Woodlands in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW south western slopes bioregions (BC Act) or Weeping Myall Woodlands (EPBC Act) (27)	E	E
Fuzzy Box Woodland on alluvial soils of the south western slopes, Darling Riverine Plains and Brigalow Belt South bioregions (202)	E	-

Notes:

a - Plant community as per *NSW Vegetation Classification and Assessment* (Benson et al 2010).
b - E = Endangered ecological community (BC and EPBC Act).
c - Areas are not mutually exclusive and are calculated based on the definition of the community within the BC Act and EPBC Act.



Santos

ONWARD CONSULTING

LEGEND

- NGP boundary
- State Forest
- NPWS Estate
- Highway
- Roads and tracks
- Watercourses

Endangered Ecological Communities

- Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (BC Act) or Brigalow (Acacia harpophylla dominant and co-dominant) (EPBC Act) (35)
- Carbeen Open Forest Community in the Darling Riverine Plains and Brigalow Belt South Bioregions (428)
- Fuzzy Box Woodland on alluvial soils of the south western slopes, Darling Riverine Plains and Brigalow Belt South bioregions (202)
- Myall Woodlands in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW south western slopes bioregions (BC Act) or Weeping Myall Woodlands (EPBC Act) (27)

NARRABRI GAS PROJECT

Figure 4.3

Endangered Ecological Communities

4.2.3 Threatened flora

Ten threatened flora listed under the BC Act and/or EPBC Act species were recorded in the Project area during field surveys and may be impacted by the Project. These species are listed in Table 4.3.

Table 4.3 - Threatened flora recorded in the Project area

Scientific name	Common name	Conservation status[a]	
		BC Act	EPBC Act
Bertya opponens	Coolabah Bertya	V	V
Diuris tricolor	Pine Donkey Orchid	V	-
Lepidium aschersonii	Spiny Peppercress	V	V
Lepidium monoplocoides	Winged Peppercress	E1	E
Myriophyllum implicatum	-	CE	-
Polygala linariifolia	Native Milkwort	E1	-
Pomaderris queenslandica	Scant Pomaderris	E1	-
Pterostylis cobarensis	Greenhood Orchid	V	-
Commersonia procumbens[b]	-	V	V
Tylophora linearis	-	V	E

Notes:

a - CE = Critically Endangered, E = Endangered (EPBC Act), E1 = Endangered (TSC Act) and V = Vulnerable.
b - Species listed as *Androcalva procumbens*, synonym for *Commersonia procumbens*, in EPBC 2014/7376. Note a recent taxonomic revision moved the species to a new genus, *Androcalva*, but *Commersonia* is used in this document for consistency with SSD-6456.

4.3 Fauna and habitat

4.3.1 Threatened and migratory fauna

Sixteen birds, ten mammals and one reptile listed as threatened under the BC Act, three mammals and one bird listed as threatened under the EPBC Act and five birds listed as migratory under the EPBC Act were recorded within the Project area during the field surveys, as presented in Table 4.6. Matters of National Environmental Significance (**MNES**) considered relevant to the Project under the EPBC approval (2014/7376) are also provided in Table 4.4 below.

Table 4.4 - Threatened and migratory fauna recorded in the Project area

Scientific name	Common name	Conservation status[a]		Type
		BC Act	EPBC Act	
Apus pacificus	Fork-tailed Swift	-	M, Mar	Migratory bird
Ardea modesta	Great Egret, White Egret	-	Mar	Wetland bird
Ardea ibis	Cattle Egret	-	Mar	Wetland bird
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-	Woodland bird
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	Hollow-dependent bird
Chthonicola sagittata	Speckled Warbler	V	-	Woodland bird
Daphoenositta chrysoptera	Varied Sittella	V	-	Woodland bird
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	Wetland bird
Glossopsitta pusilla	Little Lorikeet	V	-	Hollow-dependent bird
Grantiella picta	Painted Honeyeater	V	V	Woodland bird
Hirundapus caudacutus	White-throated Needletail	-	M, Mar	Migratory bird
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	-	Woodland bird
Merops ornatus	Rainbow Bee-eater	-	Mar	Migratory bird
Myiagra cyanoleuca	Satin Flycatcher	-	M, Mar	Migratory bird
Neophema pulchella	Turquoise Parrot	V	-	Hollow-dependent bird
Plegadis falcinellus	Glossy Ibis	-	M, Mar	Migratory bird
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	Woodland bird
Stagonopleura guttata	Diamond Firetail	V	-	Woodland bird
Circus assimilis	Spotted Harrier	V	-	Raptor
Falco subniger	Black Falcon	V	-	Raptor
Hieraaetus morphnoides	Little Eagle	V	-	Raptor
Lophoictinia isura	Square-tailed Kite	V	-	Raptor
Ninox connivens	Barking Owl	V	-	Hollow-dependent bird
Tyto novaehollandiae	Masked Owl	V	-	Hollow-dependent bird
Cercartetus nanus	Eastern Pygmy-possum	V	-	Arboreal mammal
Petaurus norfolcensis	Squirrel Glider	V	-	Arboreal mammal
Macropus dorsalis	Black-striped Wallaby	E	-	Terrestrial mammal
Pseudomys pilligaensis	Pilliga Mouse	V	V	Terrestrial mammal
Chalinolobus picatus	Little Pied Bat	V	-	Microchiropteran bat
Miniopterus schreibersii	Eastern Bentwing-bat	V	-	Microchiropteran bat

Scientific name	Common name	Conservation status[a]		Type
		BC Act	EPBC Act	
oceanensis				
Nyctophilus corbeni	South-eastern Long eared Bat / Corben's Long-eared Bat	V	V	Microchiropteran bat
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	Microchiropteran bat
Vespadelus troughtoni	Eastern Cave Bat	V	-	Microchiropteran bat
Hoplocephalus bitorquatus	Pale-headed Snake	V	-	Reptile

Notes:

CE = Critically Endangered, E = Endangered (BC Act/EPBC Act), V = Vulnerable, M = Migratory (EPBC Act) and Mar = Marine (EPBC Act).

Table 4.5 - MNES under the EPBC Act approval relevant to the Project area

Scientific name	Common name	EPBC Act status	Type
Brigalow – Belah open forest/woodland on alluvial often gilgaeied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	Brigalow woodland	E	Community
Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions	Weeping Myall woodland	E	Community
Anthochaera phrygia	Regent Honeyeater	CE	Woodland bird
Lathamus discolor	Swift Parrot	CE	Hollow-dependent bird
Polytelis swainsonii	Superb Parrot	V	Hollow-dependent bird
Phascolarctos cinereus	Koala	V	Arboreal mammal
Dasyurus maculatus	Spotted-tail Quoll	E	Terrestrial mammal
Pseudomys pilligaensis	Pilliga Mouse	V	Terrestrial mammal
Nyctophilus corbeni	South-eastern Long-eared Bat	V	Microchiropteran bat
Bertya opponens	Coolabah Bertya	V	Perennial shrub
Lepidium aschersonii	Spiny Peppercress	V	Perennial herb
Lepidium monoplocoides	Winged Peppercress	E	Perennial herb
Androcalva procumbens	*Androcalva procumbens*	V	Perennial shrub
Tylophora linearis	*Tylophora linearis*	E	Perennial herb

Notes:

CE = Critically Endangered, E = Endangered (BC Act/EPBC Act), V = Vulnerable

4.3.2 Key threatened fauna habitat

Nine fauna habitat types occur within the Project area:

- Water bodies (lakes and dams)
- Closed forest
- Riparian woodland
- Shrubby woodland
- Heathy woodland
- Shrub grass woodland
- Grassy woodland
- Heath
- Grassland

4.4 Pest plants and animals

Four Weeds of National Significance (**WoNS**), six State Priority and eight Regional Priority weeds were identified within the Project area, as presented in Table 4.4.

Table 4.6 - Pest plants - WoNS and Priority Weeds recorded in the Project area

Scientific name	Common name	WoNS	State Priority weed	Regional priority weed
Bryophyllum delagoense	Mother-of-Millions	N	Y	Y
Cestrum parqui	Green Cestrum	N	N	Y
Harrisia spp.	Harrisia cactus	N	N	Y
Lycium ferocissimum	African Boxthorn	Y	Y	Y
Olea europaea subsp. *cuspidata*	African Olive	N	N	Y
Opuntia aurantiaca	Tiger Pear	Y	Y	Y
Opuntia stricta	Prickly Pear, Common Pest Pear	Y	Y	Y
Opuntia tomentosa	Prickly Pear, Velvet Tree Pear	Y	Y	Y
Parthenium sp.	Parthenium	Y	Y	N
Ricinus communis	Castor Oil Plant	N	N	Key emerging weed
Solanum sp.		Y	Y	Y

Notes:

Listed in State of NSW 2019. North West

Recent reports within and near the project area for *Parthenium* sp and *Harrisia* spp. Cactus have been included, but have not been recorded in the Australian Virtual Herbarium (AVH, 2021) or the BioNet Atlas (DPIE 2021) at the time of writing.

Five birds and 12 mammals listed as feral species were recorded in the Project area, as presented in Table 4.5.

Table 4.7 - Pest animals recorded in the Project area

Scientific name	Common name
Canis lupus familiaris	Wild Dog
Felis catus	Cat
Vulpes vulpes	Red Fox
Bos taurus	Cow
Capra hircus	Goat
Equus sp.	Horse
Lepus capensis	Hare
Sus scrofa	Pig
Oryctolagus cuniculus	Rabbit
Ovis arues	Sheep
Mus musculus	Mouse
Rattus rattus	Rat
Streptopelia chinensis	Spotted Turtle-dove
Sturnus tristis	Common Myna
Sturnus vulgaris	Starling
Passer domesticus	House Sparrow
Turdus merula	Eurasian Blackbird

5. Project impacts

5.1 Direct impacts

5.1.1 Project overview

Construction and operation of the Project would result in the removal of up to 988.8 ha of native vegetation. The EIS determined that the indirect impacts of the Project will be equivalent to the removal of an additional 181.1 ha of native vegetation. When combined, this equates to a total impact of approximately 1,169.9 ha of vegetation or the removal of approximately 1.5% of native vegetation from the Project area. Upper disturbance limits of the Project are provided in Table 5.1. About half of the vegetation removed during construction of the Project will be immediately rehabilitated post construction. This stage of rehabilitation occurs prior to decommissioning and rehabilitation of the operational areas. The rehabilitation will occur across approximately half of the construction area, leaving access roads, maintenance areas, infrastructure footprints and any other areas required to be clear within lease areas and along infrastructure routes for operational management. See the Project Rehabilitation Management Plan for further details.

5.1.2 Phase 1

Preliminary Phase 1 impacts were calculated by intersecting the Project footprint with the approved Project EIS vegetation mapping where clearing of native vegetation is required. Final Phase 1 impacts will be calculated following completion of micro-siting processes including cultural heritage clearance in accordance with the approved Aboriginal Cultural Heritage Management Plan. The final Phase 1 impact area will be approved as part of the first Field Development Plan.

Based on preliminary impact calculations, the largest area of impact will occur in Narrow-leaved Ironbark - White Cypress Pine-Buloke tall open forest (Table 5.1). Approximately 0.5 ha of Fuzzy Box Woodland on alluvial soils of the south western slopes, Darling Riverine Plains and Brigalow Belt South bioregions EEC along Bohena Creek Road may be impacted during the Phase 1 development. Impacts to threatened species for Phase 1 have been calculated using modelling and impact area predictions from the Project EIS (Table 5.2 and Table 5.3). Following the transition from the Framework for Biodiversity Assessment to the Biodiversity Offset Scheme, an application for reasonable equivalence was made for the credit liability of the project, which is detailed in the BOS. In the transition the Black-striped Wallaby were moved from 'species credits' to 'ecosystem credits' species and the credit liability was therefore reduced to zero as 'species credits' can no longer be generated for the species. The Regent Honeyeater remained a dual credit species, i.e. both 'species credit' and 'ecosystem credit', species however only impacts to mapped important habitat areas incur a 'species credit' liability. No mapped important habitat areas occur within the project area. Accordingly, the credit liability for this species was also reduced to zero. Offsetting of impacts to these species mapped habitat consistent with the Project EIS is not reported further as the corresponding habitat for these species in the region will be protected through the retirement of ecosystem credits for associated PCTs.

Note, indirect and cumulative impacts to threatened fauna habitat have been calculated as proportions of direct impacts to remnant native vegetation. Conversely, indirect impacts to PCTs and threatened flora have been calculated as a proportion of the upper limit of the modelled impacts to PCTs. Impact calculations for offsetting purposes of indirect and also cumulative impacts will be addressed in the Phase 2 development plan in accordance with SSD 6456 conditions of consent.

Table 5.1 - Phase 1 direct impacts to native vegetation

Plant Community Type	Condition	BVT ID (Oct 2008)	BVT ID (Oct 2014)	Phase 1 direct impacts (ha)
141 - Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	Native Vegetation	NA121	NA121	0.60
404 - Red Ironbark - White Bloodwood -/+ Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Native Vegetation	NA124	NA326	1.20
405 - White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	Native Vegetation	NA124	NA390	0.97
408 - Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region	Native Vegetation	NA124	NA279	3.52
40X - White Bloodwood – Dirty Gum – Rough Barked Apple heathy open woodland on deep sand in the Pilliga forests	Native Vegetation	NA124	NA390	3.55
202 - Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South-western Slopes Bioregion	Native Vegetation	NA141	NA141	0.47
88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Native Vegetation	NA179	NA179	0.05
399 - Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion	Native Vegetation	NA197	NA255	0.03
401 - Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region	Native Vegetation	NA197	NA338	1.98
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 BBS Bioregion	Native Vegetation	NA227	NA314	12.32
			Total	**24.69**

Table 5.2 - Phase 1 estimated direct impacts to flora species using modelling from the EIS

Scientific name	Phase 1 direct impacts (individuals)
Bertya opponens (Coolabah Bertya)	0
Diuris tricolor (Painted Diuris)	2
Lepidium aschersonii (Spiny Peppercress)	0
Lepidium monoplocoides (Winged Peppercress)	0
Polygala linariifolia (Native Milkwort)	6
Pomaderris queenslandica (Scant Pomaderris)	0

Scientific name	Phase 1 direct impacts (individuals)
Pterostylis cobarensis (Cobar Greenhood Orchid)	178
Commersonia procumbens (*Commersonia procumbens*)	86
Tylophora linearis (*Tylophora linearis*)	14

Table 5.3 - Phase 1 estimated impacts to fauna species habitat

Scientific name	Phase 1 direct impacts (area)
Eastern Pygmy-possum (*Cercartetus nanus*)	23.5
Pale-headed Snake (*Hoplocephalus bitorquatus*)	24.1
Squirrel Glider (*Petaurus norfolcensis*)	24.1
Koala (*Phascolarctos cinereus*)	24.7

5.2 Indirect impacts

Phase 1 is anticipated to have minimal indirect impacts due to the scale of the clearing (i.e. less than 30 ha of native vegetation) related to the Project footprint and the extensive use of existing roads and tracks. Indirect impacts on flora and fauna during construction and operation of the Project would occur at varying magnitudes and include:

- *Fragmentation* – the Phase 1 development will result in minimal increases to fragmentation within the project area. Three of the proposed well pads occur on cleared grazing land and the remaining eight occur in existing vegetation. The vast majority of the linear infrastructure is collocated with existing tracks and trails to minimise increasing fragmentation. Phase 1 will have minimal effects on creating barriers to movement and dispersal, which can result in genetic isolation of populations. Minor increases in edge effects will occur along the new access track to well pads NA-6745-06 and NA6745-07.
- *Noise* – Construction and operation of Phase 1 will cause small localised increases in noise levels in the project area. The vast majority of impacted areas within the Phase 1 footprint will only experience temporary increases in noise during construction, i.e. flowlines and coreholes. Long-term noise impacts will occur at production well pads. These increased noise levels can impact fauna species. Some fauna species would likely tolerate an increase in noise, while others may not, causing them to leave the affected area or making the area less desirable for foraging, nesting and breeding. Noise impacts will be minimised through the Noise Management Plan and monitored through the soundscape analysis as part of the Plan monitoring program.
- *Traffic* – Minor increased traffic will occur primarily along X-line road, an existing and substantial public road, in the project area during construction and operation. The additional traffic could result in a minor increase in the indirect impacts to flora, via raised dust levels, and fauna, through potential for vehicle strike and habitat degradation through increased edge effects and disturbance levels (light, noise and dust).
- *Fencing* – Phase 1 includes 11 well pad areas that will require permanent fencing during operation. Fencing (temporary and permanent) installed around well pads and other infrastructure during construction and operation of the Project could present a hazard to fauna through entanglement. Some fauna are known to be impacted by fencing entanglement, especially nocturnal species such as bats, gliders and owls and also macropods. Linear

infrastructure construction will account for most of the temporary fencing requirements with fencing associated with this activity relatively minor in extent. ‘Fauna friendly’ exclusion fencing (i.e., without barbed wire) will be installed to minimise any tangling impacts (unless determined otherwise under a land access agreement).

- *Light* – Construction of Phase 1 of the Project will result in a minimal increase in light in the project area both due to artificial light sources and by vegetation clearance opening up gaps in intact canopy cover. Installation of artificial lighting will follow the relevant guidelines and standards to minimise light spill. Lighting increases will be restricted to the new linear infrastructure routes connecting well pads to collocated linear infrastructure and well pads (artificial lighting at all well pads and canopy gaps will be created at eight of the eleven well pads). Impacts of artificial light from vehicles and machinery on nocturnal fauna, potentially disrupting movement and behaviour, will be limited to the construction phase. Increased sunlight reaching through the canopy would have the most impact on flora species and could change the species composition to favour species that are more tolerant of increased light conditions.
- *Weed invasion* – The increased risk of weed invasion and spread throughout the project area will be managed through implementation of the Pest Plant and Animal Control Protocol (Attachment 3). Dispersal of weed propagules into areas of native vegetation could occur through vegetation clearing, erosion and from the movement of workers and vehicles. An increase in weeds may impact the composition of vegetation communities and habitat for flora and fauna species in the project area. The majority of threatened flora species recorded in the project area are threatened by habitat degradation through weed invasion.
- *Feral fauna* – Phase 1 of the Project will have a minimal effect on facilitating easier feral fauna access throughout the project area as there are relatively few new tracks being created for linear infrastructure. Phase 1 only includes 11 well pads, three of which occur on cleared agricultural land and seven of the well pads will be located relatively close together in a largely cleared location, further reducing the area of facilitated access. The indirect impacts would be minor but effect all fauna species to a degree, particularly ground foraging species that are favoured as prey by foxes, dogs and cats. Feral fauna would also introduce added competition stress on native species. For example, there is potential for increased competition for habitat and foraging resources between *Pseudomys pilligaensis* (Pilliga Mouse) and *Mus musculus* (House Mouse). Feral fauna will be managed through the implementation of the Pest Plant and Animal Control Protocol.
- *Fire* – The risk of fire during construction and operation of the Project will be managed using a hot works procedure and specialised training to minimise the risk of accidental fires. Evidence to date suggests that Santos’ presence in the Project area has contributed to increased rapid identification of naturally occurring fires (through lightning strikes) and subsequent control. Changes to natural fire regimes can adversely affect vegetation community composition and structure. Furthermore, bushfire risks are considered minimal as risk will be mitigated through design measures, for example burying of infield infrastructure. Risks related to bushfire will be managed through the Project Bushfire Management Plan.
- *Dust, erosion and sedimentation* – Indirect impacts from dust, erosion and sedimentation during construction of the Project will be managed through implementation of the Erosion and Sediment Control Plan and the Dust Suppression Protocol. The risk from these indirect impacts are created through vegetation removal, excavations and vehicular traffic (as described above). The accumulation of dust can impact on the habitat and growth of flora species and communities. Dust created during construction will be short-term and removed by wind and rain and is not expected to have a prolonged effect on plant physiology.

- *Hydrological change* – Modification to the surface layout in the project area could impact the hydrology of the project area through altering water flow and filtration. There are no anticipated impacts on the aquatic environment for Phase 1.
- *Accidental leaks and spills* – Accidental leaks and spills during construction of the Project could impact vegetation and fauna species if ingested. Controls implemented through the Pollution Incident Response Management Plan will ensure any spills are mitigated and where required appropriately managed.
- *Hunting and collecting* – Increased indirect impacts from hunting and collecting are expected to be minimal for Phase 1, given the impacts are largely limited to collocated linear infrastructure and well pads along existing roads or fenced private property. Operation of Phase 1 is unlikely to affect permeability of the project area, but may increase public knowledge of the project area to hunters and illegal collectors. These impacts are expected to be further reduced by the presence of staff and contractors within the Project area as a disincentive to access areas of the Pilliga for illegal hunting and collecting activities. Observations of illegal hunting or collecting of flora or fauna materials should be recorded and appropriate personnel should be notified.

The indirect impact on fauna habitat equates to less than 0.3 % of additional impact on foraging or breeding habitat for the threatened fauna species assessed in the EIS.

5.3 Fauna habitat removal

The removal of native vegetation in the Project area would result in the removal of known or potential fauna foraging, breeding, roosting, sheltering and dispersal habitat. Less than 2 % of habitat will be directly impacted for all threatened and migratory fauna species in the Project area.

The precise location of infrastructure will be determined through the ecological scouting framework (micro-siting). Micro-siting is expected to result in an impact reduction from 146 hollow-bearing trees to 120 hollow-bearing trees during construction of Phase 1 of the Project. The estimated impact to hollow-bearing trees based on the Project EIS modelling indicated the number of hollow-bearing trees would be approximately 300 hollow trees, indicating micro-siting could reduce the impact to important habitat features. This estimate was based on hollow size class data collected during the field surveys averaged out across each PCT and does not take into account the ecological scouting framework (micro-siting) implemented under the Field Development Protocol prior to construction to maximise avoidance of significant hollow-bearing trees. Previous assessments have shown that between 20% and 80% reduction in clearing of significant hollow bearing trees can be achieved by implementing the ecological scouting framework (micro-siting) to site infrastructure.

6. Biodiversity management measures

6.1 BMP interaction with other management plans

A number of plans may interact with the implementation of the BMP. Where any actions or requirements of another management plan may impact upon biodiversity matters and are within the bounds of impacts assessed under the EIS, then the Avoid, Minimise and Mitigate principles must be implemented and documented.

The Biodiversity Management Plan and the Rehabilitation Management Plan have integrated measures due to the biodiversity credit requirements identified in Table 10 [of the CoC]. When Santos meets the ecological rehabilitation completion criteria in the RMP to the satisfaction of the BCS, this can be used to offset relevant ecosystem and/or species credit liability for Residual Credits.

Other relevant plans include but are not limited to the following:

- Field Development Protocol;
- Aboriginal Cultural Heritage Management Plan;
- Water Management Plan and subplans; and
- Bushfire Management Plan

A description of interaction between the BMP and other management plans is provided in section 1.7.

6.2 Avoiding and minimising impacts to biodiversity values

The project (and BMP) has been designed to follow the avoid, minimise, mitigate (e.g. rehabilitation) and offset hierarchy, where residual impacts of the Project are offset as a last resort. A summary of the Projects' avoidance and mitigation measures are detailed below. Project offsets are detailed in the BOS (Attachment 1).

Santos will implement a number of avoidance and mitigation measures to be included in the design of the Project to minimise potential impacts on terrestrial flora and fauna. These include:

- minimising surface disturbance using a stacked lateral well design and multiple wells on a well pad;
- maximising the use of previously cleared areas for seismic survey;
- centralising much of the major fixed facilities at the Leewood site outside of the Pilliga forest to minimise vegetation clearing;
- co-locating linear infrastructure such as gas and water gathering systems and access tracks with existing roads, access tracks and disturbance corridors, and placing major facilities in previously cleared areas, where practicable. Further micro-alignment may be undertaken to minimise impacts on known ecological constraints such as threatened species and hollow-bearing trees, if practicable.
- implementing the Field Development Protocol for siting project infrastructure. The Protocol ensures that the planning, design and construction phases of the field infrastructure are undertaken in accordance with approval conditions including the locational criteria under consent condition B1. The following locational criteria are relevant to biodiversity:
    - No surface infrastructure within 200 metres of Yarrie Lake property boundary
    - No surface infrastructure within 50 metres of Brigalow State Conservation Area

  - No sub-surface infrastructure below Brigalow State Conservation Area, from the ground surface to a depth of at least 110 metres
  - No surface infrastructure within 50 metres of Brigalow Nature Reserve
  - No disturbance of more than 988.8 hectares of native vegetation (including derived native grassland)
  - No disturbance beyond the limits by vegetation type as identified in Table 8
  - No disturbance beyond the limits by threatened flora species type as identified in Table 9
  - No disturbance beyond the limits by threatened fauna species type as identified in Table 10 of SSD6456.
- preparing and implementing an ecological scouting framework (Appendix C), to identify the most suitable areas for proposed field infrastructure to be positioned within a given location in order to maximise avoidance of sensitive biodiversity values;
- maximisation of salvage, transplanting and/or propagation of any threatened flora found during pre-clearance surveys, in accordance with the Translocation Guidelines, where reasonable and feasible;
- a clearing procedure to further reduce the Project's impact on flora and fauna, including threatened and migratory species, populations and ecological communities;
- progressive partial rehabilitation of cleared area;
- maximisation of salvage of resources including tree hollows, vegetation and soil resources for beneficial re-use where reasonable and feasible; and
- implementation of a Pest Plant and Animal Control Protocol (Attachment 3).

6.2.1 Field Development Protocol including ecological scouting framework (micro-siting)

Santos will implement the Field Development Protocol throughout the planning, design and construction phases of the field infrastructure in accordance with approval conditions, to direct development away from sensitive ecological and cultural features. This addresses the avoidance and minimisation of direct and indirect impacts by implementing the following steps:

- Step 1: Conceptual design -Define the next stage of development relative to exclusion areas, including the conservation areas and biodiversity upper disturbance limits identified in Table 1 (Locational Criteria), condition B1 of the consent.
- Step 2: Desktop review – Refine desktop locations using ecological sensitivity mapping and other mapped constraints to minimise impacts on higher ecological sensitivity classes.
- Step 3 – Review cumulative disturbance against probabilistic estimates of disturbance (upper disturbance limits).
- Step 4: In-field micro-siting. Undertake field scouting following the procedures described in Step 4 of the Field Development Protocol
  a. Define proposed layout of infrastructure within development area.
  b. Ecological site scouting of defined area and buffer areas (approximately 50 m beyond boundary of one-hectare well pad sites and six metres either side of 12 metre linear infrastructure easements).
  c. Recommend refined infrastructure locations and alignments to maximise avoidance based on ecological data collected.

d. Constructability scouting of recommended infrastructure locations and alignments to confirm preferred locations/alignments.
e. Cultural heritage pre-clearance survey of preferred locations/alignments in accordance with the Aboriginal Cultural Heritage Management Plan. If Aboriginal cultural heritage sites are encountered in the recommended area then the survey area will extend to the original defined area (Step 4a) plus buffer in the vicinity of the find. The procedures outlined in the ACHMP will be implemented, including the avoidance commitments by Aboriginal site type. Where a re-positioning of infrastructure to avoid Aboriginal cultural heritage features can be conducted without causing additional impact to ecological features and attributes, the alignment will be modified immediately. Otherwise, an iterative approach will be followed to ensure overall ecological impact is minimised when complying with avoidance commitments by Aboriginal site type.

- Step 5: Survey and mark-out final infrastructure locations and alignments.
- Step 6: Finalise detailed design and management practices.,
- Step 7: Final check of design against locational criteria, regulatory conditions and management plans.
- Step 8: Prepare and submit Field Development Plan. The Field Development Plan will include field survey results and quantify impacts of that stage of development.

6.2.1.1 Unexpected finds

In the event a previously undetected threatened ecological community or species is identified within the micro-siting footprint, every effort will be made to avoid the entities. Micro-siting activities allow for flexibility in project design, through exploration of alternative route or placement options to provide opportunities for avoidance of impact to threatened species. In cases where this is not possible, a modification to the Project approval may be required. This does not apply to species listed after the date of approval.

6.2.1.2 Entities listed after the approval date

Micrositing surveys will target all threatened entities regardless of listing date. While no obligation exists to avoid entities listed after the approval date, all reasonable and feasible efforts will be made to avoid or minimise the impacts to these entities. In cases where a prioritisation conflict arises between an entity with an upper disturbance limit under SSD 6456 and an entity listed after the approval priority will be given to the entity with the higher listing status, i.e. Critically endangered > Endangered > Vulnerable, except where doing so will result in exceedance of the approved upper disturbance limits over the lifetime of the project. In cases where the listing status is the same priority will be given to the entity listed in SSD 6456. Exceptions to this guidance may occur on a case-by-case basis and will be justified in the relevant Field Development Plan.

6.2.2 Pre-clearance and clearing procedure

Santos will implement a pre-clearing procedure to minimise impacts or risk to fauna during vegetation removal. The purpose of the procedure is to identify and demarcate fauna and fauna habitat occurrence in the proposed clearing area, encourage fauna to relocate prior to habitat clearing and safely relocate fauna during clearing activities. The pre-clearance and clearing procedure provides guidance on the methods and steps to be taken to achieve the minimisation, such as demarcation of the clearing areas, describing the types of significant fauna habitat features to be flagged and the process for allowing resident fauna to naturally vacate the area wherever reasonable and feasible. For non-relocatable fauna detected in the clearing area works may be rescheduled to allow time for the individuals to self-relocate where reasonable and feasible.

Operations will be supervised by an appropriately qualified ecologist or fauna spotter-catcher. A detailed clearing procedure is provided in Appendix D. A summary of the key steps to be followed from this procedure are:

- planning, demarcation of approved disturbance area and environmental protection exclusion zones, habitat mark-up and walk-through;
- translocation, propagation and/or salvage of threatened flora;
- slash shrub and ground layer (under scrubbing);
- tap or agitate hollow-bearing trees the day prior to felling and leave overnight;
- remove hollow-bearing trees;
- salvage of tree hollows; and
- positive communication is maintained throughout the clearing process.

Lessons learnt from previous tree-felling operations have highlighted a number of potential risks that highlight the imperativeness of following the procedure accurately, including:

- positive communication is required to minimise the risk to personnel entering the exclusion zone and prevent fauna injury during the clearing process;
- adequate time between slashing vegetation, hollow-bearing tree tapping and hollow-bearing tree removal can reduce the occurrence of fauna during felling operation; and
- allowing adequate time for felled hollow-bearing trees to remain undisturbed is required and can reduce the risk to fauna.

To minimise impacts upon native fauna during sensitive periods, limits to the total amount of native vegetation cleared during key breeding seasons will be adhered to. The native vegetation clearing limits during key breeding seasons are as follows:

- less than 50 per cent (494 ha) of total vegetation disturbance (988.8 ha) will occur outside the most preferred period from March to June; and
- less than 20 per cent (197 ha) of total vegetation disturbance (988.8 ha) will occur during the least preferred period from September to January

A reporting template to monitor and track cumulative vegetation removal is presented in Appendix D. It may be used during the design of a site-specific development plan to assess the potential effect it will have on the clearing limits for the Project overall. Following finalisation of a design the version can be updated and stored for use in subsequent plans.

6.3 General mitigation measures

General mitigation measures to be implemented by Santos, have been provided in Table 6.1, outlining the impact, the mitigation measure in place, the timing of the measure and what entity may be impacted.

Table 6.1 - Mitigation measures by impact

Impact	Mitigation measure	Phase	Timing	Threatened entity
General ecology management				
General ecology management	A Biodiversity Management Plan (this plan) has been developed and includes management measures to minimise impacts to flora and fauna.	Pre-construction	Long-term	All flora and fauna
Direct impacts				
Vegetation removal, habitat removal, removal of threatened flora individuals	The pre-clearing procedure will identify key fauna habitat features (such as nests, hollow-bearing trees, and hollow logs) that will be removed using the slow drop technique.	Pre-construction	Short-term	Woodland birds, hollow-dependent birds, raptors, migratory birds, arboreal mammals, microchiropteran bats, reptiles
	Vegetation will be cleared in accordance with the clearing procedure to minimise impacts to fauna during vegetation removal. A suitably qualified ecologist or fauna handler will be present during clearing events.	Pre-construction, and construction	Short-term	All fauna
	The removal of large hollows ≥300 mm in diameter will be compensated for by a 1:1 replacement. Hollow salvage and nest box installation details will be confirmed in the Field Development Plan.	Construction	Short-term	Woodland birds, hollow-dependent birds, arboreal mammals
	Step three of the Field Development Protocol tracks vegetation clearance and threatened flora removal in each phase and ensures it is within the approved overall limits.	Pre-construction and construction	Long-term	All flora
	Open trenches will be inspected once daily by a suitably qualified fauna handler. Data should be collected on the species, number of individuals captured and capture locations.	Construction	Medium-term	Reptiles and mammals
	Vegetation clearing will be managed to minimise clearing during sensitive breeding periods for fauna. A hierarchical timing for clearing from most to least preferred is: March to June; February and July/August; and September to January.	Construction	Long-term	All fauna
	Rehabilitation of impacted areas would occur as soon as practicable in accordance with the Rehabilitation Management Plan (RMP). A seed bank and seed collection procedure have been developed for the Project and is provided as Appendix F.	Construction and decommissioning	Long-term	All flora and fauna
	The clearing procedure in Appendix D is designed to ensure clearing disturbance is contained within the development footprint. Furthermore, partial rehabilitation will reduce erosion and soil transportation.	Construction and post-construction	Long-term	All flora and fauna
	During Phase 1 of the Project, seed collection will be carried out within the project area in accordance with Appendix F, and stored or propagated for later rehabilitation.	Prior to Phase 2	Short-term	All flora
	Translocation of threatened flora species will be conducted where reasonable and feasible on a case by case basis in accordance with the *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee et al., 2004). Individuals and areas that will be subject to translocation plans will be identified during the implementation of the Field Development Protocol for inclusion in the relevant Field Development Plan in consultation with the required stakeholders.	Pre-construction and construction	Short-term	Perennial shrubs and herbs
Damage to native vegetation, damage to rehabilitation areas	Environmental protection exclusion zones will be established at the boundaries of native vegetation to be protected, revegetation areas and clearing boundaries to restrict access to vegetated or revegetated areas to be protected. Exclusion zones will be fenced with clearly visible flagging tape (or equivalent) with appropriate signage. Exclusion zone flagging will be installed prior to vegetation clearing activities and remain in place throughout construction.	Pre-construction, construction and decommissioning	Long-term	All flora
Degradation and/or loss of topsoil during clearing and construction	Topsoil will be managed in accordance with the Rehabilitation Management Plan – Appendix C Topsoil management and rehabilitation.	Construction	Medium-term	Topsoil
Indirect site impacts				
General indirect impacts	The monitoring program (section 8) has been designed to monitor indirect impacts of the project, including noise, and provides an adaptive management framework to address indirect impacts where required.	Pre-construction, construction and operation	Long-term	All flora and fauna
Fragmentation	Infrastructure will be co-located with existing roads wherever practicable. Production well pads located no closer than 750 m to each other. Refer also to above mitigation measures for vegetation removal.	Construction	Short-term	All flora and fauna

Impact	Mitigation measure	Phase	Timing	Threatened entity
Noise	Noise mitigation design and engineering measures will be implemented as specified in the Noise Management Plan and the Field Development Protocol.	Design, construction and operation	Long-term	All fauna
Traffic	The speed limit of 60 km/h within State Forests will be enforced. This speed limit will be reduced to 40 km/h in construction areas (i.e. lease areas and service corridors constructed for the activity). Otherwise, the posted speed limit will apply.	Construction, operation and rehabilitation	Long-term	All fauna
	Driving during high fauna activity periods (that is, from dusk through to dawn) will be minimised.	Construction, operation and rehabilitation	Long-term	All fauna
Fencing	‘Fauna friendly’ exclusion fencing (without barbed wire) will be installed around well sites during operation unless determined otherwise under a land access agreement.	Construction	Short-term	Terrestrial and arboreal
Light	Lighting will be focused on work sites during construction and on project infrastructure during operation to minimise light spill into adjoining areas.	Construction and operation	Long-term	All fauna
	Lighting will be designed to meet Australian Standard AS 4282-2019 *Control of the obtrusive effects of outdoor lighting* and the Australian / New Zealand Standard AS/NZS 1158:2010 *Lighting for roads and public spaces for roadways and plant*, as applicable. The design and operation of night lighting would also consider the good lighting design principles documented in *Dark Sky Planning Guideline: Protecting the observing conditions at Siding Spring* (NSW Department of Planning and Environment 2016)	Construction and operation	Short-term	All fauna
	Wherever possible only undertake construction during daylight hours to avoid impacts from light spill where this may be detrimental to species habitat on adjoining lands.	Construction	Medium-term	All fauna
Weed invasion	Prior to earthworks, weeds listed as Priority Weeds under the NSW Biosecurity Act 2015 that are present on the site will be removed or treated with herbicide to prevent or reduce their spread.	Construction	Short-term	Flora
	Weeds will be controlled in accordance with the Pest Plant and Animal Control Protocol.	Construction, operation and rehabilitation	Long-term	Flora
Increased feral fauna	Feral animals will be controlled in accordance with the Pest Plant and Animal Control Protocol.	Construction, operation and rehabilitation	Long-term	All flora and fauna
	No domestic pets (including cats or dogs) will be allowed within the development site.	Construction, operation and rehabilitation	Long-term	All fauna
Fire	Smoking should be restricted in the development site to decrease risk of a fire.	Construction, operation and rehabilitation	Long-term	All flora and fauna
	A bushfire hazard and risk assessment will be developed and implemented.	Construction, operation and rehabilitation	Long-term	All flora and fauna
	Fire risks and hazards will be managed in accordance with the Fire Management Plan	Construction, operation and rehabilitation	Long-term	All flora and fauna
Indirect downstream or downwind impacts				
Sedimentation, erosion and dust	Sedimentation, erosion and dust control will be managed in accordance with the Project Erosion and Sediment Control Plan and the Dust Suppression Protocol.	Construction, operation and rehabilitation	Long-term	All flora and fauna
Hydrological change	Addressed in infrastructure placement and design (section 6.2). Riparian corridors (a stream plus a buffer), have been mapped for the Project. Only linear infrastructure will intersect with riparian corridors.	Design	Short-term	All fauna
	A water management plan will be developed and implemented, to address issues associated with hydrological changes and water quality impacts for both surface and groundwater.	Construction and operation	Long-term	All flora and fauna

Impact	Mitigation measure	Phase	Timing	Threatened entity
Accidental spills and leaks	All liquids (fuel, oil, cleaning agents, drilling liquids etc.) will be stored appropriately and disposed of at suitably licensed facilities.	Construction, operation and rehabilitation	Long-term	All flora and fauna
	Spill management procedures will be implemented as required.	Construction, operation and rehabilitation	Long-term	All flora and fauna
	A chemical management procedure will be developed to control and manage chemical use on site. This would ensure that no chemicals would enter aquatic environments through runoff or direct application.	Construction and operation	Long-term	All flora and fauna
Indirect facilitated impacts				
Hunting	Observations of illegal hunting or collecting of flora or fauna materials should be recorded and appropriate personnel should be notified.	Construction, operation and rehabilitation	Long-term	All fauna

6.4 Pest Plant and Animal Control Protocol summary

6.4.1 Pest management hierarchy

The Pest Plant and Animal Control Protocol has been developed in consideration of the Santos Pest Management Hierarchy, reproduced within the protocol. The top of the hierarchy is the prevention of pests, which is the most effective and efficient means of managing pest plants and animals where they are not yet present. To prevent new incursions of pest plants and animals, the Project will implement the Santos Hygiene protocol and education through a project specific ecological induction for all Santos staff and contractors.

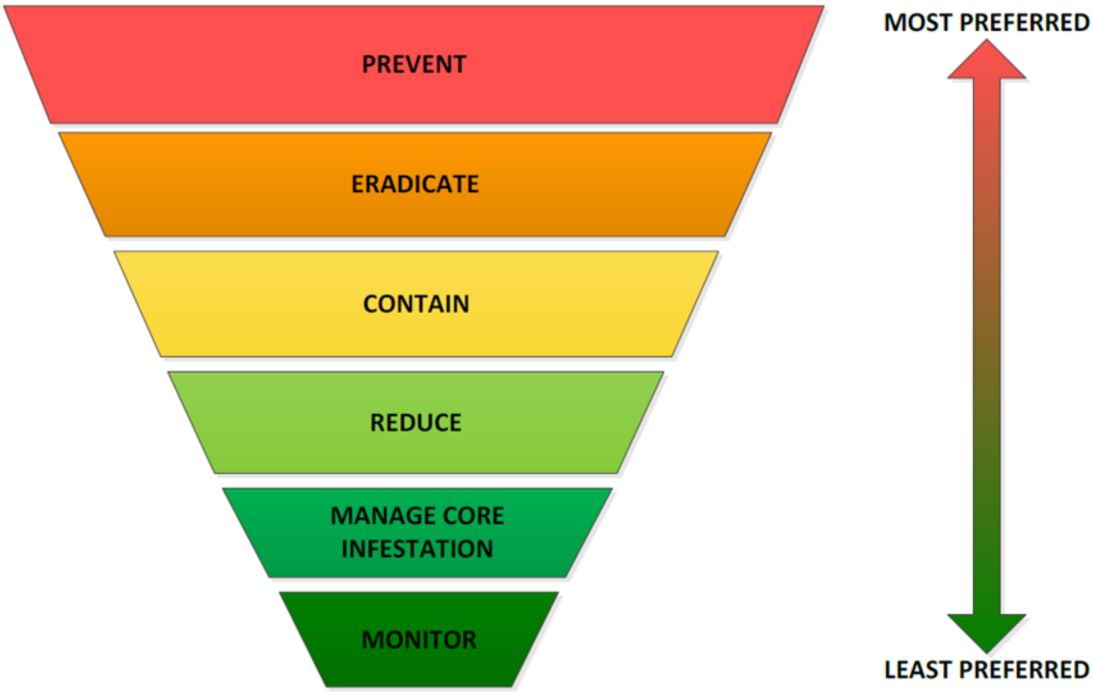


Figure 6.1 - Santos Pest Management Hierarchy

Following prevention, the Pest Plant and Animal Control Protocol identifies six management streams for dealing with pest species. The eradicate, contain spread, reduce occurrence and manage core infestation streams all require specific controls for the individual pest species. The monitor and limited action streams facilitate a prioritised and flexible approach to controlling pest plants during the Project.

6.4.2 Pest plant control methods

Pest plant control, beyond the Field Development Protocol and the Rehabilitation Management Plan, will focus upon operational areas that are impacted or regularly utilised by the Project. These areas will also include the mapped indirect impact areas and existing high traffic areas. Undeveloped areas with low exposure, i.e. do not occur along regular access routes or are outside of the development footprint and indirect impact buffer (approximately 50 m beyond boundary of one-hectare well pad sites and six metres either side of 12 metre linear infrastructure easements), to Narrabri Gas Project activities or facilitated access will not be subject to the plan.

Following the failure of the prevention and identification of pest plants through the Field Development Protocol, ecological scouting framework and hygiene protocol, 'elimination' and 'minimisation' strategies will be implemented.

Elimination (or eradication) will be managed on a site-by-site basis within the development footprint and will use best practice control methods for each species. If the elimination of the pest plant is unachievable or not practical, minimisation (contain spread, reduce occurrence and manage core infestation) will occur based on the risk assessment performed for each pest plant species.

6.4.3 Pest animal management approach

The program will utilise an integrated multi-species approach to feral animal control for two reasons:

- Targeting multiple feral species at the same time will provide substantial long-term cost savings.
- It is essential to minimise the potential for unintended trophic cascades.

The top-down predator effects and trophic relationships existing between the major feral animals present within Australian ecosystems is a key management consideration for this control program. For example, targeting foxes without also implementing control of feral cats has the potential to lead to an increase in cat numbers, as they are released from predation by foxes. Equally, controlling feral grazing animals without also controlling feral predators could lead to prey switching by feral predators to native animals.

Pest animal management will be conducted on the basis of detection and will be restricted to the development footprint and indirect impact buffers, on the basis that sightings or evidence of pest animal activity in the development footprint may have been facilitated by the increased accessibility created by the development. Feral animal management will also be driven by the impact of the species, i.e. predation of native species or herbivory and/or destruction of restoration areas. Specific control actions suitable for the species that are likely to be detected are provided in the Pest Plant and Animal Control Protocol.

6.4.4 Threatened flora and fauna

BC Act and EPBC Act listed flora and fauna species relevant to the project that are recognised as being under threat of pest plants and animals are listed below in Table 6.2. The pest plant and animal management methods and approach outlined above aim to minimise negative impacts to these species due to pest plants and animals.

Table 6.2 - Threatened flora and fauna at risk of pest species impacts

Type	Scientific name	Common name	Conservation status[a]	
			BC Act	EPBC Act
Flora	*Androcalva procumbens*	-	V	V
	Bertya opponens	Coolabah Bertya	V	V
	Diuris tricolor	Pine Donkey Orchid	V	-
	Lepidium aschersonii	Spiny Peppercress	V	V
	Lepidium monoplocoides	Winged Peppercress	V	V

Type	Scientific name	Common name	Conservation status[a]	
			BC Act	EPBC Act
	Myriophyllum implicatum	-	CE	-
	Polygala linariifolia	Native Milkwort	E	-
	Pomaderris queenslandica	Scant Pomaderris	E	-
	Pterostylis cobarensis	Greenhood Orchid	V	-
	Tylophora linearis	-	V	E
Birds	*Anthochaera phrygia*	Regent Honeyeater	CE	CE
	Ardea modesta	Great Egret, White Egret	-	Mar
	Ardea ibis	Cattle Egret	-	Mar
	Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	-
	Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-
	Chthonicola sagittata	Speckled Warbler	V	-
	Daphoenositta chrysoptera	Varied Sittella	V	-
	Glossopsitta pusilla	Little Lorikeet	V	-
	Grantiella picta	Painted Honeyeater	V	V
	Lathamus discolor	Swift Parrot	E	CE
	Merops ornatus	Rainbow Bee-eater	-	Mar
	Neophema pulchella	Turquoise Parrot	V	-
	Plegadis falcinellus	Glossy Ibis	-	M, Mar
	Polytelis swainsonii	Superb Parrot	V	V
	Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-
	Stagonopleura guttata	Diamond Firetail	V	-
	Ninox connivens	Barking Owl	V	-
Mammals	*Cercartetus nanus*	Eastern Pygmy-possum	V	-
	Dasyurus maculatus	Spotted-tail Quoll	V	E
	Petaurus norfolcensis	Squirrel Glider	V	-
	Phascolarctos cinereus	Koala	V	E
	Macropus dorsalis	Black-striped Wallaby	E	-
	Pseudomys pilligaensis	Pilliga Mouse	V	V
Microchiropteran bats	*Chalinolobus picatus*	Little Pied Bat	V	-
	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	-
	Vespadelus troughtoni	Eastern Cave Bat	V	-

Notes:

CE = Critically Endangered, E = Endangered (BC Act/EPBC Act), V = Vulnerable, M = Migratory (EPBC Act) and Mar = Marine (EPBC Act).

6.5 Grazing and agriculture

The majority of the Phase 1 development is located within State Forest where there are no grazing or agricultural activities. The proposed new pilot and one new core hole are located on private freehold land used for grazing. Santos' activities on these properties will be managed through a Land Access Agreement with the landholders. In addition, Property Management Plans, prepared as part of the Field Development Plan in accordance with condition B4(h)(ii) will be developed in consultation with landholders to ensure that coexistence of activities is managed effectively. This will ensure the Project is able to meet its responsibilities and facilitate continued and future planned land uses at the individual property level in consultation with landholders. The project area does not contain mapped biophysical strategic agricultural land.

Santos proposes to irrigate treated amended produced water on its Leewood property during Phase 1 of the Project. The Irrigation Management Plan identifies measures to minimise impacts on biodiversity from the irrigation activities. These include specific water quality criteria for produced amended water to be irrigated, an irrigation schedule and monitoring (soil, shallow groundwater, and vegetation) requirements.

The irrigation system has been designed to protect the Brigalow woodland and Pilliga Box-White Cypress grassy open woodland native vegetation communities located on the northern boundary of the site. A 10 m buffer has been implemented between the irrigated land and the native vegetation. Potential for sprinkler mist to affect the native vegetation is minimised by using low-pressure drop nozzles. When necessary, spans or individual nozzles can be shut down in susceptible areas. Regular visual inspections along the boundary of the sprinkler system would be undertaken. The quality of the treated water is such that there would be negligible impact on this vegetation community, and the pivot is managed to avoid spray drift to this area.

6.6 Rehabilitation

All disturbances for the Project will be rehabilitated in accordance with the Rehabilitation Management Plan required under consent condition B83. The Rehabilitation Management Plan identifies rehabilitation objectives and preliminary and final completion criteria for each end land use, including native vegetation communities. The completion criteria for rehabilitation provides targets or values for a variety of performance indicators, for example, the slope, species diversity and groundcover. Indicators provide a defined criterion to measure against in order to demonstrate the progress and success of rehabilitation. The completion criteria have been developed consider site specific risks and final land use objectives for each phase of rehabilitation so that the success can be quantitively tracked throughout the life of the project. Examples of native ecosystem completion criteria include, but are not limited to:

- habitat features such as rocks, logs and small stumps have been recovered during vegetation clearance activities, salvaged and stockpiled and used for final rehabilitation to the greatest extent possible;
- seeds collected from native vegetation have been used in final rehabilitation to the greatest extent possible;
- there are no significant weed infestations and weed presence is no greater in rehabilitated areas than at reference sites; and
- there is representation of a range of species characteristics from each faunal assemblage group (e.g. reptiles, birds, mammals), present in the ecosystem type, based on pre-Project fauna lists and sighted within the three-year period.

For an extensive list of performance indicators and completion criteria, refer to section 9.1 of the Rehabilitation Management Plan.

Rehabilitation will aim to enhance vegetation connectivity and wildlife corridors. For native vegetation communities, completion criteria include species richness and vegetation structure targets to be measured against reference sites indicative of the surrounding vegetation. Where diversity or structural targets are not being met, assisted regeneration, seeding and planting will occur with appropriate canopy, sub-canopy, understory and ground strata species as required.

Rehabilitation areas will incorporate salvaged habitat features such as fallen logs and woody debris.

Topsoil stripped from disturbance areas will be managed in accordance with the Rehabilitation Management Plan Appendix C – Topsoil Management and Rehabilitation for beneficial re-use within rehabilitation areas and Project disturbance areas. There will be no additional land management obligations once the land has met the rehabilitation completion requirements to the satisfaction of the BCD in accordance with consent condition B49 and the site has been surrendered. Burning and harvesting at a minimum will need to be excluded from the active rehabilitation sites to maximise the success of rehabilitation.

6.7 Erosion and sediment control

Erosion and sedimentation impacts arising from vegetation disturbance processes will be controlled via mitigation measures outlined in the Project Erosion and Sediment Control Plan. In general, the following measures will be implemented where erosion and sediment controls (ESCs) are required:

- All ESCs will be designed, installed and maintained in accordance with the guidance series *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom, 2004) and *2E Mines and Quarries* (DECC, 2008);
- ESCs when required, will be implemented at all sites associated with the construction activities, including:
  - access roads and tracks;
  - standard lease pads or similar;
  - RoWs.
- Relevant ESC measures will be implemented for each particular section of works prior to or in conjunction with the commencement of topsoil stripping or earthworks; and
- Additional ESC measures will be implemented as required during construction work.

A comprehensive list of erosion and sediment controls to be implemented during the project are included in the Project Erosion and Sediment Control Plan.

6.8 Bushfire

Several mitigation measures will be implemented to reduce the risk of damage to local biodiversity by bushfire. Mitigation measures include:

- Management of ignition risks via:
  - restriction of smoking within the development site;
  - restriction of machinery usage during periods of high bushfire risk;
  - hot works controlled via Santos Work Permit Procedure;
- Training of personnel in bushfire hazards and risks via the Bushfire Awareness Program;

Bushfire risks and hazards will be managed in accordance with the project Bushfire Management Plan.

7. Koala Research Program

In accordance with CoC B51(g), the BMP includes a Koala Research Program that:

i. Is designed to determine the location and size of remnant koala populations in the Pilliga Forest;
ii. Investigates why suitable areas of koala habitat may not be occupied by Koalas; and
iii. Guides adaptive management of the Koala population in the project area and any land-based offset areas used to retire species credits for the Koala.

A proposal for the Koala research program has been developed in consultation with the stakeholders identified in section 1.4 and is included as Attachment 2. The research proposal is for Phase 1 of the Project only and therefore primarily focuses on determining the location and size of extant koala populations in the Pilliga (consent condition B51(g)(i)). For subsequent phases of the Project, the results of initial investigations will be used to determine reasons that suitable areas of habitat may not be occupied (condition B51(g)(ii)) and adaptive management measures for koala populations in the Project area and offset areas (condition B51(g)(iii)).

The methodology in the Koala Research Program proposal is indicative and will be refined, in consultation with key stakeholders, throughout the program. This will include post-desktop consideration of alternative survey techniques including (but not limited to) infrared drone, sound recognition, motion sensor cameras, and fauna detector dogs.

The Koala Research Program may assist DPE's NSW Koala Strategy by informing key objectives of the strategy through koala habitat data collection. Key objectives that may benefit from data collected via the program include:

- 22,000 ha of koala habitat protected;
- 25,000 ha of koala habitat restored;
- baseline surveys in up to 50 populations;
- an ongoing monitoring program with 20+ population monitoring sites; and
- continue research in areas of key knowledge gaps.

Santos will implement the Proposal for Phase 1 and will update the BMP, and the KRP, prior to Phase 2. Further consultation with relevant stakeholders, in particular BCS and FCNSW, will occur as part of this update.

A review of all available data will be routinely undertaken during the process of finalising preliminary survey design and/or reporting on results of the KRP. It should be noted that the data being referred to in the BCS and FCNSW submissions (i.e. results arising from the 5km x 5km acoustic / camera survey) is not yet publicly available. The data from the study, once made available, will incorporated into the overall project field survey design and preliminary records analyses.

The BCS submission additionally refers to an analyses of available landscape information as a means of addressing the habitat component of the consent condition. Habitat use by koalas across the study area is demonstrably and primarily influenced by the availability of preferred food tree species, specifically 'boxes' and 'red gums'. To address B51(g)(ii) it will thus be important for any positive sites to be underlain by good mapping, which is of itself only part of the occupancy equation given that presence of resident koala populations can be broadly demonstrated to be independent of habitat quality because of social interplay at the local koala population levels.

The proposed KRP survey grid can be locked onto the 5km x 5km survey grid that is referred to in the submissions, with the review and incorporation of available data from this grid and elsewhere to be undertaken during the reporting stage. The KRP will also produce an underlying map of Preferred Koala

Habitat based on the relative abundance of preferred koala food trees, informing data coming from historical data and that derived from SAT sites sampled during the field work component; details to be included in KRP.

8. Biodiversity offsets

The Project will deliver biodiversity offsets in accordance with the *Biodiversity Offset Scheme* defined within Part 6.2 of the BC Act through a BOS. The BOS will be implemented once approved by the Planning Secretary. The strategy follows a three-step approach:

1. quantification of the impacts of the Project informed by the Framework for Biodiversity Assessment (OEH, 2014) to guide the development of the offset strategy including direct, indirect and cumulative impacts, as well as the contribution that undertaking progressive rehabilitation post construction makes to reducing the overall offset liability (provided rehabilitation meets the criteria defined in the Rehabilitation Management Plan and only contributes to offsetting the final 30% of the estimated credit requirements for the Project as per CoC B49);
2. undertaking 'reasonable steps' to locate like-for-like offsets, including:
   - (i) checking the Biodiversity Offset Scheme Credit supply register;
   - (ii) liaising with the BCS and Narrabri Shire Council to obtain a list of potential sites that meet the requirements for offsetting;
   - (iii) considering properties for sale in the area;
   - (iv) providing evidence of why offset sites are not feasible;
3. for the remaining offset liability to be held for eventual transfer into the Biodiversity Conservation Fund.

The BOS proposes a phased approach to offsetting the impacts of the Project in line with the development Phases, with a focus on delivery prior to commencement of Phase 2 (see Attachment 1).

9. Biodiversity monitoring methods

9.1 Overview

The biodiversity monitoring program has been designed to be an adaptive and integrated program that is based on sound scientific principles. These principles inform monitoring surveys and methodologies, performance measures and reporting requirements.

Clear articulation of the aims and objectives of the biodiversity monitoring program and understanding the resources required for delivery, provides clarity and reduces the complexity of a monitoring program such as this.

The biodiversity monitoring program has been developed to match field development phases. Monitoring for Phase 1 has been developed to allow statistical analysis of data collected to be undertaken while also maintaining spatial representativeness across the Phase 1 Project area. Subsequent development plans will expand upon this monitoring program, however as expansion occurs, the initial monitoring effort and the universal applicability of reference sites will be considered and incorporated into final program design. Ensuring the monitoring program remains achievable and relevant is essential for a fit for purpose program.

The aim of the monitoring program is to:

- Monitor the environmental performance of the Project in relation to terrestrial biodiversity and to contribute and support long-term ecological monitoring that is already being conducted in the Pilliga Forest, by the NSW National Parks and Wildlife Service (**NPWS**), FCNSW and Australian Wildlife Conservancy (**AWC**).
- Dialogue with these stakeholders of the Pilliga Forest has been initiated and any conversations or communications will be used to inform the final monitoring program. It is expected the indirect impacts of the project will have no discernible effect on the biodiversity of the Pilliga Forest.
- To achieve this aim and assess the effects of the indirect impacts, the adaptive and integrated monitoring program has been designed to:
    - progressively establish an effective and relevant monitoring program for Phase 1, while maintaining flexibility to account for future phases and simplify the complexities of monitoring at the scale of the Project;
    - account for the iterative nature of impacts, from field development, on-going gas field planning and management;
    - allow flexibility for implementing Trigger Action Response Plans (TARPs) should monitoring triggers identify the need for management action or additional monitoring;
    - lead with science, by providing a mechanism and program that can incorporate advances in technology, efficiencies and scientific learnings (such as soundscape analysis);
    - ensure statistical evaluations are embedded with monitoring design and principles (sound statistical design);
    - be fit for purpose, practical, reasonable and functional;
    - incorporate qualitative and quantitative assessments;
    - incorporate survey techniques that reduces chances of observer variability and inconsistency;
    - incorporate a data management plan; and

- generate useful knowledge that contributes to the protection and conservation of biodiversity in the Pilliga.

9.2 Impact tracking monitoring

Direct impacts for Phase 1 will be tracked through the implementation of the Field Development Protocol and reported in the annual monitoring report. This will ensure impacts to all threatened entities do not exceed the approved upper disturbance limits, including for MNES.

9.3 BMP monitoring program

Biodiversity monitoring will target assessment of indirect impacts, rehabilitation and pest species occurrence using a series of reference, control and impact sites to determine any impacts at the local or regional scale. The threatened flora and fauna targeted through biodiversity monitoring are previously listed in Table 4.4. Some aerial migratory species (i.e. Fork-tailed Swifts), reptiles and raptors are unlikely to be captured in the biodiversity monitoring program as they are not readily detected by passive detection methods. These species have large home ranges and are unlikely to experience a detectable indirect impact.

The monitoring program has been designed to efficiently capture data on ecosystem function within indirect impact buffers and to enable valid statistical analyses. Measures of ecosystem function have been selected to provide a holistic approach to biodiversity monitoring for the Project that can be used to monitor the hospitability of the surrounding landscape and identify changes that may indicate a greater than anticipated indirect impact to threatened entities or their habitat. Implementation of the monitoring program will be progressive, in line with construction progress and the phases of the development.

The following program is specific to Phase 1 only and will form the basis of a broader program to be expanded upon in subsequent phases of the development. Results of the methodology comparisons, i.e. rapid BAM compared to full BAM vegetation plots and soundscape compared to conventional acoustic surveys, will be provided to BCS for consultation as part of the monitoring program review.

9.3.1 BMP monitoring sites

Terminology for the monitoring program:

- *Reference sites* = aligned with existing FCNSW[4], where possible, otherwise located within remnant vegetation representative of the same habitat type as impact and control sites within the Project area;
- *Control site* = monitoring site within Project area at least 500 m from well pad and 300 m from roads.
- *Impact site* = monitoring site within Project area adjacent to new linear infrastructure (i.e. road or pipeline) or gas well.
- *Monitoring site* = includes reference, control and impact sites.
- *Habitat types* = Shrub grass woodland, Heathy woodland, Riparian woodland and Shrubby woodland.

Initially the monitoring program will establish paired monitoring locations within the two habitat types hosting approximately 85% of the total impact of Phase 1:

[4] Co-location of sites was proposed to leverage collaboration opportunities and the potential for reference data pre-dating development. Santos understands that exposure to these factors may be unavoidable in a working forest and will work with FCNSW to identify suitable monitoring sites.

- Shrub grass woodland, i.e. PCTs 88 and 398 (approximately 15 ha)
- Heathy woodland, i.e. PCTs 40X, 405 and 408 (approximately 11 ha)

Each impact monitoring site will be established with paired impact and control plots within the same habitat type. The treatment plots will include one within 50 - 100 m of a well pad and one in a control area more than 500 m from the well pad and 300 m from roads as far as practicable.

Additionally, reference monitoring sites will be established outside the Project area within the two most impacted habitat types for Phase 1 (three in each Shrub grass woodland and Heathy woodland) to account for natural variation, including temporal and climatic changes. Wherever possible, reference sites will be co-located with current FCNSW monitoring within the Pilliga and established as far as possible within intact vegetation.

The establishment of the sites will aim to maximise spatial representativeness to avoid concentration of monitoring effort that is not reflective of the overall project.

Monitoring sites should be established prior to construction commencement to allow for the collection of site-specific baseline data. Where this is not possible, the nearest FCNSW monitoring location will be used for baseline data reference.

Each monitoring site will have the following survey techniques conducted:

- Soundscape recording device – set up to record data for soundscape analysis, diurnal bird surveys and microbat recordings.
- Rapid vegetation plot assessment, based on the Biodiversity Assessment Method (BAM)
- Photo monitoring point
- Baited camera trap

Initially, monitoring of the sites will occur twice a year. Changes to the schedule of monitoring, as well as the rate of monitoring per site, will be reviewed for subsequent phases to ensure the program is fit for purpose and achievable. The rotating design may change over time to adapt to the construction schedule, response to adaptive management, and / or environmental anomaly (e.g. bushfire). The monitoring program will be expanded progressively for subsequent phases of the development

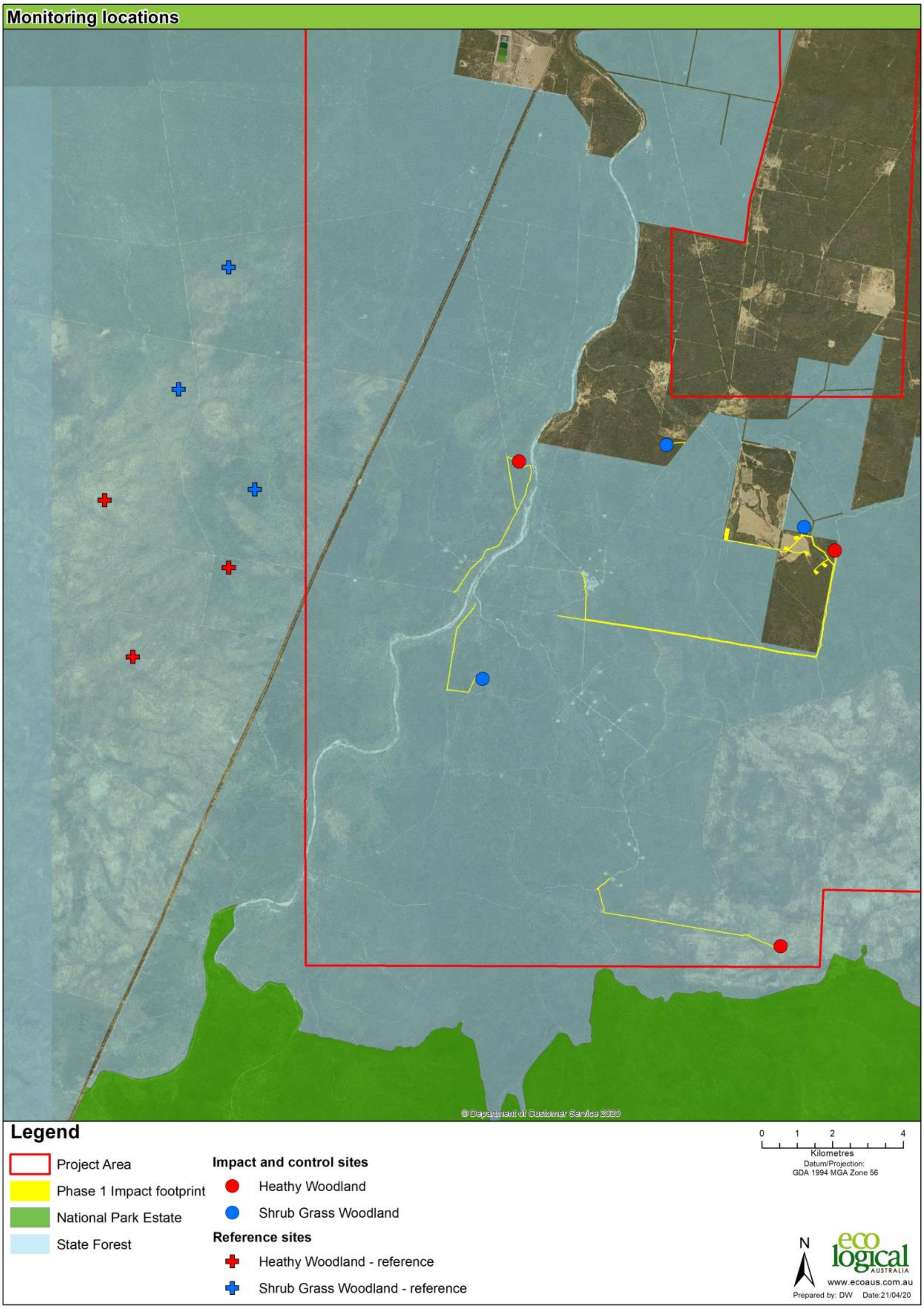


Figure 9.1 - Conceptual locations of Phase 1 monitoring locations

9.3.2 Biodiversity monitoring methods

9.3.2.1 Monitoring survey timings

BMP monitoring surveys will be conducted in spring which represents the highest activity period for most fauna species, and the highest diversity for native plant communities (including weeds). Following closure and rehabilitation of a well pad or linear infrastructure area with a BMP monitoring site, monitoring will continue until the completion criteria is met.

9.3.2.2 Vegetation surveys

The rapid vegetation integrity survey plot informed by the BAM, to achieve a rapid vegetation integrity (condition) score, will be conducted concurrently with a BAM plot. Full BAM plots will follow the methods described in the Biodiversity Assessment Method (DPIE, 2020). The intention of the rapid approach is to provide a method that can rapidly generate a vegetation integrity condition score to measure change, comparable to the full BAM method, while at the same time increasing efficiency and reducing observer variability (common within the former Biobanking Assessment Method and current BAM). For phase 1 the methods will be compared and after two years of monitoring is complete a decision will be made about which method to continue based on the outcomes of the comparison.

The use of hemispherical lenses or smartphone technology to capture projected foliage cover of canopy and mid layers will be used to reduce observer variability in condition assessments. Four photographs will be taken, at 130 cm above the ground level perpendicularly to the sky, within each 20 x 20m monitoring plot and the foliage cover will be calculated using an appropriate application. Hemispherical lens attachments for mobile devices as well as applications to record and process the images are readily available. Photos should be taken in the morning or afternoon as direct sunlight overhead may distort the imagery and confound the results. The results of the four photos should be averaged for each plot to obtain a result for the plot. Photos should have a clear view of the canopy and be relatively unobstructed by mid-storey cover and the photographer where possible.

The data collected for the rapid surveys includes all variables currently used in a BAM assessment but uses bands to categorise results for each variable. The bands used are N/A, low (0.1 – 33.3% of benchmark), moderate (33.34 – 66.6% of benchmark) and high (66.7%+ of benchmark). The variables to be collected are common to both methods and include:

- Structure: an estimate of the overall percentage of each growth form group , i.e. sum percent cover of each species in the following growth forms – trees, shrubs, grass & grass-like, forb, fern and other
- Composition, a count of each distinct species (requires knowledge of species growth forms or collection of reference material) i.e. species richness in each growth form – trees, shrubs, grass & grass-like, forb, fern and other, (direct counts)
- Function (recorded as per the BAM):
    - Number of large trees
    - Length of fallen logs
    - Total litter cover
    - Regeneration present (stems <5cm diameter at breast height)
    - Number of stem size classes present (5 – 9 cm, 10 – 19 cm, 20 – 29 cm, 30 – 49 cm, 50 – 79 cm and 80 cm+)

The vegetation surveys will utilise electronic devices (such as a smartphone) to improve data entry efficiencies and real-time survey data management.

The rapid survey technique (or a variation of) is currently employed by a number of NSW Government agencies to determine vegetation condition, including DPE (BCS), Biodiversity Conservation Trust (BCT) and Local Land Services (LLS).

9.3.2.3 Soundscape surveys

Sound recording is a low impact way to collect a lot of information about a site with little capital outlay (see Ng et al. (2018) for an example cost analysis). A sound recorder can capture continuous data through years while field surveys offer snapshots at given points in time, making sound an ideal candidate for long term monitoring (such as through soundscape analysis) for applications such as project impacts, offset maintenance and rehabilitation progress. The analysis of sound data can provide an in-depth view of biological activity at the monitoring sites allowing detection of potential changes in the use of indirectly impacted areas by biodiversity. Changes in the biological activity at sites can be used as a proxy for ecosystem function to detect changes that may be related to indirect impacts of the Project for further investigation. These methods will also be used for comparison with methods used for previous monitoring, i.e. diurnal bird recordings and microbat acoustic recordings, to compare the efficacy of the methods. The soundscape analysis is likely to demonstrate a greater ability to detect changes in the landscape through collecting and automatedly processing the large volume of data. This removes the reliance on human observers who can provide differing results depending on observer experience and the level of effort applied.

Detailed methods for the processing and analysis of the data are provided in Appendix G.

Acoustic monitoring has been applied to noise pollution in urban areas and to biological studies of specific species for years. However, the use of all sound in a landscape as opposed to the sounds made by specific sources only began in the last decade. The term 'soundscape' has been used in several different disciplines as early as 1969 (Southworth, 1969) and refers to 'sounds occurring over an area' (Pijanowski et al., 2011a). More specifically, soundscapes are:

> *'the collection of biological, geophysical and anthropogenic sounds that emanate from a landscape and which vary over space and time reflecting important ecosystem processes and human activities'* (Pijanowski et al., 2011b).

Following this, a soundscape is made up of:

- biological sounds (biophonies) produced by organisms (Krause, 1987) such as vibrations, songs and contact or alarm calls;
- geophysical sounds (geophonies) produced by natural, nonbiological sources (Krause, 1987) such as wind, running water and rain; and
- anthropogenic sounds (anthrophonies) produced by the moving parts of manmade objects such as vehicles, windmills and aeroplanes (Farina, 2014; Gage et al., 2004, 2001; Napoletano, 2004; Pijanowski et al., 2011b).

Changes to an environment can be heard in a soundscape. For example, construction of a gas well will involve the use of various construction plant and equipment (including but not limited to excavators, dozers, skid steer loaders and trucks) a drill rig and other specialised equipment such as a mud pump engine, mud shaker, hydraulic power unit and high pressure cement unit. During operation, the well is likely to operate with a constant low frequency sound associated with pumping and/or a separation process. Each of these activities creates a signature sound, which can be recognised within the soundscape and produce a change between the impacted and pre-existing (baseline) soundscapes of a site. Impacts to biodiversity associated with the project may be recognised as changes to the biological component of the soundscape if vocalising species appear, disappear or change their behaviour in response to the project. Soundscapes can therefore be used as an indicator of change and coupled with the benefits of minimal effort and time (cost) to collect large quantities of valuable environmental data, they are a powerful and objective means of monitoring that is well suited to application within the long-term monitoring program.

Acoustic data collection is a commonly used method in ecological monitoring and the same methods are employed for soundscape data collection. Soundscapes are captured using the same sound recorders ecologists deploy to monitor for threatened species such as masked owl (*Tyto novaehollandiae*), koala (*Phascolarctos cinereus*) or little pied bat (*Chalinolobus picatus*), all threatened species relevant to this project. The recorders are programmed and left in the environment to record continuously for at least 120 hours (five days) (Bradfer-Lawrence et al., 2019) at an appropriate sampling rate. The recordings will be stored in 10-minute blocks to facilitate data handling and mitigate the risk of data loss in the event of a recorder failing part way through a deployment. The standard sample rate for most consumer audio and in the production of audio CDs is 44.1 kHz. This rate is appropriate for monitoring all sound (the soundscape) that the average human can hear (frequencies between approximately 20 Hz and 20 kHz). If the soundscape is to include sounds produced by microbats, a higher sample rate will be required to enable quality recording within the ultrasonic frequency range (above the range of average human hearing).

9.3.2.4 Remote camera surveys

Remote camera surveys to detect presence of feral animals will be placed at each monitoring location concurrently with the soundscape data collection. The results of the camera traps will help to determine presence of pest animal species and indicate whether frequency of detection increases near impact sites or their presence is consistent throughout the landscape. A remote camera will be placed one metre from the ground on a suitable tree with a universal bait mixture at each site. A stake with a scale will be permanently placed approximately three metres from the camera to ensure repeatable placement and provide a scale for animal size to assist identification. The stake will be used as the origin point for the vegetation monitoring point, including photo monitoring point.

A detection is defined as the first occurrence of an individual animal on each day or night, subsequent photographs of the same individual during the same period are not counted.

9.3.2.5 Diurnal bird surveys

It is proposed to conduct diurnal bird analysis through traditional acoustic recordings (SongMeter) during the initial monitoring of Phase 1, in conjunction with the soundscape analysis. This will aim to demonstrate and support the strength of soundscapes. Following the initial monitoring for Phase 1, an assessment will be made with the intention of continuing with just the soundscape analysis when the BMP is updated for subsequent development plans. However, if significant or varied results occur between the analysis methods, then this will trigger an adaptive management response for a re-assessment of the monitoring methods.

A SongMeter will be set at each monitoring site recording continuously (i.e. all day and all night) for five days. The continuous recording will be saved by the recorder as 10 minute blocks to allow easier data transfer and handling of data. If a new bird species was heard, an additional five minutes will be analysed. This method is in accordance with the species time curve approach which is described in the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004). The data from all monitoring sites will be collated to obtain an overall species richness and a species list for each site.

9.3.2.6 Microbat surveys

Similar to the diurnal bird analysis, microbat analyses will be conducted through traditional acoustic recordings during the two-year initial monitoring period. An assessment of the methods will be made with the intention of continuing with just the soundscape analysis, following the initial monitoring. However, if significant or varied results occur between the analysis methods, then this will trigger an adaptive management response for a re-assessment of the monitoring methods (refer to section 10, Table 10.1).

A SongMeter will be set at each monitoring site to record microbat activity from sunset to sunrise each night for five nights. The SongMeters record ultrasonic data in WAV format, which will be converted on a computer using the Anabat Insight to a ZC format for analyses (Titley Electronics). The bat calls will be analysed by a suitable qualified expert.

9.3.3 Qualified personnel

Biodiversity monitoring surveys will be conducted by suitably qualified ecologists or technical specialists as listed below (Table 9.1).

Table 9.1 - Suitably qualified personnel

Personnel	Task
Experienced botanist	Vegetation surveys
Experienced ecologist	Soundscape site deployment, songmeter and camera deployment
Qualified ecologist	Field assistance for vegetation surveys and soundscape
Ornithologist or suitably experienced ecologist	Diurnal bird analysis

10. Risk assessment and contingency plan

10.1 Risk assessment

Risks to the implementation of the BMP were assessed during the preparation of the EIS using the Santos Risk Matrix, as presented in Table 10.1 (definitions for the likelihood and consequence can be found in the Project EMS). These risks were developed in consultation with FCNSW, Santos and suitably trained ecologists. The risks considered in this assessment specifically relate to general biodiversity (flora and fauna) issues associated with Phase 1 and the implementation of this Plan.

Table 10.1 - Risk assessment matrix for biodiversity

Likelihood	Consequence					
	Negligible	Minor	Moderate	Severe	Major	Critical
Almost certain	Low	Medium	High	Very high	Very high	Very high
Likely	Low	Medium	High	High	Very high	Very high
Occasional	Low	Low	Medium	High	High	Very high
Possible	Very low	Low	Low	Medium	High	Very high
Unlikely	Very low	Very low	Low	Low	Medium	High
Remote	Very low	Very low	Very low	Low	Medium	Medium

As presented in Table 10.2, the risks have been assessed based on the relevant phase of the development and include an assessment prior (initial risk) and post (residual risk) to the implementation of mitigation measures.

Other risks and contingency measures can be found in the EMS and risks to specific threatened entities are assessed in the EIS.

Table 10.2 - Assessed biodiversity (flora and fauna) risks of the Project

Discipline	Risk number	Risk activity	Description of consequences/impact	Project stage	Existing field development rules, design standards and operational rules and recommended mitigation	Residual risks		
						Likelihood	Consequence	Risk rating
Flora and fauna	FF001	Vegetation clearing / vegetation disturbance	Clearing beyond limit for vegetation communities	Construction and operation	Avoidance and minimisation by implementing the Field Development Protocol, including the Ecological Scouting Framework and database tracking ha of each vegetation community removed. Additional mitigation includes fencing, restrict activity outside of clearing footprint and educate field staff	Possible	Moderate	Low
Flora and fauna	FF002	Vegetation clearing / vegetation disturbance	Clearing beyond limit for threatened flora individuals, causing significant impact on species	Construction and operation	Avoidance and minimisation by implementing the Field Development Protocol, including the Ecological Scouting Framework and database tracking ha of each vegetation community removed. Additional mitigation includes fencing, restrict activity outside of clearing footprint and educate field staff	Unlikely	Moderate	Low
Flora and fauna	FF003	Vegetation clearing / vegetation disturbance	Clearing beyond limit for threatened ecological communities, causing significant impact on community	Construction and operation	Avoidance and minimisation by implementing the Field Development Protocol, including the Ecological Scouting Framework and database tracking ha of each vegetation community removed. Additional mitigation includes fencing, restrict activity outside of clearing footprint and educate field staff	Unlikely	Moderate	Low
Flora and fauna	FF004	Vegetation clearing / vegetation disturbance	Impacting on wetland habitat (significant impact on *Myriophyllum* habitat and wetland fauna habitat)	Construction and operation	Additional mitigation includes fencing, signs and educate field staff	Unlikely	Severe	Low
Flora and fauna	FF005	Vegetation clearing / vegetation disturbance	Fragmenting habitat, leading to a significant impact on a threatened species/community	Construction and operation	Monitoring of threatened species/communities using the biodiversity monitoring program through lifetime of Narrabri Gas Project	Possible	Severe	Medium
Flora and fauna	FF006	Noise emissions from various activities	Noise impacts decreasing habitat value to extent which has a significant impact on a threatened species/community	Construction and operation	Noise dampening infrastructure, monitoring of threatened species/communities through lifetime of Narrabri Gas Project	Possible	Moderate	Low
Flora and fauna	FF007	Vehicular activities in study area	Vehicular collision causing fauna death	Construction and operation	Restriction of speed limit in construction areas (40 km/h), restriction of vehicular activity from dusk to dawn where possible	Occasional	Minor	Low
Flora and fauna	FF008	Installing fencing	Fauna death from interaction with fencing	Construction and operation	Fauna friendly fencing only to be used in study area	Possible	Minor	Low
Flora and fauna	FF009	Vehicular activities in study area, infrastructure built in study area	Light impacts decreasing habitat value to extent which has significant impact on a threatened species/community	Construction and operation	Light spill controlled through design and infrastructure, monitoring of threatened species/communities through lifetime of Narrabri Gas Project	Possible	Moderate	Low
Flora and fauna	FF010	Vehicular/personnel movement around study area and vegetation disturbance	Weed invasion into threatened ecological communities, to extent which has a significant impact on a threatened ecological community	Construction and operation	Pest and weed management plan (weed inspections in study area, weed control, wash down point at the Narrabri Operations Centre, machinery checks, education of field staff about how to minimise weed transportation)	Unlikely	Severe	Low

Discipline	Risk number	Risk activity	Description of consequences/impact	Project stage	Existing field development rules, design standards and operational rules and recommended mitigation	Residual risks		
						Likelihood	Consequence	Risk rating
Flora and fauna	FF011	Vehicular/personnel movement around study area and vegetation disturbance	Weed invasion into native vegetation, impacting habitat for threatened species to extent which has a significant impact on a threatened species	Construction and operation	Pest and weed management plan (weed inspections in study area, weed control, wash down point at the Narrabri Operations Centre, machinery checks, education of field staff about how to minimise weed transportation)	Unlikely	Moderate	Low
Flora and fauna	FF012	Vegetation clearing / vegetation disturbance	Increased movement and abundance of feral fauna	Construction and operation	Pest and weed management plan adaptive management and participation or contribution to regional control efforts as negotiated with the relevant control authority.	Possible	Moderate	Low
Flora and fauna	FF013	Flaring, mulching, smoking, machinery use, increased personnel activity	Increased frequency of fire	Construction and operation	Water trucks for each mulcher (as required), restrict smoking in study area (esp. near areas of vegetation), education of field staff of risks managed in accordance with the Fire Management Plan and access arrangements with FCNSW. Refer to the Fire Management plan for details on bushfire suppression resources as identified in the access arrangement with FCNSW.	Remote	Severe	Low
Flora and fauna	FF014	Vegetation clearing / vegetation disturbance	Increased sedimentation that would decrease habitat value or community composition to extent which has a significant impact on a threatened species/community	Construction and operation	Sediment and erosion control management plan	Unlikely	Severe	Low
Flora and fauna	FF015	Vegetation clearing / vegetation disturbance, vehicular activity, construction activities	Increased dust production that would decrease habitat value or community composition to extent which has a significant impact on a threatened species/community	Construction and operation	Sediment and erosion control management plan, speed limits, water truck along unsealed roads, sealing of high use roads	Remote	Severe	Low
Flora and fauna	FF016	Vegetation clearing / vegetation disturbance	Increased erosion that would decrease habitat value or community composition to extent which has a significant impact on a threatened species/community	Construction and operation	Sediment and erosion control management plan	Remote	Severe	Low
Flora and fauna	FF017	Use of chemicals on site	Chemical runoff into wetland habitat	Construction and operation	All chemical use to be authorised (and follow MSDS) Potential for impact on wetland habitat to be assessed prior to any chemical use in study area.	Remote	Severe	Low
Flora and fauna	FF018	Use of chemicals on site	Chemical runoff into vegetation communities that would decrease habitat value or community composition to extent which has a significant impact on a threatened species/community	Construction and operation	All chemical use to be authorised (and follow MSDS) Potential for impact on vegetation to be assessed prior to any chemical use in study area.	Possible	Moderate	Low
Flora and fauna	FF019	Removal of hollow-bearing trees	Loss of hollow-bearing trees to extent which has a significant impact on a threatened species	Construction	Pre-clearance and clearance procedures, scouting framework. Hollow reinstallation or replacement at 1:1 ratio for large hollows (i.e. greater than 300 mm).	Unlikely	Severe	Low
Flora and fauna	FF020	Removal of dead wood and dead trees	Removal of dead wood and dead trees to extent which has a significant impact on a threatened species	Construction	Pre-clearance and clearance procedures, scouting framework	Remote	Moderate	Very low

Discipline	Risk number	Risk activity	Description of consequences/impact	Project stage	Existing field development rules, design standards and operational rules and recommended mitigation	Residual risks		
						Likelihood	Consequence	Risk rating
Flora and fauna	FF021	Clearing or unauthorised access to rehabilitated areas	Trampling or destruction of rehabilitation areas	Construction and operation	Rehabilitation monitoring, education of field staff of importance of rehabilitation areas	Unlikely	Minor	Very low
Flora and fauna	FF022	Removal of hollow-bearing trees	Accidental fauna death through removal of hollow-bearing trees	Construction	Pre-clearance and clearance procedures	Remote	Minor	Very Low
Flora and fauna	FF023	Trenching for gathering system	Accidental fauna death through falling in trenches	Construction	Trenches to be checked twice daily. Sticks and logs will be placed within trenches to allows any fauna that fall into a trench to escape.	Unlikely	Minor	Very low
Flora and fauna	FF024	Personnel accessing study area - staff not removing rubbish	Increased rubbish dumped in study area	Construction and operation	Rubbish to be managed in study area, education of field staff.	Unlikely	Negligible	Very low
Flora and fauna	FF025	Vehicular/personnel movement around study area and vegetation disturbance	Transportation of weeds including noxious weeds in study area	Construction and operation	Vehicle checks prior to entering site. Pest and weed management plan (weed inspections in study area, weed control, wash down points, machinery checks, education of field staff about how to minimise weed transportation)	Unlikely	Minor	Very low

10.2 Contingency plan

The monitoring programs contained in this BMP and its sub-plans are specifically designed to identify and manage the biodiversity performance of the Project. Performance indicators and triggers have been determined based on prior knowledge of the system to allow early detection of changes to ecosystem function and to facilitate an adaptive approach to managing any trigger exceedances. A contingency procedure for trigger exceedances or the failure of any of the controls listed in Table 10.3 is provided to inform the responsible person/s on the correct procedure to follow.

Table 10.3 - Contingency plan

Step	Responsible person	Example actions
Potential or actual trigger exceedance or non-compliance detected and reported internally	Environmental Advisor	Notify Project Manager.
Area Manager notified of potential or actual trigger exceedance or non-compliance.	Team Leader - Onshore Environment	Notify relevant agencies in line with notification requirements in the EMS
Investigate cause	Environmental Advisor	Conduct internal investigation into causative factors for the trigger exceedance or non-compliance.
Implement emergency measures where appropriate, e.g. cease work/operations, utilise spill kit, install temporary exclusion fencing	Team Leader - Onshore Environment	Record any actions taken and ensure none contravene the Development Consent.
Response to trigger or non-compliance	Environmental Advisor	Develop plan to address or remedy exceedance or non-compliance for consultation with relevant agencies.
Submit plan or response to agency for approval	Team Leader - Onshore Environment	Review and update plan to satisfaction of agency heads.
Implement approved plan	Environmental Advisor	Enact approved plan
Review BMP	Environmental Advisor	Determine if trigger or non-compliance was isolated or requires updates to BMP or sub-plans to avoid future occurrences.

11. Trigger action response plan

Using adaptive management principles, the TARP for the Project has been developed to allow for flexible and appropriate management responses to any non-compliance or trigger exceedance. The TARP provided in Table 11.1 provides specific responses related to the results of monitoring specific to the BMP. Triggers were selected based on the relevant measures from the monitoring program to investigate changes in ecosystem function, i.e. changes in biological acoustic activity, increased feral animal activity and declines in vegetation integrity. A significant difference between impact and either the control and / or reference sites will be set at $p < 0.05$. Triggers will result in further investigations into the source or cause of the difference following the responses outlined below.

Further TARPs are included in the BOS and the Pest Plant and Animal Control Protocol.

Table 11.1 - Biodiversity trigger action response plan

Biodiversity variable	Trigger	Response
Biodiversity		
Noise causes a decline in ecosystem function	First monitoring event: Significant difference (95% confidence interval) between treatments (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index. Second and subsequent monitoring event: Significant difference (95% confidence interval) between medians of paired differences in treatments between years (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index, diurnal bird or microbat species richness.	Investigate whether noise impacts could be responsible for the difference measured at impact sites. Review the implementation of existing controls and as necessary identify additional controls (e.g. redesign of generator insulation to reduce noise). Develop a program to implement the additional controls and review monitoring results. Review BMP and monitoring program for improvement opportunities.
Light spill causes a decline in ecosystem function	First monitoring event: Significant difference (95% confidence interval) between treatments (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index. Second and subsequent monitoring event: Significant difference (95% confidence interval) between paired differences in treatments between years (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index, diurnal bird or microbat species richness..	Investigate whether light spill impacts could be responsible for the difference measured at impact sites. Review the implementation of existing controls and as necessary identify additional controls (e.g., reduced lighting at well pads, installation of filters on lights around well infrastructure). Develop a program to implement the additional controls and review monitoring results. Review BMP and monitoring program for improvement opportunities.
Traffic causes a decline in ecosystem function	First monitoring event: Significant difference (95% confidence interval) between treatments (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index. Second and subsequent monitoring event: Significant difference (95% confidence interval) between paired differences in treatments between years (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index , diurnal bird or microbat species richness..	Investigate whether noise impacts could be responsible for the difference measured at impact sites. Review the implementation of existing controls and as necessary identify additional controls (e.g., further limitation on frequency of vehicular access to well pads to the periphery of the development area, further reduce speed limits on well pad access roads, particularly for infrequently accessed areas). Develop a program to implement the additional controls and review monitoring results. Review BMP and monitoring program for improvement opportunities.
Fragmentation causes a decline in vegetation condition	First monitoring event: Significant difference (95% confidence interval) between treatments (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index. Second and subsequent monitoring event: Significant difference (95% confidence interval) between paired differences in treatments between years (Impact-Control, Impact-Reference, check Control-Reference) of at least one soundscape index , diurnal bird or microbat species richness. OR decrease of 10 or greater in VI score at any individual impact site in the absence of a similar decline at the paired control site.	Investigate the most likely indirect impact(s) responsible for the difference. This may include for example monitoring of additional survey plots in indirect impact area to determine if differences are localised rather than indicative of systemic change in condition in area. After determining the most likely indirect impact(s), develop and enact plan to ameliorate or remediate in consultation with relevant government department. Review BMP and monitoring program for improvement opportunities.
Pest plant and animals		
Previously undetected priority weed or alert species	Identification of previously undetected species listed as priority weeds in the North West Local Land Services Regional Strategic Weed Management Plan at monitoring sites, or as part of routine or opportunistic site inspections	Immediately notify Environment Advisor in writing, i.e. email. Obtain sample and provide to suitably qualified individual (e.g. Project Ecologist), the National Herbarium of New South Wales or similar institute for confirmation of species identification (if required). Report to Narrabri Shire Council weeds officer or authorised official for further escalation as necessary, e.g. to regional weed committee or relevant NSW government department. Prioritise for eradication or control. Approach may require coordination with other relevant stakeholders. Note: Emergency response may be initiated by other agencies, which may include Santos cooperation operationally and/or financially.
Weed infestation spread	Identification of species at monitoring site/s it did not occur at previously, or as part of routine or opportunistic site inspections	Complete and record inspection on Santos approved tool or system and notify the Environmental Advisor in writing. Refer to the pest risk assessment in the Pest Plant and Animal Control Protocol and prioritise according to the Santos pest management hierarchy.

Biodiversity variable	Trigger	Response
New pest animal in area	Identification of pest species not previously detected, as listed in section 4.4, at monitoring sites, or as part of routine or opportunistic site inspections	Complete and record inspection on Santos approved tool or system and notify the Environmental Advisor in writing. Review and report sighting using appropriate method from the Pest Plant and Animal Control Protocol. Document notification.
Increase in population or sightings of previously detected pest animal	Significantly higher number of pest animal detections at impact sites compared to control and / or reference sites in a monitoring event.	Complete and record inspection on Santos approved tool or system and notify the Environmental Advisor in writing. Investigate species and coordinate targeted controls depending on species involved.

12. Record keeping

Santos has a data management plan for the NGP that outlines the policies and procedures that will be implemented to ensure that data is managed in a consistent, efficient and effective manner in order to provide accurate records of activity operations and enhance the value of the data collected.

Santos uses a number of systems and platforms to manage the documentation and data associated with the activities under this Plan. These include Sharepoint for management plans, procedures and laboratory reports; Santos' EHS Toolbox for capturing inspections and field assessments; and EQuIS[5], an advanced environmental data management and decision support system, for capturing all data and any laboratory results.

Details of data collection, inspection and maintenance key records associated with this BMP that are stored and managed include:

- inspection and monitoring records;
- records of any review of the BMP;
- operational monitoring and performance data;
- sampling and laboratory analytical reports;
- calibration records for field instruments and continuous monitoring systems; and
- annual inspection reports and/or certifications.

Monitoring data is subject to quality assurance (**QA**) and quality control (**QC**) protocols and procedures that ensure that data is accurate and usable. Data is subjected to consistent validation and verification procedures. Any data that fails QA and QC procedures is rejected for future use.

Note that records will be kept in a legible form for production to any inspector for a period not less than four years following the expiry or termination of a prospecting title (refer to sections 97D and 97E of the PO Act).

[5] EQuIS (Environmental Quality Information System) is a proprietary software application.

13. Reporting, evaluation and review

13.1 Biodiversity related incidents and non-compliance

A biodiversity related incident occurs where an action or facilitated action conducted in relation to the Project results in potential or real harm to a biodiversity value. Where biodiversity related incidents or non-compliances are identified, Santos will:

- take all reasonable and feasible steps to ensure that the incident or non-compliance ceases and does not reoccur;
- consider all reasonable and feasible options for remediation (where relevant) and submit a report to the relevant department(s) describing options and any preferred remediation measures or other courses of action; and
- implement remediation measures as directed by the relevant department(s).

In accordance with CoC D6, Santos will notify the Department and any other relevant agencies immediately after becoming aware of an incident. Incident notification will be made in writing via the DPE's Major Projects Portal, describing the location and nature of the incident.

In accordance with CoC D7, Santos will notify the DPE within 7 days of becoming aware of the non-compliance. The notification will be made in writing via the DPE's Major Projects Portal, setting out the non-compliance, the reason (if known) for the non-compliance and what actions have or will be taken to address the non-compliance.

Further details regarding the procedures for notifying, responding and reporting incidents and non-compliances are set out in the Project EMS.

13.2 Annual review

By the end of March each year, Santos will review the performance of its biodiversity management program for the previous calendar year and report results within the Annual Review to the satisfaction of the Secretary as described in section 8 of the EMS and in accordance with condition D8. The Annual Review will report on the progress of biodiversity credits retirements and the associated actual versus proposed surface disturbance for each stage. The Annual Review will be submitted to the DPE via the Major Projects Portal and will also make recommendations for any additions, changes or improvements to the biodiversity management plan and sub-plans.

13.3 BMP review and evaluation

Consent condition D4 states that Santos must review the suitability of existing strategies, plans and programs required under this consent, within two months of:

(a) the submission of an incident report;

(a) the submission of an Annual Review;

(b) the submission of an Independent Environmental Audit;

(c) the submission of a Field Development Plan;

(d) the submission of a Groundwater Model Update; or

(e) the approval of any modification of the conditions of this consent.

In view of the various conditions requiring annual reviews, suitability assessments and performance evaluations, it is recommended that this Plan be reviewed and, if necessary, updated in at least the following circumstances:

- in accordance with any direction from the NSW EPA or the Minister administering the PO Act;
- due to any significant change to the management processes as described herein. If there is ambiguity in relation to whether there is a significant change, Santos must consult with the Planning Secretary to determine whether the BMP must be reviewed; and
- otherwise at intervals of no longer than one year.

Subject to agreement by the Planning Secretary under CoC A24, updates to the BMP between Phase 1 and Phase 2 will be conducted in consultation with the entities listed below and resubmitted to the Planning Secretary for approval prior to commencement:

- Biodiversity, Conservation & Science directorate within DPE
- Department of Agriculture, Water, and Environment
- Forestry Corporation of New South Wales
- Narrabri Shire Council
- The Project's Biodiversity Advisory Group

The review history table in the front of this Plan provides the details of each review, conducted in accordance with condition D4.

As required by CoC D5, if the review under condition D4 determines that the BMP and any of the sub-plans require revision - to either improve the environmental performance of the Project, cater for a modification or comply with a direction - then Santos will submit the revised document to the Planning Secretary for approval within 6 weeks of the review.

Note that in accordance with CoC B52, Santos will implement the BMP once it has been approved by the Planning Secretary.

Santos will pay the full cost of an Independent Environmental Audit within one year of commencement of Phase 1 and every three years thereafter in accordance with consent condition D9. This is further addressed in section 8.3 of the EMS.

Further details on the reporting, evaluation and review of the BMP are provided in section 8 of the EMS.

14. Complaints management

In accordance with CoC D3(h)(ii), complaints received in relation to biodiversity management will be managed in accordance with Santos' *Complaints Management Procedure* that is communicated to all relevant staff members. Complaints can be directed to Santos via phone or email 24 hours a day, 7 days a week. Contact details are publicly available on the Project website.

All complaints are logged on a complaint form which includes the following details:

- date and time of the complaint;
- complainant details;
- details of the issue or complaint;
- actions taken to remediate the issue, if any;
- follow up actions required, if any;
- details of further liaison with complainant, if any; and
- closure date and time of the issue.

Further details on the complaint procedure are set out in the Project EMS.

15. References

AVH (2021). https://avh.ala.org.au/occurrences/search?taxa=Harrisia+OR+Parthenium&q=#tab_mapView. Accessed 02/08/2021. Australian Virtual Herbarium

Bradfer-Lawrence, T., Gardner, N., Bunnefeld, L., Bunnefeld, N., Willis, S.G., Dent, D.H (2019). *Guidelines for the use of acoustic indices in environmental research*. Methods Ecol. Evol. 10, 1796–1807. https://doi.org/10.1111/2041-210X.13254.

Farina, A. (2014). *Soundscape Ecology - Principles, Patterns, Methods and Applications*. Springer, Urbino, Pesaro-Urbino, Italy.

Gage, S.H., Napoletano, B., Cooper, M. (2001). *Assessment of ecosystem biodiversity by acoustic diversity indices*. J. Acoust. Soc. Am. 109, 2430.

Gage, S.H., Ummadi, P., Shortridge, A., Qi, J., Jella, P. (2004). *Using GIS to develop a network of acoustic environmental sensors*, in: ESRI International User Conference 2004. ESRI, San Diego, pp. 1–10.

GHD (2017). *Narrabri Gas Project Environmental Impact Statement*. Prepared for Santos Ltd.

Krause, B.L. (1987). *Bioacoustics, habitat ambience in ecological balance*. Whole Earth Rev 57, 14–18.

Napoletano, B. (2004). M*easurement, quantification and interpretation of acoustic signals within an ecological context*. MSc thesis, Michigan State University, East Lansing.

Ng, M.-L., Butler, N., Woods, N. (2018). *Soundscapes as a surrogate measure of vegetation condition for biodiversity values: A pilot study*. Ecol. Indic. 93, 1070–1080. https://doi.org/10.1016/j.ecolind.2018.06.003.

DPIE (2020). *Biodiversity Assessment Method*. NSW Department of Planning, Industry and Environment

DPIE (2021). *BioNet Atlas*. Data accessed 02/08/2021. NSW Department of Planning, Industry and Environment

NPWS. (2000a). *Brigalow Belt South: Regional Assessment (Stage 1). Report on Preliminary Fauna Survey of Pilliga and Goonoo Forests, November 1999 to January 2000*. (NSW NPWS Ed.). Government Document. NSW National Parks and Wildlife Service

NPWS. (2000b). *Preliminary Overview of the Brigalow Belt South Bioregion (Stage 1). NSW Western Regional Assessments* (NSW NPWS Ed.). Government Document. NSW National Parks and Wildlife Service

Pijanowski, B.C., Farina, A., Gage, S.H., Dumyahn, S.L., Krause, B.L., (2011a). *What is soundscape ecology? An introduction and overview of an emerging new science*. Landsc. Ecol. 26, 1213–1232. https://doi.org/10.1007/s10980-011-9600-8.

Pijanowski, B.C., Villanueva-Rivera, L.J., Dumyahn, S.L., Farina, A., Krause, B.L., Napoletano, B.M., Gage, S.H., Pieretti, N., (2011b). *Soundscape Ecology: The Science of Sound in the Landscape*. Bioscience 61, 203–216. https://doi.org/10.1525/bio.2011.61.3.6.

Southworth, M. (1969). *The sonic environment of cities*. Environ. Behav. 1, 49–70.

Standards Australia (2019). *Australian Standard/New Zealand Standard International Standards Organisation 4282:2019 - Control of the obtrusive effects of outdoor lighting*.

Standards Australia (2010). *Australian Standard/New Zealand Standard International Standards Organisation 1158:2010 - Lighting for roads and public spaces for roadways and plant*.

16. Glossary

Term	Definition[6]
Amended treated water	Produced water that has undergone treatment and amendment, as generally described in the EIS, to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling, construction and dust suppression
Approved disturbance area	The disturbance areas shown in the EIS as modified by any approved Field Development Plan
Beneficial use	Beneficial use refers to the use of waters, including produced water from an oil or gas well, for a secondary purpose that has a positive value. Potential beneficial use options for produced water include domestic and livestock supply, industrial supply, irrigation supply, dust suppression and recreation.
Council	Narrabri Shire Council
Department	NSW Department of Planning and Environment (DPE)
Ecosystem	An interconnected biological community of organisms that interact with each other and their physical environment.
EIS	The Environmental Impact Statement titled Narrabri Gas Project Environmental Impact Statement, dated 31 January 2017, submitted with the development application, including the Applicant's response to submissions and supplementary response to submissions, and the additional information provided by the Applicant to the Department in support of the application
Exploration well	A petroleum well that is drilled to: a) Explore for the presence of petroleum or natural underground reservoirs suitable for storing petroleum, or b) obtain stratigraphic information for the purpose of exploring for petroleum. For clarity, an exploration well is not a production well
Feasible	Means what is possible and practical in the circumstances
Gas well	Pilot wells and production wells
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
Linear infrastructure	Project related infrastructure of a linear nature including gas and water gathering lines, gas and water pipelines, access tracks, power lines, communication lines and other service lines
Major facilities	Leewood facility and Bibblewindi facility
Material harm	Is harm that: • involves actual or potential harm to the health or safety of human beings or to the environment that is not negligible, or • results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment) This definition excludes "harm" that is authorised under either SSD 6456 or any other statutory approval
Minimise	Implement all reasonable and feasible mitigation measures to reduce the impacts of the Project
Mitigation	Activities associated with reducing the impacts of the development
Petroleum Assessment Lease 2	A PAL is required to hold exclusive right to prospect for petroleum and to

[6] The majority of the definitions are as provided in the Development Consent for SSD 6456.

Term	Definition[6]
(PAL 2)	assess any petroleum deposit over a specified area of land in NSW. A lease allows the holder to maintain a title over a potential area, without having to commit to further exploration. The holder can, however, continue prospecting operations and to recover petroleum in the course of assessing the viability of commercial mining. PAL 2 is held by the following titleholders: • Santos NSW Pty Ltd
Petroleum Exploration Licence 238 (PEL 238)	Before exploration for minerals or petroleum in NSW, an explorer must first obtain a Petroleum Exploration Licence (PEL) under the *Petroleum (Onshore) Act 1991*. An exploration licence gives the licence holder exclusive rights to explore petroleum or specific minerals within a designated area but it does not permit mining, nor does it guarantee a mining or production lease will be granted. PEL 238 is held by the following titleholders: • Santos NSW Pty Ltd • Santos NSW(Narrabri Gas) Pty Ltd
Petroleum Production Lease 3 (PPL 3)	A petroleum production lease gives the titleholder the exclusive right to extract petroleum within the production lease area during the term of the lease. PPL 3 is held by the following titleholders: • Santos QNT Pty Ltd • Santos NSW (Hillgrove) Pty Ltd • Santos NSW (Eastern) Pty Ltd
Petroleum production lease application (PPLA)	A petroleum production lease gives the titleholder the exclusive right to extract petroleum within the production lease area during the term of the lease. Development consent under the *Environmental Planning and Assessment Act 1979* must be in place before a petroleum production lease can be granted. Santos, on behalf of its joint venture partner, lodged four petroleum production lease applications under the PO Act in May 2014 for the Project area, being PPLAs 13, 14, 15 and 16. The ownership of the application is as follows: • Santos NSW Pty Ltd
Pilot well	A well for gas and water extraction, for the purpose of exploration, appraisal and assessment of the gas field potential
Planning Secretary	Planning Secretary under the EP&A Act, or nominee
Pollution incident	Has the same meaning as in the POEO Act
Production well	A well for gas and water extraction, for the purpose of commercial gas production and/or use
Project area	The area of approximately 95,000 hectares that encompasses the Project
Project footprint	The area of surface expression being about 1,000 hectares occupied by the infrastructure components of the Narrabri Gas Project
Project-related infrastructure	All infrastructure and other structures associated with the development. This includes linear infrastructure and non-linear infrastructure, surface infrastructure and subsurface infrastructure, major facilities, wells and well pads and other gas field infrastructure
Reasonable	Means applying judgement in arriving at a decision, considering mitigation benefits, cost of mitigation versus benefits provided, community views and the nature and extent of potential improvements
Unacceptable risk	The level of risk at which mitigation actions are deemed to be warranted.
Watercourse	A river, creek or other stream, including a stream in the form of an anabranch

Term	Definition[6]
	or tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events: In a natural channel, whether artificially modified or not, or in an artificial channel that has changed the course of the stream. It also includes weirs, lakes and dams
Well	Pilot wells and production wells
Well pad	An area of up to 1 hectare in size upon which the gas wells are to be located, with the area decreasing to no more than 0.25 hectares following rehabilitation[7], or other area as may be approved in the Field Development Plan

[7] Workover activities will be contained within the operational area of the well pad area of around 0.2 ha, with an additional laydown area that could be approximately 0.2 ha in size.

Appendix A - Consultation records

Appendix B - Compliance conditions relevant to this Plan

Table B1 - SSD 6456 consent conditions directly relevant to this BMP

SSD 6456 consent conditions directly relevant to this BMP		Section reference
Consent condition A1, Schedule 2 In meeting the conditions of this consent, the Applicant must implement all reasonable and feasible measures to prevent and, if prevention is not reasonable and feasible, minimise any material harm to the environment that may result from the construction, operation or rehabilitation of the development.		Section 1.3
Consent condition A5, Schedule 2 The Applicant may only undertake the development in the following stages:		Section 1.3
a)	Phase 1, comprising ongoing exploration and appraisal activities;	
b)	Phase 2, comprising construction activities for production wells and related infrastructure;	
c)	Phase 3, comprising gas production operations; and	
d)	Phase 4, comprising gas well and infrastructure decommissioning, rehabilitation and mine closure.	
Consent condition A23 Schedule 2 With the approval of the Planning Secretary, the Applicant may:		
a)	prepare and submit any strategy, plan or program required by this consent on a staged basis (if a clear description is provided as to the specific stage and scope of the development to which the strategy, plan or program applies, the relationship of the stage to any future stages and the trigger for updating the strategy, plan or program	Section 1.3
b)	combine any strategy, plan or program required by this consent (if a clear relationship is demonstrated between the strategies, plans or programs that are proposed to be combined);	N/A – this plan is not combined with any other
c)	update any strategy, plan or program required by this consent (to ensure the strategies, plans and programs required under this consent are updated on a regular basis and incorporate additional measures or amendments to improve the environmental performance of the development); and	Section 1.3
d)	combine any strategy, plan or program required by this consent with any similar strategy, plan or program required by a consent	N/A – this plan is not combined with any other
Consent condition B1 Schedule 2 The Applicant must ensure that petroleum mining operations in the Project area comply with the locational criteria in Table 1.		Section 6
Conservation areas	• No surface infrastructure within 200 metres of Yarrie Lake property boundary • No surface infrastructure within 50 metres of Brigalow State Conservation Area • No sub-surface infrastructure below Brigalow State Conservation Area, from the ground surface to a depth of at least 110 metres • No surface infrastructure within 50 metres of Brigalow Nature Reserve	

SSD 6456 consent conditions directly relevant to this BMP		Section reference
Biodiversity	• No disturbance of more than 988.8 hectares of native vegetation (including derived native grassland) • No disturbance beyond the limits by vegetation type as identified in Table 8. • No disturbance beyond the limits by threatened flora species type as identified in Table 9 • No disturbance beyond the limits by threatened fauna species type as identified in Table 10	
Consent condition B2 Schedule 2 Prior to the commencement of Phase 1, the Applicant must prepare a Field Development Protocol for the development to the satisfaction of the Planning Secretary. This plan must: (d) describe the process for siting gas field infrastructure, based on: (i) … (ii) … (iii) in-field micro-siting, including: • ground-truthing survey against all locational criteria; • ecological survey, in accordance with the Biodiversity Management Plan;		Section 6.2 Appendix C
Consent condition B43 Schedule 2 The Applicant must retire the biodiversity credits specified in Tables 8, 9 and 10 below, subject to the staged retirement conditions below, to offset the biodiversity impacts of the development. The retirement of credits must be carried out in consultation with BCS and, apart from the retirement of credits through ecological rehabilitation, in accordance with the Biodiversity Offsets Scheme of the BC Act and to the satisfaction of the BCT.		Attachment 1 – Biodiversity Offset Strategy Section 1.3 Section 13.
Consent condition B44 Schedule 2 Prior to the commencement of Phase 1, the Applicant must retire any ecosystem and species credit liabilities generated by the works proposed in the applicable Field Development Plan to the satisfaction of the BCT.		BOS section 4.2
Consent condition B45 Schedule 2 Prior to the commencement of Phase 2, the Applicant must retire the ecosystem and species credits liability identified as Phase 2 Credits in Tables 8, 9 and 10 to the satisfaction of the BCT. Any credits retired during Phase 1 may be deducted from the Phase 2 credit liability.		BOS section 4.3
Consent condition B46 Schedule 2 Prior to exceeding the Phase 2 area or individuals limits in Tables 8, 9 and 10, the Applicant must retire the relevant ecosystem and species credit liabilities to enable any exceedances of the limits to the satisfaction of the BCT and/or by providing ecological rehabilitation credit offsets for the exceedances.		Not relevant to Phase 1
Consent condition B47 Schedule 2 The calculation of credits must be based on the Framework for Biodiversity Assessment of the NSW Biodiversity Offset Policy for Major Projects (OEH, 2014) and consistent with the calculation of credits applied during the preparation of the EIS.		BOS section 2.2

SSD 6456 consent conditions directly relevant to this BMP	Section reference
Consent condition B48 Schedule 2 With the agreement of the Planning Secretary, the Applicant may adjust the staging of credit retirements. Any adjustments must be agreed, and the relevant credits must be retired, prior to the commencement of the associated impact on that ecosystem or species.	BOS section 4.2 No adjustment of staging credit requirements
Consent condition B49 Schedule 2 If the Applicant meets the ecological rehabilitation completion criteria in the Rehabilitation Management Plan to the satisfaction of BCS, then the Applicant may use the rehabilitated land to offset the relevant ecosystem and/or species credit liability for the 'Residual Credits' in Tables 8, 9 and 10. Ecological rehabilitation credits may be offset at a rate of: (a) 12 credits per hectare for plant community types in Table 8; (b) 7.1 credits per individual for relevant flora species in Table 9; and (c) 7.1 credits per hectare of suitable habitat for relevant fauna species in Table 10. Ecological rehabilitation credit offsets may only be sought for: • plant community types in Table 8; • flora and fauna species identified as 'Yes' to ecological rehabilitation in Tables 9 and 10; and • flora and fauna species identified as 'Potential' to ecological rehabilitation in Tables 9 and 10, subject to the Applicant demonstrating that the relevant species is suitable for ecological rehabilitation, to the satisfaction of the BCS.	BOS section 2.3
Consent condition B50 Schedule 2 The Applicant must establish and facilitate the operation of a Biodiversity Advisory Group for the development to the satisfaction of the Planning Secretary. The group must: (a) comprise of biodiversity expert representatives whose appointments have been approved by the Planning Secretary, including representatives from: (i) BCS; (ii) the scientific community, comprising suitably qualified persons (at least 2 representatives); (iii) relevant community representative (at least 2 representatives); be established prior to the commencement of Phase 1; (b) meet at least twice a year; and (c) provide advice on project-related biodiversity management issues, including preparation and implementation of the: (i) Biodiversity Management Plan; and (ii) Field Development Plan, including micro-siting investigations. **Notes**: The Biodiversity Advisory Group is an advisory committee only and has no compliance or enforcement functions.	Section 2 and 13.3
Consent condition B51 Schedule 2 Prior to the commencement of Phase 1, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	This plan

SSD 6456 consent conditions directly relevant to this BMP	Section reference
a) be prepared by a suitably qualified and experienced person/s approved by the Planning Secretary;	This document and section 1.3
b) be prepared in consultation with the BCS, DCCEEW, FCNSW, Council and the Biodiversity Advisory Group;	Section 1.5 and Appendix A
c) describe the short term, medium and long-term measures to be undertaken to manage vegetation and fauna habitat in the project area including measures to avoid and/ or minimise impacts on threatened ecological communities;	Section 6 Table 6.1
d) describe how biodiversity management would be integrated with similar measures in the Water Management Plan and RMP;	Sections 1.7, 6.1, 6.3 and 6.5
e) describe the measures to be implemented for undertaking micro-siting investigations for the Field Development Plan, including procedures for	Section 6.2
(i) desk top review and ground surveys for all proposed gas field infrastructure; and	Section 6.2
(ii) managing any threatened species or ecological communities identified during the investigations, including measures to avoid and/or minimise disturbance of threatened species or ecological communities; and	Section 6.2
f) include a Biodiversity Offset Strategy that:	Section 8 BOS section 1.2 BOS section 4
(i) is prepared in consultation with MEG (in addition to the agencies referred to in (b) above), in relation to the potential for resource sterilisation;	
(ii) is prepared consistent with the NSW Biodiversity Offsets Policy for Major Projects;	
(iii) describes how the biodiversity credits in Tables 8, 9 and 10 of the CoC will be identified, secured and retired;	
(iv) prioritises land-based offsets for retiring ‘Phase 2 Credits’ identified in Tables 8, 9 and 10 of the CoC;	
(v) describes the staging of credit retirements and associated surface disturbance areas; and	
(vi) describes how threatened species under the EPBC Act would be suitably offset;	
g) include a Koala Research Program that:	Section 7 and Attachment 2
(i) is designed to determine the location and size of remnant Koala populations in the Pilliga Forest;	
(ii) investigates why suitable areas of habitat may not be occupied by Koalas; and	
(iii) guides adaptive management of the Koala population in the project area and any land-based offset areas used to retire species credits for the Koala;	
h) describe the measures to be implemented within approved disturbance areas in the Project area to:	
(i) minimise the amount of clearing and employ temporary vegetation strategies;	Section 6.2, 6.3 and Table 6.1

SSD 6456 consent conditions directly relevant to this BMP	Section reference
(ii) minimise impacts on fauna, including undertaking pre-clearance surveys and targeted clearing windows and protocols to minimise impacts during key breeding seasons for threatened bats and birds;	Section 6.2
(iii) maximise the salvage, transplanting and/or propagation of any threatened flora found during pre-clearance surveys, in accordance with the *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee et al., 2004), where reasonable and feasible; and	Table 6.1 and Appendix C
(iv) maximise the salvage of resources, including tree hollows, vegetation and soil resources, for beneficial reuse, including fauna habitat enhancement;	Table 6.1 and Appendix D
i) describes the measures to be implemented in the Project area to:	
(i) minimise impacts on fauna habitat resources such as hunting and foraging areas, habitat trees, fallen timber and hollow-bearing trees;	Section 6.2 and 6.3
(ii) enhance the quality of vegetation, vegetation connectivity and wildlife corridors including through the assisted regeneration and/or targeted revegetation of appropriate canopy, sub-canopy, understorey and ground strata;	Section 6.6 and the Rehabilitation Management Plan
(iii) introduce naturally scarce fauna habitat features such as nest boxes and salvaged tree hollows and promote the use of these introduced habitat features by threatened fauna species;	Section 6.3 (Table 6.1), Section 6.6, BOS section 2.5.1
(iv) manage any potential conflicts with Aboriginal heritage values;	Section 6.2.1 and refer to the Field Development Protocol and the Aboriginal Cultural Heritage Management Plan
(v) protect vegetation and fauna habitat outside of the approved disturbance areas;	Section 6.2.2 (Table 6.1)
(vi) manage potential indirect impacts on threatened flora and fauna species;	Section 6.3 (Table 6.1)
(vii) manage the collection and propagation of seed from the local area;	Section 6.3 (Table 6.1) and Appendix F
(viii) control weed, including measures to avoid and mitigate the spread of noxious weeds;	Section 6.4 and Attachment 3
(ix) control feral pests with consideration of actions identified in relevant threat abatement plans;	Section 6.4 and Attachment 3
(x) control erosion;	Section 6.7
(xi) manage any grazing and agriculture;	Section 6.5
(xii) control access to vegetated or revegetated areas; and	Section 6.3 (Table 6.1) and Rehabilitation Management Plan
(xiii) manage bushfire hazards	Section 6.82 and Fire Management Plan

SSD 6456 consent conditions directly relevant to this BMP	Section reference
j) include a seasonally based program to monitor and report on the effectiveness of the above measures, progress against the detailed performance and completion criteria in the Rehabilitation Management Plan, and improvements that could be implemented to improve biodiversity outcomes;	Section 9 Section 13
k) identify the potential risks to the successful implementation of the Biodiversity Offset Strategy, and include a description of the contingency measures to be implemented to mitigate against these risks; and	BOS section 3.4
l) include details of who would be responsible for monitoring, reviewing, and implementing the Plan.	Section 10.2 Also refer to the EMS
Consent condition B52 Schedule 2 The Applicant must implement the Biodiversity Management Plan once approved by the Planning Secretary.	Section 1.8
Consent condition B59 Schedule 2 Prior to the commencement of Phase 1, the Applicant must prepare an Aboriginal Cultural Heritage Management Plan for the development to the satisfaction of the Planning Secretary. The plan must: **d) describe the measures to be implemented for:** • maintaining and managing reasonable access for relevant Aboriginal stakeholders to Aboriginal objects and Aboriginal places in any biodiversity offset areas managed by the Applicant; and • facilitating ongoing consultation and involvement of Registered Aboriginal Parties in the conservation and management of Aboriginal cultural heritage in any biodiversity offset areas managed by the Applicant;	Sections 4 and 5 of Biodiversity Offset Strategy (Attachment 1) and the Aboriginal Cultural Heritage Management Plan
Consent condition B83 Schedule 2 Prior to the commencement of Phase 1, the Applicant must prepare a Rehabilitation Management Plan for the development to the satisfaction of the Resources Regulator. This plan must: • describe how the rehabilitation of the project area would achieve the objectives identified in Table 10 and be integrated with the measures in the Biodiversity Management Plan;	Sections 3.5 Section 6.1
Consent condition D3 Schedule 2 The Applicant must ensure that (where relevant) the management plans required under this consent include:	
a) summary of relevant background or baseline data;	Section 4
b) details of:	
(i) the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3
(ii) any relevant limits or performance measures and criteria; and	Section 6.6
(iii) the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Section 10.2
c) any relevant commitments or recommendations identified in the documents that together comprise the NGP EIS;	Section 3.4

SSD 6456 consent conditions directly relevant to this BMP	Section reference
d) a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	Section 6
e) a program to monitor and report on the:	Section 9 Section 10
(i) impacts and environmental performance of the development; and	
(ii) effectiveness of the management measures set out pursuant to paragraph (d);	
f) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 10.2
g) a program to investigate and implement ways to improve the environmental performance of the development over time	Section 13
h) a protocol for managing and reporting any:	
(iii) incident, non-compliance or exceedance of any impact assessment criterion and performance criterion	Section 13.1 Section 14
(iv) complaint; or	
(v) failure to comply with other statutory requirements; and	
i) a protocol for periodic review of the plan.	Section 13
Consent condition D4 Schedule 2 Within 2 months of:	Section 13.3
a) the submission of an incident report;	
b) the submission of an Annual Review;	
c) the submission of an Independent Environmental Audit;	
d) the submission of a Field Development Plan;	
e) the submission of a Groundwater Model Update; or	
f) the approval of any modification of the conditions of this consent,	
the Applicant must review the suitability of existing strategies, plans and programs required under this consent.:	
Consent condition D5 Schedule 2 If the review determines that the strategies, plans and programs required under this consent require revision – to either improve the environmental performance of the development, cater for a modification or comply with a direction - then the Applicant must submit the revised document to the [Planning] Secretary for approval within 6 weeks of the review. **Note**: *This is to ensure strategies, plans and programs are updated on a regular basis and to incorporate any recommended measures to improve the environmental performance of the development.*	Section 13.3
Consent condition D6 Schedule 2 The Applicant must notify the Department and any other relevant agencies via the Major Projects Portal immediately after it becomes aware of the incident. This notice must describe the location and nature of the incident.	Section 13.1 and refer to the EMS

SSD 6456 consent conditions directly relevant to this BMP	Section reference
Consent condition D7 Schedule 2 Within 7 days of becoming aware of a non-compliance with the conditions of this consent, the Applicant must notify the Department of the non-compliance via the Major Projects Portal. This notice must set out the non-compliance, the reasons for the non-compliance (if known) and what actions have been taken, or will be taken, to address the non-compliance. **Note**: *A non-compliance which has been notified as an incident does not need to also be notified as a non-compliance*	Section 13.1 and refer to the EMS
Consent condition D8 Schedule 2 By the end of March each year, unless the Planning Secretary agrees otherwise, the Applicant must submit an Annual Review of the environmental performance of the development to the Department via the Major Projects Portal. This review must: • report on the progress of biodiversity credits retirements and the associated actual versus proposed surface disturbance for each stage;	Section 13.2
Consent condition D9 Schedule 2 Within one year of commencement of Phase 1 and every 3 years thereafter, unless the Planning Secretary directs otherwise, the Applicant must commission and pay the full cost of an Independent Environmental Audit of the development.	Section 13.3
Consent condition D13 Schedule 2 From the commencement of Phase 1, until the completion of all rehabilitation required under this consent, the Applicant must:	Section 1.8, 12 and 13
• make copies of the following information publicly available on its website:	
• keep such information up to date.	

Table B2 - EPBC 2014/7376 consent conditions directly relevant to this BMP

EPBC 2014/7376 consent conditions directly relevant to this BMP	Section reference
Approval condition 2 Part A The approval holder must not clear more than 989 hectares (ha) of native vegetation within the project area and must not clear outside the project area.	Section 6.2
Approval condition 25 Part A The approval holder must comply with conditions B43 – B52 of the NSW approval as they relate to the following protected matters: a) Brigalow woodland; b) Weeping Myall woodland; c) Regent Honeyeater; d) Koala; e) Spotted-tail Quoll; f) Swift Parrot; g) Superb Parrot; h) South-eastern Long-eared Bat; i) Pilliga Mouse; j) *Bertya opponens*; k) *Lepidium aschersonii*; l) *Lepidium monoplocoides*; m) *Commersonia procumbens*; and n) *Tylophora linearis*.	See Table B1
Approval condition 26 Part A The approval holder must, prior to any exceedance of Phase 2 credits specified in Tables 8-10 of the NSW approval, advise the Department [DCCEEW] in writing of the actual impacts to any protected matters listed in condition 25 (a-i), or modelled impacts for protected matters listed in condition 25 (j-n), and the residual credits to be retired for protected matters.	Not relevant to Phase 1
Approval condition 27 Part A Prior to the commencement of Phase 3, the approval holder must provide the Department [DCCEEW] with: a) shapefiles and other identifying information, as agreed to in writing by the Department [DCCEEW], of all records of protected matters located during surveys undertaken for the assessment of the action and for in-field micro-siting; b) shapefiles of the actual clearance areas for each of the protected matters; and c) a copy of either the credit retirement report or statement of assessment of reasonable equivalence issued by BCS and shapefiles of the final offset/s.	Not relevant to Phase 1.
Approval condition 29 Part A The approval holder must notify the Department [DCCEEW] in writing of the date of commencement of the action within 10 business days after the date of commencement of the action.	Refer to the EMS

Approval condition 33 Part A The approval holder must prepare a compliance report every calendar year from commencement of the action. The approval holder must: d) publish each compliance report on the website within 60 business days following the relevant 12 month period; e) notify the Department by email that a compliance report has been published on the website and provide the weblink for the compliance report within 5 business days of the date of publication; f) keep all compliance reports publicly available on the website until this approval expires; g) exclude or redact sensitive ecological data from compliance reports published on the website; and h) where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication.	Refer to the EMS
Approval condition 35 Part A The approval holder must notify the Department in writing of any incident within 2 business days, or any non-compliance with the conditions of this approval within 10 business days. The notification must specify: a) any condition which is or may be in breach, including a reference to the relevant NSW condition (if required); b) a short description of the incident and/or non-compliance; and c) the location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, provide the best information available.	Refer to the EMS
Approval condition 36 Part A The approval holder must provide to the Department the details of any incident or noncompliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying: a) any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future; b) the potential impacts of the incident or non-compliance; and c) the method and timing of any remedial action that will be undertaken by the approval holder.	Refer to the EMS

Appendix C - Ecological Scouting Framework

Exclusion areas and maximising avoidance

The desktop review process, incorporating steps 1 to 3 below, optimises the location of infrastructure and environmental outcomes and identifies likely suitable development areas. The geographic information system (**GIS**) database that is utilised during desktop review includes:

- geologic features and knowledge of gas resources;
- ecological sensitivity mapping as described in section 7.1, as well as other ecological data;
- the location of known Aboriginal cultural heritage and historic heritage sites, described in section 9 of the Field Development Protocol;
- existing access tracks and roads that can be used for the Project development, minimising development scope and disturbance through co-location;
- existing infrastructure including gas and water gathering and transmission pipelines, ponds, dams, electrical infrastructure and compression infrastructure;
- the location of surface water resources, riparian corridors and 1 % Annual Exceedance Probability (**AEP**) flood event levels; and
- sensitive receptors, which could potentially be impacted by noise or air emissions.

<u>Step 1 – Define the next stage of development relative to exclusion areas (conceptual design)</u>

This process involves the development of the initial conceptual infrastructure design and takes into account the gas resource, locational criteria, exclusion areas, existing infrastructure and other relevant information. The conceptual design of infrastructure also informs the land access negotiations.

<u>Step 2 – Review of the proposed infrastructure against ecological and other spatial constraints</u>

This step utilises the conceptual design from in Step 1 and seeks to optimise the placement of infrastructure using the ecological sensitivity class hierarchy (described in section 7.1 of the Field Development Protocol) and the potential for impacts on other constraint classes. Initially, this process involves reviewing the proposed infrastructure locations relative to the ecological sensitivity maps. Through this process, infrastructure locations will be directed (where practicable) to less sensitive ecological classes in accordance with the general rules and specifications.

As detailed in the constraint matrix (Table 7.1 of the Field Development Protocol), this will result in the majority of the well pads being located outside of high and moderately high ecological sensitivity classes (disturbance to the high ecological sensitivity class is limited to 0.5% of total class area), as detailed in Appendix J of the EIS. Linear infrastructure will be less constrained – development will be directed firstly to areas adjacent to existing linear infrastructure where practicable and/or the shortest feasible routes to minimise the total clearing required.

Where the total extent of clearing is similar between two potential options, linear infrastructure will be directed to the areas with the lowest aggregate disturbance of higher-order ecological sensitivity classes. Following optimisation for ecological sensitivity, consideration is given to the remaining constraints. Where necessary, the placement of infrastructure will be modified.

It is to be noted that Steps 1 and 2 are not mutually exclusive and are undertaken in parallel as an iterative process to ensure the infrastructure locations are optimised.

Step 3 – Review of cumulative disturbance against predicted estimates of disturbance

Step 3 involves reconciliation of the potential disturbance of each development stage against the predicted cumulative disturbance calculations for development. The reconciliation of potential disturbance provides a critical component of the framework for tracking of performance, as well as ensuring the conceptual design and optimisation described in Steps 1 and 2 above are maintained within the approved ecological disturbance limits over the life of the Project.

Micro-siting

Step 4 – In-field micro-siting

Micro-siting involves, amongst other things, ensuring compliance with all the relevant avoidance measures and constraints at the site-scale. Micro-siting seeks to further direct the development away from sensitive ecological and cultural features and involves field scouting of ecological features (such as threatened flora and hollow-bearing trees) and pre-clearance surveys for Aboriginal cultural heritage within the proposed area of the development. The micro-siting process will be conducted as follows:

Step 4a – Mark-out of the proposed layout of infrastructure within the development area.

Step 4b – Ecological site scouting of the marked-out area and buffer areas to survey for the presence of the high value ecological features, including threatened flora, significant fauna habitat features and hollow-bearing trees (see Table C1). For the purposes of the site scouting, the survey buffers will comprise an area approximately 50 m beyond the boundary on the one-hectare well pad sites and 6 m on either side of the 12 m linear infrastructure easements. Note, step 4b may be conducted prior to 4a marking up of the proposed layout of infrastructure for efficiency. The site scouting procedure is further described in section 6.2.1 of the Biodiversity Management Plan (**BMP**).

The hierarchical structure as presented in Table C1 will be applied to the relocation of infrastructure to avoid or minimise impacts on key features and attributes identified during micro-siting. Priority will also be given to avoiding exacerbation of edge effects, fragmentation and habitat connectivity, wherever possible, by minimising width of clearing, co-location with existing roads or infrastructure and using short direct routes. If an endangered ecological community is identified that was not mapped at that particular location (as part of the EIS), an attempt will be made to avoid the community. If avoidance is not possible, then the impact will count toward the upper disturbance limit for that endangered ecological community. For all other impacts, the upper clearing limits will be assessed as per the mapped plant community type.

Step 4c – The data collected during site scouting will be used to recommend refined infrastructure locations and alignments to maximise avoidance, whilst remaining within engineering limits for construction and operation. The data collected during site scouting will also be used to inform future desktop reviews (Steps 1 to 3).

Step 4d – Following completion of the ecological micro-siting component, a constructability scout will be performed to confirm the preferred refined infrastructure locations and alignments.

Step 4e – Following completion of the ecological micro-siting component and constructability scout, a cultural heritage pre-clearance survey will be conducted within the preferred refined infrastructure locations and alignments:

- this survey will be undertaken in accordance with the process described in section 5.8.5 of the Aboriginal Cultural Heritage Management Plan (**ACHMP**) and confirm the presence or absence of Aboriginal cultural heritage sites;
- all currently known sites will be avoided; and
- if Aboriginal cultural heritage sites are encountered in the recommended area then the survey area will extend to the original marked out area plus buffer in the vicinity of the find. The procedures outlined in the ACHMP will be implemented, including the avoidance commitments by Aboriginal site type. Where a repositioning of infrastructure to avoid Aboriginal cultural heritage features can be conducted without causing additional impact to ecological features and attributes, the alignment will be modified immediately. Otherwise, an iterative approach (a repeat of some or all of steps 4a to 4e) will be followed to position and reposition the infrastructure until a location can be determined that ensures overall ecological impact is minimised whilst fully complying with avoidance commitments by Aboriginal site type.

The cumulative ecological disturbance limits will then be verified. The Field Development Plan will include a trigger action response plan (TARP) to avoid exceedances of the various performance criteria. This is further addressed in section 5.4 of the Field Development Plan.

Table C1 - Ecological avoidance hierarchy in order of priority

Priority	Ecological feature of attribute	
1	**Endangered Ecological Communities by listing status**	
	Ranking (highest to lowest)	**Status**
	1	EPBC Act Endangered
	2	BC Act Endangered
2	**Threatened flora species prioritised by listing status**	
	Ranking (highest to lowest)	**Status**
	1	EPBC Act Critically Endangered
	2	BC Act Critically Endangered
	3	EPBC Act Endangered
	4	BC Act Endangered
	5	EPBC Act Vulnerable
	6	BC Act Vulnerable
3	**Hollow-bearing trees prioritised by size class**	
	Ranking (highest to lowest)	**Size class (hollow)**
	1	> 300 millimetres (**mm**)
	2	> 200 mm < 300 mm
	3	< 200 mm
4	**Significant fauna habitat (e.g. Pilliga Mouse habitat, nests including stick nests for raptors, mistletoe, termite mounds, hollow logs and rock piles)**	

<u>Step 5 – Complete final survey and mark-out of the development area.</u>

The final infrastructure locations and alignments will then be surveyed and delineated in the field. Delineation will be achieved through the installation and application of a combination of survey stakes and pegs, flagging tape and marking paint to identify the boundaries of the development area, the limits of clearing and any ecological features to be avoided or relocated.

Design

Step 6 – Detailed design and management control planning

Detailed designs and management practices for the proposed development are finalised after considering:

- constructability; and
- environmental and construction hazards and risks; and management controls (to mitigate potential impacts) and management practices (for example erosion and sediment controls).

Step 7 – Final check to verify compliance with all Project conditions and management plans

A final check for the proposed infrastructure locations to ensure compliance with locational criteria, regulatory conditions and management plans.

Step 8 – Prepare and submit a Field Development Plan

In accordance with CoC B4 and B5, prior to the construction of any gas field infrastructure, Santos will prepare a Field Development Plan for the applicable gas field infrastructure for each phase to the satisfaction of the Planning Secretary. This plan will:

- be prepared by a suitably qualified and experienced person/s;
- include detailed plans of existing gas field infrastructure in the Project area, and proposed gas field infrastructure to be developed under the Field Development Plan;
- include incremental and cumulative analysis of compliance with the locational criteria;
- provide detailed consideration of the proposed gas field infrastructure for each phase against the provisions of the Field Development Protocol. There may be multiple plans for each phase, with the Field Development Plan being revised and updated to reflect the scope of the proposed infrastructure, including wells, core holes, groundwater monitoring wells, gathering lines, roads, tracks, seismic surveys, flaring infrastructure, utilities and services;
- provide the results of all surveys undertaken as part of in-field micro-siting;
- describe the performance criteria to be implemented to ensure compliance with the water performance measures in Table 7 of the CoC, and to meet the rehabilitation objectives in Table 11 of the CoC, including a:
  - TARP to identify risks and actions to avoid exceedances of the performance criteria, including tiered triggers to provide for early detection of impacts; and
  - contingency plan that expressly provides for adaptive management where monitoring indicates that there has been an exceedance of the performance criteria, or where an exceedance appears likely;
- include site-scale ecological constraints maps, to quantify impacts/avoidance of impacts and reflect compliance with ecological disturbance limits set out in Tables 8, 9 and 10 of the CoC;
- include a:
  - Public Safety Management Plan, prepared in consultation with Rural Fire Service, the Forestry Commission of NSW and NSW Health, to ensure public safety and manage access in the Project area, including verification of minimum safe separation distances

between all potentially hazardous facilities; and

- Property Management Plans, prepared in consultation with landowners upon which gas field infrastructure is proposed to be located, to manage impacts and access arrangements on the properties.

Each Field Development Plan will be prepared in consultation with the:

- EPA, DPE Water, BCS, Resources Regulator, Heritage NSW and Council;
- owners of land not owned by Santos, upon which gas field infrastructure is proposed to be located;
- CCC;
- Water Technical Advisory Group;
- Greenhouse Gas Emissions Advisory Group;
- Aboriginal Cultural Heritage Advisory Group; and the
- Biodiversity Advisory Group.

The Field Development Plan will be submitted to DPE for approval prior to implementation. Digital spatial datasets of existing and proposed infrastructure will also be provided. Once approved, the Field Development Plan will be made publicly available on the Project website.

Appendix D - Clearing procedure

The following clearing procedure has been developed to minimise potential impacts or risk to fauna during construction. The purpose of the procedure is to encourage fauna to relocate outside of the disturbance footprint prior to habitat clearing or alternatively move fauna during clearing. A pre-clearing survey by appropriately trained ecologists or fauna spotter-catcher is required to be undertaken prior to commencing clearing. The pre-clearing survey includes marking all hollow-bearing trees or other significant fauna habitat features (nests, termite mounds, rock piles, hollow bearing logs and stags) with highly visible flagging tape different to any tape used for demarcation of boundaries and recording the location using a GPS.

The clearing procedure outlines best practise and is designed to be adaptive depending on site-specific conditions that arise during clearing. The clearing procedure will follow four steps:

1. Planning
2. Slash shrub and ground layer
3. Tap hollow-bearing trees
4. Remove hollow-bearing trees and other significant fauna habitat features

Prior to the commencement of clearing, the boundary of the active works area should be clearly marked in the field with high visibility flagging tape (or equivalent) and environmental protection exclusion zones should be clearly marked in the field to ensure all clearing and construction activities occur within the approved footprint. All access to active work areas should be through existing roads and designated service corridors.

Step 1: Planning

1. All appropriate licences with respect to working with native fauna are to be obtained prior to clearing.
    a. Ecologists working with fauna require a current scientific licence issued by the NSW Department of Planning, Industry and Environment and ethics approval issued by the Animal Welfare Unit of the NSW Department of Primary Industries.
    b. Project Approval is required.
2. The nearest veterinary clinic should be notified of the clearing works prior to clearing commencing and their phone number on hand if fauna are injured or distressed.
    a. Veterinary clinic:
        - Practice: Western Namoi Veterinary Clinic
        - Principal Vet: Dr Michael Reed
        - Contact: 02 6792 4388
        - Address: 24 Francis Street, Narrabri.
    b. WIRES: 13 000 WIRES or 13 000 94737
    c. WIRES (central northern branch): 1300 131 554
3. Discuss clearing procedure, equipment / machinery required, schedule. All staff and contractors involved in the clearing will undertake the ecological induction prior to commencing work.
4. Where reasonable and feasible if non-relocatable fauna are detected in a clearing area works should be rescheduled to allow time for the individuals to relocate prior to commencement.

Step 2: Transplanting, propagation and/or salvage of threatened flora

Threatened flora observed within the vegetation clearing zone during the pre-clearance inspection will be collected for translocation/ propagation by the ecologist in accordance with the *Guidelines for the Translocation of Threatened Plants in Australia* (Vallee et al., 2004), and seed collection procedure (Appendix F) where reasonable and feasible to do so prior to the commencement of vegetation clearing. Propagated/ salvaged plants will be re-established within an appropriate suitable site, i.e rehabilitated well pad of which the material has been removed from, restoration sites currently managed by Santos, or offset sites managed by Santos. Recipient site must be a PCT in which the species is predicted or known to occur in.

Step 3: Slash shrub and ground layer

Clearing of shrub and groundcover vegetation (under-scrubbing) around the hollow-bearing trees can commence, once threatened flora has been translocated and habitat features have been surveyed and marked, to encourage dispersal of fauna from the active features. Under-scrubbing should be undertaken at least one day prior to removal of hollow-bearing trees to allow fauna time to self-relocate from the disturbance footprint.

Step 4: Tap hollow-bearing trees

1. Hollow-bearing trees are to be agitated (nudged by heavy machinery or with a chainsaw) the day prior to felling and left over-night.
2. Active roosts, dens or dormitories are to be re-inspected following agitation to confirm absence of fauna prior to clearing.

Step 5: Removing HBTs and other significant fauna habitat features

1. A suitably qualified fauna ecologist or fauna spotter-catcher with training/experience in fauna capture and rescue is to be present during the felling process.
2. Pre-felling procedures for all trees to be felled will include a visual inspection for fauna immediately prior to tree removal and care should be taken to allow all fauna to vacate a given tree prior to felling. Each tree is to be nudged and shaken immediately prior to felling to encourage fauna such as birds to vacate the tree. Felling cannot commence until the supervising ecologist or fauna spotter-catcher has signalled that it is safe to do so.
3. The “slow drop” technique is to be attempted when removing all hollow-bearing trees. This technique aims to lower hollow-bearing trees to the ground whilst minimising disturbance to hollows. This involves nudging and shaking the tree, followed by lowering of the tree to the ground. Practical execution of this method may involve the use of the bulldozer blade or mulcher bar to push the tree mid-trunk to initiate felling, followed by lowering the blade / bar to the base of the tree trunk. It is essential to ensure that suitable exclusion zones are implemented during these activities and personnel are not exposed to increased risk by implementing these procedures. Job Hazard Analyses (JHAs) and step back are to be completed prior to completing felling activities.
    a. Careful demolition of other significant fauna habitat, that cannot otherwise be relocated, will be conducted at the direction of the supervising fauna ecologist.
4. Once on the ground, hollows are to be inspected for resident fauna (fibre optic camera technology is useful for deeper and angled hollows). If injured or juvenile fauna are present, they must be cared for. Injured fauna should be taken to the veterinary clinic (details above). Juvenile fauna should be taken to WIRES if it is not possible to relocate them to a suitable location. The ability for the parents to continue to care for the juvenile fauna should be

considered at this stage. Fauna captured and not requiring treatment are to be relocated into the same habitat near the point of rescue at dusk or left inside the hollow. Trees are to be left on the ground overnight giving fauna trapped in the trees an opportunity to escape. Hollows with fauna left inside should be re-checked the following day to ensure the fauna have self-relocated during the evening.

5. All data on species and number of hollow dependent fauna are to be recorded.
6. Salvage of suitable large hollows or other significant fauna habitat features will be maximised re-use in adjoining vegetation or rehabilitation areas where feasible in consultation with FCNSW. Limb and trunk hollows suitable for re-use as ground-dwelling fauna habitat will be pieced from felled trees using a chainsaw or suitable equivalent equipment and set-aside from clearing operations to be moved into adjoining vegetation or rehabilitation areas.
7. Note that if fauna are observed to be in the tree that cannot self-relocate (e.g. chicks that haven't yet fledged) it may be necessary to contact an appropriately trained ecologist, fauna spotter-catcher and/or wildlife carer to be present to encourage the removal and provide care for the animal/s. Where the animal is in good health and hasn't otherwise self-relocated, the ecologist, fauna spotter-catcher and/or wildlife carer can capture the animal for release. Any native fauna individuals that are captured during clearing operations must be released approximately 50 metres into adjacent native vegetation on the same land holding.

Communication

Positive communication between the ecologist or fauna spotter-catcher supervising the clearing and the machinery operator is paramount to clearing being undertaken in a safe and efficient manner. Communication will operate by the following procedure:

1. Daily discussion prior to work commencing, outlining the areas of operation for the day.
2. A 2-way radio will be used for communication which will be set on a dedicated channel.
3. The ecologist or fauna spotter-catcher will outline the clearing procedure to be followed. This will include outlining the following communication points during the clearing process:
    a. Confirm location ecologist or fauna spotter-catcher should stand to observe felling. The minimum safe distance when felling will be determined by the height of the tree plus an extra 10 m for observer safety (expected to be 30 m). If the mulcher drum is operational, the safe distance will be a minimum of 100 m.
    b. 'Ok to tap' to nudge the tree.
    c. 'Ok to start' to start felling the tree.
    d. 'Ok to access' for ecologist to inspect hollows in felled tree (once felling has been completed and machinery has been switched off).
    e. 'Stop work' to stop clearing due to fauna observed or a safety concern.

Lessons learnt

Previous experience in tree-felling operations have informed us of potential risks involved in the clearing operations. Areas of high risk are:

- Lack of positive communication increases the risk associated with the ecologist entering the exclusion zones and the risk of potentially injuring fauna during the clearing process.
- Not allowing adequate time between slashing vegetation, hollow-bearing tree tapping and hollow-bearing tree removal can increase the occurrence of fauna during felling.
- Not allowing adequate time for felled hollow-bearing trees to remain undisturbed can lead to increased risk to fauna.

Appendix E - Reporting template for clearing

PCT	Plant Community Type name	Condition	Upper limit	Impacts from prior stages	Current phase impacts	Limit remaining
27	**Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (BC Act and EPBC Act – Endangered)**	Native Vegetation	0.1			
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Derived Native Grassland	0.5			
35	**Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (BC Act and EPBC Act – Endangered)**	Native Vegetation	19.3			
35	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	Derived Native Grassland	37.2			
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	Native Vegetation	3.9			
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	Derived Native Grassland	1.7			
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Native Vegetation	40.8			
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Derived Native Grassland	8.8			
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	Native Vegetation	19.5			
202	**Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion (BC Act – Endangered)**	Native Vegetation	5.9			
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	Native Vegetation	0.3			

PCT	Plant Community Type name	Condition	Upper limit	Impacts from prior stages	Current phase impacts	Limit remaining
408	Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region	Native Vegetation	33.3			
408	Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region	Derived Native Grassland	0.4			
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	Native Vegetation	323.4			
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Derived Native Grassland	3.9			
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Native Vegetation	3.4			
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Derived Native Grassland	0.2			
402	Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion	Native Vegetation	1.6			
402	Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion	Derived Native Grassland	1.6			
379	Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the Brigalow Belt South Bioregion	Native Vegetation	2.7			
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the	Native	1.0			

PCT	Plant Community Type name	Condition	Upper limit	Impacts from prior stages	Current phase impacts	Limit remaining
	Pilliga - Warialda region, Brigalow Belt South Bioregion	Vegetation				
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	Derived Native Grassland	1.3			
401	Rough-barked Apple - Blakely's Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region	Native Vegetation	46.4			
401	Rough-barked Apple - Blakely's Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region	Derived Native Grassland	18.1			
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Native Vegetation	86.6			
405	White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	Native Vegetation	247.1			
405	White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	Derived Native Grassland	1.9			
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	Native Vegetation	69.0			
418	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion	Native Vegetation	0.2			
418	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion	Derived Native Grassland	0.3			
425	Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion	Native Vegetation	8.4			
		Total	**988.8**			

Notes:

Communities commensurate with a EPBC listed threatened ecological community are highlighted in **bold**.

Scientific Name	Common Name	Upper limit	Impacts from prior stages	Current phase impacts	Limit remaining
Flora (individuals)					
Bertya opponens	Coolabah Bertya	10,309			
Diuris tricolor	Pine Donkey Orchid	52			
Lepidium aschersonii	Spiny Peppercress	77,691			
Lepidium monoplocoides	Winged Peppercress	1,116			
Polygala linariifolia	Native Milkwort	252			
Pomaderris queenslandica	Scant Pomaderris	467			
Pterostylis cobarensis	Greenhood Orchid	6,658			
Commersonia procumbens	-	3,717			
Tylophora linearis	-	513			
Fauna habitat (area)					
Cercartetus nanus	Eastern Pygmy-possum	774.8			
Hoplocephalus bitorquatus	Pale-headed Snake	885.1			
Petaurus norfolcensis	Squirrel Glider	865.7			
Phascolarctos cinereus	Koala	988.8			

Appendix F - Seed collection procedure

Appendix – Narrabri Gas Project – Threatened Flora Seed Collection Procedure

Santos Limited

ecological AUSTRALIA
A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au

DOCUMENT TRACKING

Project Name	Appendix – Narrabri Gas Project – Threatened Flora Seed Collection Procedure
Project Number	15567
Project Manager	Daniel Watts
Prepared by	Liam Scanlan
Reviewed by	Gordon Patrick, Sophie Powrie
Approved by	Rachel Murray
Status	Final
Version Number	1
Last saved on	13 April 2022

This report should be cited as 'Eco Logical Australia 2022. *Santos NGP BMP Appendix - Seed Collection Procedure*. Prepared for Santos Limited.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd.

Contents

List of Figures

List of Tables

1. Purpose

The Threatened Flora Seed Collection Procedures have been prepared to guide seed collection for individuals of threatened flora species that are directly impacted by works in the project area of the Santos Narrabri Gas Project. Seed collection from impacted individuals of threatened species is a mitigation measure in the Santos Narrabri Gas Project Biodiversity Management Plan to be carried out within the project areas during Phase 1 of the project.

The plants grown from seed collected will be reintroduced to the rehabilitated well pads, or other restoration sites managed by Santos.

The purpose of these Threatened Flora Seed Collection Procedures is to ensure that:

- threatened flora species are detected and correctly identified,
- seed that is collected is of high quality with the highest chance of being viable for storage or propagation,
- correct data is collected and compiled into an accessible database,
- seeds are stored and catalogued with full traceability across collection, storage, propagation and planting.

The procedures are adapted from Florabank Guidelines (Commander 2021, version 2) for application in the Pilliga region with the relevant threatened plant species.

1.1. Why collect seed?

Propagation from seed is the preferred method to source plants for revegetation and conservation. Seed collection is used to source local genetic material and to propagate plants that are not readily available from other sources. Seed is more appropriate for medium – long term storage; can be easily transported if required for conservation purposes (e.g. storage at the Australian Botanic Garden SeedBank); and seed batches can be divided up for different propagation treatments or storage at multiple locations.

As these procedures are to be applied to individuals that will be directly impacted, it is appropriate to carry out multiple methods of propagation if there is sufficient material. In situations where low numbers of plants are involved, seed and vegetative material (for cuttings or tissue culture) may be collected from the same individual plant. Collection of vegetative material may also be undertaken when seed is unavailable; limited in quantity; or returning low germination rates.

Additionally, translocation of threatened flora species will be conducted where reasonable and feasible on a case-by-case basis in accordance with the Guidelines for the Translocation of Threatened Plants in Australia (Vallee et al. 2004). Individuals and areas that will be subject to translocation plans will be identified during the implementation of the Field Development Protocol for inclusion in the relevant Field Development Plan in consultation with the required stakeholders.

2. Licensing requirements

2.1. Collecting material from wild populations

Written permission is required for collecting seed on private or public (e.g. State Forest, National Park, local council) land including Pilliga East, Bibblewindi and Jacks Creek State Forests. Licenses will be required for collecting seed from threatened species, populations or ecological communities listed under NSW *Biodiversity Conservation* Act (BC Act) or Commonwealth *Environmental Protection and Biodiversity Conservation* Act (EPBC Act), and schedule 13 Protected native plants under the *National Parks and Wildlife Act 1974*.

2.2. Collecting material from directly impacted individuals

Additional permission or permits are not required to collect propagation material from plants within the project area that are directly impacted. Any material or plants grown must only be used for revegetation/conservation purposes and must not be sold for commercial purposes.

2.3. Contractor qualifications

Contractors engaged for seed collection should be reputable, with a demonstrable history of successful seed collection for large scale revegetation projects and experience in or knowledge of threatened flora collection/propagation in the Pilliga region, or greater Northwest Plains or Northwest Slopes regions.

Contractors undertaking seed collection should be trained in advanced plant identification skills and have access to resources (including plant profiles, botanical descriptions, photographs, GPS locations of plants) relevant to the target species listed in Table 1.

3. Seed collection methods

3.1. Target species

The plants targeted for seed collection and propagation are individuals of threatened species which will be directly impacted by the Narrabri Gas Project. **Table 1** lists the target species.

Table 1: Threatened flora species that may be targeted for seed collection

Family	Scientific name	Common name	Growth Form	Conservation status[a]	
				BC Act	EPBC Act
Euphorbiaceae	*Bertya opponens*	Coolabah Bertya	Shrub	V	V
Orchidaceae	*Diuris tricolor*	Pine Donkey Orchid	Forb (orchid)	V	-
Brassicaceae	*Lepidium aschersonii*	Spiny Peppercress	Forb	V	V
Brassicaceae	*Lepidium monoplocoides*	Winged Peppercress	Forb	E1	E
Haloragaceae	*Myriophyllum implicatum*	-	Forb	CE	-
Polygalaceae	*Polygala linariifolia*	Native Milkwort	Forb	E1	-
Rhamnaceae	*Pomaderris queenslandica*	Scant Pomaderris	Shrub	E1	-
Orchidaceae	*Pterostylis cobarensis*	Cobar Greenhood Orchid	Forb (orchid)	V	-
Malvaceae	*Commersonia procumbens*[b]	-	Shrub	V	V
Apocynaceae	*Tylophora linearis*	-	Vine	V	E

a - CE = Critically Endangered, E = Endangered (EPBC Act), E1 = Endangered (TSC Act) and V = Vulnerable.
b - Species listed as *Androcalva procumbens*, synonym for *Commersonia procumbens*, in EPBC 2014/7376. Note a recent taxonomic revision moved the species to a new genus, *Androcalva*, but *Commersonia* is used in this document for consistency with SSD-6456.

3.2. Pre-clearing surveys

A pre-clearing procedure has been developed as part of the BMP, in which key fauna habitat features (such as nests, hollow-bearing trees, and hollow logs) will be identified. Pre-clearing surveys will also identify any threatened flora species, which will be marked with flagging tape and GPS locations recorded.

3.3. Plant identification

A positive species identification is required of the donor plant. Some species may be considered taxonomically unresolved outside of New South Wales (e.g. *Polygala linariifolia*) therefore species identification must follow taxonomy accepted by PlantNET (2021).

Where identification is uncertain, a voucher sample from the plant along with representative photographs of key features required for identification should be collected. If a positive identification cannot be made, the voucher sample and photographs may be sent to an experienced botanist or NSW Herbarium for identification. Essential data to be collected for plant identification includes:

- Unique collecting number assigned to the collection by the collector

- Name of collector
- Date of collection
- Latitude and longitude
- Written description of the plant (e.g. plant height, form, flower features), collection site and habitat, and broad soil type.

Equipment for plant identification should be available in the field, such as:

- Species profiles with photographs
- Selection of both plastic and paper sample bags, jeweller's tags
- Plant press consisting at least of cardboard and newspaper
- Hand lens, camera, binoculars
- Secateurs.

3.4. Method selection

Table 2 lists the appropriate seed collection method for each species addressed in this procedure.

Manual seed collection will be an appropriate method for the majority of the species (Table 2). Seed traps are recommended for all species and must be used for orchid species.

Mechanical seed collection methods are not recommended.

3.4.1. Manual collection

Stems/branches holding a large amount of seed can be removed from the plant for processing. The amount of non-fruit material that is collected should be minimised to reduce damage to plants (particularly if whole plant translocation is also being considered) and assist the processing method. Fruit can be collected by hand and transported in ziplock bags, or brown paper bags if drying is required. Secateurs must be clean and sharp to reduce the impact to the plant.

Table 2: Harvest methods for target species

Scientific name	Seed dispersal mechanism	Harvest methods
Bertya opponens	Wind	Seed trap or strip mature fruit by hand
Diuris tricolor	Wind	Seed trap or collect mature capsule
Lepidium aschersonii	Gravity/wind/water	Seed trap or strip mature fruit by hand
Lepidium monoplocoides	Gravity/wind/water	Seed trap or strip mature fruit by hand
Myriophyllum implicatum	Wind/water	Collect cuttings
Polygala linariifolia	Gravity/wind/water	Seed trap or strip mature fruit by hand
Pomaderris queenslandica	Gravity/water	Seed trap, strip mature fruit by hand, or sieve soil seed bank
Pterostylis cobarensis	Wind	Seed trap

Scientific name	Seed dispersal mechanism	Harvest methods
Commersonia procumbens	Gravity/water	Seed trap, strip mature fruit by hand, or sieve soil seed bank
Tylophora linearis	Wind	Seed trap

3.4.2. Seed traps

Seed traps can be used to catch seed when it is dispersed from the parent plant, when the timing of seed shed is uncertain or when seed maturation is spread over a long period of time.

A simple seed trap can be made by placing an organza bag (or bag made from other light weight, breathable, UV resistant material) over the immature fruit structure (**Figure 1**). The bag must be fastened appropriately (e.g. with cord or zip tie) so the seed cannot fall out, and the bag cannot be lost.

Figure 1: Seed trap on immature grass seeds to be collected later (Photo: Commander 2021)

4. Seed processing methods

Appropriate seed processing will maximise seed viability and storage longevity. The method for processing seed consists of:

1. Place seed bearing material into appropriate storage area for post-harvest drying (dry and free from pests) to allow material to dry and for seed to be released from fruit (**Figure 2**).
    - Material can be dried in a container outdoors in direct sunlight or indoors in a dry, warm position. Care should be taken if seeds are dried outdoors to ensure seeds are not blown away or become wet in rain or condensation. Re-wetting of seed can lead to a rapid loss in viability.
    - Severe damage to seed lots can occur if air circulation is poor and the humidity and temperature within the drying material rises.
2. If necessary, extract seeds from fruits or dry fruit further if seeds aren't readily dislodged.
3. Clean seeds to remove chaff and non-seed using sieves and mesh screens if needed.
4. Dry the seed prior to storage and then store the seeds under appropriate conditions.

Post-harvest storage:

For mature seeds, as soon as the collection arrives at the processing facility it should be stored under dry conditions to prevent mould and maximise longevity. Ideal conditions are 15-30°C and <50% relative humidity (RH).

For immature fruits/seeds, retain seeds within fruits and on stems or branches if applicable. Hold material under (natural) ambient conditions for 1 – 2 weeks until signs of maturity are evident, then dry as for mature seeds.

Ideal pre-storage drying conditions are:

- Prior to long- or medium-term storage: 15-20°C and 15-20% RH.
- Prior to short-term storage: ~23°C, <50% RH.

Figure 2: Seed in trays placed on shelves to dry. Perforated trays increase air flow, as long as seeds cannot fall through perforations (Photo by Commander 2021)

5. Seed storage

Appropriate seed storage is required to maintaining seed quality and viability from the time of collection to the time of propagation. Seed storage primarily focuses of controlling storage temperature and seed moisture content. As a general rule, the longer the intended storage period, the cooler and direr the storage conditions should be (**Table 3**) (Commander 2021).

Table 3: Recommended storage specifications for different storage duration and purposes

Variables	Specifications		
Storage duration and purpose	**Short (< 5 years) for restoration/revegetation**	**Medium (5-10 years) for restoration**	**Long term (>10 years) for conservation**
Size of collection	Large or small scale	Large or small scale	Small scale
Drying conditions	Air-conditioned room approx. 23° C; ambient conditions (indoor or outdoor) if relative humidity <50%.	Relatively humidity 15-20%, temperature 15-20° C	Relatively humidity 15-20%; temperature 15-20° C
Storage conditions	Air-conditioned room approx. 30° C, or refrigerator or cool room (5-15° C); ambient relative humidity <50%	Refrigerator or cool room (5-10° C); relatively humidity 15-20%	Freezer (minus 20° C)
Storage containers	**Small batches** – calico bags, sealed plastic sandwich bags placed within sealable plastic/glass food containers **Large batches** – large calico bags, woven polypropylene bags, wool bales	As per short-term storage and if RH of room 15-20%. Press sealed or heat-sealed plastic bags for small collections if RH of room 15-20%. Air-tight, seal laminated foil bags or glass jars to small collections and if RH not controlled (e.g. a refrigerator).	Air-tight, sealed laminated foil bags. Glass jars.

It is recommended that seed is stored within labelled sealed plastic bags, in labelled plastic/glass food storage containers in a refrigerator. Separate seed batches must be individually labelled and stored in their own sealed plastic bags. Storage bags of the same species can be stored in the same plastic/glass container.

6. Adjunct methods

6.1. Collection of vegetative propagation material

As seed is being collected from individuals that will be directly impacted, it is also appropriate to propagate these individuals from vegetative material or by translocating the whole plants.

Vegetative propagation should be prioritised for species that do not reliably produce viable seeds, with seed collection undertaken secondarily.

For species that do reliably produce viable seed, vegetative propagation can be used to produce additional plants which will increase nursery stock as an insurance against poor seed germination, or failure of seedlings grown from seed.

Collection of vegetative material to propagate cuttings is useful for species that do not reliably set seed, when germination from seed is difficult, or if seed is very limited. If whole plants are selected to be physically translocated, material that is removed to reduce transpiration from translocated plants may be used to strike cuttings. Propagation from vegetative material is the main method recommended for propagation of *Myriophyllum implicatum*.

Collection of cutting material uses the same principles for most species.

6.1.1. Field procedure

- Take cuttings from healthy plants. Depending on the species, cuttings may be taken from old or new growth. Generally, cuttings are best taken from stems after around one year of growth, when they are not too soft or hard.
- Using sterilised secateurs, cut stem lengths 10-20 cm where possible (depending on species and availability of plant material).
- Place cuttings directly into large plastic bags (e.g. large sealable sandwich bags), with a generous spray of water, and seal the bag.
- Store collection bags flat and out of the sun in an esky or bag to transport to vehicle.
- Once at the vehicle, store collection bags in a fridge (or chilled esky if available) set at about 6-7° C for transport to the nursery.
- Transport to with nursery immediately or within 2 days at most. If the transport is longer, re-package the cuttings in damp paper towel in collection bags.

6.1.2. Nursery procedure

- Ensure working area is sterilised and use sterilised cutting equipment.
- Cut lengths of plant approximately 7-10 cm. Cut the stem just below a leaf node.
- Remove approximately 3/4 leaves from the cutting, leaving some remaining at the top of the cutting (**Figure 3**). Removal of leaves may not be required for some species e.g. *Lepidium aschersonii*.
- For plants with large leaves (e.g. *Bertya opponens*), cut remaining leaves in half.
- For cuttings with hardened stems (woody), a fine outer layer of the stem can be scrapped back to exposure the cambium layer.
- Dip lower portion of cutting in rooting hormone, wiping of excess liquid/powder.

- Use a small dibbling stick to create holes in the propagation media to a similar size of the cutting.
- Place cutting in the hole and gently press around the base to keep cutting upright.
  Keep cuttings warm and moist, but not wet, in a glasshouse environment.

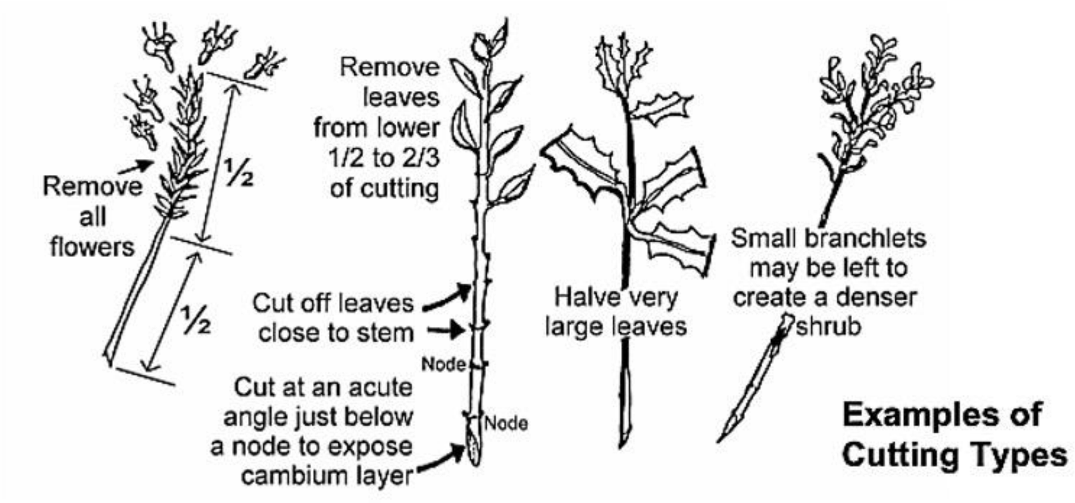


Figure 3: Examples of cutting types and methods (Illustration by Australian Plant Society NSW)

6.2. Translocation and salvage of whole plants

Any individual plants of threatened species may be considered for translocation, where reasonable and feasible, considered on a case-by-case basis.

Translocating individuals is a cost-effective method of establishing additional plants in-situ or ex-situ that do not need to be grown in a nursery.

The following points will be used to prioritise individuals for translocation:

- High chance of failure of nursery grown plants (e.g. orchids)
- High conservation value (e.g. Endangered plants may be considered higher priority for translocation than Vulnerable plants)
- Benefit in establishing new populations (e.g. species with very low abundance in the study area)
- Readily available recipient site adjacent to impacted areas (e.g. a restoration site is close to the impacted site and plants can be translocated directly into the restoration site)
- High chance of translocation success (e.g. species with

6.2.1. Translocation procedure

Removal of plants should occur in the early morning and plants should not be moved in conditions of high temperatures or strong winds. Plants should be watered with a solution of water and Seasol 9 L : 30 mL within one hour of being removed from the ground to reduce the transplanting shock (unless there has been high rainfall in the previous 12 hours e.g. >20mm). Plants may have up to 20% of excessive upper foliage trimmed to reduce transpiration, if deemed necessary due to leggy growth or high foliage cover. Small seedlings are unlikely to require removal of foliage.

Plants may be removed by hand in a mass of soil approximately 50 cm diameter by 50 cm deep, centred on the existing stem. The soil wads should be carefully removed from the ground and bundled with hessian material to retain as much soil as possible (including as much in-situ Mycorrhizal fungi as possible).

The plants are to be transported by either wheelbarrow or 'Dingo' mini digger and planted into prepared holes at the new translocation site. Plants can be gently covered with damp hessian material (or similar) to protect from sun exposure or wind if needed.

Care must be taken to ensure the shape of the recipient hole conforms to the shape of the soil wad to prevent air spaces in the soil or settling that could adversely affect plant survival. Soil wads are to be placed into their recipient hole, backfilled with soil that was removed from the hole, and watered again, ensuring all air spaces are filled with soil and adequately compressed to ensure the roots are well protected and stable.

6.2.2. Salvage of whole plants

Impacted plants that are not going to be translocated may be salvaged and stored in a nursery setting for planting at a later date. Plants should be removed from the ground as per translocation methods. Small plants can be removed from the ground with a smaller soil wad. The plants can then be placed in an appropriately sized container (large enough to contain soil wad) and stored under shade cloth with regular irrigation and no impedance to container drainage. A potting mix of 4 parts composted pine bark to 1-part perlite may be used to fill gaps between the soil wad and plant container. Plant condition should be monitored with changes to watering or shade cover made as needed.

Plants should gradually be hardened off in sunlight prior to planting.

7. Recipient sites

There are several options for appropriate recipient sites in which the propagated/salvaged plants can be planted into.

The most appropriate site is the rehabilitated well pad that the material has been removed from.

Restoration sites currently managed by Santos may also be utilised for replanting.

Offset sites managed by Santos can also be used for replanting the threatened species. Recipient sites must be a Plant Community tType (PCT) in which the species is predicted or known to occur in.

8. Threatened species propagation notes

Threatened species can be challenging to propagate and there is limited, published trial data. **Table 4** provides a summary of current literature on propagation methods, seed collection timing, and additional notes on propagation difficulties.

Propagation by seed and / or vegetative material is recommended. For species that indicate cuttings and seed are suitable propagation methods, it is recommended that both methods are utilised / trialled. In situations where low numbers of plants are involved, seed and vegetative material may be collected from the same individual plant. Propagation difficulty has been predicted based on the literature review and past experience propagating plants in the same genera / family.

Table 4: Threatened species and propagation notes

Scientific name	Predicted propagation difficulty			Timing	Notes
	Seed	Cuttings	Translocation		
Bertya opponens	Moderate	Moderate	Moderate	Flowering time is July and August, although seed formation can commence as early as July, especially in Jacks Creek State Forest (OEH 2021).	Species in the Euphorbiaceae family generally can be propagated reliably from cuttings. Reports of this species resprouting from rootstock following disturbance suggests vegetative reproduction is possible (NPWS 2002). Other *Bertya* species have been shown to be difficult to propagate (Trueman and Roberts 2016). Seed traps are recommended for seed collection. Propagation from seed may involve treatment with gibberellic acid (Scott (1997) cited in NPWS (2002)). Wildfires may increase the rate of germination from the seed bank, suggesting that imitating fire through hot water treatment or smoke water may improve germination. Cuttings or whole plant translocation is recommended following methods of Trueman and Roberts (2016). The Jacks Creek State Forest population usually flowers July to August, with this population having the highest observed abundance of male and female flowers of any of the four main populations. The flowers per area of foliage were as high as 150 flowers/m^2 on some individuals (J. Austen pers. comm. cited in NPWS (2002)). This may reflect the apparent overall health of this population but may also have been influenced by above average rainfall recorded at the time of surveying in 1998 (NPWS 2002). For *Bertya* spp., Ralph (1994) states oval papery capsules, 8-10mm long, dry capsules to open and sieve to clean. Ralph (2003) states grown from seed. Sow within 6 months of collection.
Diuris tricolor	Difficult	N/A	Moderate - difficult	Peak flowering has been observed in mid- to late-September, but less than 20% of plans may flower on a given day. Therefore a 'one-off' survey may overlook the majority	Hand pollination may be appropriate to maximise seed set, and seed traps must be used for seed collection. Propagation requires specialised equipment that is generally not part of a native plant nursery. Specialists with previous experience

Scientific name	Predicted propagation difficulty			Timing	Notes
	Seed	Cuttings	Translocation		
				of a population (Vizer (2013) cited in Bell (2019)). OEH (2021) lists peak flowering as early October.	growing orchids from seed should be engaged (e.g. Australian Botanic Gardens, Mount Annan or Royal Botanic Gardens Victoria, Cranbourne) if growing this species from seed is necessary. In the Hunter Valley, translocation of individuals of this species has been successful and whole plant translocation methods may be based on Bell (2021). Capsule production has been observed to occur in less than 3% of plants with herbivory identified as a limiting factor in seed production (Vizer (2013) cited in Bell (2019)).
Lepidium aschersonii	Moderate - easy	Moderate - easy	Moderate - easy	Recorded flowering from Spring to Autumn. Plants in the Narrabri population have been observed producing abundant seed. Populations have been known to immediately disappear following inundation by flooding, reappearing several seasons later. An apparent increase in numbers during drought conditions has also been observed (OEH 2021).	Successfully translocated in Victoria (Silcock 2021) with high survival rate in first year and 60% of plants producing fruit. High plant death the following year due to drought conditions and herbivory from ducks. No recruitment recorded. No literature available on propagation from seed. Anecdotal evidence suggests cuttings are likely to be appropriate and it is suggested that ongoing recruitment for seed germination may require disturbance (Silcock 2021). Seed trapping and protection of plants during fruiting period may reduce plant damage from feral pigs and improve seed collection yield. For *Lepidium* spp. Ralph (2003) states seed usually provides moderate to good results. First seedlings emerge in 2-4 weeks. *L. ferdinandi* and *L. muelleri* have best results at lower temperatures (around 12°c). *L. oxytrichum* has best results at 20°c. Seed of *L. calapycnon* may be dormant. GA3 treatment (25mg/l) resulted in 90% germination for *L. calapycnon.*
Lepidium monoplocoides	Moderate - easy	Moderate - easy	Moderate - easy	Recorded flowering in spring and summer (Mavromihalis 2010) while OEH (2021) advises flowering occurs from late winter to spring, or August to October. OEH (2021) advises	Successfully translocated whole plants in Victoria (Silcock 2021) with high survival rate and high rate of second generation. Cuttings and seed are also likely to be

Scientific name	Predicted propagation difficulty			Timing	Notes
	Seed	Cuttings	Translocation		
				to use seed-heads to identify. Survey about 1 month after significant rain.	appropriate. Seasonal abundance (natural seed germination) is highly dependent on rainfall (Mavromihalis 2010). For *Lepidium* spp. Ralph (2003) states seed usually provides moderate to good results. First seedlings emerge in 2-4 weeks. *L. ferdinandi* and *L. muelleri* have best results at lower temperatures (around 12°c). *L. oxytrichum* has best results at 20°c. Seed of *L. calapycnon* may be dormant. GA3 treatment (25mg/l) resulted in 90% germination for for *L. calapycnon.*
Myriophyllum implicatum	Moderate	Moderate - easy	Moderate	Hunter (2017) recommends surveying in late winter to late spring when inundation has occurred in wetlands and is only recently receding. OEH (2021) advises survey after inundation, more than once if not found at first survey, over a 2 month period. Species can also be detected by soil seed analysis. Very difficult to identify and requires sample and confirmation from Botanic Gardens. Does not persist for very long when dry. Flowering is reported from August into summer, and fruiting until February.	No literature currently exists on propagation methods for this species, although it readily forms roots from stems, and as such, cuttings should be appropriate for plant propagation. Seasonal abundance (and available seed and plant material) is likely to be highly dependent on rainfall and inundation of ephemeral gilgai wetlands (Hunter 2017). If known plants cannot be found in a given year due to low rainfall, soil seed bank samples may be taken, transferred to native plant nursery, placed in a wetted, but not inundated growing media within a glasshouse environment (Hunter 2017).
Polygala linariifolia	Moderate - easy	Moderate - easy	Moderate - easy	Recorded flowering September – February. OEH (2021) advises use flowers to identify, as easily confused with Polygala japonica. Reliably flowering, Oct - Feb, but will flower sporadically at other times thoughout the year. OEH (2021) also notes that recent surveys in the Pilliga area observed significant declines in populations over autumn and winter, apparently the result of P. linariifolia increasing with the previous summer's high rainfall then declining under below-average conditions.	Seed and cuttings likely to be appropriate for propagation subject to availability of seed/vegetative material. Plant may be less abundant during dry periods and becoming abundant with higher rainfall. No literature exists on propagation.

Scientific name	Predicted propagation difficulty			Timing	Notes
	Seed	Cuttings	Translocation		
Pomaderris queenslandica	Difficult	Moderate	Moderate	Recorded flowering spring – summer.	Has been successfully grown from seed and cuttings. Seed has been collected using seed traps and by sieving soil (Whitehaven 2017). Germination from seed will likely require heat treatment to simulate fire conditions. Heat treatment may be undertaken by hot water treatment or heat shock treatment. Heat shock treatment has been trialled on Pomaderris species in Tasmania and involves subjecting the seeds to short periods of high temperatures (e.g. 80, 110, 140, and 170 °C for five minutes (Moro et al. 2021) or 60, 80, 100 and 120 °C applied for 10 minutes (Hanley and Lamont 2000). For *Pomaderris* spp. Ralph (1994) states close monitoring is required as clusters of small capsules release seeds at maturity. Cut clusters of unopened capsules that are brown, paper and dry. Seed is light brown. To extract seed from dry capsules, rub against a fire wire screen. Seed may require scarification. For *Pomaderris* spp. Ralph (2003) states seed requires heat treatment for good results. Usually has high viability. Hot or boiling water treatment dramatically improves results. Dry heat is also very successful e.g. *P. halmaturina* has very good results after dry heat treatment (10 minutes at 150°c). A follow-up treatment with smoke may further improve results. Also propagated from cuttings.
Pterostylis cobarensis	Difficult	N/A	Moderate - difficult	OEH (2021) advises to use flowers to locate and identify, September – November, usually in October. Rosette growth and flowering dependent on soaking rains in autumn and winter. Plants are deciduous and die back to the large, underground tubers after seed release or in dry weather, and become undetectable.	Various *Pterostylis* species have been translocated as whole plants, protocorms or grown from seed in South Australia and Victoria (Silcock 2021). Success has generally been low due to failure of plants to establish or due to inappropriate development of translocation area.

Scientific name	Predicted propagation difficulty			Timing	Notes
	Seed	Cuttings	Translocation		
					No literature exists on propagation of this species from seed. Hand pollination may be appropriate to maximise seed set and seed traps must be used. Propagation requires specialised equipment that is generally not part of a native plant nursery. Specialists with previous experience growing orchids from seed should be engaged if growing this species from seed is deemed necessary.
Commersonia procumbens	Moderate - difficult	Moderate	Moderate	Flowering has been recorded from August to December with fruiting period summer to autumn.	*Commersonia* species have been from propagated from seed and cuttings and whole seedlings translocated with no readily available information on the success of these projects (Silcock 2021). The species appears to produce seed which persists long-term in the seed bank. Large germination events have been observed following bushfires where the species was not recorded prior to burning. Soil sieving may be appropriate for seed collection if no other method is available. Seed may require heat or smoke treatment considering the species association with fire events. For *C. bartramia*, Ralph (2003) states seed has good results following treatment with boiling water. Fresh seed is recommended; however, older seed may be worth trying.
Tylophora linearis	Moderate - easy	Moderate - easy	Moderate - easy	Flowering has been reported during November, March, April and May (Whitehaven 2017). Flowers in spring, with flowers recorded in November or May and is suspected to be related to rainfall, with fruiting probably 2 to 3 months later (OEH 2021).	Has been successfully grown from seed (Whitehaven 2017). Collect seed with seed trap. Propagation of tissue culture at a suitable laboratory may be considered. For *Tylophora* spp. Ralph (2003) states usually grown from cuttings.

9. Additional considerations for orchid species

Terrestrial orchids are typically associated with mycorrhizal fungi that are considered necessary for seed germination and growth. Successful orchid propagation will require isolating collected seed, isolating mycorrhizal fungi (from hyphal coils from mature orchid plants (Batty et al. 2001) or seed baiting (Somberville et al. 2008)) and culturing the mycorrhizal fungi on agar plates in a sterile laboratory environment so it can be sown with the orchid seeds. The methods for this process are well established, however may be time consuming and costly compared to translocation which has been successfully undertaken for *Diuris tricolor* (Bell 2021).

Propagation from seed has benefits such as providing a source of seed for long-term storage and allowing multiple plants to be propagated from a single seed-bearing individual.

It is recommended that orchid propagation methods are developed, and work is undertaken in consultation with organisations that have first-hand experience such as the Australian Botanic Gardens, Mount Annan and NSW Department of Planning and Environment.

10. Data collection and record keeping requirements

Meticulous record keeping is required to ensure accountability, traceability and quality assurance across all aspects of the seed supply chain. Record keeping will track species collected, quantity of seed collected, and all associated field data, which will be used when planning propagation and future planting actions.

The collection of propagation material and subsequent propagation of understudied species presents an opportunity to trial various methods and contribute valuable information to the field of threatened flora conservation. This requires seed collection and propagation regimes to be documented so that it can be repeated in the future by other conservation practitioners.

When new seed or vegetative material comes into the nursery, the seed collection data (**Table 5**) must be entered into the seed batch database as soon as possible (**Table 6**). A unique identification number will be assigned to the seed batch which will remain with the seed batch across the seed to planting process. At least one physical tag, with the seed batch number, must always remain with the seed through the drying, processing, storage and propagation stages.

Data collection for propagation trials will vary depending on the methods employed. Details such as trial methods, and data to be collected should be planned in advance.

Table 5: Seed collection field data sheet

Collector number:	**Collector name:**
Company:	
Voucher reference:	
Species name:	
Species confirmed by:	
Collection Latitude:	Longitude:
Location (State, region, LGA, property/park name, nearest road):	
Collection date:	
Population size:	Number of plants collected from:
Collection area:	
Plant description (height, flower colour, leaf morphology, leaf colour, bark, form, habit):	
Habitat description:	
Soil colour and texture:	
Topography:	
Vegetation community:	
Associated species:	
Additional collection notes:	

Table 6: Example seed batch database

Seed batch number	Scientific name	Common name	Date collected	Collected by	Location	Site description	Notes
#001							
#002							
#003							
#004							
#005							

11. References

Bell, S.A. (2019). Translocation 'success' is all about detection: experiences with two threatened orchids from the Hunter Valley of NSW. Threatened plant translocation case study. Available: https://www.anpc.asn.au/wp-content/uploads/2019/09/APC_28-1_Jun-Aug19_Bell.pdf

Bell, S.A. (2021). Successful recruitment following translocation of a threatened terrestrial orchid (*Diuris tricolor*) into mining rehabilitation in the Hunter Valley of NSW. Ecological Management and Restoration. Available: https://onlinelibrary.wiley.com/doi/10.1111/emr.12473

Commander, L.E., Coates, D.J., Broadhurst, L., Offord, C.A., Makinson, R.O., Matthes, M. (2018). Guidelines for the Translocation of Threatened Plants in Australia. Second Edition. Australian Network for Plant Conservation, Canberra.

Commander, L.E. (Ed) (2021). FloraBank Guidelines - best practice guidelines for native seed collection and use, 2nd edn, FloraBank Consortium, Australia.

Hanley, M., Lamont, B. (2000). Heat pre-treatment and the germination of soil- and canopy-stored seeds of Western Australian species. Acta Oecologica. 315-321. 10.1016/S1146-609X(00)01087-0.

Hunter, J. (2017). Survey for Myriophyllum implicatum (in the Pilliga reserve network). Available: https://www.researchgate.net/publication/315115742_Survey_for_Myriophyllum_implicatum

Silcock, J., Simmons, L., Monks, L., Dillon, R., Coates, D. (2021). Australian Plant Translocation Database. Australian Network for Plant Conservation, The University of Queensland. Data Collection.

Mavromihalis, J. 2010. National Recovery Plan for the Winged Peppercress Lepidium monoplocoides. Department of Sustainability and Environment, Melbourne. Available: https://www.awe.gov.au/sites/default/files/documents/lepidium-monoplocoides.pdf

Moro, A., Bravo, S., Abdala, N., Borghetti, F., Chaib, A., Galetto, L. (2021). Heat shock effects on germination and seed survival of five woody species from the Chaco region, Flora, Volume 275, 2021, 151751, ISSN 0367-2530, https://doi.org/10.1016/j.flora.2020.151751. (https://www.sciencedirect.com/science/article/pii/S0367253020302504)

NPWS (2002). Bertya sp. Cobar-Coolabah (Cunningham & Milthorpe s.n., 2/8/73) Recovery Plan. NSW National Parks and Wildlife Service, Hurstville NSW. Available: https://www.awe.gov.au/sites/default/files/documents/bertya-sp.pdf

Office of Environment and Heritage (OEH). (2021). Threatened biodiversity profiles. NSW Government. Available: https://www.environment.nsw.gov.au/threatenedspeciesapp/

PlantNET (The NSW Plant Information Network System). (2021). Royal Botanic Gardens and Domain Trust, Sydney. Available: https://plantnet.rbgsyd.nsw.gov.au

Ralph, M. (1994). Seed Collection of Australian Native Plants For Revegetation, Tree Planting and Direct Seeding. Second Edition. Published by Murray Ralph, Victoria, Australia.

Ralph, M (2003). Growing Australian Native Plants from Seed. For revegetation, tree planting and direct seeding. Second Edition. Published by Murray Ralph, Victoria, Australia.

Trueman, R., Roberts, K. (2016). Propagation of Pomaderris clivicola and Bertya pedicellata FINAL REPORT. Published by Genecology Research Center, University of the Sunshine Coast (USC). Available: https://www.northburnett.qld.gov.au/wp-content/uploads/2016/09/023-Vegetation-Offset-Plant-Propagation-USC-Feb-2016.pdf

Vizer, C. (2013). Contributions to the understanding of the ecology and biology of D. tricolor and Prasophyllum sp. Wybong in the Upper Hunter Region, NSW. Thesis for Bachelor of Environmental Science and Management (Hons), University of Newcastle, May 2013.

Whitehaven Coal Limited (2017). Maules Creek Biodiversity Management Plan. Available: https://whitehavencoal.com.au/wp-content/uploads/2019/08/MCC-Biodiversity-Management-Plan.pdf

1300 646 131
www.ecoaus.com.au

Appendix G - Soundscape analysis

Soundscape stations

Monitoring sites will be located at reference locations and paired impact and control sites associated with either a coal seam gas (CSG) well pad or other infrastructure across the project. At paired monitoring sites, the impact site is in an indirect impact area within the 20 m buffer zone around the well pad/infrastructure and the corresponding control site is within equivalent habitat type at least 500 m away from impacted areas and 300 m from vehicle tracks wherever possible. The paired monitoring sites are located within the same habitat type, broad condition class and on similar topography to avoid potential confounding effects from these factors.

Sound Recording

Recorders set up to record for soundscapes will also provide ample data for species composition analysis.

Equipment

Dedicated commercially available digital sound recorders such as Wildlife Acoustics Song Meter or Frontier Labs Bioacoustic Audio Recorder will be used. The same make and model recorder will be used throughout the project and in all sample locations.

The recorders may be deployed short term (e.g. up to 1.5 months for a Song Meter SM4) using internal batteries or may be installed longer term and powered by a solar panel and external battery. The same set up will be applied throughout the project.

SanDisk branded Ultra or Extreme SD cards with high speed rating (currently Class 10 or at least UHS Speed Class 1) will be used.

Recorder set up

The latest firmware will be applied to each recorder prior to each deployment.

Each recorder will be given a standardised prefix indicating the physical site location or landmark and type (e.g. control vs impact). By default, this prefix will be added to the name of each sound file recorded and allow for easy data handling.

Recorders will be programmed to record in uncompressed .wav format for at least 120 hrs (equivalent to 5 days of continuous recording) (see Bradfer-Lawrence et al. (2019)) in 10-minute blocks using a 44.1 kHz sampling rate on a single channel (Mono). Data storage using 10-minute blocks improves the ease of data processing and limits the risk of data loss in the case of a recorder failure part way through a deployment. Recorders will be programmed to begin recording at an hour before sunset. All recorders will be given the same program file but with a unique prefix for identification purposes. The same program files will be used during each deployment.

To avoid recording sounds related to monitoring activities, the 120 hrs must begin after staff have completed other monitoring tasks and left all sites and must end before staff return to collect the recording data. It is recommended that recorders are deployed for at least two weeks to allow for weather events that may impact recordings. The actual deployment period will depend on the chosen recording schedule.

The local time and site location will be set on each recorder to allow scheduling relative to sunrise and sunset. Time zone will be set to UTC+10:00 and daylight savings time adjustments will be ignored. The time on all machines will be synchronised to allow comparisons in soundscapes at different sites at any point in time.

Where the recorder model has the option, LEDs will be turned off or masked. The light can influence animal behaviour and affect recordings. For instance, birds have been observed trying to peck at the blinking light on a Song Meter, resulting in the addition of pecking sounds to the sound recordings. High pass filters will be turned off as the full range of frequencies is desired.

Testing

All recording equipment will be tested prior to each deployment to ensure the schedule records as expected, equivalent sound quality is achieved across all recorders and memory cards write as expected. Microphones will be replaced where required to ensure equivalent sound quality is achieved.

Field placement

Recorder stations will be permanently marked for the duration of the Monitoring Plan.

Two star pickets (or wooden equivalent) will be driven into the ground to form a stable frame that will be left in place and reused each monitoring event. The star pickets will be placed at a distance that allows a recorder to be secured to both pickets without placing pressure on or shielding microphones. The recorder will be mounted at approximately 1.5 m above the ground. 1.8 m long star pickets (or wooden equivalent) driven 30 cm into the ground and topped with safety caps are recommended, the actual lengths will depend on substrate type with longer lengths required to provide a stable frame in looser soil.

Recorder stations will be located central to vegetation condition plots to allow soundscapes to be compared with vegetation condition data for a holistic view of environmental values.

Location

Detection distance varies with environmental factors including signal frequency, vegetation type, topography and weather conditions. It is important that detection distance is considered when placing recorders for impact/control monitoring. The following criteria (similar to Ng et al. (2018)) will be applied as much as ground conditions allow:

- Paired sites must occur within the same ecosystem type;
- Paired sites are at least 500 m apart to allow for 200 m radius per recorder and avoid overlap in recordings;
- Vegetation patches are at least 300 m in radius and sites are at least 250 m from a vegetation patch edge to avoid any edge effects;
- Paired sites should be placed such that confounding factors are minimised (i.e. away from other sources of human interference such as machinery other than the impact well, tracks/fence lines, firebreaks or roads, and natural sources of sound such as flowing water and patch edges (wind));
- The assumed 200 m detection distance should be tested and confirmed for the project area prior to commencement of the monitoring program, with distances adjusted to align with the actual detection distance used.

Timing

The soundscape monitoring will aim to commence prior to development to establish baseline values at each site. The monitoring will continue for the life of the Monitoring Plan.

Annual recording events will occur to capture and characterise the soundscape of each site during each spring. Preferential timing includes:

- Periods of fair weather as wind and rain can affect the biological soundscape, for example birds sing less when it is very windy or raining.
- Periods typical of spring and avoidance of seasonal changes as these may impact soundscape characterisation.
- Allowing enough time for the official recording time to begin the day after field staff are on site setting the recorders and conducting other facets of the project, such as vegetation monitoring, and end the day before the recorders are collected to avoid any interference caused by field staff.

Data analysis

Background

Soundscape metrics

The main goal of soundscape ecology is to extract information about the environment from sound recordings. Sound data can be listened to, visualised or analysed for various characteristics.

The spectrogram, or sonogram, is a common tool used to visualise sound. It represents three dimensions of sound (time, frequency and intensity) in a two dimensional space by plotting time along the x-axis, frequency [Hz] along the y-axis and representing intensity by a colour gradient (Farina, 2014; Pijanowski et al., 2011b).

The spectral analysis approach to analysis is popular in bioacoustic and environmental studies. It is based on analysis of the spectral representation of sound, considers different frequencies and relative intensities of sound within a specific time frame (Farina, 2014) and often results in the calculation of an acoustic index. An acoustic index is a statistic that summarises some aspect of the distribution of acoustic energy in a recording (Towsey and Zhang, 2014). Selected published metrics developed to identify the ecological characters of a soundscape, independent of sound sources include:

- Acoustic Complexity Index (ACI) (Pieretti et al., 2011);
- Acoustic Diversity Index (ADI) (Villanueva-Rivera et al., 2011);
- Acoustic Entropy Index (H) (Sueur et al., 2008b);
- Acoustic Evenness Index (AEI) (Villanueva-Rivera et al., 2011);
- Bioacoustic Index (Bio) of relative avian abundance (Boelman et al., 2007);
- Normalized Difference Soundscape Index (NDSI) (Kasten et al., 2012);
- Acoustic Dissimilarity Index (D) (Sueur et al., 2008b);
- Soundscape Frequency Spectrum (SFS) (Kasten et al., 2012).

Long duration false colour spectrograms

Long duration false colour (LDFC) spectrograms are used to visualise the content of long-duration audio recordings on multiple scales, from hours, days, months to years, facilitating navigation and yielding ecologically meaningful information (Towsey and Zhang, 2014). Following Towsey and Zhang (2014), indices are calculated for each frequency bin for each one-minute segment of a recording, a colour is assigned to each index and indices (and their respective colours) are combined (colours added together) to produce a false colour spectrogram.

Five indices used in the false colour spectrograms are described in Towsey (2017):

- Acoustic Complexity Index (ACI)
- Temporal Entropy (ENT)
- Event Count (EVN)
- Background Noise (BGN)
- Power minus Noise (PMN).

Metric calculation and analysis

Wildlife Acoustics Kaleidoscope Pro software or the software R (R Core Team, 2020) may be used for metric calculation.

The software R (R Core Team, 2020) will be used for analysis and result presentation, including functions from the packages tuneR (Ligges et al., 2013), seewave (Sueur et al., 2008a), ineq (Zeileis, 2013), soundecology (Villanueva-Rivera and Pijanowski, 2013), gplots (Warnes et al., 2014), vegan (Oksanen et al., 2019) and lme4 (Bates et al., 2015).

The parameters applied to each metric are summarised in the table below.

Table G1 - Soundscape metrics and parameters

Soundscape Metric Name	Parameters	Reference	Source
Acoustic Complexity Index (ACI)	max_freq=9000 j=5 fft_w=512	(Pieretti et al., 2011)	Soundecology
Acoustic Diversity Index (ADI)	max_freq=9000 db_threshold=-50 freq_step=1000 shannon=TRUE	(Villanueva-Rivera et al., 2011)	Soundecology
Acoustic Evenness Index (AEI)	max_freq=9000 db_threshold=-50 freq_step=1000	(Villanueva-Rivera et al., 2011)	Soundecology
Bioacoustic Index of relative avian abundance (BIO)	min_freq=2000 max_freq=9000 fft_w=512	(Boelman et al., 2007)	Soundecology
Normalized Difference Soundscape Index (NDSI)	fft_w=512 anthro_min=1000 anthro_max=2000	(Kasten et al., 2012)	Seewave

Soundscape Metric Name	Parameters	Reference	Source
	bio_min=2000 bio_max=9000		
Acoustic Entropy Index (H)	f=44100 wl=512 envt="hil"	(Sueur et al., 2008b)	Seewave
Soundscape Frequency Spectrum (SFS)	f=44100 wl=1024 wn="hamming" ovlp=50	(Kasten et al., 2012)	Seewave
Acoustic Dissimilarity Index (D)	Default values	(Sueur et al., 2008b)	Seewave

Source: Ng. et al (2018)

False colour spectrograms

QUT Ecoacoustics Analysis Programs software package (Towsey et al., 2018) will be used to create false colour spectrograms.

Reporting

Reporting may include, but is not limited to:

- methods;
- results;
- illustration of typical recording files as spectrograms
  - Representation of calculated metrics in plot format
    - examples include box and whisker plots, bar charts, scatter or line graphs
    - daily, annual variation
  - comparison between sites, treatments, years
    - examples include
      - ANOVA and Tukey's Honestly Significant Difference testing
      - cluster dendrogram – diagram that shows the hierarchical relationship between objects and assists in our understanding of the similarity between sites, treatments, years
      - heat map – used to show the magnitude of difference between objects in two dimensions and used to assist in our understanding of the similarity between sites, treatments, years as calculated by statistical test results
  - presentation of false colour spectrograms
- discussion of findings, trends, observations and project performance; and
- recommendations for improvement.

References

Bates, D., Mächler, M., Bolker, B., Walker, S., 2015. Fitting Linear Mixed-Effects Models Using lme4. J. Stat. Softw. 67, 1–48. https://doi.org/10.18637/jss.v067.i01

Boelman, N.T., Asner, G.P., Hart, P.J., Martin, R.E., 2007. Multi-Trophic Invasion Resistance in Hawaii: Bioacoustics, Field Surveys, and Airborne Remote Sensing. Ecol. Soc. Am. 17, 2137–2144.

Bradfer-Lawrence, T., Gardner, N., Bunnefeld, L., Bunnefeld, N., Willis, S.G., Dent, D.H., 2019. Guidelines for the use of acoustic indices in environmental research. Methods Ecol. Evol. 10, 1796–1807. https://doi.org/10.1111/2041-210X.13254

Farina, A., 2014. Soundscape Ecology - Principles, Patterns, Methods and Applications. Springer, Urbino, Pesaro-Urbino, Italy.

Gage, S.H., Napoletano, B., Cooper, M., 2001. Assessment of ecosystem biodiversity by acoustic diversity indices. J. Acoust. Soc. Am. 109, 2430.

Gage, S.H., Ummadi, P., Shortridge, A., Qi, J., Jella, P., 2004. Using GIS to develop a network of acoustic environmental sensors, in: ESRI International User Conference 2004. ESRI, San Diego, pp. 1–10.

Kasten, E.P., Gage, S.H., Fox, J., Joo, W., 2012. The remote environmental assessment laboratory's acoustic library: An archive for studying soundscape ecology. Ecol. Inform. 12, 50–67. https://doi.org/10.1016/j.ecoinf.2012.08.001

Krause, B.L., 1987. Bioacoustics, habitat ambience in ecological balance. Whole Earth Rev 57, 14–18.

Ligges, U., Krey, S., Mersmann, O., Schnackenberg, S., 2013. tuneR: Analysis of music.

Napoletano, B., 2004. Measurement, quantification and interpretation of acoustic signals within an ecological context. MSc thesis, Michigan State University, East Lansing.

Ng, M.-L., Butler, N., Woods, N., 2018. Soundscapes as a surrogate measure of vegetation condition for biodiversity values: A pilot study. Ecol. Indic. 93, 1070–1080. https://doi.org/10.1016/j.ecolind.2018.06.003

Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Henry, M., Stevens, H., Szoecs, E., Wagner, H., 2019. vegan: Community Ecology Package. R package version 2.5-6.

Pieretti, N., Farina, A., Morri, D., 2011. A new methodology to infer the singing activity of an avian community: The Acoustic Complexity Index (ACI). Ecol. Indic. 11, 868–873. https://doi.org/10.1016/j.ecolind.2010.11.005

Pijanowski, B.C., Farina, A., Gage, S.H., Dumyahn, S.L., Krause, B.L., 2011a. What is soundscape ecology? An introduction and overview of an emerging new science. Landsc. Ecol. 26, 1213–1232. https://doi.org/10.1007/s10980-011-9600-8

Pijanowski, B.C., Villanueva-Rivera, L.J., Dumyahn, S.L., Farina, A., Krause, B.L., Napoletano, B.M., Gage, S.H., Pieretti, N., 2011b. Soundscape Ecology: The Science of Sound in the Landscape. Bioscience 61, 203–216. https://doi.org/10.1525/bio.2011.61.3.6

R Core Team, 2020. R: A Language and Environment for Statistical Computing v3.6.3. R Foundation for Statistical Computing, Vienna, Austria.

Southworth, M., 1969. The sonic environment of cities. Environ. Behav. 1, 49–70.

Sueur, J., Aubin, T., Simonis, C., 2008a. Seewave, a free modular tool for sound analysis and synthesis. Bioacoustics 18, 213–226. https://doi.org/10.1080/09524622.2008.9753600

Sueur, J., Pavoine, S., Hamerlynck, O., Duvail, S., 2008b. Rapid acoustic survey for biodiversity appraisal. PLoS One 3, e4065. https://doi.org/10.1371/journal.pone.0004065

Towsey, M., 2017. The calculation of acoustic indices derived from long-duration recordings of the natural environment. Brisbane, Australia.

Towsey, M., Truskinger, A., Cottman-Fields, M., Roe, P., 2018. Ecoacoustics Audio Analysis Software v18.03.0.41. https://doi.org/10.5281/zenodo.1188744

Towsey, M., Zhang, L., 2014. False-colour spectrograms of long duration acoustic recordings. Brisbane, Australia.

Villanueva-Rivera, L.J., Pijanowski, B.C., 2013. soundecology: Soundscape ecology [WWW Document]. R Packag. version 1.1. URL http://cran.r-project.org/package=soundecology

Villanueva-Rivera, L.J., Pijanowski, B.C., Doucette, J., Pekin, B., 2011. A primer of acoustic analysis for landscape ecologists. Landsc. Ecol. 26, 1233–1246. https://doi.org/10.1007/s10980-011-9636-9

Warnes, G.R., Bolker, B., Bonebakker, L., Gentleman, R., Huber, W., Liaw, A., Lumley, T., Maechler, M., Magnusson, A., Moeller, S., Schwartz, M., Venables, B., 2014. gplots: Various R programming tools for plotting data [WWW Document]. R Packag. version 2.13.0. URL http://cran.r-project.org/package=gplots

Zeileis, A., 2013. ineq: Measuring Inequality, Concentration, and Poverty [WWW Document]. R Packag. version 0.2-11. URL http://cran.r-project.org/package=ineq

Attachment 1 - Biodiversity Offset Strategy

Narrabri Gas Project: Biodiversity Offset Strategy

Santos NSW (Eastern)

ecological AUSTRALIA
A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au

DOCUMENT TRACKING

Project Name	Narrabri Gas Project: Biodiversity Offset Strategy
Project Number	19NEW-13556
Project Manager	Dan Watts
Prepared by	**Martin Sullivan, Dan Watts and Robert Humphries**
Reviewed by	**Robert Humphries**
Approved by	**Robert Humphries**
Status	**Final**
Version Number	**Revision 0B**
Last saved on	**11 November 2022**

This report should be cited as 'Eco Logical Australia 2022. *Narrabri Gas Project: Biodiversity Offset Strategy*. Prepared for Santos NSW (Eastern).'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd. Cover photo: 'Myall Valley' stewardship site – M. Sullivan (ELA - 2020)

Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
BAG	Biodiversity Advisory Group
BAM	Biodiversity Assessment Method (2020)
BBAM	Biobanking Assessment Methodology
BC Act	NSW *Biodiversity Conservation Act 2016*
BCD	Former Biodiversity Conservation Division, now Biodiversity Conservation and Science (BCS)
BCF	Biodiversity Conservation Fund
BOS	Biodiversity Offset Strategy
BVT	Biometric Vegetation Type
CCA	Community Conservation Area
CHMP	Cultural Heritage Management Plan
CMA	Catchment Management Authority
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DNG	Derived Native Grassland
DoTE	former Commonwealth Department of Environment (now DAWE)
DPE	NSW Department of Planning and Environment
DPIE	Former NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EPA Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FBA	Framework for Biodiversity Assessment
FCNSW	Forestry Corporation New South Wales
FDP	Field Development Plan
IBRA	Interim Biogeographic Regionalisation for Australia
IPC	Independent Planning Commission
LALC	Local Aboriginal Land Council
MEG	Regional NSW – Mining, Exploration and Geoscience
MNES	Matters of National Environmental Significance
NPW Act	NSW *National Parks and Wildlife Act 1974*
NPWS	NSW National Parks and Wildlife Service
NSW	New South Wales
NT	Native Title
OEH	former NSW Office of Environment and Heritage

Abbreviation	Description
OTG	Offset Trading Group (as per BAM 2020)
PA	Planning Agreement
PCT	Plant Community Type
RVC	Regional Vegetation Class
SEARs	Secretary's Environmental Assessment Requirements
TBD	To be determined
TSC Act	Former NSW *Threatened Species Conservation Act 1995 (now BC Act 2016)*

1. Introduction

Eco Logical Australia (ELA) was commissioned by Santos NSW (Eastern) Pty Ltd, the Proponent, to prepare a Biodiversity Offset Strategy for the Narrabri Gas Project (the Project). The Biodiversity Offset Strategy (BOS) has been prepared to meet Condition B51 of the Development Consent granted by the Independent Planning Commission (IPC) for the project on 30 September 2020. It updates the draft BOS (ELA 2018) prepared as part of the Environmental Impact Statement (EIS) to support the Proponent's application for development consent for the Project (GHD 2015 & ELA 2015).

The Biodiversity Offset Strategy provides a comprehensive strategy for the residual impacts of the Project following implementation of avoidance, minimisation and mitigation strategies which are detailed in the Ecological Impact Assessment (ELA 2015) which supports the EIS (GHD 2015). The Biodiversity Offset Strategy is a framework document which will guide offsetting the biodiversity impacts of the Project by detailing methods and steps taken to meet the credit liability as described in the development consent (SSD 6456) for the Narrabri Gas Project. Offsets will largely be managed through the establishment of Biodiversity Stewardship Agreement Sites (BSAs) in accordance with the *Biodiversity Conservation Act* 2016 and the 'retirement' of 'biodiversity credits' generated from these sites and/or payments to the Biodiversity Conservation Fund (BCF).

The study area for the Project is shown in Figure 1.1.

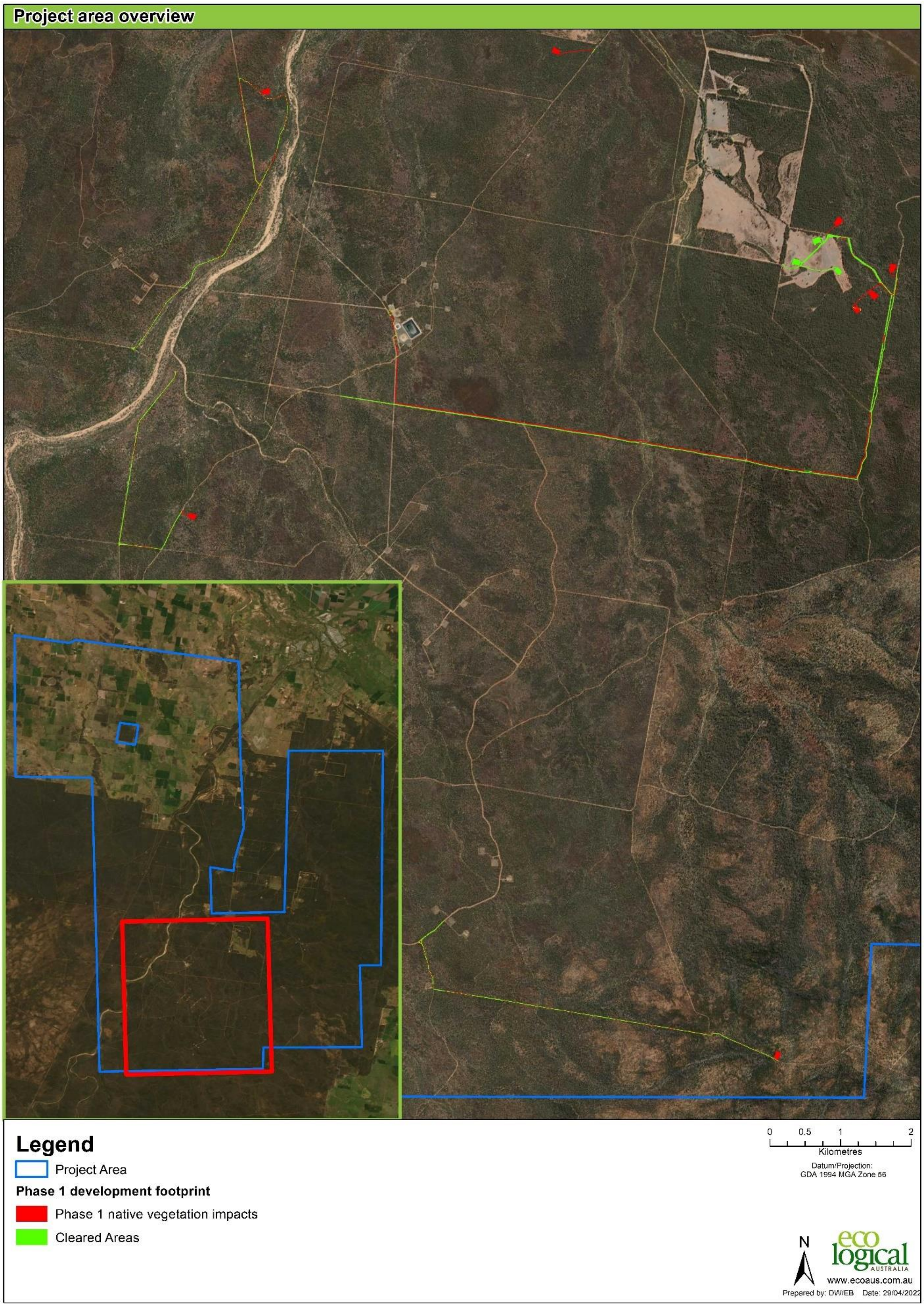


Figure 1.1 - Project area and indicative Phase 1 development footprint

1.1. NSW Development Consent SSD 6456

A number of conditions relate to offsetting the impacts of the Project and are addressed in this strategy as part of the over-arching Biodiversity Management Plan (Table 1.1). Condition 25 of the EPBC Approval 2014/7376 directs the proponent to comply with conditions B43 – B52 of the NSW approval and is addressed broadly through the Project Biodiversity Management Plan. For this reason, the condition is not specifically referenced further in this BOS.

The objective of this Biodiversity Offset Strategy is to meet the conditions specific to offsetting the impacts of the Project as they relate to Phase 1 of the development. Refer to the Biodiversity Management Plan for a description of Phase 1 of the development.

Table 1.1 – Relevant NSW Consent Conditions (SSD 6456) and Commonwealth Approval (EPBC 2014/7376)

Approval Condition	Requirement	Section Addressed in this Biodiversity Offsets Strategy
	NSW Development Consent SSD 6456	
B43	The Applicant must retire the biodiversity credits specified in Tables 8, 9 and 10 below, subject to the staged retirement conditions below, to offset the biodiversity impacts of the development. The retirement of credits must be carried out in consultation with BCS and, apart from the retirement of credits through ecological rehabilitation, in accordance with the Biodiversity Offsets Scheme of the BC Act and to the satisfaction of the BCT.	Section 3.1.1
	Staged retirement	
B44	Prior to the commencement of Phase 1, the Applicant must retire any ecosystem and species credit liabilities generated by the works proposed in the applicable Field Development Plan to the satisfaction of the BCT.	Section 4.1
B45	Prior to the commencement of Phase 2, the Applicant must retire the ecosystem and species credits liability identified as Phase 2 Credits in Tables 8, 9 and 10 to the satisfaction of the BCT. Any credits retired during Phase 1 may be deducted from the Phase 2 credit liability.	Sections 4.2 and 4.3
B46	Prior to exceeding the Phase 2 area or individuals limits in Tables 8, 9 and 10, the Applicant must retire the relevant ecosystem and species credit liabilities to enable any exceedances of the limits to the satisfaction of the BCT and/or by providing ecological rehabilitation credit offsets for the exceedances.	To be determined in subsequent updates to BOS as part of the relevant phase.
B47	The calculation of credits must be based on the *Framework for Biodiversity Assessment of the NSW Biodiversity Offset Policy for Major Projects* (OEH, 2014) and consistent with the calculation of credits applied during the preparation of the EIS.	Section 2.1
B48	With the agreement of the Planning Secretary, the Applicant may adjust the staging of credit requirements. Any adjustments must be agreed, and the relevant credits must be retired, prior to the commencement of the associated impact on that ecosystem or species.	Section 4
	Ecological Rehabilitation and Credit Offsets	
B49	If the applicant meets the ecological rehabilitation completion criteria in the Rehabilitation Management Plan to the satisfaction of BCS, then the Applicant may use the rehabilitated land to offset the relevant ecosystem and/or species	Section 2.3

Approval Condition	Requirement	Section Addressed in this Biodiversity Offsets Strategy
	credit liability for the 'Residual Credits' in Tables 8, 9 and 10. Ecological rehabilitation credits may be offset at a rate of: (a) 12 credits per hectare for plant community types in Table 8; (b) 7.1 credits per individual for relevant flora species in Table 9; and (c) 7.1 credits per hectare of suitable habitat for relevant fauna species in Table 10. Ecological rehabilitation credit offsets may only be sought for: • plant community types in Table 8 • flora and fauna species identified as 'Yes' to ecological rehabilitation in Tables 9 and 10; and flora and fauna species identified as 'Potential' to ecological rehabilitation in Tables 9 and 10, subject to the Applicant demonstrating that the relevant species is suitable for ecological rehabilitation, to the satisfaction of the BCS.	
	Biodiversity Management Plan	
	Prior to the commencement of Phase 1, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	
	(b) …be prepared in consultation with BCS, DCCEEW, FCNSW, Council and the Biodiversity Advisory Group	Section 1.2 BMP Appendix A
B51	(f) include a Biodiversity Offset Strategy that:	
	i. is prepared in consultation with MEG (in addition to the agencies referred to in(b) above), in relation to the potential for resource sterilisation	Section 1.2 BMP Appendix A
	ii. is prepared consistent with the NSW Biodiversity Offsets Policy for Major Projects;	Section 3
	iii. describes how the biodiversity credits in Tables 8, 9 and 10 will be identified, secured and retired;	Section 3.3
	iv. prioritises land-based offsets for retiring 'Phase 2 Credits' identified in Tables 8, 9 and 10;	Section 4.3
	v. describes the staging of credit retirements and associated surface disturbance areas; and	Section 4
	vi. describes how threatened species under the EPBC Act would be suitably offset;	Section 2.4
	Aboriginal Cultural Heritage Management Plan	
B59	Prior to the commencement of Phase 1, the Applicant must prepare an Aboriginal Cultural Heritage Management Plan for the development to the satisfaction of the Planning Secretary. The plan must: … (d) describe the measures to be implemented for: (v) maintaining and managing reasonable access for relevant Aboriginal stakeholders to Aboriginal objects and Aboriginal places in any biodiversity offset areas managed by the Applicant; and	Section 5

Approval Condition	Requirement	Section Addressed in this Biodiversity Offsets Strategy
	(vi) facilitating ongoing consultation and involvement of Registered Aboriginal Parties in the conservation and management of Aboriginal cultural heritage in any biodiversity offset areas managed by the Applicant.	

1.2. Project consultation

This Biodiversity Offset Strategy is required to be developed in consultation with various external stakeholders in accordance with SSD 6456 condition B51(f).

Drafts of this BOS were provided to each of the following stakeholders in accordance with Condition B51 in November 2021, and the BCS and BAG in March 2022 and the comments raised by these groups have been incorporated into this Final BOS:

- Biodiversity Conservation and Sciences Directorate (BCS) within the Department of Planning and Environment
- Federal Department of Agriculture, Water and the Environment (DAWE)
- Forestry Corporation of NSW (FCNSW)
- The Department of Regional NSW (mining, Exploration and GeoScience)
- Narrabri Shire Council (Council)
- Biodiversity Advisory Group.

Consultation records and matters raised during the consultation process have been addressed in **Appendix A** of the BMP.

2. Biodiversity offset requirements

2.1. Offset requirements of the Project

Consent condition B43 states that the impacts of the Project are to be offset in accordance with the Biodiversity Offset Scheme of the *Biodiversity Conservation Act 2016* (BC Act) and to the satisfaction of the Biodiversity Conservation Trust (BCT). Condition B49 provides an exception to this rule for credits generated through successful rehabilitation (as described in the Rehabilitation Management Plan (RMP)) for any residual credit liability after Phase 2 credits have been retired.

The Project can stage retirement of credits under the condition in multiple phases (see Table 2.1, Table 2-2 and Table 2-3) and in consultation with the Department of Planning and Environment (DPE)'s Biodiversity, Conservation and Sciences Directorate (BCS). Credit numbers stated in the three tables below are in Framework for Biodiversity Assessment (FBA) terms and where these credits are not available or another means of acquiring the credit is proposed, e.g. through the establishment of a

Biodiversity Stewardship Site using the Biodiversity Assessment Method (BAM), then an assessment of reasonable equivalence is required to convert these credit liabilities into BAM credit equivalents (see Section 2.2).

Table 2.1 - Clearing limits and credit requirements for Plant Community Types as stated in consent SSD-6456

Plant Community Type	Phase 2 credits		Residual credits		Maximum area directly impacted (ha)
	Area (ha)	Credits required[1]	Area (ha)	Credits required[1]	
Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions – Woodland (BCA and EPBC listed EEC) (PCT 27)	0.1	5	N/A	N/A	0.1
Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – DNG (PCT 27)	0.5	20	N/A	N/A	0.5
Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion – Woodland (BCA and EPBC listed EEC) (PCT 35)	19.3	1,305.5	N/A	N/A	19.3
Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion – Woodland - *DNG* (PCT 35)	26.0	910.7	11.2	390.3	37.2
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Woodland (PCT 55)	2.7	153.8	1.2	65.91	3.9
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – DNG (PCT 55)	1.2	45.5	0.5	19.5	1.7
Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion – Woodland (PCT 88)	28.6	1,991.9	12.2	853.7	40.8
Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion – DNG (PCT 88)	6.2	198.1	2.6	84.9	8.8
Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (PCT 141)	13.65	538.3	5.85	223.23	19.5
Fuzzy Box on loams in the Nandewar Bioregion and northern Brigalow Belt South Bioregion (BCA EEC) (PCT 202)	4.1	502.5	1.77	145.0	5.9

[1] Credit values denoted here are provided directly from the NSW Conditions of Consent SSD 6456. Purchasing or generating partial credits is not possible, so a whole integer credit is required to account for any partial credit liability.

Plant Community Type	Phase 2 credits		Residual credits		Maximum area directly impacted (ha)
	Area (ha)	Credits required[1]	Area (ha)	Credits required[1]	
Green Mallee tall mallee woodland rises in the Pilliga – Goonoo regions, southern BBS Bioregion (PCT 256)	0.2	10.8	0.1	4.62	0.3
Inland Scribbly Gum - White Bloodwood - Red Stringybark – Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the BBS Bioregion – Woodland (PCT 379)	1.89	145.3	0.8	62.4	2.7
Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, BBS Bioregion – Woodland (PCT 397)	0.7	44.5	0.3	19.1	1
Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, BBS Bioregion – DNG (PCT 397)	0.9	23.1	0.4	9.9	1.3
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 BBS Bioregion – Woodland (PCT 398)	226.4	17,576	97.0	6,075.3	323.4
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 BBS Bioregion – DNG (PCT 398)	2.7	128.8	1.2	55.2	3.9
Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion – Woodland (PCT 399)	2.4	155.8	1.0	64.4	3.4
Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion – DNG (PCT 399)	0.14	0	0.06	0	0.2
Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region – Woodland (PCT 401)	32.5	2,604.1	13.9	1,045.2	46.4
Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region – DNG (PCT 401)	12.7	452.2	5.43	193.8	18.1
Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion – Woodland (PCT 402)	1.1	65.1	0.5	27.9	1.6

Plant Community Type	Phase 2 credits		Residual credits		Maximum area directly impacted (ha)
	Area (ha)	Credits required[1]	Area (ha)	Credits required[1]	
Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion – DNG (PCT 402)	1.1	0	0.5	0	1.6
Red Ironbark - White Bloodwood - /+ Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Woodland (PCT 404)	60.6	4,407.1	26.0	1,888.7	86.6
White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions – Woodland (PCT 405)	173.0	12,003.9	74.1	4,795.3	247.1
White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions – DNG (PCT 405)	1.3	50.4	0.6	21.6	1.9
White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland/ open forest mainly in east Pilliga forests – Woodland (PCT 406)	48.3	2,970.4	20.7	1,273.1	69
Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region – Woodland (PCT 408)	23.3	1,750.5	10.0	660	33.3
Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region – DNG (PCT 408)	0.3	7	0.1	3	0.4
White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion – Woodland (PCT 418)	0.14	10.4	0.06	4.5	0.2
White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion – DNG (PCT 418)	0.2	5.6	0.1	2.4	0.3
Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion (PCT 425)	5.9	396.3	2.5	166.4	8.4
Total	**692.2**	**48,078.3**	**296.6**	**18,554.8**	**988.8**

Table 2-2 - Clearing limits and credit requirements for threatened flora species as stated in consent SSD-6456

Flora species	Phase 2 Credits		Residual Credits		Maximum number individuals directly impacted	Ecological Rehabilitation Credits allowed
	Individuals	Credits Required	Individuals	Credits Required		
Bertya opponens	7,216	101,028	3,093	43,298	10,309	Yes
Diuris tricolor	36	473	16	203	52	No
Lepidium aschersonii	54,384	761,372	23,307	326,302	77,691	Potential
Lepidium monoplocoides	781	11,718	335	5,022	1,116	Potential
Polygala linariifolia	176	2,646	76	1,134	252	Potential
Pomaderris queenslandica	327	4,577	140	1,961	467	Yes
Pterostylis cobarensis	4,661	69,766	1,997	25,966	6,658	No
Commersonia procumbens	2,601	39,018	1,115	16,722	3,716	Yes
Tylophora linearis	359	5,721	154	2,001	513	No

Table 2-3 - Clearing limits and credit requirements for threatened fauna species as stated in consent SSD-6456

Fauna species	Phase 2 Credits		Residual Credits		Maximum Area of habitat directly impacted (ha)	Ecological Rehabilitation Credits allowed
	Area (ha)	Credits Required	Area (ha)	Credits Required		
Black-striped Wallaby (*Macropus dorsalis*)	692	22,006	297	8,450	989	Potential
Eastern Pygmy-possum (*Cercartetus nanus*)	542	13,026	232	4,924	775	No
Pale-headed Snake (*Hoplocephalus bitorquatus*)	620	24,457	266	9,283	885	No
Squirrel Glider (*Petaurus norfolcensis*)	603	15,927	259	6,026	862	No
Regent Honeyeater (*Anthochaera phrygia*)	34	3,035	14	1,220	48	No

Fauna species	Phase 2 Credits		Residual Credits		Maximum Area of habitat directly impacted (ha)	Ecological Rehabilitation Credits allowed
	Area (ha)	Credits Required	Area (ha)	Credits Required		
Koala (*Phascolarctos cinereus*)	692	22,005	297	8,449	989	No

2.2. Reasonable equivalence

Since the EIS (and accompanying Ecological Impact Assessment and Biodiversity Assessment Report) was submitted, the FBA has been replaced with the BAM under the NSW Biodiversity Offset Scheme. The Biodiversity Offset Scheme provides a new approach for determining the quantum of credits required to offset a development and generated from the establishment of a Biodiversity Stewardship Site. The Project was assessed under the FBA and the credit requirement in the development consent is calculated in this framework. Where a project has an existing obligation to obtain and retire BioBanking credits under a consent and the credits required do not exist, an application for an '*assessment of reasonable equivalence*' of biodiversity credits (henceforth referred to as 'reasonable equivalence') must be made to DPE. The conversion provides an equivalent quantum of Biodiversity Offset Scheme credits that allows the Project to meet its offset obligation within the new framework.

The Project has made reasonable attempts to identify suitable BioBanking credits on the open market (see section 3.3) and did not identify suitable numbers of credits for the Project at this stage.

An application for 'reasonable equivalence' was submitted to (then) DPIE on 15 December 2020. The result of the assessment was received on the 10 of May 2021, determining that the number of biodiversity credits required to be retired under the TSC Act are reasonably equivalent to the number and class of biodiversity credits under the BC Act (refer to Appendix A). The results are summarised below in Table 2-4, Table 2-5 and Table 2-6. Note some species had BBAM/ FBA credits available for purchase at the time of the equivalency and may be purchased and retired as part of the Phase 1 Offsets (see Section 4.2). The equivalent BAM credits have been provided in Table 2-5 and Table 2-6 and the 'ratio' of BAM to FBA credits used to calculate the Phase 1 offset obligations.

Following the issue of the Statement of Reasonable Equivalence (refer to Appendix A) it is noted that the Black-striped Wallaby was reclassified by DPE from a 'species credits' to 'ecosystem credits' species and the credit liability was therefore reduced to zero as 'species credits' can no longer be generated for the species. Whilst the Regent Honeyeater remained a dual credit species, i.e. both 'species credit' and 'ecosystem credit', only impacts to mapped 'important habitat' areas incur a 'species credit' liability. As there is no mapped 'important habitat' within the Project area, the credit liability for this species was also reduced to zero. However, habitat for these species in the region will still be protected through the retirement of credits for associated PCTs listed in Table 2.4.

Table 2-4 - Conversion from FBA to Biodiversity Offset Scheme credits for PCTs following the assessment of reasonable equivalence

Plant Community Type	Framework for Biodiversity Assessment credit requirements		Biodiversity Offset Scheme equivalent credit requirements[2]		Estimated offset area range (using 4 - 6 credits per ha)	
	Phase 2	Residual	Phase 2	Residual	Phase 2	Residual
Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions – Woodland (BCA and EPBC listed EEC) (PCT 27)	5	N/A	4	N/A	0.67 - 1	N/A
Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – DNG (PCT 27)	20	N/A	13	N/A	2.17 - 3.25	N/A
Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion – Woodland (BCA and EPBC listed EEC) (PCT 35)	1,305.5	N/A	938	N/A	156.33 - 234.5	N/A
Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion – Woodland - DNG (PCT 35)	910.7	390.3	570	243	135.5 - 203.25	40.5 - 60.75
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Woodland (PCT 55)	153.8	65.91	86	36	20.33 - 30.5	6 - 9
Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – DNG (PCT 55)	45.5	19.5	23	9	5.33 - 8	1.5 - 2.25
Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion – Woodland (PCT 88)	1,991.9	853.7	864	369	205.5 - 308.25	61.5 - 92.25
Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion – DNG (PCT 88)	198.1	84.9	73	30	17.17 - 25.75	5 - 7.5
Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (PCT 141)	538.3	223.23	247	105	58.67 - 88	17.5 - 26.25

[2] Phase 2 credit equivalencies have been rounded up to the nearest whole number as partial credits cannot be created or retired.

Plant Community Type	Framework for Biodiversity Assessment credit requirements		Biodiversity Offset Scheme equivalent credit requirements[2]		Estimated offset area range (using 4 - 6 credits per ha)	
	Phase 2	Residual	Phase 2	Residual	Phase 2	Residual
Fuzzy Box on loams in the Nandewar Bioregion and northern Brigalow Belt South Bioregion (BCA EEC) (PCT 202)	502.5	145.0	269	114	63.83 - 95.75	19 - 28.5
Green Mallee tall mallee woodland rises in the Pilliga – Goonoo regions, southern BBS Bioregion (PCT 256)	10.8	4.62	6	2	1.33 - 2	0.33 - 0.5
Inland Scribbly Gum - White Bloodwood - Red Stringybark – Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the BBS Bioregion – Woodland (PCT 379)	145.3	62.4	64	27	15.17 - 22.75	4.5 - 6.75
Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, BBS Bioregion – Woodland (PCT 397)	44.5	19.1	19	8	4.5 - 6.75	1.33 - 2
Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, BBS Bioregion – DNG (PCT 397)	23.1	9.9	8	3	1.83 - 2.75	0.5 - 0.75
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 BBS Bioregion – Woodland (PCT 398)	17,576	6,075.3	7,053	3,022	1679.17 - 2518.75	503.67 - 755.5
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 BBS Bioregion – DNG (PCT 398)	128.8	55.2	53	22	12.5 - 18.75	3.67 - 5.5
Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion – Woodland (PCT 399)	155.8	64.4	66	28	15.67 - 23.5	4.67 - 7
Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion – DNG (PCT 399)	0	0	0	0	0 - 0	0 - 0
Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region – Woodland (PCT 401)	2,604.1	1,045.2	1,120	479	266.5 - 399.75	79.83 - 119.75

Plant Community Type	Framework for Biodiversity Assessment credit requirements		Biodiversity Offset Scheme equivalent credit requirements[2]		Estimated offset area range (using 4 - 6 credits per ha)	
	Phase 2	Residual	Phase 2	Residual	Phase 2	Residual
Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region – DNG (PCT 401)	452.2	193.8	171	73	40.67 - 61	12.17 - 18.25
Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion – Woodland (PCT 402)	65.1	27.9	28	11	6.5 - 9.75	1.83 - 2.75
Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion – DNG (PCT 402)	0	0	0	0	0 - 0	0 - 0
Red Ironbark - White Bloodwood - /+ Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Woodland (PCT 404)	4,407.1	1,888.7	1,923	823	457.67 - 686.5	137.17 - 205.75
White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions – Woodland (PCT 405)	12,003.9	4,795.3	5,038	2,159	1199.5 - 1799.25	359.83 - 539.75
White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions – DNG (PCT 405)	50.4	21.6	19	8	4.5 - 6.75	1.33 - 2
White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland/ open forest mainly in east Pilliga forests – Woodland (PCT 406)	2,970.4	1,273.1	1,262	540	300.33 - 450.5	90 - 135
Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region – Woodland (PCT 408)	1,750.5	660	726	310	172.67 - 259	51.67 - 77.5
Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region – DNG (PCT 408)	7	3	3	0	0.5 - 0.75	0 - 0
White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion – Woodland (PCT 418)	10.4	4.5	5	2	1.17 - 1.75	0.33 - 0.5

Plant Community Type	Framework for Biodiversity Assessment credit requirements		Biodiversity Offset Scheme equivalent credit requirements[2]		Estimated offset area range (using 4 - 6 credits per ha)	
	Phase 2	Residual	Phase 2	Residual	Phase 2	Residual
White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion – DNG (PCT 418)	5.6	2.4	3	0	0.5 - 0.75	0 - 0
Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion (PCT 425)	396.3	166.4	170	72	40.33 - 60.5	12 - 18
Total	**48,078.3**	**18,554.8**	**20,824**	**8,495**	**4,886.51 – 7,329.75**	**1,415.83 – 2,123.75**

Table 2-5 - Conversion from FBA credits to Biodiversity Offset Scheme credits for threatened flora species following the assessment of reasonable equivalence

Species	Framework for Biodiversity Assessment credit requirements		Framework for Biodiversity Assessment credits included in equivalency calculation[2]		Biodiversity Offset Scheme equivalent credit requirements residual	
	Phase 2	Phase 2 FBA credits available on the Credits register	Phase 2 FBA credits available on the Credits register	BAM credit equivalent if FBA credits are not used	Phase 2	Residual
Bertya opponens	101,028	43,298	-	-	21,649	9,278
Diuris tricolor	473	203	-	-	167	71
Lepidium aschersonii	761,372	326,302	-	-	437	186
Lepidium monoplocoides	11,718	5,022	-	-	36	15
Polygala linariifolia[3]	2,646	1,134	21	3	332	141
Pomaderris queenslandica	4,577	1,961	-	-	40	16
Pterostylis cobarensis	69,766	25,966	-	-	1,956	837

[3] FBA credits were available for purchase at the time of the statement of equivalence (Appendix A) so equivalent BAM credits are provided for these entities in parentheses.

Species	Framework for Biodiversity Assessment credit requirements		Framework for Biodiversity Assessment credits included in equivalency calculation[2]		Biodiversity Offset Scheme equivalent credit requirements residual	
	Phase 2	Phase 2 FBA credits available on the Credits register	Phase 2 FBA credits available on the Credits register	BAM credit equivalent if FBA credits are not used	Phase 2	Residual
Commersonia procumbens	39,018	16,722	-	-	212	90
Tylophora linearis	5,721	2,001	-	-	2,154	922
Total	**895,291**	**379,311**	**21**	**3**	**5,334**	**2,278**

Table 2-6 - Conversion from FBA credits to Biodiversity Offset Scheme credits for threatened fauna species following the assessment of reasonable equivalence

Species	Framework for Biodiversity Assessment credit requirements		Framework for Biodiversity Assessment credits included in equivalency calculation[2]		Biodiversity Offset Scheme equivalent credit requirements residual	
	Phase 2	Residual	Phase 2 FBA credits available on the Credits register	BAM credit equivalent if FBA credits are not used	Phase 2	Residual
Black-striped Wallaby (*Macropus dorsalis*)	22,006	8,450	-	-	0	0
Eastern Pygmy-possum (*Cercartetus nanus*)	13,026	4,924	1,293	2,882	25,119	11,999
Pale-headed Snake (*Hoplocephalus bitorquatus*)	24,457	9,283	-	-	32,704	14,015
Squirrel Glider (*Petaurus norfolcensis*)	15,927	6,026	8,023	16,693	15,256	13,687
Regent Honeyeater (*Anthochaera phrygia*)	3,035	1,220	-	-	0	0
Koala (*Phascolarctos cinereus*)	22,005	8,449	18,849	30,086	3,942	14,582
Totals	**100,456**	**38,352**	**46,017**	**49,661**	**77,021**	**54,283**

2.3. Rehabilitation credits

Under condition B49 of SSD-6456, if the ecological rehabilitation completion criteria in the Project Rehabilitation Management Plan are met, the proponent may use the rehabilitated land to offset the relevant ecosystem and/or species credits for any portion of the 'Residual Credits' in (Table 2.1, Table 2-2 and Table 2-3). Rehabilitation credits for ecosystem credits and some flora 'species credit' species may be offset at the following rates:

- 12 credits per hectare for PCTs (see Table 2.1)
- 7.1 credits per individual for relevant flora species as listed below.

Six flora 'species credit' species were identified in consent condition B43 (Table 9). In the table the species are listed as allowing, or potentially allowing subject to demonstration the relevant species is suitable for ecological rehabilitation, ecological rehabilitation credits. These species listed below:

- *Bertya opponens* – rehabilitation credits allowed
- *Lepidium aschersonii* – rehabilitation credits potentially allowed
- *Lepidium monoplocoides* – rehabilitation credits potentially allowed
- *Polygala linariifolia* – rehabilitation credits potentially allowed
- *Pomaderris queenslandica* – rehabilitation credits allowed
- *Commersonia procumbens* (syn. *Rulingia procumbens*) – rehabilitation credits allowed

Most of the fauna species have not been included due to the long timeframe required for re-establishment and regrowth of important habitat features which will be removed, such as mature trees, habitat structure and complexity, and hollows.

2.4. EPBC offset requirements

The project was referred to the Commonwealth Department of the Environment on 3 November 2014 (EPBC 2014/7376). The project was determined a 'controlled action' on 1 December 2014 due to potential impacts on listed threatened species and communities, a water resource, in relation to coal seam gas and large coal mining development, and commonwealth land. Assessment of the Project was delegated to the State under the assessment bilateral agreement with the NSW Government. The EPBC Act approval 2014/7376 was issued with conditions on 24 November 2020. Specifically, condition 25 of EPBC Act Approval 2014/7376 states:

- "The approval holder must comply with conditions B43 - B52 of the NSW approval…"

Effectively the Project must be offset in accordance with the NSW Biodiversity Offset Scheme.

2.5. Supplementary measures and statements of commitments

During the EIS assessment phase some commitments were outlined as part of an offsetting strategy that would provide real conservation outcomes for the Project Area by means of supplementary measures or other actions. Some of those measures were subsequently not supported as supplementary measures in the final development consent (SSD-6456).

- A nil-tenure feral animal control plan was proposed to manage feral animals at a landscape scale to manage the threat within the project area and a 10 km buffer. The program would have contributed up to 30 % of the Projects total offset liability. The program will not be developed or implemented as part of the Project as the cost and scope of implementation are prohibitive outside of an offsetting framework. Feral animal management will still occur in the project area in accordance with the Project Pest Plant and Animal Control Plan.

  - Feral animals were identified in the EIS as one of the most prevalent threats to biodiversity in the Pilliga. Concerted efforts in a nil-tenure management framework that targets feral species at the scale of home ranges is likely to be more effective than many individual targeted control efforts. Furthermore, a nil-tenure feral animal control program is anticipated to have greater positive outcomes for the biodiversity of the impacted region compared to the equivalent value of land-based offsets. While the nil-tenure program does not form part of the current BOS it is still considered a valuable addition as a supplementary measure for future phases. The program may be structured in a way similar to existing Biodiversity Stewardship Agreements with a fund set up for management in perpetuity.

- A koala research program to contribute to 10% of the total offset liability was also proposed. The program was incorporated as an additional measure under condition B51 (g) and is in addition to any offset requirements (see the Biodiversity Management Plan).
- Prepare a Biodiversity Offset Management Plan. This commitment has evolved into this Biodiversity Offset Strategy to reflect the changes in the mechanisms of securing biodiversity offsets in NSW under the BAM. Individual Biodiversity Stewardship Sites have Management Action Plans that are specific to that site and the parties that hold the subject land are responsible for its implementation, audit and review. Duplication of those plans within a consolidated management plan is not considered an appropriate or efficient means of managing the sites.

2.5.1. Hollow-bearing trees

Hollow-bearing trees with large hollows are an important and relatively scarce resource within the project area and the proponent committed to compensating their loss in the EIS statement of commitments (GHD, 2015). The removal of large hollows (>300 mm) will be compensated for by at least a 1:1 replacement with either artificial nestboxes or hollows.

Where large hollows cannot be avoided by the final footprint, their suitability for salvage and reinstatement will be assessed by a suitably qualified and experienced ecologist or fauna handler. If salvage of the hollow is unlikely, a suitable nest box will be installed to replace the hollow.. This will be located within 100 metres of the demarcated clearing limits for the well pad or infrastructure. If salvage of the hollow is possible it would be prepared and reinstated as soon as reasonably practicable following felling activities, within 100 metres of the demarcated clearing limits.

Trees for salvaged hollow or nest box emplacement should be selected to be:

- as close as possible to the location of the hollow removed
- within the same vegetation type
- large enough to support the salvaged hollow or nest box
- not have any hollows, where this is not possible, select a tree that has no large hollows.

Salvaged hollows and nest boxes must be installed using tree protecting fixtures, such as steel cable or chain encased in rubber hosing or similar. Salvaged hollows must be suitably prepared before installation. For guidance on installation and preparation see the Biodiversity Conservation Trust's *Guideline for Artificial Hollows* publication (August 2020) (accessible at https://www.bct.nsw.gov.au/sites/default/files/2020-08/BCT_Artificial%20Hollow%20Guidelines_Final%20for%20publication.pdf).

Monitoring and maintenance of salvaged hollows and nest boxes will occur throughout the operational life of the related asset. .

As part of nest box monitoring, Santos will identify any nest boxes requiring repair or replacement or are being inhabited by pest fauna species. Based on these findings, Santos will then undertake any requisite rectification program to ensure nest boxes are in good working order and are being utilised for native species as designed.

Nest box installation, monitoring, maintenance and any plan for decommissioning will be agreed in consultation with FCNSW.

3. Biodiversity offset strategy and options

This Biodiversity Offset Strategy has been prepared to ensure the residual impacts of the Project are adequately compensated for in accordance with the conditions of consent and that long-term conservation outcomes are achieved consistent with the NSW Biodiversity Offset Policy for Major Projects (OEH 2014). This Biodiversity Offset Strategy considers threatened, populations and ecological communities listed under the NSW *Biodiversity Conservation Act* 2016 (BC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

A Biodiversity Offset Package (Section 4) has been prepared to identify the steps to account for offset liability through land-based offsets and contributions to the Biodiversity Conservation Fund (BCF).

3.1.1. NSW Biodiversity Offset Scheme

The NSW Biodiversity Offset Scheme incorporates offset rules that provide pathways for a proponent to offset a credit liability. These pathways are the offsetting rules stated in Section 6.2 of Part 6 of the *Biodiversity Conservation Regulation 2017* and include:

a. the retirement of the required number and class of like-for-like biodiversity credits,
b. the retirement of the required biodiversity credits in accordance with the variation rules,
c. the funding of a biodiversity conservation action that would benefit the relevant threatened species or ecological community and that is equivalent to the cost of acquiring the required like-for-like biodiversity credits as determined by the offsets payment calculator referred to in section 6.32 of the Act,
d. in the case of State significant development or infrastructure under the *Environmental Planning and Assessment Act 1979* that is mining under a mining lease—an obligation to undertake ecological rehabilitation of the impacted site that has the same credit value (determined in accordance with the ancillary rules) as the retirement of like-for-like biodiversity credits,
e. the payment under section 6.30 of the Act of an amount into the Biodiversity Conservation Fund (BCF) determined in accordance with the offsets payment calculator to satisfy the requirement to retire biodiversity credits.

3.2. Offset approach

The Biodiversity Offset Strategy considers two methods for meeting the offset liability of the Project, which will be predominantly land based offsets:

1. Undertaking ‘reasonable steps’ to locate like-for-like offsets, including:

    a. Checking the biobanking and Biodiversity Offset Scheme public registers and having an expression of interest (EOI) for credits wanted for at least six months to identify any suitable credits that could be purchased.
    b. Liaising with interested landholders to identify potential sites that meet the requirements for offsetting and enter into agreements with the landholder to establish a Biodiversity Stewardship Agreement site on their land holding and make the credit available to purchase and retire.

   c. Considering properties for sale in the area with relevant biodiversity values to purchase and register as Biodiversity Stewardship Sites and determine long term management arrangements

2. Transfer any remaining offset liability to the Biodiversity Conservation Fund (BCF) by the purchase of biodiversity credits through the Biodiversity Offsets Payment Calculator (BOPC).

3.3. Offset strategy implementation

The Narrabri Gas Project will be developed in phases due to the iterative nature of gas field development. The Project offsets will be delivered using a primarily land-based approach with residual offsetting requirements satisfied through payments to the Biodiversity Conservation Fund.

Please refer to Section 4 to see the details of the offset package specific to Phase 1.

3.3.1. Investigation of options to meet the offset requirements

The availability and suitability of potential offset sites in the region was investigated as part of the Response to Submissions report published on the NSW Government's Major Projects website during assessment of the EIS and continues to be evaluated. This process has sought to demonstrate the majority of the like-for-like offset liability of the Project could be achieved through land-based offset sites. This process has included:

1. Checking the BioBanking public register and having an expression of interest (EOI) for credits wanted for at least six months (completed).
2. Checking the Biodiversity Offset Scheme credit supply register for suitable and available credits (ongoing).
3. Liaising with landholders to identify potential sites that meet the requirements for offsetting.
4. Considering properties for sale in the region.

This process included identifying lands with appropriate conservation values in proximity to the Project, identifying where these lands have potential to provide like-for-like vegetation and threatened species habitat, and where cost effective management can be implemented to improve the overall conservation value of the land.

Wherever possible, further detailed investigation of potential offsets will be directed to areas adjacent to existing conservation areas to improve the overall extent and connectivity of conserved land in the region.

Should potential offsets be considered not feasible, suitable evidence will be provided (e.g. unwillingness of landowner to sell or establish a Biobank site, or sale price significantly above market rates).

3.3.1.1. Biobanking public register and expression of interest

An expression of interest was lodged on the Biobanking 'credits wanted register' on 27 February 2017. While some initial interest was generated, no land was nominated which could substantially satisfy the requirements of the Project.

An updated review of the Biobanking public register was undertaken in May 2022. Several ecosystem and species credits were identified that are relevant to the Project (Table 3-1). The low quantum of credits available (compared to the Project's needs) as well as the duplication and likely high costs relative to establishing land-based offsets make purchasing the available credits undesirable as part of the Project's offset strategy, other than to meet the residual credit requirements for Phase 1 (see Section 4.1).

Table 3-1 - Available FBA/Biobanking credits that could be purchased to facilitate offsetting of the Project (as at May 2022)

Entity	FBA Credits available	Like for like group	The Project's FBA offset requirements	Suitability of offset
NA297 (equivalent to PCT 256)	2,524	NA292	15	Low - Myall Valley Stewardship (see Section 4.2.1) site meets whole of Phase 1 requirements and future BSAs are likely to contribute the remaining credits.
NA397 (equivalent to PCT 418)	6,085	NA409	23	Low - Myall Valley Stewardship (see Section 4.2.1) site meets whole of the Project's requirements under variation rules for this PCT.
Eastern Pygmy-possum (*Cercartetus nanus*)	1,132	N/A	17,950	Low/moderate – Small number of credits and duplication of costs make overall suitability low, however these credits may be considered for offsetting Phase 1 impacts.
Koala (*Phascolarctos cinereus*)	17,992	N/A	30,454	Low/moderate – Small number of credits and duplication of costs make overall suitability low, however these credits may be considered for offsetting Phase 1 impacts.
Native Milkwort (*Polygala linariifolia*)	21	N/A	3,780	Low – Small number of credits available makes these undesirable as offsets.
Squirrel Glider (*Petaurus norfolcensis*)	7,195	N/A	21,953	Low/moderate – Small number of credits and duplication of costs make overall suitability low, however these credits may be considered for offsetting Phase 1 impacts.

There were two sites still listed under the Biobank site expression of interest register, however, these EOI's are now no longer relevant as landowners can no longer register Biobanking Agreements under the BC Act.

3.3.2. Biodiversity Offset Scheme (BAM) credit supply register

A review of the BAM credits available (or pending an/or expression of interest) within the Pilliga and Pilliga Outwash sub-regions was undertaken in 2020, 2021 and 2022 and found a moderate supply of credits that may be suitable for Phase 2 offsetting requirements (Table 3.), however, at this stage are not relevant to the Phase 1 credit liability (other than the Myall Valley Stewardship site (see Phase 1 credit sources in Section 4.2.1) and are therefore not currently considered suitable. Note for some entities there may be duplication between the BioBanking credit register (Table 3-1) and the Biodiversity Offset Scheme credit supply register through equivalency assessments to convert from Biobanking into Biodiversity Offset Scheme credits.

Table 3.2 - Summary of Biodiversity Offset Scheme credit supply register as of 25 May 2021

Credit ID	Entity	Status	Offset trading group	BAM credits available	BAM Credit requirement	Current suitability as offset
CR-384	PCT 27	Pending Review	Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	4,080	17	Low – this credit type is not required for Phase 1. Possible future use as credit requirement for this PCT is low.
CR-5910	PCT 309	Pending Review	Western Slopes Dry Sclerophyll Forests <50%	5,341	25,270 (for whole offset trading group)	Low – Myall Valley Stewardship site (see Section 4.2.1) satisfies full liability for Phase 1 for this offset trading group.
CR-4398	PCT 27	Issued	Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	203	17	Low – this credit type is not required for Phase 1. Possible future use as credit requirement for this PCT is low.
CR-4401	PCT 55	Issued	North-west Floodplain Woodlands >=70% and <90%	23	154	Low – this credit type is not required for Phase 1. Possible future use if still available in Phase 2.

Credit ID	Entity	Status	Offset trading group	BAM credits available	BAM Credit requirement	Current suitability as offset
CR-6951	PCT 291	Pending Review	Western Slopes Dry Sclerophyll Forests <50%	304	25,270 (for whole offset trading group)	Low – Myall Valley Stewardship site (see Section 4.2.1)satisfies full liability for Phase 1 for this offset trading group.
CR-7165	PCT 402	Pending Review	Western Slopes Dry Sclerophyll Forests <50%	191	39	High – credits from to Myall Valley Stewardship site (see Section 4.2.1)
CR-7164	PCT 398	Pending Review	Western Slopes Dry Sclerophyll Forests <50%	7	10,150	High – credits from to Myall Valley Stewardship site (see Section 4.2.1)
CR-7162	PCT 256	Pending Review	Inland Rocky Hill Woodlands <50%	12	8	High – credits from Myall Valley Stewardship site (see Section 4.2.1)
CR-7167	PCT 431	Pending Review	Western Slopes Dry Sclerophyll Forests <50%	1,789	25,270 (for whole offset trading group)	High – credits from Myall Valley Stewardship site (see Section 4.2.1)
CR-6303	PCT 417	Issued	Western Slopes Dry Sclerophyll Forests <50%	186	25,270 (for whole offset trading group)	Low – Myall Valley Stewardship site (see Section 4.2.1) satisfies full liability for Phase 1 for this offset trading group.
Various	Koala	Various	N/A	19,839	37,372	Moderate – various sources of credits may be suitable particularly for Phase 1.
BIMS-CR-013	Native Milkwort	Equivalence credit	N/A	22	491	Low - credits related to Myall Valley Stewardship site (see Section 4.2.1) wholly satisfy Phase 1 requirements for this species.
CR-7172	Native Milkwort	Various	N/A	94	491	High – credits related to Myall Valley Stewardship site (see Section 4.2.1) wholly satisfy Phase 1 requirements for this species.
CR-7171	Spiny Peppercress	Various	N/A	14	623	High – credits related to Myall Valley Stewardship site (see Section 4.2.1) wholly satisfy Phase 1 requirements for this species.

Credit ID	Entity	Status	Offset trading group	BAM credits available	BAM Credit requirement	Current suitability as offset
Various	Squirrel Glider	Various	N/A	13,989	36,964	Moderate – various sources of credits may be suitable particularly for Phase 1.

3.3.3. Analysis of suitable vegetation/habitats on freehold land in the Pilliga and Pilliga Outwash IBRA subregions

The availability of freehold land in the Pilliga and Pilliga Outwash IBRA subregions was investigated as part of the development of this biodiversity offset strategy. This analysis demonstrates the potential availability of suitable offsets in the region.

To identify suitable freehold land and biodiversity values present, the following spatial analysis was undertaken:

- The following IBRA subregions were merged to form a 'study area' data layer (Figure 3-1):
    - Pilliga
    - Pilliga Outwash
    - Castlereagh-Barwon
    - Liverpool Plains
    - Liverpool Range
    - Peel
    - Northern Outwash
    - Northern Basalts
    - Kaputar
    - Eastern Nandewars
- The Border Rivers Gwydir / Namoi and Central West / Lachlan Regional Native Vegetation PCT Maps (OEH 2015a,b) were merged and clipped to the study area to form a 'PCT' data layer
- The NSW Cadastre was clipped to the study area and all records denoting freehold land were selected to form a 'freehold land' data layer.
- The PCT and freehold land data layers were combined (using the union tool) and the following fields were added:
    - 'patch veg' which identifies PCTs included in the patch size analysis (described below)
    - 'TargetedPCTs' which identifies if the mapped PCTs correspond to any of the potential PCTs suitable for offsetting as defined by the Major Projects Credit Calculator
    - 'VariatPCTs' which identifies if the mapped PCTs correspond to any of the potential PCTs suitable for offsetting based on the variation rules outlined in the NSW Biodiversity Offset Policy for Major Projects (i.e. the same vegetation formation that has undergone an equal or greater amount of clearing)

- Patches of native vegetation were defined in accordance with the FBA, whereby patches that were separated by less than 100 m were considered part of the same patch. This step was required to eliminate breaks in mapping caused by roads, powerlines, fences etc.
- Areas of consolidated vegetation (greater than 1,000 hectares) were identified through a data review. 1,000 hectares was selected as large, consolidated patches of native vegetation are likely to provide better conservation outcomes as well as providing value for money.

For PCTs targeted as part of the analysis (those ‘like for like’ communities included in the credit profile for each PCT), a total of 282,000 hectares of native vegetation was identified on freehold land in the study area (3). Following the variation rules permitted under the FBA (subject to being able to demonstrate not being able to locate suitable ‘like for like’ offsets), there is no meaningful difference in the total amount of native vegetation available on freehold land (Table 3.). This is due to the large number of PCTs (and corresponding ‘like for like’ communities) already included as part of the targeted analysis. The key difference is that for each targeted PCT, there is greater flexibility in which PCTs offsets are permitted in (Table 3.3).

It is not possible to undertake a detailed analysis of the availability of ‘species credit’ species from a desktop perspective without undertaking detailed field investigation. However, considering the ‘like for like’ nature of these PCTs, it is considered highly likely that suitable habitat for the required ‘species credit’ species would occur on the freehold land identified in the study area. To confirm this assumption, a review of the Threatened Species Profile Database (TSPD) was undertaken which identified that all of the ‘species credit’ species required to be offset by the Project are associated with on average 24 of the ‘like for like’ PCTs identified in the regional analysis (range 1 and 43 PCTs per species).

To further support this conclusion, there are records in the Atlas of NSW Wildlife (OEH, 2017) for 73% of the ‘species credit’ species required to be offset as part of the Project on freehold land identified as part of this analysis. This is significant due to the private tenure and relatively low amount of survey in the region.

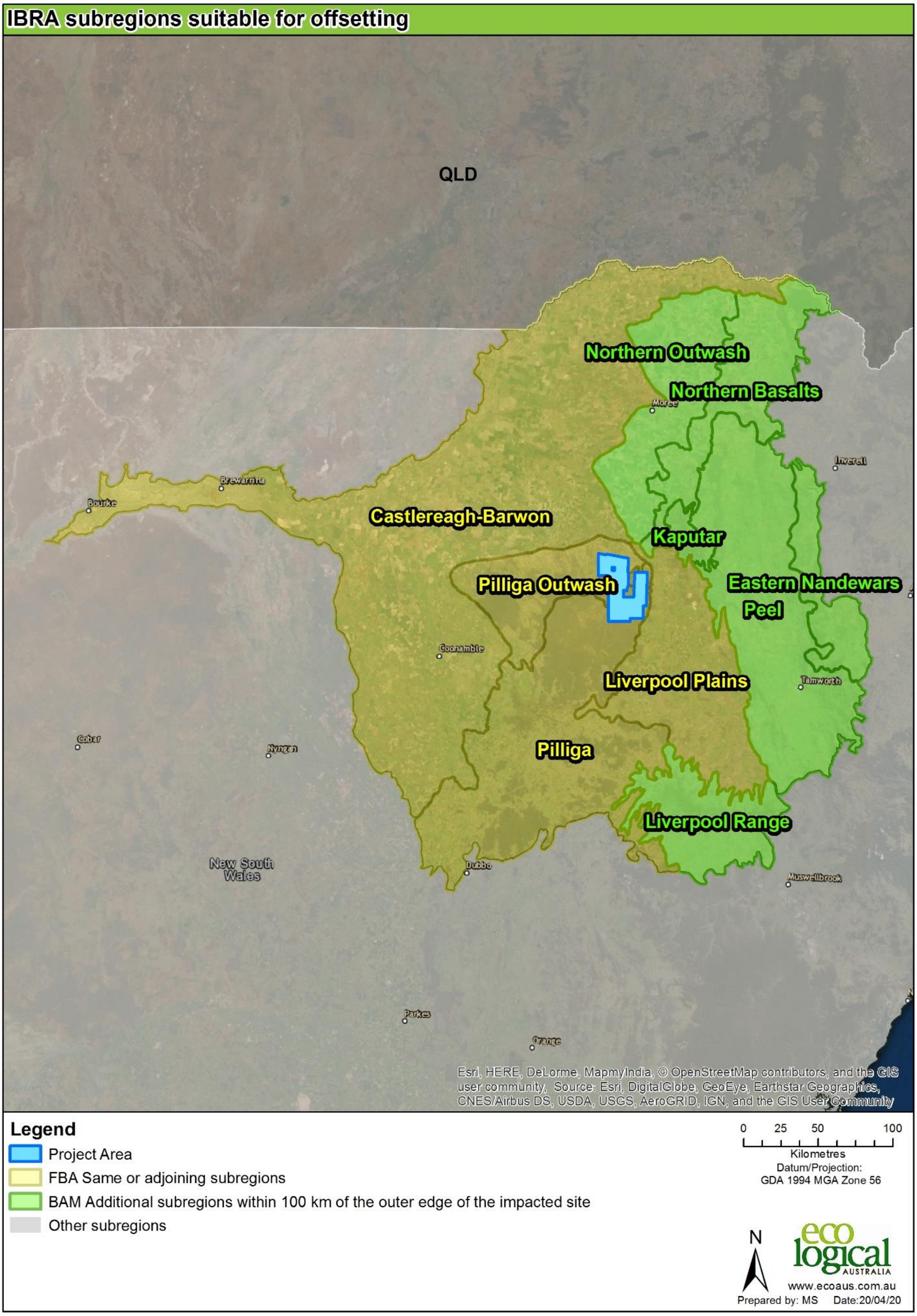


Figure 3-1 – Suitable IBRA subregions for Biodiversity offsets

Table 3.3 - Potential offsets available on freehold land in the study area

PCT	Biometric Vegetation Type	Estimated BAM Offset Required (ha)	Potential offset available (ha)	Potential offset available (variation rules)
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	2.84 - 4.25	361	10,252
35	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	332.33 - 498.5	7,441	7,441
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	33.16 - 49.75	2,451	10,252
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	289.17 - 433.75	17,785	17,785
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	76.17 - 114.25	45,964	72,819
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	82.83 - 124.25	1,286	1,286
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	1.66 - 2.5	138	2,404
379	Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the Brigalow Belt South Bioregion	19.67 - 29.5	77,796	198,129
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	8.16 - 12.25	42,901	50,720
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	2199.01 - 3298.5	64,024	83,722
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	20.34 - 30.5	77,796	198,129
401	Rough-barked Apple - Blakely's Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region	399.17 - 598.75	44,537	53,528
402	Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion	8.33 - 12.5	20,867	8,408
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	594.84 - 892.25	77,796	198,129
405	White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	1565.16 - 2347.75	77,796	179,283
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	390.33 - 585.5	77,796	198,182

PCT	Biometric Vegetation Type	Estimated BAM Offset Required (ha)	Potential offset available (ha)	Potential offset available (variation rules)
408	Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region	224.84 - 337.25	77,796	179,283
418	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion	2 - 3	24,620	72,819
425	Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion	52.33 - 78.5	77,796	198,129
	Total	6,302.34 – 9,453.50	282,861[4]	282,539[4]

3.3.4. Liaising with interested landowners in region

A number of land-based offset opportunities with land holders interested in registering BSAs are currently being explored near the Project area.

The recently registered 392 ha “Myall Valley Stewardship Site” (see section 4.2) will satisfy approximately 95% of the ‘ecosystem credit’ requirements for Phase 1 impacts. Other suitable property holders are being identified within the area for approach during Phase 2 planning.

Generation of ‘species credit’ entities is difficult to predict without detailed field surveys and represent the largest source of risk for the future phases of the Project securing the required credits (see Sections 2.1 and 2.2 for more detail).

3.3.5. Properties for sale in the region

An analysis of properties for sale in the region (defined as the Brigalow Belt South IBRA Bioregion) was undertaken in 2020 and investigated as part of the development of this biodiversity offset strategy. To identify suitable properties and their biodiversity values, the following criteria were used:

- Rural properties in Narrabri, Coonabarabran and Pilliga and surrounding areas.
- Minimum land size of (500 hectares).
- Suitable properties (i.e. those with large areas of remnant vegetation) were manually selected based on a review of aerial photography.
- Lot/DPs for the suitable properties were identified and mapped.
- Properties outside of the Brigalow Belt South IBRA Bioregion were excluded.
- Regional vegetation mapping (OEH 2015a,b) was then queried to identify the type and quantum of likely PCTs present.

[4] This is the total of all potential offset PCTs, not a cumulative total for each PCT. Cumulative totals for all PCT do not provide an accurate representation of available vegetation as each PCT impacted can generally be offset with multiple PCTs which then may be also suitable to offset other impacted PCTs.

Searches of www.realestate.com.au were undertaken on 11 December 2017 and again on 19 March 2020, returning a total 11 and nine suitable properties respectively. Based on regional vegetation mapping, a total of 6,796 hectares of native vegetation was identified across 11 properties on December 2017 (Table 3.4) and 7,547.4 hectares of native vegetation across nine properties on March 2020 (Table 3-25). This analysis indicated that there are likely to be a number of properties offered for sale that are suitable and viable to be registered as BSAs that are able to meet a proportion of the ecosystem credit requirement for the Project.

It is very difficult to undertake a detailed analysis of the availability of 'species credit' species from a desktop perspective for properties for sale in the region without undertaking also undertaking detailed field investigations. There are no records in the Atlas of NSW Wildlife / BioNet for the 'species credit' species required to be offset as part of the Project on land currently for sale. This is not unexpected given the private tenure and relatively low amount of survey effort in the region. However, considering the 'like for like' nature of these Plant Community Types, it is considered likely that suitable habitat for a significant proportion of the required 'species credit' species would occur on the properties for sale identified in the region.

Table 3.4 - Type and quantum of PCTs present on properties for sale during December 2017 search

PCT	PCT Name	Hectares
1	Candidate Native Grasslands	1,300
35	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	558
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	7
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	72
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	321
101	Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion	12
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	1
244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	1
379	Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the Brigalow Belt South Bioregion	5
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	658
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	483
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	182
401	Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region	1,078
411	Buloke - White Cypress Pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, Brigalow Belt South Bioregion	521

PCT	PCT Name	Hectares
417	Black Cypress Pine - Narrow-leaved Ironbark - red gum +/- White Bloodwood shrubby open forest on hills of the southern Pilliga, Coonabarabran and Garawilla regions, Brigalow Belt South Bioregion	847
433	White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, BBS Bioregion	0
440	Red Stringybark - Narrow-leaved Ironbark - Black Cypress Pine - hill red gum sandstone woodland of southern NSW Brigalow Belt South Bioregion	525
455	Rough-barked Apple - Red Stringybark - Black Cypress Pine - red gum sand valley woodland of the Garawilla region, Brigalow Belt South Bioregion	2
457	White Bloodwood - Red Ironbark - Black Cypress Pine woodland on sandstone hills in the Garawilla - Liverpool Plains region, Brigalow Belt South Bioregion	113
467	Blue-leaved Ironbark - Black Cypress Pine shrubby sandstone open forest in the southern Brigalow Belt South Bioregion (including Goonoo)	17
468	Narrow-leaved Ironbark - Black Cypress Pine +/- Blakelys Red Gum shrubby open forest on sandstone low hills in the southern Brigalow Belt South Bioregion (including Goonoo)	3
511	Queensland Bluegrass - Redleg Grass - Rats Tail Grass - spear grass - panic grass derived grassland of the Nandewar Bioregion and Brigalow Belt South Bioregion	88
	Total	6,796

Table 3-2 - Type and quantum of PCTs present on properties for sale during March 2020 search

PCT	Name	Area (ha)
35	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	0.7
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	4.6
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	736.3
101	Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion	42.2
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	9.2
206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	124.8
379	Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the Brigalow Belt South Bioregion	349.0
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	104.0
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	1441.4
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	1633.2
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	319.1

PCT	Name	Area (ha)
401	Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region	1277.1
411	Buloke - White Cypress Pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, Brigalow Belt South Bioregion	269.8
417	Black Cypress Pine - Narrow-leaved Ironbark - red gum +/- White Bloodwood shrubby open forest on hills of the southern Pilliga, Coonabarabran and Garawilla regions, Brigalow Belt South Bioregion	574.5
425	Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion	3.7
440	Red Stringybark - Narrow-leaved Ironbark - Black Cypress Pine - hill red gum sandstone woodland of southern NSW Brigalow Belt South Bioregion	28.3
458	White Cypress Pine - Buloke - White Box shrubby open forest on hills in the Liverpool Plains - Dubbo region, Brigalow Belt South Bioregion	8.2
467	Blue-leaved Ironbark - Black Cypress Pine shrubby sandstone open forest in the southern Brigalow Belt South Bioregion (including Goonoo)	563.4
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	7.3
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	16.9
599	Blakelys Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	33.9
Total		**7547.4**

3.3.6. 'Species credit' species on land-based offset sites

In securing land-based offset sites for 'species credit' species for the Project the presence of the species on an offset site will first be confirmed by targeted survey, followed by an assessment of the extent of 'suitable habitat'(as defined by Section 5.2.5 of the BAM and to the satisfaction of the BCT).

For 'species credit' fauna species, the Proponent is proposing to identify suitable potential habitat (as defined through Plant Community Type associations contained in the Threatened Species Profile Database) on offset sites, rather than specifically identifying and mapping individual areas of habitat for these species. The presence of species on an offset site will be confirmed using field surveys and habitat will be mapped based on the known habitat associations, followed by an estimate of habitat present. Mapping of habitat may also include the use of expert reports prepared by accredited species experts and to the satisfaction of the BCT.

In calculating the number of credits generated for 'species credit' species on land-based offset sites, the Proponent is proposing to:

1. Identify suitable habitat as defined through Plant Community Type associations for each species.
2. Confirm the presence of each species through targeted survey.
3. Determine a habitat polygon consistent with Section 5.2.5 of the BAM and to the satisfaction of the BCT.

3.4. Biodiversity Conservation Fund option

Based on the current version of the BOPC (May 2022), the current cost to secure all offset requirements of the Project via the BCF is in excess of $200M as the Project will pay a 'premium' price for the credits and will also be required to secure the credits as separate entities (i.e. ecosystem and species credits). Many land-based offsets will be able to provide both ecosystem and species credits from the same site, avoiding duplication and significantly reducing the cost. The option of using the BCF is therefore a last resort for Santos and can be regarded as the contingency measure.

Once all land-based offsets have been exhausted, the remaining offset liability, if any, for the Project will be satisfied through payments to the Biodiversity Conservation Fund. The proponent cannot at this stage anticipate the quantum of credits that will require payment into the fund and will be contingent on the development Phase requirements. Given the availability of potential offsets in the region and the current options being explored for land-based offsets, it is considered that land-based offsets for nearly all 'ecosystem credits' will be achieved and any entities requiring payment into the fund will likely be a residual proportion of 'species credit' species and any rare and dispersed vegetation communities that could not be secured in BSA sites.

The Biodiversity Conservation Fund will then be used by the fund program manager (the NSW Biodiversity Conservation Trust) to meet the remaining liability of the Project to ensure the 'like for like' conservation of biodiversity values impacted in the study area.

4. Biodiversity offset package

It is proposed that credit retirement will be addressed in a staged approach, consistent with NSW consent SSD-6456, based on the credit liability calculated to offset the impacts of each development plan to the satisfaction of the BCT.

The Biodiversity Offset Package for the Project will deliver environmental, cultural, and socio/economic benefits through:

- Land-based offsets which will seek to increase landscape connectivity and conservation of ecological values unique to the Pilliga Region.
- An aim to incorporate areas of land into the offset package because of their Aboriginal cultural heritage values, or that the land is owned by the Aboriginal community, as well as their biodiversity values. This is dependent on the feasibility for the Aboriginal community and timing constraints for the retirement of credits prior to commencement of phase 2.
- Providing ongoing access to this land for traditional cultural activities and practices.
- Encouraging the active involvement of Aboriginal people in the management of some offset land.

The Biodiversity Offset Package for the Project will contain a combination of:

- **Like-for-like offsets** secured via an appropriate conservation mechanism (including purchase and retirement of biodiversity credits (where available), protection under Biodiversity Stewardship Agreements.
- **NSW Biodiversity Conservation Fund** will be used for remaining offset liability.

The biodiversity offset package described in sections 4.1and 4.2 specifically relates to the impacts of the Phase 1 appraisal development, using a staged approach for offsetting. Subsequent stages will be addressed through updates to the strategy as certainty around the Projects impacts are resolved. Accordingly, the strategy to meet the offset requirements of the Project's Phase 2 credit liability will be part of a future update to this Biodiversity Offset Strategy.

For Phase 1 of the project, land based offsets have been sought in the first instance with the Proponent having already supported the assessment of one Biodiversity Stewardship Site, Myall Valley, with the resultant credits generated by the agreement being purchased and to be retired by Santos (See Section 4.2.1).

The residual impacts of Phase 1 not offset by the credits generated by the Myall Valley Biodiversity Stewardship Site will be offset through a combination of biobanking and/or Biodiversity Offset Scheme credits, where available and financially viable, and a payment into the Biodiversity Conservation Fund.

Land-based offsets are favoured as the preferred mechanism for offsetting under the Biodiversity Offset Scheme and represent the most cost-effective means to meet the offset liability for the Project.

4.1. Phase 1 development offset requirements

The proposed Phase 1 development will impact approximately 23 hectares of native vegetation, five threatened flora species and their habitat and habitat for four threatened fauna species (refer to Table 4-1) and Figure 4-1. The Phase 1 footprint has reduced the area of impact from 29.52 ha to 24.68 ha by using existing cleared land to the maximum extent possible to access wells in accordance with the approved Field Development Protocol. This footprint was then further refined through engineering efficiencies to 23 ha.

Table 4-1 - Summary of impacts related to the Project Phase 1 Field Development Plan to vegetation communities and threatened species

Entity	Offset trading group/Category	Area (ha)	FBA credits required (BBAM Credits)	BIODIVERSITY OFFSET SCHEME credits required (BBAM Credits)
88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Pilliga Outwash Dry Sclerophyll Forests / 4	0.05	4	2
141 - Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	Pilliga Outwash Dry Sclerophyll Forests / 4	0.51	20	10
202 - Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion (EEC)	Western Slopes Grassy Woodlands / Fuzzy Box EEC/3	0.47	52	31
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 BBS Bioregion	Western Slopes Dry Sclerophyll Forests / 4	10.82	792	338
399 - Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion	Western Slopes Dry Sclerophyll Forests / 4	0.03	2	1
401 - Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region	Western Slopes Dry Sclerophyll Forests / 4	2.17	171	75
404 - Red Ironbark - White Bloodwood -/+ Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Western Slopes Dry Sclerophyll Forests / 4	1.34	98	43
405 - White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	Western Slopes Dry Sclerophyll Forests / 4	4.8	327	140
408 - Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland of the Pilliga forests and surrounding region	Western Slopes Dry Sclerophyll Forests / 4	2.8	203	88
Total		**23**	**1,669**	**728**
Flora		**Individuals**		

Entity	Offset trading group/Category	Area (ha)	FBA credits required (BBAM Credits)	BIODIVERSITY OFFSET SCHEME credits required (BBAM Credits)
Diuris tricolor	-	2	26	10
Polygala linariifolia	-	6	90	12
Pterostylis cobarensis	-	161	2,315	68
Commersonia procumbens	-	78	1,170	7
Tylophora linearis	-	13	196	78
Fauna		**Area (ha)**		
Eastern Pygmy-possum (*Cercartetus nanus*)	-	21.70	503	503***
Pale-headed Snake (*Hoplocephalus bitorquatus*)	-	22.50	858	1,188
Squirrel Glider (*Petaurus norfolcensis*)	-	22.50	574	574***
Koala (*Phascolarctos cinereus*)	-	23.00	709	709***

***BBAM Credits available at 1:1 (as per Equivalency Statement at **Appendix A**)

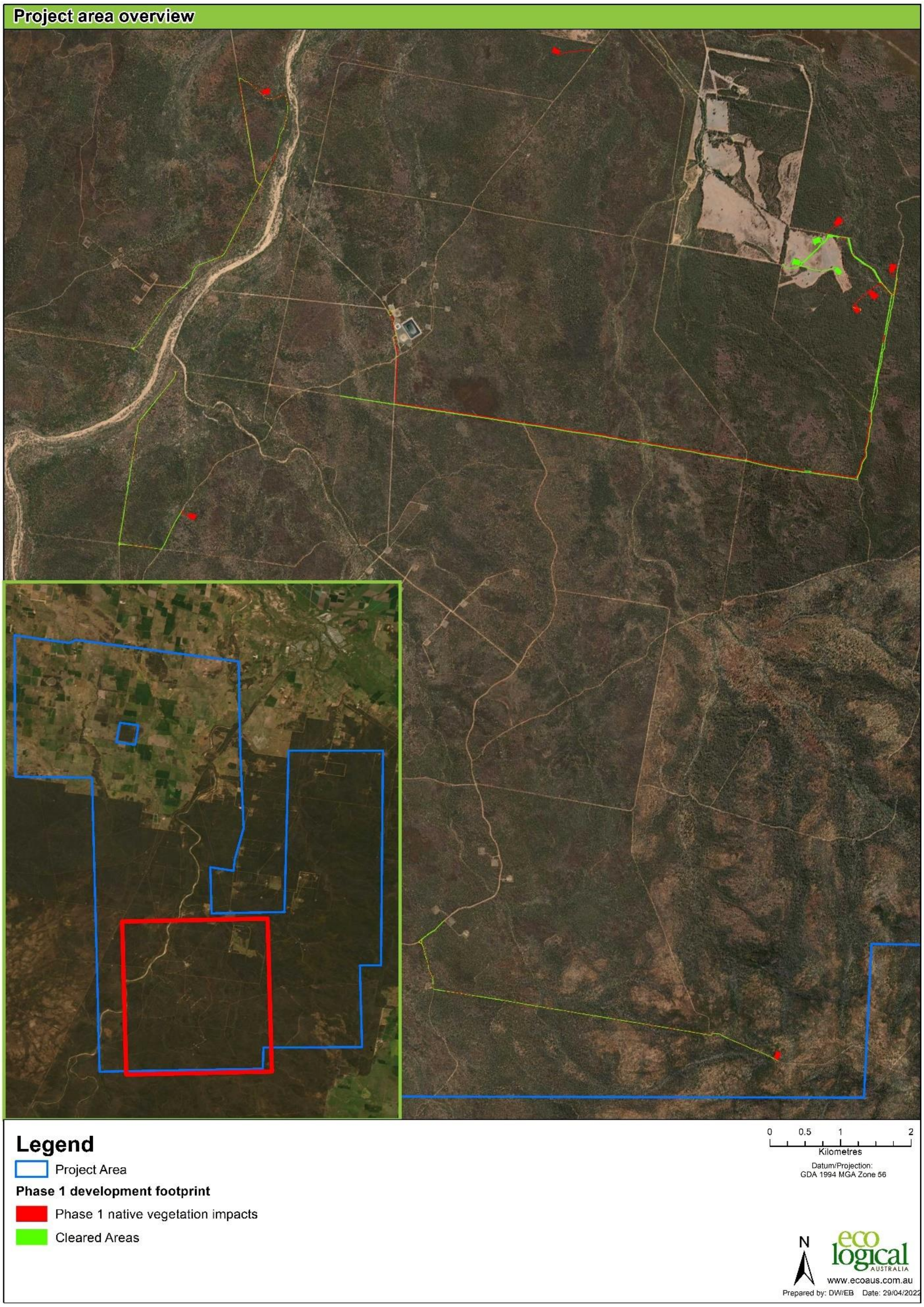


Figure 4-1 - Indicative development footprint of Phase 1

4.2. Meeting Phase 1 credit requirements

The Phase 1 offset requirements will be met by:-

i. Retiring credits purchased by Santos from the established Myall Valley Biodiversity Stewardship site (BSA); and
ii. Purchase and retirement of BBAM credits from existing Biobank sites in the region (where still available); and
iii. Payment into the BCF.

In accordance with CoC B44, all required ecosystem and species credits generated by the works proposed in the Field Development Plan for Phase 1 of the Project will be retired prior to the commencement of Phase 1, in accordance with the Biodiversity Offset Scheme of the BC Act and to the satisfaction of the BCT.

4.2.1. Myall Valley Biodiversity Stewardship Site

The Myall Valley Biodiversity Stewardship Site was registered on 19 October 2022. The Stewardship site generated 2,385 ecosystem and 110 species credits as shown in Table 4-2.

Santos (Eastern) Pty Ltd has entered into a legally binding credit purchase agreement with the owners of Myall Valley, to purchase all credits generated by the BSA. The credits that match the Phase 1 requirements (in accordance with the Offset Trading Groups (OTG) of the Biodiversity Offset Scheme) are shown in Table 4-2 and will be retired by the Proponent prior to the commencement of Phase 1.

The credits generated by the Myall Valley BSA will satisfy approximately 90% of the required 'ecosystem credit' requirements for the Phase 1 development (Table 4-2). Only species credits for *Polygala linariifolia* will be directly relevant to the Phase 1 development (Table 4-3). The credit requirements for this species is wholly satisfied by the quantum generated by the Myall Valley Biodiversity Stewardship Site.

Table 4-2 - Ecosystem credits generated by the Myall Valley Biodiversity Stewardship Site as it relates to Phase 1 development offset requirements

Offset trading group	Offset Trading Group category	Pro-rata credits required (Phase 1) (FBA)	Credits required (Phase 1) (BAM)	Credits created (Myall Valley)	Credit deficit/ surplus
Brigalow Clay Plain Woodlands	Brigalow EEC	0	0	0	0
Western Slopes Grassy Woodlands	Fuzzy Box EEC	52	31	0	-31
Pilliga Outwash Dry Sclerophyll Forests	7	24	12	37	25
Western Slopes Dry Sclerophyll Forests	7	1,593	685	1,987	1,302
Inland Rocky Hill Woodlands	7		0	12	12

Offset trading group	Offset Trading Group category	Pro-rata credits required (Phase 1) (FBA)	Credits required (Phase 1) (BAM)	Credits created (Myall Valley)	Credit deficit/ surplus
North-west Slopes Dry Sclerophyll Woodlands	7		0	74	74
Western Vine Thickets	7		0	103	103
Yetman Dry Sclerophyll Forest	7		0	172	172
Total		**1669**	**728**	**2,385**	**-31**

Table 4-3 - 'Species credits generated by the Myall Valley Biodiversity Stewardship Site as it relates to Phase 1 development offset requirements

Species	Pro-rata credits required (FBA)	Credits required (Biodiversity Offset Scheme- BAM)	Credits created (Myall Valley)	Credit deficit/surplus
Flora				
Commersonia procumbens	1170	7	0	-7
Diuris tricolor	26	10	0	-10
Polygala linariifolia	90	12	96	84
Pterostylis cobarensis	2,315	68	0	-68
Tylophora linearis	196	78	0	-78
Fauna				
Eastern Pygmy-possum (Cercartetus nanus)	503	503***	0	-503
Pale-headed Snake (Hoplocephalus bitorquatus)	858	1188	0	-1188
Squirrel Glider (Petaurus norfolcensis)	574	574***	0	-574
Koala (Phascolarctos cinereus)	709	709	0	-709

***Credits can be purchased at a ratio of 1 FBA : 1 BAM as per the Credit Equivalency Statement in **Appendix A**.

4.2.2. Purchase/retirement of remaining Phase 1 credits

The remaining credit liabilities for Phase 1 are largely related to species credits.

For the outstanding Phase 1 credit requirements, biobanking and/or Biodiversity Offset Scheme credits have been purchased where available and financially viable. All outstanding credit liabilities following the credit purchases from the market will be satisfied through a payment into the Biodiversity Conservation Fund.

Table 4.4 shows how all Phase 1 offset requirements will be acquitted, including those purchased from the market or paid into the Biodiversity Conservation Fund. The status of each of the required offset credits is also provided.

A number of offset credits are yet to be purchased and/or retired as is shown in Table 4.4. These transactions will be completed prior to the commencement of Phase 1 as is required by CoC B44. Once retired, Santos will provide evidence of this to DPE also prior to the commencement of Phase 1.

Table 4.4 - Acquittal of ecosystem and species credits as they relate to Phase 1 development offset requirements

Offset Trading Group	Offset trading group/Category	Pro-rata credits required (FBA)	Credits required Phase 1 (BAM)	Credits purchased from BSA (Myall Valley)	Credits purchased from the registered biobank sites	Credits purchased from the Biodiversity Conservation Fund	Status (@11/11/2022)	Credit Deficit / Surplus
Ecosystem								
Western Slopes Grassy Woodlands	Fuzzy Box EEC	52	31	0		31	To be purchased	0
Pilliga Outwash Dry Sclerophyll Forests	7	24	12	37			Awaiting credit transfer	25
Western Slopes Dry Sclerophyll Forests	7	1,593	685	1,987			Awaiting credit transfer	1,302
Flora								
Commersonia procumbens		1,170	7			7	Retired	0
Diuris tricolor		26	10			10	Retired	0
Polygala linariifolia		90	12	96			Awaiting credit transfer	84
Pterostylis cobarensis		2,315	68			75	Retired	7
Tylophora linearis		196	78			85	Retired	7
Fauna								
Eastern Pygmy-possum (*Cercartetus nanus*)		503	503***	0		545	To be purchased	42
Pale-headed Snake (*Hoplocephalus bitorquatus*)		858	1,188	0		1,,273	Retired	85
Squirrel Glider (*Petaurus norfolcensis)*		574	574***	0	614		To be retired	40
Koala (P*hascolarctos cinereus)*		709	709	0	795		To be retired	86

4.3. Retirement of remaining Phase 2 credits / future Biodiversity Stewardship Site options

The proponent is currently investigating several other potential Biodiversity Stewardship Sites for offsetting the impacts of the Project (Figure 4.2). Specific locations and names of sites remains commercial in confidence to preserve the integrity of the process for all parties. Land-based offsets will be sought as a priority for satisfying the Phase 2 credit liability.

One site is approximately 2,648 hectares and is contiguous with an existing conservation area. Vegetation mapping across the site was validated in 2015 and confirmed that four PCTs occur within the site that are either like for like (approximately 1,028 hectares) or meet the FBA variation rules (approximately 1,620 hectares). These 'ecosystem credits' would account for an estimated 40% of the Projects overall 'ecosystem credit' liability or 60% of the Phase 2 liability. It is quite likely that a proportion of species credits will also be met by this site.

Other options for large Biodiversity Stewardship Sites are currently being investigated within the IBRA subregions suitable for offsetting with a Bias to the Pilliga and Pilliga Outwash subregions. Methods for identifying these properties are described in section 4. Santos will continue investigating properties for sale in the region and expand a community liaison program to identify parties that may be interested in establishing Biodiversity Stewardship Agreements on their landholding that would otherwise not appear on Expressions of Interest registers or properties for sale. These sites are being prioritised based on the following features:

- Suitability of vegetation present, i.e. sites within the Pilliga and Pilliga Outwash subregions
- Size of land holding and extent of remnant native vegetation, greater than 200 hectares minimum with a preference for 1,000 hectares and greater
- Condition of the existing vegetation within the land holding and thus likely hood of species credits also being present and the relative costs of on-going management obligations.
- Presence of a highly desirable credit type, e.g. vegetation communities with limited like-for-like trading options and no applicable variation rules
- Connectivity to surrounding landscape, i.e. landholdings with links to existing conservation areas; and
- Proximity to other suitable land parcels for multiple acquisitions to create larger amalgamated biodiversity stewardship sites.

The proponent will also submit a new expression of interest on the Biodiversity Offset Scheme credits wanted register to further aid in finding any potential offset sites that have otherwise not been identified.

All required credits for Phase 2 will be retired prior to the commencement of Phase 2 in accordance with the Biodiversity Offset Scheme of the BC Act and to the satisfaction of the BCT. All required credits for each subsequent stage of development will be retired prior to the commencement of that stage.

Santos' progress on the biodiversity credit identification and retirements will be provided to the Department in the Annual review, as required by CoC D8(c).

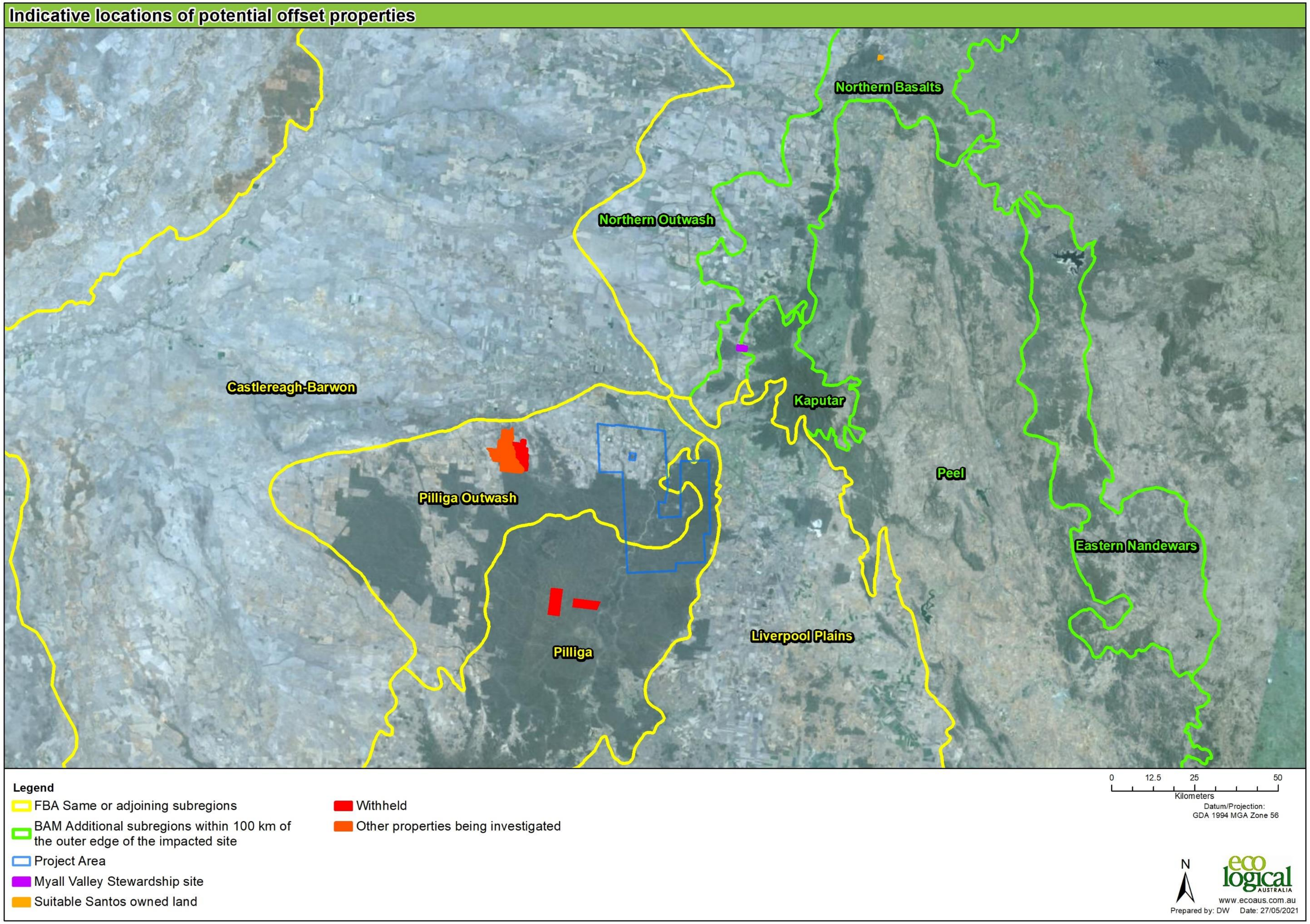


Figure 4.2 - Indicative locations of offset areas and relevant IBRA subregions

5. Statement of commitments

This Biodiversity Offset Strategy is the Proponents' commitment to adequately offset the residual impacts of the Project following implementation of avoidance, minimisation and mitigation strategies.

The Biodiversity Offset Strategy ensures that long-term conservation outcomes are achieved in recognition of the NSW Offsetting Principles and the NSW Biodiversity Offset Policy for Major Projects. The ecological impact assessment of the Project determined that there would be no significant impact to MNES, therefore offsets for MNES are not required under the EPBC Act Offset Policy, however as the NSW Biodiversity Offset Policy for Major Projects and Framework for Biodiversity Assessment apply to the Project, MNES will be directly and indirectly offset as part of this Biodiversity Offset Strategy.

In line with the contents of this Biodiversity Offset Strategy, the Proponent will:

- Commit to delivering biodiversity offsets which meets the offset quantum determined by the Framework for Biodiversity Assessment (and the Statement of Reasonable Credit Equivalence), including the development of an offset package which includes a combination of:
    - retirement of credits purchased from registered Biobank and/or Biodiversity Stewards ship sites in accordance with each stage of development and Table 8 in the consent for SSD 6456 and the Statement of Reasonable Credit Equivalence (Appendix A)
    - Like-for-like offsets secured via registration of Biodiversity Stewardship Agreements to the satisfaction of the BCT .
    - Payment into the Biodiversity Conservation Fund for any remaining offset liabilities in accordance with each stage of development.
- Identify cultural heritage values as part of the Biodiversity Offset Package[5], including:
    - Incorporation of Aboriginal cultural heritage values in land-based offset sites.
    - Community access to biodiversity offsets that are owned and/or operated by Santos. Some Biodiversity Stewardship Sites will remain in private landholdership and access to these locations is legally outside of the control of Santos.
    - Community management of land-based offsets will be prioritised where options are available.
- Undertake reporting for land-based offsets owned and managed by the Proponent in accordance with the Biodiversity Assessment Methodology, and/or prior to the commencement of each development stage.
- Undertake a periodic review of the Biodiversity Offset Strategy every 5 years in accordance with the Biodiversity Assessment Methodology.
- Update the Department on progress of biodiversity credit identification and retirements in the Annual Review required by COC D8(c); and

[5] Unfortunately, there will be no opportunities for community access and management for Phase 1 offsets as they are primarily privately owned land not controlled by Santos.

- Provide evidence of the retirement of biodiversity credits prior to the commencement of each development stage.

6. References

ELA (2015). Narrabri Gas Project - *Ecological Impact Assessment.* Prepared for Santos NSW (Eastern) Pty Ltd.

ELA (2018). Narrabri Gas Project – *Biodiversity Offset Strategy (Draft).* Prepared for Santos NSW (Eastern) Pty Ltd.

GHD (2017). *Narrabri Gas Project –Environmental Impact Statement*. Prepared for Santos NSW (Eastern) Pty Ltd.

OEH (2014). *NSW Biodiversity Offsets Policy for Major Projects*.

OEH (2015a). *Border Rivers Gwydir / Namoi Regional Native Vegetation PCT Map Version 1.0. VIS_ID 4467*, NSW Office of Environment and Heritage, Sydney, Australia.

OEH (2015b). *Central West / Lachlan Regional Native Vegetation PCT Map Version 1.0. VIS_ID 4468*, NSW Office of Environment and Heritage, Sydney, Australia.

Onward Consulting (2021). Santos Narrabri Gas Project Field Development Plan Phase 1. Report prepared for Santos Revision E 15 September 2021.

Appendix A – Statement of Reasonable Equivalence

DOC21/89273-1

Statement of assessment of reasonable equivalence of biodiversity credits

A delegate of the Environment Agency Head of the Department of Planning Industry and Environment has determined that the number of biodiversity credits required to be retired under the *Threatened Species Conservation Act 1995* (**TSC Act**) as part of the development consent listed in Part 1, are reasonably equivalent to the number and class of biodiversity credits under the *Biodiversity Conservation Act 2016* (**BC Act**) set out in Part 2.

This document outlines that determination, made in accordance with clause 22(3) of the *Biodiversity Conservation (Savings and Transitional) Regulation 2017*.

Part 1 Existing statutory obligation to retire credits

Request made by:	Santos NSW (Eastern Pty Ltd)
Date request received	15th December 2020
Development Consent reference	SSD 6456
Development name	Narrabri Gas Project

Existing statutory obligation reference[1]	Biodiversity credit name (Plant Community Type name and ID, or threatened species name)	IBRA sub region[2]	Number of credits shown in development consent[3]
SSD 6456	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (NA219/PCT27)	Pilliga and Pilliga Outwash	5
SSD 6456	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (NA219/PCT27- Derived Native Grasslands)	Pilliga and Pilliga Outwash	20
SSD 6456	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to	Pilliga and Pilliga	1,306

[1] There are three Biobanking calculator cases that generate credit obligations for SSD 6456: 0027/2018/4783MP, 0027/2018/4784MP and 0027/2018/4785MP.
[2] The impact associated with SSD 6456 occurs across two Interim Biogeographic Regionalisation for Australia (IBRA) sub regions.
[3] Some credit obligations generated in the Biobanking calculator cases differ from the credit obligations listed in the consent for SSD 6456. The applicant has requested that this credit equivalence be undertaken based on the credit obligations listed in the consent for SSD 6456.

Existing statutory obligation reference[1]	Biodiversity credit name (Plant Community Type name and ID, or threatened species name)	IBRA sub region[2]	Number of credits shown in development consent[3]
	Goondiwindi, Brigalow Belt South Bioregion (NA117/PCT35)	Outwash	
SSD 6456	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (NA117/PCT35- Derived Native Grasslands)	Pilliga and Pilliga Outwash	1,301
SSD 6456	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (NA102/PCT55)	Pilliga and Pilliga Outwash	220
SSD 6456	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (NA102/PCT55- Derived Native Grassland)	Pilliga and Pilliga Outwash	65
SSD 6456	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (NA179/PCT88)	Pilliga and Pilliga Outwash	2,846
SSD 6456	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (NA179/PCT88- Derived Native Grassland)	Pilliga and Pilliga Outwash	283
SSD 6456	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (NA121/PCT141)	Pilliga and Pilliga Outwash	807
SSD 6456	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion (NA141/PCT202)	Pilliga and Pilliga Outwash	648
SSD 6456	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion (NA292/PCT256)	Pilliga and Pilliga Outwash	15
SSD 6456	Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the Brigalow Belt South Bioregion (NA294/PCT379)	Pilliga and Pilliga Outwash	208
SSD 6456	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow	Pilliga and Pilliga	64

Existing statutory obligation reference[1]	Biodiversity credit name (Plant Community Type name and ID, or threatened species name)	IBRA sub region[2]	Number of credits shown in development consent[3]
	Belt South Bioregion (NA324/PCT397)	Outwash	
SSD 6456	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion (NA324/PCT397- Derived Native Grasslands)	Pilliga and Pilliga Outwash	33
SSD 6456	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 (NA314/PCT398)	Pilliga and Pilliga Outwash	23,651
SSD 6456	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 (NA314/PCT398- Derived Native Grasslands)	Pilliga and Pilliga Outwash	184
SSD 6456	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (NA255/PCT399)	Pilliga and Pilliga Outwash	220
SSD 6456	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (NA255/PCT399- Derived Native Grasslands)	Pilliga and Pilliga Outwash	0
SSD 6456	Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region (NA338/PCT401)	Pilliga and Pilliga Outwash	3,649
SSD 6456	Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region (NA388/PCT401- Derived Native Grasslands)	Pilliga and Pilliga Outwash	646
SSD 6456	Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion (NA307/PCT402)	Pilliga and Pilliga Outwash	93
SSD 6456	Mugga Ironbark - White Cypress Pine - gum tall	Pilliga and	0

Existing statutory obligation reference[1]	Biodiversity credit name (Plant Community Type name and ID, or threatened species name)	IBRA sub region[2]	Number of credits shown in development consent[3]
	woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion (NA307/PCT402- Derived Native Grasslands)	Pilliga Outwash	
SSD 6456	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests (NA326/PCT404)	Pilliga and Pilliga Outwash	6,296
SSD 6456	White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions (NA390/PCT405)	Pilliga and Pilliga Outwash	16,799
SSD 6456	White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions (NA390/PCT405- Derived Native Grasslands)	Pilliga and Pilliga Outwash	72
SSD 6456	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests (NA389/PCT406)	Pilliga and Pilliga Outwash	4,244
SSD 6456	Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region (NA279/PCT408)	Pilliga and Pilliga Outwash	2,411
SSD 6456	Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region (NA279/PCT408- Derived Native Grasslands)	Pilliga and Pilliga Outwash	10
SSD 6456	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion (NA409/PCT418)	Pilliga and Pilliga Outwash	15
SSD 6456	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion (NA409/PCT418- Derived Native Grasslands)	Pilliga and Pilliga Outwash	8
SSD 6456	Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion (NA363/PCT425)	Pilliga and Pilliga Outwash	563

Existing statutory obligation reference[1]	**Biodiversity credit name (Plant Community Type name and ID, or threatened species name)**	**IBRA sub region**[2]	**Number of credits shown in development consent**[3]
SSD 6456	Coolabah Bertya (*Bertya opponens*)	Not applicable	144,326
SSD 6456	Pine Donkey Orchid (*Diuris tricolor*)	Not applicable	676
SSD 6456	Spiny Peppercress (*Lepidium aschersonii*)	Not applicable	1,087,674
SSD 6456	Winged Peppercress (*Lepidium monoplocoides*)	Not applicable	16,740
SSD 6456	Native Milkwort (*Polygala linariifolia*)	Not applicable	3,780
SSD 6456	Scant Pomaderris (*Pomaderris queenslandica*)	Not applicable	6,538
SSD 6456	Greenhood Orchid (*Pterostylis cobarensis*)	Not applicable	95,732
SSD 6456	Commersonia procumbens (*Commersonia procumbens*)	Not applicable	55,740
SSD 6456	Tylophora linearis (*Tylophora linearis*)	Not applicable	7,722
SSD 6456	Black-striped Wallaby (*Macropus dorsalis*)	Not applicable	30,456
SSD 6456	Eastern Pygmy-possum (*Cercartetus nanus*)	Not applicable	17,950
SSD 6456	Pale-headed Snake (*Hoplocephalus bitorquatus*)	Not applicable	33,740
SSD 6456	Squirrel Glider (*Petaurus norfolcensis*)	Not applicable	21,953
SSD 6456	Regent Honeyeater (*Anthochaera phrygia*)	Not applicable	4,255
SSD 6456	Koala (*Phascolarctos cinereus*)	Not applicable	30,454

Part 2 Determination of reasonable equivalence

The number and class of biodiversity credits that are reasonably equivalent under the BC Act are:

1. Ecosystem Credits

1. **Name of Plant Community Type:** Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (PCT27)

Number of ecosystem credits required	4
Offset trading group	Artesian Springs Ecological Community in the Great Artesian Basin
Hollow bearing trees	Not applicable
Vegetation class	Riverine Plains Woodlands
Vegetation formation	Semi-arid Woodlands (Grassy sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

2. **Name of Plant Community Type:** Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (PCT27)

Number of ecosystem credits required	13
Offset trading group	Artesian Springs Ecological Community in the Great Artesian Basin
Hollow bearing trees	Not applicable
Vegetation class	Riverine Plains Woodlands
Vegetation formation	Semi-arid Woodlands (Grassy sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

3. **Name of Plant Community Type:** Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (PCT35)

Number of ecosystem credits required	938
Offset trading group	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
Hollow bearing trees	Vegetation containing hollow-bearing trees

Vegetation class	Brigalow Clay Plain Woodlands
Vegetation formation	Semi-arid Woodlands (Grassy sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

4. **Name of Plant Community Type:** Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion (PCT35)

Number of ecosystem credits required	813
Offset trading group	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions
Hollow bearing trees	Not applicable
Vegetation class	Brigalow Clay Plain Woodlands
Vegetation formation	Semi-arid Woodlands (Grassy sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

5. **Name of Plant Community Type:** Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (PCT55)

Number of ecosystem credits required	122
Offset trading group	North-west Floodplain Woodlands with a percent cleared value ≥70% and <90%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	North-west Floodplain Woodlands
Vegetation formation	Semi-arid Woodlands (Grassy sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

6. **Name of Plant Community Type:** Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions (PCT55)

Number of ecosystem credits required	32
Offset trading group	North-west Floodplain Woodlands with a percent cleared value ≥70% and <90%
Hollow bearing trees	Not applicable
Vegetation class	North-west Floodplain Woodlands
Vegetation formation	Semi-arid Woodlands (Grassy sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

7. **Name of Plant Community Type:** Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (PCT88)

Number of ecosystem credits required	1233
Offset trading group	Pilliga Outwash Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Pilliga Outwash Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

8. **Name of Plant Community Type:** Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion (PCT88)

Number of ecosystem credits required	103
Offset trading group	Pilliga Outwash Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Pilliga Outwash Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

9. **Name of Plant Community Type:** Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion (PCT141)

Number of ecosystem credits required	352
Offset trading group	Pilliga Outwash Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Pilliga Outwash Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

10. **Name of Plant Community Type:** Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion (PCT202)

Number of ecosystem credits required	383
Offset trading group	Pilliga Outwash Dry Sclerophyll Forests with a percent cleared value ≥70% and <90%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Pilliga Outwash Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

11. **Name of Plant Community Type:** Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion (PCT256)

Number of ecosystem credits required	8
Offset trading group	Inland Rocky Hill Woodlands with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Inland Rocky Hill Woodlands
Vegetation formation	Semi-arid Woodlands (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

12. **Name of Plant Community Type:** Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the Brigalow Belt South Bioregion (PCT379)

Number of ecosystem credits required	91
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Semi-arid Woodlands (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

13. **Name of Plant Community Type:** Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion (PCT397)

Number of ecosystem credits required	27
Offset trading group	Pilliga Outwash Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Pilliga Outwash Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

14. **Name of Plant Community Type:** Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion (PCT397)

Number of ecosystem credits required	11
Offset trading group	Pilliga Outwash Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Pilliga Outwash Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

15. **Name of Plant Community Type:** 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 (PCT398)

Number of ecosystem credits required	10,075
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

16. **Name of Plant Community Type:** 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 (PCT398)

Number of ecosystem credits required	75
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

17. **Name of Plant Community Type:** Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (PCT399)

Number of ecosystem credits required	94
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

18. **Name of Plant Community Type:** Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion (PCT399)

Number of ecosystem credits required	0
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

19. **Name of Plant Community Type:** Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region (PCT401)

Number of ecosystem credits required	1,599
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

20. **Name of Plant Community Type:** Rough-barked Apple - Blakelys Red Gum - Black Cypress Pine woodland on sandy flats, mainly in the Pilliga Scrub region (PCT401)

Number of ecosystem credits required	244
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

21. **Name of Plant Community Type:** Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion (PCT402)

Number of ecosystem credits required	39
Offset trading group	Western Slopes Dry Sclerophyll Forests
Hollow bearing trees	Vegetation containing hollow-bearing trees with a percent cleared value <50%
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

22. **Name of Plant Community Type:** Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, Brigalow Belt South Bioregion (PCT402)

Number of ecosystem credits required	0
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

23. **Name of Plant Community Type:** Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests (PCT404)

Number of ecosystem credits required	2,746
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

24. **Name of Plant Community Type:** White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions (PCT405)

Number of ecosystem credits required	7,197
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

25. **Name of Plant Community Type:** White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions (PCT405)

Number of ecosystem credits required	27
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

26. **Name of Plant Community Type:** White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests (PCT406)

Number of ecosystem credits required	1,802
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

27. **Name of Plant Community Type:** Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region (PCT408)

Number of ecosystem credits required	1,036
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

28. **Name of Plant Community Type:** Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region (PCT408)

Number of ecosystem credits required	3
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

29. **Name of Plant Community Type:** White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion (PCT418)

Number of ecosystem credits required	7
Offset trading group	North-west slopes dry sclerophyll woodlands with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	North-west slopes dry sclerophyll woodlands
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

30. **Name of Plant Community Type:** White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, Brigalow Belt South Bioregion (PCT418)

Number of ecosystem credits required	3
Offset trading group	North-west slopes dry sclerophyll woodlands with a percent cleared value <50%
Hollow bearing trees	Not applicable
Vegetation class	North-west slopes dry sclerophyll woodlands
Vegetation formation	Dry Sclerophyll forests (shrub/grass sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

31. **Name of Plant Community Type:** Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion (PCT425)

Number of ecosystem credits required	242
Offset trading group	Western Slopes Dry Sclerophyll Forests with a percent cleared value <50%
Hollow bearing trees	Vegetation containing hollow-bearing trees
Vegetation class	Western Slopes Dry Sclerophyll Forests
Vegetation formation	Dry Sclerophyll forests (Shrubby sub-formation)
IBRA subregion	Pilliga and Pilliga Outwash, and any IBRA subregion that adjoins the subregion within which the development occurs and any such subregion that is within 100 kilometres of the outer edge of the impact site.

2. Species Credits

1. **Name of threatened species**: Coolabah Bertya (*Bertya opponens*)

Number of species credits required	30,927

2. **Name of threatened species:** Pine Donkey Orchid (*Diuris tricolor*)

Number of species credits required	238

3. **Name of threatened species:** Spiny Peppercress (*Lepidium aschersonii*)

Number of species credits required	623

4. **Name of threatened species**: Winged Peppercress (*Lepidium monoplocoides*)

Number of species credits required	51

5. **Name of threatened species:** Native Milkwort (*Polygala linariifolia*)

Number of species credits required	491[4]

[4] Matching credits are available on the Biobanking Register from one BioBanking Agreement. There are 21 credits for *Polygala linariifolia available from* (Henribark Pty Ltd). The credit equivalence is 1:1 ratio for 21 credits, plus a full recalculation for the remaining 3,759.

6. **Name of threatened species:** Scant Pomaderris (*Pomaderris queenslandica*)

Number of species credits required	56

7. **Name of threatened species**: Greenhood Orchid (*Pterostylis cobarensis*)

Number of species credits required	2,793

8. **Name of threatened species:** Commersonia procumbens (*Commersonia procumbens*)

Number of species credits required	302

9. **Name of threatened species:** Tylophora linearis (*Tylophora linearis*)

Number of species credits required	3,076

10. **Name of threatened species**: Black-striped Wallaby (*Macropus dorsalis*)

Number of species credits required	Black-striped Wallaby is now considered an ecosystem credit species under the Biodiversity Assessment Method (BAM). The credit obligation for Black-striped Wallaby is met through ecosystem credit obligations at the site.

11. **Name of threatened species:** Eastern Pygmy-possum (*Cercartetus nanus*)

Number of species credits required	38,410[5]

12. **Name of threatened species:** Pale-headed Snake (*Hoplocephalus bitorquatus)*

Number of species credits required	46,719

[5] Matching credits are available on the Biobanking Register from three BioBanking Agreements. There are 1,293 credits for Eastern Pygmy Possum available from BA299, BA341 and BA320. The credit equivalence is 1:1 ratio for 1,293 credits, plus a full recalculation for the remaining 16,657.

13. Name of threatened species: Squirrel Glider (*Petaurus norfolcensis*)

Number of species credits required	36,964[6]

14. Name of threatened species: Regent Honeyeater (*Anthochaera phrygia*)

Number of species credits required	Regent Honeyeater is now considered a dual species credit species under the BAM, with 'species credit' habitat being as per mapped important areas. There are no mapped important areas in the project area, therefore the equivalent number of BAM credits for this species is 0.

15. Name of threatened species: Koala (*Phascolarctos cinereus*)

Number of species credits required	37,372[7,8]

This statement was issued on 10/05/2021.

Authorised by:

MICHELLE CHUNG
Director Biodiversity Offsets Scheme
Department of Planning Industry and Environment
Delegate of the Environment Agency Head

[6] Matching credits are available on the Biobanking Register from seven BioBanking Agreements. There are 8,032 credits for Squirrel Glider available from BA228, BA402, BA449, BA391, BA402, BA353, BA167. The credit equivalence is 1:1 ratio for 8,032 credits, plus a full recalculation for the remaining 13,921.

[7] Matching credits are available on the Biobanking Register from 21 BioBanking Agreements. There are 18,849 credits for Koala available on these 21 Biobanking Agreements, including BA398, BA228, BA379, BA258 and BA449. The credit equivalence is 1:1 ratio for 18,849 credits, plus a full recalculation for the remaining 11,605.

[8] Note that although Koala are listed as a dual species and ecosystem credit under the BAM, advice from BAM Operations is that Koala should be treated as a species credit species under the BAM (DOC21/141366).

1300 646 131
www.ecoaus.com.au

Attachment 2 - Koala Research Program Proposal

CONSERVING KOALAS ACROSS THE PILLIGA SCRUB
RESEARCH PROPOSAL

February, 2022

Chief Investigator: Dr. Stephen Phillips
PO Box 3196 Uki NSW 2484
Tel: 02 6679 5523
(Email: steve@biolink.com.au)

Preamble

The last 2 decades have seen a significant decline in koala occupancy rates across the Pilliga region in central-western NSW, data arising from intensive field surveys between 2013 – 2014 by teams of independent researchers concluding that over the last three koala generations (*i.e.,* 18 – 20 years) a reduction of as much as 79% in the habitat occupancy rate had occurred (Lunney *et al*. 2017). While this outcome on its own warrants reflection, in 2019, survey results from a further 104 sites distributed across the southern half of the Pilliga, through the Warrumbungles and into the northern portions of the Gilgandra Shire failed to find <u>any</u> evidence of recent habitat use by koalas (Brearley *et al*. 2019).

The reasons for the decline remain to be determined beyond speculation, but likely include the effects of a long period of drought and high summer temperatures, compounded by the cumulative impacts of high frequency and severe wildfire events, all of which are arguably a progressive consequence of anthropogenic climate change. While the occasional koala is still reported from the Pilliga (the most recent from near Etoo Creek in late 2021), on the strength of the 2019 survey, Brearley *et al*. (2019) speculated that the species had possibly become functionally extinct in the area.

The Pilliga is a large contiguous habitat area; the distribution of remaining koala population cells, aside from generally (but not always) being associated with proximity to water, remains difficult to model and/or predict with certainty, if indeed koala population cells still occur. Whatever the reasons for the decline of koalas across the Pilliga, there is value in better understanding what has happened, testing the hypothesis of functional extinction and, if the hypothesis is rejected, potentially assisting the process of koala recovery by way of directing management effort into those areas supporting remaining population cells. Hence, to focus management effort efficiently and expeditiously, there is clearly a need to know more about exactly where any remaining populations may be located.

There are two techniques that can be bent to the task of finding any remaining koala populations in the Pilliga: (i) the prudent analyses of historical koala records, and (ii) a systematic (Pilliga-wide) field-based survey effort that has the capacity to be adaptive in response to new information. We have developed approaches to the analyses of historical koala records that focus on elucidating changes in the key range parameters *Extent of Occurrence* (EoO) and *Area of Occupancy* (AoO), while also identifying Areas of (Koala) Generational Persistence. The EoO is a coarse range parameter typically presented in the form of a Minimum Convex Polygon (MCP), while the latter two analyses are undertaken using grid-based approaches otherwise constrained by the Historical EoO. Of particular interest to analyses are changes in these parameters that occur over time frames of relevance to koala management / conservation, most typically comparing data for the 3 most recent koala generations (*i.e.*, 18 years) to those that have preceded it, but also at a finer resolution track-back through time by single generation. Independent field surveys (see below) have established that the results obtained by the approaches we have developed, subject to the intercedence of last generation stochastic influences, accurately reflect on-ground reality.

Based on the Spot Assessment Technique (SAT) of Phillips and Callaghan (2011), Grid-based Spot Assessment Technique (Grid-SAT) field-based sampling in both Rapid[1] and Full SAT formats has been applied throughout eastern Australia in areas where koalas occur, the technique repeatedly demonstrating a capacity to provide robust data and information about koala presence/absence, distribution, and population size, both at the local population and macro-landscape scale. SAT sampling is the preferred habitat sampling tool advocated by the Commonwealth Government's EPBC Act Referral Guidelines for the Vulnerable Koala (DoE 2014), as well as the more recently revised SEPP 44 Koala Habitat Protection assessment guidelines (NSW DIPE 2020).

Grid-SAT offers several advantages over more conventional and developing survey techniques because it embodies a relatively unbiased yet systematic approach to sampling while also being able to operate at varying scales of resolution depending on the specific research objective. By example, naïve occupancy data (*i.e.* amount of habitat being utilised by koalas can be obtained by using a Rapid-SAT sampling regime of regularly spaced field sites (located at intervals several kilometres apart) across a given area, while alternatively, finer-scale output that delineates the precise boundaries of resident population cells (*i.e*. areas occupied by and/or supporting resident koala populations) can be obtained using Full SAT by modelling koala activity data obtained by higher resolution (*i.e.* 500 m – 250 m) sampling intervals in areas known to be occupied (**Figure 1**).

[1] Rapid-SAT was developed on behalf of OEH / EPA for the purpose of quickly ascertaining naïve occupancy levels across large areas of koala habitat; details of initial development can be found in report by Phillips and Wallis (2016).

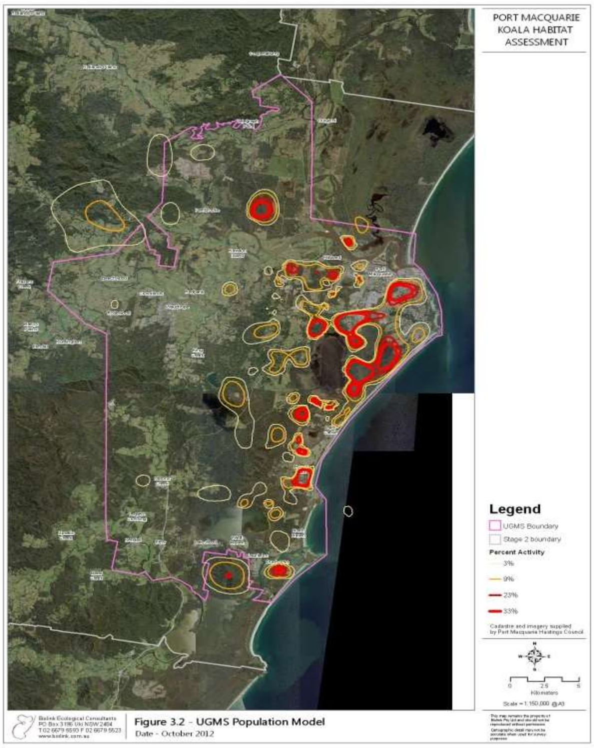


Figure 1. Koala meta-population model illustrating locations of resident koala populations for a 74,000-ha coastal portion of the Port Macquarie Hastings LGA on the mid-north coast of NSW. Koala activity contours were derived by interpolation of Full SAT data collected using a Grid-based approach with sampling intervals of 250 m – 1000 m. Across the LGA, habitat occupancy by resident populations based on records analyses was estimated to be 24.57% of available habitat, while data from field sampling at 4000 m intervals was estimated at 23.73% of available habitat (Source Biolink 2013).

The Pilliga Koala Research Proposal

Background to the KRP

The Narrabri Gas project's consent requires that prior to the commencement of Phase 1, a Biodiversity Management Plan (BMP) is to be prepared to the satisfaction of the Planning Secretary. Amongst other things, the BMP must include a Koala Research Program that:

(i) Is designed to determine the location and size of remnant Koala populations in the Pilliga Forest;
(ii) Investigates why suitable areas of habitat may not be occupied by Koalas; and
(iii) Guides adaptive management of the Koala population in the project area and any land-based offset areas used to retire species credits for the Koala.

The following research program has been developed in response to the consent conditions:

1. Desk-top Analyses

All available koala records for the Pilliga from available reports, and the Atlas of Living Australia and BioNET databases will be collated into a single data set. Records will be checked for spatial accuracy and duplication prior to being coded in terms of koala generation, working backwards from a presumed date of project commencement (*i.e.*, koala Generation 1: 2016 – 2021, Gen 2: 2010 – 2015, Gen 3: 2004 – 2009 and so on….), prior to the following measures being ascertained.

a) Changes in Extent of Occurrence (EoO)

This range parameter will be presented in the form of 3 Minimum Convex Polygons (MCPs) with associated area calculations: (i) that of the historical EoO (encompasses all available records), (ii) that for the years from date of first record to 2003, and (iii) that of the 3 most recent koala generations 2004 – 2021).

b) Area of Occupancy

While the final grid-cell size to be deployed will be determined upon consideration of the distribution of records, we envisage overlaying the historical koala EoO with either a 5 km x 5 km (2,500 ha) or 10 km x 10 km (10,000 ha) regularised grid. The koala records dataset will then be partitioned into *pre*- and *post*-2004. Using each of these data sets[2] we will then randomly sample with replacement approx. 50% of the available grid-cells and count the number that contain records; this process will be repeated many times, the results then averaged and compared for each of the two time periods being considered. *Pre*- and *post*-2003 data sets will be standardised in terms of the numbers of records that are used for analysis.

c) *Areas of Generational Persistence*

Using the same grid cells and time frames as above, we will also score each grid cell for the presence of one or more koala records for each of the three most recent koala generations to identify historical and/or contemporaneous areas of generational persistence (*i.e*., source populations). Given current knowledge about the conservation status of koalas across the Pilliga, we will also interrogate GP outcomes for changes over time to assist in identification of areas into which to direct more intensive field survey effort.

We have recently developed a nearest-neighbour analytical technique for exploring coarse changes in koala metapopulation boundaries within the 3-generation timeframe referred to above.

Using available Plant Community Type (PCT) mapping, a map of Preferred Koala Habitat will also be prepared to both guide field survey design and assist in the preliminary investigations of occupancy required by consent condition G(ii). Habitat use by koalas across the study area is primarily influenced by access to tree species that can be shown to be the focus of preferential utilisation, specifically ‘boxes’ and ‘red gums’. Accordingly, the classification of PCTs in terms of their underlying and potential importance as koala habitat will be undertake in accord with the following:

[2] Data sets contain the same numbers of records for each period; presuming one data set will be larger than the other, this is achieved by randomly selecting from the larger data set the same number of records as are present in the smaller data set.

Koala habitat type	Classification criteria
Primary koala habitat (1)	Forest and/or woodland PCTs occurring on soils of medium to high nutrient value whereupon primary PKFTs are dominant or co-dominant components of the tallest stratum.
Secondary (Class A) koala habitat (2A)	Forest and/or woodland PCTs occurring on soils of medium to high nutrient value whereupon primary PKFTs are sub-dominant components of the tallest stratum.
Secondary (Class B) koala habitat (2B)	Forest and/or woodland PCTs occurring on soils of low to medium nutrient value whereupon primary PKFTs are absent, the tallest stratum instead dominated or co-dominated by secondary food tree species only.
Secondary (Class C) / marginal koala habitat (2C)	Forest and/or woodland PCTs occurring on soils of low to medium nutrient value whereupon primary food tree species are absent and secondary food tree species are homogeneously distributed but otherwise sub-dominant components of the tallest stratum.
Other	PCTs wherein PKFTs do not typically occur and/or are at sufficiently low densities (< 0.05 PKFTs ha^{-1}) as to be capable of sustaining transient use only.

Note: The terms "Primary" and "Secondary" koala food tree species[3] as used in the classifications above are based on the regression models of PKFT utilisation described by Phillips *et al.* (2000) and Phillips and Callaghan (2000)..

2. Field Survey

A key outcome from this proposal is creation/establishment of a fixed 500 m x 500 m (25 ha) survey grid across the entire ~ 600,000 ha of the Pilliga Scrub (*i.e.*, establishing a pool of **Permanent Monitoring Points** the resolution of which for sampling purposes can be scaled up or down in response to a particular ecological question / assessment task). It is envisaged that this grid will be locked onto a 5 km survey grid recently established by FCNSW for acoustic and camera survey work, thus assisting the concept of multiple species monitoring at pre-determined sampling points while also facilitating collection of comparative koala-related data using different survey techniques. Field survey will involve 3 levels of investigation as follows:

Minimum Pilliga-wide survey effort

Subject to consideration of detection probability[4], we initially propose to deploy a systematic survey that samples for koala presence / absence across the Pilliga at 5 km - 7.5 km sampling intervals (*i.e.*, 120 – 150 primary field sites). The primary sampling protocol for this and/or adaptive / GP sampling (see below) will be **Rapid-SAT**, defaulting to full **SAT**

[3] A Primary Food Tree requires preferential use by koalas to be significantly higher than other congeners with a measure of utilisation that is also independent of size class (Phillips *et al*. (2000) refers) whereas a Secondary Food Tree also requires a level of use that is significantly higher than other congeners but with a utilization model that is typically size-class dependent (Phillips and Callaghan (2000) refers).

[4] Current estimates indicate a likely detection probability of 0.005 – 0.01 may apply.

where any evidence of recent koala activity is recorded. **Rapid-SAT** sampling protocols are reliant upon the presence of diagnostic koala faecal pellets within a prescribed search area of 1 m around the bases of Preferred Koala Food Trees (PKFTs) ≥ 300 mm DBH. The measure here is not koala activity *per se*, but rather whether a site and immediately adjacent areas of habitat are being utilised by koalas or not. Based on the earlier work of (Phillips and Wallis 2016), the **Rapid-SAT** approach offers an efficient and resource-effective survey technique predicated by knowledge that in areas of western NSW that are being utilized by koalas, there is a 57% probability of faecal pellets occurring within 1 m of the base of any PKFT ≥ 300 mm DBH.

At the coarse scale, some flexibility with site placement (typically ± 50 m) will be permitted to optimise the numbers of PKFTs being sampled. Assessment at a given sampling point ceases when one or more koala faecal pellets have been detected. Conversely, if no pellets are being detected, sampling ceases once a minimum of **six** to maximum of **nine** PKFTs have been assessed, these numbers affording a high level of statistical confidence (*e.g.*, 95% or 99% respectively) that koalas were not using habitat in the immediate vicinity.

a) Adaptive / infill / higher-resolution sampling
We will inspect all localities at which a koala has been sighted within the current koala generation (i.e., 2016 – 2021), sampling available 500 m grid-cell intervals (+/- 25 m) for the surrounding 1.5 km or, if evidence of recent activity by koalas is detected, until the full extent of the area being utilised can be delineated by full SAT.

Last known areas of GP will also be identified for higher-resolution sampling at 1 km grid-cell intervals for the surrounding 5 km, with infilling at 500m intervals if evidence of recent koala activity is detected, in which case the full extent of the area being utilised will be captured by full SAT.

Direct count techniques are embedded in the SAT approach such that any higher-resolution models will also be accompanied by koala density estimates with the actual number of animals comprising each population cell identified with 95% confidence.

3. Research Output / Reporting

The key findings from the minimum Pilliga-wide and follow-on higher-resolution sampling components would be communicated in a format suitable for use by agencies and/or industry in terms of directing any management responses that may be required, and secondly in the form of one or more manuscripts for submission to a suitable peer-reviewed scientific journal.

The habitat conundrum
The extent of occupied habitat remaining in the project area is not known at this point in time, and thus the detailing of a specific approach to addressing consent condition G(ii) would be ill-advised and premature. That said, at a course level and presuming viable population cells are detected and their extent accurately mapped, then the basis for 'presence / absence / suitable areas of habitat…' hypotheses construction, as well as an assessment of potential threats to longer-term viability, will be informed from intersection of presence data with underlying landscape attributes.

Recommendations for adaptive management
For the purpose of addressing condition G(iii), if one or more koala population cells are located, activity threshold contours and appropriate buffers will be provided that effectively capture those areas being utilized with a view to enabling a focus for management/recovery efforts on such issues as weed control (*e.g.*, tiger pear), fire suppression and other threatening processes.

All spatial data arising from the project will be supplied to key stakeholders as required.

4. Collaboration & Training

Opportunities for collaboration on various aspects of the project potentially exist with university-based researchers and stakeholder agencies such as FCNSW and/or DPE. Government/community/industry staff could also be trained in the SAT survey techniques with a view to facilitating a program of ongoing assessment and monitoring.

5. Alignment with NSW Koala Research Plan

The KRP is expected to contribute to key knowledge gaps identified by the NSW Koala Research Plan 2019 – 2028 as follows:

Climate change and extreme weather events (all sub-themes),
Habitat (all sub-themes) and
Other (fire).

6. Project Cost:

Depending on exactly how much survey work is required, we are estimating a cost-recovery budget of between $135,000 and $150,000 (Exc GST) to undertake this project as outlined above, the latter figure considered to be an upper-limiting fee if the project is undertaken as proposed. While cost estimates have been rounded out for the purpose of this proposal, a more detailed breakdown of estimated costs can be provided on request.

References:

Biolink. (2013). Port Macquarie-Hastings Koala Habitat & Population Assessment. Final Report to Port Macquarie Hastings Council. Biolink Ecological Consultants.

Brearley, G., Phillips, S., Wallis, K., and Lane, A. (2019). *A bird in the hand - coming to grips with the concepts and components of Koala Source Populations.* Presentation to Koala Research Symposium, 65th meeting of Australian Mammal Society, Veterinary Science Conference Centre, The University of Sydney, 7 – 11 July 2019.

Department of Environment. (2014). *EPBC Act referral guidelines for the Vulnerable Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory*. Commonwealth of Australia.

Lunney, D., Predavec, M., Sonawane, I., Kavanagh, R., Barrott-Brown, G., Phillips, S**.,** *et al*. (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*.

NSW Department of Planning, Industry, and Environment (DPIE) (2020). Koala Habitat Protection Guideline – Implementing *State Environmental Planning Policy (Koala Habitat Protection) 2019*.

Phillips, S., Callaghan, J., and Thompson, V. (2000). The tree species preferences of koalas (*Phascolarctos cinereus*) inhabiting forest and woodland communities on Quaternary deposits in the Port Stephens area, New South Wales. *Wildlife Research* **27**, 1 - 10.

Phillips, S. and Callaghan, J. (2000). Tree species preferences of a koala (*Phascolarctos cinereus*) population in the Campbelltown area south-west of Sydney, New South Wales. *Wildlife Research* **27**, 569 - 575.

Phillips, S., and Callaghan, J. (2011). The "Spot Assessment Technique": a tool for determining localized levels of habitat use by Koalas *Phascolarctos cinereus*. *Australian Zoologist* **35(3)**, 774 – 780.

Phillips. S., and Wallis, K. (2016). *Koala Likelihood Mapping - Baseline Koala Survey Analysis and Reporting*. Final Report to NSW Environment Protection Authority.

Attachment 3 - Pest Plant and Animal Control Protocol

Santos

NARRABRI GAS PROJECT

Pest Plant and Animal Control Protocol

PHASE 1

Date	Revision	Reason for Issue	Author	Checked	Approved
11 November 2022	0B	For approval	Eco Logical Australia / Onward Consulting	RM/LD	TD

Prepared by:

Title	Name	Signature	Date
Senior Ecologist, Eco Logical Australia	Dan Watts	DW	11 November 2022
Senior Environmental Manager	S. van der Meulen Onward Consulting		11 November 2022

Reviewed by:

Title	Name	Signature	Date
Principal Environmental Consultant, Eco Logical Australia	Rachel Murray	RMurray	11 November 2022
Team Leader Environment - Approvals	Liz Dunlop		11 November 2022

Approved by:

Title	Name	Signature	Date
Development Manager NSW	Todd Dunn		11 November 2022

ONWARD CONSULTING

Document review history

In accordance with consent condition D4, this document has been reviewed as follows:

Review Date	Reason for review	Reviewed by	Revision required (Y/N)

Acronyms and abbreviations

Acronym	Description
AWC	Australian Wildlife Conservancy
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016*
BMP	Biodiversity Management Plan
BOMP	Biodiversity Offset Management Plan
BCD	The former Biodiversity Conservation Division within DPE
BCF	Biodiversity Conservation Fund
BCS	The Biodiversity, Conservation & Science directorate within DPE (formerly BCD)
BCT	Biodiversity Conservation Trust
BVT	Biometric Vegetation Type
Cth	Commonwealth
CoC	Conditions of consent for the NGP SSD 6456
CSG	coal seam gas
DCCEEW	Cth Department of Climate Change, Energy, the Environment and Water
DPE	NSW Department of Planning and Environment
DPIE	Former NSW Department of Planning, Industry and Environment
EEC	Endangered Ecological Community
EIS	environmental impact statement
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2021
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPL	environment protection licence under the POEO Act
FCNSW	Forestry Corporation of New South Wales
kg	kilogram
kg/ha	kilograms per hectare
L	litre
LGA	Local Government Area
m	metre
mm	millimetre
MEG	Regional NSW - Mining, Exploration and Geoscience (formerly the Division of Resources and Geoscience)
MNES	Matters of National Environmental Significance
NPWS	NSW National Parks and Wildlife Service
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PAL	petroleum assessment lease under the PO Act

Acronym	Description
PCT	Plant Community Types
PEL	petroleum exploration licence under the PO Act
PO Act	*Petroleum (Onshore) Act 1991* (NSW)
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
POEO Regulation	Protection of the Environment Operations (General) Regulation 2022
PPL	petroleum production lease under the PO Act
PPLA	petroleum production lease application under the PO Act
RMP	Rehabilitation Management Plan
RTS	Response to Submissions
SRTS	Supplementary Response To Submissions
SMS	Santos Management System
SSD	State Significant Development
TEC	Threatened ecological communities
TSC Act	*Threatened Species Conservation Act 1995* (NSW) (repealed)
UAV	unmanned aerial vehicle (drone)
WoNS	Weeds of National Significance

Table of contents

Tables

Figures

1. Introduction

The Pest Plant and Animal Control Protocol (this **Protocol**) outlines the specific management actions, relevant monitoring and reporting requirements for pest plants and animals in the development footprint, as summarised in sections 6.3 and 8.4 of the Biodiversity Management Plan (**BMP**). For the purpose of this Protocol the following definitions will be applied:

- pest plant: any plant, native or non-native, that poses a threat to the biodiversity or agricultural values of land within the development footprint, the successful recovery of rehabilitated land or surrounding indirect impact buffer as determined in the EIS;
- pest animal: any vertebrate animal, native or non-native, that poses a threat to the biodiversity or agricultural values of land within the development footprint, the successful recovery of rehabilitated land or surrounding indirect impact buffer as determined in the EIS;
- feral animal: any non-native animal;
- operational and development footprint: areas where regular activities and surface infrastructure occur, and the surrounding land required during construction activities;
- indirect impact buffer: a buffer of indirect impacts around the operational and development footprint areas. For well pads and major infrastructure the buffer is 50 metres (**m**) and for access tracks and infrastructure corridors the buffer is 10 m; and
- Project disturbance area: encompasses the operational and development footprint and the indirect impact buffer. Refer to the glossary provided in the BMP for a full definition.

Specific commitments from the EIS directly relating to this Protocol are listed in section 3.3.

2. Performance objectives

Santos is committed to protecting the environment and has developed the following objectives:

- prevent the introduction and spread of new pest plant and animal species into the Project area.
- provide a strategic and coordinated approach to pest plant and animal management.
- identify and prioritise pest plants and animals, their distribution and associated impacts.
- detail actions required for management of pest plants and animals.
- ensure appropriate resources are available to manage pest plants and animals.

As per the *NSW Invasive Species Plan 2018-2021* (DPI, 2018) (**Invasive Species Plan**), pest plant and animal management can be divided into four clear stages, each with diminishing economic returns for control efforts, as presented in Figure 2.1.

The best form of control is prevention, as it entirely avoids any impact to biodiversity, agriculture and society, while also providing the best return on investment. The management streams and priorities of this Protocol have been based on this framework for control categories to managing pest plants and animals in the Project area.

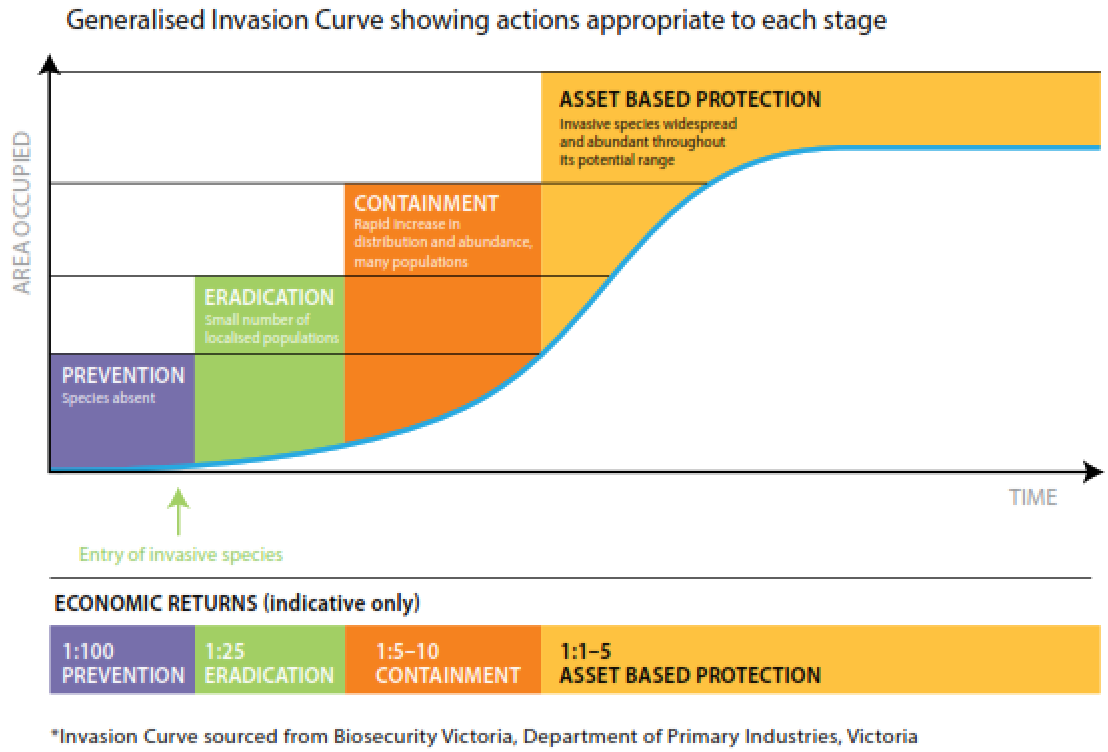


Figure 2.1 - Generalised invasion curve

3. Regulatory framework

The framework for management of biosecurity priorities is driven by the NSW *Biosecurity Act 2015* and establishes a state-wide framework for the management of biosecurity matters.

3.1 Relevant codes, standards, policies and guidelines

The *Australian Weeds Strategy 2017-2027* (DAWE, 2017) prescribes responsibilities for landholders (public and private) and co-existing land users. Santos' responsibilities under the Strategy include:

- detect and report new weed occurrences;
- control and manage weeds to mitigate, as necessary, the impacts on their own assets, or as required by regulation;
- take reasonable steps to minimise the impacts of weeds on other landholders, particularly through participation in programs of collective industry or community-led action, and on people and the broader environment;
- identify and manage all biosecurity risks, including risks associated with goods, vehicles and people entering the Project area;
- implement weed seed hygiene procedures to minimise establishment or spread of high risk weed species;
- cooperate with and plan weed management activities jointly with neighbours, including state, territory and local governments, within a landscape scale/cross-tenure approach; and
- apply knowledge and skills to improve weed management and understand the need to use multiple approaches (e.g. chemical, physical, biological) to prevent weeds from adapting to existing controls.

3.1.1 Weeds of National Significance

The Weeds of National Significance (**WoNS**) are a list of prioritised weeds assessed on their invasiveness, potential for spread and environmental, social and economic impacts agreed by Australian governments.

Six WoNS were identified within the Project area and a further 19 occur within NSW and are thought to be a risk to the project. A list of exotic species detected within the Project area is provided in Table A1 in Appendix A. Table 3.2 lists all WoNS species with potential to occur within the Project area. Detailed profiles and current control methods are provided for some of these species in Appendix B.

3.1.2 NSW Invasive Species Plan 2018 - 2021

The Invasive Species Plan provides an overview for governance and guiding documents for invasive species management in NSW. It also lists four goals adopted by the Plan:

Goal 1	Exclude - prevent the establishment of new invasive species
Goal 2	Eradicate or contain - eliminate, or prevent the spread of new invasive species
Goal 3	Effective management - reduce the impacts of widespread invasive species
Goal 4	Capacity building - ensure NSW has the ability and commitment to manage invasive species.

Through the implementation of the BMP the Project will directly address all of the above listed goals of the NSW invasive species.

The Invasive Species Plan also outlines the responsibilities of different stakeholders, including industry listed below:

- managing invasive species on land and in aquatic environments used for production;
- managing risks when trading in potential or known invasive species used for, or held by, nurseries, zoos and collectors, agriculture, horticulture, aquaculture and biofuel developments; and
- managing vectors or pathways for invasive species to prevent the establishment of invasive species, through movement of goods, produce and equipment or related activities.

3.1.3 North West Regional Strategic Plans

The *North West Regional Strategic Pest Animal Management Plan 2018 -2023* and the *North West Regional Strategic Weed Management Plan 2017 - 2022* jointly address the regions specific focuses for pest plants and animals. These plans have been developed by the North West Local Land Services (**North West LLS**) to fulfil one of their responsibilities under the *NSW Biosecurity Act 2015*. Priority pest species identified in the regional plans that occur, or could potentially occur within the Project area, region or state, are presented in Table 3.1 and 3.2. Note that some state priority weeds do not yet occur in NSW and are listed due to the high risk associated of transport into and establishment within the state. These weeds have been excluded from Table 3.2 to provide a more focused approach to weed management for the Project.

Table 3.1 - Priority pest animal species for the North West LLS

Common name	Scientific name	Management Category
Wild Dog	*Canis lupus familiaris*	Asset based protection
Feral Pig	*Sus scrofa*	Asset based protection
Red Fox	*Vulpes vulpes*	Asset based protection
Wild Rabbit	*Oryctolagus cuniculus*	Asset based protection
Feral goat	*Capra aegagrus*	Asset based protection
Red, Fallow and Chital Deer	*Cervus elaphus*, *Dama dama* and *Axis axis*	Asset based protection
Wild Horses	Equus ferus	Containment
Feral Cat	*Felis catus*	Asset based protection
Mice*	*Mus musculus*	Limited action
Indian Myna	*Acridotheres tristis*	Limited action
Common Carp	*Cyprinus carpio*	Limited action

Note:

*Triggers the NSW Department of Primary Industries and LLS response during plague situations.

Table 3.2 - Priority national, state and regional pest plant species

Common name	Scientific name	Weeds of National Significance	Priority weed	Management Category	Detected during EIS survey
Tropical Soda Apple	*Solanum viarum*		State and regional	Eradication	
Mexican Feathergrass	*Nassella tenuissima*		State and Regional	Prevention	
Parthenium weed	*Parthenium hysterophorus*	WoNS	National, State and Regional	Prevention	
Alligator weed	*Alternanthera philoxeroides*	WoNS	National, State and Regional	State – containment; Regional - eradication	
Galenia	*Galenia pubescens*		Regional	Emerging weed	
Bridal Creeper	*Asparagus asparagoides*	WoNS	Regional	Emerging weed	
Onion Weed	*Asphodelus fistulosus*		Regional	Emerging weed	
Nodding Thistle	*Carduus nutans subsp. nutans*		Regional	Emerging weed	
Fireweed	*Senecio madagascariensis*	WoNS	National, State and Regional	State - asset protection; Regional – key emerging	
Devil's Rope Pear	*Cylindropuntia imbricata*	WoNS	National, State and Regional	Asset protection	
	Cylindropuntia leptocaulis	WoNS	National, State and Regional	Asset protection	
	Cylindropuntia spp.	WoNS	National, State and Regional	Asset protection	
Tiger Pear	*Opuntia aurantiaca*	WoNS	National, State and Regional	Asset protection	Y
	Opuntia elatior	WoNS	National, State and Regional	Asset protection	
	Opuntia spp.	WoNS	National, State and Regional	Asset protection	
Common Prickly Pear	*Opuntia stricta*	WoNS	National, State and Regional	Asset protection	Y
	Opuntia stricta var. *dillenii*	WoNS	National, State and Regional	Asset protection	
Spiny Pest Pear	*Opuntia stricta* var. *stricta*	WoNS	National, State and Regional	Asset protection	
Velvet Tree Pear	*Opuntia tomentosa*	WoNS	National, State and Regional	Key emerging	Y
Japanese Honeysuckle	*Lonicera japonica*		Regional	Emerging weed	
Mother of millions	*Bryophyllum delagoense*		Regional	Asset protection	Y
Toothed spurge, David's spurge	*Euphorbia davidii*		Regional	Key emerging weed	
Honey Locust	*Gleditsia triacanthos*		Regional	Containment	
Black Locust	*Robinia pseudoacacia*		Regional	Key emerging weed	
Frogbit / Spongeplant -	*Limnobium spp.* (all species)			Asset protection	
Anchord Water Hyacinth				Asset protection	
Osage Orange	*Maclura pomifera*		Regional	Key emerging weed	
African Olive	*Olea europaea* subsp. *cuspidata*		Regional	Asset protection	Y
Whisky Grass	*Andropogon virginicus*		Regional	Key emerging weed	
Chilean Needle Grass	*Nassella neesiana*	WoNS	National, State and Regional	State - asset protection; Regional - containment	
Giant Parramatta Grass	*Sporobolus fertilis*		Regional	Key emerging weeds	
Sweet Briar	*Rosa rubiginosa*		Regional	Asset protection	
Blackberry complex	*Rubus fruticosus* sp. agg.	WoNS	National, State and Regional	State - asset protection; Regional - containment	
Black Willows	*Salix* nigra.	WoNS	National and Regional	Asset protection	Y
Green Cestrum	*Cestrum parqui*		Regional	Containment	Y
African Boxthorn	*Lycium ferocissimum*	WoNS	National, State and Regional	Asset protection	Y
Silver-leaved Nightshade	*Solanum elaeagnifolium*	WoNS	National, State and Regional	Asset protection	
Athel Tree	*Tamarix aphylla*	WoNS	National and State	Asset protection	
Lantana	*Lantana camara*	WoNS	National and State	Asset protection	
Mesquite	*Prosopis* spp.	WoNS	National, State and Regional	State - asset protection; Regional - containment	
Serrated Tussock	*Nassella trichotoma*	WoNS	National, State and Regional	State - asset protection; Regional - containment	

3.2 General biosecurity duty

Part 3 section 22 of the *NSW Biosecurity Act 2015* describes 'general biosecurity duty':

'Any person who deals with biosecurity matter or a carrier and who knows, or ought reasonably to know, the biosecurity risk posed or likely to be posed by the biosecurity matter, carrier or dealing has a biosecurity duty to ensure that, so far as is reasonably practicable, the biosecurity risk is prevented, eliminated or minimised.'

The general biosecurity duty is applicable to all matters addressed in this Protocol and is additional to any other specific actions detailed in the following sections. The general biosecurity duty applies to all Santos employees and contractors who visit site. Failing to discharge the general biosecurity duty constitutes an offence which may incur substantial fines and/or imprisonment for an individual and/or corporation.

3.3 EIS commitments

In the EIS Chapter 31, and updated in Appendix B of the Response to Submissions, Santos has committed to implement a number of measures pending Project approval and a final investment decision. The EIS commitments relevant to pest plant and animal management have been reproduced in Table 3.3, in accordance with consent condition D3(c) which states that Santos must ensure that (where relevant) the management plans include any relevant commitments or recommendations identified in the EIS.

Table 3.3 - EIS commitments relevant to general environmental management

Number	EIS commitment relevant to general environmental management
1.2	A project wide environmental management strategy, comprising a number of sub-plans to be used throughout the planning and design, construction, operation and decommissioning and rehabilitation stages of the Project are described in Chapter 30 [of the EIS]. The sub-plans are[1]: • …. • Pest Plant and Animal Control Plan [part of the Biodiversity Management Plan]; • ….
6.11	Prior to earthworks, weeds listed as noxious under the NSW *Noxious Weeds Act 1993*[2] that are present on the site will be removed or treated with herbicide to prevent or reduce their spread.
6.12	Feral animals will be managed in accordance with a Pest Plant and Animal Control Plan

As described in section 13 of the BMP, this Protocol will be subject to regular evaluation and review. This will include a review of the EIS commitments to ensure they remain current, applicable, and generally improve the environmental performance of the Project.

[1] Only the plans relevant to biodiversity management have been listed. The full list of sub-plans is provided in the EMS section 3.5.

[2] The *Noxious Weeds Act 1993* (NSW) has been repealed, and replaced by the *Biosecurity Act 2015* (NSW).

4. Existing environment

4.1 Pest plants detected in the Project area

Pest plants typically spread easily by producing large numbers of seeds or reproducing vegetatively. They are often excellent at surviving and reproducing in disturbed environments and are commonly the first species to colonise and dominate in these conditions. Seeds and other plant material can spread into natural and disturbed environments via wind, animals, waterways and people (including contaminated clothing, hats, footwear, tools, equipment, machinery and vehicles).

Pest plants have the potential to displace, degrade habitat and alter environmental processes suitable for native, locally occurring flora. They can also have an impact on agriculture by reducing crop yields and outcompeting more suitable pasture species.

A total 116 exotic plant species in 327 floristic plots were detected in the Project area during the EIS surveys. Of those, four are listed as WoNS as presented in Table 4.1 - one as a State priority weed and three as a North West regional priority or emerging weed. A further 20 species have profiles on NSW WeedWise, a constantly expanding resource for weed education in NSW.

Table 4.1 - Weeds of National Significance, priority species and NSW WeedWise profiles

Family	Scientific name	Common name	WoNS	State priority weed[1]	Regional priority weed	NSW WeedWise
Amaranthaceae	*Alternanthera pungens*	Khaki Weed	N	N	N	Y
Asteraceae	*Carthamus lanatus*	Saffron Thistle	N	N	N	Y
Asteraceae	*Cirsium vulgare*	Black Thistle, Spear Thistle	N	N	N	Y
Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	N	N	N	Y
Asteraceae	*Conyza sp.*		N	N	N	Y
Asteraceae	*Conyza sumatrensis*	Tall Fleabane	N	N	N	Y
Asteraceae	*Xanthium italicum*	Hunter Burr	N	N	N	Y
Asteraceae	*Xanthium occidentale*	Noogoora Burr	N	N	N	Y
Asteraceae	*Xanthium sp.*		N	N	N	N OR -
Boraginaceae	*Heliotropium amplexicaule*	Blue Heliotrope	N	N	N	Y
Brassicaceae	*Lepidium sp.*		N	N	N	N OR -
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	Y	Y	Y	Y
Cactaceae	*Opuntia stricta*	Prickly Pear, Common Pest Pear	Y	Y	Y	Y
Cactaceae	*Opuntia tomentosa*	Prickly Pear, Velvet Tree Pear	Y	Y	Y	Y
Crassulaceae	*Bryophyllum delagoense*	Mother-of-Millions	N	Y	Y	Y
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant	N	N	Key emerging weed	Y
Fabaceae Faboideae	*Medicago sp.*	Medic	N	N	N	Y
Lamiaceae	*Marrubium vulgare*	Horehound	N	N	N	Y
Oleaceae	*Olea europaea subsp. cuspidata*	African Olive	N	N	Y	Y
Polygonaceae	*Emex australis*	Spiny Emex, Doublegee	N	N	N	Y
Salicaceae	*Salix babylonica*	Weeping Willow	N	N	N	Y
Solanaceae	*Cestrum parqui*	Green Cestrum	N	N	Y	y
Solanaceae	*Lycium ferocissimum*	African Boxthorn	Y	Y	Y	Y
Solanaceae	*Solanum sp.*		Y	Y	Y	N OR -
Verbenaceae	*Phyla canescens*	Lippia	N	N	N	Y
Poaceae	*Eragrostis curvula*	African Lovegrass	N	N	N	Y
Poaceae [a]	*Hyparrhenia hirta*	Coolatai Grass	N	N	N	Y

Notes:

a - Listed in State of NSW 2019. North West

4.2 Pest animals detected in the Project area

Pest animals are also a costly problem for biodiversity and agriculture in the Project area. They can have impacts such as habitat degradation, vegetation destruction, and high mortality rates of native fauna. They can impose substantial economic and social pressures on agricultural areas through the degradation of arable or pasture lands, predation of livestock and disease spread.

Five birds and 12 mammals listed as feral species were recorded in the Project area during surveys for the EIS, as presented in Table 4.2.

Table 4.2 - Pest animal species detected within the Project area

Scientific name	Common name	North West region priority pest species
Feral predators		
Canis lupus familiaris	Wild Dog	Yes
Felis catus	Cat	Yes
Vulpes vulpes	Red Fox	Yes
Feral herbivores		
Bos taurus	Cow	
Capra hircus	Goat	Yes
Equus sp.	Horse	Yes
Lepus capensis	Hare	
Sus scrofa	Pig	Yes
Oryctolagus cuniculus	Rabbit	Yes
Ovis aries	Sheep	
Other feral fauna		
Mus musculus	Mouse	
Rattus rattus	Rat	
Streptopelia chinensis	Spotted Turtle-dove	
Sturnus tristis	Common Myna	
Sturnus vulgaris	Starling	
Passer domesticus	House Sparrow	
Turdus merula	Eurasian Blackbird	

5. Pest plant and animal management approach

5.1 Pest plant and animal management principles

Management of pest plants and animals relies upon an effective adaptive management framework to guide responses to identified pests in the Project area. Effective pest management is integrated and incorporates the following principles:

- identify;
- prevention;
- elimination – when prevention has failed; and
- minimisation – when prevention has failed and elimination is not practicable, efforts to minimise the impact of the weed infestation must be implemented.

These principles are incorporated into the Protocol by using the proposed pest management hierarchy detailed in section 5.3 and the pest risk assessment management streams (section 5.6).

5.2 Integrated pest management

Integrated pest management combines multiple control methods in a coordinated manner to manage an identified pest plant or animal. One off applications of single control methods are typically unsuccessful in achieving any sustained control of a pest.

5.3 Pest management hierarchy

This Protocol has been developed to consider the pest management hierarchy as presented in Figure 5.1. Each level of the hierarchy is addressed by one or more of the designated management streams (see below), except for 'Prevent'. Prevention of spread is a key component of managing the threat of pest plants in particular as most of the pest animals that pose a threat to the area already occur and are widespread. These management streams will be used to assist in prioritising effort and investment for the management of pests for the project, i.e. from most preferred to least preferred actions.

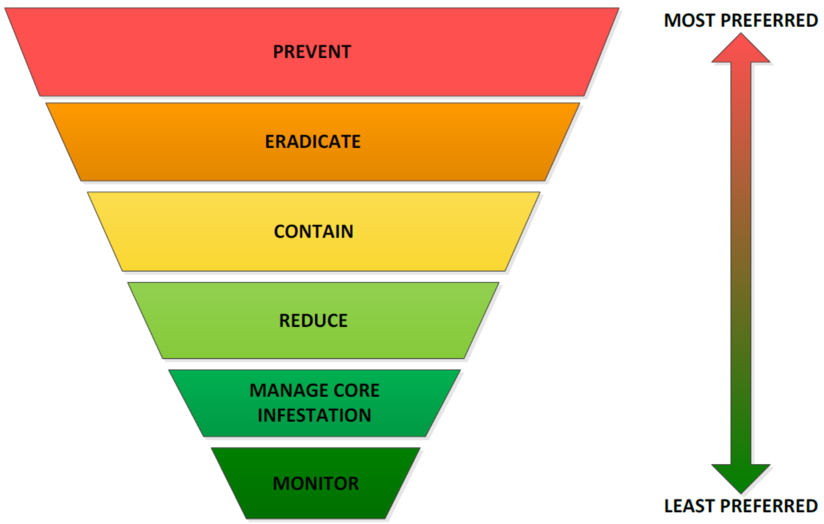


Figure 5.1 - Santos Pest Management Hierarchy

5.4 Prevent

The prevention of pest plants and animals is the most effective and efficient means of management for those areas where they are not yet present. Prevention is the cheapest and most effective form of weed management. This plan will focus upon prevention as the primary method of weed management as the Pilliga currently exhibits relatively low levels of weed infestations, particularly in areas of native vegetation. Pest plants typically thrive in nutrient enriched areas with abundant water resources. The Pilliga is characteristically dry with low-nutrient sandy loam to sand soil types, which precludes the establishment of most highly invasive weeds.

This Protocol aims to prevent new incursions of pest plants and animals through the implementation of the hygiene protocol, a hygiene inspection process presented in Appendix C and education through a Project-specific ecological induction for all Santos staff and contractors. Most pest animals identified in this Protocol already occur within the Project area and prevention is no longer possible. The Project has the potential to facilitate spread of pest animals by creating new tracks, however, the forest structure is already relatively open, and the new tracks are unlikely to facilitate this movement much more than is already possible.

The risk remains that incursions may occur despite controls, either through human error or through increased access to the Project area by members of the public. The Project in predominantly located within the state forest and public access cannot be controlled. Given the mixed use of the Pilliga East State Forest and its accessibility the risk of new incursions is elevated and in these instances beyond the control of Santos. Risk assessments for pest plant and animal species that may occur in the area have been completed and are presented in section 5.6 and Appendix D.

Collaboration with public agencies and authorities, such as the North West Local Land Services and Narrabri Shire Council, will form a part of regular prevention activities. A collaborative approach to pest plant management within the region will assist in ensuring efficient responses to emerging threats.

5.4.1 Site induction

An ecological induction has been developed for the Project and will be conducted by all Santos staff and contractors. The induction will broadly address the following key areas:

- the ecological values present within the Project area;
- the risks posed to ecological values by the Project;
- an overview of the avoidance and mitigation measures employed to manage the risks;
- actions and activities required by contractors and staff to prevent/manage ecological damage; and
- points of contact for reporting any ecological incidents or near misses.

The ecological induction will directly address pest plant and animals and the risks they pose to the environment. Careful control for pest plants and animals within the Project area is necessary in the avoidance and mitigation of the projects impacts to biodiversity and more broadly upon economic assets, owned by Santos and other private entities. Santos has a duty to minimise the risks and impacts of their activities on the introduction or spread of pest plants and animals in the Project area and surrounding lands, as far as practicable.

Further details on the environmental induction is provided in section 9.1 of the EMS.

5.4.2 Hygiene protocol

Vehicles and equipment will be subjected to the hygiene protocol to minimise the opportunities for spread of pest plant species and pathogens. A hygiene protocol, as presented in Appendix C, has been developed for vehicles and equipment entering the Project area. It will be applied to all new or returning items. Key considerations include:

- hygiene inspections should be conducted on a regular basis for all Santos and contractor vehicles and equipment;
- any new or returning vehicles and/or equipment to the Project area should wash down and/or otherwise clean the exterior and interior, ensuring as far as practicable no dirt (fine dirt is acceptable – any clumps of dirt or mud with potential to contain seeds or pathogens must be removed) or plant material remains;
- hygiene inspections must be conducted by an appropriately trained and competent Santos employee; and
- a record of each inspection must be completed and stored in a Santos approved tool or system for environmental reporting.

Vehicle and equipment pest plant inspections are a vital first step in the management hierarchy. Following completing the washdown or in cases where vehicles and/or equipment are moving from areas with pest plants and have potentially been contaminated a pest inspection will be completed and recorded for:

- any vehicles or equipment moving between sites within the Project area. Attempt to organise work schedules to facilitate movement from areas of least to high contamination/infestation, e.g. native remnant vegetation to exotic pasture;
- after moving through or working in a pest plant infested area vehicles and equipment will be checked for any residual mud, dirt or plant material and remove it. Once removed the material will be disposed of in general waste or left at the site of origin; and
- even when moving between infested sites it is always important to carry out the above checks to minimise the potential of spreading different weeds to new locations.

5.5 Pest species prioritisation

The development of the Project increases the risks associated with pest plants and animals through:

- clearing native vegetation, resulting in ground disturbance and open areas that can facilitate establishment or spread of pest plants and animals;
- transport and use of potentially contaminated machinery in the development footprint that may introduce or spread pest plants; and
- creation of new tracks that may facilitate the movement and spread of pest plants and animals throughout the Project area.

These risks can have long-term consequences if not managed effectively. In the event prevention fails or a pest plant or animal already occurs within the Project area, an approach to guiding pest species control aims and prioritisation has been developed, as presented in Table 5.1. The matrix is based on management streams that align with the pest management hierarchy (see section 5.3) and considers the potential impact to biodiversity or agriculture (pest hazard) and feasibility of control in a native vegetation or agricultural context.

The matrix uses a contemporary risk analysis framework to identify the appropriate level of control from the pest management hierarchy for each pest species. Opportunities for concurrent control using suitable methods on multiple pests should be sought where possible to maximise the efficiency of control efforts regardless of prioritisation. For example, if a species in a lower priority management stream occurs in close proximity to another species in a higher priority management stream, then the lower priority species should also be controlled as a cost saving effort.

Table 5.1 - Pest plant and animal risk matrix

Pest risk matrix		Feasibility of control				
		Negligible	Low	Moderate	High	Very high
Pest hazard	Negligible	Limited action	Limited action	Limited action	Limited action	Limited action
	Low	Limited action	Limited action	Limited action	Monitor	Monitor
	Moderate	Manage core infestation	Manage core infestation	Manage core infestation	Manage core infestation	Contain
	High	Reduce	Reduce	Reduce	Contain	Eradicate
	Very high	Reduce	Reduce	Contain	Eradicate	Eradicate

(Adapted from South East Pest Management Strategy – Part 2 (South East Natural Resources Management Board 2009)

The risk assessment has been completed for each pest plant and animal species (refer to Appendix D) utilising the following resources:

- exotic species within 100 km of the Project area, based on the records from The *Australian Virtual Herbarium* (AVH, 2019);
- exotic species detected during surveys for the Project;
- Weeds of National Significance with a known or potential distribution overlap with the Project area;
- species listed in Schedule 2 – Prohibited Matter from the *NSW Biosecurity Act 2015* and Schedule 3 – Weeds from the *Biosecurity Regulation 2017* (NSW) within the now defunct Namoi Catchment Management Authority (used as proxy for species likely to occur in the area);
- the *North West Regional Strategic Weed Management Plan 2017 - 2022*; and
- the *North West Regional Strategic Pest Animal Management Plan 2018 - 2022*.

All management streams are underpinned by regular Project-wide surveillance and mapping to assist in early detection of new or emerging pest threats as detailed in section 7. Some pest animals for the purpose of this Protocol may include native herbivores in the area, however, only low-impact and non-lethal control methods will be employed for these species, such as temporary exclusion fencing.

5.5.1 Eradicate

“Eradicate” is the aim for any new detections of pest species in the first instance. Otherwise, species in this category have a high to very high pest hazard and/or high to very high feasibility of control. Eradicate aims to remove the pest from the development footprint and where detected in Project area in relation to the Projects activities permanently by:

- destruction of all populations/individuals present, including juveniles in the case of pest animals, using integrated pest management where applicable;
- destruction of seed bank, as necessary;
- destruction of all infestations, aiming for local eradication at feasible sites;
- monitoring progress towards eradication; and
- prevention of re-entry into Project area.

5.5.2 Contain

“Contain” relates to species that have a moderate pest hazard with a high feasibility of control, a high pest hazard and high feasibility of control or a very high pest hazard and moderate feasibility of control. “Contain” aims to prevent the ongoing spread of the weed species in the Project area by:

- control of all infestations, aiming for a substantial reduction in pest plant or animal density within the Project disturbance area; and
- prevent or otherwise minimise additional entry and movement into development footprint and more broadly throughout the Project area where practicable, using signage and/or protective fencing.

5.5.3 Reduce

“Reduce” relates to species with a high pest hazard and negligible to moderate feasibility of control or a very high pest hazard and a negligible to low feasibility of control. “Reduce” aims to reduce the overall environmental, economic and social impact of specific pests throughout the development footprint and indirect impact buffer through:

- Implementation of integrated pest management practices to aim for a reduction in pest density and abundance; and
- Regular monitoring of development footprint and indirect impact buffer, throughout the development of the gas field.

5.5.4 Manage core infestation

“Manage core infestations” relates to species with a moderate pest risk and a negligible to high feasibility of control. “Manage core infestations” aims to minimise the impact of species in this management category by focusing on areas of particularly high abundance or densities of the pest. Practically, few pest animal species can be managed through this stream as the populations are often extremely wide-spread and far-ranging.

- control of infestations near high traffic areas, aiming for a substantial reduction in pest density;
- monitoring change in current distribution of already established populations within and near to the development footprint and indirect impact buffer; and

- map and track core infestations of pests in this management stream.

5.5.5 Monitor

This management stream is independent of the monitoring program summarised in section 7. The management stream should only be used to guide aims for control and prioritisation for specific species that may occur within the Project area.

“Monitor” aims to track the progress of species with a low pest hazard and a negligible to high feasibility of control. Control activities may be directed at these pests if higher priority pests are already dealt with, if monitoring suggests the species-specific risk assessment to be incorrect or conditions changed, or if there is an opportunity to streamline control efforts, e.g. the pest can be controlled concurrently with others already targeted for control in a higher priority management stream.

Control of these species will only be carried out if it is economically viable and the level of control achievable can justify the effort, e.g. if a low level of control was conducted on a species with a negligible feasibility of control those efforts may ultimately be wasted.

5.5.6 Limited action

“Limited action” applies to species with negligible pest hazard and negligible to high feasibility of control or a low pest hazard and a negligible to moderate feasibility of control. Little can be done to combat these pests within the Project area, and the cost of control is likely to detract from other more meaningful control activities.

If a pest in this category poses a risk to other land uses or begins to display characteristics and impacts outside of the assigned pest hazard assessment category control measures will be undertaken.

5.6 Risk assessment

A risk assessment was conducted during the development of the EIS to assist in identifying other risks associated with the establishment or spread of pest plants or animals in the Project area. These risks relate to both the development of the Project development footprint through space and time as well as the ongoing activities related to or facilitated by the Project. A standard risk assessment matrix, presented in Table 5.2 was used to assess pre-control and post-control risk ratings for various scenarios and activities, presented in Table 5.3. As the gas field develops, additional high-risk locations or activities may be identified. These can be included in this Protocol through reviews, under the adaptive management framework.

The risk assessment of pest plant species as presented in Appendix D was used to identify which species pose the highest risk to the Project and/or may become a problem due to the construction, operation or decommissioning of the Project. The risk assessment considered the biology of each species, the hazard of the species to biodiversity and/or agriculture and the feasibility of control within areas of native vegetation and agricultural areas. The pest plants of highest risk, based on the risk assessment and related management stream, have individual profiles included in Appendix B to assist in educating and recognising these species and to guide appropriate responses. No profiles have been developed for species identified in the limited action management stream.

Table 5.2 - Assessment matrix for incursion and spread risks

Consequences	Likelihood: Very likely (could happen at any time)	Likely (could happen infrequently)	Unlikely (could happen very rarely)	Very unlikely (could happen but generally never will)
Major – (multiple widespread infestations with low-negligible feasibility of control, extensive environmental damage or costs to agricultural land and/or practices >$100k)	H1	H2	H3	M7
Moderate – (several difficult to reduce or contain infestations, resulting in noticeable environmental degradation, moderate impairment to agricultural lands or practices resulting in costs >$50k but <$100k)	H4	H5	M8	M9
Minor – (several infestations with good prospects of containment or eradication, relatively close together, minimal environmental damage, encroaching on agricultural lands and practices costs <$50k)	H6	M10	M11	L14
Insignificant – (limited action species or readily eradicated infestation, no discernible environmental impact, little or no impairment to agricultural lands or practices)	M12	M13	L15	L16

Table 5.3 - Pest plant and animal risk assessment of high traffic/activity areas

Event	Uncontrolled risk weighting			Management action/s	With control/s risk weighting		
	Likelihood	Consequences	Risk		Likelihood	Consequences	Risk
Pest plant incursion along the Newell Highway	Likely	Moderate	H5	Hygiene protocol implemented by all staff; Public access along highway remains uncontrolled.	Unlikely	Moderate	M8
Pest plant spread from the Newell Highway into Project area at high utilisation access areas.	Likely	Moderate	H5	Regular inspection of all project entry points to detect pest plan infestations; Slashing and weed spraying to prevent build-up of seed bank prior to flowering times for highly infested grass areas; Hygiene protocol implemented by all staff; If necessary, pullover on unvegetated areas and avoid driving through long grass.	Unlikely	Moderate	M8
Pest spread facilitated by gas field development	Likely	Moderate	H5	Site induction Pre-clearance surveys; Targeted eradication within micro-sited areas; Vehicle and Plant hygiene protocol; Installation of dedicated washdown bays at NOC and all major facilities	Unlikely	Minor	M11
Pest plant and animals spread through the state forest by general public	Likely	Moderate	H5	Signage and biosecurity warnings; Relatively uncontrolled	Likely	Moderate	H5
Plant and equipment entering Project area from out of state	Very likely	Moderate	H4	Hygiene protocol implemented by all staff	Unlikely	Moderate	M8
Pest plant spread from construction works within 5 km of Bohena Creek	Likely	Moderate	H5	Hygiene protocol implemented by all staff	Unlikely	Moderate	M8

6. Management actions

6.1 Surveillance and mapping

Detailed information on the distribution of pests throughout the Project area is not currently available due to the iterative approach to and the phased development of the Project. Pre-impact mapping was conducted during the EIS biodiversity surveys across 327 floristic plots.

Surveillance of the development footprint and indirect impacts buffer area will be conducted annually as a minimum, with incidental observations recorded throughout the year for opportunistic sightings. The annual pest surveillance will be conducted predominantly through the rehabilitation monitoring and annual pest plant and animal monitoring of the development footprint and indirect impact buffer, as detailed in Section 7. Monitoring must be conducted by suitably qualified or trained individual/s, e.g. ecologist, horticulturist or other professional trained in environment and land management.

6.1.1 Identification of pest plant and animal species

Early identification of pest plants and animals is essential to mounting rapid and effective control to eradicate or successfully contain any new or spreading species detected in the Project area. A proforma in a Project-based GIS system is the preferred method for completing and recording field inspections. Minimum data requirements for new detections are provided on the New Pest Plant Reporting Form, provided in Appendix E. Clear photos of all parts of the plant including habit (form), leaves and flowers/fruits should be taken at the first encounter and supplied to the Environment Advisor for further identification. Specimens can be identified by the Project ecologist, or through the NSW Herbarium. Similarly, any new species of pest animal detected within the Project area during monitoring or opportunistic sightings should also be reported to the Environment Advisor.

6.1.2 Prevent

Prevention applies to all pest plants species as a means to reduce the risk to extant remnant native vegetation and agricultural areas. Prevention of further spread of pest species, even where they already occur, throughout the Project area is an important component of pest management and must be conscientiously carried out.

Prevention will be achieved through the strict implementation of the hygiene protocol as presented in Appendix C and through an ecological induction given to all staff and contractors prior to commencing work within the Project area. Preventing the spread of pest animals is more challenging due to their ability to move easily through the landscape.

6.2 Implementing integrated pest management for the project

Where an infestation or population of a pest plant or animal species is already established or initial eradication has failed, ongoing management may be required. Integrated pest management will be implemented using Pest Action Sheets presented in Appendix F to identify the target species, the areas where control is required and methods suitable for the control of that species. The sheets will include a log of all control methods used to date and the measured success of the control method. Areas subject to a Pest Action Sheet will be tracked in the Project-wide GIS with the relevant sheet associated with the data to ensure all relevant information is readily accessible for personnel to implement controls.

6.2.1 Pest plant control methods

The aim for all control is to manage the pest species as far as practicable to allow natural regeneration and recruitment to support or establish native plant dominance.

6.2.1.1 Physical control

Physical control methods are often highly effective, but labour intensive and costly, particularly when dealing with large areas or plants that are difficult to remove. Many methods are available and suitability depends on the context in which it is used. Methods of control suitable in a farming context:

- haymaking, mowing and grazing;
- mulching and tilling;
- burning, hand removal or flaming;
- steaming;
- solarisation; and
- slashing (note slashing should not be conducted where pest plants have commenced flowering or seed set).

Methods of control potentially suitable in a native vegetation context:

- hand pulling;
- digging and removing corms, bulbs and tubers;
- crowning;
- cut and paint – also utilises herbicide simultaneously;
- stem injection or frilling/chipping;
- scrape and paint; and
- stem swipe.

Post treatment management depends upon the species and may include bagging and disposing of the pest plant material in a manner that ensures spread is not possible.

6.2.1.2 Chemical control

Herbicides can be used in the control of many pest plant species and should be considered as part of a wholistic approach to control and not used as a sole control method. Some of the above-mentioned physical control methods also utilise herbicides to maximise effectiveness of the physical control. All herbicides must be applied by an appropriately trained and experienced person.

The appropriate method of herbicide application should be chosen based on the target species and likely effectiveness and may include:

- foliar spray;
- gas gun/splatter gun;
- rope/wick applicators;
- basal bark spraying and stem injection;
- cut stump – suitable for larger shrubs and trees;
- cut and swab – suitable for vines and multi-stemmed shrubs; and
- stem scraping.

6.2.1.3 Biological control

Biological controls can be an extremely effective, economical and self-sustaining method of control, particularly in hard-to-reach locations. However, biological control agents are only available for a very select number of species and require careful planning and research prior to the implementation to avoid unintended consequences. Biological control can form part of an integrated pest management approach and may include:

- classical biocontrol, such as the release of a natural predator from the weeds home range; and
- non-classical, includes inundative (mass-release of the agent, e.g. mycoherbicides) and augmentative (mass rearing and release of large numbers of an agent that cannot be used as a mycoherbicide).

6.2.1.4 Cultural control

Cultural controls are largely associated with farming systems and may not be suitable for areas of native vegetation. Some methods that may be used in crop and/or pasture conditions include but are not limited to:

- use high quality seeds, as they are more likely to produce competitive plants;
- increase seeding rates and narrow row spacings;
- use fertilisers in optimal growth period of desired plant species;
- if possible, use plant species that are native to the area;
- rotate crops and rotate species with different seasonal and growing cycles; and
- rotate herbicides with different modes of action to avoid or delay the development of herbicide resistance.

6.2.2 Pest animal control methods

Integrated pest animal control is most likely to have the greatest positive controlling effect on target species. Combining multiple control methods over time and implementing them over a long-term period will also improve the likelihood of success.

6.2.2.1 Chemical

- Baiting - can be used with specific and non-specific toxins applied to a bait, e.g. sodium monofluoroacetate (1080) in meat baits, dispersed through the management area either by:
  - aerial sowing – dispersal of baits by dropping pre-determined clusters of baits across the landscape, often most suitable for large areas;
  - hand sown on the ground: dispersal of baits throughout the landscape by hand-placing baits on the ground, often off the back of a vehicle; or
  - canid pest injectors - another form of baiting that uses a specifically designed delivery system that reduces non-target species uptake of baits. They are capable of delivering a lethal dose with less overall toxin applied with the toxin degrading or dissipating.

6.2.2.2 Physical

- trapping – a variety of trapping methods may be used, such as cage traps and net traps, depending on the target species and the final goal, i.e. lethal or non-lethal control methods;

- shooting – A lethal method that can be used to compliment other control methods and improve overall success. In some settings, i.e. bushland with ample cover and refuge for the target species, shooting can be time consuming and expensive;
- exclusion fencing – can be particularly useful for the control of native herbivores on rehabilitation areas, i.e. relatively small areas, to allow successful regeneration of the native flora species. Exclusion fencing in other situations will likely be too expensive and cumbersome to employ over larger areas; and
- mustering – can be used for commercially valuable species or otherwise susceptible animals, primarily goats, where they can then be euthanised or sold. This method may be useful; however, it can also create an impetus for landholders to encourage numbers to increase prior to mustering.

6.2.2.3 Biological

Biological controls in pest animal management is unlikely to succeed, due to the low density and widespread populations of the target species within the Project area and the likelihood of the development of resistance in the population.

6.3 Proposed control program

6.3.1 Proposed pest plant control program

The primary objective and focus of the pest plant control program is preventing the spread of pre-existing pest plants and new pest plants into the Project area. The approach used to achieve this is outlined in section 5.4. However, it may be necessary to perform control actions on pest plant species identified within the Project disturbance area that fall within the 'Manage core infestation', 'Reduce' and 'Contain' management streams as identified in the pest species risk assessment. Suggested control methods for each species are provided in the Project Pest Plant profiles in Appendix B and supported by the suggested timing of control actions for the first year of management as presented in Appendix G.

6.3.1.1 Indicative cost basis of pest plant control program

The cost of broad scale weed control will depend on a number of variables: density of infestation, type of treatment required (e.g. herbicide application or mechanical control), frequency of treatment required, area of infestation, density of infestation, types of weeds present and climate and terrain of the area to be treated. As such, it is difficult to provide an estimate of the cost of weed control. As presented in Figure 6.1, the detailed floristic plot data from 327 plots within the Project area have been used to create a visualisation of the areas with the highest weed occurrence, noting that generally weed occurrence is low throughout the Project area.

There is little data available concerning the cost of weed control and the figures available show high variability. This variability in control costs is evident in Table 6.1 below, which identifies approximate costs of controlling a few of the weeds of concern in the Project area. For example, the cost of controlling Opuntioid cacti species by spraying with herbicides can range from a few hundred dollars to $8,000 or more per hectare.

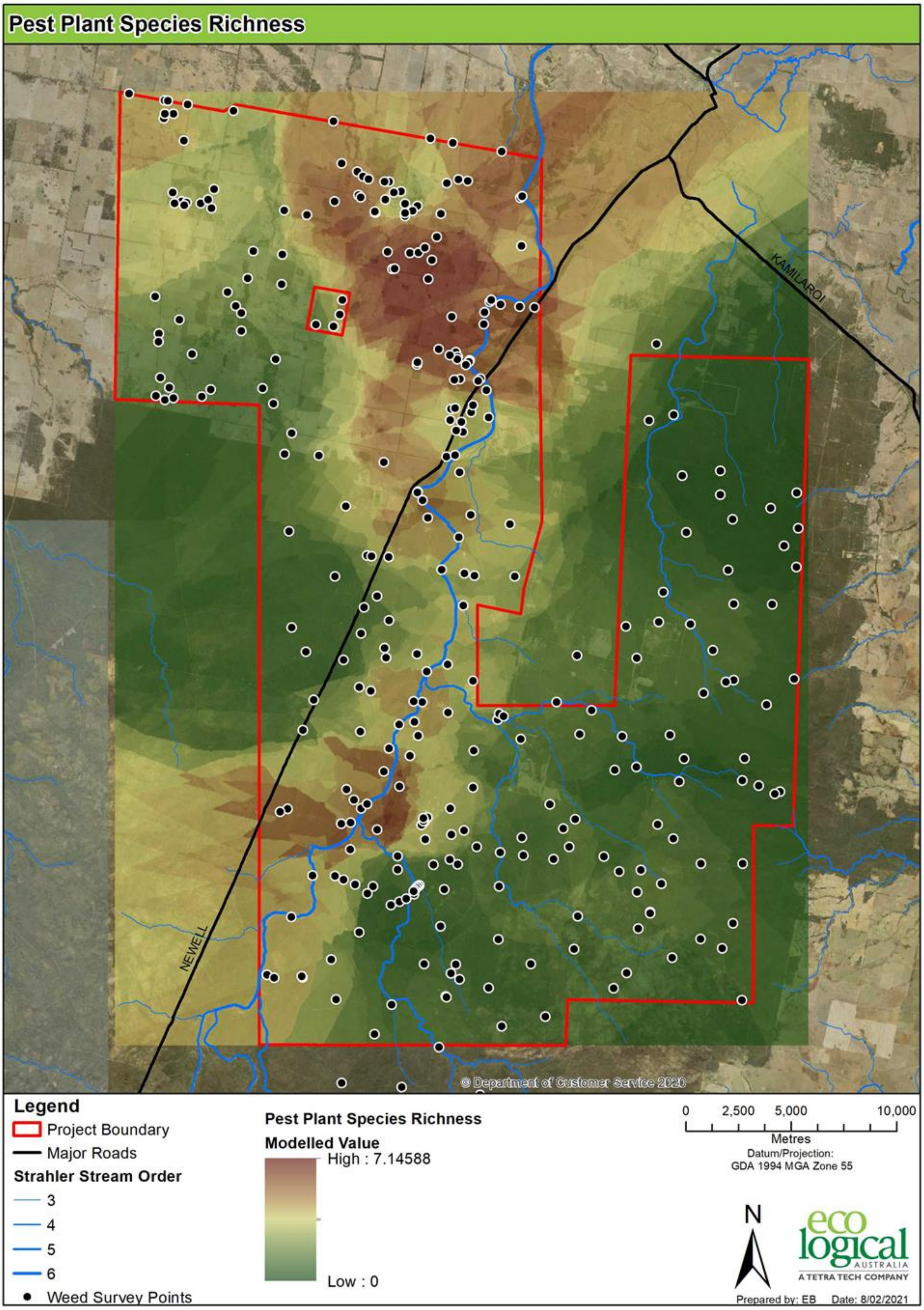


Figure 6.1 - Visualisation of the areas of highest weed occurrence

Table 6.1 - Approximate costs per hectare for the control of weeds of concern

Weed Species	Control Method	Cost per ha	Details and location	Reference
African boxthorn	Spraying with herbicides and mechanical excavation of plants	$130-140	3-year trial of control in remnant vegetation in Murray CMA	(Institute for Land, Water and Society, 2007)
Coolatai grass	Spraying with glyphosate/flupropanate	>$360	Pasture, North West Slopes NSW	(McCormick, Lodge, & McGullicke, 2002)
	Spot spraying with glyphosate or flupropanate	$180-220	Kwiambal National Park Northern NSW	(McCormick et al., 2002)
	Flupropanate	<$100 chemical cost + $100-249 labour costs Total ~ $200-349	Roadsides North and Central Coast NSW	(DPI, 2020)
Lippia	Spraying with DP-600	<$100 chemical cost + $100-249 labour costs	Unimproved grazing areas NSW	(Leigh & Walton, 2004)
Opuntia spp.	Spot spraying/ digging out	<$100 chemical cost + $100-249 labour costs Total ~$349	NSW	(DPI, 2020)
	Spraying	$750-1000	Leander QLD	(Lloyd & Reeves, 2014)
	Spraying (triclopyr, picloram or Access)	Few hundred dollars to >$8000	Western Australia	(Lloyd & Reeves, 2014)

6.3.2 Proposed pest animal control program

Approximately one percent of the total Project area will be directly and indirectly impacted by the Project. Much of the construction and operational areas and indirect buffer will have fencing installed around the perimeter which will avoid the movement of many pest animals into the Project impact area. The remainder of the Project area occurs within State Forest and some areas of privately managed land.

Attempting to control pest animals that are already established within the Project area and are able to freely move throughout the landscape is a redundant and costly approach. As pest animals are controlled and removed, new individuals will colonise. Therefore, Santos will liaise and collaborate where practicable with the Forestry Corporation of NSW (**FCNSW**) in their current pest animal control program, which will more effectively control pest animals throughout the broader landscape. This collaborative approach is also suggested for performing pest animal control on privately managed land. However, included below are some insights into the potential control methods and cost of controlling the priority species that are known to occur within the Project area.

The Australian Government's Department of Climate Change, Energy, the Environment and Water (**DCCEEW**) and NSW Department of Planning and Environment (**DPE**) list Key Threatening Processes (**KTPs**) in the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) and BC Act respectively, that are considered to threaten the survival, abundance or evolution of a native species or ecological community. Five feral animal species found within the application area are specifically listed as representing a KTP and so their management is a very high priority:

- Rabbit (*Oryctolagus cuniculus*): competition and land degradation by rabbits (Commonwealth and NSW)
- Goat (*Capra hircus*): competition and land degradation by unmanaged goats (Commonwealth and NSW)
- European Red Fox (*Vulpes vulpes*): predation by European Red Fox (Commonwealth and NSW)
- Cat (*Felis catus*): predation by feral cats (Commonwealth and NSW)
- Pig (*Sus scrofa*): predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs. (Commonwealth and NSW)

The top-down predator effects and trophic relationships existing between the major feral animals present within Australian ecosystems is a key management consideration for any control program and is an issue that is raised in the Threat Abatement Plans (TAP) for Rabbits, Goats, European Red Fox, Cats and Pigs. For example, targeting foxes without also implementing control of feral cats has the potential to lead to an increase in cat numbers, as they are released from predation by foxes. Fox control must incorporate not just cat control, but also rabbit control to prevent population spikes as fox predation declines. Equally, controlling feral grazing animals without also controlling feral predators could lead to prey switching by feral predators to native animals[3].

It should be noted that required levels of control for any feral species will differ across the application area, depending on conditions, and can be expected to be adjusted based on data collected during initial monitoring, which is likely to reduce the extent of control required, and then throughout the monitoring program as data shows variation in feral animal numbers. In addition, control efforts should be combined to achieve cost savings (e.g. combined aerial shooting or baiting programs). It is expected that costs will reduce over time where effective control is achieved. Table 6.2 provides a summary of key pest animal control information and strategies. Suggested timing of pest animal control actions are presented in Appendix G.

Methods other than lethal control are especially important considerations for feral cat management given the recurrent inputs required for lethal control of cats. Cats are more successful hunters in open landscapes and hunting success rates are related to the structure of habitat surrounding prey. Cat hunting success rates in open landscapes was 70 %, compared to 17 % in landscapes with dense grass cover or complex rock terrain. Therefore, by maximising grass cover, and complex vegetation stratification and maintaining areas of complex rock terrain across the landscape predation rates and the abundance of feral cats can be reduced locally. This ties in with the need to control feral herbivores that will increase vegetation density and complexity and is likely to add significantly to the biodiversity benefits obtained by controlling cat numbers alone.

Preventing the spread of pest animals is the most effective method of control, particularly for species that are not yet established. The Threat Abatement Plan for the Biological Effects, Including Lethal Toxic Ingestion, Caused by Cane Toads (2011) highlights the propensity of Cane Toads to be inadvertently spread by human movement and therefore, adherence to the hygiene protocol is a key tool that will be

[3] Department of the Environment, 2015. Threat abatement plan for predation by feral cats, Commonwealth of Australia 2015. [Threat abatement Plan for Predation by Feral Cats (awe.gov.au)]

used to prevent this. Similarly, adherence to the hygiene protocol is important to avoid the spread of pathogens and disease into the project area. Both the Threat Abatement Plan for Disease in Natural Ecosystems Caused by *Phytophthora cinnamomi* (2018) and the Threat Abatement Plan for Infection of Amphibians with Chytrid Fungus Resulting in Chytridiomycosis (2016) recommend the primary objective of the plans to be to reduce further spread.

6.3.2.1 Predicted cost of pest animal control program

The cost of pest animal control is highly variable and depends on several factors: the environment, the scale of infestation, the species being controlled and the trophic relationships that exist between species. Table 6.3 compares the costs of various control methods on the pest animal species detected within the Project area. Control efforts should be combined to achieve cost savings (e.g. combined aerial shooting or baiting programs) and to minimise the potential for unintended trophic cascades.

Table 6.2 - A summary of key pest animal control information and strategies

Target Species	Red Fox	Cat	Pig	Goat	European Rabbit
Home Range	1 individual (arid zone) is 20 km^2 6-7 individuals (resource rich areas) every 3-5 km^2	Average of 248 ha in Western NSW	Seasonal range for boars is 43 km^2 Daily home range is less	In high rainfall areas, 1-13.5 km^2. In dryer areas, 14-460 km^2	Males 0.67 ha, females 0.39 ha in western NSW.
Active time	Nocturnal	Nocturnal and Diurnal	Evenings and cooler times of the day. In high heat become nocturnal.	Diurnal	Nocturnal
Diet Strategies	Food caches in spring & recovers in winter	Prefers live prey (Commonwealth of Australia, 2015)[4], bait at times of low prey availability	Opportunistic and omnivorous	Grazing generalist herbivores.	Graze and browse on vegetation
Primary Control Technique	The background document for the Threat Abatement Plan for the European Red Fox (2015) recommends that aerial baiting may be most effective for large sites and baiting must be intensive. Bait with 1080 (DEWHA 2008a) [5]: use highly palatable fresh meat. 5-10 baits per square km	Bait with 1080 (Commonwealth of Australia, 2015): application rate of 50 baits per square km	The Threat Abatement Plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (2017)[6] notes the most effective methods of large-scale management are poisoning and aerial shooting. Bait with 1080 (Commonwealth of Australia, 2017): 1577-1874 bait units per unit of pig density.	The Threat Abatement Plan for Competition and Land Degradation by Unmanaged Goats recognises trapping of goats at waterpoints as an effective method in areas of low rainfall with few waterpoints[7].	Bait with 1080 (Commonwealth of Australia 2016)[8]: 4-6 kg/ha with carrot baits (PestSmart)
Timing for Primary Control Technique	Annually: 4 X per year.	Annually: 2 X per year in Autumn & early Winter when live prey availability is low.	Annually: winter	Annually: 2x per year summer / autumn for five years and then as recommended based on post control numbers	Not recommended at present. Otherwise annually: 2 X per year in winter unless drought conditions concentrate animals in a different season
Secondary & Follow up control options	Annual trapping in winter when prey numbers are low and population is at its lowest for the year.	The background document for the Threat Abatement Plan for Predation by Feral Cats (2015) recommends trapping when populations have already been reduced and individual cats need to be targeted. Annual trapping in Winter is most effective as prey numbers are low and population is at its lowest for the year.	Annual trapping at water points and targeted shooting if numbers increase in response to good conditions.	Aerial shooting every 3-4 years, depending on numbers recorded.	The Threat Abatement Plan for Competition and Land Degradation by Rabbits (2016) recommends an integrated approach utilising multiple control methods. Therefore, Warren ripping or fumigation may be useful as a secondary control in conjunction with baiting if the use of warrens is confirmed. To be conducted every second year.

[4] Department of Environment, (2015). Threat abatement plan for predation by feral cats. Commonwealth of Australia, Canberra.
[5] Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008a). Background document for the threat abatement plan for predation by the European red fox, DEWHA, Canberra
[6] Department of Environment and Energy (2017). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017) Commonwealth of Australia, Canberra.
[7] Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008b). Background document for the threat abatement plan for competition and land degradation by unmanaged goats, DEWHA, Canberra.
[8] Department of Environment and Energy (2016). Background document to the Threat abatement plan for competition and land degradation by rabbits, Commonwealth of Australia, Canberra.

Table 6.3 - Comparative costs for pest animal control methods in similar environments

Target Species	Control Method	Cost per hectare	Details and Location
Red Fox	Aerial baiting	$0.37 / ha	Based on Western Shield program WA (3.5 million ha/ year): baiting four times per year, 5 baits per km^2 per session Includes $200,000 operating expenses equivalent to ~$0.06/ha
	Canid pest ejectors with $10 fox modifier	$72 per ejector	Ejector costs based on using one ejector every 500 m along all roads within the project are and buffer (based on AWC's methodology).
	Ground baiting	$0.60-1.20 / ha	This figure is based on data from Central NSW: baiting four times per year, 3 baits/km^2 which are checked every 3-5 days and replaced if taken up to 5 times. Includes labour.
Cat	Aerial baiting	$0.52 / ha	Based on the WA Western Shield program's fox control costs as above. Cost of Eradicat® bait is $0.3 per unit. Western Shield uses 50 baits per km^2. Therefore, cat baiting could be integrated into a fox baiting program for an added cost of approximately $0.15/ha.
	Leg-hold trapping	$0.15 / ha	The average cost of 10 days of leg hold trapping in Western Australia. 40 km transect with traps spaced 0.5 km apart.
Pig	Ground baiting	$0.58-1.77 / ha	Upper figure based on slopes and plains
	Aerial baiting	$2.47 / ha	Based on costs in dry tropical savannah (Qld). Warfarin used.
	Trapping	$1.50-14.82 / ha	Lower figure from Alpine forest (Kosciusko NP) with lower pig density. Higher figure from Dry tropical savannah (Qld)
	Aerial shooting	$0.19-2.09 / ha	Upper figure based on woodland in Western NSW
Goat	Aerial shooting	$0.67-1.48	Based on costs from Coolah Tops NP NSW
	Mustering	$0.99-1.02	Based on costs from Coolah Tops NP NSW
	Trapping at waterpoints	$0.42-6.32	Lower figure from South-western QLD, upper figure from Western NSW
	Ground shooting	$0.22-2.38	Figures based on Kennedy Range NP and Cape Range NP, Western Australia
Rabbit	Warren ripping	$5-25 / ha	Not likely to be suitable in Pilliga forest due to access issues, but would be suitable for farmland Frequency of treatment depends on soil type- on sandy soils 62% of warrens may be reopened within 6 months vs. 12% in 10 years on heavy soils
	Warren fumigation	$15.92-$31.85 / ha	Not likely to be suitable in Pilliga forest due to access issues, but would be suitable for farmland Cost given is for large-scale contracts. Cost varies depending on the density of warrens and the nature of the terrain and vegetation.
	Poisoning (Pindone or 1080)	$9.55-12.74 / ha	Likely the most useful broadscale control for the current proposal. Frequency of treatment is 1-6 years. Cost given is for large-scale contracts and includes all materials and labour. The cost of poisoning is relatively insensitive to variations in density of rabbits and warrens

7. Pest plant and animal monitoring

Monitoring for pest plants and animals, and the efficacy of control measures, will be implemented through the monitoring associated with the Rehabilitation Management Plan (**RMP**) and the BMP and during regular pest plant and animal inspections. Implementing a dedicated long-term monitoring program dedicated to pest plants and animals that is practicable is challenging due to the scale and complexity of the project. However, by integrating some aspects of the pest plant and animal monitoring into BMP and RMP monitoring for the Project, within an adaptive framework, implementation of pest species control monitoring becomes more achievable and cost-effective.

Risk assessments are based upon current knowledge of the threat posed by the species. Monitoring may indicate a particular pest poses a higher or lower risk than initially assessed. In these cases, a revision of the risk assessment may be undertaken to reflect the observed risk, e.g. a particular pest plant poses a risk higher than initially assessed and should be elevated to a higher priority management stream.

7.1 Baseline data

Site-specific baseline data of the development footprint was collected during flora and fauna surveys for the EIS. This approach is required due to the iterative nature of the development of the gas field. Project area wide baseline data is not practical and would misdirect resources that would be better utilised to control species that pose a more immediate threat.

Flora surveys included 327 biometric plots following the BioBanking Assessment Methodology and over 1,300 rapid vegetation validation plots. Extensive fauna surveys were also undertaken during the EIS surveys. These included 1,505 camera trap nights, Elliot trapping, sand plots, opportunistic observations and scat analysis. These surveys indicated that there were 116 exotic plant species and 17 exotic animal species present within the study area, respectively presented in Tables 4.1 and Table 4.2.

Weed species richness was generally higher closer to Bohena creek, which likely acts as a major disperser and receiver of pest plant propagules within the Project area (refer to Figure 6.1). Importantly the areas surrounding Bohena Creek likely experience greater access to water and as such, a large number of the pest plant species detected are likely dependent on more reliable water sources than are typically found throughout the rest of the Project area, e.g. (Noogoora Burr Xanthium occidentale). Higher numbers of pest plant species were also detected on land historically used for agriculture and grazing within the Project area.

7.2 Pest plant monitoring

An effective pest plant monitoring program is needed to ensure new infestations of pest plants are located, existing infestations are monitored and the efficacy of control actions are measured. Due to the scale of the Project, pest plant monitoring will be carried out during RMP and BMP monitoring, and during regular pest plant site inspections.

Rehabilitation monitoring will be conducted at sites following progressive rehabilitation efforts. Any pest plant species identified during these surveys will be reported to the Environmental Advisor for further consideration and possible action. The BMP will utilise sound scape monitoring combined with floristic plots and camera traps, with a site setup similar to the monitoring currently used by Forestry Corporation of NSW throughout the Pilliga. The monitoring will have floristic plots conducted at each monitoring site as described in the Project BMP. Weed species presence and high threat exotic cover will be recorded in these monitoring sites.

Another aspect of the pest plant monitoring involves regular pest plant site inspections. The program will allow new pest plant occurrences and infestations to be documented during the progressive development of the gas field and associated infrastructure. There will be a focus on the areas of state forest and remnant native vegetation as these areas provide a uniquely difficult challenge relating to implementation of controls due to their remoteness and sensitivity of the surrounding vegetation.

After pre-clearance assessments and construction activities a system of regular inspections of the development footprint and associated indirect impact buffer will commence. Annual inspections will occur in all areas for the first five years following construction. If after five years no new pest plants have been detected, inspections will be conducted biennially until full decommission of the asset is complete, e.g. a well pad has had all infrastructure removed, or access track is no longer used and has been successfully rehabilitated. In the event of a detection, inspections related to that asset and corresponding indirect impact buffer will continue annually, until the pest plant is no longer detected in that area for five subsequent inspections. Inspections can then revert to a biennial cycle.

Records of any detections and their extent will be assessed against the weed risk assessment for the species and determine the management stream/s present at the site. Follow-up actions will be determined based on the weed risk assessment and the relative size of the infestation. Age of the infestation may also be important if it has had an opportunity to set seed. Additional control efforts may be required in these cases if early detection fails.

7.3 Pest animal monitoring

Pest animals pose a risk to the native biodiversity and ecosystem of the Project area, as well as a risk of damage to restoration and rehabilitation areas through herbivory by introduced and native herbivores. Pest animal monitoring will occur through the BMP monitoring and regular pest animal inspections within the Project disturbance area.

As mentioned above, the BMP monitoring will measure changes in ecological health across the Project area through soundscape analysis paired with vegetative surveys and camera trapping at monitoring sites. Surveys for feral animals and native fauna species detectable on camera traps will be conducted at each monitoring site. To ensure the maximum potential to detect fauna the cameras will be set up using documented standardised protocol. Cameras will collect data for a two-week sampling period and will be baited with two perforated lure tubes, one containing a standard bait (peanut butter, rolled oats and honey mix) and one containing rolled chicken pieces.

BMP monitoring also involves the establishment of a SongMeter (or similar acoustic recording device) and a rapid vegetation integrity (condition) survey plot within a paired impact, control and reference survey design. These, combined with the camera traps, will enable the collection of data regarding pest animal population estimates as well as monitoring changes in native vegetation condition and native fauna assemblages. Collection of this data will allow links to be made between pest animal control, pest plant control, improvement of native vegetation and fauna biodiversity.

Sightings and/or signs of pest animal activity will also be recorded during pest inspections of all assets. The impact of the sighted species or the extent of the damage or signs of activity, e.g. pig diggings, will be recorded to assist in assessing the appropriate response based on the individual pest risk assessment. Additionally, opportunistic reports of feral activity and sightings can be recorded and documented using an approved system or tool. Records of sightings by employees and contractors will be documented and reported in the Annual Environmental Monitoring Report. For the purpose of this

Protocol, pest animals include native grazing herbivores, e.g. macropods or “kangaroos”, in rehabilitation areas that may compromise the success of the natural regeneration.

7.4 Remote sensing opportunities

Remote sensing provides a unique opportunity for large scale, efficient monitoring of pest species within the development footprint. Santos will investigate the use of high resolution multi-spectral imagery across the development footprint to rapidly identify and quantify pest plant infestations. The investigation will focus on a subset of the highest impact pest plant species and focus on the feasibility of implementation and constraints of a remote sensing-based approach. To be effective the target species will need to have suitable biological traits that are detectable using remote sensing, e.g. a unique spectral signature relative to the surrounding vegetation or distinct photosynthetic activity relative to the vegetation it grows amongst. Imagery resolution is also extremely important and can be determined based on the determined minimum size for detection considering data management and cost feasibility. Large areas of high-resolution imagery are expensive and result in extremely large quantities of data.

There are also opportunities to engage with external contractors using an Unmanned Aerial Vehicle (UAV), otherwise known as drones, fitted with high resolution multispectral sensors to map the entire Project area and use ecologically trained artificial intelligence to detect pest and native plant and animal species. This method may be beneficial as it allows for an integrated monitoring approach and is suitable for large areas. However, a number of limitations exist when using UAVs and remote sensing, including the inability to penetrate a dense canopy and detection issues for smaller species.

7.5 Administrative and procedural controls management

Direct measures of the effectiveness of these management practices are difficult, due to a lack of controls. Tracking the rate of the implementation of prevention activities can assist in demonstrating their commitment to preventing the spread of pest plants throughout the Project area.

7.6 Prevention

All hygiene inspections and subsequent actions carried out under the hygiene protocol to be recorded and documented in a Santos approved system or tool.

7.7 Detection

Any pest plant species detected during the rehabilitation monitoring, pre-clearance surveys or regular inspections must be documented and recorded in a Santos approved management tool or system to assist in annual reporting.

8. Triggered management actions

8.1 Responses and prioritisation

Pest plant and animal management actions have been developed on a pro-rata basis in a reactive framework. Critical review and prioritisation are essential to ensuring pest plants and animals are managed effectively. Uncoordinated control efforts can be as bad as doing nothing in some cases. Prioritisation for control efforts is based upon the Santos pest management hierarchy and the pest risk assessments. Any detections of pest plant or animal species should be reported immediately to the Environmental Advisor for escalation as required. Management and co-ordination of all control efforts, as presented in Table 8.1, are the responsibility of the Environmental Advisor.

Table 8.1 - Pest plant and animal detection actions

Detection type	Response	Escalation
Detection of priority weed or alert species	Immediately notify Environmental Advisor in writing, i.e. email. Obtain sample and provide to suitably qualified individual (e.g. Project Ecologist), the National Herbarium of New South Wales or similar institute for confirmation of species identification.	Report to Narrabri Shire Council weeds officer or authorised official for further escalation as necessary, e.g. to regional weed committee or relevant NSW government department. Narrabri Shire Council Weeds Officer, (or in case of a prevention weed, example *Parthenium)*, NSW Department of Primary Industries (DPI) needs to be notified within 24 hours. The weed is not to be removed by anyone other than an Authorised Weeds Officer Prioritise for eradication or control. Approach may require coordination with other relevant stakeholders. Note: Emergency response may be initiated by other agencies, which may include Santos cooperation operationally and/or financially. .
New infestation detected	Complete and file inspection on Santos approved tool or system and notify the Environmental Advisor in writing	Refer to pest risk assessment (Appendix D - Pest species risk assessment) and prioritise control efforts according to Santos pest management hierarchy. If the new infestation is already extensive i.e.: Covers a large surface area. Is a high hazard species with low feasibility of control Many individuals are already present The species is currently flowering/fruiting then prioritisation outside of the pest risk assessment management streams may be appropriate.
Infestation spread	Complete and file inspection on Santos approved tool or system and notify the Environmental Advisor in writing.	Refer to pest risk assessment (Appendix D - Pest species risk assessment) and prioritise according to Santos pest management hierarchy. Develop and implement Pest Action Sheet as required.

Detection type	Response	Escalation
New pest animal in area	Complete and file inspection on Santos approved tool or system and notify the Environmental Advisor in writing.	Environmental Advisor to review and report sighting using appropriate method from section 0 Document notification.
Increase in signs of previously detected pest animal	Complete and file inspection on Santos approved tool or system and notify the Environmental Advisor in writing.	Investigate species and coordinate targeted controls depending on species involved and liaison with other relevant stakeholders for coordinated response.

8.2 Detection of a regional reportable species

8.2.1 Pest plant species requiring local control authority notification

Pest plant alert species for the North West LLS (NW LLS 2017a) if sighted must be reported to the Narrabri Council Weeds Officer and include:

- Gamba Grass - *Andropogon gayanus*
- Pond Apple - *Annona glabra*
- Bridal Veil Creeper - *Asparagus declinatus*
- Kochia - *Bassia scoparia (*excluding subsp*. trichophylla*)
- Spotted Knapweed - *Centaurea stoebe subsp. australis*
- Black Knapweed - *Centaurea x moncktonii*
- Siam Weed - *Chromolaena odorata*
- Koster's Curse - *Clidemia hirta*
- Rubber Vine - *Cryptostegia grandiflora*
- Anchored Water Hyacinth - *Eichhornia azurea*
- Hawkweed - *Hieracium spp*. (all species)
- Hydrocotyl/Water Pennywort - *Hydrocotyle ranunculoides*
- Lagarosiphon - *Lagarosiphon major*
- Frogbit / Spongeplant - *Limnobium spp*. (all species)
- Yellow Burrhead - *Limnocharis flava*
- Miconia - *Miconia spp*. (all species)
- Mikania Vine - *Mikania micrantha*
- Mimosa - *Mimosa pigra*
- Eurasian Water Milfoil - *Myriophyllum spicatum*
- Mexican Feather Grass - *Nassella tenuissima* (syn. Stipa tenuissima)
- Broomrape - *Orobanche spp*. (all species except the native O. *cernua* var. australiana and O. *minor*)
- Water Soldier – *Stratiotes aloides*

- Witchweed - *Striga spp*. (except the native *S. parviflora*)
- Water Caltrop - *Trapa spp*. (all species)
- Karoo Acacia - *Vachellia karroo* (syn. *Acacia karroo*)
- Prickly Acacia - Vachellia nilotica (syn. *Acacia nilotica*)
- Parthenium Weed - *Parthenium hysterophorus*
- Tropical Soda Apple - *Solanum viarum*
- Boneseed - *Chrysanthemoides monilifera* subsp. *monilifera*
- Parkinsonia - *Parkinsonia aculeata*.

Reports are to be made by contacting Narrabri Shire Council and request councils Weed Officer for assistance:

- Ph: (02) 6799 6866
- F: (02) 6799 6888
- council@narrabri.nsw.gov.au

The FCNSW will also be made aware of the pest plant alerts sent to Narrabri Shire Council.

8.2.2 Regional pest animal alert species

Pest animal alert species for the North West LLS if sighted must be reported and include:

- Sambar Deer (*Rusa unicolor*)
- Rusa Deer (*Rusa timorensis*)
- Mozambique Tilapia (*Oreochromis mossambicus*)
- Cane Toad (*Rhinella marina*).

The report can be completed through the North West LLS:

- Report an Unusual Sighting Form
- Call: 1800 680 244
- Email: invasive.species@dpi.nsw.gov.au

Appendix A - Exotic species detected in the Project area

Table A1 - Exotic species detected in the Project area

Family	Scientific name	Common name	WoNS	State Priority weed[9]	Regional priority weed
Aizoaceae	*Trianthema portulacastrum*	Giant Pigweed, Black Pigweed	N	N	N
Amaranthaceae	*Alternanthera pungens*	Khaki Weed	N	N	N
Amaranthaceae	*Alternanthera sp. (unidentified)*		N	N	N
Amaranthaceae	*Amaranthus sp.*	Amaranth	N	N	N
Amaranthaceae	*Gomphrena celosioides*	Gomphrena Weed	N	N	N
Apocynaceae	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	N	N	N
Asteraceae	*Arctotheca calendula*	Capeweed	N	N	N
Asteraceae	*Aster sp. (unidentified)*		N	N	N
Asteraceae	*Aster subulatus*	Wild Aster	N	N	N
Asteraceae	*Bidens pilosa*	Farmer's Friend, Cobblers Pegs	N	N	N
Asteraceae	*Bidens sp.*		N	N	N
Asteraceae	*Bidens subalternans*	Greater Beggar's Ticks	N	N	N
Asteraceae	*Carthamus lanatus*	Saffron Thistle	N	N	N
Asteraceae	*Centaurea melitensis*	Maltese Cockspur	N	N	N
Asteraceae	*Chondrilla juncea*	Skeleton Weed	N	N	N
Asteraceae	*Cirsium vulgare*	Black Thistle, Spear Thistle	N	N	N
Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	N	N	N
Asteraceae	*Conyza sp.*		N	N	N
Asteraceae	*Conyza sumatrensis*	Tall Fleabane	N	N	N
Asteraceae	*Gamochaeta calviceps*	Cudweed	N	N	N
Asteraceae	*Gamochaeta sp.*		N	N	N
Asteraceae	*Hedypnois rhagadioloides subsp. cretica*	Cretan Weed	N	N	N
Asteraceae	*Helianthus annuus*	Sunflower	N	N	N
Asteraceae	*Hypochaeris microcephala var. albiflora*	White Flatweed	N	N	N
Asteraceae	*Hypochaeris radicata*	Catsear, False Dandelion	N	N	N
Asteraceae	*Lactuca serriola*	Prickly Lettuce, Compass Plant	N	N	N
Asteraceae	*Soliva anthemifolia*	Dwarf Jo-jo, Button Burrweed	N	N	N

9 Listed in State of NSW 2019. North West

Family	Scientific name	Common name	WoNS	State Priority weed9	Regional priority weed
Asteraceae	*Soliva sessilis*	Bindii, Bindi-eye, Jo-Jo	N	N	N
Asteraceae	*Sonchus asper*	Prickly Sow-thistle, Rough Milk-thistle	N	N	N
Asteraceae	*Sonchus oleraceus*	Common Sow-thistle, Milk-thistle	N	N	N
Asteraceae	*Tagetes minuta*	Stinking Roger	N	N	N
Asteraceae	*Taraxacum officinale*	Dandelion	N	N	N
Asteraceae	*Verbesina encelioides*	Crownbeard	N	N	N
Asteraceae	*Xanthium italicum*	Hunter Burr	N	N	N
Asteraceae	*Xanthium occidentale*	Noogoora Burr	N	N	N
Asteraceae	*Xanthium sp.*		N	N	N
Boraginaceae	*Heliotropium amplexicaule*	Blue Heliotrope	N	N	N
Brassicaceae	*Lepidium africanum*	Common Peppercress	N	N	N
Brassicaceae	*Lepidium bonariense*	Cut-leaf Peppercress	N	N	N
Brassicaceae	*Lepidium sp.*		N	N	N
Brassicaceae	*Rapistrum rugosum*	Turnip Weed, Giant Mustard	N	N	N
Cactaceae	*Harrisia sp. (unidentified)*		N	N	N
Cactaceae	*Opuntia aurantiaca*	Tiger Pear	Y	Y	Y
Cactaceae	*Opuntia stricta*	Prickly Pear, Common Pest Pear	Y	Y	Y
Cactaceae	*Opuntia tomentosa*	Prickly Pear, Velvet Tree Pear	Y	Y	Y
Caryophyllaceae	*(Caryophyllaceae genus unknown*		N	N	N
Caryophyllaceae	*Polycarpon tetraphyllum*	Four-leaf Allseed	N	N	N
Caryophyllaceae	*Silene gallica*	French Catchfly	N	N	N
Caryophyllaceae	*Spergularia rubra*	Sandspurry	N	N	N
Crassulaceae	*Bryophyllum delagoense*	Mother-of-Millions	N	Y	Y
Cucurbitaceae	*Citrullus sp.*		N	N	N
Euphorbiaceae	*Ricinus communis*	Castor Oil Plant	N	N	Key emerging weed
Fabaceae Faboideae	*Medicago sp.*	Medic	N	N	N
Fabaceae Faboideae	*Trifolium campestre*	Hop Clover	N	N	N
Fabaceae Faboideae	*Trifolium glomeratum*	Clustered Clover	N	N	N

Family	Scientific name	Common name	WoNS	State Priority weed9	Regional priority weed
Fabaceae Faboideae	*Vicia sp. (unidentified)*		N	N	N
Fumariaceae	*Fumaria sp.*	Fumitory	N	N	N
Gentianaceae	*Centaurium sp.*	Centaury	N	N	N
Gentianaceae	*Centaurium tenuiflorum*	Centaury	N	N	N
Lamiaceae	*Marrubium vulgare*	Horehound	N	N	N
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	N	N	N
Oleaceae	*Olea europaea subsp. cuspidata*	African Olive	N	N	Y
Onagraceae	*Oenothera indecora subsp. bonariensis*		N	N	N
Oxalidaceae	*Oxalis sp.*		N	N	N
Papaveraceae	*Argemone ochroleuca*	Mexican Poppy	N	N	N
Plantaginaceae	*Veronica peregrina*	Wandering Speedwell	N	N	N
Polygonaceae	*Emex australis*	Spiny Emex, Doublegee	N	N	N
Polygonaceae	*Polygonum arenastrum*	Wireweed	N	N	N
Polygonaceae	*Polygonum aviculare*	Wire Weed	N	N	N
Polygonaceae	*Rumex crispus*	Curled Dock	N	N	N
Polygonaceae	*Rumex sp.*	Dock	N	N	N
Portulacaceae	*Portulaca pilosa*		N	N	N
Primulaceae	*Anagallis arvensis*	Pimpernel	N	N	N
Rubiaceae	*Galium aparine*	Cleavers, Goose-grass, Bedstraw	N	N	N
Salicaceae	*Salix babylonica*	Weeping Willow	N	N	N
Solanaceae	*Cestrum parqui*	Green Cestrum	N	N	Y
Solanaceae	*Lycium ferocissimum*	African Boxthorn	Y	Y	Y
Solanaceae	*Solanum nigrum*	Blackberry Nightshade	N	N	N
Solanaceae	*Solanum sp.*		Y	Y	Y
Verbenaceae	*Glandularia aristigera*	Mayne's Pest, Moss Verbena	N	N	N
Verbenaceae	*Glandularia aristigera*	Mayne's Pest, Moss Verbena	N	N	N
Verbenaceae	*Phyla canescens*	Lippia	N	N	N
Verbenaceae	*Phyla nodiflora*	Carpet Weed, Lippia	N	N	N
Verbenaceae	*Verbena incompta*		N	N	N
Verbenaceae	*Verbena quadrangularis*		N	N	N
Verbenaceae	*Verbena sp.*	Verbena	N	N	N
Alliaceae	*Nothoscordum gracile*	Onion Weed	N	N	N
Cyperaceae	*Cyperus eragrostis*	Drain Flat-sedge, Umbrella Sedge	N	N	N

Family	Scientific name	Common name	WoNS	State Priority weed9	Regional priority weed
Cyperaceae	*Schoenoplectus erectus*		N	N	N
Juncaceae	*Juncus bufonius*	Toad Rush	N	N	N
Poaceae	*Aira sp.*		N	N	N
Poaceae	*Avena ludoviciana*	Ludo Wild Oats	N	N	N
Poaceae	*Avena sativa*	Oats	N	N	N
Poaceae	*Briza sp.*		N	N	N
Poaceae	*Bromus brevis*		N	N	N
Poaceae	*Bromus catharticus*	Prairie Grass	N	N	N
Poaceae	*Cenchrus incertus*	Spiny Burrgrass	N	N	N
Poaceae	*Chloris gayana*	Rhodes Grass	N	N	N
Poaceae	*Cynodon dactylon*	Couch, Bermuda Grass	N	N	N
Poaceae	*Dactylis glomerata*	Cocksfoot, Cocksfoot Grass	N	N	N
Poaceae	*Digitaria sanguinalis*	A Summer Grass, Crab Grass	N	N	N
Poaceae	*Echinochloa crus-galli*	Barnyard Grass	N	N	N
Poaceae	*Eragrostis curvula*	African Lovegrass	N	N	N
Poaceae	*Hyparrhenia hirta*	Coolatai Grass	N	N	N
Poaceae	*Lolium perenne*	Perennial Ryegrass	N	N	N
Poaceae	*Lolium sp.*	Ryegrass	N	N	N
Poaceae	*Melinis repens*	Red Natal Grass	N	N	N
Poaceae	*Panicum maximum*	Guinea Grass	N	N	N
Poaceae	*Paspalum dilatatum*	Paspalum	N	N	N
Poaceae	*Phalaris paradoxa*	Paradoxa Grass	N	N	N
Poaceae	*Polypogon monspeliensis*	Annual Beardgrass, Rabbit-foot Grass	N	N	N
Poaceae	*Setaria parviflora*	Slender Pigeon Grass	N	N	N
Poaceae	*Setaria sp. (unidentified)*		N	N	N
Poaceae	*Sporobolus africanus*	Parramatta Grass	N	N	N
Poaceae	*Vulpia muralis*	Rats-tail Fescue	N	N	N
Poaceae	*Vulpia sp. (unidentified)*	Rats-tail Fescue	N	N	N

Appendix B - Pest plant profiles

Mexican Poppy – *Argemone ochroleuca*	
	
Photographs via PlantNET, credit: John & Patricia Edwards (L), NSW DPI (R)	
NSW WeedWise	Mexican poppy is an erect annual herb growing to one metre high, with spiky leaves, bright yellow flowers and globular seed heads. It is poisonous to stock and humans but is rarely eaten by stock due to its unpalatable bitter yellow sap; however, contamination of stock feed with seeds of Mexican poppy may result in poisoning. Seeds can be spread in water, mud, fodder and grain, and on machinery. Mexican poppy is native to Mexico. Mexican poppy may be confused with two related species - *Argemone ochruleuca*, and *Argemone subfusiformis*, both also commonly called Mexican poppy. Argemone ochruleuca has creamy white to pale yellow flowers and *Argemone subfusiformis* has flowers similar to *Argemone mexicana* but with broader petals (2.8-3.3 centimetres wide compared to 1.7-2.5 centimetres wide for *Argemone mexicana*).
Weeds Australia	Mexican poppy seeds germinate at any time of the year provided adequate moisture is available. Under normal seasonal conditions, young plants form a rosette during winter and produce flowering stems during spring. Flowering can occur throughout most of the year, but most often during spring and summer. Mature seeds remain dormant for up to three months after being shed from the parent plant.
PlantNET	Erect glabrous annual to 1.5 m high. Leaves alternate, to 12 cm long, pale green mottled with white, irregularly toothed or lobed, each lobe or tooth ending in a spine. Petals c. 25 mm long, creamy white to yellow, readily shed. Capsule 2–4 cm long, ovoid to oblong.
Control	As is the case with many annual weeds, control of Mexican Poppy should be aimed at the prevention of seed formation. Successful control of Mexican Poppy may be achieved by hand-pulling, grubbing or cutting plants before any fruits ripen. Seedlings can be controlled effectively with herbicide or by mowing. For recommended herbicides please visit the Mexican Poppy profile on NSW WeedWise.

Green Cestrum – *Cestrum parqui*	
	
Photographs via NSW WeedWise, credit: G. Wisemantel	
NSW WeedWise	The species is extremely toxic to both livestock and humans. Palatability is low however livestock poisoning often occurs when other feed is scarce. It is spread most commonly in droppings from birds that have eaten the berries. Green cestrum seeds germinate mainly in autumn with young plants taking two or more years to flower and set seed. Mature plants will flower and seed each year. Green cestrum will sucker freely from its base if stumps are not treated after cutting. The plant will also grow from sections of the fleshy root which remain after a plant has been partly dug or pulled out.
PlantNET	Woody shrub to 3 m high; new shoots and leaf axils minutely hairy. Leaves narrow-elliptic to lanceolate, 2–7 cm long, usually 1–3 cm wide; petiole to 1 cm long. Inflorescences terminal, panicle-like, congested; flowers sessile or on pedicels ≤ 10 mm long. Calyx 3–5 mm long; lobes triangular, c. 1 mm long. Corolla greenish yellow; tube narrow, 15–18 mm long. Staminal filaments 6–7 mm long, swollen and retrorsely hairy in lower part; anthers 0.5–1 mm long. Berry ± ovoid, 10–15 mm long, black.
Control	Total eradication of green cestrum requires a combination of control techniques and frequent follow up work. Once a single control event occurs green cestrum can have vigorous regrowth from stumps or roots not removed or from dormant seed in the ground. Monitor control areas for regrowth and if necessary, retreat the area using another form of control. New infestations should be destroyed before they flower and produce berries. Physical control Green cestrum can be controlled by repeated cutting down, digging or pushing out by mechanical equipment. All the yellow roots must be removed and destroyed appropriately to prevent regrowth. The roots can be burnt. Chemical control Herbicides are often the most effective and economical way of controlling green cestrum. However, only a registered herbicide should be used to control green cestrum infestations. Take care not to contaminate watercourses near clumps of green cestrum. Also, ensure that spray drift does not affect desirable plants in areas being treated and that operators follow the recommended safety precautions when handling and using herbicides. Mulch

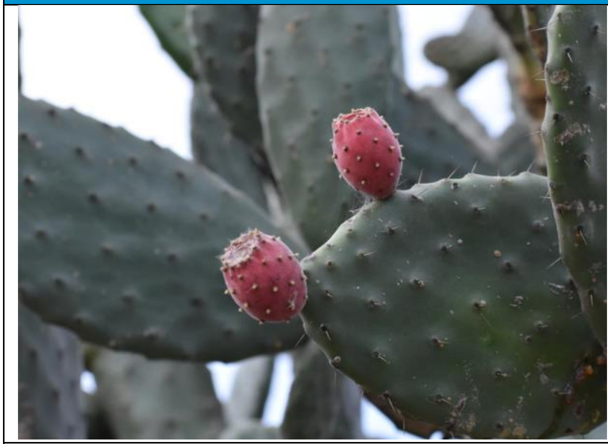
	Mulch can be used to suppress seedling growth after chemical or physical control. Mulch also retains moisture in the soil and provides protection for native plants that can be sown to replace the green cestrum plants. Competition After the removal of green cestrum plants, a vigorous pasture or appropriate native species should be established to compete with any green cestrum seedlings and regrowth. For advice on suitable species and establishment methods for the situation consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au).

Blue Heliotrope – *Heliotropium amplexicaule*	
	
Photographs via NSW WeedWise, credits: J Edwards (L) and J.J. Dellow (R)	
NSW WeedWise	Heliotrope is not very palatable to livestock, and consequently tends to be avoided; however, some individuals continue to eat it indiscriminately. Heliotrope will be eaten if no other feed is available. Continual ingestion by livestock of large amounts of heliotrope plants (either fresh or dried), or of their seeds as contaminants in stock feed, can cause liver damage and reduced productivity It can reproduce from both seed and root fragments. Blue heliotrope spreads aggressively, as it produces many sticky seeds that adhere to animals and machinery. Seed can pass unharmed through the digestive tracts of most animals. Blue heliotrope can also regenerate from root fragments. It is most commonly spread by road graders, farm machinery, livestock, humans and the movement of water along watercourses.
PlantNET	Perennial herb, prostrate to ascending, up to 15 cm high, finely hairy with simple and glandular hairs. Leaves oblanceolate to lanceolate, 2–8 cm long, 5–15 mm wide, obtuse to acute, margins undulate, lamina finely hairy with short glandular hairs and longer simple hairs; subsessile. Flowers in long branched scorpioid cymes; bracts absent. Sepals to 3.5 mm long, acute. Corolla 3–3.5 mm long, purple or lilac with a yellow throat; lobes about as long as the tube. Anthers acuminate, tips free. Style very short; stigma broad, pubescent. Mericarps 2, glabrous, succulent at first, becoming wrinkled at maturity.
Control	Eradication of blue heliotrope is difficult and usually involves a combination of pasture management, grazing management, cultivation, biological control and chemical control. At high densities the blue heliotrope leaf-beetle can completely defoliate blue heliotrope, with both the larvae and adults feeding on the leaves. The blue heliotrope leaf-beetle has the potential to build up population levels rapidly, as each beetle lays several hundred eggs, however it is a difficult agent to establish requiring multiple, short interval releases. Herbicides should only be applied to blue heliotrope when it is actively growing and commencing flowering (late February to March). Avoid spraying stressed plants. See NSW WeedWise for more details and a list of herbicides that can be used on the species.

African Boxthorn – *Lycium ferocissimum*

Photographs via NSW WeedWise, credit: Bob Trounce

NSW WeedWise	Fruit set generally occurs in autumn, but, again, it can occur at any time of the year depending on conditions. Seeds can germinate at any time of the year if there is adequate moisture and warmth. The plant has an extensive, deep, branched taproot that will sucker and produce new growth if broken. Early root growth is rapid to allow seedlings to compete with other plants.
PlantNET	Intricately branched shrub to 4 m high with long, rigid branches; lateral branches leafy, ending in stout spines. Leaves usually clustered, obovate to elliptic, usually 10–40 mm long and 4–10 mm wide; lamina slightly fleshy, glabrous, green. Pedicels 5–16 mm long. Calyx 4–7 mm long; split irregularly once or twice in fruit. Corolla 10–12 mm long, pale lilac or white towards limb, lobes lilac in centre; limb strongly reflexed. Stamens 5, exserted for 2–4 mm. Berry globose to broad-ovoid, 5–10 mm diam., dull orange-red; seeds 35–70.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include a combination of mechanical removal, cultivation, replacement/competition with appropriate plants, native vegetation (see the Rehabilitation Management Plan of the Project Biodiversity Management Plan), pastures (in suitable agricultural lands), regular monitoring and chemical control. For details on the above methods refer to NSW WeedWise African Boxthorn page.

Opuntia sp. (Tiger Pear, Common Pear, Velvet Tree Pear)	
	
Photographs via NSW WeedWise, credit: Paul Marynissen (L), John Hosking (R)	
Managing Opuntioid Cacti in Australia Manual (DPIRD, 2017)	Opuntioid cacti are set apart from other Cactaceae sub-families by the presence of glochids – small detachable, barbed bristles that are found in the plant's areoles. Glochids detach readily by disturbance and can often cause irritation to skin, eyes and lungs. Opuntioid cacti are also characterised by jointed cladodes and seeds that have a hard, pale sheath. Opuntioid cacti are long lived (>10 years) and have adapted to arid environments. Many opuntioid species reproduce rapidly through the ingestion of fruits and the spread of seed by bird species. However, all opuntioid species can reproduce vegetatively by the rooting of cladodes, fruit or flowers. Seed germination often occurs following heavy rain.
NSW WeedWise	Common Pear (Opuntia stricta) is a clumping bush that can grow up to 2 m tall. The cladodes are bluish green, oval shaped and can be spineless or have up to 11 spines per aerole. The flowers are yellow and the fruit are purplish-red and up to 6 cm in diameter. Tiger Pear (Opuntia aurantiaca) is a low spreading cactus that is generally less than 40 cm high. The plant consists of numerous segments to 20 cm long with large spines that can be 5 cm long. Flowers are yellow. The fruit is egg-shaped with a depressed top, red to purple and 2.5-3.5 cm long. Seeds in this species are sterile and so only reproduces vegetatively. Velvet Tree Pear (Opuntia tomentosa) is a tree like cactus with a trunk and is 2-6 m tall. It has a distinctive velvety covering on the stem segments which are 15-30 cm long and 6-12 cm wide. Flowering is in late spring to summer and the orange flowers are 4-5 cm in diameter. Fruit are pear shaped, 5 cm long, covered in velvety hairs and red when ripe.
Control	The control methods used will depend on the infestation size and location, as well as the growth form and cladode type. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include a combination of physical, chemical or biological control and will require follow-up control and monitoring. For a detailed description of control methods, chemicals used and a decision support tool for selecting appropriate control options refer to Managing Opuntioid Cacti in Australia manual (DPIRD, 2017, Fig. 4.1)

Khaki Weed – *Alternanthera pungens*	
	
Photographs via NSW WeedWise, credit: Auld and Medd (L), unknown (R)	
NSW WeedWise	Prostrate herb with perennial root system with annual above ground growth. Khaki weed spreads by seed within spiny bracts that adhere to clothing, tyres and animals. Local spread may also occur through spreading stems that root at nodes. Commonly found in disturbed areas. Spines are a problem with dogs and stock but are particularly troublesome to humans and easily penetrate the skin.
Weeds Australia	A matt forming perennial herb with a deep woody taproot. The spreading stems are up to 500-600 mm long and reddish with soft silky hairs. Leaves are opposite pairs of unequal size and obovate to ovate. The flowers are cream and are found in ovoid clusters. Seeds germinate after spring and summer rains. Plants flower and seed in summer and autumn and the aerial growth dies off by late autumn. New shoots are produced from the crown each spring.
PlantNET	Prostrate ephemeral or perennial with stems softly hairy, to 60 cm long, rooting at the nodes. Leaves obovate to circular, 0.5-5 cm long, to 10 mm wide, glabrous except for scattered hairs on lower midrib and base of lamina, mucronate, petiolate. Inflorescence ellipsoid, to 15 mm long and 10 mm wide; rachis glabrous or slightly hairy. Bracts lanceolate, pungent. Stamens 4 or 5, staminoides 1 or 0.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include a combination of chemical or physical control. Hand hoeing can be an effective method for individual weeds and recent outbreaks that haven't released seeds yet, but it is important the entire tap root is removed. For larger infestations herbicides can be used as a foliar spray. For a list of suitable herbicides please visit the Khaki Weed profile at WeedWise NSW.

Gomphrena Weed – *Gomphrena celosioides*	
	
Photographs via PlantNET, credit: L. von Richter	
PlantNET	Prostrate to ascending annual or perennial, stems pubescent to woolly or glabrous, to 25 cm high. Leaves oblong to spathulate, 2-5 cm long, 6-15 mm wide, acute, upper surface sparsely hairy to glabrous, lower surface pubescent to woolly. Inflorescence 1-4 cm long, 10-12 mm wide. Perianth segments 4-6 mm long, white, shining, papery.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Bidens sp. (Cobblers Pegs & Great Beggars Ticks)

Photographs via PlantNET, credit: L. von Richter (L), G. Harden (R)

Bidens species are erect annual herbs with oppositely arranged leaves and flowerhead with few or no ray florets and numerous yellow disc florets, at the ends of branches. Fruit is ribbed and has 2-3 slender, barbed awn-like structures (pappus) that cling to clothing and wool (Richardson, Richardson, & Shepherd, 2006).

PlantNET	Bidens pilosa: Almost glabrous to densely hairy woody herb to 1 m or more high. Leaves toothed, 3- or 5-lobed, terminal and lateral leaflets ovate to lanceolate, 6-12 cm long, 4-8 cm wide, petiole very slightly winged. Heads ovoid, 5-15 mm diam.; outer involucral bracts with finely hairy margins, shorter than inner bracts. Ray florets white. Achenes linear, curved, 6-12 mm long with tubercle-based barbs overall or mainly on the ribs; pappus awns 2 or 3, erect or spreading. Flowers throughout the year, but chiefly summer-autumn. Bidens subalternans: Almost glabrous woody herb to 1.6 m high. Leaves toothed or entire, hairy on the lower surface, pinnatifid, usually 5-lobed, sometimes 7-lobed, lobes linear to lanceolate, 4-11 cm long, 3-6 cm wide; petiole very slightly winged. Heads 5-10 mm diam., ovoid; outer bracts with minutely hairy margins, shorter than inner bracts. Ray florets yellow. Achenes linear, slightly laterally compressed, with a few barbs on the ribs; outer achenes 6-8 mm long, inner achenes 8-14 mm long; pappus awns 2 or 3, 1-2.5 mm long. Flowering in summer to autumn.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Mother of Millions – *Bryophyllum delagoense*	
	
Photographs via NSW WeedWise, credit: John Hosking	
NSW WeedWise	Mother of Millions reproduces rapidly by producing hundreds of tiny plantlets along the edges of its leaves. It also produces numerous seeds which can survive in the soil for a number of years before germinating. It is for these reasons that follow-up control is essential in reducing infestations of Mother of Millions. It is adapted to dry conditions and can survive long periods of drought. It is toxic when ingested by livestock and poisonous to humans and pets.
PlantNET	Herb to 1 m high, slender and erect with simple stems suckering at the base, stems cylindrical, pinkish brown or greyish. Leaves linear, cylindrical, 2.5-15 cm long, notched towards apex where plantlets are produced, lamina spotted violet-brown. Flowers in a corymbose cluster. Calyx tubular, 5-10 mm long. Corolla tube to 30 mm long, lobes obovate and about a third as long, salmon coloured to scarlet.
Weeds Australia profile	Mother of Millions are short-lived perennials, usually living for two or three years. They remain in the vegetative stage of growth for one or two years, depending on growing conditions, and then flower and die in the second or third year. Flowering usually occurs during winter and early spring.
Control	Preventing the spread of Mother of Millions is the best control measure. Check for it in winter when the plants are in flower and remove immediately using a combination of control methods depending on the size of infestation. Small infestations can be removed by hand, but avoid removal when plantlets are present along edges of leaves. Large infestations can be removed with a controlled burn, biological control (four species of insects currently undergoing testing) and herbicide application. For a more detailed description of control methods and a list of suitable herbicides, please visit NSW WeedWise Mother of Millions profile. Follow-up control and monitoring for this species is essential to ensure there are no future infestations.

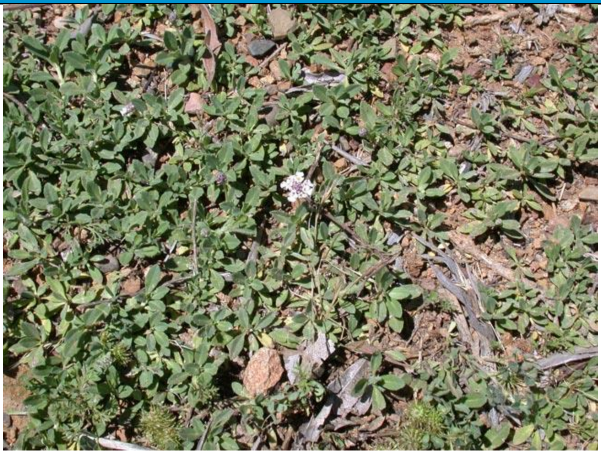
Horehound – *Marrubium vulgare*	
	
Photographs via NSW WeedWise, credit: Annie Johnson (L), J.J. Dellow (R)	
NSW WeedWise	Horehound infestations are extremely hardy once established, preventing desirable species from growing. The seed capsules cling to wool and clothing and may cause considerable matting of sheep fleeces. Horehound is commonly found in degraded environments.
Weeds Australia profile	The seeds of Horehound germinate primarily in autumn in response to rainfall. In higher rainfall areas (400+ mm) seed will germinate at other times if sufficient rainfall occurs. Flowers are produced mainly in spring but can occur at other times in higher rainfall areas. Burrs and seeds are produced in summer.
PlantNET	Perennial shrub to 60 cm high; branches erect, many-branched from near base; indumentum greyish to white, dense. Leaves with lamina rhombic-ovate to circular, 1-3.5 cm wide; apex rounded; base truncate to cordate; margins deeply toothed, teeth rounded; upper surface reticulate-wrinkled; indumentum greyish to white, dense; petiole 14-20 mm long. Inflorescence with dense clusters of > 12 flowers per leaf axil; peduncle distinct. Calyx tube 4-7 mm long, hairy; lobes reduced to 10 hooked spines, glabrous. Corolla 6-12 mm long, white.
Control	Control of Horehound requires a combination of different techniques for best results. Manual removal is suitable only for small patches. Larger infestations can be burned to stimulate seed germination and the resulting plants ploughed and buried before flower. The spraying of herbicides is also appropriate for larger infestations. Refer to the Horehound profile on WeedWise NSW for a list of suitable herbicides. There are also opportunities for biological control of Horehound. There are currently two moth species that have been released to control the weed. The Plume Moth (*Wheelaria spilodactylus*) has shown to have a significant impact on Horehound infestations but is difficult to rear. Whereas the Clear Wing Moth (*Chamaesphecia mysiniformis*) has had a good impact and is easier to rear.

<table>
<tr><th colspan="2">Paddy's Lucerne – Sida rhombifolia</th></tr>
<tr><td colspan="2"> </td></tr>
<tr><td colspan="2">Photograph via PlantNET, credit: L. von Richter</td></tr>
<tr><td>PlantNET</td><td>Erect subshrub to 1 m high, stems finely stellate-pubescent, mostly becoming glabrous.
Leaves lanceolate to linear-oblong, sometimes rhombic, 1.5-8 cm long, entire towards base, crenate-toothed towards apex, upper surface finely stellate-pubescent, lower surface usually densely so.
Flowers solitary on slender peduncles 10-30 mm long, sometimes 3 or 4 at the ends of the branches. Calyx basally 10-ribbed, lobes acuminate. Corolla 7-8 mm long, yellow to pale orange.
Fruit 5-6 mm diam.; mericarps 9-12, glabrous, transversely wrinkled and 2-ribbed on the back, 2-awned.</td></tr>
<tr><td>Weeds Australia profile</td><td>Paddy's Lucerne is a serious competitor for light and nutrient in crops, pasture, grasslands and woodlands. Paddy's Lucerne reproduces and disperses only by seed which can catch in fibrous material. Seed is also spread in streams and irrigation water, as impurities in hay and pasture seed, and in mud sticking to footwear, hooves, machinery and vehicles.</td></tr>
<tr><td>Control</td><td>The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au).
Control methods may include a combination of chemical, physical control or biological control. Small infestations can be grubbed out before flowering, with care being taken to cut the root well below the surface to prevent regrowth. Research is currently being conducted to determine the most effective biological control agent.</td></tr>
</table>

African Olive - *Olea europaea* subsp. *cuspidata*

Photographs via NSW WeedWise, credit: John Hosking

NSW WeedWise	African Olive is a long-lived small tree or shrub with a dense canopy. It invades bushland and shades out native plants. Leaves mostly 6-10 cm long, 10-25 mm wide, often with a hooked apex, lower surface green or yellowish brown. Flowers are yellow-white to creamy white with 4 petals. The fruit are 15-30 mm long and round with a sharp tip at the base. African Olive is spread through ingestion of the seeds by birds and the production of suckers when the trees are damaged.
Weeds Australia profile	African Olive is a perennial plant. Seeds germinate in autumn, and African Olive grows for several years before flowering commences. Flowers are borne in summer, and fruits ripen in the winter.
Control	African Olive is most effectively controlled using a combination of methods. Small seedlings can be pulled out by hand – ensure all roots are removed. Chemical control using herbicides and the cut and paint method are effective in removing plants up to 10 cm diameter. Stem injection can be used for plants with a stem diameter of > 10 cm. Follow-up control and monitoring is essential to remove new growth. A suitable list of herbicides can be found in the African Olive profile on WeedWise NSW.

Lippia – *Phyla canescens*	
	
Photographs via NSW WeedWise, credit: J.J. Dellow (L), J. Hosking (R)	

WeedWise NSW	Lippia is a major pastoral and environmental weed. It has little to no grazing value and causes major environmental impacts in terms of increasing soil erosion and decreasing stream bank stability due to loss of perennial grasses and the reduction of plant diversity. Lippia can be difficult to control as it is an aggressive plant that dominated pastures where ground cover has been reduced by overgrazing. Lippia spreads both vegetatively and by seed. Plants break up during flooding and can quickly re-establish in moist soils as floodwater subsides. Seeds must be covered with water for a short period in order to germinate. Any area where water may sit for a week or more provides opportunity for Lippia seed to germinate.
PlantNET	Perennial herb with slender procumbent or ascending flowering branches; stem much branched, usually 30-90 cm long, hoary with closely appressed hairs or nearly glabrous. Leaves with petiole 1-8 mm long; lamina obovate, spathulate or narrowly ovate, sometimes elliptic or cuneiform, fleshy, 1-2(-3) cm long, 0.3-0.7(-1) cm wide; margin coarsely toothed on distal half; surface minutely puberulent or glabrous. Inflorescence with peduncles axillary, but only 1 to each pair of leaves, 1-11 cm long; spikes 0.5-0.8 cm long at maturity, many-flowered. Calyx shorter than the bract, deeply 2-cleft, slightly 2-keeled, 1.5-2.5 mm long. Corolla purple or pink to white; limb at first white, afterwards lilac with a darker dot, 2-3 mm across, the lower lip twice as long as the upper one and about half as long as the tube. Fruit ellipsoid to globose, 1.5-2 mm long. Flowers mostly October-April
Control	Herbicides are an important component of Lippia management and should be used in conjunction with cropping, pasture improvement and grazing management where appropriate. When seasonal conditions allow, two herbicide applications within a growing season have been shown to give significantly better control of Lippia than single applications. A late spring or early summer application combined with a late summer application is recommended. Single applications can leave small amounts of viable rhizome/root tissue, allowing rapid re-infestation of treated areas. Follow up treatment when the regrowth Lippia begins to flower should be made even if a high kill rate has been achieved with the first application. Herbicide application timing is critical – herbicides should only be applied when Lippia is actively growing and starting to flower prolifically. At least 50 mm of rainfall (over one or two days) is needed before spraying to provide adequate subsoil moisture for good growth and to allow the Lippia to flower. However, herbicides should not be applied within 4 days of heavy rainfall nor if heavy rainfall is forecast to prevent pollution of streams and aquatic environments with the herbicide. Generally the first application of herbicide will kill a high percentage of Lippia plants. However, the small number of plants that survive need to be controlled or they will rapidly re-invade the following season. For a list of suitable herbicides please see the WeedWise NSW profile for Lippia.

Carpet Weed – *Phyla nodiflora*	
	
Photographs via Atlas of Living Australia, credit: G. Sinclair (L), L. Solyma (R)	

PlantNET	Perennial, prostrate creeping herb; stem much-branched, usually 30-90 cm long, with ascending flowering branches, often hairy. Leaves with lamina usually obovate, spathulate or narrow-ovate, 1-6 cm long, 3-7 mm wide, fleshy, usually coarsely toothed in upper half, minutely pubescent or glabrous; petiole 1-8 mm long. Inflorescence solitary in leaf axils; spikes very dense, many-flowered, 1-2.5 cm long at maturity; peduncles axillary but only 1 to each pair of leaves, 1-11 cm long. Calyx 1.5-2 mm long. Corolla 2-3 mm diam., usually white to purplish white; limb at first white, afterwards lilac with a darker dot. Fruit ellipsoid to globose, 1-2 mm long, splitting into 2 mericarps, each 1-seeded. Flowering mostly October to April.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Umbrella Sedge – *Cyperus eragrostis*	
	
Photographs via PlantNET, credit: L. von Richter	
PlantNET	Tufted perennial, with very short rhizome. Culms trigonous, smooth, 25-90 cm high, 2-4 mm diam. Leaves slightly septate-nodulose, as long as culms or shorter, 4-8 mm wide. Inflorescence simple to decompound with up to 12 primary branches to 12 cm long; digitate clusters 10-50 mm diam.; involucral bracts leaf-like, 5-9 exceeding inflorescence. Spikelets flattened, numerous per cluster, to 30-flowered, 5-15 mm long, 3 mm wide; rachilla not winged, persistent. Glumes with 3-nerved midrib, 2-2.5 mm long, surface conspicuously isodiametric-reticulate, greenish to white or straw-coloured, tinged yellowish or red-brown. Stamen 1. Style 3-fid. Nut triquetrous, obovoid, about half as long as glume, 1-1.4 mm long, c. 0.5 mm diam., dark brown to greyish. Flowers spring to summer.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Spiny Burrgrass – *Cenchrus incertus*

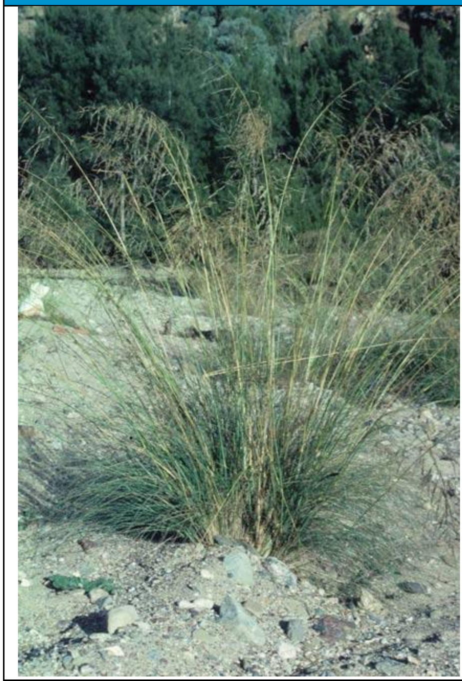
Photographs via NSW WeedWise, credit: Bruce Auld (L), NSW DPI (R)

NSW WeedWise	Spiny Burrgrass is a weed because of its sharp and clingy burr, ability to spread rapidly and tendency to develop into dense infestations in favourable conditions. It is also difficult and expensive to manage, especially in marginal rainfall areas. Spiny Burrgrass prefers sandy to light soils and is generally not found on heavy clay soils. It readily establishes on disturbed sites such as roadsides, creeks and riverbanks. The major spread of this weed is by seed. The seed is well equipped for spread because of the barbed spines on the burr, which detach easily from the mature plant. Seeds are normally produced from late spring to late autumn depending on available soil moisture. There are up to three seeds produced by each burr resulting in each plant producing up to 1000 seeds. The first-formed, or primary seed, is the largest and is capable of germinating within a few months of maturity. The other seeds, or secondary seeds, are usually dormant for up to three years.
PlantNET	Tufted annual or occasionally biennial to 0.8 m high. Leaves with sheath glabrous or sparsely pilose; ligule ciliate; blade flat or folded, glabrous, finely scabrous, 2-6 mm wide. Panicle spike-like, not very dense, 2-8.5 cm long; burrs variable, from ovoid to globose, spines rigid, long and slender to broad and subdeltoid. Spikelets 2-4 in each burr, ovate, acute, 3.5-5.8 mm long. Lower glume 1-3.3 mm long, 1-nerved; upper 2.8-5 mm long, 5-7 nerved. Lower lemma sterile, 3-6 mm long, 4-7 nerved; palea scabrous. Upper lemma bisexual, 3.4-6 mm long, 3-nerved. Flowering in summer.
Control	The key to the effective control of spiny Burrgrass is to prevent seeding and exhaust any reserves of seed in the soil. It is also important to limit the spread of seed with good hygiene practices, such as cleaning of vehicles and limiting unnecessary site access. Herbicides are best applied when the weed is actively growing (late spring/early summer) before the burrs are produced. For a list of suitable herbicides please visit the NSW WeedWise Spiny Burrgrass profile.

Rhodes Grass – *Chloris gayana*	
	
Photographs via PlantNET, credit: L. von Richter	
Rhodes Grass Profile (DAF QLD, 2020)	Rhodes grass is a native of south and east African. Rhodes grass produces 3-4 million seeds per kilogram and can reproduce by a number of methods to smother native ground cover species and form almost pure stands. There are many different Chloris species. Rhodes grass should not be confused with Chloris virgata and several native Chloris species.
PlantNET	Rhodes grass is an erect, mostly glabrous perennial to 1.2 m high, usually stoliniferous, sometimes tufted; culms usually branched, slightly geniculate at the base, tough and wiry. Leaves with sheath glabrous to scabrous, often ciliate apically; blade 5-10 mm wide. Spikes 6-18, subdigitate, 5-10 cm long, spreading to erect. Spikelets rather densely imbricate, 3- or 4-flowered, 3-5 mm long, usually lowest bisexual, second male or bisexual, and rest sterile. Glumes lanceolate to narrow-ovate, lower 1.4-2.8 mm long, upper 2.2-3.5 mm long. Fertile lemma 2.5-4.2 mm long, ovate to obovate to elliptic, awn 1.5-6.5 mm long; second similar, awn 0.8-3.2 mm long; upper florets awnless or awn-tipped. Flowering in summer.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling or digging out individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are at early head stage.

Couch – *Cynodon dactylon*	
	
Photographs via Weeds of Australia, credit: Sheldon Navie	
Weeds of Australia	This very common lawn and pasture grass is sometimes considered native and at other times it is considered to be an important environmental weed. In certain situations, Couch spreads quickly via creeping stems and can form dense populations in natural habitats.
PlantNET	Rhizomatous and/or stoloniferous mat-forming perennial, to 0.3 m high, rooting at the nodes; culms erect or geniculate. Leaves with ligule a dense row of short hairs on a membranous rim with longer hairs at each end; blade flat, linear-triangular, 2-15 cm long, 1-4 mm wide, pointed, glabrous or sparsely pubescent, minutely scabrous on the margin. Inflorescence of 2-7 spikes each 2-6 cm long, linear, green or purple. Spikelets broad, laterally compressed, to 3 mm long. Glumes acuminate, 1-2.5 mm long. Lemma keeled, mucronate, 1.5-3 mm long, ciliolate along the keel; sterile rachilla extension 0.5-1.5 mm long, sometimes topped with a vestigial spikelet. Flowering in summer.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Cocksfoot – *Dactylis glomerata*	
	
Photographs via Weeds of Australia, credit: S. Navie	
PlantNET	Densely tufted perennial to 1.4 m high; culms erect or spreading. Leaves with ligule membranous, 2-10 mm long; blade folded at first, to 14 mm wide, with an acute, boat-shaped apex. Panicles narrow-oblong or elliptic to ovate, 15-30 cm long. Spikelets oblong-elliptic to almost cuneate, 5-9 mm long, arranged in 1-sided clusters; florets laterally compressed, bisexual. Glumes shorter than the lemmas, finely pointed. Lemmas closely overlapping, the keel ciliolate and extended into a short awn, firm except for the translucent margins. Paleas slightly shorter than the lemmas, 2-keeled, the keels minutely hairy or rough. Flowers in spring.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

African Lovegrass – *Eragrostis curvula*	
	
Photographs via NSW WeedWise, credit: J.J. Dellow (L), Luke Pope (R)	
NSW WeedWise	African Lovegrass is a hardy, drought-tolerant grass that grows in clumps. It is poor quality feed for livestock and can quickly colonise overgrazed and disturbed sites. The seed of African lovegrass is spread short distances by wind and longer distances in water and by the movement of vehicles and machinery.
PlantNET	Tufted perennial to 1 m high. Leaves with orifice often with hairs to 4 mm long; ligule a ciliate rim with hairs to 0.5 mm long; blade flat or rolled, to 3 mm wide, glabrous or with hairs to 1 mm long. Inflorescence open or contracted, 13-30 cm long, 2.5-10 mm wide; axils of primary branches glabrous or with hairs 0.5-3 mm long; pedicels 0.5-4 mm long. Spikelets 4-10 mm long, 1-2 mm wide, florets 4-14; rachilla with hairs < 0.25 mm long. Glumes 1.5-2.5 mm long, acute, glabrous; lower glume often narrower and 75% length of upper. Lemmas 2-2.5 mm long, acute, usually scabrous, keeled, lateral nerve closer to margin than midnerve. Palea subequal to lemma. Flowers in summer.
Control	It is essential to use a combination of control methods to remove African Lovegrass. It is recommended that mature plants are controlled all year round, with extra effort in spring before flowering. Look for flushes of seedlings after rain when temperatures are over 10°C and kill the seedlings before they are six weeks old. Keep looking for new plants each year as some seed remains viable for up to 17 years. To prevent new infestations of African Lovegrass avoid unnecessary movement throughout the area. Heavy infestations can be burnt in winter and then spray herbicides on the regrowth. For a list of suitable herbicides see the African lovegrass profile on NSW WeedWise.

Santos

Coolatai Grass – *Hyparrhenia hirta*

Photographs via NSW WeedWise, credit: John Hosking

NSW WeedWise	Coolatai Grass is an invasive drought, fire and herbicide tolerant tussock forming perennial grass. Coolatai Grass poses a huge risk to the biodiversity of the fragmented areas of native ecosystems remaining across NSW as it easily invades relatively undisturbed ecosystems. The plants are long lived and are able to produce fertile seed from a single plant. The seed is highly mobile and will germinate over a wide range of temperatures.
PlantNET	Densely tufted perennial to 1.2 m tall. Lower sheaths usually glabrous; ligule scarious, truncate to acute, ciliate-denticulate (minutely toothed), 2–3 mm long; blade 2–3 mm wide, somewhat glaucous, glabrous or with a few scattered long hairs. Spatheate panicle elongated, loose, rather sparse, 15–40 cm long. Branches 1–few-nate, filiform, unequal, 3–30 cm long, often geniculate. Spatheoles very narrowly linear-lanceolate, long attenuate to a fine point, 4–6 cm long, glabrous or with a few long scattered hairs, turning reddish. Peduncle filiform, c. 5–6 cm long, slightly to strongly arched, pubescent towards the apex and with long white spreading hairs. Racemes slightly diverging, straight or curved, erect or nodding, 1.5–5 cm long, whitish or greyish-villous, each with c. 5–8 awned spikelets, a pair of alike, male spikelets at the base of the lower or both racemes; pedicels short, villous. Fertile spikelets linear-oblong, 4–6 mm long, the callus linear-cuneate, grooved, subacute. Lower glume 9–11-nerved loosely villous; upper glume thinner, 3-nerved, mucronate, ciliate. Lower lemma linear-oblong, obtuse, ciliate, almost as long as the glume; upper lemma narrowly linear to almost stipiform 2.5–4.5 mm long with two short, membranous, lobes, the geniculate awn slender, 15–35 mm long with the column pubescent; palea absent or minute. Pedicellate spikelets male, narrowly linear-oblong, acute, 4–7 mm long, more or less loosely villous, greenish to reddish. Glumes equal; lower subherbaceous, truncate to acute to mucronulate, 9–11-nerved; upper glume thinner, 3-nerved. Lemmas linear-oblong, hyaline, ciliate, the lower 2-nerved, the upper 1-nerved or reduced. Flowers in summer.
Control	Coolatai grass is tolerant of most commonly used herbicides and suppression of growth is the most likely outcome. Research has shown that pre-treatments of burning and slashing can reduce control as it supresses the active growth of Coolatai grass which should have sufficient green leaves and be actively growing for the highest levels of control. Regardless of application, up to three applications of glyphosate in the same growing season will be required. The repeat application times for when there is sufficient regrowth of fresh leaves. A list of other recommended herbicides can be found on the Coolatai grass profile on NSW WeedWise.

Red Natal Grass – *Melinis repens*	
	
Photographs via Brisbane City Council weed identification tool, credit: none supplied.	
PlantNET	Tufted annual or perennial to 1.2 m high. Leaves with ligule ciliate rime with hairs to 2 mm long; blade flat or folded, 3-6 mm wide, glabrous or with tubercle-based hairs to 1 mm long. Inflorescence open, 7-17 cm long, to 0.7 cm wide, hairy; hairs pink, red or shining white. Spikelets 3-5 mm long, to 2 mm wide (excluding awn and hairs), florets 2, lower floret male, upper floret bisexual. Lower glume < 1 mm long, with hairs to 1.5 mm; upper 3-5 mm long (excluding awn and hair), with hairs to 5 mm long, 2-lobed, sometimes with an awn to 4 mm long from sinus. Male lemma 3-5 mm long (excluding awn and hair), 2-toothed, with tubercle-based hairs to 5 mm long, sometimes with a subterminal awn to 3 mm long; palea subequal to lemma. Bisexual lemma 2-3 mm long, 2-toothed, awnless, shiny; palea subequal to lemma. Flowers in summer.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Parramatta Grass – *Sporobolus africanus*

Photographs via PlantNET, credit: L. von Richter

Weeds Australia profile	Parramatta grass is a tough perennial tussock grass that grows to a height of 50 cm and reproduces from seed. Parramatta grass seeds germinate in spring. The young seedlings develop rapidly and produce flowering stems in mid-to-late summer. Established plants grow rapidly from the crown during the warmer months but growth slows in late autumn. Parramatta grass is spread by seed and can be spread in soil on machinery and vehicles. Although it has no awn or hairs, it becomes sticky when wet, and can adhere to animals and clothing. Seed production can be in the order of 300 seeds per head with over two million seed heads per hectare recorded.
PlantNET	Erect tufted perennials to 80 cm tall. Ligule to 0.3 mm long, a fringe of hairs; blade to 2 mm wide. Inflorescence to 32 cm long, of irregular spicate appressed main branches; branches solitary to whorled, bearing spikelets along their whole length, as long or longer than the adjacent internode; pedicels 0.7-0.9 mm long. Spikelets 1.5-1.8 mm long. Glumes membranous; lower 0.6-0.7 mm long, obtuse (frequently torn), nerveless; upper glume 0.9-1.1 mm long, at least 50% spikelet length, obtuse, 1-nerved. Lemma 0.9-1.1. mm long, narrowly truncate, 1-nerved; palea 0.8-1 mm long, subequal to the lemma, 2-nerved, obtuse.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include hand pulling of individual plants and small infestations. Larger infestations may require herbicide application, which is best applied when plants are actively growing.

Castor Oil Plant – *Ricinus communis*

Photographs via NSW WeedWise, credit: NSW DPI (L), Maria Edmonds (R)

NSW WeedWise	Castor oil plant is a medium to tall shrub. The whole plant is considered poisonous to humans and livestock. Castor oil plants grow vigorously in disturbed areas and out-compete native species for resources thus excluding them.
PlantNET	Tall shrub, herbaceous or stem woody and tree-like. Leaves peltate; lamina 10-40 cm long, palmately 7-9 lobed, margins toothed; petiole twice as long as lamina; stipules absent. Panicles erect to 15 cm long; pedicels to 10 mm long. Perianth segments ovate, 6-8 mm long. Capsule ovoid, 3-lobed, 15 mm diam., spiny; seeds smooth, mottled grey and white. Flowers and fruits mainly summer.
Control	Small, immature plants can be removed physically. Saplings can be controlled by applying herbicide using the cut stump/scrape stem application. Large trees and shrubs can be controlled using the stem injection method. For a list of suitable herbicides visit the NSW WeedWise Castor oil plant profile.

Harrisia spp. (Harrisia Cactus & Moonlight Cactus)


Photographs via Weeds of Australia, credit: Land Protection (L), Sheldon Naive (R)

QLD Weeds of Australia	A long-lived, fleshy plant that clambers across the ground and forms tangled mats usually 30-60 cm tall. It may also scramble or climb over other plants to a height of 2 m. Clambering succulent with numerous angular branches, 1-3 robust spines 2-3 cm long are surrounded by 3-5 shorter more slender ones in each areole. Flowers showy, white or pinkish and usually open at night and wither in the day. Fruit red, 3-5-6 cm diameter, with small spines.
PlantNET	Harrisia Cactus (*Harrisia tortuosa*) is a very spiny prostrate plant that forms impenetrable thickets. Stems to 3 m long, 4-5 cm diam., 6-8 ridged. Areoles with central spine 3-5 cm long, surrounded by 4-8 spines 1-3 cm long. Perianth white. Fruit 2-4 cm diam., red, tuberculate, radial spines. Moonlight Cactus (*Harrisia martinii*) is a vigorously growing plant with stems much branched and tangled together and forming an impenetrable mass, to 3 m long, 3-4 cm diam., mostly with 4 or 5 ridges. Areoles with central spine 2-3 cm long, yellow with a dark tip, surrounded by a row of short radial spines 3-6 mm long and 1-3 spines 10-15 mm long. Perianth white. Fruit 2-4 cm diam., red, not tuberculate, sometimes without spines.
Control	The control methods used will depend on the infestation size and location. For advice on the most appropriate methods for your situation, consult the Narrabri Shire Council's Weed Officer (Ph: (02) 6799 6866, council@narrabri.nsw.gov.au). Control methods may include a combination of physical, chemical or biological control and will require follow-up control and monitoring. For further details regarding control and a suitable list of herbicides, visit the Harrisia Cactus profile on NSW WeedWise.

Appendix C - Hygiene inspection proforma

Santos

Santos ENSW Pest Plant Inspection Form

Santos NSW – Pest[1] Hygiene Inspection Form

Has the inspector completed the following training packages?:

- Inspect machinery for plant, animal and soil material; and/or — YES NO
- Clean machinery of plant, animal and soil material. — YES NO

Reason for Inspection:

	Travelled from outside the applicable biosecurity management region	YES	NO
Has the inspection item:	Been exposed to Pest Species	YES	NO
	Appear 'dirty' and may contain pest matter such as insects and/or seeds	YES	NO

Item Details:

Type (e.g. car, dozer, truck, trailer, equipment, soil)		**Registration / Engine / Frame Number / Amount**	
Make		**Location source (from)**	

Owner / Supplier Details:

Name		**Contact Number**	
Company		**Email**	
Signature			

Inspection Details:

Inspection Date			
Inspected by		**Contact Number**	
Position / Company		**Email**	
Item clean?	YES NO	**Follow up required:**	
Inspection Comments			

Checklist – Heavy Machinery

Drivers Cab	❑	Engine	❑	Fuel Cells	❑
Tracks/track Frame	❑	Battery Box	❑	Buckets	❑
Belly Plates	❑	Hydraulic Covers	❑	Stabilisers	❑

Checklist – Vehicles

Radiator	❑	Engine Bay	❑	Cabin	❑
Cabin Wheel Well	❑	Mud Flaps	❑	Chassis Rails	❑
Sump Guards	❑	Wheels	❑	Spare Wheels	❑
Suspension	❑	Load of Vehicle	❑	Tray	❑

Checklist – Materials

Source	❑	Load	❑	Covers	❑
Carrier (Machinery)	❑	Container/Case	❑		

[1] Pests refers to items defined as biosecurity risks under the NSW *Biosecurity Act* 2015

Appendix D - Pest species risk assessment

Species	Common Name	Outcome
Alternanthera pungens	Khaki Weed	Manage core infestation
Arctotheca calendula	Capeweed	Limited action
Argemone ochroleuca	Mexican Poppy	Manage core infestation
Aster subulatus	Wild Aster	Limited action
Avena ludoviciana	Ludo Wild Oats	Limited action
Avena sativa	Oats	Limited action
Bidens pilosa	Farmer's Friend, Cobblers Pegs	Manage core infestation
Bidens sp.		Manage core infestation
Bidens subalternans	Greater Beggar's Ticks	Manage core infestation
Bromus brevis		Limited action
Bromus catharticus	Prairie Grass	Limited action
Bryophyllum delagoense	Mother-of-Millions	Limited action
Carthamus lanatus	Saffron Thistle	Limited action
Cenchrus incertus	Spiny Burrgrass	Manage core infestation
Centaurea melitensis	Maltese Cockspur	Limited action
Centaurium tenuiflorum	Centaury	Limited action
Cereus sp. (unidentified)		Reduce
Cestrum parqui	Green Cestrum	Limited action
Chloris gayana	Rhodes Grass	Reduce
Chondrilla juncea	Skeleton Weed	Limited action
Cirsium vulgare	Black Thistle, Spear Thistle	Limited action
Citrullus sp.		Limited action
Conyza bonariensis	Flaxleaf Fleabane	Limited action
Conyza sp.		Limited action
Conyza sumatrensis	Tall Fleabane	Limited action
Cynodon dactylon	Couch, Bermuda Grass	Manage core infestation
Cyperus eragrostis	Drain Flat-sedge, Umbrella Sedge	Reduce
Dactylis glomerata	Cocksfoot, Cocksfoot Grass	Manage core infestation
Digitaria sanguinalis	A Summer Grass, Crab Grass	Limited action
Echinochloa crus-galli	Barnyard Grass	Limited action
Emex australis	Spiny Emex, Doublegee	Limited action
Eragrostis curvula	African Lovegrass	Reduce
Galium aparine	Cleavers, Goose-grass, Bedstraw	Limited action
Gamochaeta calviceps	Cudweed	Limited action
Gamochaeta sp.		Limited action
Glandularia aristigera	Mayne's Pest, Moss Verbena	Limited action
Gomphocarpus fruticosus	Narrow-leaved Cotton Bush	Limited action
Gomphrena celosioides	Gomphrena Weed	Manage core infestation
Hedypnois rhagadioloides subsp. cretica	Cretan Weed	Limited action
Helianthus annuus	Sunflower	Limited action
Heliotropium amplexicaule	Blue Heliotrope	Manage core infestation

Species	Common Name	Outcome
Hyparrhenia hirta	Coolatai Grass	Reduce
Hypochaeris microcephala var. albiflora	White Flatweed	Limited action
Hypochaeris radicata	Catsear, False Dandelion	Limited action
Juncus bufonius	Toad Rush	Limited action
Lactuca serriola	Prickly Lettuce, Compass Plant	Limited action
Lepidium africanum	Common Peppercress	Limited action
Lepidium bonariense	Cut-leaf Peppercress	Limited action
Lepidium sp.		Limited action
Lolium perenne	Perennial Ryegrass	Limited action
Lycium ferocissimum	African Boxthorn	Reduce
Lysimachia arvensis	Pimpernel	Limited action
Marrubium vulgare	Horehound	Reduce
Medicago sp.	Medic	Limited action
Melinis repens	Red Natal Grass	Reduce
Nothoscordum gracile	Onion Weed	Limited action
Oenothera indecora subsp. bonariensis	Small-flower Evening-primrose	Monitor
Olea europaea subsp. cuspidata	African Olive	Reduce
Opuntia aurantiaca	Tiger Pear	Reduce
Opuntia stricta	Prickly Pear, Common Pest Pear	Reduce
Opuntia tomentosa	Prickly Pear, Velvet Tree Pear	Reduce
Oxalis sp.		Limited action
Panicum maximum	Guinea Grass	Limited action
Paspalum dilatatum	Paspalum	Limited action
Phalaris paradoxa	Paradoxa Grass	Limited action
Phyla canescens	Lippia	Manage core infestation
Phyla nodiflora	Carpet Weed, Lippia	Manage core infestation
Polycarpon tetraphyllum	Four-leaf Allseed	Limited action
Polygonum arenastrum	Wireweed	Limited action
Polygonum aviculare	Wire Weed	Limited action
Polypogon monspeliensis	Annual Beardgrass, Rabbit-foot Grass	Limited action
Portulaca pilosa		Limited action
Rapistrum rugosum	Turnip Weed, Giant Mustard	Limited action
Ricinus communis	Castor Oil Plant	Contain
Rumex crispus	Curled Dock	Limited action
Salix babylonica	Weeping Willow	Monitor
Schoenoplectus erectus		Limited action
Setaria parviflora	Slender Pigeon Grass	Limited action
Sida rhombifolia	Paddy's Lucerne	Manage core infestation
Silene gallica	French Catchfly	Limited action
Solanum nigrum	Blackberry Nightshade	Limited action
Soliva anthemifolia	Dwarf Jo-jo, Button Burrweed	Limited action
Soliva sessilis	Bindii, Bindi-eye, Jo-Jo	Limited action

Species	Common Name	Outcome
Sonchus asper	Prickly Sow-thistle, Rough Milk-thistle	Limited action
Sonchus oleraceus	Common Sow-thistle, Milk-thistle	Limited action
Spergularia rubra	Sandspurry	Limited action
Sporobolus africanus	Parramatta Grass	Manage core infestation
Tagetes minuta	Stinking Roger	Limited action
Taraxacum officinale	Dandelion	Limited action
Trianthema portulacastrum	Giant Pigweed, Black Pigweed	Manage core infestation
Trifolium campestre	Hop Clover	Limited action
Trifolium glomeratum	Clustered Clover	Limited action
Verbena incompta		Limited action
Verbena quadrangularis		Limited action
Verbesina encelioides	Crownbeard	Limited action
Veronica peregrina	Wandering Speedwell	Limited action
Vulpia muralis	Rats-tail Fescue	Limited action
Xanthium italicum	Hunter Burr	Monitor
Xanthium occidentale	Noogoora Burr	Monitor
Xanthium sp.		Monitor

Species	Common name	Outcome
Feral predators		
Canis lupus familiaris	Wild Dog	Manage populations
Felis catus	Feral Cat	Reduce
Vulpes vulpes	Red Fox	Reduce
Feral herbivores		
Bos taurus	Cow	Manage populations
Capra hircus	Goat	Reduce
Equus sp.	Horse	Manage populations
Lepus capensis	Hare	Manage populations
Sus scrofa	Pig	Reduce
Oryctolagus cuniculus	Rabbit	Reduce
Ovis aries	Sheep	Manage populations
Other feral fauna		
Mus musculus	Mouse	Manage populations
Rattus rattus	Rat	Manage populations
Streptopelia chinensis	Spotted Turtle-dove	Manage populations
Sturnus tristis	Common Myna	Manage populations
Sturnus vulgaris	Starling	Manage populations
Passer domesticus	House Sparrow	Manage populations
Turdus merula	Eurasian Blackbird	Manage populations

Appendix E - New pest plant alert form

Santos

<table>
<tr><td colspan="2">Reporter:
______________________</td><td colspan="2">Date of report:
____________</td><td colspan="2">Nearest infrastructure identification:
________________________________</td></tr>
<tr><td colspan="6">Contact details – this information may be used for further investigation by Santos and will not be distributed.</td></tr>
<tr><td colspan="2">Email address:
______________________</td><td colspan="2">Contact number:
____________</td><td colspan="2">Employer: ❑ Santos ❑ Other (please specify below)
________________________________</td></tr>
<tr><td>Coordinates</td><td colspan="3">Latitude:</td><td colspan="2">Longitude:</td></tr>
<tr><td colspan="6">Brief description of location, including any landmarks:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="4">Collector:</td><td colspan="2">Date collected:</td></tr>
<tr><td colspan="4">Habitat:
❑ - Native vegetation ❑- Native vegetation (roadside)
❑ - Rehabilitation (Well pad) ❑ - Rehabilitation (linear)
❑ - Cropland ❑ Pasture</td><td colspan="2"></td></tr>
<tr><td colspan="6">Growth form: ❑ - Tree ❑ - Large shrub ❑ - Small shrub ❑ - Herb ❑ - Vine ❑ - Other</td></tr>
<tr><td colspan="3">Height: . . . . . (m)</td><td colspan="3">Abundance: ❑ - <5 ❑ - <10 ❑ - <20 ❑ - <50 ❑ - 50+</td></tr>
<tr><td colspan="3">Flowers present: ❑ - Yes ❑ - No</td><td colspan="3">Fruits/seeds present: ❑ - Yes ❑ - No</td></tr>
<tr><td colspan="6">Photos: Ensure photos are in focus and clear (can also be attached in email)</td></tr>
<tr><td colspan="3">Habitat (photo of the plant and the surrounding vegetation)</td><td colspan="3">Growth form (Photo of the whole plant)</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="3">Photos of fruits/seeds (if present)</td><td colspan="3">Photos of flowers (if present</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
</table>

Appendix F - Pest action sheets

Author: **Date:**	**Reviewed by:** **Date:**		**Approved by:** **Date:**
Pest/s:			❑ - Native ❑ - Introduced
Start date:	Proposed end date:	Actual end date:	
Location (describe where the works will be conducted including associated infrastructure, attach map):			
Description of Methods:			
Chemicals used:			
Assessment of results of control methods:			
Insert map:			

Appendix G - Suggested timing for pest species control

Target Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method	Comments	Date Completed	Weed Contractor Notes
	Summer		Autumn			Winter		Spring			Summer					
Mexican Poppy													Physical removal or herbicide application.			
Green Cestrum													Initial control: stem injection of herbicide. Follow-up control: physical removal or herbicide application to regrowth.			
Blue Heliotrope													Foliar spray.	Control only when plants actively growing.		
African Boxthorn													Cut and paint or basal bark.			
Opuntia sp.													Physical removal and suitable disposal. Foliar spraying.	Ensure all vegetative features removed.		
Umbrella Sedge													Hand hoeing for isolated individuals and foliar spray for larger infestations.			
Khaki Weed													Hand hoeing for isolated individuals and foliar spray for larger infestations.	Ensure all vegetative features removed.		
Gomphrena Weed													Hand pulling of individual plants. Foliar spraying of larger infestations.			
Horehound													Hand removal of isolated plants. Foliar spraying of larger infestations.			

Target Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method	Comments	Date Completed	Weed Contractor Notes
	Summer		Autumn			Winter		Spring			Summer					
Bidens sp.													Hand pulling of individual plants. Foliar spraying of larger infestations.	Ideally before seed is set.		
Mother of Millions													Hand removal of isolated plants. Herbicide application for larger infestations.	Aim to remove before plantlets are present.		
Paddy's Lucerne													Hand removal of isolated plants. Foliar spraying of larger infestations.	Ideally before seed set.		
African Olive													Small seedlings pulled by hand (ensure all roots removed). Cut and paint (diam. < 10 cm), stem injection (diam. > 10 cm).			
Lippia													Foliar spraying. Two herbicide applications recommended in growing season.	Only apply herbicide when actively growing and flowering.		
Carpet Weed													Foliar spraying. Two herbicide applications recommended in growing season.	Only apply herbicide when actively growing and flowering.		
Spiny Burrgrass													Foliar spray.	Ideally before seed set.		
Rhodes Grass													Hand pulling of individual plants. Foliar spraying for larger infestations.	Ideally when plants at early head stage.		

Target Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method	Comments	Date Completed	Weed Contractor Notes
	Summer		Autumn			Winter		Spring			Summer					
Couch													Hand pulling of individual plants. Foliar spraying for larger infestations.			
Cocksfoot													Hand pulling of individual plants. Foliar spraying for larger infestations.			
African Lovegrass													Hand pulling of individual plants. Foliar spraying for larger infestations.			
Coolatai Grass													Hand pulling of individual plants. Foliar spraying for larger infestations.	Three herbicide applications per growing season.		
Red Natal Grass													Hand pulling of individual plants. Foliar spraying for larger infestations.			
Parramatta Grass													Hand pulling of individual plants. Foliar spraying for larger infestations.			
Castor Oil Plant													Hand removal of small, isolated plants. Saplings using cut stump/scrape stem. Larger plants using stem injection.	Ideally before seed set.		
Harrisia sp.													Physical removal and suitable disposal. Foliar spraying.	Ensure all vegetative features are removed.		

Legend
Recommended treated period
Suitable treatment period

Information adapted from NSW WeedWise (DPI, 2021), PlantNET (National Herbarium of NSW, 2020) and Weeds Australia (Centre for Invasive Species Solutions, 2020). Where no information was available, the general period of active growth was chosen (generally late spring to early autumn). Recommended treatment periods consider suitable treatment timing for different species to allow multiple species to be treated in the same period. Due to spatial and temporal variation in rainfall and temperature, the optimum time to control may vary.

Target Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method	Comments	Date Completed	Contractor Notes
	Summer		Autumn			Winter		Spring			Summer					
Cat													Bait with 1080: 2 x per year.	Avoid periods of high rainfall.		
Red Fox													Bait with 1080: 4 x per year.	Use highest quality fresh meat baits available.		
Pig													Bait with 1080. Aerial shooting.			
Goat													Trapping at water points: 2 x per year.			
European Rabbit													Not recommended at present. Otherwise bait with 1080: 2 x per year.	If drought conditions, choose another suitable season.		